The Language of Medical Terminology II

The Language of Medical Terminology II

An Introduction to Pharmacology

SUSANNE ERICKSON AND LISA STURDY

NORQUEST COLLEGE
EDMONTON, AB

Contents

Introduction 1

Chapter I. Introduction to Pharmacology

1.1 Introduction to Pharmacology 5
1.2 Medication Trade and Generic Names 7
1.3 Medication Forms and Routes 14
1.4 Parenteral Medication Forms and Routes 33
1.5 Types of Medication Orders 50
1.6 Review 55

Chapter II. Urinary System and Medications

2.1 Introduction to the Urinary System and Medications 59
2.2 The Urinary System 62
2.3 Urinary System Pathologies 70
2.4 Urinary System Medications 77
2.5 Review 90

Chapter III. Digestive System and Medications

3.1 Introduction to the Digestive System and Medications 95
3.2 The Digestive System 97
3.3 Digestive System Pathologies 113

3.4 Digestive System Medications 121
3.5 Review 141

Chapter IV. Musculoskeletal System and Medications

4.1 Introduction to the Musculoskeletal System and Medications 145
4.2 The Musculoskeletal System 147
4.3 Musculoskeletal System Pathologies 155
4.4 Musculoskeletal System Medications 166
4.5 Review 185

Chapter V. Respiratory System and Medications

5.1 Introduction to Respiratory System and Medications 191
5.2 The Respiratory System 193
5.3 Respiratory System Pathologies 206
5.4 Respiratory System Medications 216
5.5 Review 235

Chapter VI. Cardiovascular System and Medications

6.1 Introduction to the Cardiovascular System and Medications 241
6.2 Cardiovascular System 243
6.3 Cardiovascular System Pathologies 251
6.4 Cardiovascular Medications 263
6.5 Review 282

Chapter VII. Hematological System and Medications

7.1 Introduction to the Hematological System and Medications 287
7.2 The Hematological System 290
7.3 Hematological Pathologies 301
7.4 Hematological Medications 308
7.5 Review 320

Chapter VIII. Endocrine System and Medications

8.1 Introduction to the Endocrine System and Medications 325
8.2 The Endocrine System 328
8.3 Endocrine Pathologies 338
8.4 Endocrine System Medications 346
8.5 Review 369

Chapter IX. Nervous System and Medications

9.1 Introduction to the Nervous System and Medications 373
9.2 The Nervous System 375
9.3 Nervous System Pathologies 387
9.4 Nervous System Medications 396
9.5 Review 409

Chapter X. Psychiatric Conditions & Medications

10.1 Introduction to Psychiatric Conditions and Medications 413
10.2 Psychiatric Pathologies 415
10.3 Antidepressant and Anti-Anxiety Medications 423
10.4 Other Psychiatric Medications 434
10.5 Review 443

Chapter XI. Analgesic Medications

11.1 Introduction to Analgesic Medications 447
11.2 Physiology of Pain 449
11.3 Non-Narcotic Analgesics 458
11.4 Narcotic and Adjuvant Analgesics 468
11.5 Review 481

Chapter XII. Antimicrobial Medications

12.1 Introduction to Antimicrobial Medications 485
12.2 Antimicrobial Basics 487
12.3 Antibiotic Medications 495
12.4 Other Antimicrobial Medications 509
12.5 Review 520

Glossary 523
Abbreviations 543
Common Suffixes 581
Complete Medication List 584

Introduction

Welcome to the *Language of Medical Terminology II* OER

It is very exciting to learn about body systems and medications, which are the focus of this open educational resource (OER). This resource was designed for a Medical Terminology II course for hospital unit clerks at NorQuest College; however, it is likely to be useful for individuals in other healthcare professions as well.

To assist with learning this content, each chapter has embedded H5P activities, including a final chapter review. We have also included content on abbreviations, common suffixes in medication names, and a glossary. We hope that this textbook will provide a thorough, however basic, overview of the concepts of pharmacology in the healthcare setting.

How to Use This OER

Learning medical terminology and pharmacology requires a lot of commitment. In order to get the full benefits of this textbook, review is important, and using the review exercises and activities in the chapters will help you learn and remember the content.

For instructors, our hope is that you can use the content and adapt it as necessary for your own programs and courses.

Attribution

A number of open educational textbooks and other reference materials were used in the creation of this resource. The works listed below are those most often referenced in this OER. For each chapter, attribution is provided for these and other resources that were used.

- Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0
- Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

Cover image: *VariousPills*, by MorgueFile, CC BY SA 3.0

This resource was produced by NorQuest College in partnership with the University of Alberta Library's Open Education Alberta publishing project.

UNIVERSITY OF ALBERTA LIBRARY

CHAPTER I

INTRODUCTION TO PHARMACOLOGY

1.1 Introduction to Pharmacology

Learning Objectives

By the end of this chapter, you should be able to

1. Differentiate between a brand name and a generic drug name
2. Describe common forms of medications
3. Describe the various routes of medication administration, including their abbreviations
4. Describe what a prescription is
5. List the components of a medication order or prescription
6. Describe the different types of medication orders
7. Identify abbreviations used in medication orders

Chapter Overview

Most of us have a taken a medication at some point in our lives, for example, an analgesic for a headache or an antibiotic for a bacterial infection. Because they are so commonly used, the study and understanding of medications is integral knowledge for any medical professional, and even members of the general population. **Pharmacology** is a complex topic of study, but this book, and this chapter in particular, will strive to explain this concept in simple terms to ensure that you have the understanding necessary to work in the medical field. The basics of drug names, forms, administration routes, and medication orders will be discussed. This will create a foundation of knowledge you will use throughout this book, which will focus on body systems and the medications used to treat the pathologies that affect them.

1.2 Medication Trade and Generic Names

Brand and Generic Medication Names

All medications have **generic names**, and these are the same worldwide. They also have **brand names**, which can vary between parts of the world and are created by the companies that sell the medications. **Brand** names are often also referred to as **trade** names. The terms are used interchangeably. A generic medication can be sold under multiple brand names. Usually brand names are easier to pronounce and remember, which makes the medications easier to sell. Both generic and brand name drugs must have the same active ingredients, but the inactive ingredients might differ. This can become an issue if a patient has dietary restrictions or allergies. Generic and brand name drugs may differ in size, shape, and colour. Generic drugs are typically less expensive than brand name drugs (CADTH, 2022).

The Canadian drug reference is the **Compendium of Pharmaceuticals and Specialties (CPS)** and is the resource that all pharmacists and physicians use to reference medications. Nowadays, it is available through an online subscription as well as an app that can be downloaded and regularly updated. Previously, it was only available in paper format and, as such, was only updated annually. In the CPS, brand names are boldface or underlined and generic names are italicized.

Table 1.1. Brand and Generic Drug Names

Brand Name	Generic Name
Benadryl	*diphenhydramine*
Gravol	*dimenhydrinate*
Motrin	*ibuprofen*
Tylenol	*acetaminophen*

Although the table above lists just a few examples, typically the brand name is the more recognized name among the general population compared to the generic name, which is typically more complex and harder to remember.

What's in a Name?

Generic drug names are the chemical names and are usually more difficult to pronounce. Brand names, on the other hand, are created by the drug companies that make their version of the generic drugs. Pharmaceutical companies do not have to follow any language rules when creating their drug names. Some drug names indicate the reason for use, such as Boniva, a drug for treating bone loss. The name might also indicate how often it should be given, as in Lithobid, which is given twice daily ("bid" is a medical abbreviation for "two time a day"), or the drug company may want to produce a positive feeling; for example, the name Viagra, a drug that treats erectile dysfunction, evokes a feeling of vitality. Once a name is created, it is reviewed by the Food and Drug Administration (FDA) (Pfizer, 2022).

Fig. 1.1

Fig. 1.1 shows a package of the medication Lipitor (the brand name) and also shows the generic name, Atorvastatin calcium, on the label. The drug name was created to indicate that it is used to treat lipids, and in this case, it is used to lower "bad" (LDL) cholesterol. The label also indicates the dosage in each tablet (40 mg) and that the box contains 28 tablets.

Fig. 1.2

Review

An interactive H5P element has been excluded from this version of the text. You can view it online here:

https://openeducationalberta.ca/medicalterminologyii/?p=170#h5p-10

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College.. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Canadian Agency for Drugs and Technologies in Health (CADTH). (2022). *Similarities and differences between brand name and generic drugs.* https://www.cadth.ca/similarities-and-differences-between-brand-name-and-generic-drugs

Pfizer. (2022). *Part 2: What's in a brand name? How drugs get their names.* https://www.pfizer.com/news/articles/part_2_what_s_in_a_brand_name_how_drugs_get_their_names

Image Credits (images are listed in order of appearance)

Atorvastatin40mg by Panthro, CC BY-SA 3.0
Tylenol by Mrbeastmodeallday, CC BY-SA 4.0

1.3 Medication Forms and Routes

Medication Routes and Forms

Medications can be given using many routes, and different forms of medication can be given through those routes. Also, some medications can be given in various routes; for example, Gravol can be given orally, intravenously, and intramuscularly. However, this does not apply to all medications. The route and form in which a medication is given will vary depending on the medication itself, the reason for administering the medication, and the patient. The most common drug routes and drug forms are described below; parenteral routes will be described in the next section.

Oral Medication Route

The **oral route** (abbreviation **po**) is one of the most common for medication administration, and many forms of medication can be given this way. The main advantage of the oral route is ease of administration. Medication taken via the oral route has slower onset, and typically the effect lasts longer but is less potent than other routes. There are some disadvantages to the oral route because some medications cannot be given orally, and some patients cannot take oral medications due to nausea and vomiting or if they are unconscious. In addition, some oral medications interact with certain foods and beverages, which can cause the

medication to become inactive or produce severe side effects. In these cases, the medication would be given through another route.

Oral Drug Forms

Tablets

A **tablet** (abbreviation **tab**) consists of an active ingredient, which is the medication, and an inactive ingredient, which consists of fillers and binders so that the medication has a certain shape, size, and colour. Sometimes this is important to those that are on oral medications because it helps them identify their pills once they are taken out of the original packaging. There are several tablet drug forms described in the highlighted box below.

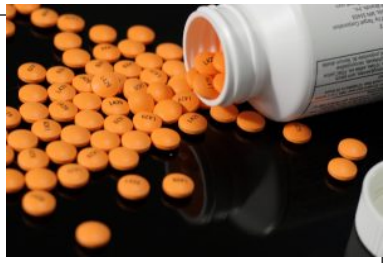


Fig. 1.4

Fig. 1.3

One or more interactive elements has been excluded from this version of the text. You can view them online here:

https://openeducationalberta.ca/medicalterminologyii/?p=371#video-371-1

Tablet Forms

- **Scored:** This type of tablet is marked so it can be divided into equal portions depending on the dose prescribed (Fig. 1.3). If only half a dose is needed, the patient can easily break the tablet into two separate doses.
- **Enteric coated:** This type of tablet has a hard outer coating that helps make it easier to swallow and protects the stomach from irritation (Fig. 1.4). The coating dissolves slowly so the medication is absorbed in the small intestine rather than the stomach.
- **Effervescent:** This type of tablet must be dissolved in water before being administered to a patient and "fizzes" as it dissolves; click on the video above to view this process. Antacid medications are an example of an effervescent tablet.
- **Slow release:** This type of tablet is produced so that the effects last over a longer period of time. Abbreviations associated with the trade names of these tablets include **CD** (controlled delivery), **ER**

(extended release), **LA** (long lasting), **SR** (slow release), and **XL** (extended length).

- **Caplet:** This type of tablet is usually oblong in shape and tends to be easier to swallow than other tablet types (Fig. 1.5).
- **Lozenge:** This is a hardened, usually sweetened tablet form and is almost candy-like (Fig. 1.6). It should not be swallowed, but rather placed in the mouth and allowed to slowly dissolve. Lozenges are typically used to treat a sore throat.

Fig. 1.6

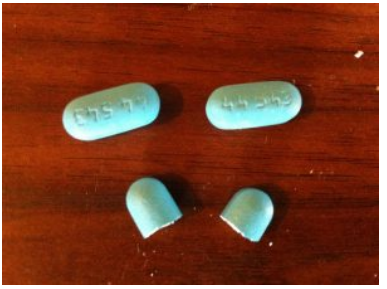


Fig. 1.5

Capsules

A **capsule** (abbreviation **caps**) is either one piece—a liquid medication enclosed in a soft outer layer—or two hard pieces that fit together and are filled with either a powder or small

granules. The hard capsules come in various colours, which helps patients identify their medications. Most capsules are intended to be swallowed whole, but there are exceptions. In any case, it is important to speak to a pharmacist to ensure that the medication is taken properly. Fig. 1.7 shows two soft, one-piece, liquid-filled capsules and two hard, two-piece, powder- or granule-filled capsules .

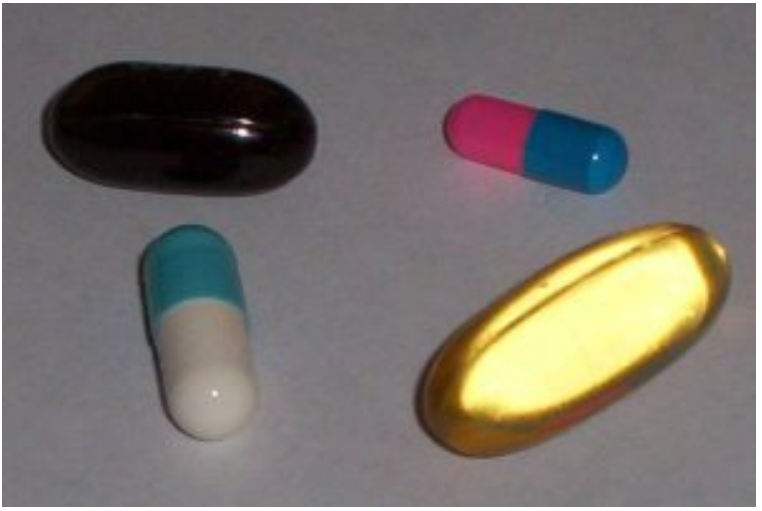


Fig. 1.7

Liquids

Many medications come in **liquid** form and can be given orally, but can also be given through other routes, including a nasogastric or gastrostomy tube. These routes will be discussed in more detail later in the chapter. The textbox below lists and describes the most common oral liquid drug forms.

Liquid Drug Forms

- **Elixir:** This type of liquid medication is mixed with water and alcohol, as well as additional flavouring and colouring to enhance taste and appearance. It is commonly used for children and elderly patients who have difficulty swallowing.
- **Syrup:** This type of medication is mixed with thickened water, colour, and flavouring. Because this liquid is thicker and coats the throat as it is swallowed, it has a soothing effect and is often used for medications that treat sore throats and coughs.
- **Suspension:** This type of liquid medication contains fine particles of the drug suspended in either water or an oil base (Fig. 1.8). It is very important to **shake** this medication well before taking it because the medication usually settles to the bottom, and the water or oil remains on the top.

Fig. 1.8

Sublingual and Buccal Routes

The **sublingual route** (abbreviation **sl**) is similar to oral medication administration but differs in one key aspect—in sublingual medication administration, the medication is held **under the tongue** and dissolves. This is ideal in that the medication does not need to be swallowed and begins working more quickly because it is absorbed through the mucous membranes under the tongue.

The **buccal route** is similar to the sublingual route in the sense that the medication is not swallowed, but rather the medication,

usually a tablet, is placed in the pouch between the cheek and the lower lining of the gums.

The textbox below describes some of the most common drug forms that can be given via the sublingual and buccal routes.

Sublingual and Buccal Drug Forms

- **Film:** This is a small dissolving strip that contains a medication and can either be placed under the tongue or in the buccal pouch, where the strip dissolves and the medication is absorbed quickly into the bloodstream (Fig. 1.9).
- **Liquid spray:** Sprays are usually administered sublingually, but depending on the medication, can also be sprayed into the mouth and absorbed via the mucous membranes. Fig. 1.10 (right) shows a common example, nitroglycerine, in a red spray bottle.
- **Tablet:** Sublingual and buccal tablets should not be swallowed and are most effective when placed under the tongue or placed between the cheek and gum and allowed to dissolve.
- **Powder:** This type of powder is emptied from the packet and placed sublingually so it can dissolve and be absorbed into the bloodstream (Fig. 1.9).

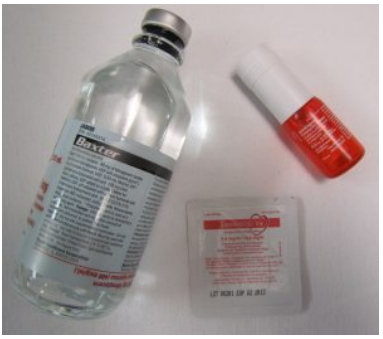


Fig. 1.10

Fig. 1.9

Nasogastric and Gastrostomy Tube Routes

The **nasogastric (N/G)** and **gastrostomy routes** are generally used when a patient cannot take their medication orally. The medication is delivered either through a **nasogastric tube (N/G tube)** or a **gastrostomy tube (G-tube)** that goes directly into the stomach or small intestines. Most medication that can be given orally can be given in this manner. Once approved by the pharmacist, medication can be crushed and administered via the tube or can come from the pharmacy already prepared. Fig. 1.11 is an image of an NG tube, and Fig. 1.12 shows medication being instilled into a gastrostomy tube. The preferred drug form for this route is liquid because it decreases the risk of blockage within the N/G or G-tube, and the absorption rate is better when the liquid drug form is used.

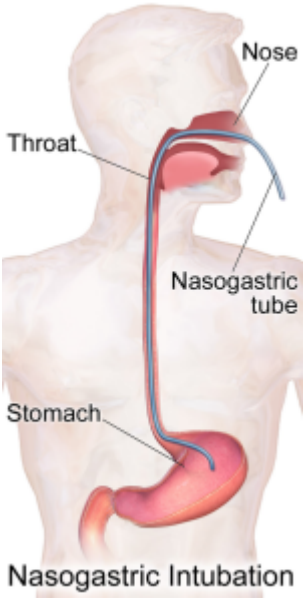


Fig. 1.11

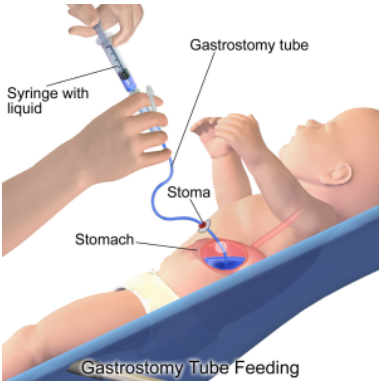


Fig. 1.12

Inhalation Route

The most common way to administer medication via the inhalation route is by **inhaler**. There are a number of different types of inhalers, and they vary depending on the medication and the reason for administration. The most common drug forms given via the inhalation route are powders, liquids, and gas in some type of container (inhaler) that allows the medication to be inhaled and absorbed into the lungs. A **nebulizer** is another way that inhaled medications are delivered. A nebulizer is a small machine that changes liquid medication into a mist that the patient breathes in, usually through a mask worn over the nose and mouth. The textbox

below lists the different devices that are used for the inhalation route.

Fig. 1.13

Fig. 1.14

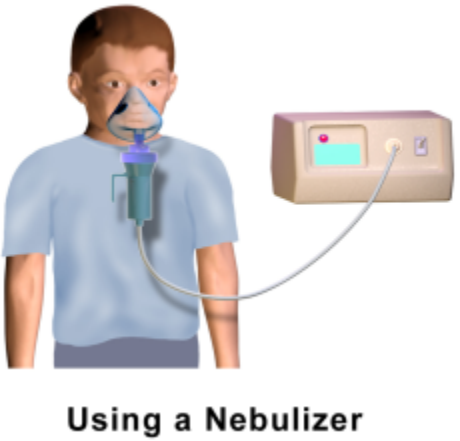


Fig. 1.15

Inhalation Drug Devices

The following devices can be used to deliver various inhalation drug forms:

- Metered-dose inhaler (MDI) (Fig. 1.13)
- Dry powder inhaler (Fig. 1.14)
- Nebulizer (Fig. 1.15)

These devices will be discussed further in Chapter 5, section 5.4 Respiratory Medications.

Rectal Route

The **rectal route** (abbreviation **pr**) is used when a patient has issues taking medication orally. It is also commonly used with children because many young patients are unable to take medication orally or have difficulty swallowing medication. Some pain medication can be given through the rectal route in the form of **suppositories**, but others can be given in the form of **creams**, **lotions**, or **ointments**. If a patient is constipated or needs contrast for a scan, they might be given an **enema**. The textbox below describes the different drug forms that can be administered rectally.

Fig. 1.16

Fig. 1.17

Rectal Drug Forms

- **Suppositories:** A rectal suppository is shown in Fig. 1.16. Several medications can be given in this form, including analgesics, anti-inflammatories, and laxatives.
- **Creams, lotions, and ointments:** These medication forms are used to treat conditions such as rectal pain, itching, and inflammation and hemorrhoids.
- **Enema:** An enema is shown in Fig 1.17. Medications are given as an enema to treat conditions such as constipation and sometimes as a preparation for a test (e.g., barium enema).

Vaginal Route

Medication delivered using the **vaginal route** (abbreviation pv) is absorbed quickly, and this route might be used to treat specific conditions such as vaginal fungal and yeast infections and vaginal dryness, or for contraception or hormone replacement (Lillis, 2018). The drug forms used for the vaginal route are **suppositories**, **vaginal tablets**, **creams**, **foams,** and **ointments.** Fig. 1.18 shows vaginal foam and vaginal tablets (suppositories) used for contraception.

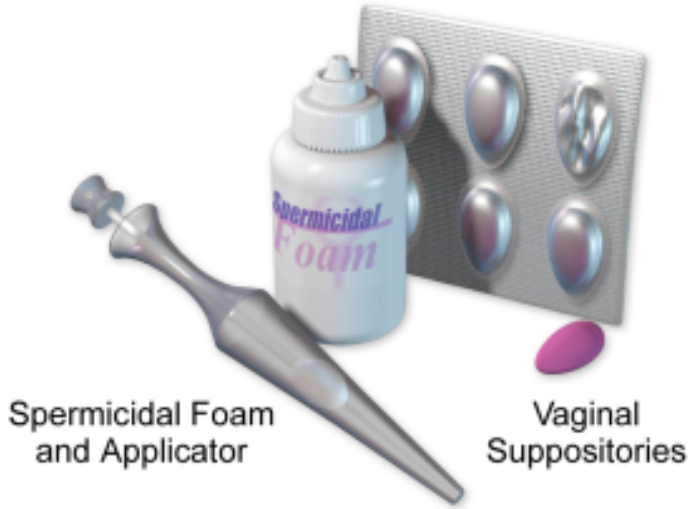


Fig. 1.18

Topical Route

Topical medications can be applied to the skin, eyes, and ears. They typically work locally, which means they only have a therapeutic affect on the area where they are applied. Absorption is usually

slower through the skin but generally produces a steady, longer-lasting effect. Various drug forms that can be used topically are briefly described in the textbox below.

Topical Drug Forms

- **Drops:** Various drop solutions can be given either into the eye, ear, or nose, depending on the reason for administration. Some common medication types are antibiotics, numbing agents, and lubricating drops. The abbreviation for drops is **gtt**.
- **Lotion, creams, and ointments:** These are all similar, the main difference being the amount of oil or water that is used in combination with the active ingredients of the medication. The abbreviation for ointment is **ungt**.
- **Powder:** Powders are applied to an affected area and are used to treat various pathologies such as fungal infections, which can be treated with nystatin powder (Cleveland Clinic, 2022).

Transdermal Route

The **transdermal route** is very similar to the topical route, but there are differences. Transdermal patches are applied to the skin and left on so the medication can be absorbed slowly. A common example is the nicotine patch (Fig. 1.19), which is used to help people quit smoking. Medications are also given via this route for pain,

depression, pregnancy prevention, nausea, heart issues such as angina, and hormone replacement (Fig. 1.20). Another difference between transdermal patches and the topical route is that transdermal medications typically act systemically, which means the medications have a therapeutic effect throughout the body rather than just locally.

Fig. 1.19

Fig. 1.20

Review

An interactive H5P element has been excluded

from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=371#h5p-7

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=371#h5p-8

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=371#h5p-9

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Cleveland Clinic. (2022). *Nystatin topical powder.* https://my.clevelandclinic.org/health/drugs/18930-nystatin-topical-powder

Lillis, C. (2018, August 29). *How do you use vaginal suppositories?* Medical News Today. https://www.medicalnewstoday.com/articles/322908#what-are-vaginal-suppositories-used-for

Image Credits (images are listed in order of appearance)

Methocarbamol 750 MG Oral Tablet by National Library of Medicine (NLM), Public domain

Regular strength enteric coated aspirin tablets by Ragesoss, CC BY-SA 4.0

Effervescent tablet (video) by Hangsna, CC BY-SA 3.0

Three Blue Cold and Allergy Caplets by ParentingPatch, CC BY-SA 3.0

Hustenbonbons 02 by Kritzolina, CC BY-SA 4.0

Gelcaps by Keffy, CC BY-SA 2.5

Mebendazole_liquid by Whispyhistory, CC BY-SA 4.0

8-2 Suboxone by Sintegral, CC BY-SA 4.0

Nitro by James Heilman, CC BY-SA 3.0

Nasogastric Intubation by BruceBlaus, CC BY-SA 4.0

Gastric Feeding Tube Infant by BruceBlaus, CC BY-SA 4.0

Inhaler1 by ben dalton, CC BY 2.0

Dry powder inhalers by BrettMontgomery, CC BY-SA 4.0

Nebulizer Mask (Child) by BruceBlaus, CC BY-SA 4.0

Suppositorien by Nynyny, CC BY-SA 3.0

Enema prepared, disposable by Helen4780, CC BY-SA 4.0

Spermicidal Foam & Suppositories by BruceBlaus, CC BY-SA 4.0

NicotinePatch by Styroks, CC BY-SA 4.0

Generic estradiol (Mylan) 0.1 mg per day once-weekly transdermal systems by Medgirl131, CC BY-SA 4.0

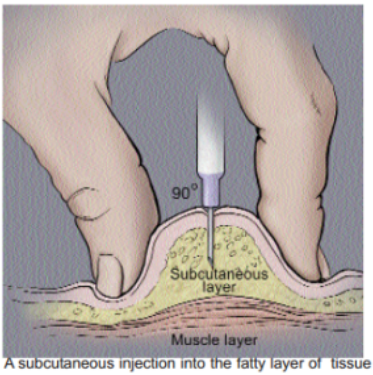
1.4 Parenteral Medication Forms and Routes

The **parenteral route** sometimes refers to any route of administration other than oral, but more often, it refers to a route that involves injecting medication into the body. This section will discuss all parenteral routes of administration that involve injecting medication or fluids. There are benefits and drawbacks to all these routes, and many factors must be considered when determining the best route for a given medication.

Subcutaneous (sc) Route

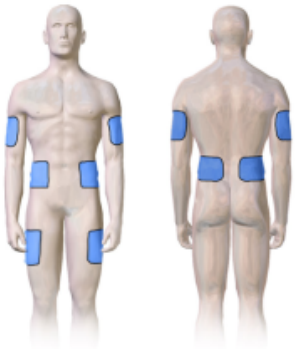
The **subcutaneous route** (abbreviation **sc**) delivers medication into the deepest layer of the skin, which is composed of fats and tissues (Ernstmeyer & Christman, 2020). The medication is injected with a syringe and needle and has a relatively predictable rate of absorption. The benefit of this route is that the therapeutic effects last longer than other routes, such as the intravenous route, for example. The location and means of injecting the medication make it easier for patients to self-administer at home compared to other routes, such as the intramuscular route. One of the drawbacks of the subcutaneous route compared to oral or other noninvasive routes is the possibility of infection because the patient's skin is pierced. Also, the therapeutic effects generally take longer to take effect as compared to medications administered via the intravenous route, so the subcutaneous route is not ideal in an emergency (Ernstmeyer & Christman, 2020). Fig. 1. 21 provides an example of

how subcutaneous injections are administered, and Fig. 1.22 shows locations where subcutaneous injections can be given.



A subcutaneous injection into the fatty layer of tissue (pinched up to give the injection) under the skin.

Fig. 1.21



Sites on the Body Where a Subcutaneous Injection Can Be Given

Fig. 1.22

Intramuscular (IM) Route

The **intramuscular route** (abbreviation **IM**) delivers medication into a patient's muscle (Ernstmeyer & Christman, 2020). The therapeutic effects tend to last longer via this route as compared to the subcutaneous route. However, the main drawback for this route is that because of the location and the technique

required to do the injection, it is highly unlikely that a patient would be able to self-administer medication at home. There is also a higher chance of infection because the needle is inserted more deeply and at a 90° angle into the tissue, as can be seen in Fig. 1.23. This route is ideal for administering many medications as well as vaccines (Ernstmeyer & Christman, 2020).

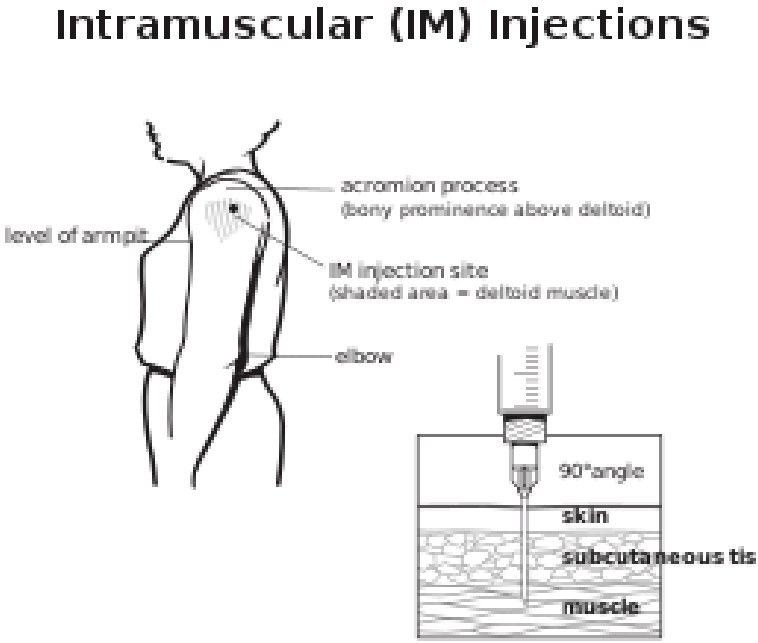


Fig. 1.23

Medication Forms

Medication that is to be administered by either of the routes shown above and, in some cases, intravenously, usually comes in a **vial** or **ampoule** and is drawn up into a syringe (Ernstmeyer & Christman, 2020).

Vials are shown in Fig.1.24 and can be used multiple times because the medication is drawn up through a sealed stopper on the top. The medication may come as a liquid in the vial or a powder that is then reconstituted with sterile water or normal saline, then shaken to mix the contents.

Fig. 1.25 shows an **ampoule** that contains liquid medication; the ampoule is opened by breaking the top, and the medication withdrawn with a syringe (Ernstmeyer & Christman, 2020). Ampoules cannot be reused, so any unused medication must then be discarded as per the hospital's policy.

Fig. 1.24

Fig. 1.25

Intradermal Route

The **intradermal route** is less common for administering medications and involves injecting a medication or other substance into the dermis, which is right below the epidermis. This route is often used for tuberculosis and allergy testing, but it is also used to inject local anesthetics (Ernstmeyer & Christman, 2020), for example, if a patient requires stitches. Fig. 1.26 demonstrates how an intradermal injection is completed, and Fig.1. 27 provides a comparison of four different parental routes.

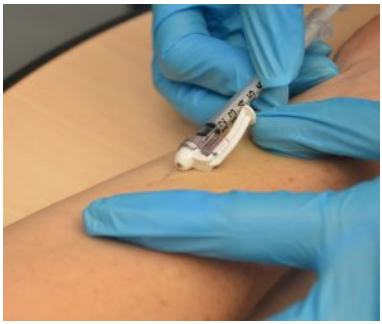


Fig. 1.26

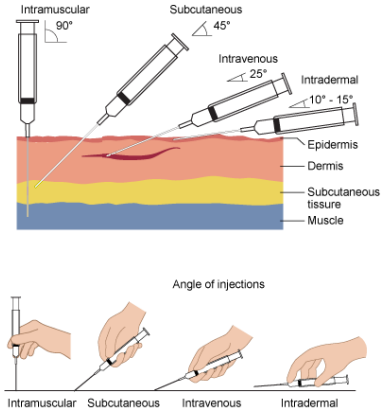


Fig. 1.27

Intravenous (IV) Route

The **intravenous route** (abbreviation **IV**) delivers medication through an intravenous line that is connected to a small catheter in a patient's vein. The therapeutic effects of medication given intravenously occur faster as compared to intramuscular and subcutaneous injections but do not last as long. However, the immediate therapeutic effect makes it a desirable route in an emergency, where it is important for the patient to receive the medication as quickly as possible. There can also be complications with this route if the intravenous catheter dislodges from the vein. This is called **extravasation**, and in this situation, the fluid from the intravenous line flows into the subcutaneous tissue rather than

the vein. This can become very uncomfortable for the patient, and the area around the intravenous site will begin to swell. Another complication is called **vesicant**, whereby the medication in the intravenous line irritates the skin, causing blisters or necrosis, when it contacts the subcutaneous tissue. When this is a concern for a particular medication, the intravenous site should be monitored regularly for any issues.

The equipment needed for administering medication via the intravenous route includes the following:

- Bag of intravenous fluid
- Connective tubing (Fig. 1.28)
- Roller clamp to control the flow (Fig. 1.28)
- Needle or flexible catheter (Fig. 1.29)
- Infusion pump, if available

Fig. 1.29

Fig. 1.28

Reasons for Administering an Intravenous Infusion

It is relatively commonplace for patients to receive intravenous (IV) infusions when they are in hospital. Some reasons are listed below:

- **To replace lost fluids:** Fluids may need to be replaced because the patient has lost blood or is dehydrated.
- **To administer medication:** When a patient receives medication via the IV route, that medication is combined with an IV solution and usually run as a piggyback to the main line. This is discussed in more detail below, where different types of IVs are explained.
- **To maintain electrolyte balance:** Electrolytes such as potassium (K), for example, can be given via IV if the patient has low levels of a specific, or all, electrolytes.
- **Potential to become depleted:** An IV can be run at a low rate to avoid potential loss of fluids or electrolytes if they are likely to become depleted.
- **Emergency situations:** Emergency situations can occur during surgery or in the emergency department. In these situations, a patient may require various IV medications and fluid replacement.
- **To administer blood and blood products:** When blood or blood products are administered via an IV line, the line is always run secondary to an IV line of fluid in case the patient has a reaction to the blood product being given.

Different Types of Intravenous Infusions

There are different ways that IV fluids or medications can be given, and most of the subtypes of IV administration are listed below. All involve some form of IV access, which is usually through a small catheter placed into a patient's vein.

- **Primary infusion:** This type of IV administration involves a bag of IV fluid connected to a primary IV line, which is attached to a small catheter in a patient's vein. The IV line may be attached to a machine or simply use gravity, and the medication administration is measured by drip rate.
- **Piggyback:** In the piggyback method, a smaller secondary bag and line are attached to the primary IV infusion. This is shown in Fig. 1.30 below, where you can see the smaller bag hanging from the pole. Typically, medication is added to the secondary bag as a way of slowly administering it to the patient.
- **Saline lock:** In this method, a small IV line is attached to the catheter inside the patient's vein and "locked" with a saline solution. A port on the end allows a primary infusion line to be attached if IV fluids are needed. Saline locks allow patients to be mobilized more easily because they can be detached from the longer IV line and pole. Medication can also be given through the saline lock. Another option available is a **heparin lock**, which allows a small dose of heparin, an anticoagulant, to be instilled in the catheter. This is less common in many hospitals but is sometimes used because it can prevent blood from clotting around the IV site and ensures that the site is not lost.
- **Direct IV:** In this method, shown in Fig. 1.31, medication in a syringe is attached to a port on the IV line and injected into the line so the patient receives the medication at a faster rate than they would with a piggyback.
- **IV bolus:** A bolus is a large amount of fluid administered in a very short time. It can also be used as a way of administering IV fluids quickly in an emergency situation.
- **Keep the vein open:** This is a very slow-rate infusion, often about 30 mL/hr, and is only used as a means of not losing an IV site. This is often used when there is a concern that the IV site would be lost if a saline lock was used. The abbreviation for this type of infusion is **KVO**.

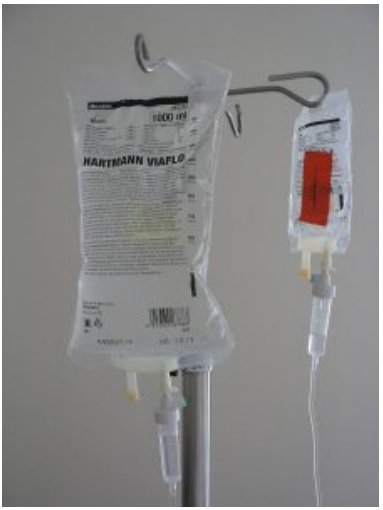
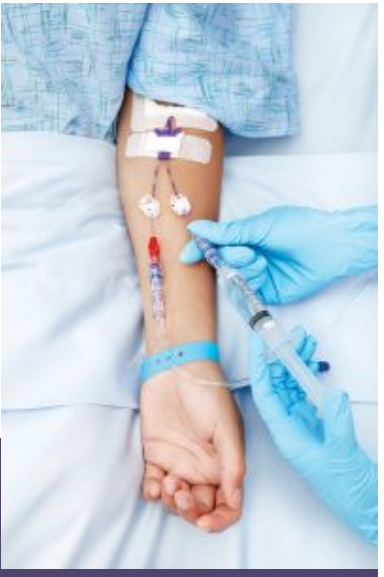


Fig. 1.30



Intravenous (IV) Solutions

Fig. 1.31

Various IV solutions can be used for intravenous

infusions, and many of them are used regularly in the hospital setting. The more common types are listed below, but there are others that may be used on specialty units within the hospital:

1. **Normal saline 0.9%:** This is one of the most commonly used IV solutions and is a mixture of sodium chloride and water. It has many uses in the hospital, the most common being fluid replacement. The abbreviation for this solution is **NS**.
2. **Normal saline 0.45%:** This is a less-common form of normal saline and can be considered **1/2 normal saline** because the percentage of sodium chloride is half of what it would normally be.
3. **2/3 dextrose and 1/3 normal saline:** This solution is a mixture of dextrose (sugar) and normal saline. The common abbreviation is **2/3–1/3.**
4. **5% dextrose in water:** This solution is a mixture of dextrose (sugar) and water. The percentage indicated can vary depending on the amount of dextrose in the solution; for example, it could be 10% or 50%. The abbreviation is **D5W** and may vary depending on the level of dextrose; for example, 10% dextrose in water would be D10W.
5. **5% dextrose in saline:** This solution is similar to D5W but is a mixture of dextrose (sugar) and saline instead of water. The amount of dextrose can vary, similar to the dextrose and water solution. The abbreviation is **D5NS** and can also vary depending on the level of dextrose.
6. **Ringer's lactate:** This solution is commonly used for fluid replacement and contains water, sodium

chloride, sodium lactate, potassium chloride, and calcium chloride. The abbreviation is **R/L**.

Fig. 1.32

Intravenous solutions come in a variety of sizes of bags, and the intended use usually determines the size selected. Primary infusions, for example, often use a larger size, whereas piggybacks

use smaller solution bags. Some available sizes include the following:

- 1,000 cc (1 litre) (Fig. 1.32)
- 500 cc
- 250 cc
- 100 cc
- 50 cc
- 25 cc

Central Lines

Central lines are often used to continuously infuse intravenous fluids and medications. As seen in Fig. 1.33, a catheter is inserted into a vein in the arm, or in some cases the neck, then the catheter is threaded through the vein and positioned near the entrance to the heart. These lines are ideal if intravenous medications are going to be administered for a long period of time and in cases when starting an intravenous line is difficult because of the patient's vasculature.

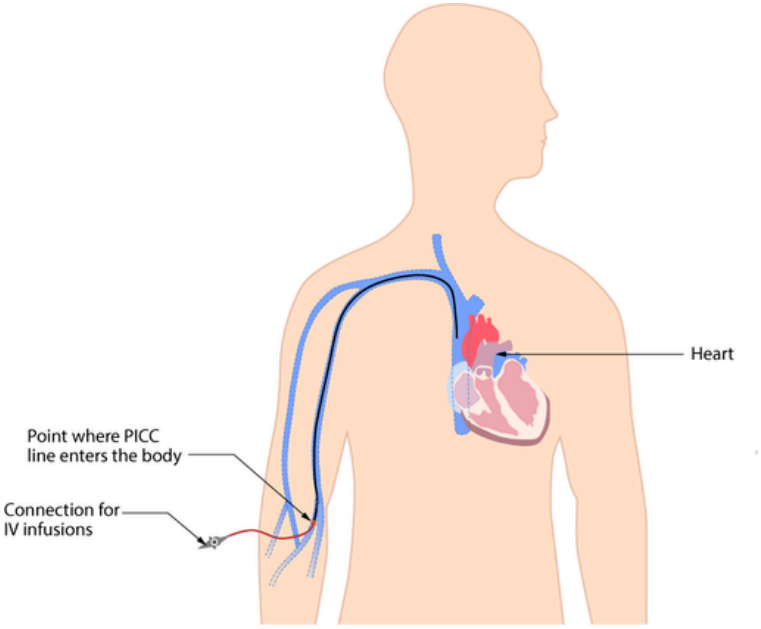


Fig. 1.33

Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=373#h5p-12

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Doyle, G. R., & McCutcheon, J. A. (2020). *Clinical procedures for safer patient care*. BCcampus Open Education. https://opentextbc.ca/clinicalskills/, licensed under CC BY 4.0

References

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

Image Credits (images are listed in order of appearance)

Subcutaneous_injection by National Institutes of Health, Public domain

Injection Sites Subcutaneous by BruceBlaus, CC BY-SA 4.0

Intramuscular (IM) Injections by Immunization Action Coalition, Public domain

Depo-Estradiol (estradiol cypionate) vials by Medgirl131, CC BY-SA 4.0

ParaldehydeAmpoule by Colin Harkness, Public domain

Intradermal injection by British Columbia Institute of Technology (BCIT), CC BY-SA 4.0

Needle-insertion-angles-1 by British Columbia Institute of Technology (BCIT), CC BY-SA 4.0

Капельница by Vlish, CC BY-SA 3.0

IV Catheters 15 by Intropin (Mark Oniffrey), CC BY-SA 4.0

Infuuszakjes by Harmid, Public domain

ICU IV 1 by Calleamanecer, CC BY-SA 3.0

Intravenous therapy oxcytocin by Eliran t, CC BY-SA 4.0

Peripherally inserted central catheter (PICC) by Glynda Rees Doyle and Jodie Anita McCutcheon, CC BY-SA 4.0

1.5 Types of Medication Orders

Prescriptions (Rx)

Traditionally, physicians wrote prescriptions by hand, usually on a prescription pad or preprinted form. Prescriptions had to be completed in ink and included in a patient's medical record. As technology has advanced, prescriptions have too, and most of the time in North America, they are now provided electronically, though in some cases, a handwritten prescription may still be used. There are certain components that should be included in all prescriptions, and these are explained below.

Components of a Medication Order/Prescription

Medication orders are written by doctors and use specific components, including directions for the person giving the drug.

The components of a medication order are the following:

1. **Medication name**

Some orders give not only the name of the medication, but also indicate a specific form of the drug (given in italics):

- Neosporin ointment *ophthalmic*
- Aspirin *EC*
- Aspirin *supp*

2. **Administration route**

Medications may be given through different routes, though any medication may be prepared to be administered by different methods. Examples include **po (oral)**, **sl (sublingual)**, **sc (subcutaneous)**, and **IV (intravenous)**.

3. **Administration frequency**

All hospitals have a schedules of hours for the administration of medications. You must learn the schedule for your particular hospital unit. Military time (the 24-hour clock) is used in place of standard time in the healthcare system.

4. **Medication dose**

The dose is the amount of medication to be given. Quantities can be specified in many different forms; for example, in L, mL, mg, and mcg, among others.

5. **Qualifying phrases**

Qualifying phrases are used when the doctor wants the medication to be administered for a specific reason or condition. These are not included in all medication orders.

Examples of qualifying phrases:

- For severe pain
- For stomach spasm
- For N&V (nausea and vomiting)
- For insomnia
- While awake only

Examples of Medication Orders

Examples of medication orders:

1. Ampicillin 500 mg bid po x 10 days for toe infection
2. Benadryl 50 mg bid po

Explanation:

1. Ampicillin 500 milligrams twice a day by mouth for 10 days for a toe infection
2. Benadryl 50 milligrams twice a day by mouth

Types of Medication Orders and Prescriptions

Certain types of medication orders that may be seen in the hospital and community setting include the following:

Prescriptions: Medications that must be prescribed by a physician because they are not safe to take unless under professional medical supervision.

Over the Counter (OTC): Medications that do not need a prescription and can be purchased in local stores.

Scheduled medication orders: These orders must be recorded on the medication administration record (MAR) and have times or frequencies assigned. The orders specify that medications are to be given once a day, twice a day, or at a certain time.

PRN orders: These orders do not have times or frequencies assigned. They are given as needed; for example, when the patient is in pain or experiencing nausea.

One-time or short-series orders: These orders are for medication that is given one time only or for a limited number of doses; for example, two doses in 24 hours.

STAT orders: This type of order is for medications that are

ordered from the pharmacy by phone or computer and must be filled immediately, then followed up with a pharmacy requisition. This type of order must be processed right away so that the medication can be given to the patient immediately.

Verbal orders: Verbal orders are given by a physician over the phone or sometimes in person, usually to a charge nurse, who then documents the order to be signed by the physician at a later time. This often occurs in the evening, when the physician is away, so that the medication can be ordered and given to the patient prior to the physician returning to the unit. The nurse who takes this order writes **v/o** next to it in the chart, and the when the physician comes in, they will sign the order.

Standing or preprinted orders: These orders vary among units and are created for common procedures or patient conditions so that a physician can simply check off their desired order on a set of preprinted orders, and then sign the document. This helps make ordering medications easier for both the physician and other medical professionals who process the orders.

Automatic stop order: This type of order originates in the hospital pharmacy and is not written by the physician. An automatic stop order is given for all medications, especially for certain types of medications that may be detrimental for patients if they are given for a long period of time. Some patients stay in the hospital for a long time, and an automatic stop order reminds the physician that the medication order will be discontinued after a certain number of days if not reordered.

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

1.6 Review

Abbreviations Review

Test your knowledge of abbreviations.

Note: If you need a refresher on abbreviations, refer to the Appendix at the end of the book.

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=379#h5p-11

Review

An interactive H5P element has been excluded from this version of the text. You can view it online here:

https://openeducationalberta.ca/medicalterminologyii/?p=379#h5p-16

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=379#h5p-17

CHAPTER II

URINARY SYSTEM AND MEDICATIONS

2.1 Introduction to the Urinary System and Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Define the term “diuretic medication”
2. Identify common diuretic medications
3. Explain the importance of potassium chloride drugs when a patient is on certain diuretic medications
4. Define urinary tract infections and identify common medications for treating this condition
5. Define overactive bladder and list common medications for treating this condition
6. Define benign prostatic hypertrophy and list common medications for treating this condition
7. Define prostate cancer

8. Define erectile dysfunction and list common medications for treating this condition

9. Define polycystic kidney disease

10. Define chronic kidney disease

Chapter Overview

The urinary system consists of the kidneys, ureters, bladder, and urethra. A thorough explanation of the system and its components will be provided to lay the foundation for the discussion of common urinary system pathologies and the medications used to treat them. A basic explanation of medication categories and their mechanisms of action within the body will be discussed. Common medication names, both trade and generic, will be listed to increase your understanding of this topic. A few of the medication categories in this chapter are explained in further detail in other systems, but they will be briefly discussed in this chapter as well because some medication categories can be used for multiple systems. It is imperative to be familiar with these medications because all of them are common in the hospital setting and many in the community as well.

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

2.2 The Urinary System

The **urinary system**, shown in Fig. 2.1, is responsible for cleansing the blood and removing wastes from the body. However, it has other equally important functions, including regulating pH and blood pressure, concentrating solutes in the blood, producing erythropoietin (EPO) to stimulate red blood cell production, performing the final synthesis step of vitamin D production, and producing the active form of vitamin D. The urinary system, controlled by the nervous system, also stores urine until a convenient time for disposal, then provides the structures for transporting liquid waste from the body.

This system consists of the **kidneys**, **urinary bladder**, **ureters**, and **urethra**. This section will focus on the kidneys because they are a complex organ that is responsible for many of the functions in the urinary system. They are also often, though not always, the organ affected when urinary system medications are administered.

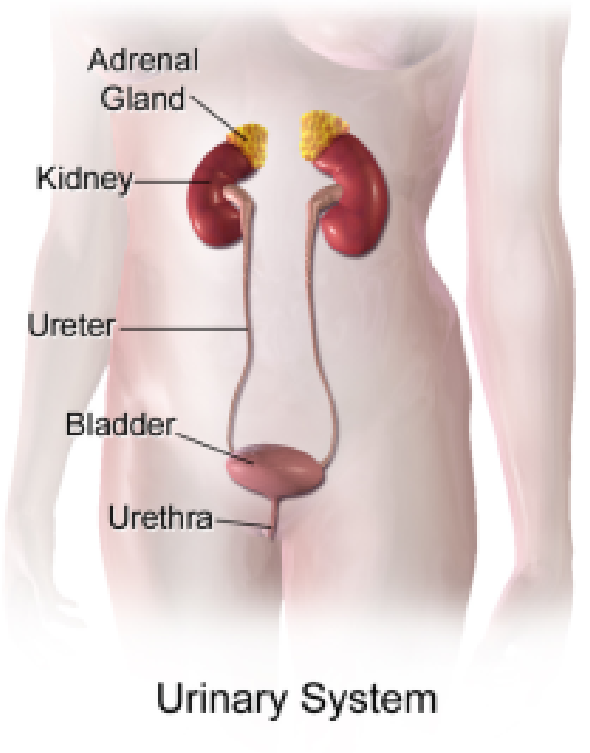


Fig. 2.1

The Kidneys

The two kidneys lie on either side of the spine in the retroperitoneal space between the parietal peritoneum and the posterior abdominal wall, well protected by muscle, fat, and the ribs. They are roughly the size of your fist, and male kidneys are typically a bit larger than female kidneys. The kidneys have many blood vessels, which makes

them well vascularized, and receive about 25% of the cardiac output at rest.

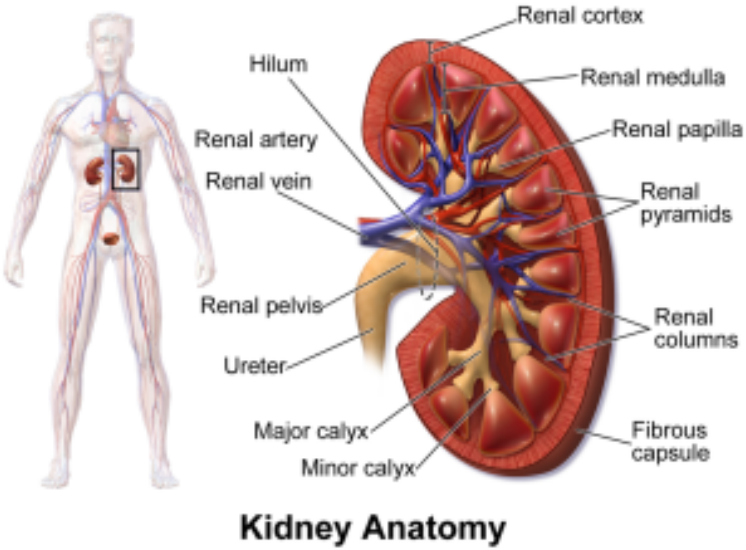


Fig. 2.2

A frontal section through the kidney reveals an outer region called the **renal cortex** and an inner region called the **medulla**. The **renal columns** are connective tissue extensions that radiate downward from the cortex through the medulla to separate the most characteristic features of the medulla, the **renal pyramids** and **renal papillae**. The papillae are bundles of collecting ducts that transport urine made by **nephrons** to the **calyxes** of the kidney for excretion. The renal columns also divide the kidney into six to eight lobes and provide a supportive framework for vessels that enter and exit the cortex. The pyramids and renal columns taken together constitute the **kidney lobes**. Fig. 2.2 shows all these parts of the kidney. The

video below provides an overview of the kidneys and the functions they provide in the human body.

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=775#oembed-1*

(TED-Ed, 2015)

Renal Hilum

The **renal hilum** is the entry and exit site for the structures that service the kidneys—the vessels, nerves, lymphatics, and ureters. Emerging from the hilum is the **renal pelvis**, which is formed from the **major and minor calyxes** in the kidney. The smooth muscle in the renal pelvis uses **peristalsis** to funnel urine into the ureter.

Cortex

In a dissected kidney, it is easy to identify the **cortex**—it appears lighter in colour compared to the rest of the kidney. All the renal corpuscles as well as both the proximal convoluted tubules (PCTs) and distal convoluted tubules (DCTs) are found here.

The urinary system's ability to filter the blood resides in about 2 to 3 million tufts of specialized capillaries, called the **glomeruli**, which are distributed more or less equally between the two kidneys. Because the glomeruli filter the blood based mostly on particle size, large elements such as blood cells, platelets, antibodies, and albumen are excluded. The glomerulus is the first part of the

nephron, which then continues as a highly specialized tubular structure responsible for creating the final urine composition.

Nephrons

Nephrons, as can be seen in Fig. 2.3, are the functional units of the kidney; they cleanse the blood and balance the constituents of circulation. The **afferent arteriole** forms a tuft of high-pressure capillaries called the **glomerulus**. The rest of the nephron consists of a continuous sophisticated tubule whose proximal end surrounds the glomerulus. This end is referred to as **Bowman's capsule**. The glomerulus and Bowman's capsule together form the **renal corpuscle**. The **glomerular capillaries** filter blood based on particle size. After passing through the renal corpuscle, the capillaries form a second arteriole, the **efferent arteriole**. Next, they form a capillary network around the more distal portions of the nephron tubule, the **peritubular capillaries** and the **vasa recta**, before returning to the venous system. As the glomerular filtrate progresses through the nephrons, these capillary networks recover most of the solutes and water, and return them to the circulation.

With up to 180 litres per day passing through the nephrons of the kidney, it is quite obvious that most of that fluid and its contents must be reabsorbed. That recovery occurs in the **proximal convoluted tubule (PCT)**, **loop of Henle**, **distal convoluted tubule (DCT)**, and the **collecting ducts**. Various portions of the nephron differ in their capacity to reabsorb water and specific solutes, which means that substances such as sodium (Na), potassium (K), chloride (Cl), urea, and many others are only absorbed, or reabsorbed, in certain parts of the nephron.

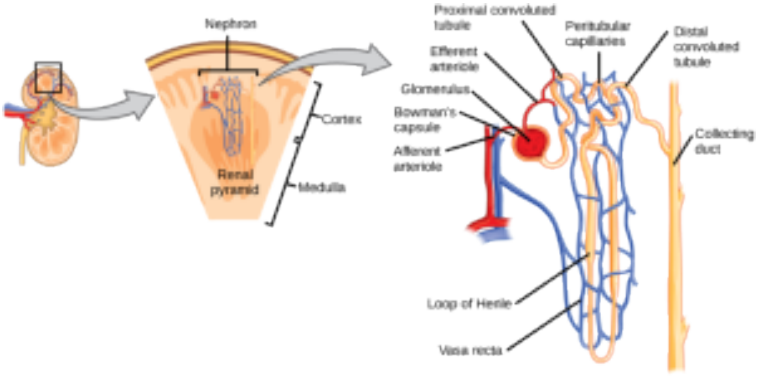


Fig. 2.3

Urine Volumes

The table below is a great review of key terms in reference to urine volumes and gives a general idea of normal daily urine volumes as compared to what is seen when certain pathologies are present.

Table. 2.1. Urine Volumes

Volume condition	Volume	Causes
Normal	1–2 L/day	
Polyuria	>2.5 L/day	Diabetes mellitus, diabetes insipidus, excess caffeine or alcohol, kidney disease, sickle cell anem certain drugs, such as diuretics
Oliguria	300–500 mL/day	Dehydration, blood loss, diarrhea, cardiogenic shock, kidney disease, and enlarged prostate
Anuria	<50 mL/day	Kidney failure, enlarged prostate, and obstruction, such as a kidney stone or tumour

(Betts el al., 2013)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

References

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

TED-Ed. (2015, February 9). *How do your kidneys work? – Emma Bryce* [Video]. YouTube. https://www.youtube.com/watch?v=FN3MFhYPWWo

Image Credits (images are listed in order of appearance)

Urinary System (Female) by BruceBlaus, CC BY-SA 4.0

Blausen 0592 KidneyAnatomy 01 by BruceBlaus, CC BY-SA 3.0

Figure 41 03 03 by CNX OpenStax, CC BY-SA 4.0

2.3 Urinary System Pathologies

There are a number of pathologies that can affect the urinary system, and the most common pathologies will be discussed below. Many of these pathologies can be treated with medications that will be discussed later in this chapter.

Common Pathologies

Benign prostatic hyperplasia (BPH): The prostate normally doubles in size during puberty. At approximately age 25, it gradually begins to enlarge again. This enlargement does not usually cause problems; however, abnormal growth of the prostate, known as benign prostatic hyperplasia (BPH), can cause constriction of the urethra where it passes through the middle of the prostate gland. This can lead to a number of lower urinary tract symptoms, such as a frequent and intense urge to urinate, a weak stream, and a sensation that the bladder has not emptied completely. Fig. 2.4 shows a normal prostate and an enlarged prostate. By age 60, approximately 40% of men have some degree of BPH. By age 80, the number of affected individuals jumps to about 80%. Treatment for BPH attempts to relieve the pressure on the urethra so that urine can flow more normally. Mild to moderate symptoms are treated with medication, whereas severe enlargement of the prostate is treated with surgery in which a portion of the prostate is removed.

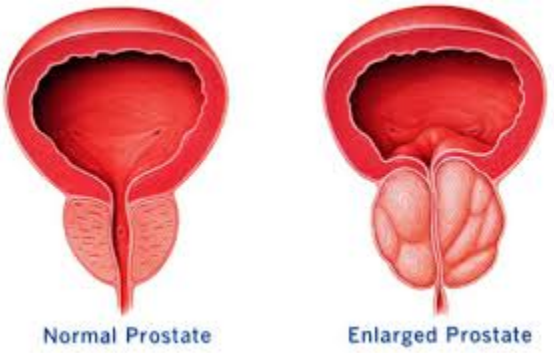


Fig. 2.4

Chronic kidney disease: This condition causes the kidneys to stop functioning. Causes vary, and the cause may determine the course of treatment (Mayo Clinic, 2021). The following video gives a detailed explanation of kidney disease, its causes, and treatment options.

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=771#oembed-1*

(Mayo Clinic, 2021)

Erectile dysfunction (ED): This is a condition in which a man has difficulty either initiating or maintaining an erection. The combined prevalence of minimal, moderate, and complete ED is approximately 40% in men at age 40 and reaches nearly 70% by age 70. In addition to aging, ED is associated with diabetes, vascular disease, psychiatric disorders, prostate disorders, the use of some drugs

such as certain antidepressants, and problems with the testes resulting in a low concentration of testosterone. These physical and emotional conditions can lead to interruptions in the vasodilation pathway and result in the inability to achieve an erection. Fig. 2.5 shows various causes of ED.

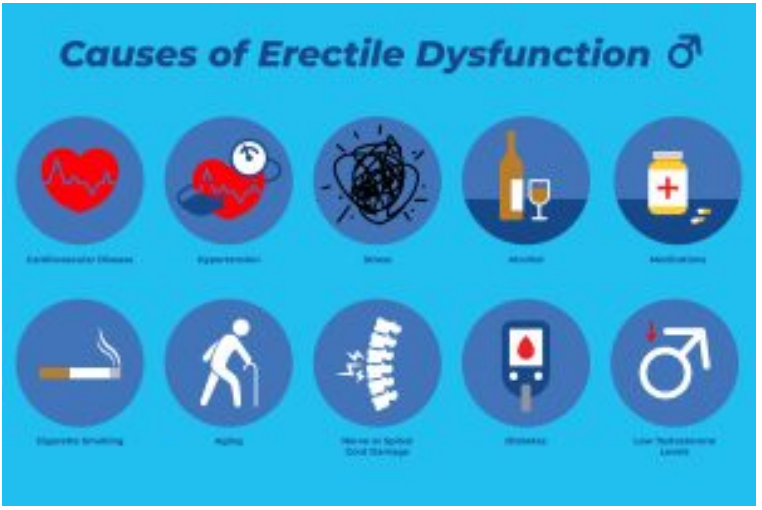


Fig. 2.5

Overactive bladder: This can be a very frustrating condition in which a person feels the urge to void frequently and at times may even experience urinary **incontinence**. It is important to seek medical attention to find the cause of overactive bladder. Certain conditions might play a significant role in this condition, such as multiple sclerosis, diabetes, bladder tumours, or an enlarged prostate, to name just a few. A physician might recommend behavioural modifications, managing pre-existing conditions, or introducing new medications to help treat overactive bladder (Mayo Clinic, 2023a).

Polycystic kidney disease (PKD): This genetic disorder causes

fluid-filled cysts to grow within the kidneys. These cysts, in turn, can cause the kidneys to not function properly and lead to kidney failure. Fig. 2.6 is an image of a normal kidney and a kidney with PKD. Fig. 2.7 is an image of two kidneys with PKD, and you can clearly see the cyst formation on each of the kidneys. Treatment might include medications to treat hypertension and pain, as well as dialysis or a kidney transplant.

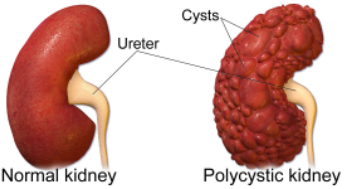


Fig. 2.6

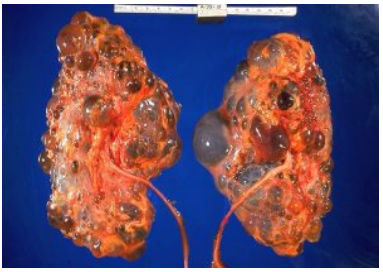


Fig. 2.7

Prostate cancer: Another common disorder involving the prostate is prostate cancer. According to the Centers for Disease Control and Prevention (CDC), prostate cancer is the second most common cancer in men (CDC, 2022). However, some forms of prostate cancer grow very slowly, and thus may not ever require treatment. Aggressive forms of prostate cancer, in contrast, involve metastasis to vulnerable organs like the lungs and brain. There is no link between BPH and prostate cancer, but the symptoms are similar. Prostate cancer is detected by medical history, a blood test, and a rectal exam that allows physicians to palpate the prostate and check for unusual masses. If

a mass is detected, the cancer diagnosis is confirmed by a biopsy of the cells.

Urinary tract infection (UTI): Urinary tract infections occur in the urinary system, most commonly in the bladder or urethra. They tend to be more common in females than males. Initial symptoms may include frequent urination and pain and burning when urinating. It is important to see a doctor immediately because if a UTI is not treated, the result may be additional health concerns, including kidney infection. A urinalysis will likely be performed (see Fig. 2.8), and if a UTI is found, an antibiotic medication will likely be ordered (Mayo Clinic, 2023b).

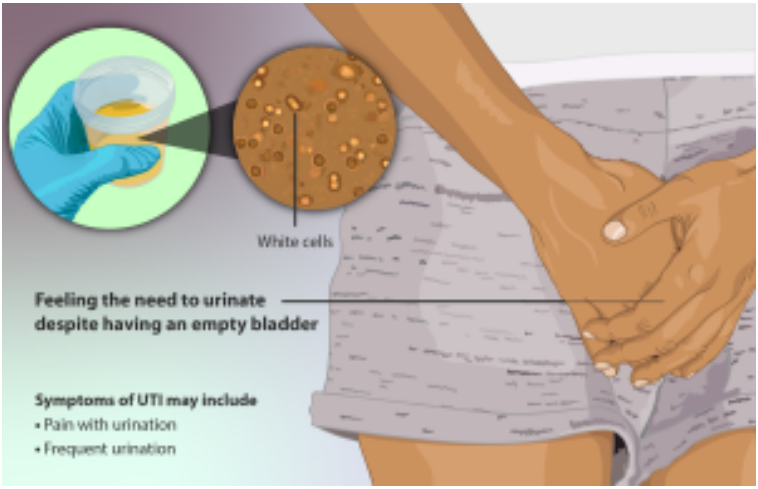


Fig. 2.8

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Centers for Disease Control and Prevention (CDC). (2022). *Prostate cancer*. https://www.cdc.gov/cancer/prostate/index.htm

Mayo Clinic. (2023a). *Overactive bladder*. https://www.mayoclinic.org/diseases-conditions/overactive-bladder/symptoms-causes/syc-20355715#:~:text=Overactive%20bladder%2C%20also%20called%20OAB,of%20urine%20(urgency%20incontinence)

Mayo Clinic. (2023b). *Urinary tract infection (UTI)*. https://www.mayoclinic.org/diseases-conditions/urinary-tract-infection/symptoms-causes/syc-20353447

Mayo Clinic. (2021, December 16). *Mayo Clinic explains kidney disease* [Video]. YouTube. https://www.youtube.com/watch?v=OVk4YXwJp98&t=2s

Image Credits (images are listed in order of appearance)

Normal and enlarged prostate by ناطق1, CC BY-SA 3.0

Common causes of erectile dysfunction by Click2pharmacy.co.uk, CC BY 2.0

Polycystic Kidney by BruceBlaus, CC BY-SA 4.0

Polycystic kidneys, gross pathology 20G0027 lores by CDC/Dr. Edwin P. Ewing, Jr., Public domain

Depiction of a lady who has a Urinary Tract Infection (UTI) by myUpchar, CC BY-SA 4.0

2.4 Urinary System Medications

Various categories of medications can be used to treat the urinary pathologies described in the previous section. The medications listed below are some of the more common ones prescribed both in the hospital and in the community for patients with these pathologies. Urinary system medications can also be prescribed to treat disorders of other body systems such as hypertension and congestive heart failure, conditions that occur within the cardiovascular system, which will be described in a later chapter. Hypertension is often treated with a medication that combines a diuretic, which is a urinary system medication, and a medication that directly affects the heart, which would be a cardiovascular medication.

Diuretic Medications

Diuretic medications are often referred to as "water pills." Most diuretics work by removing sodium, and in turn water, from the body in the form of urine (Mayo Clinic, 2023). Diuretics promote **polyuria**. They are used to decrease blood pressure and to decrease symptoms of fluid overload when patients have **congestive heart failure (CHF)** and generalized **edema**.

There are several categories of diuretics, and a patient's condition will determine which category of diuretic will be used (Mayo Clinic, 2023). This section will discuss three categories of diuretics: loop, thiazide, and potassium sparing. There are others, but they will not be discussed here.

Loop Diuretic Medications

Loop diuretics inhibit the absorption of sodium and chloride in the loop of Henle and the proximal and distal tubules, causing fluid loss, along with the loss of sodium, potassium, calcium, and magnesium. These diuretics are considered **potassium-wasting diuretics** because potassium is excreted in the patient's urine, which can cause **hypokalemia**. This, in turn, can cause serious issues with the patient's heart rate (Mayo Clinic, 2023). Patients taking loop diuretic medications are often also prescribed a potassium supplement, which will be discussed later on this page. These diuretics are very potent and are used to treat conditions such as edema, **hypertension**, and, more specifically, **pulmonary edema**.

The following are the most common loop diuretics:

- furosemide (Lasix) (Fig. 2.9)
- ethacrynic acid (Edecrin)

Fig. 2.9

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=773#oembed-1

(Dr Matt & Dr Mike, 2022)

Thiazide Diuretic Medications

Thiazide diuretics work near the distal tubule to promote the excretion of sodium and water, thus increasing urine output. This category of diuretics is also considered potassium wasting and would likely require a patient to be on a potassium supplement. They are one of the first treatments used for hypertension (Mayo Clinic, 2022).

Some common thiazide diuretics are the following:

- hydrochlorothiazide (HCTZ)
- indapamide (Lozide)
- metolazone (Zaroxolyn)

Key Concept

A common **suffix** seen with **thiazide diuretics** is **-thiazide**.

Example: hydrochlorothiazide

Note: **HCTZ** is an abbreviation often used for **hydrochlorothiazide**.

Potassium-Sparing Diuretic Medications

Some diuretic medications are potassium sparing, meaning that they don't cause the body to lose potassium like loop and thiazide diuretics. This category of diuretics is called **potassium-sparing medications**. If a patient is on one of the diuretics from the other two categories and their potassium levels are low, there is an option to switch to a potassium-sparing diuretic (Mayo Clinic, 2022). One of the most common potassium-sparing diuretic drugs is called spironolactone or Aldactone (brand name). Spironolactone causes increased amounts of sodium and water to be excreted while potassium is retained. It is used to treat hypertension and to control edema in patients with heart failure or liver dysfunction.

The following are common potassium-sparing diuretics:

- spironolactone (Aldactone)
- amiloride (Midamor)

Key Concept

Loop and thiazide diuretics are **potassium-wasting medications** and may cause a patient to have seriously low levels of potassium in their blood, or **hypokalemia**. A physician might first try a diet high in potassium to elevate the patient's blood potassium levels, and if this is ineffective, the patient will be prescribed **potassium chloride (KCL)** (Mayo Clinic, 2022).

Potassium chloride medications often have the letter **K** in their drug name, indicating the chemical element

potassium; for examples, see the medications listed in Table 2.2 below. Potassium chloride is measured in **milliequivalents** (**mEq**). Patients should have potassium blood levels drawn to ensure that the medication is working for them and that their potassium levels are within the normal range (WebMD, 2023).

Table 2.2. Common Potassium Chloride Medications

potassium chloride	K-Dur
potassium chloride	Klor-Con
potassium chloride	Micro-K
potassium chloride	K-Lyte (Fig. 2.10)

Fig. 2.10

(WebMD, 2022)

Medications for Treating Urinary Tract Infections (UTIs)

Fluoroquinolones

Fluoroquinolones are a category of antibiotics used to treat urinary

tract infections, but they can be used to treat other infections as well, including pneumonia and complicated skin infections. They are **bacteriocidal** and take action against the DNA of bacterial cell walls. Many fluoroquinolones are **broad spectrum** and are effective against a wide variety of both gram-positive and gram-negative bacteria. Levofloxacin (Levaquin) is an example of a common fluoroquinolone used to treat UTIs (WebMD, 2023).

Sulfonamides

Sulfonamides are one of the oldest broad-spectrum antimicrobial agents and work by competitively inhibiting the bacterial metabolic enzymes needed for bacterial function. Sulfonamides are used to treat urinary tract infections, but they are also used to treat otitis media, acute exacerbations of chronic bronchitis, and travellers' diarrhea. Trimethoprim-sulfamethoxazole (Bactrim and Septra) is a common sulfonamide medication used to treat UTIs.

Other Antibiotics

Other antibiotics are used to treat urinary tract infections and don't fit into the above categories but are commonly used. Macrobid is a **nitrofuran antibiotic** and is often prescribed to treat uncomplicated urinary tract infections. Monurol is a broad-spectrum antibiotic, and its primarily use is to treat uncomplicated UTIs as well. Keflex is a **cephalosporin antibiotic** that can be prescribed to treat various bacterial infections, including UTIs. **Anti-infectives** will be discussed in more detail in a later chapter (WebMD, 2023).

Cranberries for a UTI, yes or no?

Fig. 2.11

There have been studies on the idea that cranberries, shown in Fig. 2.11, may help cure UTIs (WebMD, 2023). The research indicates that although cranberries don't work for everyone, they might work as a preventative measure but should not be used to treat a urinary tract infection that someone already has. The reasoning behind cranberries being helpful for preventing UTIs is that they make the urine more acidic so that bacteria cannot grow. Also, cranberries make the urinary tract walls stickier so that bacteria cannot adhere to them, thus creating an unfavourable environment for the bacteria (WebMD, 2023). There are some risks with taking too much cranberry juice, extract, or whole cranberries, including an increased risk of kidney stones and interactions with other medications. It is always important to speak with your physician and pharmacist prior to taking any supplement, including cranberries.

https://www.youtube.com/watch?v=MctSKRKxk3E

(UMCCVideos, 2020)

Medications for Treating Overactive Bladder

Muscarinic antagonists, referred to as **anticholinergics**, is a category of medications used to treat overactive bladder. They inhibit the action of acetylcholine, which causes the smooth muscle in the bladder to relax, and by doing so, decrease bladder contractions and incontinence. Detrol and Ditropan are two common medications used to treat overactive bladder.

Medications for Treating Benign Prostatic Hypertrophy

Alpha1-Receptor Blocker Drugs

Benign prostatic hypertrophy (BPH) presents with symptoms of hesitancy to urinate and a lower-than-normal urinary stream owing to an enlarged prostate gland compressing the urethra. Tamsulosin selectively blocks alpha receptors in the prostate, allowing the smooth muscles in the bladder, neck, and prostate to relax, and thus improving urine flow and reducing the symptoms of BPH.

Key Concept

A common **suffix** seen with **alpha1-receptor blocker drugs** is **-losin.**

Example: tamsulosin (Flomax)

5-Alpha-Reductase Inhibitors

This category of medications is also used to treat the symptoms of BPH, but it has additional actions in that it halts the growth of the prostate if taken regularly as prescribed. An example of a **5-alpha-reductase inhibitor** is finasteride (Proscar) (WebMD, 2023).

Medications for Erectile Dysfunction

Phosphodiesterase (PDE-5) Inhibitor Drugs

Sildenafil (Viagra) is commonly known to treat erectile dysfunction (ED) (see Fig. 2.12 for an image of Viagra). This medication is taken orally in the form of a tablet. It **inhibits phosphodiesterase (PDE-5)** in the pulmonary smooth muscle and corpus cavernosum, allowing the smooth muscle to relax and the corpus cavernosum to dilate, facilitating erection. This medication was originally developed to treat pulmonary hypertension, but it has been found to be useful for other conditions, including ED. However, it must be used with caution in patients with decreased hepatic, renal, and cardiac functions. One possible side effect is prolonged **priapism** that lasts longer than four hours. If this occurs, the patient should seek medical attention.

Fig. 2.12

Tadalafil (Cialis) is another medication that inhibits phosphodiesterase (PDE-5) and is used for ED. It can also be used to treat benign prostatic hyperplasia (BPH) because it decreases inflammation in the prostate (WebMD, 2023). This medication must be used with caution in patients with cardiac conditions such as recent myocardial infarction and in those with uncontrolled arrhythmias (WebMD, 2023) .

Table 2.3. Common Urinary System Medications

Generic Name	Trade Name	Reason for Administering
furosemide	Lasix	HTN, CHF, edema
ethacrynic acid	Edecrin	HTN, CHF, edema
hydrochlorothiazide	HCTZ	HTN, CHF, edema
indapamide	Lozide	HTN, CHF, edema
metolazone	Zaroxolyn	HTN, CHF, edema
spironolactone	Aldactone	HTN, CHF, edema
amiloride	Midamor	HTN, CHF, edema
levofloxacin	Levaquin	UTI
trimethoprim-sulfamethoxazole	Bactrim, Septra	UTI
nitrofurantoin	Macrobid	UTI
fosfomycin	Monurol	UTI
cephalexin	Keflex	UTI
tolterodine	Detrol	Overactive bladder
oxybutynin	Ditropan	Overactive bladder
finasteride	Proscar	BPH
sildenafil	Viagra	Erectile dysfunction
tadalafil	Cialis	Erectile dysfunction

(WebMD, 2023)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Dr Matt & Dr Mike. (2022, February 22). *Loop diuretics in 2 minutes!* [Video]. YouTube. https://www.youtube.com/watch?v=THqDmN4HcM8

Mayo Clinic. (2023). *Diuretics.* https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/diuretics/art-20048129#:~:text=Diuretics%2C%20sometimes%20called%20water%20pills,through%20your%20veins%20and%20arteries

Mayo Clinic. (2022). *Diuretics: A cause of low potassium?* https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/expert-answers/blood-pressure/faq-20058432#:~:text=Diuretics%20are%20commonly%20used%20to,in%20the%20blood%20(hypokalemia)

UMCCVideos. (2020, February 6). *Facts about cranberry juice to treat UTIs* [Video]. YouTube. https://www.youtube.com/watch?v=MctSKRKxk3E

WebMD. (2023). *Drugs & medications* A-Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

Furosemide (1) by Intropin, CC BY 3.0

K-Lyte (Potassium Suplement) by Miansari66, CC0 1.0 Universal

Cooking cranberries in El Paso by Susan Barnum, CC BY-SA 4.0
Viagra in Pack by SElefant, CC BY-SA 3.0

2.5 Review

Urinary System Review

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=779#h5p-21

Urinary Pathology Review

An interactive H5P element has been excluded from this version of the text. You can view it

online here:
https://openeducationalberta.ca/medicalterminologyii/?p=779#h5p-22

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=779#h5p-23

Urinary Medication Review

An interactive H5P element has been excluded from this version of the text. You can view it online here:

https://openeducationalberta.ca/medicalterminologyii/?p=779#h5p-24

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=779#h5p-25

CHAPTER III

DIGESTIVE SYSTEM AND MEDICATIONS

3.1 Introduction to the Digestive System and Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Identify the major components and functions of the digestive system
2. Define the common causes and symptoms of digestive system pathologies
3. List common medications used to treat digestive system pathologies
4. List the most common medications for treating treat diarrhea and constipation
5. Identify antiemetic medication and what it is prescribed for

Chapter Overview

Digestive system complaints are a commonplace occurrence. How many times have you heard someone complain about an upset stomach, heartburn, nausea, constipation, or diarrhea? Occasionally, these ailments will go away on their own, but if they do not, there are a variety of medications that can be used to treat the disease or symptoms. Treatment can involve both the use of prescription and nonprescription medications in addition to non-pharmacological interventions. In this chapter, you will learn about the digestive system, common pathologies, and medications used to treat these common disorders.

3.2 The Digestive System

The function of the digestive system is to break down the foods you eat, release their nutrients, and then absorb those nutrients into the body. The small intestine, where the majority of digestion occurs and where most of the released nutrients are absorbed into the blood or lymph, is the workhorse of the system, but each of the digestive system organs also makes a vital contribution to this process. Figure 3.1 shows all the major components of the digestive system.

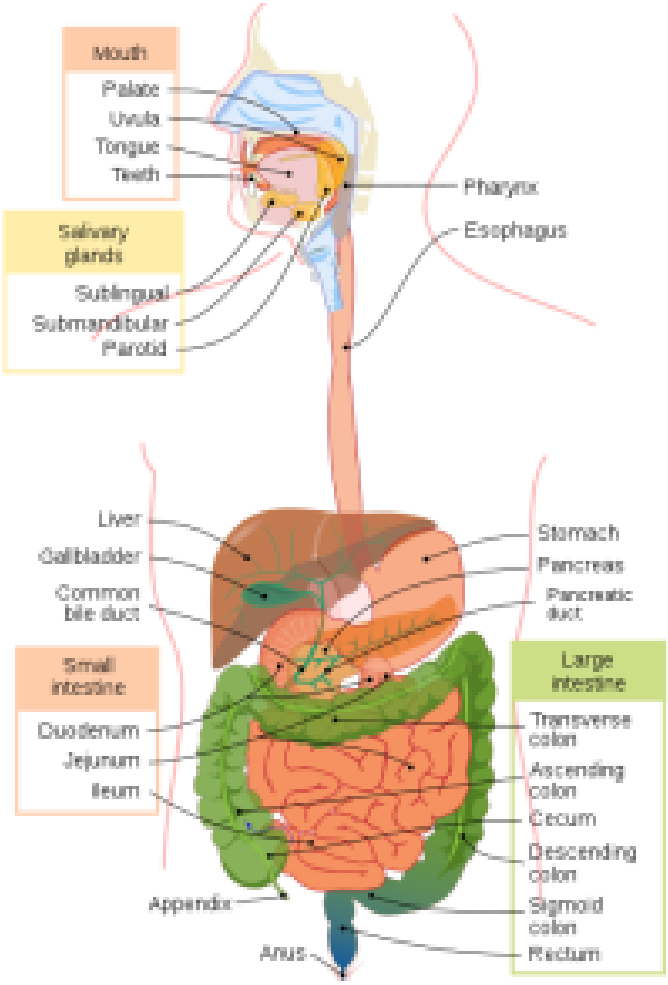


Fig. 3.1

As is the case with all the body systems, the digestive system does not work in isolation—it functions cooperatively with the other systems of the body. Consider for example, the interrelationship between the digestive and cardiovascular systems. Arteries supply

the digestive organs with oxygen and processed nutrients, and veins drain the digestive tract. These intestinal veins, which constitute the hepatic portal system, are unique because they do not return blood directly to the heart. Rather, the blood is diverted to the liver where its nutrients are offloaded for processing before the blood completes its circuit back to the heart. At the same time, the digestive system provides nutrients to the heart muscle and vascular tissues to support their functioning.

The interrelationship of the digestive and endocrine systems is also critical. Hormones secreted by several endocrine glands, as well as the endocrine cells of the pancreas, stomach, and small intestine, contribute to the control of digestion and nutrient metabolism. In turn, the digestive system provides the nutrients to fuel endocrine function. Table 3.1 below gives a brief overview of how these other systems contribute to the functioning of the digestive system.

Table. 3.1. Benefits of the Digestive System to Other Body Systems

Body System	Benefits Received by the Digestive System
Cardiovascular	Blood supplies the digestive organs with oxygen and processed nutrients.
Endocrine	Endocrine hormones help regulate secretion in the digestive glands and accessory organs.
Integumentary	The skin helps protect the digestive organs and synthesizes vitamin D for calcium absorption.
Lymphatic	Mucosa-associated lymphoid tissue and other lymphatic tissues defend against the entry of pathogens; lacteals (lymphatic capillaries) absorb lipids, and lymphatic vessels transport lipids to the bloodstream.
Muscular	The skeletal muscles support and protect the abdominal organs.
Nervous	Sensory and motor neurons help regulate secretions and muscle contractions in the digestive tract.
Respiratory	The respiratory organs provide oxygen and remove carbon dioxide.
Skeletal	The bones help protect and support the digestive organs.
Urinary	The kidneys convert vitamin D into its active form, allowing calcium absorption in the small intestine.

(Betts et al., 2013)

The video below provides an overview of the digestive system and gives you a foundation of knowledge that you can use as you read through this chapter.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=1061#oembed-1

(DrBruce Forciea, 2015)

Digestive System Organs

The easiest way to understand the digestive system is to divide its organs into two main categories. The first category is the organs that make up the alimentary canal. Accessory digestive organs comprise the second group and are critical for orchestrating the breakdown of food and the assimilation of its nutrients into the body. The accessory digestive organs, despite their name, are critical to the functioning of the digestive system.

Alimentary Canal Organs

The **alimentary canal**, also called the **gastrointestinal (GI) tract** or **gut**, is a one-way tube about 7.62 metres (25 feet) long during life and closer to 10.67 metres (35 feet) in length when measured

after death, once smooth muscle tone is lost. The main function of the organs of the alimentary canal is to nourish the body. This tube begins at the **mouth** and terminates at the **anus**. Between those two points, the canal is modified as the **pharynx**, **esophagus**, **stomach**, and **small and large intestines** to fit the functional needs of the body. Both the mouth and the anus are open to the external environment, so food and wastes within the alimentary canal are technically considered to be outside the body. Only through the process of absorption do the nutrients in food enter into and nourish the body's "inner space."

Accessory Structures

Each accessory digestive organ aids in the breakdown of food. Within the mouth, the **teeth** and **tongue** begin mechanical digestion while the **salivary glands** begin chemical digestion. Once food products enter the small intestine, the **gallbladder**, **liver**, and **pancreas** release secretions such as bile and enzymes that are essential for digestion to continue. Together, these are called **accessory organs** because they sprout from the lining cells of the developing gut (mucosa) and augment its function; indeed, you could not live without their vital contributions, and many significant diseases result from their malfunction. Even after their development is complete, they maintain a connection to the gut by way of ducts.

The Peritoneum

The digestive organs within the abdominal cavity are held in place by the **peritoneum**, a broad, serous membranous sac made up of **squamous epithelial tissue** surrounded by **connective tissue**. It is composed of two different regions: the **parietal peritoneum**, which

lines the abdominal wall, and the **visceral peritoneum**, which envelops the abdominal organs (Fig. 3.2). The peritoneal cavity is the space bounded by the visceral and parietal peritoneal surfaces. A few millilitres of watery fluid act as a lubricant to minimize friction between the serosal surfaces of the peritoneum.

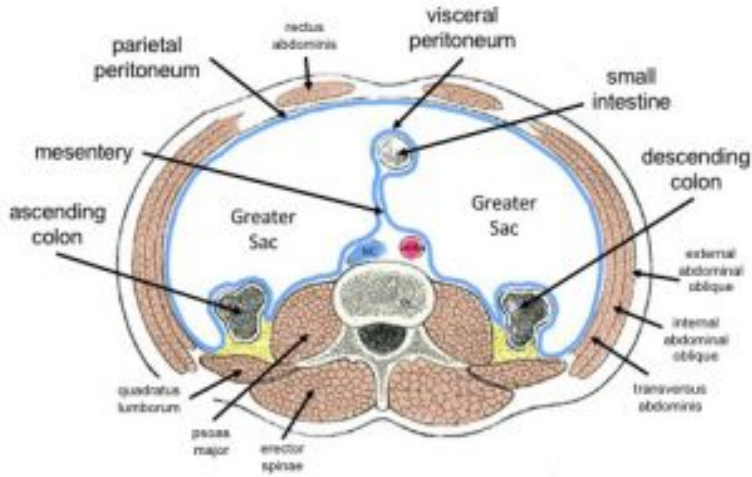


Fig. 3.2

The digestive system uses mechanical and chemical activities to break food down into absorbable substances during its journey through the digestive system. Table 3.2 provides an overview of the basic functions of the digestive organs.

Table 3.2. Functions of the Digestive Organs

Organ	Major Functions	Other Functions
Mouth	• Ingests food • Chews and mixes food • Begins the chemical breakdown of carbohydrates • Moves food into the pharynx • Begins the breakdown of lipids via lingual lipase	• Moistens and dissolves food, allowing you to taste it • Cleans and lubricates the teeth and oral cavity • Has some antimicrobial activity
Pharynx	• Propels food from the oral cavity to the esophagus	• Lubricates food and passageways
Esophagus	• Propels food to the stomach	• Lubricates food and passageways

Organ	Major Functions	Other Functions
Stomach	• Mixes and churns food with gastric juices to form chyme • Begins the chemical breakdown of proteins • Releases food into the duodenum as chyme • Absorbs some fat-soluble substances (e.g., alcohol, aspirin) • Possesses antimicrobial functions	• Stimulates protein-digesting enzymes • Secretes the intrinsic factor required for vitamin B_{12} absorption in the small intestine
Small intestine	• Mixes chyme with digestive juices • Propels food at a rate slow enough for digestion and absorption to occur • Absorbs the breakdown products of carbohydrates, proteins, lipids, and nucleic acids, along with vitamins, minerals, and water • Performs physical digestion via segmentation	• Provides an optimal medium for enzymatic activity

Organ	Major Functions	Other Functions
Accessory organs	• *Liver*: Produces bile salts, which emulsify lipids, aiding their digestion and absorption • *Gallbladder*: Stores, concentrates, and releases bile • *Pancreas*: Produces digestive enzymes and bicarbonate	• Bicarbonate-rich pancreatic juices help neutralize the acidic chyme and provide an optimal environment for enzymatic activity
Large intestine	• Further breaks down food residues • Absorbs most of the residual water, electrolytes, and vitamins produced by enteric bacteria • Propels feces toward the rectum • Eliminates feces	• Food residue is concentrated and temporarily stored prior to defecation • Mucus eases the passage of feces through the colon

(Betts et al., 2013)

Digestive Processes

The process of digestion includes six activities: ingestion, propulsion, mechanical or physical digestion, chemical digestion, absorption, and defecation.

The first of these, **ingestion**, refers to the entry of food into the alimentary canal through the mouth. There, the food is chewed and mixed with saliva, which contains enzymes that begin breaking down the carbohydrates in the food plus some lipid digestion via lingual lipase. Chewing increases the surface area of the food and allows an appropriately sized bolus to be produced.

Food leaves the mouth when the tongue and pharyngeal muscles move it into the esophagus. This act of swallowing, the last voluntary act until defecation, is an example of **propulsion**, which refers to the movement of food through the digestive tract. It includes both the voluntary process of swallowing and the involuntary process of peristalsis. **Peristalsis** consists of sequential, alternating waves of contraction and relaxation of the alimentary wall smooth muscles, which act to propel food along (Fig. 3.3). These waves also play a role in mixing food with digestive juices. Peristalsis is so powerful that the foods and liquids you swallow enter your stomach even if you are standing on your head.

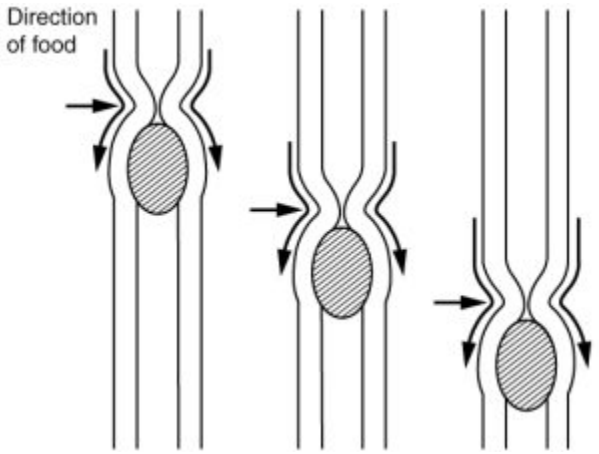


Fig. 3.3

Digestion includes both mechanical and chemical processes. **Mechanical digestion** is a purely physical process that does not change the chemical nature of the food. Instead, it makes the food smaller to increase both surface area and mobility. It includes **mastication**, or chewing, as well as tongue movements that help break food into smaller bits and mix it with saliva. Although there may be a tendency to think that mechanical digestion is limited to the first steps of the digestive process, it occurs after the food leaves the mouth as well. The mechanical churning of food in the stomach serves to further break it apart and expose more of its surface area to digestive juices, creating an acidic "soup" called **chyme**. **Segmentation**, which occurs mainly in the small intestine, consists of localized contractions of the circular muscle of the **muscularis layer** of the alimentary canal. These contractions isolate small sections of the intestine, moving their contents back and forth while continuously subdividing, breaking up, and mixing the contents. By moving food back and forth in the **intestinal lumen**, segmentation mixes food with digestive juices and facilitates absorption.

In **chemical digestion**, which starts in the mouth, digestive secretions break down complex food molecules into their chemical building blocks (for example, proteins into separate amino acids). These secretions vary in composition, but typically contain water, various enzymes, acids, and salts. The process is completed in the small intestine.

Food that has been broken down is of no value to the body unless its nutrients enter the bloodstream and are put to work. This occurs through the process of **absorption**, which takes place primarily within the small intestine. There, most nutrients are absorbed from the lumen of the alimentary canal into the bloodstream through the epithelial cells that make up the mucosa. Lipids are absorbed into **lacteals** and are transported via the lymphatic vessels to the bloodstream (the subclavian veins near the heart).

In **defecation**, the final step in digestion, undigested materials are removed from the body as feces. In some cases, a single organ is in charge of a digestive process. For example, ingestion occurs only in the mouth and defecation only in the anus. However, most digestive processes involve the interaction of several organs and occur gradually as food moves through the alimentary canal; see Fig. 3.4 for more detail on the functions of the organs involved in digestion.

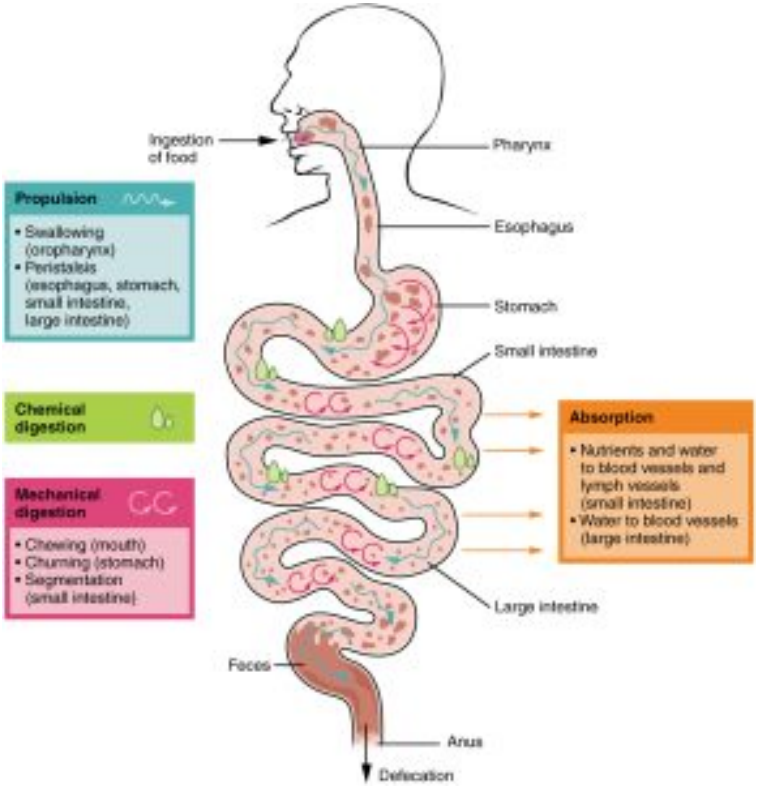


Fig. 3.4

The following video gives an a overview of how the digestive system works and provides a great summary of the content you have learned so far in this chapter.

One or more interactive elements has been excluded

— *from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=1061#oembed-2*

(Bryce, 2017)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

References

Bryce, E. (2017, December 14). *How your digestive system works – Emma Bryce* [Video]. YouTube. https://youtu.be/Og5xAdC8EU

DrBruce Forciea. (2015, March 18). *Anatomy and physiology of the digestive system* [Video]. YouTube. https://youtu.be/1ssJV-EpfiQ. All rights reserved. Used with permission.

Image Credits (images are listed in order of appearance)

Digestive system diagram en by LadyofHats, Public domain

General Distribution of the Peritoneum by Dennis M DePace, PhD, CC BY-SA 4.0

2404 PeristalsisN by OpenStax College, CC BY 3.0

2405 Digestive Process by OpenStax College, CC BY 3.0

3.3 Digestive System Pathologies

There are a number of pathologies that can affect the digestive system; the more common ones will be discussed below. Many of these pathologies can be treated with medications that will be discussed later in this chapter.

Constipation: The definition of constipation may vary, but it is often defined as fewer than three bowel movements in a week and hard stool that is difficult to pass. If **defecation** is delayed for an extended time, additional water is absorbed, making the feces firmer and potentially leading to constipation. Constipation has several causes, including lack of fluids or fibre in the diet, lack of ambulation, various disease processes, recovery from surgical anesthesia and opiates, and the side effects of many medications. Because there are several potential causes of constipation, treatment should always be individualized to the patient. Many times, constipation can be treated with simple changes in diet, exercise, or routine.

Diarrhea: This is the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual). Frequent passing of formed stools is not considered diarrhea. Diarrhea has multiple causes, such as bacteria or parasites from contaminated food or water, viruses, medicines such as antibiotics or cancer drugs, and food intolerances and sensitivities. The most severe complication that results from diarrhea is dehydration caused by the loss of water and electrolytes (WHO, 2017).

Gastroesophageal reflux disease (GERD): This condition is often referred to as heartburn, indigestion, or sour stomach. GERD is caused by excessive hydrochloric acid that backs up, or refluxes,

into the lower esophagus. A common cause of GERD is the ineffective working of the lower esophageal sphincter (Fig. 3.5), which then allows the stomach contents, including hydrochloric acid, to backflow into the esophagus.

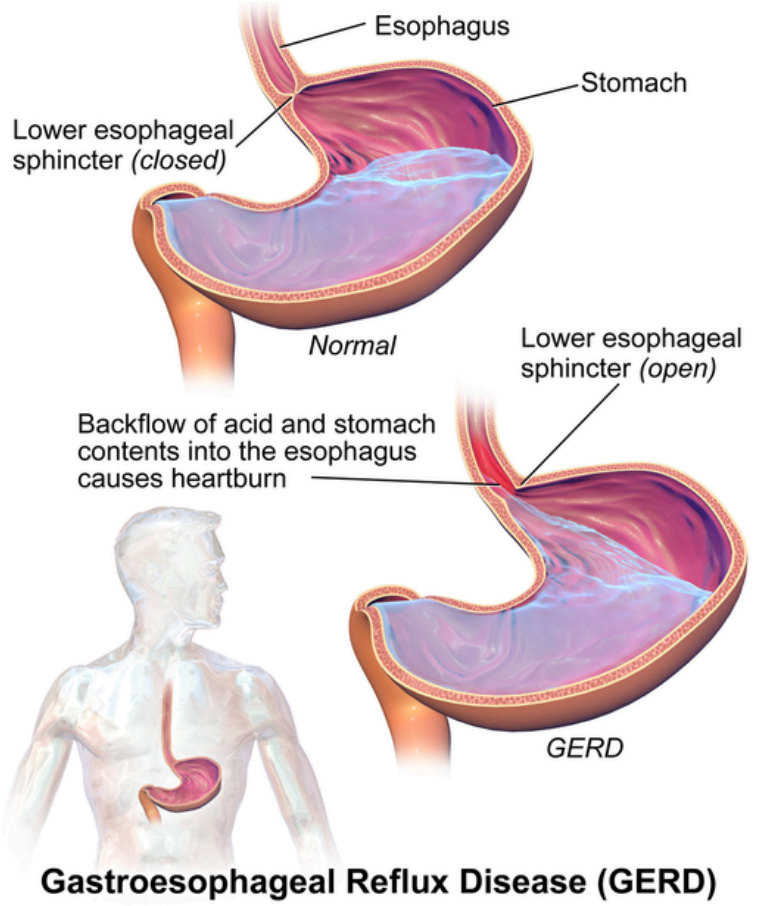


Fig. 3.5

Inflammatory bowel disease (IBD): This chronic bowel condition

cannot be cured, but the signs and symptoms can be treated to make the patient more comfortable. There are two types of IBD: **ulcerative colitis** and **Crohn's disease**. Fig. 3.6 shows the most common areas of the small intestine and colon affected by ulcerative colitis and Crohn's disease.

- **Ulcerative colitis** causes irritation, inflammation, and ulcers in the lining of the colon (large intestine) and affects mainly the lower section of the colon. The symptoms can vary, but patients often experience bloody diarrhea, cramping, lack of appetite, and weight loss (WebMD, 2023).
- **Crohn's disease** results in inflammation and irritation of the upper portion of the intestines. The signs and symptoms can include diarrhea, stomach cramps, fever, loss of appetite, and weight loss (Cleveland Clinic, 2023).

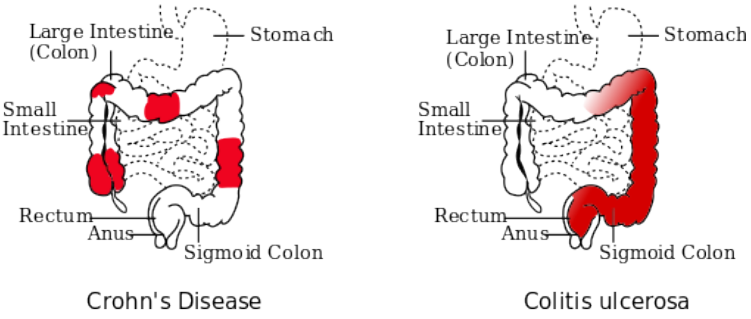


Fig. 3.6

Irritable bowel syndrome (IBS): Unlike IBD, the cause of IBS is unknown and the symptoms may not be chronic. Signs and symptoms include abdominal cramping, diarrhea, constipation, gas, and bloating (Healthline, 2023). IBS is often treated with diet,

lifestyle changes, and over-the-counter medications. Fig. 3.7 provides details of the symptoms and the location of discomfort for those with IBS.

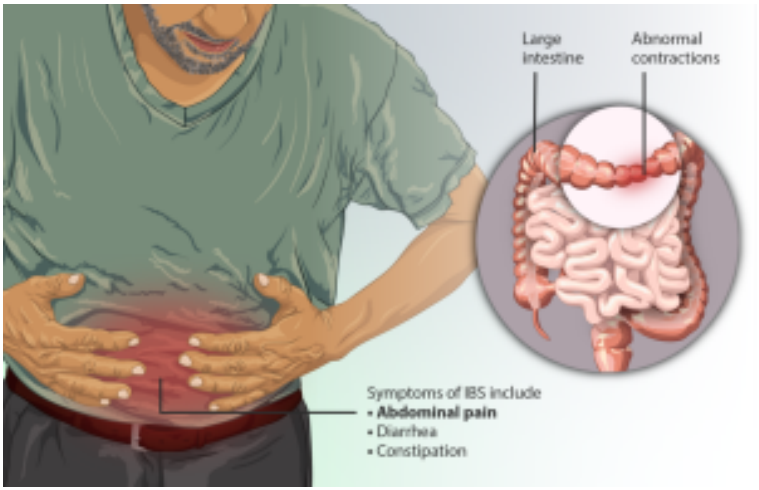


Fig. 3.7

Nausea and vomiting (N&V): Nausea and vomiting is more a sign and symptom rather than a pathology that a patient may experience; however, it is important to discuss the potential causes because they affect how it is treated. Nausea and vomiting is very common both in the hospital and in the general community. **Nausea** is defined as the unpleasant sensation that feels like the need to vomit. **Vomiting** is the often-forceful expulsion of stomach contents.

There are a number of potential causes of nausea and vomiting:

- Morning sickness during pregnancy
- Gastroenteritis and other infections
- Migraine headaches
- Motion sickness
- Food poisoning

- Side effects of medicines, including those used for cancer chemotherapy
- GERD and ulcers
- Intestinal obstruction
- Poisoning or exposure to a toxic substance
- Diseases of other organs (cardiac, renal, or liver)

Peptic ulcers: These ulcers are open sores that occur in the inner lining of the stomach and parts of the small intestine (Mayo Clinic, 2023). The mucosal barrier works to protect the stomach and intestines; however, in some cases, gastric juices eat away at the superficial lining of the stomach mucosa, creating erosions, which often heal on their own. However, deeper and larger erosions are called ulcers. The signs and symptoms can vary, but the main symptom that patients experience is stomach pain (Fig. 3.8). There are different causes of peptic ulcers, but the most common are the bacterium ***Helicobacter pylori*** and long-term use of nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen (Mayo Clinic, 2023). Factors such as stress and diet do not cause peptic ulcers, but they can make the symptoms worse (Mayo Clinic, 2023).

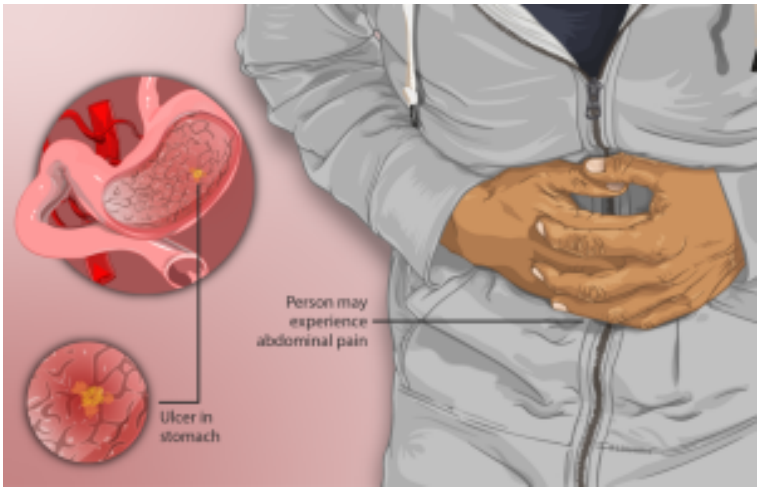


Fig. 3.8

A potential complication of ulcers is perforation (Betts et al., 2013). Perforated ulcers create a hole in the stomach wall, resulting in **peritonitis**. These ulcers must be repaired surgically (Betts et al., 2013).

Key Concept

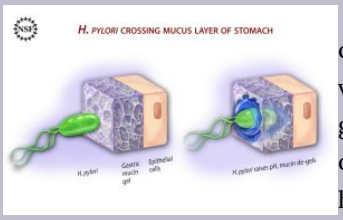


Fig. 3.9

Helicobacter pylori, a common cause of ulcers, is very common within the general population. Many of us have it but will not have any signs or symptoms. However, once it crosses the stomach lining, as shown in Fig. 3.9, it can cause ulcers, which can be very difficult to treat. Some of the potential treatments are discussed in the next section of this chapter.

The video below provides more details on ulcers and their potential causes.

One or more interactive elements has been excluded from this version of the text. You can view them online

here: https://openeducationalberta.ca/medicalterminologyii/?p=1063#oembed-1

(Ted-Ed, 2017)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

Cleveland Clinic. (2023). *Crohn's disease.* https://my.clevelandclinic.org/health/diseases/9357-crohns-disease

Healthline. (2023). *Everything you want to know about IBS.* https://www.healthline.com/health/irritable-bowel-syndrome#symptoms

Mayo Clinic. (2023). *Peptic ulcer.* https://www.mayoclinic.org/diseases-conditions/peptic-ulcer/symptoms-causes/syc-20354223

Ted-Ed. (2017, September 28). *The surprising cause of stomach*

ulcers – Rusha Modi [Video]. YouTube. https://www.youtube.com/watch?v=V_U6czbDHLE

WebMD. (2023). *Ulcerative colitis (UC)*. https://www.webmd.com/ibd-crohns-disease/ulcerative-colitis/what-is-ulcerative-colitis

World Health Organization (WHO). (2017, May 2). *Diarrhoeal disease*. https://www.who.int/en/news-room/fact-sheets/detail/diarrhoeal-disease

Image Credits (images are listed in order of appearance)

GERD by BruceBlaus, CC BY-SA 4.0

Crohn's Disease vs Colitis ulcerosa by Samir, CC BY-SA 3.0

Depiction of a person suffering from Irritable Bowel Syndrome (IBS) by myUpchar, CC BY-SA 4.0

Depiction of a patient suffering from peptic ulcers by myUpchar, CC BY-SA 4.0

Ulcer-causing Bacterium (H. Pylori) Crossing Mucus Layer of Stomach by Zina Deretsky, National Science Foundation, Public domain

3.4 Digestive System Medications

Some of the more common digestive system medications are discussed below. The focus is on the pathologies already mentioned in this chapter because of their prevalence.

Medications for Gastroesophageal Reflux Disease (GERD)

Antacids

Fig. 3.10

Antacids, as shown in Fig. 3.10, are weak bases and are usually one of the first medications used to treat GERD. They work by neutralizing stomach acid and do so by elevating the pH of the stomach, which weakens the acid and lessens stomach irritation. Antacids are used to reduce the symptoms of heartburn, acid indigestion, and upset stomach. There are many over-the-counter (OTC) medications available for this purpose that contain one of the following active ingredients: calcium carbonate, aluminum hydroxide, and magnesium hydroxide. Antacids come in many different forms, including chewable tablets, capsules, and liquids, all taken orally. Many antacids also contain **simethicone**, an

antiflatulent used for gas relief. Simethicone is described in detail at the end of this page. Some common OTC antacids for GERD are aluminum hydroxide gel, calcium carbonate (Alka-Seltzer, Tums), magnesium hydroxide (Milk of Magnesia, or MOM), Gaviscon, Maalox, Rolaids, and Pepto-Bismol (WebMD, 2022).

H2-Receptor Antagonists, or H2 Blockers

H2-receptor antagonists block histamine's action at the H2 receptor of the parietal cell, thus reducing the production of hydrochloric acid. H2-receptor antagonists are used to treat GERD, peptic ulcers, erosive esophagitis, and hypersecretory conditions, or as adjunct treatment for the control of upper GI bleeding. The most common routes for H2-receptor antagonists are oral and intravenous. If taken orally, the medication is most effective when taken 15 to 60 minutes before eating or drinking. A common H2-receptor antagonist is **famotidine**. It is available over the counter (OTC) and is also often prescribed orally or as an intravenous injection in the hospital setting. Other H2-receptor antagonists include **cimetidine** and **ranitidine (Zantac)**, shown in Fig. 3.11. **Cimetidine** has a high risk of medication interactions, especially in elderly patients, because of its binding action within the liver, which affects the metabolism of other medications.

Fig. 3.11

Key Concept

A common **suffix** in **generic H2-receptor antagonist** medication names is **-tidine**.

Examples: ranitidine (Zantac), cimetidine (Tagamet), famotidine (Pepcid)

Some of the medications listed above may include an abbreviation after the brand name that indicates what it is used for; for example, Pepcid AC (acid controller). The table below is a short list of common abbreviations used with H2-blocker medications.

Table 3.3. Common H2-Blocker Abbreviations

Abbreviation	Meaning
AR	acid reducer
HB	heartburn
AC	acid controller or before meals

Proton Pump Inhibitors

Proton pump inhibitors (PPIs) work by reducing the amount of stomach acid produced by glands in the stomach lining. They bind to the hydrogen-potassium ATPase enzyme system of the parietal cell, also referred to as the "proton pump" because it pumps hydrogen ions into the stomach. PPIs also inhibit the secretion of hydrochloric acid. A common proton pump inhibitor, **pantoprazole** (Fig. 3.12) may be administered using various routes, including orally, with a nasogastric tube, or as an **intravenous** injection in the hospital setting. Other PPIs include **esomeprazole**, **lansoprazole**, and **omeprazole** (Fig. 3.13). PPIs are more powerful than antacids and H2-receptor antagonists. Pantoprazole is used to treat damage from gastroesophageal reflux disease (GERD) in adults and children five years of age and older; it allows the esophagus to heal and prevents further damage. It is also used to treat conditions in which the stomach produces too much acid, such as Zollinger-Ellison syndrome in adults. PPIs may also be given in combination with antibiotics to treat ***H. pylori*** infections, a common cause of ulcers.

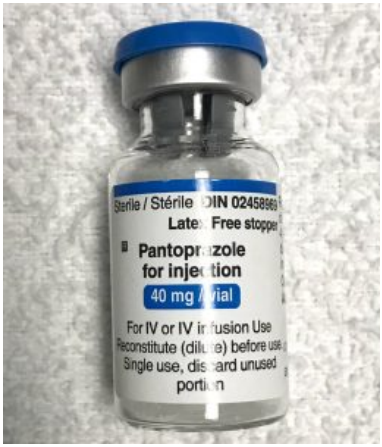


Fig. 3.12

Fig. 3.13

Key Concept

A common **suffix** for generic **proton pump inhibitor** medications is **-prazole**.

Examples: lansoprazole (Prevacid), omeprazole (Prilosec), pantoprazole (Pantoloc), esomeprazole (Nexium)

Medications for Peptic Ulcers

Mucosal Protectants

Mucosal protectants protect the mucosal lining of the stomach from gastric acid. **Sucralfate** is one example and is used to cover and protect gastrointestinal ulcers, as shown in Fig. 3.14. Sucralfate locally covers the ulcer site in the GI tract and protects it against further attack by acid, pepsin, and bile salts. It is important to administer sucralfate on an empty stomach, two hours after or one hour before meals. Patients with kidney disease or diabetes should use caution when taking sucralfate because of the potential for

complications. It is available in tablet form or as a suspension (Mayo Clinic, 2023d).

If a peptic ulcer is caused by ***H. pylori***, the course of treatment will be different and will include antibiotics, a proton pump inhibitor, and possibly an OTC medication, such as Pepto-Bismol, to protect the stomach (Cleveland Clinic, 2021). Fig. 3.15 is an image of the multiple medications, including pantoprazole, metronidazole, amoxicillin, clarithromycin, and Pepto-Bismol, used to treat a peptic ulcer cause by *H. pylori*.

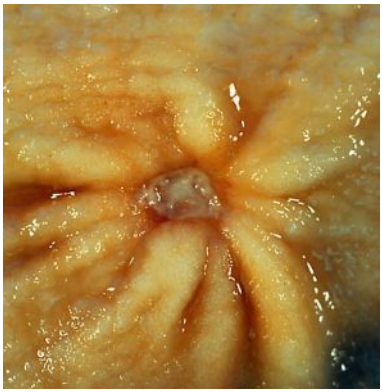


Fig. 3.14

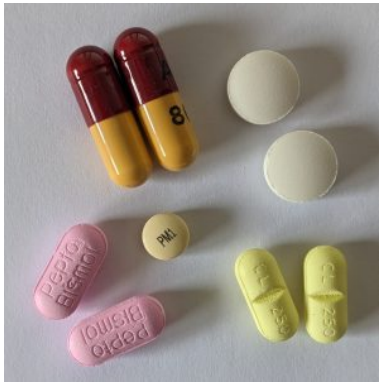


Fig. 3.15

Medications for Constipation

Laxatives and Laxative Classes

There are five categories of laxative medications commonly used to treat constipation: fibre supplements, stool softeners, osmotic agents, lubricants, and stimulants. Fibre supplements and stool softeners can be used daily to prevent constipation, whereas the other laxative categories are used to treat constipation. Table 3.4 below lists each category of laxative, common medications, and how each one works.

Table 3.4. Laxative Categories

Category	Prototypes	Mechanism of Action
Fibre supplements	psyllium (Metamucil)	Bulk forming to facilitate the passage of stool through the rectum
Stool softeners	docusate (Colace)	Facilitates the movement of water and fats into the stool
Osmotic agents	Milk of Magnesia; polyethylene glycol (PEG) 3350 (Miralax)	Causes water to be retained with the stool, increasing the number of bowel movements and softening the stool so it is easier to pass
	lactulose (Cephulac)	
Lubricants	mineral oil enema (Fleet)	Coats the stool to help seal in water
Stimulants	bisacodyl (Dulcolax)	Causes the intestines to contract, inducing stool to move through the colon
	senna (Senokot)	Causes water to be reabsorbed in the intestines which then promotes movement of the stool within the intestines

Medications for Nausea and Vomiting

The category of medications used to treat nausea and vomiting is called **antiemetics**. Antiemetics are prescribed for a number of reasons, including nausea and vomiting associated with surgical recovery from anesthesia and/or opiate analgesia, treatment of motion sickness, severe nausea and vomiting associated with chemotherapy, postoperative nausea and vomiting, and hyperemesis during pregnancy. Several classes of medications fit into this category, including anticholinergics, antihistamines, dopamine antagonists, prokinetics, and serotonin antagonists. Each category is described in further detail below and works on different areas of the body. The following is a short list of common medications used to treat nausea and vomiting from each of these categories:

- scopolamine (Scopace, Maldemar)
- dimenhydrinate (Gravol)
- prochlorperazine (Stemetil)
- metoclopramide (Maxeran)
- ondansetron (Zofran)

Anticholinergics

Scopolamine is an example of an **anticholinergic medication** that is often used to treat motion sickness or nausea and vomiting associated with surgical recovery from anesthesia and/or opiate analgesia. Anticholinergics block ACh receptors in the brain to prevent nausea-inducing stimuli to the **chemoreceptor trigger zone (CTZ)** and the **vomiting centre (VC)**. They also dry GI secretions and reduce smooth muscle spasms. Scopolamine comes in the form of transdermal patch and is designed for the continuous release of the drug following application to an area of intact skin on

the head, typically behind the ear. The patch is formulated to deliver approximately 1 mg of scopolamine over three days.

Antihistamines

Dimenhydrinate is an example of an **antihistamine medication** used to treat and prevent nausea and vomiting. It works by competitively blocking H1 receptors, which then prevents the action of histamine on bronchial smooth muscle and capillaries, and gastrointestinal smooth muscle (National Center for Biotechnology Information, 2023). As a result, it decreases gastrointestinal smooth muscle spasms, thereby decreasing nausea and vomiting (National Center for Biotechnology Information, 2023). This medication comes in many forms, including tablets, suppositories, and solutions for injections or intravenous administration.

Dopamine Antagonists

Prochlorperazine is an example of a **dopamine antagonist** used to treat nausea and vomiting. It can also be used as an antipsychotic medication. Prochlorperazine blocks dopamine in the chemoreceptor trigger zone (CTZ). It also calms the central nervous system and may also block acetylcholine. Prochlorperazine can be administered orally, **intramuscularly**, rectally, or intravenously. It is contraindicated in children under age two or under 20 pounds.

Prokinetics

Metoclopramide (Fig. 3.16) is an example of a **prokinetic medication**. It blocks dopamine and may also sensitize tissues to acetylcholine. It is used to promote **peristalsis** to empty the

gastrointestinal tract and therefore reduce nausea. Metoclopramide can be administered orally, **intramuscularly**, and **intravenously**.

Fig. 3.16

Serotonin Antagonists

Ondansetron, shown in Figs. 3.17 and 3.18, is an example of a **serotonin (5HT) antagonist** often used to treat severe nausea and vomiting associated with chemotherapy, postoperative nausea and vomiting, and hyperemesis during pregnancy. Ondansetron blocks serotonin receptors in the GI tract, the chemoreceptor trigger zone (CTZ), and the vomiting centre (VC). Ondansetron can be taken orally, **sublingually**, or as an injection for patients who are too nauseated to tolerate oral medication.

Fig. 3.17

Fig. 3.18

Antiflatulent Medications

Antiflatulent medications are used in the treatment and prevention of excessive amounts of gastrointestinal gas (Drugs.com, 2022). **Simethicone** is an antiflatulent that is commonly found in other OTC antacids and is used to treat the symptoms of gas, such as uncomfortable or painful pressure, fullness, and bloating. It is also safe for use in infants. Gas commonly occurs in the GI tract because of the digestive processes and swallowing air. Gaseous distension can also occur postoperatively. Simethicone is usually taken four times a day, after meals and at bedtime. It comes in capsules, tablets, and liquid suspensions (Mayo Clinic, 2023c).

Antidiarrheal Medications

Antidiarrheal medications have three common mechanisms of action: **adsorbents**, which help eliminate toxins or bacteria from the GI tract; **antimotility agents**, which slow **peristalsis**; and **probiotics**, which help restore the normal bacteria found in the lower intestine. **Oral rehydration agents** may also be used in patients with diarrhea to replace fluid and electrolyte loss, but they do not treat diarrhea. **Antibacterial agents** may also be used to treat diarrhea caused by specific infections, such as campylobacter or giardia, but they are not routinely needed (WHO, 2017).

Adsorbents

Bismuth subsalicylate (Pepto-Bismol) is an example of an adsorbent (Fig. 3.19). Adsorbent medications work by coating the walls of the GI tract and binding the causative bacteria or toxin for elimination from the GI tract through the stool (Lilley et al., 2014). In addition, adsorbents work by protecting the intestines, easing inflammation, and helping with the symptoms of nausea. This medication is taken orally and comes as a suspension, tablets, chewable tablets, and capsules (Mayo Clinic, 2023a).

Fig. 3.19

Antimotility Medications

Antimotility medications help treat diarrhea by slowing **peristalsis**. There are two categories of antimotility medications: **anticholinergics** and **opiate-like medications**. Anticholinergic medications work on the smooth muscle of the GI tract to inhibit propulsive motility and decreases gastric acid secretion. A common anticholinergic medication is **hyoscyamine**.

Loperamide (Fig. 3.20) has an opioid-like chemical structure but causes fewer central nervous system effects. It can be used to treat both acute and chronic diarrhea (Mayo Clinic, 2023b) and works by decreasing the flow of fluids and electrolytes into the bowel and by slowing down the movement of the bowel to decrease the number of bowel movements (WebMD, 2023b). It comes in various forms, including capsules, tablets, liquid solutions, and suspensions (Mayo Clinic, 2023b).

Fig. 3.20

Fig. 3.21

Probiotics

Probiotics (Fig. 3.21) help replenish normal bacterial flora in the gastrointestinal tract. They are used for the prevention and treatment of diarrhea and are often combined with antibiotics to prevent the common associated side effects of diarrhea. An example of a probiotic is **lactobacillus**.

Table 3.5. Common Digestive System Medications

Generic Name	Trade Name	Reason for Administering
aluminum hydroxide gel	Amphojel	GERD
calcium carbonate	Tums	GERD
magnesium hydroxide	Milk of Magnesia	GERD, constipation
alginate, magnesium	Gaviscon	GERD
aluminum hydroxide	Maalox	GERD
calcium carbonate	Rolaids	GERD
bismuth subsalicylate	Pepto-Bismol	GERD
ranitidine	Zantac	GERD
cimetidine	Tagamet	GERD
famotidine	Pepcid	GERD
lansoprazole	Prevacid	GERD
omeprazole	Prilosec	GERD
pantoprazole	Pantoloc	GERD
esomeprazole	Nexium	GERD
sucralfate	Sulcrate	Ulcers
psyllium	Metamucil	Constipation
docusate	Colace	Constipation
polyethylene glycol (PEG)	Miralax	Constipation
lactulose	Cephulac	Constipation
mineral oil enema	Fleet	Constipation
bisacodyl	Dulcolax	Constipation
senna	Senokot	Constipation
scopolamine	Scopace, Maldemar	Nausea related to motion sickness
dimenhydrinate	Gravol	Nausea and vomiting
prochlorperazine	Stemetil	Nausea and vomiting

metoclopramide	Maxeran	Nausea and vomiting
ondansetron	Zofran	Nausea and vomiting
simethicone	Oval	Antiflatulent
hyoscyamine	Levsin	Peptic ulcers, decreases gastric secretions and motility
loperamide	Imodium	Diarrhea

(WebMD, 2023b)

References

Cleveland Clinic. (2021). *H. pylori infection.* https://my.clevelandclinic.org/health/diseases/21463-h-pylori-infection#:~:text=H.%20pylori%2Dcaused%20ulcers%20are,(Flagyl%C2%AE)%20and%20tetracycline

Drugs.com. (2022). *Antigas antiflatulent ultra strength.* https://www.drugs.com/otc/119157/antigas-antiflatulent-ultra-strength.html

Lilley, L. L., Rainforth Collins, S., & Snyder, J. S. (2014).

Pharmacology and the nursing process (7th ed.) (pp. 782–862). Elsevier.

Mayo Clinic. (2023a). *Bismuth subsalicylate (oral route)*. https://www.mayoclinic.org/drugs-supplements/bismuth-subsalicylate-oral-route/description/drg-20068521

Mayo Clinic (2023b). *Loperamide (oral route)*. https://www.mayoclinic.org/drugs-supplements/loperamide-oral-route/description/drg-20064573

Mayo Clinic (2023c). *Simethicone (oral route)*. https://www.mayoclinic.org/drugs-supplements/simethicone-oral-route/description/drg-20068838

Mayo Clinic (2023d). *Sucralfate (oral route)*. https://www.mayoclinic.org/drugs-supplements/sucralfate-oral-route/description/drg-20066120

National Center for Biotechnology Information. (2023). *PubChem compound summary: Dimenhydrinate*. https://pubchem.ncbi.nlm.nih.gov/compound/Dimenhydrinate

WebMD. (2023b). *Drugs & medications* A–Z. https://www.webmd.com/drugs/2/index

WebMD. (2023a). *Loperamide – Uses, side effects, and more*. https://www.webmd.com/drugs/2/drug-4789-4025/loperamide-oral/loperamide-oral/details

WebMD. (2022). *Which OTC meds treat heartburn?* https://www.webmd.com/heartburn-gerd/guide/treating-heartburn-over-counter-medicine

World Health Organization (WHO). (2017, May 2). *Diarrhoeal disease*. https://www.who.int/en/news-room/fact-sheets/detail/diarrhoeal-disease

Image Credits (images are listed in order of appearance)

Antacid-L478 by Midnightcomm, CC BY-SA 3.0

Zantac Pill and Pill Pack by ParentingPatch, CC BY-SA 3.0

PantoIV by James Heilman, MD, CC BY-SA 3.0

Omeprazole 20mg by Siufaiho, Public domain

Benign gastric ulcer 1 by Ed Uthman, MD, Public domain

H.pyloriTx by Doc James, CC BY-SA 4.0

Metoclopramide by Intropin (Mark Oniffrey), CC BY-SA 4.0

Ondansetron 3 by Intropin (Mark Oniffrey), CC BY-SA 4.0

000817lg Zofran 8 MG Oral Tablet by National Library of Medicine, NIH, Public domain

PeptoBismol Bottle by ParentingPatch, CC BY-SA 3.0

Loperamide2mg by Kristoferb, CC BY-SA 3.0

Biogaia_Lactobacillus_Reuteri_Product by openfoodfacts.org, CC BY-SA 3.0

3.5 Review

Exercises

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=1068#h5p-29

CHAPTER IV

MUSCULOSKELETAL SYSTEM AND MEDICATIONS

4.1 Introduction to the Musculoskeletal System and Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Describe the main components and functions of the musculoskeletal system
2. Describe common pathologies that affect the musculoskeletal system
3. List common medications used to treat musculoskeletal system pathologies
4. Identify common suffixes seen within musculoskeletal medication names

Chapter Overview

In the musculoskeletal system, the muscular and skeletal systems work together to support and move the body. The bones of the skeletal system serve to protect the body's organs, support the weight of the body, and give the body shape. This chapter will provide an overview of this body system, common pathologies, and medications that can be used to treat these conditions. The occurrence of musculoskeletal pathologies is common in the general community and in the hospital patient population.

4.2 The Musculoskeletal System

The musculoskeletal system consists of all the bones, muscles, joints, tendons, and cartilage found in the human body (Figs. 4.1 and 4.2). The purpose of this system is to support the body, facilitate movement, and protect the internal organs. Bones are also vital in the production of red blood cells and for storing and releasing minerals and fats. Some resources show the muscular and skeletal systems as separate; however, for the purposes of this book, they are combined in order to provide a basic overview of their components, functions, and pathologies.

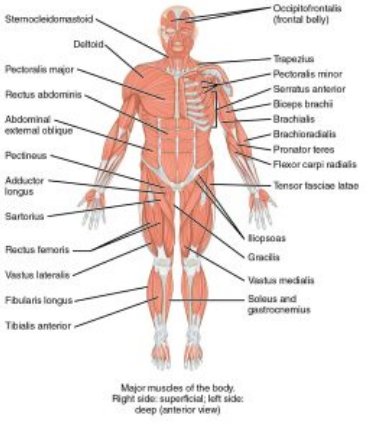


Fig. 4.2

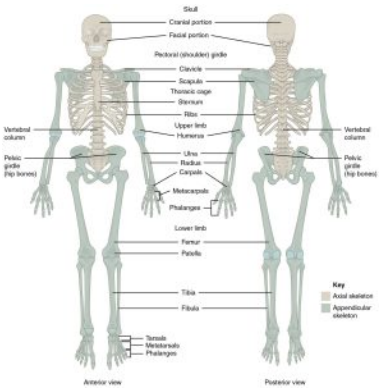


Fig. 4.1

Functions of the Musculoskeletal System

Support, Movement, and Protection

The most apparent functions of the skeletal system are the gross functions—those visible by observation. Simply by looking at a person, you can see how the bones support and protect the body and facilitate movement. Just as the steel beams of a building provide a scaffold to support its weight, the bones and cartilage of your skeletal system compose the scaffold that supports your body. Without the skeletal system, you would be a limp mass of organs, muscle, and skin.

Bones also facilitate movement by serving as points of attachment for your muscles. Although some bones only serve as a support for the muscles, others also transmit the forces produced when your muscles contract. From a mechanical point of view, bones act as levers and joints serve as fulcrums (Fig. 4.3). Unless a muscle spans a joint and contracts, a bone will not move.

Fig. 4.3

Bones also protect internal organs from injury by covering or surrounding them. For example, your ribs protect your lungs and heart, the bones of your vertebral column (spine) protect your spinal cord, and the bones of your cranium (skull) protect your brain (Fig. 4.4).

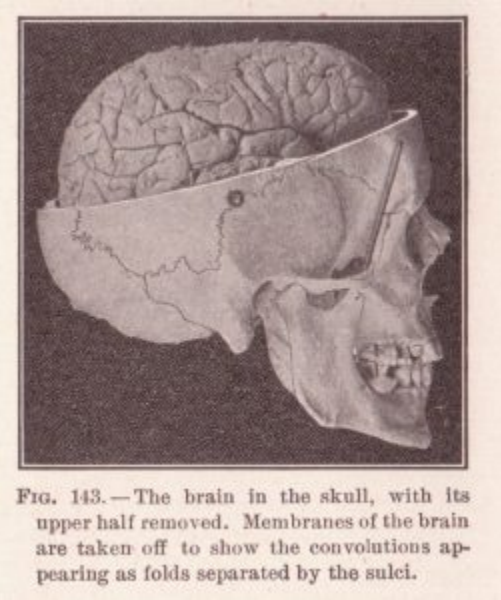


FIG. 143.—The brain in the skull, with its upper half removed. Membranes of the brain are taken off to show the convolutions appearing as folds separated by the sulci.

Fig. 4.4

Key Concept

An orthopedist is a doctor who specializes in diagnosing and treating disorders and injuries related to the musculoskeletal system. Some orthopedic problems can be treated with medications, exercises, braces, and other devices, but others may be best treated with surgery.

While the origin of the word **orthopedics** (**orth/o** = "straight"; **ped/o** = "child"), literally means "straightening of

the child," orthopedists can have patients who range from pediatric to geriatric. Orthopedists commonly treat bone and joint injuries, but they also treat other bone conditions, including curvature of the spine.

Mineral Storage, Energy Storage, and Hematopoiesis

On a metabolic level, bone tissue performs several critical functions. For one, bone acts as a reservoir for a number of minerals important to the functioning of the body, especially calcium and phosphorus. These minerals, incorporated into bone tissue, can be released back into the bloodstream to maintain the levels needed to support physiological processes. Calcium ions, for example, are essential for muscle contractions and controlling the flow of other ions involved in the transmission of nerve impulses.

Bone also serves as a site for fat storage and blood cell production. The softer connective tissue that fills the interior of most bone is referred to as **bone marrow** (Fig. 4.5). There are two types of bone marrow—yellow marrow and red marrow. **Yellow marrow** contains adipose tissue; the triglycerides stored in the adipocytes of the tissue can serve as a source of energy. **Red marrow** is where **hematopoiesis** takes place. Red blood cells, white blood cells, and platelets are all produced in the red marrow.

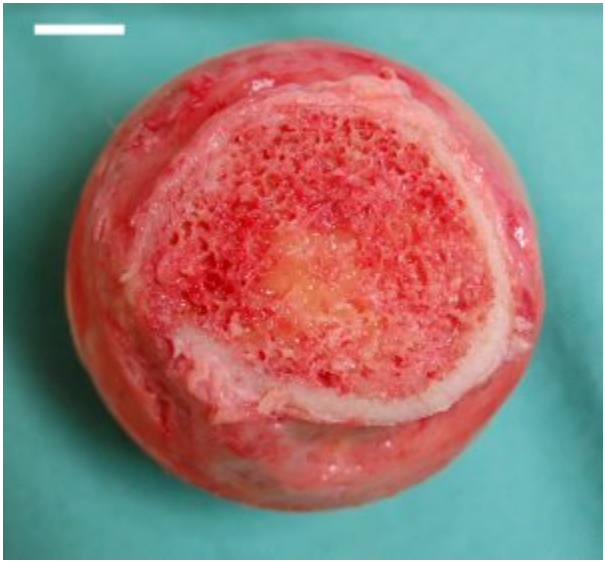


Fig. 4.5

Muscles, Tendons, and Ligaments

The other parts of this system also provide integral functions within the human body. Think about the things you do each day—talking, walking, sitting, standing, and running. All of these activities require the movement of particular **skeletal muscles**. Skeletal muscles are even used during sleep. The **diaphragm**, for example, is a sheet of skeletal muscle that has to contract and relax for you to breathe day and night.

The ability to move the skeleton is complex and requires the tension created by the contraction of the fibres in the skeletal muscles to be transferred to the tendons. **Tendons** are strong bands of dense, regular connective tissue that connect muscles to bones. The bone connection is why this muscle tissue is called "skeletal muscle." There are a number of different components within this system that work together in order for the skeleton to move and

to perform other important functions within the body, such as the diaphragm noted above.

The following video provides an overview of the musculoskeletal system and some of the pathologies that can occur in this system.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=1818#oembed-1

(Alila Medical Media, 2020)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

References

Alila Medical Media. (2020, May 20). *Overview of the musculoskeletal system, animation.* [Video]. YouTube. https://www.youtube.com/watch?v=gSW2ryFmihk

Image Credits (images are listed in order of appearance)

Axial *Skeleton-01-2014×2048* by LadyofHats, Public domain

1105 Anterior and Posterior Views of Muscles by OpenStax College, CC BY 4.0

Leg Press 2 by SAgbley, CC BY-SA 4.0

Page 215 Skull and Brain by Sue Clark, Public domain

Caput femoris cortex medulla by Stevenfruitsmaak, Public domain

4.3 Musculoskeletal System Pathologies

There are a number of pathologies that can affect the musculoskeletal system, and the most common pathologies will be discussed below. Many of these pathologies can be treated with medications that will be discussed later in this chapter.

Common Pathologies

Arthritis: This common disorder involves inflammation of the joint, often resulting in significant joint pain, along with swelling, stiffness, and reduced joint mobility. There are more than 100 different forms of arthritis. Arthritis may arise from aging, damage to the articular cartilage, autoimmune diseases, bacterial or viral infections, or unknown (likely genetic) causes.

Osteoarthritis (OA): Osteoarthritis is the most common type of arthritis and is associated with aging and "wear and tear" of the cartilage. Risk factors that may lead to osteoarthritis later in life include injury to a joint, jobs that involve physical labour, sports that require running, twisting, or throwing actions, and being overweight. These factors put stress on the cartilage that covers the surfaces of bones at the synovial joints, causing the cartilage to gradually become thinner. As the cartilage layer wears down, more pressure is placed on the bones. The joint responds by increasing production of the lubricating synovial fluid, but this can lead to swelling of the joint cavity, causing pain and joint stiffness as the articular capsule is stretched. The bone tissue underlying the damaged cartilage also responds by thickening, producing

irregularities and causing the articulating surface of the bone to become rough or bumpy. Moving the joint then results in pain and inflammation.

In its early stages, the symptoms of osteoarthritis may be reduced by mild activity that "warms up" the joint, but the symptoms may worsen following exercise. In individuals with more advanced osteoarthritis, the affected joints can become more painful and therefore difficult to use effectively, resulting in decreased mobility. There is no cure for osteoarthritis, but several treatments can help alleviate the pain. These treatments may include lifestyle changes such as weight loss and low-impact exercise and over-the-counter or prescription medications that help alleviate the pain and inflammation. For severe cases, **arthroplasty** may be required. See Fig. 4.6 for a comparison of a normal joint, a joint with osteoarthritis, and a joint with rheumatoid arthritis.

Fig. 4.6

Gout: This form of arthritis results from the deposition of uric acid crystals in a joint (Fig. 4.7). Usually only one or a few joints are

affected, such as the big toe, knee, or ankle. The attack may only last a few days, but may return to the same or another joint. Gout occurs when the body makes too much uric acid or the kidneys do not properly excrete it. A diet with excessive fructose has been associated with an increased chance of developing gout.

Fig. 4.7

Rheumatoid arthritis (RA): This type of arthritis is an autoimmune disease that results in the joint capsule and synovial membrane becoming inflamed (Fig. 4.8). As the disease progresses, the articular cartilage is severely damaged or destroyed, resulting in joint deformation, loss of movement, and severe disability. The most commonly involved joints are the hands, feet, and cervical spine, with corresponding joints on both sides of the body usually affected. Rheumatoid arthritis is also associated with lung fibrosis, **vasculitis**, coronary heart disease, and premature mortality. With no known cure, treatments are aimed at alleviating symptoms.

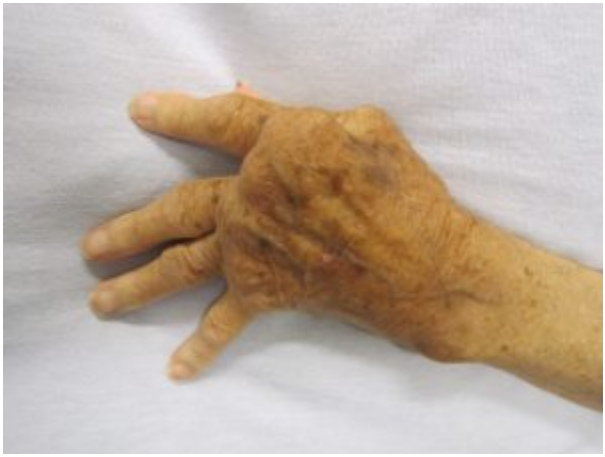


Fig. 4.8

Bursitis: This condition is the inflammation of a bursa near a joint (Fig. 4.9), which causes pain, swelling, or tenderness of the bursa and surrounding area, and may also result in joint stiffness. Bursitis is most commonly associated with the bursae found at or near the shoulder, hip, knee, or elbow joints. It can be either acute (lasting only a few days) or chronic and can arise from muscle overuse, trauma, excessive or prolonged pressure on the skin, rheumatoid arthritis, gout, or infection of the joint. Repeated acute episodes of bursitis can result in a chronic condition.

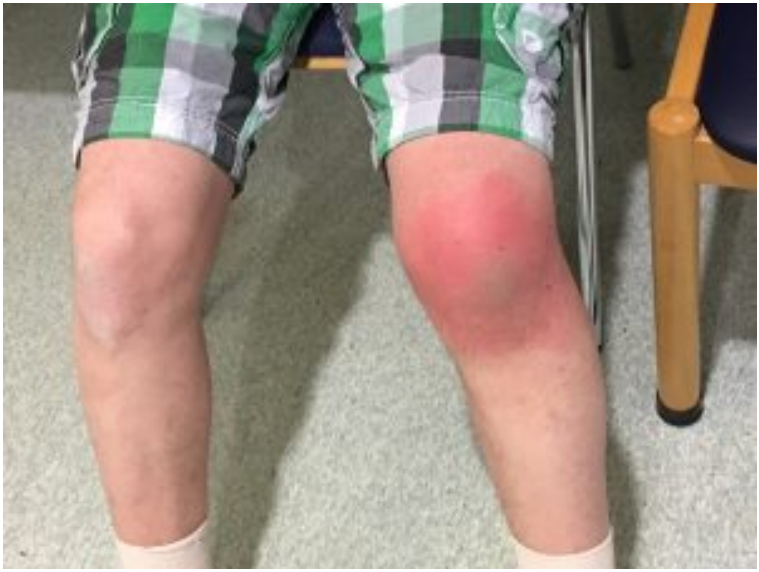


Fig. 4.9

Paget's disease: This condition usually occurs in adults over the age of 40. It is a disorder of the bone remodelling process that begins with overactive **osteoclasts**. This essentially means more bone is resorbed than is laid down. The **osteoblasts** try to compensate, but the new bone they lay down is weak and brittle and therefore prone to fracture. Although some people with Paget's disease have no symptoms, others experience pain, bone fractures, and bone deformities as shown in Fig. 4.10. Bones of the pelvis, skull, spine, and legs are the most commonly affected. When Paget's disease occurs in the skull, it can cause headaches and hearing loss. It is not known what makes the **osteoclasts** become overactive. Hereditary may play a role, and some scientists believe Paget's disease is caused by an as-yet-unidentified virus.

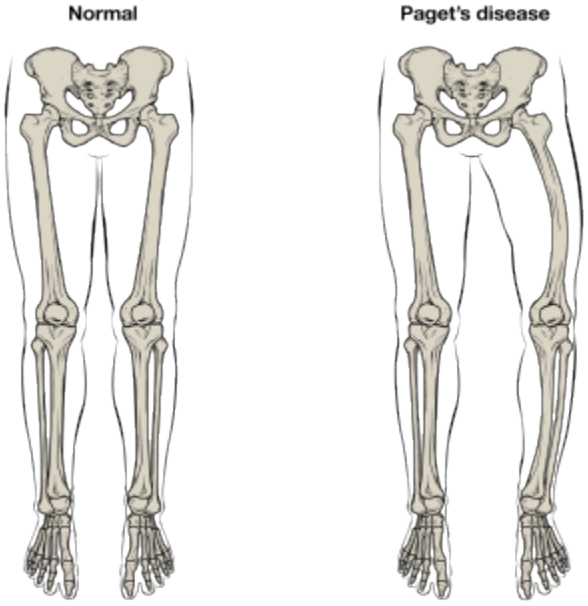


Fig. 4.10

Osteoporosis (OP): This disease is characterized by a decrease in bone mass that occurs when the rate of bone resorption exceeds the rate of bone formation, a common occurrence as the body ages (Fig. 4.11). Note how this is different from Paget's disease. In Paget's disease, new bone is formed in an attempt to keep up with the resorption by overactive **osteoclasts**, but the new bone is produced haphazardly. In fact, when a physician is evaluating a patient with thinning bones, they will test for osteoporosis and Paget's disease, as well as other diseases. Osteoporosis does not have the elevated blood levels of alkaline phosphatase found in Paget's disease.

Fig. 4.11

Although osteoporosis can involve any bone, it most commonly affects the proximal ends of the femur, vertebrae, and wrists. As a result of the loss of bone density, the osseous tissue may not provide adequate support for everyday functions, and something as simple as a sneeze can cause a vertebral fracture. When an elderly person falls and breaks a hip, it is very likely the femur that breaks first, which results in the fall. Histologically, osteoporosis is characterized by a reduction in the thickness of compact bone and an increase in the number and size of trabeculae in cancellous (spongy) bone.

Women lose bone mass more quickly than men starting at about 50 years of age (Fig. 4.12). This occurs because 50 is the approximate age at which women go through menopause. Not only do their menstrual periods lessen and eventually cease, but their ovaries reduce in size and then cease to produce estrogen, a hormone that promotes **osteoblast** activity and the production of bone matrix. Thus, osteoporosis is more common in women than in men, but men can develop it, too. Anyone with a family history of osteoporosis has a greater risk of developing the disease, so the

best treatment is prevention, which should start with a childhood diet that includes adequate intake of calcium and vitamin D and a lifestyle that includes weight-bearing exercise. These actions, as discussed above, are important for building bone mass. Promoting proper nutrition and weight-bearing exercise early in life can maximize bone mass before the age of 30, thus reducing the risk of osteoporosis at a later age.

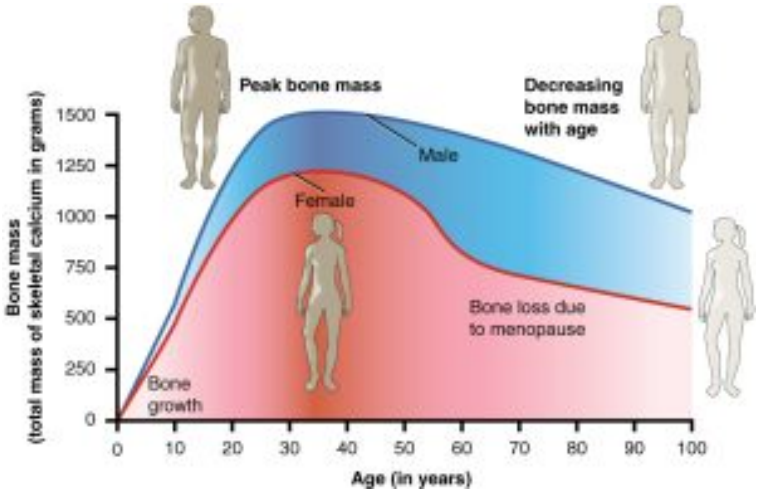


Fig. 4.12

For many elderly people, a hip fracture can be life threatening. The fracture itself may not be serious, but the reduced mobility required by the healing process can lead to the formation of blood clots that may lodge in the capillaries of the lungs, resulting in respiratory failure, pneumonia caused by the lack of poor air exchange that accompanies immobility, pressure sores (bed sores) that allow pathogens to enter the body and cause infections, and urinary tract infections from catheterization.

Current treatments for managing osteoporosis include medications, which will be discussed further in the next section,

and minimizing the risk of falls by removing tripping hazards, for example.

Scoliosis: This pathology is an abnormal, lateral curvature of the vertebral column, accompanied by twisting. Fig.4. 13 shows an X-ray of a young girl diagnosed with scoliosis. Compensatory curves may also develop in other areas of the vertebral column to help maintain the position of the head over the feet. Scoliosis is the most common vertebral abnormality among girls. The cause is usually unknown, but it may result from weakness of the back muscles, defects such as differential growth rates in the right and left sides of the vertebral column, or differences in the length of the lower limbs. When present, scoliosis tends to get worse during adolescent growth spurts. Although most individuals do not require treatment, a back brace may be recommended for growing children. In extreme cases, surgery may be required.

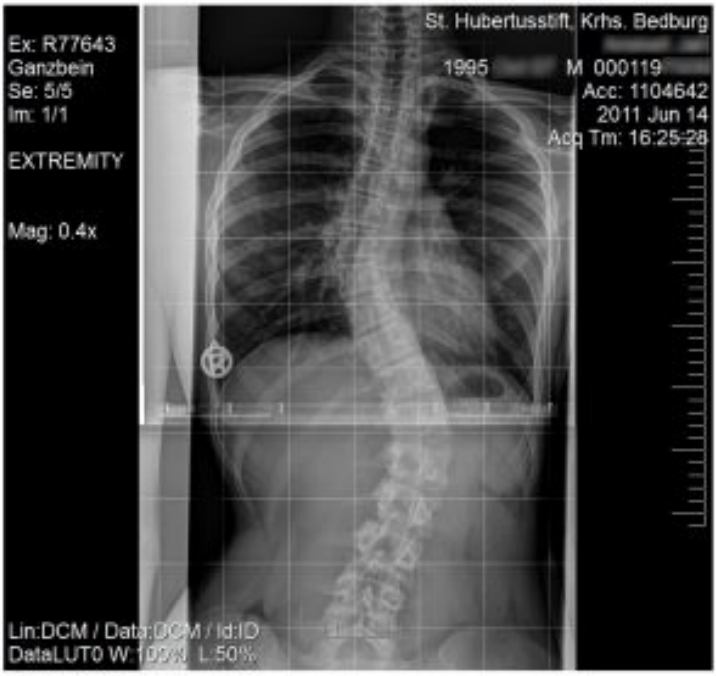


Fig. 4.13

Tendinitis: This condition is characterized by inflammation of a tendon, which is the thick band of fibrous connective tissue that attaches a muscle to a bone, and causes pain and tenderness in the area around a joint. On rare occasions, a sudden serious injury will cause tendinitis. Most often, the condition results from repetitive motions over time that strain the tendons needed to perform the tasks. People whose jobs, sports, or hobbies involve performing the same movements over and over again are often at the greatest risk of tendinitis—you may have heard of tennis and golfer's elbow, jumper's knee, and swimmer's shoulder. In all cases, overuse of the joint causes a microtrauma that initiates the inflammatory response. Tendinitis is routinely diagnosed through a clinical examination. In cases of severe pain, X-rays can be examined to rule

out the possibility of a bone injury. Severe cases of tendinitis can even tear loose a tendon. Surgical repair of a tendon is painful, and because connective tissue in the tendon does not have an abundant blood supply, the healing process is slow. Treatment may involve physical therapy, medications, and preventive measures to decrease the chance of reoccurrence.

Now that we have reviewed the musculoskeletal system and its common pathologies, we will now discuss medication-related treatment options for these conditions.

4.4 Musculoskeletal System Medications

Some of the more common musculoskeletal system medications are discussed below. Focus is placed on the pathologies already mentioned in this chapter, and many of the pathologies are treated with the same medications. It is also important to note that many musculoskeletal pathologies are treated with multiple medications in addition to other types of therapies.

Medications for Osteoarthritis (OA)

Osteoarthritis (OA) is typically treated with a variety of non-opioid analgesics. The goal is to reduce pain and improve the ability to move more comfortably (Mayo Clinic, 2023f). In addition, treatment may include lifestyle changes, such as weight loss and low-impact exercise, and for severe cases, **arthroplasty** may be required (Betts et al., 2013). Some of the common medications used to treat OA are described below. Many, as previously mentioned, are used to treat other musculoskeletal pathologies and will be described later on this page (Betts et al., 2013).

Acetaminophen

Acetaminophen (**Tylenol**) (Fig. 4.14) is a non-opioid analgesic that can be used for mild to moderate pain. It also has an **antipyretic** therapeutic effect. It does not cause stomach irritation and is well tolerated if taken as prescribed. Acetaminophen should not be used

to treat inflammation because it has no anti-inflammatory properties. The preferred route is oral, and the medication comes in the form of liquid, tablets, and capsules but can also be taken rectally in the form of a suppository. Acetaminophen can be used to treat pain associated with OA but not inflammation (Arthritis Society Canada, 2023a).

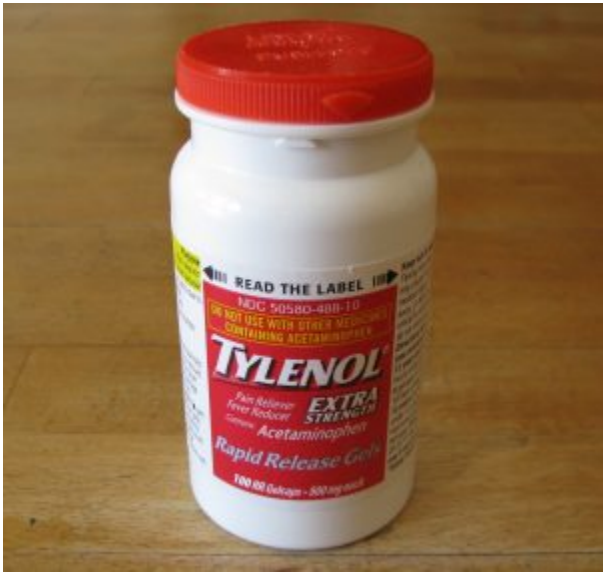


Fig. 4.14

Salicylate Medications

Salicylate medications can be taken to help alleviate pain and can be administered in a variety of routes, including orally and topically. These medications can be used when pain is not relieved by acetaminophen or for those wanting an alternative medication route; typically, for OA, the preferred medication route is topical.

The following are some common topical creams used for OA (Arthritis Society of Canada, 2023h):

- antiphlogistine (Rub A535)
- menthol topical (BenGay)
- trolamine salicylate (Aspercreme)

Acetylsalicylic acid (**Aspirin**) is a common salicylate medication that relieves pain and reduces inflammation and fever by inhibiting the production of **prostaglandins**. It also decreases **platelet aggregation**. For OA, it would primarily be used for its anti-inflammatory and analgesic effects. The preferred route for acetylsalicylic acid is orally, but it can be taken rectally and intravenously as well. It can cause stomach irritation and is available as an enteric-coated tablet that should not be crushed, chewed, or broken; it should be swallowed whole. The chewable tablet form must be chewed before swallowing.

Key Concept

A common abbreviation for **acetylsalicylic acid** is **ASA**.

Acetylsalicylic acid (Aspirin) has the following four therapeutic effects:

- anticoagulant
- analgesic
- antipyretic
- anti-inflammatory

Nonsteroidal Anti-Inflammatory Drugs (NSAIDs)

Nonsteroidal anti-inflammatory drugs (NSAIDs) have analgesic, antipyretic, and anti-inflammatory effects. If there is inflammation involved in the pathology, then the NSAIDs listed below could be used in the course of treatment. Fig. 4.15 is an image of the common NSAID **ibuprofen**, which is often the first line of treatment for OA (Arthritis Society Canada, 2023f). NSAIDs help with both the pain and inflammation associated with OA, but they do not change the course of the disease (Arthritis Society Canada, 2023f). NSAIDs are often used in combination with **disease-modifying antirheumatic drugs (DMARDs)** or **biologics** (Arthritis Society Canada, 2023e). **Diclofenac (Voltaren)** is a commonly used topical treatment for the pain of OA and is often preferred over oral NSAID medications (Fig. 4.16).

The following is a list of common NSAIDs used for OA that have been recommended by the Arthritis Society of Canada (2023f):

- diclofenac (Voltaren)
- flurbiprofen (Ansaid)
- ibuprofen (Advil, Motrin)
- indomethacin (Indocid)
- ketorolac (Toradol)
- naproxen (Aleve)

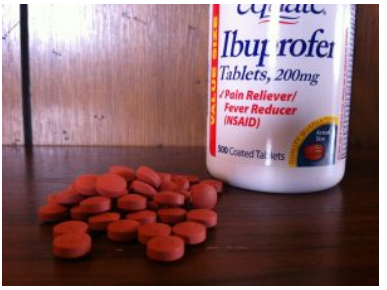


Fig. 4.15

Fig. 4.16

Key concept

A common **suffix** in generic **nonsteroidal anti-inflammatory (NSAID)** medication names is **-profen**.

Examples: ibuprofen (Advil), flurbiprofen (Ansaid)

COX-2 Inhibitor Medications

Celecoxib (Celebrex) is a COX-2 inhibitor and is currently the only COX-2 inhibitor available on the market in Canada. It specifically inhibits the enzyme COX-2 that is required for the synthesis of **prostaglandins**. Celecoxib is used to treat the pain associated with

osteoarthritis, as well as rheumatoid arthritis (including juvenile), and ankylosing spondylitis.

Key Concept

The common **suffix** with **COX-2 inhibitor** medications is **-coxib**.

Example: Celecoxib (Celebrex)

Corticosteroid Medications

Corticosteroid medications are similar to the hormones produced by the human body and reduce pain and inflammation. Corticosteroids can be used to treat various conditions, including respiratory ailments such as COPD and asthma, dermatologic pathologies, and many others, including various musculoskeletal pathologies such as osteoarthritis, rheumatoid arthritis, bursitis, and tendinitis.

Prednisone is perhaps the most widely used of the systemic corticosteroids. It is generally used as an anti-inflammatory and immunosuppressive agent; however, prednisone is not recommended for osteoarthritis (Arthritis Society of Canada, 2023g). Corticosteroids should never be stopped abruptly, and if a patient has been using them for more than 10 days, the dose must be slowly **tapered**. This means starting with a larger dose and slowing decreasing it. Fig. 4.17 shows an example of a tapered dose of medication.

Corticosteroids can be taken by various routes, including orally, topically, intravenously, and by subcutaneous or intramuscular injection. Most commonly with osteoarthritis, corticosteroids are injected directly into the joint or around the tendon, and the lasting effects vary from days to months (Arthritis Society Canada, 2023i).

Fig. 4.17

The following is a list of common corticosteroids medications that are used to treat various types of arthritis, including osteoarthritis (Arthritis Society Canada, 2023g):

- betamethasone (Celestone Soluspan)
- methylprednisolone (Depo-medrol)
- prednisone (Winpred)
- triamcinolone (Kenalog, Aristospan)

Key concept

Common **suffixes** in generic **corticosteroid** medication names are **-lone** and **-sone**.

Examples: methylprednisolone (Depo-medrol), prednisone (Winpred), betamethasone (Celestone)

Medications for Gout

There are a couple of primary medications used in the treatment of gout. **Colchicine** (**Colchicine-Odan**) is used to help treat and prevent gout attacks. It has two therapeutic effects: anti-inflammatory and analgesic. This medication is taken orally in pill form and works best if taken within 24 hours of a gout attack (Arthritis Society Canada, 2023d).

Allopurinol (**Zyloprim**) is another frequently used medication in the treatment of gout. It is used to decrease the levels of uric acid in the blood and helps prevent the reoccurrence of a gout attack. Allopurinol blocks the production of uric acid by the body's cells, and by doing so, lowers the risk of an attack (Arthritis Society Canada, 2023b). It is administered orally in tablet form, and the dose may require adjustment based on a patient's renal function (Arthritis Society Canada, 2023b). It can take several weeks for allopurinol to take effect, so it may be used in combination with an NSAID or colchicine (Arthritis Society Canada, 2023b).

Medications for Rheumatoid Arthritis (RA)

The treatment of all arthritis pathologies can be complicated; each patient's experience can vary, so their treatment plan may vary as well (Betts et al., 2013). This section will focus on some of the common medications used to treat rheumatoid arthritis, but it is certainly not a complete list—there is always new research and new medications being developed. RA can be treated with non-prescription medications such as **acetaminophen** and **NSAIDs** as described above, but these are usually prescribed in combination with medications from other categories. One of these medication categories is called **disease modifying anti-rheumatic drugs (DMARDs)**. The goal of DMARDs is to reduce inflammation and prevent joint damage. Medications in this category can be administered orally, subcutaneously, or intramuscularly, depending on the medication (Arthritis Society Canada, 2023e). The corticosteroid **prednisone** might be prescribed as well and is taken orally.

Biologics or **biosimilars** are medications produced from living cells and work by suppressing the immune system with the goal of reducing pain, improving the symptoms related to RA, and slowing the disease progression (Arthritis Society Canada, 2023g). Biologics can be given subcutaneously or intravenously (Arthritis, Society Canada, 2023c).

The following list includes only a few examples of medications in each of the categories described above (Arthritis Society Canada, 2023c):

Disease-modifying anti-rheumatic drugs (DMARDs):

- hydroxychloroquine (Plaquenil)
- methotrexate (Metoject)

Corticosteroids:

- prednisone (Winpred)

Biologics:

- abatacept (Orencia)
- adalimumab (Humira)
- etanercept (Enbrel)

The video below gives an overview of the medications used to treat arthritis. You can find a complete list of medications in the Arthritis Society Canada Medication Reference Guide.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=1823#oembed-1

(Arthritis Society Canada, 2018)

Medications for Bursitis

Treatments for **bursitis** can include **antibiotics** if the bursitis is caused by an infection or **anti-inflammatory** agents, such as **nonsteroidal anti-inflammatory drugs (NSAIDs)** or **corticosteroids**, which can be injected into the bursa if the bursitis is caused by trauma or overuse. Injections usually work quickly and typically only one injection is needed for the patient to have relief (Mayo Clinic, 2023a). Chronic bursitis may require that fluid be drained, but additional surgery is usually not required. In addition to medications, patients may be encouraged to rest, apply ice, and see a physical therapist (Mayo Clinic, 2023a).

Medications for Tendinitis

The treatment for **tendinitis** may be a combination of therapies, including rest, ice, and physical therapy, and if the symptoms do not diminish, then surgical repair might be considered. The pain associated with tendinitis can be treated with **acetaminophen**, **NSAIDs**, and **acetylsalicylic acid**, which are most commonly administered either orally or topically (Mayo Clinic, 2023d). At times, a **steroid injection** into the tendon might be considered for the pain, but it is not recommended that this treatment be repeated because it can increase the likelihood of the tendon weakening and tearing (Mayo Clinic, 2023d).

Medications for Osteoporosis (OP)

Current treatments for managing **osteoporosis (OP)** typically include one of the medications discussed below. Various medications are available, and treatment plans vary depending on an individual's results and experiences with side effects. Patients are encouraged to investigate different options and choose the one that works best for them.

Bisphosphonates

Current treatments for managing osteoporosis include **bisphosphonates**—the most common class of drugs prescribed for osteoporosis (Betts et al., 2013). These medications work by binding to the bones and slowing the action of the **osteoclasts**, allowing the **osteoblasts** to be more productive.

The following is a list of common bisphosphonate medications

used to treat osteoporosis, the administration route, and how often these medications are taken (Osteoporosis Canada, 2023a).

- alendronate (Fosamax) – a daily or weekly pill
- risedronate (Actonel) – a daily or weekly pill
- etidronate (Didrocal) – taken daily for two weeks followed by a blue calcium tablet daily for an additional 10 weeks
- zoledronic acid (Aclasta) – intravenously once a year

Key Concept

A common **suffix** in generic **bisphosphonate** medication names is **-dronate**.

Examples: alendronate (Fosamax), risedronate (Actonel), etidronate (Didrocal)

Human Monoclonal Antibodies

Denosumab (**Prolia**) is in a class of medications called **human monoclonal antibodies** (Osteoporosis Canada, 2023b). It is a fairly new medication used to treat osteoporosis and works by stopping the activation of **osteoclasts**. It is administered by injection twice a year and has been shown to decrease the risk of fractures in both men and women (Osteoporosis Canada, 2023b).

Hormone Therapy (HT)

Hormone therapy (HT) is another treatment option for osteoporosis, more specifically estrogen/progesterone as these hormones play a role in maintaining bone density (Osteoporosis Canada, 2023c). Menopause leads to a decrease in these hormones, which in turn can result in bone thinning and loss. Ideally, the treatment should use the lowest dose possible that is needed to prevent this from happening because hormone treatment has been shown to increase the risk of some cancers, stroke, blood clots, and cardiovascular disease (Osteoporosis Canada, 2023c). Because of these risks, other treatment options should be considered for the prolonged treatment of postmenopausal osteoporosis. Treatment could involve a combination of both progesterone and estrogen or just estrogen alone. Both hormones are typically taken orally in the form of a tablet (Osteoporosis Canada, 2023c).

Selective Estrogen Receptor Modulators (SERMs)

Raloxifene (**Evista**) is a common medication that acts like estrogen but belongs to a class of medications known as **selective estrogen receptor modulators (SERMs)** (Web MD, 2023a). It improves bone density in postmenopausal women without the dangerous side effects associated with estrogen, but it unfortunately can still increase the risk of blood clots (Mayo Clinic, 2023c). Raloxifene is taken once a day orally, preferably around the same time every day (Osteoporosis Canada, 2023c).

Medications for Paget's Disease

Bisphosphonates, as mentioned above, are medications that

decrease the activity of osteoclasts and are often used to treat **Paget's disease**. However, in a small percentage of cases, bisphosphonates have been linked to an increased risk of fractures because the old bone that is left after the medication is administered becomes worn out and brittle (Betts et al., 2013). Still, in many cases, the benefits more than outweigh the risks. Bisphosphonate treatment can reduce the overall risk of deformities or fractures, which in turn reduces the need for surgical repair and its associated risks and complications (Betts et al., 2013).

Table 4.1. Common Musculoskeletal System Medications

Generic Name	Trade Name	Reason for Administering
antiphlogistine	Rub A535	OA
betamethasone	Celestone Soluspan	OA
diclofenac	Voltaren	OA
flurbiprofen	Ansaid	OA
indomethacin	Indocid	OA
menthol topical	BenGay	OA
methylprednisolone	Depo-Medrol	OA
triamcinolone	Kenalog, Aristospan	OA
trolamine salicylate	Aspercreme	OA
ibuprofen	Advil, Motrin	OA, gout
ketorolac	Toradol	OA, gout
naproxen	Aleve	OA, gout
celecoxib	Celebrex	OA, RA
acetaminophen	Tylenol	OA, RA, tendinitis
acetylsalicylic acid	Aspirin	OA, tendinitis
allopurinol	Zyloprim	Gout

colchicine	Colchicine-Odan	Gout
abatacept	Orencia	RA
adalimumab	Humira	RA
etanercept	Enbrel	RA
hydroxychloroquine	Plaquenil	RA
methotrexate	Metoject	RA
prednisone	Winpred	RA
alendronate	Fosamax	OP
denosumab	Prolia	OP
estrogen/ progesterone	–	OP
etidronate	Didrocal	OP
raloxifene	Evista	OP
risedronate	Actonel	OP

(WebMD, 2023b)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Arthritis Society Canada. (2023a). *Acetaminophen*. https://arthritis.ca/treatment/medication/medication-reference-guide/medications/acetaminophen

Arthritis Society Canada. (2023b). *Allopurinol*. https://arthritis.ca/treatment/medication/medication-reference-guide/medications/allopurinol

Arthritis Society Canada. (2023c). *Biologics and biosimilars for the treatment of inflammatory arthritis*. https://arthritis.ca/treatment/medication/biologics-and-biosimilars

Arthritis Society Canada. (2023d). *Colchicine*. https://arthritis.ca/treatment/medication/medication-reference-guide/medications/colchicine

Arthritis Society Canada. (2023e). *Disease-modifying anti-rheumatic drugs (DMARDs)*. https://arthritis.ca/treatment/medication/disease-modifying-anti-rheumatic-drugs-(dmards)

Arthritis Society Canada. (2023f). *Non-steroidal anti-inflammatory drugs (NSAIDs)*. https://arthritis.ca/treatment/medication/medication-reference-guide/medications/non-steroidal-anti-inflammatory-drugs-(nsaids)

Arthritis Society Canada. (2023g). *Prednisone*. https://arthritis.ca/treatment/medication/medication-reference-guide/medications/prednisone

Arthritis Society Canada. (2023h). *Salicylate*. https://arthritis.ca/treatment/medication/medication-reference-guide/medications/salicylate

Arthritis Society Canada. (2023i). *Steroid injection*. https://arthritis.ca/treatment/medication/medication-reference-guide/medications/steroid-injection

Arthritis Society Canada. (2018, March 23). *Inflammatory arthritis medications simplified* [Video]. YouTube. https://www.youtube.com/watch?v=gqGo9qiHDZU

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

Mayo Clinic. (2023a). *Bursitis*. https://www.mayoclinic.org/diseases-conditions/bursitis/diagnosis-treatment/drc-20353247

Mayo Clinic. (2023b). *Osteoarthritis*. https://www.mayoclinic.org/diseases-conditions/osteoarthritis/diagnosis-treatment/drc-20351930

Mayo Clinic. (2023c). *Osteoporosis treatment: Medications can help*. https://www.mayoclinic.org/diseases-conditions/osteoporosis/in-depth/osteoporosis-treatment/art-20046869

Mayo Clinic. (2023d). *Tendinitis*. https://www.mayoclinic.org/diseases-conditions/tendinitis/diagnosis-treatment/drc-20378248

Osteoporosis Canada. (2023a). *Bisphosphonates*. https://osteoporosis.ca/bisphosphonates/

Osteoporosis Canada. (2023b). *Denosumab*. https://osteoporosis.ca/denosumab/

Osteoporosis Canada. (2023c). *Hormone therapy (HT)*. https://osteoporosis.ca/hormone-therapy/

Osteoporosis Canada. (2023d). *SERMs: Selective estrogen receptor modulators*. https://osteoporosis.ca/serms/

WebMD. (2023a). *Evista strengthens bone, safe on uterus.* https://www.webmd.com/osteoporosis/news/20030718/evista-strengthens-bones-safe-on-uterus

WebMD. (2023b). *Drugs & medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

Tylenol bottle closeup (loose crop) by Colin, CC BY-SA 2.0

Equate Ibuprofen Pills and Bottle by ParentingPatch, CC BY-SA 3.0

Вольтарен Эмульгель by Schekinov Alexey Victorovich, CC BY-SA 4.0

Sandoz.Methylprednisolone.4mg by Anonymous, Public domain

4.5 Review

Review of the Musculoskeletal System

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=1825#h5p-33

Review of Musculoskeletal Pathologies

An interactive H5P element has been excluded

from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=1825#h5p-34

Review of Medications

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=1825#h5p-35

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

CHAPTER V

RESPIRATORY SYSTEM AND MEDICATIONS

5.1 Introduction to Respiratory System and Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Describe the respiratory system, its functions, and its main components
2. Describe common respiratory system pathologies
3. Define the effects of bronchodilator medications on the airway
4. Identify medications for treating respiratory conditions, both generic and brand names
5. Define what is meant by a "combination medication" to treat respiratory disorders

Chapter Overview

Every year, millions of Canadians visit their healthcare provider for respiratory conditions such as allergies, asthma, bronchitis, the common cold, chronic obstructive pulmonary disease (COPD), and pneumonia.

Because of the high number of people with respiratory-related illnesses, theses conditions affect individuals and their families, schools, workplaces, neighbourhoods, cities, and provinces. As a result of the prevalence of respiratory-related illnesses, it is likely all of us know someone, or of someone, with one of these conditions. This makes it even more important to be familiar with these conditions and how they are treated. Before we learn about medications that are used to treat respiratory conditions, it is integral that we review the respiratory system, its components, and the pathologies that can affect it.

5.2 The Respiratory System

The major organs of the respiratory system function primarily to provide oxygen to body tissues for cellular respiration, remove the waste product carbon dioxide, and help maintain the acid-base balance. Portions of the respiratory system are also used for non-vital functions such as sensing odours, speech production, and straining, such as during childbirth or coughing. These components, as well as an overview of the whole respiratory system, are show in Fig. 5.1.

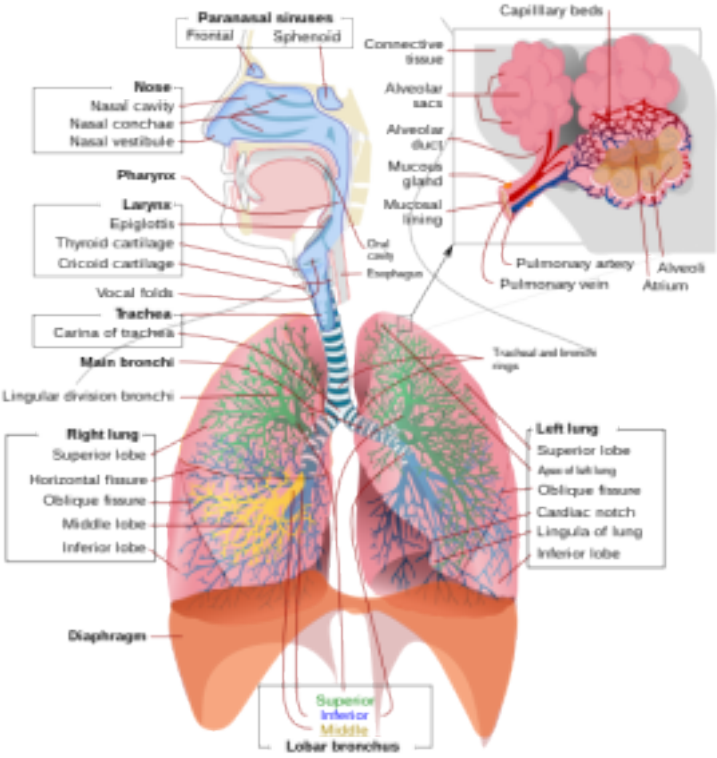


Fig. 5.1

Functionally, the respiratory system can be divided into a conducting zone and a respiratory zone. The **conducting zone** includes the organs and structures not directly involved in gas exchange. Gas exchange occurs in the **respiratory zone**.

Conducting Zone Components

Nose

The major entrance and exit for the respiratory system is through the nose. Several bones help form the walls of the **nasal cavity** and create air-containing spaces called the **paranasal sinuses**, which serve to warm and humidify incoming air. These sinuses are lined with **mucosa**. Each paranasal sinus is named for its associated bone: **frontal sinus**, **maxillary sinus**, **sphenoidal sinus**, and **ethmoidal sinus**. The sinuses produce mucus and lighten the weight of the skull.

The **nostrils**, also called the **nares**, and the anterior portion of the nasal cavities are lined with mucous membranes and contain sebaceous glands and hair follicles that prevent the passage of large debris, such as dirt, through the nasal cavity. An **olfactory epithelium** that detects odours is located deeper in the nasal cavity.

Pharynx

The **pharynx** is a tube formed by skeletal muscle and lined with mucous membrane that is continuous with that of the nasal cavity. The pharynx is divided into three major regions: the **nasopharynx**, **oropharynx**, and **laryngopharynx** (Fig. 5.2).

The **nasopharynx** serves as an airway passage to the rest of the respiratory system. At the top of the nasopharynx are the **pharyngeal tonsils**. Also called **adenoids**, the pharyngeal tonsils are an aggregate of lymphoid reticular tissue similar to lymph nodes and lie at the superior portion of the nasopharynx. The function of the pharyngeal tonsils is not well understood, but they contain a rich supply of **lymphocytes** and are covered with ciliated epithelium that traps and destroys invading pathogens that enter during inhalation.

The pharyngeal tonsils are large in children, but interestingly, they tend to regress with age and may even disappear. The **uvula** is a small, bulbous, teardrop-shaped structure located at the apex of the soft palate. Both the uvula and soft palate move like a pendulum during swallowing, swinging upward to close off the nasopharynx to prevent ingested materials from entering the nasal cavity. In addition, **auditory tubes** that connect to each middle ear cavity open into the nasopharynx. This connection is why colds often lead to ear infections.

The **oropharynx** is a passageway for both air and food. It is bordered superiorly by the nasopharynx and anteriorly by the oral cavity. The oropharynx contains two distinct sets of tonsils—the palatine and lingual tonsils. The **palatine tonsils** are a pair of structures located laterally in the oropharynx. The **lingual tonsils** are located at the base of the tongue. Similar to the pharyngeal tonsils, the palatine and lingual tonsils are composed of lymphoid tissue and trap and destroy pathogens entering the body through the oral or nasal cavities.

The **laryngopharynx** is inferior to the oropharynx and posterior to the **larynx**. It continues the route for ingested material and air until its inferior end, where the digestive and respiratory systems diverge. Anteriorly, the laryngopharynx opens into the larynx, whereas posteriorly, it enters the **esophagus**.

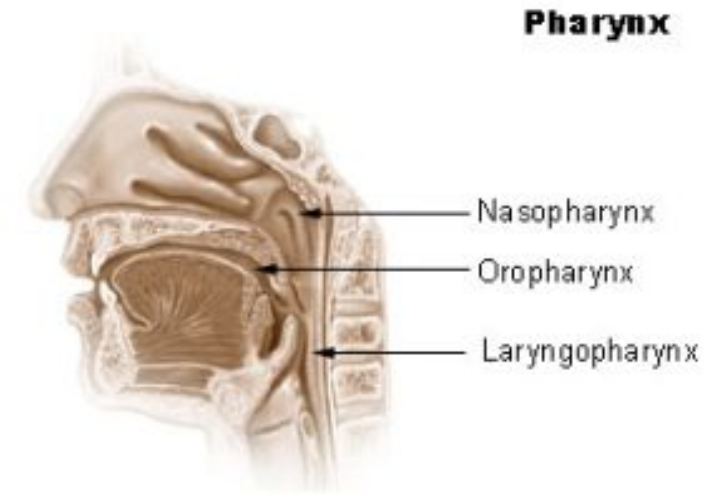


Fig. 5.2

Larynx

The **larynx** is a cartilaginous structure inferior to the **laryngopharynx** that connects the **pharynx** to the **trachea** and helps regulate the volume of air that enters and leaves the lungs. The larynx is formed by several pieces of cartilage. Three large cartilage pieces—the **thyroid cartilage** (anterior), **epiglottis** (superior), and **cricoid cartilage** (inferior)—form the major structure of the larynx. The thyroid cartilage is the largest piece of cartilage and consists of the **laryngeal prominence**, or "Adam's apple," which tends to be more prominent in males. The thick cricoid cartilage forms a ring with a wide posterior region and a thinner anterior region. Three smaller, paired cartilages—the **arytenoids**, **corniculates**, and **cuneiforms**—attach to the epiglottis and the vocal cords and muscles that help move the vocal cords to produce speech.

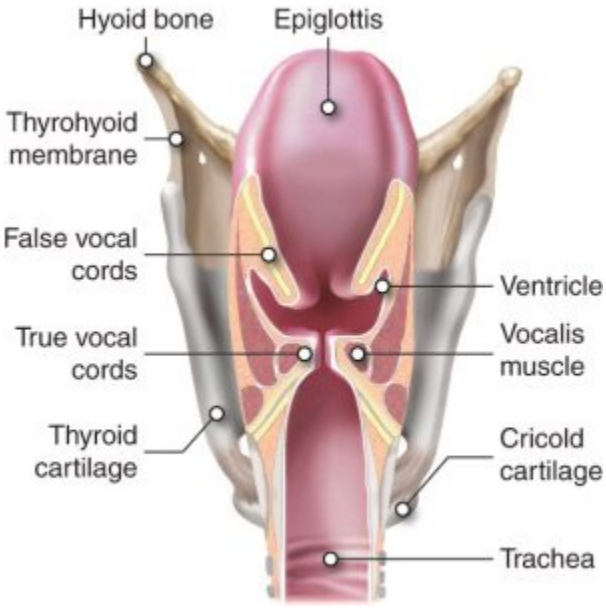


Fig. 5.3

The **epiglottis**, attached to the thyroid cartilage, is a very flexible piece of elastic cartilage that covers the opening of the trachea (Fig. 5.3). When in the "closed" position, the unattached end of the epiglottis rests on the glottis. The act of swallowing causes the pharynx and larynx to lift upward, allowing the pharynx to expand and the epiglottis of the larynx to swing downward, closing the opening to the trachea. These movements produce a larger area for food to pass through while preventing food and beverages from entering the trachea.

Trachea

The **trachea** (**windpipe**) extends from the larynx towards the lungs (Fig. 5.4). The trachea is formed by 16 to 20 stacked, C-shaped pieces of hyaline cartilage that are joined by dense connective tissue. The **trachealis muscle** and elastic connective tissue together form the **fibroelastic membrane**, a flexible membrane that closes the posterior surface of the trachea, connecting the C-shaped cartilages. The fibroelastic membrane allows the trachea to stretch and expand slightly during inhalation and exhalation, while the rings of cartilage provide structural support and prevent the trachea from collapsing. In addition, the trachealis muscle can contract to force air through the trachea during exhalation. The trachea is lined with **pseudostratified ciliated columnar epithelium**, which is continuous with the larynx. The **esophagus** borders the trachea posteriorly.

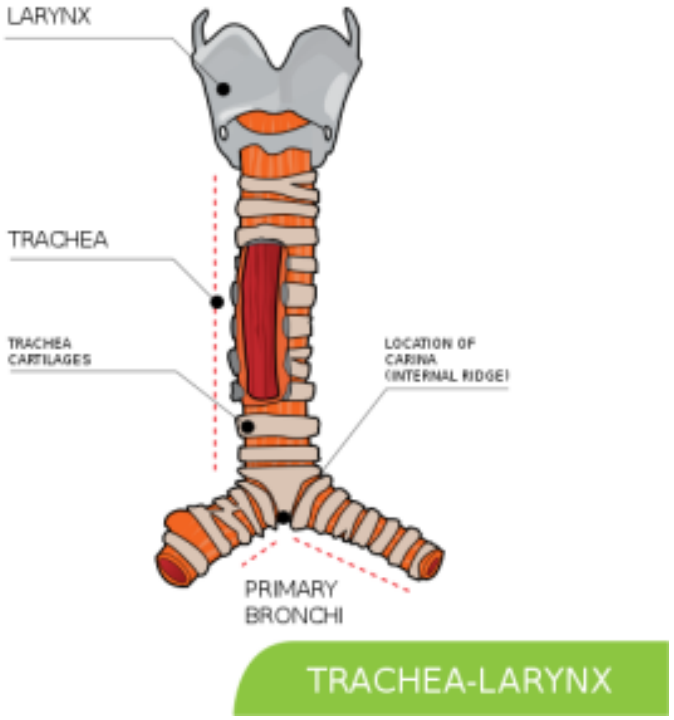


Fig. 5.4

Bronchial Tree

The trachea branches into the right and left primary **bronchi**. These bronchi are also lined by pseudostratified ciliated columnar epithelium containing mucus-producing **goblet cells**. Rings of cartilage, similar to those of the trachea, support the structure of the bronchi and prevent them from collapsing. The primary bronchi enter the lungs at the **hilum**, a concave region where blood vessels, lymphatic vessels, and nerves also enter the lungs. The bronchi continue to branch into a bronchial tree. **Bronchial tree** (or

respiratory tree) is the collective term used for these multiple-branched bronchi. The main function of the bronchi, like other conducting zone structures, is to provide a passageway for air to move into and out of the lungs. In addition, the mucous membrane traps debris and pathogens.

Bronchioles branch from the tertiary bronchi. About 1 mm in diameter, they further branch until they become the tiny **terminal bronchioles**, which lead to the structures of gas exchange. There are more than 1,000 terminal bronchioles in each lung. The muscular walls of the bronchioles do not contain cartilage like those of the bronchi, but they can change the size of the tubing to increase or decrease airflow through the tube see Fig. 5.5.

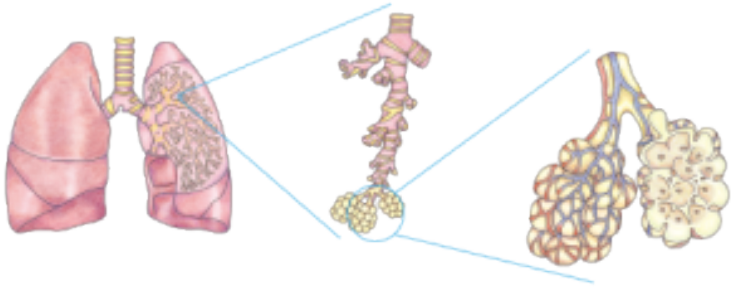


Fig. 5.5

Respiratory Zone Components

In contrast to the conducting zone, the **respiratory zone** includes structures that are directly involved in gas exchange. The respiratory zone begins where the terminal bronchioles join a **respiratory bronchiole**, the smallest type of bronchiole, which then leads to an **alveolar duct**, opening into a cluster of **alveoli**, as shown in Fig. 5.6.

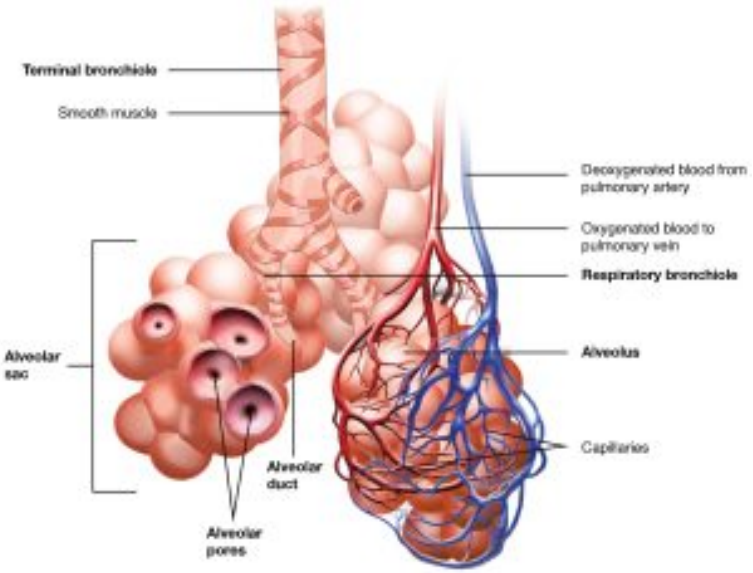


Fig. 5.6

Alveoli

An **alveolar duct** is a tube composed of smooth muscle and connective tissue that opens into a cluster of **alveoli**. An **alveolus** is one of the many small, grape-like sacs that are attached to the alveolar ducts.

An **alveolar sac** is a cluster of many individual alveoli that are responsible for gas exchange. An alveolus is approximately 200 µm (micrometres) in diameter, with elastic walls that allow the alveolus to stretch during air intake, which greatly increases the surface area available for gas exchange. Alveoli are connected to their neighbours by **alveolar pores**, which help maintain equal air pressure throughout the alveoli and lung (Fig. 5.7).

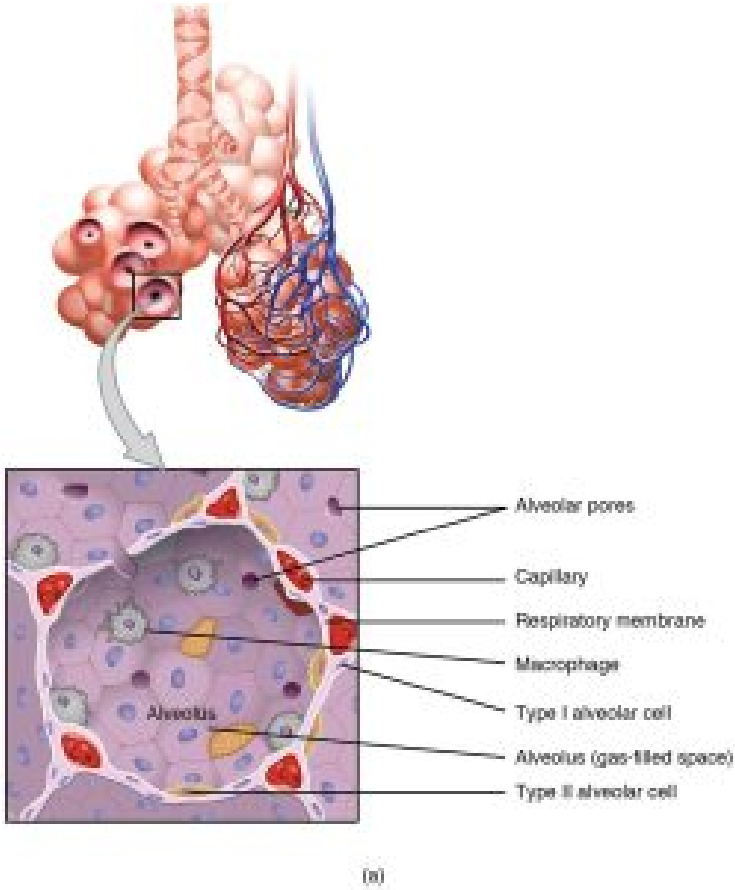


Fig. 5.7

The **alveolar wall** consists of three major cell types: **type I alveolar cells**, **type II alveolar cells**, and **alveolar macrophages**. Taken together, the alveoli and capillary membranes form a **respiratory membrane** that is approximately 0.5 μm thick. Gases cross the respiratory membrane by simple diffusion, allowing oxygen to be picked up by the blood for transport and CO_2 to be released into the air of the alveoli.

The following video provides a summary of the respiratory system anatomy and physiology.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=2009#oembed-1

(Osmosis.org, 2017)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

Reference

Osmosis from Elsevier. (2017, June 14). *Anatomy and physiology of the respiratory system* [Video]. YouTube. https://www.youtube.com/watch?v=0fVoz4V75_E

Image Credits (images are listed in order of appearance)

Respiratory system complete en.svg by LadyofHats, Public domain

Illu pharynx by Arcadian, Public domain

Anatomytool larynx and vocal cords English by Cenveo, CC BY 4.0

Trachea svg hariadhi by Hariadhi, CC BY-SA 4.0

202008 lung detailed by DataBase Center for Life Science (DBCLS), CC BY 4.0

2309 The Respiratory Zone by OpenStax College, CC BY 3.0

2310 Structures of the Respiratory Zone-a by OpenStax College, CC BY 4.0

5.3 Respiratory System Pathologies

A number of pathologies can affect the respiratory system, and the most common pathologies are discussed below. Many of these pathologies can be treated with lifestyle changes and medications that will be discussed later in this chapter.

Common Pathologies

Asthma: This common condition affects the lungs of both adults and children. Approximately 10.8% of Canadians (3.8 million people) are living with asthma (Government of Canada, 2018). In addition, asthma is the most frequent cause of hospitalization in children.

Asthma is a chronic disease characterized by inflammation and edema of the airway, as well as **bronchospasms**, which can inhibit air from entering the lungs. In addition, excessive mucus secretion can occur, which further contributes to airway occlusion.

Bronchospasms occur periodically and lead to an **asthma attack**. An attack may be triggered by environmental factors such as dust, pollen, pet hair or dander, changes in the weather, mould, tobacco smoke, and respiratory infections, or by exercise and stress. Fig. 5.8 provides an image of a normal airway and an airway during an asthma attack.

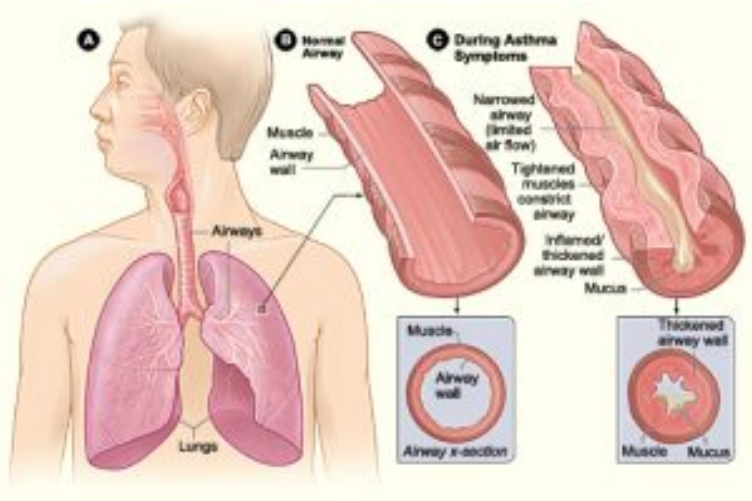


Fig. 5.8

Symptoms of an asthma attack involve coughing, shortness of breath, wheezing, and tightness of the chest. Symptoms of a severe asthma attack that requires immediate medical attention would include difficulty breathing that results in blue (cyanotic) lips or face, confusion, drowsiness, **tachycardia**, sweating, and severe anxiety. The severity of the condition, frequency of attacks, and identified triggers influence the type of medication that an individual may require and will be discussed later in this chapter. Longer-term treatments are used for those with more severe asthma. Short-term, fast-acting drugs that are used to treat an asthma attack are typically administered via an inhaler. For young children or individuals who have difficulty using an inhaler, asthma medications can be administered using a nebulizer.

In many cases, the underlying cause of the condition is unknown. However, recent research has demonstrated that certain viruses, such as human rhinovirus C (HRVC) and the bacteria *Mycoplasma pneumoniae* and *Chlamydia pneumoniae* that are contracted in

infancy or early childhood, may contribute to the development of many cases of asthma.

The following video provides a detailed description of asthma and how it affects those that have it.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=2012#oembed-1

(TED-Ed, 2017)

Key Concept

The burning of a tobacco cigarette creates multiple chemical compounds that are released through **mainstream smoke**, which is inhaled by the smoker, and through **sidestream smoke**, which is the smoke given off by the burning cigarette (Betts et al., 2013). **Second-hand smoke**, which is a combination of sidestream smoke and the mainstream smoke that is exhaled by the smoker, has been demonstrated by numerous scientific studies to cause disease (Betts et al., 2013). At least 40 chemicals in sidestream smoke that negatively impact human health have been identified and can lead to the development of

cancer or other conditions, such as immune system dysfunction, liver toxicity, cardiac arrhythmias, pulmonary edema, and neurological dysfunction. Furthermore, second-hand smoke has been found to harbour at least 250 compounds that are known to be toxic, carcinogenic, or both. Some major classes of carcinogens in second-hand smoke are polyaromatic hydrocarbons (PAHs), N-nitrosamines, aromatic amines, formaldehyde, and acetaldehyde (Betts et al., 2013).

Tobacco and second-hand smoke are considered to be **carcinogenic** (Betts et al., 2013). Exposure to second-hand smoke can cause lung cancer in individuals who are not tobacco users themselves. It is estimated that the risk of developing lung cancer is increased by up to 30% in nonsmokers who live with an individual who smokes in the house, as compared to nonsmokers who are not regularly exposed to second-hand smoke (Betts et al., 2013). Children are especially affected by second-hand smoke. Children who live with an individual who smokes inside the home have more lower respiratory infections, which are associated with hospitalizations, and a higher risk of sudden infant death syndrome (SIDS) (Betts et al., 2013). Second-hand smoke in the home has also been linked to a greater number of ear infections in children, as well as worsening symptoms of asthma (Betts et al., 2013).

Note: In the next section of this chapter, medications will be discussed that can be used to help those who want to stop smoking.

Allergies: These occur when the body's immune system reacts to a foreign substance such as pollen, bee venom, pet dander, or food.

For most people, a foreign substance does not cause a reaction, but for those who are allergic to the substance, it does.

The immune system produces proteins known as **antibodies**. When someone has allergies, the immune system makes antibodies that identify a particular substance as harmful, even though it may not be. When someone comes into contact with the allergen, the immune system's reaction can inflame the skin, sinuses, airways, or digestive system.

The severity of allergies varies from person to person and can range from minor irritation to a potentially life-threatening emergency. Although most allergies can't be cured, treatments can help relieve allergy symptoms.

Some reactions to allergens are listed below:

Hay fever, also called allergic rhinitis, can cause

- Sneezing
- Itching of the nose, eyes, or roof of the mouth
- Runny, stuffy nose
- **Conjunctivitis**

A food allergy can cause

- Tingling in the mouth
- Swelling of the lips, tongue, face, or throat
- Hives
- Anaphylaxis

An insect sting allergy can cause

- **Edema** at the sting site
- Itching or hives all over the body
- Cough, chest tightness, wheezing, or shortness of breath
- Anaphylaxis

A medication allergy can cause

- Hives
- Itchy skin
- Rash
- Facial swelling
- Wheezing
- Anaphylaxis

Atopic dermatitis, an allergic skin condition also called eczema, can cause skin to

- Itch
- Redden
- Flake or peel

Anaphylaxis: Some types of allergies, including allergies to foods and insect stings, can trigger a severe reaction known as anaphylaxis. It is a life-threatening medical emergency that can cause a person to go into shock.

Signs and symptoms of anaphylaxis include the following:

- Loss of consciousness
- Drop in blood pressure
- Severe shortness of breath
- Skin rash
- Lightheadedness
- Weak, rapid pulse
- Nausea and vomiting

Bronchitis: This is an inflammation of the lining of the bronchial tubes, which carry air to and from the lungs. Those with bronchitis often cough up thickened mucus, which may be discoloured. Bronchitis may be either acute or chronic.

Acute bronchitis is very common and often develops from a cold or other respiratory infection. Also called a **chest cold**, this type of bronchitis usually improves within a week to 10 days without lasting effects, though the cough may linger for weeks.

Chronic bronchitis, a more serious condition, is characterized by constant irritation or inflammation of the lining of the bronchial tubes, often caused by smoking. It is one of the conditions included in COPD (Mayo Clinic Staff, 2017).

The symptoms of both acute bronchitis and chronic bronchitis may include the following:

- Cough
- Production of mucus (sputum), which can be clear, white, yellowish-grey, or green; rarely, it may be streaked with blood
- Fatigue
- Shortness of breath
- Slight fever and chills
- Chest discomfort

Cold: The common cold is a viral infection of the upper respiratory tract. Many types of viruses can cause a cold. Children younger than six years of age are at greatest risk of colds, but healthy adults can also expect to have two or three colds annually. The symptoms of a common cold usually appear one to three days after exposure to a cold-causing virus. Most people recover from a common cold in a week or 10 days, though symptoms might last longer in people who smoke.

Signs and symptoms a cold, which can vary from person to person, may include the following:

- Runny or stuffy nose
- Sore throat
- Cough
- Congestion
- Slight body aches or a mild headache
- Sneezing
- Low-grade fever
- Generally feeling unwell

Chronic obstructive pulmonary disease (COPD): This chronic inflammatory lung disease causes obstructed airflow out of the lungs. Symptoms include difficulty breathing, cough, mucus (sputum) production, and wheezing. It is often caused by long-term exposure to irritating gases or dust, and most often occurs because of smoking. People with COPD are at increased risk of developing heart disease, lung cancer, and a variety of other conditions.

Emphysema and chronic bronchitis are the two types of COPD. **Emphysema** is a condition in which the alveoli at the end of the smallest air passages (bronchioles) of the lungs are destroyed and become hyperinflated. **Chronic bronchitis** is inflammation of the lining of the bronchial tubes and is characterized by daily coughing and mucus (sputum) production. See Fig. 5.9 for an illustration of normal lungs compared to lungs affected by COPD.

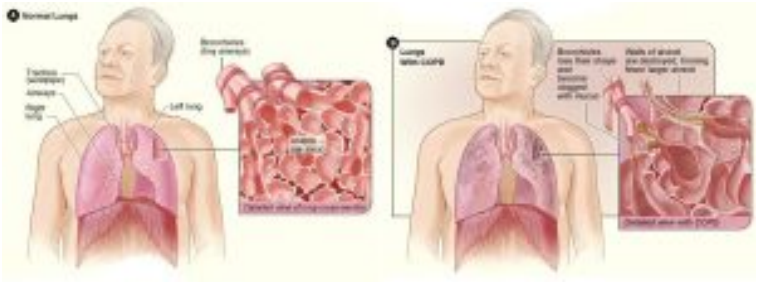


Fig. 5.9

COPD is treatable but not curable. Symptoms often do not appear until significant lung damage has occurred, and they usually worsen over time, particularly if smoke exposure continues.

Other signs and symptoms of COPD may include the following:

- Shortness of breath, especially during physical activity
- Wheezing
- Chest tightness

- Chronic cough that may produce mucus (sputum), which may be clear, white, yellow, or greenish
- Cyanosis
- Frequent respiratory infections
- Lack of energy
- Unintended weight loss (in later stages)

Unlike some diseases, COPD has a clear cause and a clear path of prevention. The majority of cases are directly related to cigarette smoking, and the best way to prevent COPD is to never smoke or to stop smoking immediately (Mayo Clinic. 2020).

The following video describes the main causes, signs and symptoms, and management of COPD.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=2012#oembed-2

(Animated COPD Patient, 2014)

https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Animated COPD Patient. (2014, August 15). *Understanding COPD*. [Video]. YouTube. https://www.youtube.com/watch?v=T1G9Rl65M-Q

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

Government of Canada. (2018). *Data blog: Asthma in Canada*. https://health-infobase.canada.ca/datalab/asthma-blog.html#:~:text=The%20age%2Dstandardized%20prevalence%20of,ranked%20health%20regions%20in%20Canada

Mayo Clinic Staff. (2022). *Allergies*. https://www.mayoclinic.org/diseases-conditions/allergies/symptoms-causes/syc-20351497

Mayo Clinic Staff. (2020). COPD. https://www.mayoclinic.org/diseases-conditions/copd/symptoms-causes/syc-20353679

Mayo Clinic Staff. (2017). *Bronchitis*. https://www.mayoclinic.org/diseases-conditions/bronchitis/symptoms-causes/syc-20355566

TED-Ed. (2017, May 11). *How does asthma work? – Christopher E. Gaw* [Video]. YouTube. https://www.youtube.com/watch?v=PzfLDi-sL3w

Image Credits (images are listed in order of appearance)

Asthma attack-illustration NIH by National Institute of Health: National Heart, Lung, Blood Institute, Public domain

Copd 2010Side by National Institute of Health: National Heart, Lung, Blood Institute, Public domain

5.4 Respiratory System Medications

Respiratory system medications are often given to alleviate allergies or cold symptoms, or to decrease or eliminate shortness of breath (SOB). These medications are available in many different formulations, including nasal sprays, inhalations, oral tablets and liquids, injections, and intravenous. It is always important to ensure that medications are given as ordered. For example, inhalations deliver the required medicine(s) directly to the lungs, which means the medication can act directly on the lung tissues, minimizing systemic side effects. On the other hand, intravenous medications act quickly but can cause systemic side effects. Additionally, some products contain more than one medicine with different dosages; for example, inhalers that combine a long-acting bronchodilator with a corticosteroid. This section will review several respiratory medication categories, common medications in each category, and key concepts related to respiratory medications.

Bronchodilator Medications

Bronchodilator medications are used to treat many pathologies, including asthma, COPD, and bronchitis. The goal of therapy is to relax the muscles around the bronchioles, which in turn helps them dilate and improves airflow to the lungs. In addition to improving airflow, the dilation of the bronchioles makes it easier to cough up excess mucus that is produced in some of these pathologies (Cleveland Clinic, 2022). **Short-acting bronchodilators** are used for acute asthma attacks and last three to six hours; they are often

referred to as **"rescue inhalers." Long-acting bronchodilators** are generally used to prevent **asthma attacks** and can last for up to 12 hours. The different types of bronchodilators are discussed below.

Beta-2 Agonist Bronchodilator Medications

Bronchodilators in this category stimulate **beta-2 adrenergic receptors** in the smooth muscle of the bronchi and bronchioles, producing **bronchodilation**. **Beta-2 agonist bronchodilators** come in both short-acting and long-acting medication forms. Short-acting **albuterol (Ventolin)** is used to prevent or treat **bronchospasms** in people with asthma or exercise-induced bronchospasm. Long-acting **salmeterol (Serevent)** is used to prevent bronchospasm.

Fig. 5.10 is an image and description of **albuterol (Ventolin)**, a short-acting beta-2 agonist bronchodilator. It and many other respiratory medications are delivered using a **metered-dose inhaler (MDI)**. To use an MDI, you have to press down on the canister to release the medication, which is then inhaled into the lungs. The dosage is measured in **puffs** or **actuations**.

An alternative device that can be used to assist with the delivery of respiratory medications such as albuterol is called a **nebulizer**. The medication comes in a small **nebule** that contains a liquid form of the medication (Fig. 5.12). The medication is then placed into a small medicine cup that sits under the facemask that is worn during administration of the medication. The nebulizer machine is then turned on, and

Key Concept

The image below shows a **metered-dose inhaler (MDI).** The dark blue cap is where the mouth piece is located, and the canister that

holds the medication can be seen at the top.

Fig. 5.10

the medication is turned into a mist that flows up into the mask and is inhaled into the lungs by the patient. An image of a patient demonstrating the use of a nebulizer is shown in Fig. 5.11.

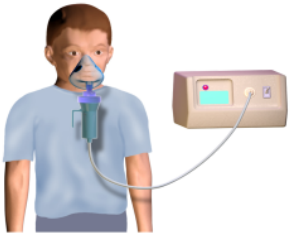


Fig. 5.11

Fig. 5.12

Common medications in this category include the following:

- albuterol (Ventolin) – short acting
- salmeterol (Serevent) – long acting

Sometimes patients have a difficult time using an inhaler properly, which can result in them not getting the entire dose of the medication. In this situation, they may need to use a device called a **spacer**. A spacer is a long, plastic chamber that holds the dose, as shown in Fig. 5.13, while the patient continues to take several breaths to inhale the medication. It is often used with pediatric and geriatric patients.

Fig. 5.13

The following video provides an overview of how to properly use a spacer.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=2014#oembed-1

(AbrahamThePharmacist, 2018)

Key Concept

A common **suffix** seen with generic **beta-2 agonist bronchodilator** medications is **-terol**.

Examples: albuterol (Ventolin), salmeterol (Serevent)

Anticholinergic Bronchodilator Medications

Anticholinergics block the action of acetylcholine in the bronchial smooth muscle, which reduces **bronchoconstrictive** substance release. This causes the bronchioles to relax and dilate. This medication category includes both short-acting and long-acting anticholinergic drugs. **Ipratropium (Atrovent)** is an example of a short-acting anticholinergic bronchodilator, and **tiotropium (Spiriva)** is an example of a long-acting anticholinergic bronchodilator. Anticholinergics are used for maintenance therapy of bronchoconstriction associated with asthma, chronic bronchitis, and emphysema.

Tiotropium (Spiriva) is slightly different than other inhaled medications because it is delivered with a device called a **HandiHaler**. This inhaler does not use canisters like other inhaler devices, but instead uses capsules that are inserted into a slot inside the inhaler. The patient then closes the lid and compresses the button on the side on the inhaler, which pierces the capsule and releases the powder inside, as shown in Fig. 5.14 and Fig. 5.15. The patient then uses the mouthpiece to inhale the medication.

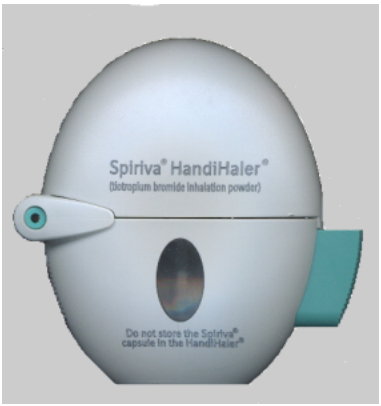


Fig. 5.14

Fig. 5.15

Key Concept

A common **suffix** seen with generic **anticholinergic bronchodilator** medications is **-tropium**.

Examples: ipratropium (Atrovent), tiotropium (Spiriva)

Corticosteroid Medications

Corticosteroids are medications similar to the hormones produced in our own bodies. They work by preventing the release of substances that cause inflammation; however, they also suppress the immune system. Corticosteroids are not used to treat an acute asthma attack but rather help prevent an asthma attack. They can be prescribed in a variety of routes. **Fluticasone (Flovent)** is an example of a commonly used inhaled corticosteroid, **prednisone** is an example of a commonly used oral corticosteroid, and **methylprednisolone** is a commonly used IV corticosteroid. The focus in this section will be on medications that are inhaled into the lungs and are administered using an inhaler device.

The following corticosteroid medications are used in the management of common respiratory pathologies such as asthma:

- fluticasone (Flovent) (Fig. 5.16)
- budesonide (Pulmicort) (Fig. 5.17)
- ciclesonide (Alvesco)
- mometasone (Asmanex)

Fig. 5.17

Fig. 5.16

Budesonide (Pulmicort) is delivered using a inhaler device called a **Turbuhaler**. The powdered corticosteroid is inside the inhaler device, and in order to get a dose (**puff**), you have to twist open the cap (the red part in Fig. 5.17) to prepare the dose. Then you place your mouth on the mouthpiece and inhale the medication into your lungs. The Turbuhaler has a dose counter on the device and usually contains 60 to 120 doses.

Key Concept

Common **suffixes** seen with generic **corticosteroid** medications are **-sone**, **-sonide**, and **-metasone**.

Examples: fluticasone (Flovent), budesonide (Pulmicort), mometasone (Asmanex)

Xanthine Derivative Medications

Xanthine derivative medications work by relaxing the bronchial smooth muscle by inhibiting the enzyme phosphodiesterase and suppressing airway responsiveness to stimuli that cause **bronchoconstriction**. They are used for long-term management of asthma that is unresponsive to beta agonists or inhaled corticosteroids. They are also used for long-term treatment of COPD that is unresponsive to other treatment. **Theophylline (Elixophyllin)** is an example of a xanthine derivative, with the common suffix **-phylline,** and is taken orally in tablet form.

Combination Medications

Inhalers can combine two medications; for example, the brand-name medication **Combivent** is a combination of a beta-2 agonist bronchodilator medication (**albuterol**) with an anticholinergic

bronchodilator medication (**ipratropium**) (WebMD, 2023d). It is most often used to treat symptoms related to COPD (WebMD, 2023d). Another common combination inhaler on the market is **Advair**, which combines the corticosteroid medication **fluticasone** with the beta-2 antagonist bronchodilator **salmeterol** (WebMD, 2023a). This inhaler is often used to treat asthma, COPD, bronchitis, and emphysema. Advair comes in an inhaler called a **Diskus device**, which is shown in Fig. 5.18 (WebMD, 2023a).

Fig. 5.18

The following video shows how to use the various types of inhaler devices that have been discussed on this page.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=2014#oembed-2

(SingHealth, 2011)

Leukotriene Receptor Antagonist Medications

Leukotriene is a chemical in the body that is produced when a person comes into contact with allergens that cause symptoms such as sneezing, running eyes, congestion, and airway constriction (WebMD, 2021). **Leukotriene receptor antagonists** work by blocking the actions of leukotriene and decreasing inflammation. The most common medication in this category is **montelukast (Singulair)**, shown in Fig. 5.19. The medication is safe for children 12 months of age and older, and is available in granule packets and chewable tablets, as well as regular tablets. Montelukast is used for long-term control of asthma and for decreasing the frequency of asthma attacks. It is also indicated for exercise-induced bronchospasm and allergic rhinitis. Patients should take the medication at the same time every day and at least two hours prior to exercise.

Fig. 5.19

Antihistamines

Antihistamines work by blocking **histamine** at H1 receptors, which then inhibits smooth muscle constriction and decreases capillary permeability, salivation, and tear formation. Antihistamines are used for the relief of allergy or cold symptoms. They may cause drowsiness, and concurrent use of alcohol or other CNS depressants should be avoided. Medications in this category are available in various routes, including orally, topically (eye drops), and intravenously. **Diphenhydramine (Benadryl)** is a commonly prescribed antihistamine and is shown in Fig. 5.20

The following is a list of common antihistamines:

- diphenhydramine (Benadryl)
- cetirizine (Zyrtec)
- fexofenadine (Allegra)
- loratadine (Claritin)
- ketotifen (Zaditor) – eye drops

(WebMD, 2023b)

Fig. 5.20

Expectorant Medications

Expectorants are used for a productive cough and loosen mucus in the respiratory tract. They reduce the **viscosity** of secretions, which helps loosen sputum (mucus) and thin bronchial secretions to make coughs more productive. A common example of an expectorant medication is **guaifenesin (Mucinex)**. Guaifenesin is taken orally in tablet, powder, or liquid form (WebMD, 2023e).

Antitussives

Antitussives are used for a dry, hacking, nonproductive cough that interferes with rest and sleep. They suppress coughs by depressing the cough centre in the **medulla oblongata** or the cough receptors in the throat, trachea, or lungs, effectively elevating the threshold for coughing. This medication is not safe for children under the age of four because it may cause nausea and drowsiness. **Dextromethorphan (Robitussin)** is an example of an antitussive. There are many over-the-counter (OTC) antitussive medications available on the market, and some are used in combination with

an expectorant such as guaifenesin; for example, **Robitussin Cough and Chest**.

Nicotine Receptor Agonists

Nicotine receptor agonists are used to treat nicotine addiction by slowly reducing the nicotine dose and thus avoiding withdrawal effects. Nicotine binds to and activates **nicotinic acetylcholine receptors**, mimicking the effect of acetylcholine at these receptors and helping to ease cravings and withdrawal symptoms. This category of medication comes in various forms, including transdermal patch (Fig. 5.21), chewing gum (Fig. 5.22), lozenges, and sprays (WebMD, 2022).

The following is a list of common nicotine receptor agonists:

- nicotine (Nicorette)
- nicotine inhaler system (Nicotrol)

Fig. 5.22

Fig. 5.21

Other Medications Used to Help Stop Smoking

Other prescription medications that might help a person stop smoking and do not contain nicotine are listed below (WebMD, 2023c, 2023f).

- bupropion (Zyban)
- varenicline (Chantix)

Table 5.1. Common Respiratory System Medications

Generic Name	Trade Name	Reason for Administering
albuterol	Ventolin	asthma
salmeterol	Serevent	asthma
ipratropium	Atrovent	asthma, chronic bronchitis, and emphysema
tiotropium	Spiriva	asthma, chronic bronchitis, and emphysema
budesonide	Pulmicort	preventing asthma attacks
ciclesonide	Alvesco	preventing asthma attacks
fluticasone	Flovent	preventing asthma attacks
mometasone	Asmanex	preventing asthma attacks
theophylline	Elixophyllin	asthma and COPD
albuterol/ipratropium	Combivent	COPD
fluticasone/salmeterol	Advair	asthma, COPD, bronchitis, and emphysema
montelukast	Singulair	allergies, preventing asthma attacks
cetirizine	Zyrtec	cold and allergy symptoms
diphenhydramine	Benadryl	cold and allergy symptoms

fexofenadine	Allegra	cold and allergy symptoms
ketotifen	Zaditor	cold and allergy symptoms
loratadine	Claritin	cold and allergy symptoms
guaifenesin	Mucinex	productive cough
dextromethorphan	Robitussin	suppresses cough
bupropion	Zyban	smoking cessation
nicotine	Nicorette	smoking cessation
nicotine inhaler system	Nicotrol	smoking cessation
varenicline	Chantix	smoking cessation

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

AbrahamThePharmacist. (2018, February 5). *How to use a spacer with an inhaler | How to use spacer device | How to use AeroChamber with Ventolin* [Video]. YouTube. https://youtu.be/o0M1lLpOu4U

Cleveland Clinic. (2022). *Bronchodilator*. https://my.clevelandclinic.org/health/treatments/17575-bronchodilator

SingHealth. (2011, November 24). *Asthma care: Step-by-step guide to various inhalers* [Video]. YouTube. https://www.youtube.com/watch?v=krHH3vrzaAI

WebMD. (2023a). *Advair Diskus blister, with inhalation device – Uses, side effects, and more*. https://www.webmd.com/drugs/2/drug-20538/advair-diskus-inhalation/details

WebMD. (2023b). *Allergy medications*. https://www.webmd.com/allergies/allergy-medications

WebMD. (2023c). *Chantix continuing month box 1 mg tablet – Uses, side effects, and more*. https://www.webmd.com/drugs/2/drug-158969/chantix-continuing-month-box-oral/details

WebMD. (2023d). *Combivent Respimat mist inhaler –Uses, side*

effects, and more. https://www.webmd.com/drugs/2/drug-161259/combivent-respimat-inhalation/details

WebMD. (2023e). *Guaifenesin – Uses, side effects, and more*. https://www.webmd.com/drugs/2/drug-3350-118/guaifenesin-oral/guaifenesin-oral/details

WebMD. (2023f). *Zyban 150 Mg tablet, extended release – Uses, side effects, and more*. https://www.webmd.com/drugs/2/drug-1609/zyban-oral/details

WebMD. (2022). *Nicotine addiction treatment*. https://www.webmd.com/smoking-cessation/treat-nicotine-addiction

WebMD. (2021). *Leukotriene modifiers and allergies*. https://www.webmd.com/allergies/leukotriene

Image Credits (images are listed in order of appearance)

Asthma Inhaler (29172634251) by NIAID, CC BY 2.0

Nebulizer Mask (Child) by BruceBlaus, CC BY-SA 4.0

Albuterol 2 by Mark Oniffrey, CC BY-SA 4.0

Treating Kids with Asthma by U.S. Food and Drug Administration, Public domain

Spiriva3 by RonEJ, Public domain

"Spiriva HandiHaler" – brand dry powder inhaler (open) by RonEJ, Public domain

Budesonide and formoterol inhaler by Metrónomo, CC BY-SA 4.0

Fluticasone by James Heilman, MD, CC BY-SA 3.0

Seretide250 by Ebruchez, Public domain

Montelukast Teva 10 mg by Ewave.one, CC BY-SA 4.0

Benadryl tablets (4438315926) by Christopher Holden, CC BY-SA 2.0

Τσίχλες νικοτίνης by Theo0221, CC BY-SA 4.0

NicotinePatch by Styroks, CC BY-SA 4.0

5.5 Review

Respiratory System Review

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=2016#h5p-38

Respiratory Pathologies Review

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=2016#h5p-39

Respiratory Medication Review

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=2016#h5p-37

Trade and Generic Name Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=2016#h5p-36

CHAPTER VI

CARDIOVASCULAR SYSTEM AND MEDICATIONS

6.1 Introduction to the Cardiovascular System and Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Identify the function and components of the cardiovascular system
2. Define different pathologies that commonly affect the cardiovascular system
3. Identify common medications used to treat cardiovascular pathologies by trade and generic names
4. Identify common suffixes found in cardiovascular medication names
5. Explain the stepped care approach to treating hypertension and other cardiovascular pathologies

Chapter Overview

The heart is the powerhouse of the body, providing oxygenated blood to organs so they can conduct the vital processes needed to keep the body functioning. Without a properly functioning heart to ensure blood flow, cells are in jeopardy of oxygen starvation, impairment, and subsequent death. It is no wonder that the heart is the most important muscle in the body. This chapter will begin with an explanation of the key components of the cardiovascular system and its pathologies. From there, we will delve into a discussion of medications that can be used to treat the pathologies that affect this system. Some of the ways these medications work are complex and can be overwhelming, so it is important to focus on the key aspects of each of the medication classifications and not the finer details. Ample review will be provided at the end of the chapter for you to solidify your knowledge.

6.2 Cardiovascular System

The **cardiovascular system** uses blood to deliver nutrients and remove wastes from the trillions of cells in the human body. The **heart**, which is the primary organ in this system, pumps **blood** throughout the body via a network of **blood vessels**. These three components—blood, blood vessels, and the heart—make up this complex system. Most of this section will discuss the heart as it is the most complex and integral part of this body system.

The Heart

The human heart is located within the **thoracic cavity**, medially between the lungs in the space known as the **mediastinum**. The great veins, the **superior vena cava** and the **inferior vena cava**, and the great arteries, the **aorta** and the **pulmonary trunk**, are attached to the superior surface of the heart, called the **base**. The base of the heart is located at the level of the third costal cartilage, as seen in Figure 6.1. The inferior tip of the heart, the **apex**, lies just to the left of the sternum between the junction of the fourth and fifth ribs.

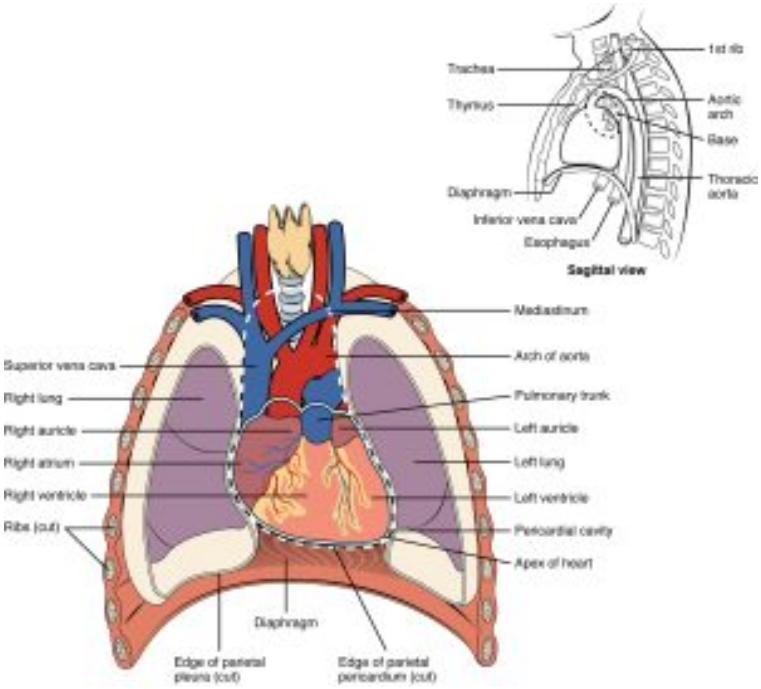


Fig. 6.1

Chambers and Circulation Through the Heart

The heart consists of four chambers: two atria and two ventricles. The **right atrium** receives deoxygenated blood from the systemic circulation, and the **left atrium** receives oxygenated blood from the lungs. The atria contract to push blood into the lower chambers, the right ventricle and the left ventricle. The **right ventricle** contracts to push blood into the lungs, and the **left ventricle** is the primary pump that propels blood to the rest of the body.

There are two distinct but linked circuits in the human circulation called the pulmonary and systemic circuits. The **pulmonary circuit** transports blood to and from the lungs, where it picks up oxygen

and delivers carbon dioxide for exhalation. The **systemic circuit** transports oxygenated blood to virtually all the tissues of the body and returns deoxygenated blood and carbon dioxide to the heart to be sent back to the pulmonary circulation. Figure 6.2 is an illustration of blood flow through the heart and blood circulation throughout the body.

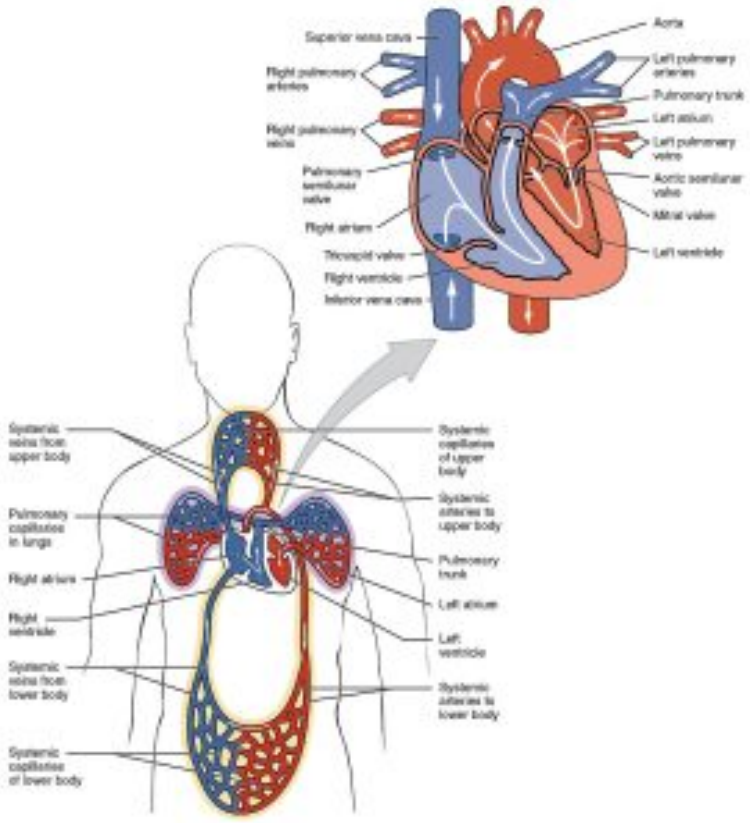


Fig. 6.2

Blood also circulates through the **coronary arteries** with each beat

of the heart. The **left coronary artery** distributes blood to the left side of the heart, and the **right coronary artery** distributes blood to the right atrium, portions of both ventricles, and the heart conduction system. See Figure 6.3 for an illustration of the coronary arteries. When a patient has a **myocardial infarction**, a blood clot lodges in one of the coronary arteries that perfuse the heart tissue. If a significant area of muscle tissue dies from lack of perfusion, the heart is no longer able to pump.

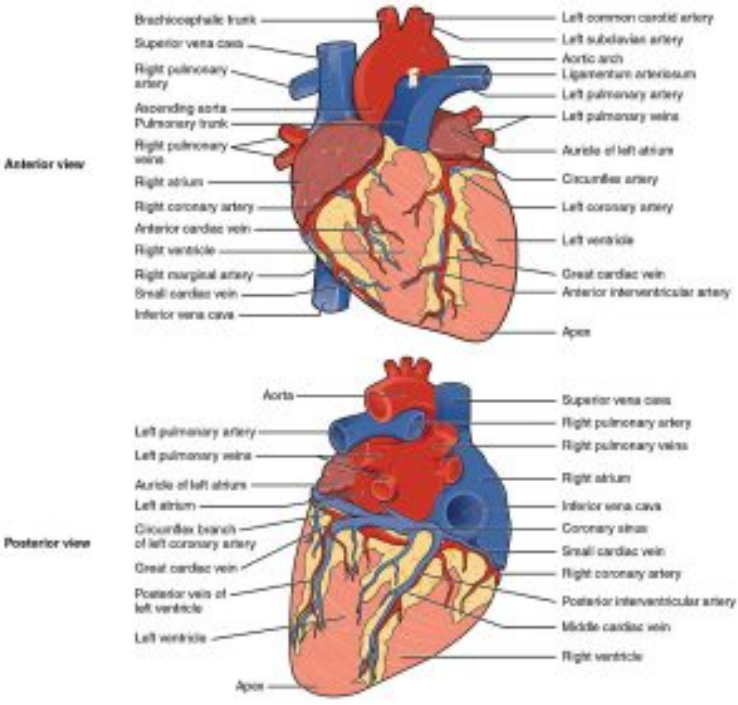


Fig. 6.3

Conduction System of the Heart

Contractions of the heart are stimulated by the **electrical conduction system**. The components of the cardiac conduction system include the **sinoatrial (SA) node**, the **atrioventricular (AV) node**, the **left and right bundle branches**, and the **Purkinje fibres**. Figure 6.4 is an image of the conduction system of the heart.

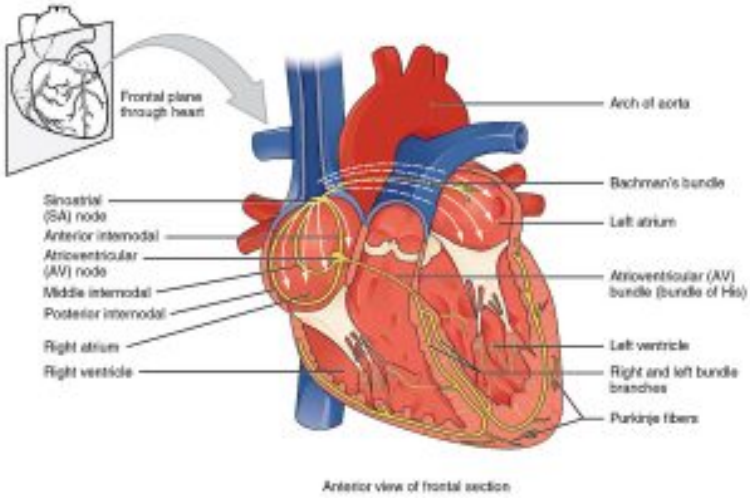


Fig. 6.4

Normal cardiac rhythm is established by the **sinoatrial (SA) node**. The SA node has the highest rate of depolarization and is known as the pacemaker of the heart. It initiates the **sinus rhythm**, the normal electrical pattern followed by heart contractions. The SA node initiates the action potential, which sweeps across the atria through the AV node to the bundle branches and Purkinje fibres, and then spreads to the contractile fibres of the ventricle to stimulate contraction of the ventricle (Betts et al., 2013).

Cardiac Cycle and Output

The period of time that begins with contraction of the atria and ends with ventricular relaxation is known as the **cardiac cycle.** The period of contraction that the heart undergoes while it pumps blood into circulation is called **systole.** The period of relaxation that occurs as the chambers fill with blood is called **diastole**. A common and important unit of measurement is **cardiac output**, which is a measurement of the amount of blood pumped by each ventricle in one minute.

Heart Rate

Heart rate (HR) can vary considerably, not only with exercise and fitness levels, but also with age. A newborn's resting heart rate may be 120 to 160 beats per minute (bpm). Heart rate gradually decreases until young adulthood, then gradually increases with age. For an adult, a normal resting HR will be in the range of 60 to 100 bpm. **Bradycardia** is the condition in which the resting heart rate drops below 60 bpm, and **tachycardia** is the condition in which the resting heart rate is above 100 bpm.

Blood Vessels

After blood is pumped out of the ventricles, it is carried through the body via **blood vessels**. An **artery** is a blood vessel that carries blood away from the heart. From there, the artery branches into ever-smaller vessels and eventually into tiny **capillaries**, where nutrients and wastes are exchanged at the cellular level. Capillaries then combine with other small blood vessels that carry blood to a **vein**, a larger blood vessel that returns blood to the heart. Compared to

arteries, veins are thin-walled, low-pressure vessels. Larger veins are also equipped with valves that promote the one-way flow of blood towards the heart and prevent backflow caused by the inherent low blood pressure in veins as well as the pull of gravity.

In addition to their primary function of returning blood to the heart, veins may be considered blood reservoirs because systemic veins contain approximately 64% of the blood volume at any given time. Approximately 21% of the venous blood is located in venous networks within the liver, bone marrow, and integument. This volume of blood is referred to as the **venous reserve**. Through venoconstriction, this reserve volume of blood can be returned to the heart quickly for redistribution to other parts of the cardiovascular system.

The following video provides an overview of the cardiovascular system and summarizes much of the content covered in this section.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=1999#oembed-1

(Alila Medical Media, 2019)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

References

Alila Medical Media. (2019, May 13). *Cardiovascular system overview animation* [Video]. YouTube. https://youtu.be/28CYhgjrBLA

Image Credits (images are listed in order of appearance)

2001 *Heart Position in ThoraxN* by OpenStax College, CC BY 3.0

2003 *Dual System of Human Circulation* by OpenStax College, CC BY 3.0

2005 *Surface Anatomy of the Heart* by OpenStax College, CC BY 3.0

2018 *Conduction System of Heart* by OpenStax College, CC BY 3.0

6.3 Cardiovascular System Pathologies

A number of pathologies can affect the cardiovascular system, and the more common ones will be discussed below. Many of these pathologies can initially be treated with lifestyle changes but often will require medications that will be discussed later in this chapter.

Common Pathologies

Hypertension: Chronically elevated blood pressure (an increase in both systolic and diastolic pressure) is known clinically as **hypertension**. High blood pressure is first treated with lifestyle changes such as diet and exercise, and if this does not work, then medication is added to the treatment plan. Approximately 6 million Canadians have hypertension (Heart and Stroke Foundation of Canada, 2015). The current guidelines state that hypertension should be treated at 130/80 mm Hg rather than the previous standard of 140/90 mm Hg.

Unfortunately, hypertension is often a "silent disorder," meaning that no symptoms occur until complications happen, so patients may fail to recognize the seriousness of their condition and fail to follow their treatment plan. The result is often a **heart attack** or **stroke**. Hypertension may also lead to an **aneurysm**, **peripheral artery disease**, **chronic kidney disease**, or **heart failure** (Betts et al., 2013).

Medications commonly used to treat hypertension include diuretics, ACE inhibitors, beta-blockers, and calcium channel

blockers. These medications will be discussed in detail in the next section.

The following video provides an overview on the topic of hypertension.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=2001#oembed-1

(Alila Medical Media, 2018)

Hyperlipidemia: Cholesterol is a **fat** that your body needs to work properly. However, too much "bad" cholesterol can increase the risk for heart disease, stroke, and peripheral vascular disease. The medical term for high blood cholesterol is **hyperlipidemia**. A list and description of the types of cholesterol can be found in the Key Concept box below.

Key Concept

- **Total cholesterol:** All the cholesterols combined.
- **High-density lipoprotein (HDL) cholesterol:** Often called "good" cholesterol because it promotes the excretion of cholesterol. Exercise helps to increase HDL and remove cholesterol from the bloodstream.

- **Low-density lipoprotein (LDL) cholesterol:** Often called "bad" cholesterol because it stores cholesterol in the bloodstream, which contributes to atherosclerosis.
- **Very-low-density lipoprotein (VLDL) cholesterol:** Another "bad" cholesterol because it carries triglycerides that are associated with plaque formation in the arteries.

(Cleveland Clinic, 2022)

For many people, abnormal cholesterol levels are partly caused by lifestyle choices, including a diet that is high in fat, being overweight, or lack of exercise. However, disorders that lead to abnormal cholesterol and triglyceride levels can also be passed down through families (Cleveland Clinic, 2022). In addition to lifestyle modifications such as eating a low-fat diet and getting more exercise, **hyperlipidemia** is treated with **antilipidemic medications**, which will be discussed in the next section.

Atherosclerosis: This condition begins with injury to the endothelium of an artery, which may be caused by irritation from high blood glucose, infection, tobacco use, excessive blood lipids, and other factors. Injury to the artery walls results in inflammation, and as the inflammation spreads further into the artery wall, it weakens and scars it, making it stiff. Circulating triglycerides and cholesterol can seep between the damaged lining cells and become trapped within the artery wall, where they are joined by leukocytes, calcium, and cellular debris. Eventually, this buildup, called **plaque**, can narrow arteries enough to impair blood flow. The term for this condition, **atherosclerosis**, describes the plaque deposits. See Figure 6.5 for an illustration of atherosclerosis (Betts et al., 2013).

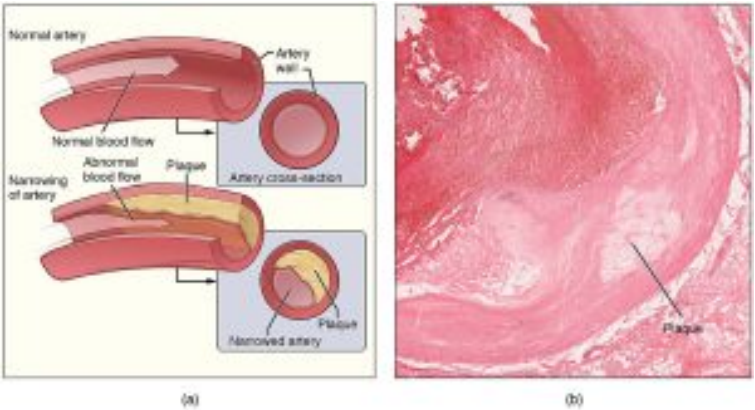


Fig. 6.5

Sometimes a plaque can rupture, causing microscopic tears in the artery wall that allow blood to leak into the tissue on the other side. When this happens, platelets rush to the site to clot the blood. This clot can further obstruct the artery, and if this occurs in a coronary or cerebral artery, it can cause a sudden **heart attack** or **stroke**. Alternatively, plaque can also break off and travel through the bloodstream as an **embolus** until it blocks a more distant, smaller artery.

Even without total blockage, narrowed vessels lead to **ischemia**. Ischemia can lead to **hypoxia**, causing a **myocardial infarction** or **cerebrovascular accident**.

Treatment of atherosclerosis includes lifestyle changes, such as weight loss, smoking cessation, regular exercise, and adoption of a diet low in sodium and saturated fats. Antilipidemic medications are prescribed to reduce cholesterol and help prevent atherosclerosis and will be discussed in more detail in the next section.

Coronary artery disease: This condition is the leading cause of death worldwide. It occurs when **atherosclerosis** within the walls of the coronary arteries obstructs blood flow. As the coronary blood vessels become blocked with plaque, the flow of blood to the tissues

is restricted, causing the cardiac cells to receive insufficient amounts of oxygen, which can cause pain called **angina**. Figure 6.6 shows the blockage of coronary arteries highlighted by the injection of dye. Some individuals with coronary artery disease report pain (angina) radiating from the chest, but others, especially women, may remain asymptomatic or have alternative symptoms of neck, jaw, shoulder, upper back, or abdominal pain. If untreated, coronary artery disease can lead to a **myocardial infarction**, or **MI**. Risk factors include smoking, family history of coronary artery disease, **hypertension**, obesity, diabetes, lack of exercise, stress, and **hyperlipidemia**. Treatment may include medication, changes to diet, exercise, a coronary angioplasty with a balloon catheter, insertion of a stent, or a coronary bypass procedure (Betts et al., 2013).

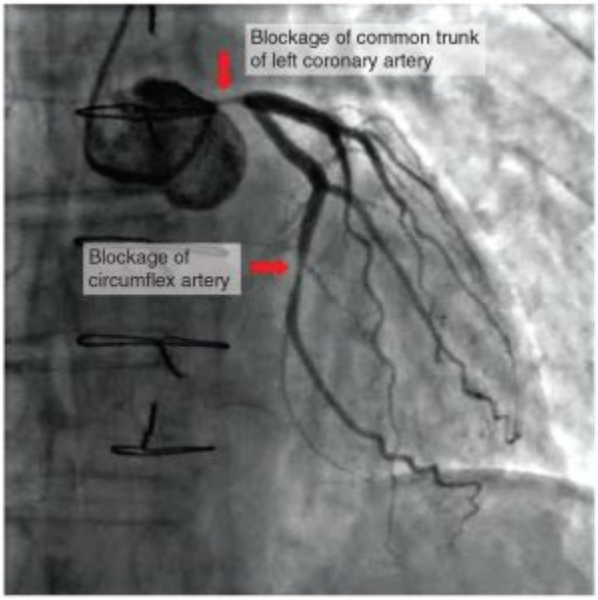


Fig. 6.6

Myocardial infarction (MI): This pathology is commonly referred to as a **heart attack** and results from lack of blood flow and oxygen to a region of the heart, causing the death of cardiac muscle cells. An MI often occurs when a coronary artery is blocked by the buildup of atherosclerotic plaque and becomes a **thrombus** or when a portion of an unstable atherosclerotic plaque travels through the coronary arterial system and lodges in one of the smaller vessels.

In the case of an acute MI, there is often sudden pain, called **angina**, beneath the sternum (**retrosternal pain**), which often radiates down the left arm in male patients (see Fig. 6.7), but does not commonly do so in female patients. In addition, patients typically present with difficulty breathing and **dyspnea**, irregular heartbeat (**palpitations**), nausea and vomiting, **diaphoresis**, anxiety, and **syncope**, though not all of these symptoms may be present. Many of the symptoms are shared with other medical conditions, including anxiety attacks and simple indigestion, so accurate diagnosis is critical for patient survival.

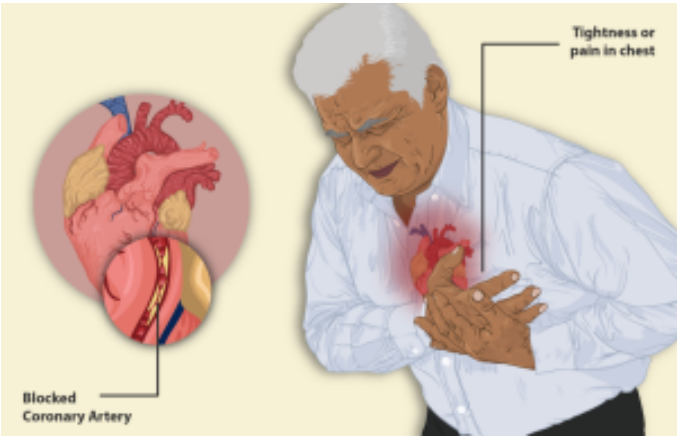


Fig. 6.7

An MI can be confirmed by examining the patient's **ECG**, which frequently reveals alterations in the ST and Q components. Immediate treatment for an MI is required and includes administering supplemental oxygen, aspirin, and nitroglycerin, which will be discussed further in the next section. Longer-term treatments may include injections of thrombolytic agents, such as tPA, that dissolve the clot, along with the anticoagulant heparin, a balloon angioplasty with stents to open blocked vessels, or bypass surgery to allow blood to pass around the site of the blockage (Betts et al., 2013).

The following video is an overview of coronary artery disease and what happens during a myocardial infarction.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=2001#oembed-2

(FreeMedEducation, 2021)

Cerebrovascular accident (CVA): A CVA results when there is lack of blood flow to part or all of the brain. The internal carotid arteries, along with the vertebral arteries, are the two primary suppliers of blood to the human brain. Given the central role and vital importance of the brain to life, it is critical that blood supply to this organ remains uninterrupted. However, blood flow may become obstructed because of **atherosclerosis** or an **embolus** that has travelled from elsewhere in the bloodstream. For example, an **arrhythmia** called **atrial fibrillation** can cause clots to form in the heart that then move to the brain. When blood flow is interrupted, even for just a few seconds, a **transient ischemic attack (TIA)**

occurs, resulting in loss of consciousness or temporary loss of neurological function. Loss of blood flow for longer periods produces irreversible brain damage or a **stroke**, also called a **cerebrovascular accident** (Betts et al., 2013).

There are two types of cerebrovascular accidents: **ischemic** and **hemorrhagic**. **Ischemic strokes** are caused by atherosclerosis or a blood clot that blocks the flow of blood to the brain (see Figure 6.8). Eighty percent of strokes are ischemic. **Hemorrhagic strokes** are caused by a blood vessel that ruptures and bleeds into the brain. Risk factors for a stroke include smoking, high blood pressure, and cardiac arrhythmias. Treatment of a stroke depends on the cause (Betts et al., 2013). Ischemic strokes are treated with thrombolytic medication such as tPA to dissolve the clot, whereas hemorrhagic strokes often require surgery to stop the bleeding.

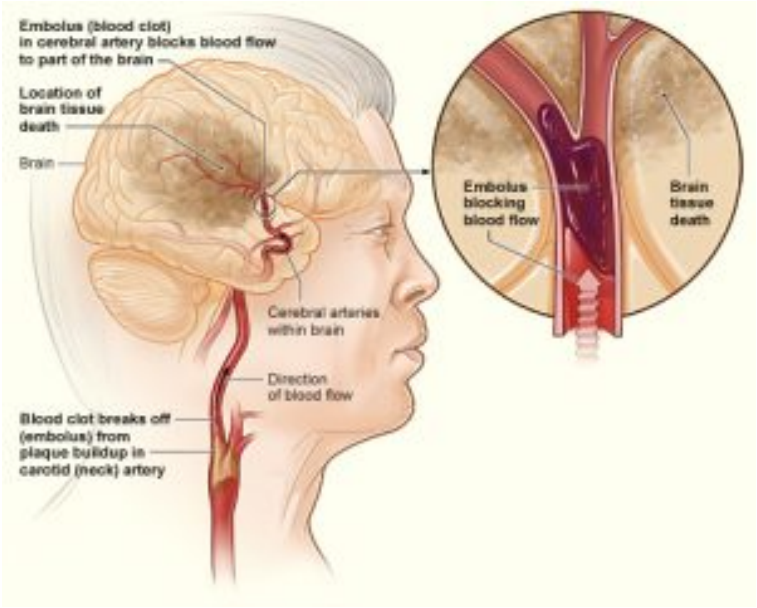


Fig. 6.8

Key Concept

The mnemonic **FAST** helps people remember what to look for when someone is dealing with a sudden loss of neurological function (Betts et al., 2013). If someone complains of feeling "funny," check these things quickly:

- Look at the person's face. Do they have problems moving **F**ace muscles and making regular facial expressions?
- Ask the person to raise their **A**rms above their head. Can the person lift one arm but not the other?
- Has the person's **S**peech changed? Are they slurring words or having trouble saying things?
- If any of these things have happened, then it is **T**ime to call for help.

(Betts et al., 2013)

Arrhythmias: Occasionally, an area of the heart other than the **SA node** will initiate an impulse that is followed by a premature contraction; such an area is known as an **ectopic focus**. An ectopic focus may be stimulated by localized ischemia, exposure to certain drugs, elevated stimulation by both sympathetic or parasympathetic divisions of the autonomic nervous system, or one of several diseases or pathological conditions. Occasional occurrences are generally temporary and are not life-threatening, but if the condition becomes chronic, it may lead to either an **arrhythmia** or **fibrillation**. Severe arrhythmias can lead to a **cardiac arrest**, which is fatal if not treated within a few minutes. Abnormalities that may be detected by ECGs are shown in Figure 6.9.

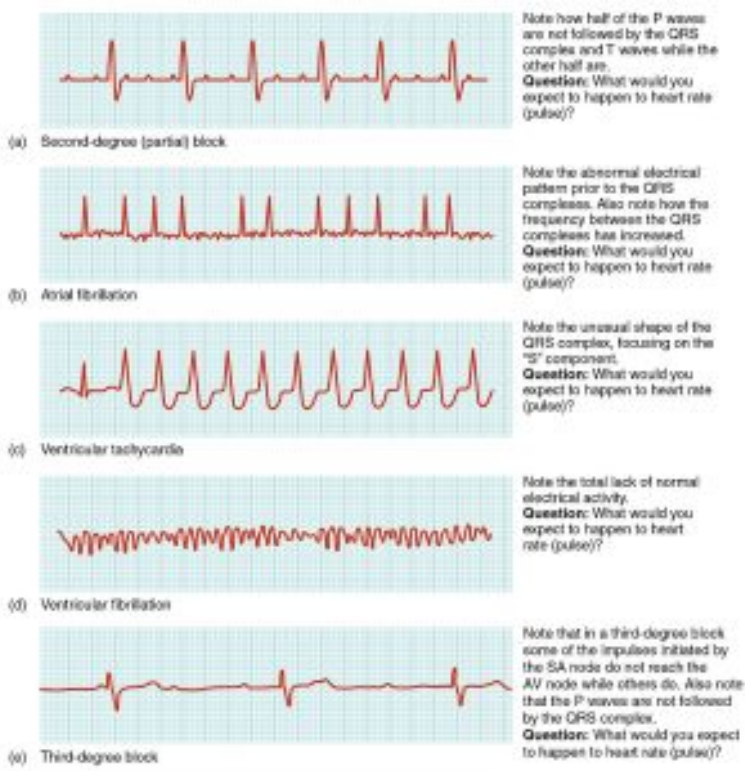


Fig. 6.9

Heart failure or congestive heart failure (CHF): Heart failure is a condition in which the heart can't pump enough blood to meet the body's needs. **Right-sided heart failure** occurs when the heart can't pump enough blood to the lungs to pick up oxygen, whereas **left-side heart failure** occurs when the heart can't pump enough oxygen-rich blood to the rest of the body. Heart failure is a very common condition, but there is no cure. The symptoms can be managed for several years with lifestyle modifications and different types of medications. Causes of heart failure include hypertension,

myocardial infarction, and other cardiac and respiratory diseases. Common symptoms of heart failure include **peripheral edema** and shortness of breath that occur as a result of fluid overload. Many patients are treated with diuretics to manage the symptoms of fluid overload, anti-hypertensive medications to manage blood pressure, and medications to increase the contractility of the heart, which will be discussed in the next section.

References

Alila Medical Media. (2018, February 13). *Hypertension – High blood pressure animation* [Video]. YouTube. https://www.youtube.com/watch?v=JtBtk00EiVM

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

Cleveland Clinic. (2022). *Cholesterol numbers and what they mean.* https://my.clevelandclinic.org/health/articles/11920-cholesterol-numbers-what-do-they-mean

FreeMedEducation. (2021, January 12). *What happens during a*

heart attack? – What is coronary heart disease? [Video]. YouTube. https://youtu.be/xBAvxnT0ZvI

Heart & Stroke Foundation of Canada. (2015). *Get your blood pressure under control*. https://www.heartandstroke.ca/-/media/pdf-files/canada/health-information-catalogue/en-get-your-blood-pressure-under-control-v21-web.ashx?la=en&hash=20493566724F3F87387717A720D49F60521C1CF2

Image Credits (images are listed in order of appearance)

2113ab Atherosclerosis by OpenStax College, CC BY 3.0

2016 Occluded Coronay Arteries by OpenStax College, CC BY 3.0

A man having a Heart Attack by myUpchar, CC BY-SA 4.0

Stroke ischemic by National Heart Lung and Blood Institute (NIH), Public domain

2024 Cardiac Arrhythmias by OpenStax College, CC BY 3.0

6.4 Cardiovascular Medications

Some of the more common cardiovascular system medications are discussed below. They are divided into several categories, with some having subcategories. Many of the medications can treat more than one of the pathologies that were discussed on the previous page, and they are often used in combination for better overall effects. Although medication treatment options are available for many of the pathologies already discussed in this chapter, often a **stepped care approach** is used for conditions such as hypertension and hyperlipidemia. This approach begins with lifestyle changes such as diet and exercise prior to the use of medications as a treatment option (Jakicic et al., 2012).

Diuretic Medications

Diuretics are used to decrease both blood pressure and the symptoms of fluid overload such as **edema**. There are many classifications of diuretics; please refer to Chapter 2, where loop, thiazide, and potassium-sparing diuretics are discussed in more detail.

Diuretics cause **diuresis** by inhibiting sodium and water reabsorption from the kidney tubules. Eliminating excess water decreases blood volume as well as blood pressure. Diuretics are often used in combination with other antihypertensive medications to reduce a patient's blood pressure.

Antihypertensive Medications

Antihypertensive medications are used to treat high blood pressure. There are several categories of these medications, and each category is explained below.

Alpha-2 Agonist Medications

Alpha-2 agonist drugs stimulate the alpha-adrenergic receptors, resulting in **vasodilation** and decreased blood pressure, increased blood flow to the kidneys, and decreased **afterload**. An example of an alpha-2 agonist medication used for hypertension is **clonidine (Catapres)**.

Other medications in this category include the following:

- guanfacine (Tenex)
- methyldopa (Aldomet)

(WebMD, 2023)

Beta-1 Antagonist (Beta-Blocker) Medications

Beta-1 antagonists medications, also known as **beta-blockers**, primarily block the beta-1 receptors in the heart, decreasing heart rate and blood pressure by dilating blood vessels (Heart and Stroke Foundation of Canada, 2023a). Medications in this category are commonly used to treat high blood pressure, chest pain caused by poor blood flow to the heart, and several heart conditions involving an abnormally fast heart rate.

Beta-1 antagonists are used as an early intervention during a **myocardial infarction** to reduce the workload on the heart. Before

administering this type of medication, it is always important to check the patient's pulse to ensure it is over 60 bpm.

The following is a list of common beta-1 antagonist medications:

- acebutolol (Sectral)
- atenolol (Tenormin)
- bisoprolol (Monocor)
- carvedilol (Coreg)
- metoprolol (Lopressor) (Figs. 6.10 and 6.11)
- propranolol (Inderal)
- timolol (Blocadren)

(Heart and Stroke Foundation of Canada, 2023)

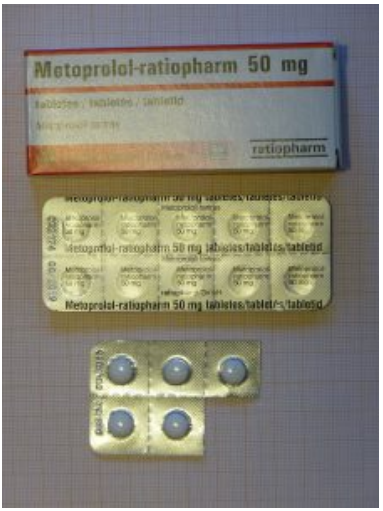


Fig. 6.10

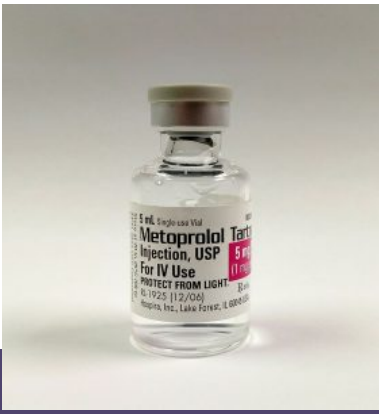


Fig. 6.11

Key Concept

A common **suffix** with generic **beta-1 antagonist** medications is **-olol**.

Examples: acebutolol (Sectral), metoprolol (Lopressor)

Angiotensin Converting Enzyme (ACE) Inhibitors

Angiotensin converting enzyme (ACE) inhibitors block the conversion of angiotensin I to angiotensin II in the **renin-angiotensin-aldosterone system (RAAS)**. This results in **vasodilation** and sodium and water excretion by blocking aldosterone, which in turn leads to lower blood pressure and decreased fluid volume. Medications in this category are used to treat hypertension and heart failure.

The following is a list of common ACE inhibitor medications:

- benazepril (Lotensin)
- captopril (Capoten)

- cilazapril (Inhibace)
- enalapril (Vasotec)
- fosinopril (Monopril)
- lisinopril (Zestril)
- perindopril (Coversyl)
- quinapril (Accupril)
- ramipril (Altace) (Fig. 6.12)
- trandolapril (Mavik)

Fig. 6.12

(Heart and Stroke Foundation, 2023b)

Key Concept

A common **suffix** seen with **angiotensin converting enzyme (ACE) inhibitors** is **-pril**.

Examples: captopril (Capoten), ramipril (Altace)

Angiotensin II Receptor Blockers (ARBs)

Angiotensin II receptor blockers are often referred to as **ARBs**. They are similar to ACE inhibitors in that they act on the **renin-angiotensin-aldosterone system (RAAS)**. However, the difference is that they block angiotensin II and cause **vasodilation** and decreased peripheral resistance, which in turn lowers blood pressure. Medications in this category are used to treat hypertension and prevent heart attack, stroke, and heart failure (Cleveland Clinic, 2022).

Examples of angiotensin II receptor blocker medications:

- candesartan (Atacand)
- irbesartan (Avapro)
- losartan (Cozaar)
- telmisartan (Micardis)
- valsartan (Diovan)

(Cleveland Clinic, 2022)

Key Concept

A common **suffix** seen with generic **angiotensin II receptor blockers (ARBs)** is **-sartan**.

Examples: telmisartan (Micardis), losartan (Cozaar)

Calcium Channel Blockers

Calcium channel blockers increase the refractory period of the AV node by slowing the influx of calcium ions, which decreases the ventricular response and decreases the heart rate. This results in relaxation of the smooth muscle and **vasodilation**, which lowers blood pressure. These medications can also be used to control heart rate associated with **supraventricular tachycardias**.

The following is a list of commonly used calcium channel blockers:

- amlodipine (Norvasc)
- diltiazem (Cardiazem)
- felodipine (Plendil)

- nifedipine XL (Adalat XL)
- verapamil (Isoptin)

(Heart and Stroke Foundation of Canada, 2023c)

Key Concept

A common **suffix** with generic **calcium channel blockers** is **-dipine**.

Example: felodipine (Plendil), amlodipine (Norvasc)

Combination Drugs for Hypertension

Diuretics are often used in combination with other antihypertensive agents to reduce a patient's blood pressure. Most of the medications listed above can be combined with a diuretic. **Hydrochlorothiazide** (Fig. 6.13) is a common thiazide diuretic used in combination with some of the above antihypertensives. It is often abbreviated as **HCT** in the name of the medication.

The following is a list of common combination medications used in the treatment of hypertension:

- Accuretic (contains quinapril and hydrochlorothiazide)
- Diovan HCT (contains valsartan and hydrochlorothiazide)
- Inderide LA (contains hydrochlorothiazide and propranolol)
- Dutoprol (contains metoprolol and hydrochlorothiazide)

(MedlinePlus, 2021)

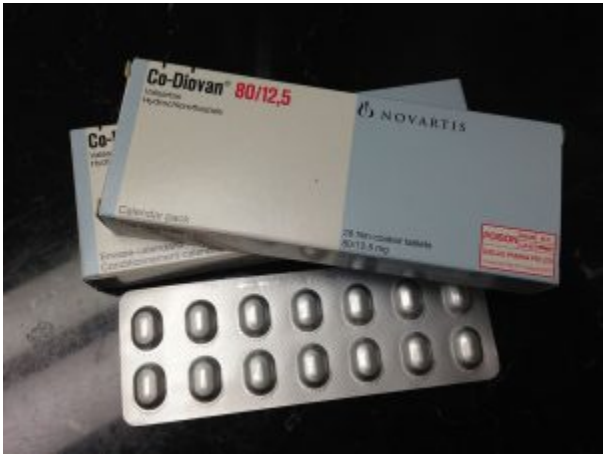


Fig. 6.13

The video below discusses the different categories of antihypertensives.

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=2003#oembed-1*

(Dr Matt & Dr Mike, 2019)

Antiarrhythmics

Antiarrhythmic medications regulate heart rate and rhythm by manipulating the conduction of electrical signals to change the heart rate or to attempt to revert an arrhythmia to a normal sinus rhythm. All antiarrhythmic medications have a risk of producing an **arrhythmia**. Some antiarrhythmic medications are used during emergency situations such as cardiac arrest, whereas others are used long term, such as those used to control **atrial fibrillation**. Monitoring electrolytes and ECG patterns are very important assessments that may need to be performed on patients taking these medications. This medication category is divided into classes, which are listed and described below.

Class I – Sodium Channel Blockers

Class I medications are **sodium channel blockers** and slow conduction and prolong depolarization by decreasing sodium influx into cardiac cells. **Quinidine** is an example of this class of medication. This medication is typically used for life-threatening **ventricular dysrhythmias** such as ventricular tachycardia or for the conversion of atrial fibrillation that has not responded to other therapy.

The following is a list of sodium channel blocker medications:

- lidocaine (Xylocaine)
- flecainide acetate (Tambocor)
- quinidine

(WebMD, 2023)

Class II – Beta-Blockers

Class II medications are **beta-blockers** and are used to decrease conduction velocity, automaticity, and the refractory period of the cardiac conduction cycle. **Betapace** (**Sotalol**) is a beta-1 and beta-2 blocker that also has Class III antiarrhythmic properties. Recall that other types of beta-blockers, such as **metoprolol (Lopressor)**, are also used to treat hypertension. Sotalol is given to patients for life-threatening arrhythmias, including ventricular arrhythmias or supraventricular arrhythmias.

Class III – Potassium Channel Blockers

Class III medications, **potassium channel blockers**, prolong repolarization by blocking the potassium channels in the cardiac cells that are responsible for repolarization. They are used for emergency treatment of **ventricular dysrhythmias** that have not responded to other available antiarrhythmics or when alternative agents could not be tolerated. **Amiodarone (Cordarone**) is an example of a medication with Class III properties.

Class IV – Calcium Channel Blockers

Class IV medications, **calcium channel blockers**, include **verapamil (Isoptin)** and **diltiazem (Cardiazem)** (Heart and Stroke Foundation of Canada, 2023c). These medications increase the refractory period of the AV node by slowing the influx of calcium ions, thus decreasing the ventricular response and decreasing the heart rate. These medications may be used to control heart rate associated with **supraventricular tachycardias**. Calcium channel blockers are also used to treat hypertension because they relax smooth muscle and cause vasodilation, as noted earlier in this section.

Adenosine

Adenosine is a unique medication given to patients who are experiencing **paroxysmal supraventricular tachycardia**. It is given in a single dose as a bolus to slow electrical conduction and restore a normal sinus rhythm. It is an emergent type of medication.

Cardiac Glycosides

Digoxin (Lanoxin) is a **cardiac glycoside** medication that has been used for centuries to treat heart failure. It can be taken orally and intravenously (Figs. 1.14 and 6.15) (WebMD, 2023). It has three effects on heart muscle: positive inotropic action (increases contractility and stroke volume to increase cardiac output), negative chronotropic action (decreases heart rate), and negative dromotropic action (decreases the conduction of cardiac cells) (McCuistion et al., 2018). Digoxin is used to treat heart failure and atrial fibrillation, but it is being used less often because of the risk of toxicity, bradycardia, nausea, vomiting, visual changes, and arrhythmias.

Fig. 6.14

Fig. 6.15

Antianginal Medications – Nitrates

Antianginal medications are used to treat **angina pectoris**. **Angina** is chest pain caused by inadequate blood flow, resulting in **hypoxia** of the cardiac tissue. It can be chronic pain caused by **atherosclerosis** in **coronary artery disease** or acute pain caused by a **myocardial infarction**.

Antianginals increase blood flow to the heart or decrease oxygen demand by the heart. **Nitrates** promote **vasodilation** of the coronary arteries and veins. Beta-blockers and calcium channel blockers are also used to decrease the workload of the heart and decrease oxygen demands.

Nitrates can be administered in a variety of routes, such as **sublingual**, extended-release tablets, creams, transdermal patches, and intravenously (Fig. 6.16). Sublingual tablets are prescribed **PRN** for patients who are experiencing chronic, stable angina caused by coronary artery disease.

An example of a nitrate medication is **nitroglycerin (Nitro-Bid)**.

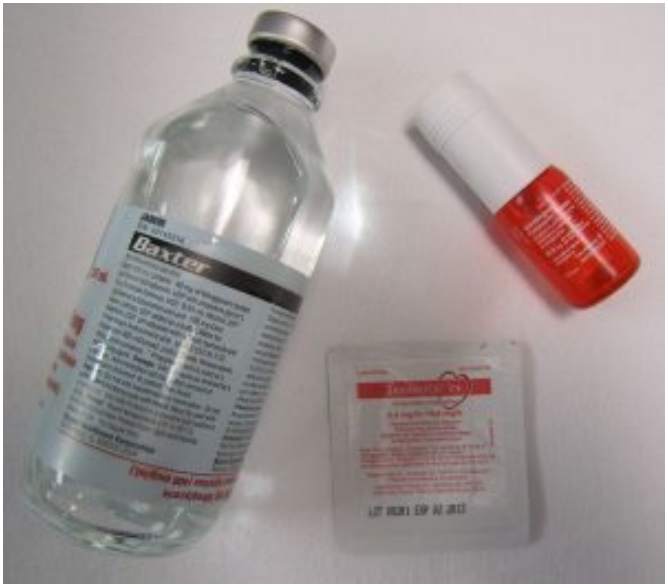


Fig. 6.16

Antilipidemic Medications

HMG-CoA Reductase Inhibitors

Antilipidemic agents reduce **hyperlipidemia** that may lead to additional health problems such as stroke, myocardial infarction, angina, and heart failure. Medications in this category inhibit HMG-CoA reductase and cholesterol synthesis, which reduces LDL (low-density lipoprotein) cholesterol. These medications should be used together with a healthy diet and exercise regime.

The following is a list of common HMG-CoA reductase inhibitors:

- atorvastatin (Lipitor)

- fluvastatin (Lescol)
- pravastatin (Lipostat)
- rosuvastatin (Crestor)
- simvastatin (Zocor)

(WebMD, 2023)

Key Concept

A common **suffix** with generic **HMG-CoA reductase inhibitors** is **-statin**.

Example: atorvastatin (Lipitor), rosuvastatin (Crestor)

Medications in this category are often referred to as **statins** (Mayo Clinic, 2022).

Selective Cholesterol Absorption Inhibitors

Medications in this category are used to treat **hyperlipidemia** and familial hypercholesterolemia. **Ezetimibe (Zetia)** is an example of a medication in this category. It works by blocking the absorption of cholesterol in the small intestines to reduce LDL (WebMD, 2023).

Blood Coagulation Modifiers

Blood coagulation modifiers affect blood coagulation and include

several types of medications such as anticoagulants, antiplatelets, and thrombolytics, as well as their associated reversal agents. Medications in this category are used to treat such pathologies as deep venous thromboembolism (DVT), **pulmonary embolism**, and acute myocardial infarction. The next chapter on the hematological system and medications will discuss this medication category in detail.

Table 6.1. Common Cardiovascular System Medications

Generic Name	Trade Name	Reason for Administering
clonidine	Catapres	hypertension
guanfacine	Tenex	hypertension
methyldopa	Aldomet	hypertension
acebutolol	Sectral	hypertension, myocardial infarction
atenolol	Tenormin	hypertension, myocardial infarction
bisoprolol	Monocor	hypertension, myocardial infarction
carvedilol	Coreg	hypertension, myocardial infarction
metoprolol	Lopressor	hypertension, myocardial infarction
propranolol	Inderal	hypertension, myocardial infarction
timolol	Blocadren	hypertension, myocardial infarction
benazepril	Lotensin	hypertension, heart failure
captopril	Capoten	hypertension, heart failure
cilazapril	Inhibace	hypertension, heart failure
enalapril	Vasotec	hypertension, heart failure
fosinopril	Monopril	hypertension, heart failure
lisinopril	Zestril	hypertension, heart failure
perindopril	Coversyl	hypertension, heart failure
quinapril	Accupril	hypertension, heart failure
ramipril	Altace	hypertension, heart failure
trandolapril	Mavik	hypertension, heart failure
losartan	Cozaar	hypertension, prevention of heart attack, stroke, and heart failure
valsartan	Diovan	hypertension, prevention of heart attack, stroke, and heart failure

candesartan	Atacand	hypertension, prevention of heart attack, stroke, and heart failure
irbesartan	Avapro	hypertension, prevention of heart attack, stroke, and heart failure
telmisartan	Micardis	hypertension, prevention of heart attack, stroke, and heart failure
amlodipine	Norvasc	hypertension
felodipine	Plendil	hypertension
nifedipine XL	Adalat XL	hypertension
quinapril, hydrochlorothiazide	Accuretic	hypertension
valsartan, hydrochlorothiazide	Diovan HCT	hypertension
hydrochlorothiazide, propranolol	Inderide LA	hypertension
metoprolol, hydrochlorothiazide	Dutoprol	hypertension
lidocaine	Xylocaine	arrhythmias
flecainide acetate	Tambocor	arrhythmias
quinidine	no brand name	arrhythmias
betapace	Sotalol	arrhythmias
amiodarone	Cordarone	arrhythmias
adenosine	–	arrhythmias
diltiazem	Cardiazem	hypertension, arrhythmia
verapamil	Isoptin	hypertension, arrhythmia
digoxin	Lanoxin	heart failure, atrial fibrillation
nitroglycerine	Nitro-Bid	angina
atorvastatin	Lipitor	high cholesterol
fluvastatin	Lescol	high cholesterol
pravastatin	Lipostat	high cholesterol
rosuvastatin	Crestor	high cholesterol
simvastatin	Zocor	high cholesterol

ezetimibe	Zetia	high cholesterol

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Cleveland Clinic. (2022). *Angiotensin II receptor blockers* (ARBs). https://my.clevelandclinic.org/health/drugs/23327-angiotensin-ii-receptor-blockers

Dr Matt & Dr Mike. (2019). *Blood pressure drugs | Pharmacology* [Video]. YouTube. https://www.youtube.com/watch?v=Ab57aXNNw34

Heart and Stroke Foundation of Canada. (2023a). *Beta-blockers.* https://www.heartandstroke.ca/heart-disease/treatments/medications/beta-blockers

Heart and Stroke Foundation of Canada. (2023b). *ACE (angiotensin converting enzyme) inhibitors.* https://www.heartandstroke.ca/heart-disease/treatments/medications/angiotensin-converting-enzyme-inhibitors

Heart and Stroke Foundation of Canada. (2023c). *Calcium channel blockers.* https://www.heartandstroke.ca/heart-disease/treatments/medications/calcium-channel-blockers

Jakicic, J. M., Tate, D. F., Lang, W., Davis, K. K., Polzien, K., Rickman,

A. D., Erickson, K., Neiberg, R. H., & Finkelstein, E. A. (2012). Effect of a stepped-care intervention approach on weight loss in adults: A randomized clinical trial. JAMA, 307(24), 2617–2626. https://doi.org/10.1001/jama.2012.6866

Mayo Clinic. (2023). *Statin side effects: Weigh the benefits and risks.* https://www.mayoclinic.org/diseases-conditions/high-blood-cholesterol/in-depth/statin-side-effects/art-20046013#:~:text=Statins%20include%20atorvastatin%20(Lipitor)%2C,of%20heart%20attacks%20and%20strokes

McCuistion, L. E., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. J. (2018). *Pharmacology: A patient-centered nursing process approach* (9th ed., pp. 443–454). Elsevier.

MedlinePlus. (2021). *Hydrochlorothiazide.* https://medlineplus.gov/druginfo/meds/a682571.html

WebMD. (2023). *Drug & medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

Metoprolol-ratiopharm by Dmitry G, Public domain

Metoprolol 1 (cropped) by Mark Oniffrey, CC BY-SA 4.0

Ramipril 1.25 MG Oral Capsule by National Library of Medicine (NLM), Public domain

Two boxes and a blister pack of Co-Diovan (Valsartan and hydrochlorothiazide), Singapore – 20150210 by Smuconlaw, CC BY-SA 4.0

Digoxin 1ml vial yellow background by Wesalius, CC BY 4.0

Digoxin 0,125 mg tbl by Tomino de WS, CC BY-SA 4.0

Nitro by James Heilman, MD, CC BY-SA 3.0

6.5 Review

Review of the Cardiovascular System

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=2134#h5p-40

Review of Cardiovascular Pathologies

An interactive H5P element has been excluded from this version of the text. You can view it

online here:
https://openeducationalberta.ca/medicalterminologyii/?p=2134#h5p-41

Review of Cardiovascular Medications

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://openeducationalberta.ca/medicalterminologyii/?p=2134#h5p-42

Brand and Generic Name Drug Review

An interactive H5P element has been excluded from

this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=2134#h5p-43

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

CHAPTER VII

HEMATOLOGICAL SYSTEM AND MEDICATIONS

7.1 Introduction to the Hematological System and Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Define the key terms for this system, such as "anticoagulant medications"
2. Identify what type of patients would most likely benefit from anticoagulant medications
3. Describe heparin and low-molecular-weight heparin (LMWH) and their usual measurements
4. Identify the most common LMWH medications
5. Describe the drug warfarin and the reasons why patients would take this medication
6. Identify common antiplatelet medications
7. Identify which patients would take aspirin on a routine basis

8. Define anemia and other common pathologies seen within this system

9. Identify the most common medications used to treat anemia

Chapter Overview

The **hematological system** consists of blood and bone marrow, and even though it is a lesser-known system, it is nonetheless very important. A thorough explanation of the system and its components will be provided to lay the foundation for the discussion of common pathologies and medications used to treat them. A basic explanation of medication categories and mechanisms of action within the body will be discussed. Common medication names, both trade and generic, will be listed to help you understand the topic. Although there are not many medication categories in this chapter, they are all important. It is imperative that you are familiar with these medications because all of them are common in the hospital and many are used in the community as well.

College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

7.2 The Hematological System

The hematological system consists of blood and bone marrow, which is involved in the production of new red blood cells through a process referred to as **hematopoiesis** (Betts et al., 2013). Blood is technically considered a connective tissue and is made up of a mix of cellular elements within an extracellular matrix. The cellular elements include **red blood cells (RBCs)**, **white blood cells (WBCs)**, and cell fragments called **platelets** (Betts et al., 2013). The extracellular matrix, which is called **plasma**, makes blood unique compared to other connective tissues because it is fluid. This fluid, which is mostly water, suspends the formed elements and enables them to circulate throughout the body (Betts et al., 2013). Watch the video below as an introduction to the topic of blood and how it works within the human body.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=74#oembed-1

(CrashCourse, 2015)

Functions of Blood

The primary function of blood is to deliver oxygen and nutrients and

then remove wastes from body cells (Betts et al., 2013). However, blood performs other functions in the body, including defence, distribution of heat, and maintenance of **homeostasis**.

Transportation

Blood transports many different substances throughout the body on an ongoing basis. The nutrients from the foods that are eaten are absorbed in the digestive tract and then travel in the bloodstream directly to the liver (Betts et al., 2013). Once there, they are processed and released back into the bloodstream for delivery to body cells. In the lungs, oxygen from the air you breathe diffuses into the blood, then moves from the lungs to the heart, which pumps it to the rest of the body. Endocrine glands scattered throughout the body release their products, called hormones, into the bloodstream, which then carries them to distant target cells (Betts et al., 2013). Blood also picks up cellular wastes and byproducts, and transports them to various organs for removal. For instance, blood moves carbon dioxide to the lungs for exhalation from the body, and various waste products are transported to the kidneys and liver to be excreted in the form of urine or bile (Betts et al., 2013).

Defence

Many types of white blood cells (WBCs) protect the body from external threats, such as bacteria that can enter the bloodstream from a wound. Some types of WBCs seek out and destroy internal threats, such as cells with mutated DNA that could multiply to become cancerous, or even body cells infected with viruses (Betts et al., 2013).

When damage to the vessels results in bleeding, blood platelets

and certain proteins dissolved in the plasma, the fluid portion of the blood, interact to block the ruptured areas of the blood vessels involved (Betts et al., 2013). This protects the body from further blood loss or hemorrhage.

Maintenance of Homeostasis

Blood is also involved in regulating body temperature. For example, if you were exercising on a warm day, your rising core body temperature would trigger several **homeostatic** mechanisms, including increased transport of blood from the core to the extremities, which are typically cooler (Betts et al., 2013). As blood passes through the vessels of the skin, heat would be released to the environment, and the blood returning to the body core would be lower in temperature. In comparison, on a cold day, blood is diverted away from the skin in order to maintain a warmer body core (Betts et al., 2013).

Blood also helps to maintain the chemical balance of the body. Proteins and other compounds in the blood act as buffers, helping to regulate the pH of body tissues. Blood also helps regulate the water content of body cells (Betts et al., 2013).

Composition of Blood

Blood is made up of three main components: **hematocrit**, a **buffy coat**, and **plasma** (Betts et al., 2013). Within the body, these three components are mixed together and work collaboratively to perform all the functions that blood needs to accomplish. When a blood sample is analyzed, these three components are generally separated as shown in the image below. **Hematocrit** consists of red blood cells (also called **erythrocytes**) and generally amounts to approximately 45% of a given blood sample. This percentage varies

for males and females; for females, the percentage is generally between 37% to 40%, and for males, it is approximately 42% to 52%. There is also a pale, thin layer composed of the remaining formed elements of blood, which include white blood cells, platelets, and thrombocytes (Betts et al., 2013). This layer is referred to as the **buffy coat** because of its colour, and it normally constitutes less than 1% of a blood sample. Above the buffy coat in the test tube is the blood **plasma**, which is normally a pale, straw-coloured fluid and constitutes the remainder of the sample (Betts et al., 2013). Fig. 7.1 provides a breakdown of the blood components found in the body and in a given sample.

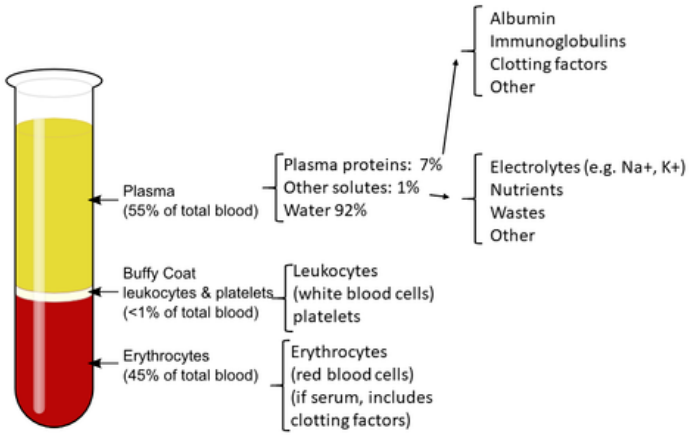


Fig. 7.1

Characteristics of Blood

Often when someone thinks about blood, the first characteristic

that comes to mind is its colour. Blood that has just taken up oxygen in the lungs is bright red, and blood that has released oxygen to the tissues is a more dusky red. This is because the **hemoglobin** in the blood is a pigment that changes colour depending on the degree of oxygen saturation (Betts et al., 2013).

Blood is **viscous** and somewhat sticky to the touch. Its viscosity is approximately five times greater than that of water. Viscosity is a measure of a fluid's thickness or resistance to flow and is influenced by the presence of the plasma proteins and formed elements within the blood (Betts et al., 2013). The viscosity of blood has a dramatic impact on blood pressure and flow. Consider the difference in flow between water and honey. The more viscous honey has a greater resistance to flow than the less viscous water (Betts et al., 2013).

The normal temperature of blood is slightly higher than normal body temperature and is usually about 38°C (or 100.4°F), compared to 37°C (or 98.6°F) for an internal body temperature reading (Betts et al., 2013). Although the surface of blood vessels is relatively smooth as blood flows through them, the blood experiences some friction and resistance, especially as vessels age and lose their elasticity, which then produces heat (Betts et al., 2013).

Blood Clots and Other Key Terms

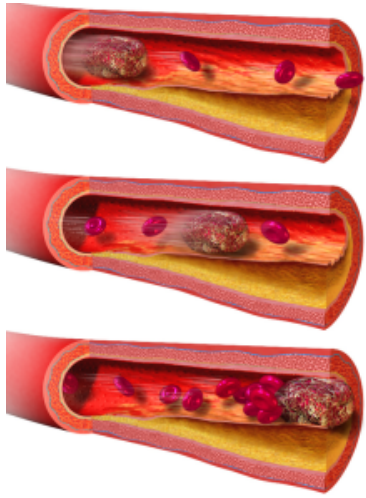


Fig. 7.2

Blood clots can form in the body in response to damage and help the body control bleeding both internally and externally. **Thrombus** is the term for a blood clot that forms in a vein or artery. **Thrombi** (the plural form of "thrombus") are commonly caused by damage to a blood vessel, which then activates the clotting process within that vessel. Often the terms "blood clot" and "thrombus" are used interchangeably, with the main difference being the location of origin. A blood clot, or thrombus, is generally made up of a collection of platelets, red blood cells, and white blood cells that are kept together by a substance called **fibrin**.

An **embolus** is a thrombus, or blood clot, that breaks off and moves through the blood vessels until it reaches a vessel that is so small it becomes stuck. When this happens, blood flow is stopped beyond that area. Fig. 7.2 shows how an embolus may travel through a vessel until it ultimately becomes trapped and blocks blood from travelling beyond that site.

The formation of a thrombus, or blood clot, can be called **coagulation**, which is the process of a liquid, in this case blood, changing to a solid or semi-solid state. The process is sometimes seen as a cascade because one event prompts the next in this complex and sequential process.

Coagulation Cascade

The **coagulation cascade** is a complex process the body goes through in order for a blood clot to form. This process can begin through either intrinsic or extrinsic pathways, which simply means it can begin through an injury (extrinsic) or as a result of internal damage to a cell wall (intrinsic) (Betts et al., 2013). Once it begins, the cascade involves the activation of a series of clotting factors (Factors I–VIII) that are required for a clot to ultimately be formed. Clotting factors are proteins involved in the clotting process and are secreted mainly by the liver. Vitamin K, biotin, folate, and calcium are heavily involved and are required by the liver to produce these clotting factors (Betts et al., 2013). Fig. 7.3 below provides a very detailed illustration of the process the body goes through and the factors that play a role in the process.

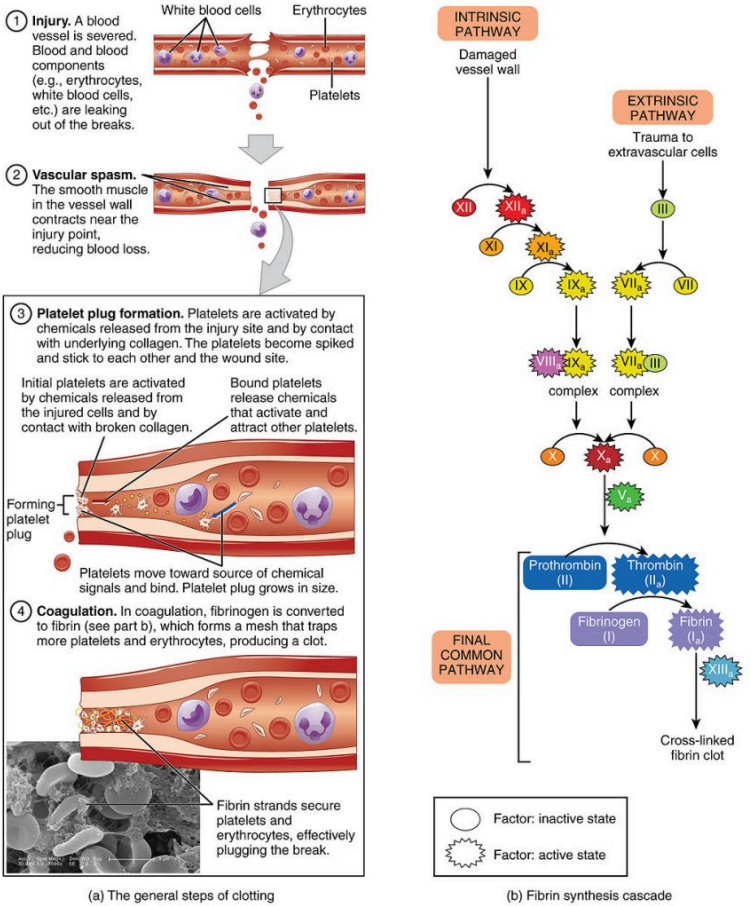


Fig. 7.3

Another key concept to understand is the role of**anticoagulants**, which are substances that oppose coagulation. Your body naturally has several circulating plasma anticoagulants that limit the coagulation process at the region of injury and restore a normal, clot-free condition of blood. Anticoagulant medications work in various ways; however, they often involve inhibiting the clotting factors in the blood or inhibiting the formation of clotting factors in

the liver, which requires vitamin K. They can also prevent platelets from adhering to the site of an injury and from clumping together to begin to form a clot. Finally, anticoagulants can also decrease the viscosity of the blood and increase red blood cell flexibility so as to increase blood flow.

Another class of drugs is known as **thrombolytic** agents, and these are used, not to prevent a clot, but rather to dissolve an unwanted clot. Thrombolytic agents are given to a patient within a few hours after a cerebrovascular accident (stroke) or myocardial infarction (heart attack) to dissolve the clot and improve the patient's prognosis.

Did you know?

According to the Institute for Safe Medication Practices (ISMP) 2016 *Annual Report*, there is a high risk of acute injuries for patients taking anticoagulants outside the hospital setting. Anticoagulants are commonly used by the geriatric population to reduce the risk of ischemic stroke. An estimated 3.8 million people took oral anticoagulants in 2016 (Institute for Safe Medication Practices, 2017). Centers for Disease Control data show that adverse effects of oral anticoagulants account for more emergency department visits than any other class of drugs. Adverse effects range from gastrointestinal bleeding to cerebral hemorrhages and resulted in over 3,000 deaths in 2016 (Institute for Safe Medication Practices, 2017).

Diagnostic Lab Tests

It is always important to evaluate a patient's response to a medication, and this is especially true with **anticoagulants**. Often, laboratory tests are ordered to ensure that the patient's blood is clotting as it should. If it is clotting too much, then the patient is at risk for a blood clot, or embolus, and if it is not clotting enough, then the patient is at risk of hemorrhage. Many anticoagulant medications also require regular dose adjustments to produce the desired effect. For example, intravenous heparin is often administered according to a protocol that requires dose adjustment based on **partial thromboplastin time** (PTT) lab results to achieve a therapeutic range and avoid overdosing, which can result in a life-threatening hemorrhage.

Many patients outside the hospital setting may take anticoagulant medications such as warfarin to prevent blood clots. Warfarin requires regular laboratory monitoring and dose adjustments based on **prothrombin time** (PT) and **international normalized ratio** (INR) lab results. All of these lab tests involve some manner of assessing the effectiveness of clotting factors in a sample of serum.

References

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

CrashCourse. (2015, August 3). *Blood, part 1 – True blood: Crash Course anatomy & physiology #29* [Video]. YouTube. https://www.youtube.com/watch?v=HQWlcSp9Sls

Institute for Safe Medication Practices (ISMP). (2017, July 27). *QuarterWatch™ (2016 Annual Report) part II: Oral anticoagulants—The nation's top risk of acute injury from drugs*. https://www.ismp.org/resources/quarterwatchtm-2016-annual-report-part-ii-oral-anticoagulants-nations-top-risk-acute

Image Credits (images are listed in order of appearance)

Components_of_blood by Alan Sved, CC BY-SA 4.0

Blausen_0089_BloodClot_Motion by BruceBlaus, CC BY 3.0

1909_Blood_Clotting by OpenStax College, CC BY 3.0

7.3 Hematological Pathologies

There are a number of pathologies that can affect the hematological system; the more common ones will be discussed below. Many of these pathologies can be treated with medications that will be discussed later in this chapter.

Common Pathologies

Anemia: This is a deficiency in the number of red blood cells (RBCs) or hemoglobin. There are more than 400 types of anemia, but the condition can be broken down into three major groups: anemia caused by blood loss, anemia caused by faulty or decreased red blood cell production, and anemia caused by excessive destruction of red blood cells. The signs and symptoms of anemia include fatigue, lethargy, and an increased risk for infection. The resulting oxygen deficit in the brain impairs the patient's ability to think clearly and may prompt headaches and irritability. The patient may also become short of breath because of lack of oxygen, and the heart and lungs must work harder in response to the deficit.

Key Concept

The following is a list of some common types of anemia:

- **Aplastic anemia:** A condition in which the body does not produce enough red blood cells
- **Thalassemia:** An inherited disorder in which the body does not produce enough hemoglobin
- **Sickle cell anemia:** An inherited disorder in which the red blood cells are crescent-shaped rather than round
- **Vitamin deficiency anemia** or **pernicious anemia:** A condition in which the body lacks vitamin B12, which is required to produce red blood cells
- **Iron-deficiency anemia:** A condition in which the body lacks iron, which is carried on the red blood cells and allows the red blood cells to carry oxygen
- **Hemolytic anemia:** A condition that can either be inherited or develop later in life and is caused by the body destroying red blood cells faster than they can be produced

(Mayo Clinic, 2022)

Cerebrovascular accident (CVA): This pathology is often referred to as a **stroke** and results from loss of blood flow to part of the brain; it can result in irreversible damage if not treated right away. There are two types of cerebrovascular accidents: ischemic and hemorrhagic. **Ischemic strokes** are caused by atherosclerosis or a blood clot (embolus) that blocks the flow of blood to the brain. **Hemorrhagic strokes** are caused by a blood vessel that ruptures and then hemorrhages into the brain. Fig. 7.4 provides a list of some of the more common symptoms of a cerebrovascular accident.

Fig. 7.4

Deep vein thrombosis (DVT): This condition can occur when blood in the veins, typically in the legs, remains stationary for long periods, such as during and after surgery. The patient develops a blood clot, often within the calf, which presents with swelling, redness, and pain in the area. The blood clot can then break off and become an embolus, which can then travel throughout the body and cause such conditions as a pulmonary embolus or ischemic stroke. Fig. 7.5 below shows a patient who has a DVT with redness and swelling of the affected limb.

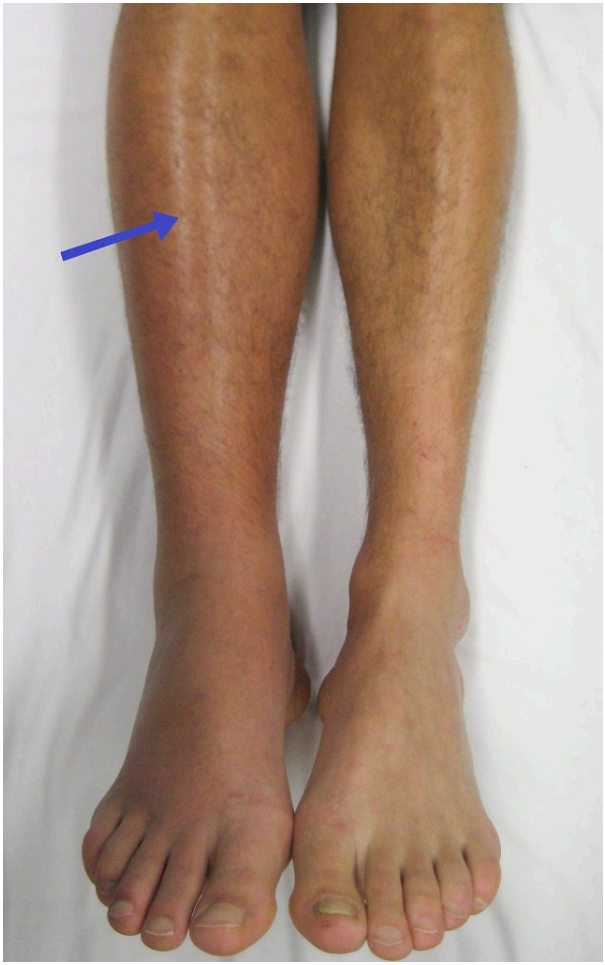


Fig. 7.5

Hemophilia: In this inherited bleeding disorder, the patient is prone to hemorrhage because of a lack of clotting factors. There are differing levels of severity depending on the level of blood clotting factors that the patient has in their blood (UCLA Health, 2022).

Myocardial infarction (MI): This condition was discussed in the

prior chapter and is important for this system because it is often caused by an embolus. As a refresher, an MI results from lack of blood flow and oxygen to a part of the heart, which can then result in the death of cardiac muscle cells. Figure 7.6 is an illustration of how a myocardial infarction can occur and the resulting death of cardiac muscle.

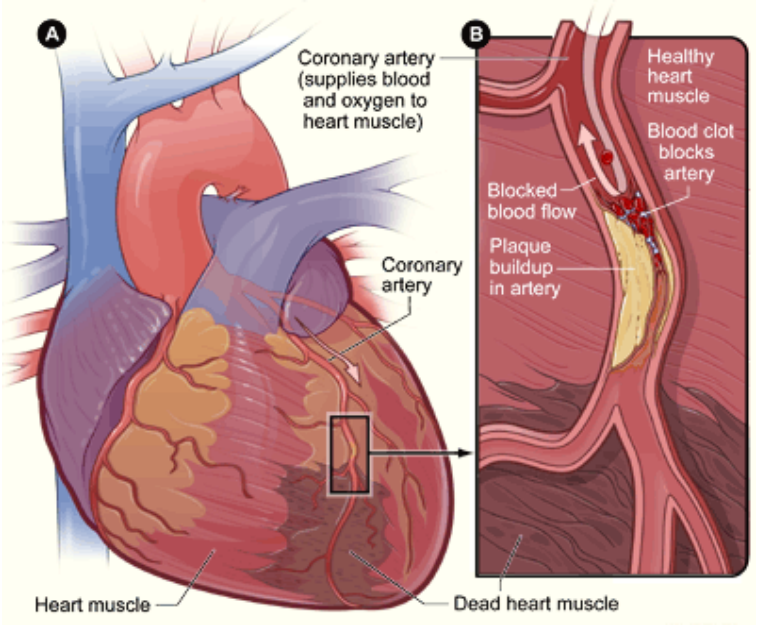


Fig. 7.6

Pulmonary embolus (PE): This occurs when a blood clot, often within the calf, breaks off and becomes an embolus that then travels to the lungs. This is a medical emergency in which the patient becomes immediately short of breath and can result in death if not treated. Fig. 7.7 shows an example of where an embolus may become lodged and prevent circulation to the area distal to that location.

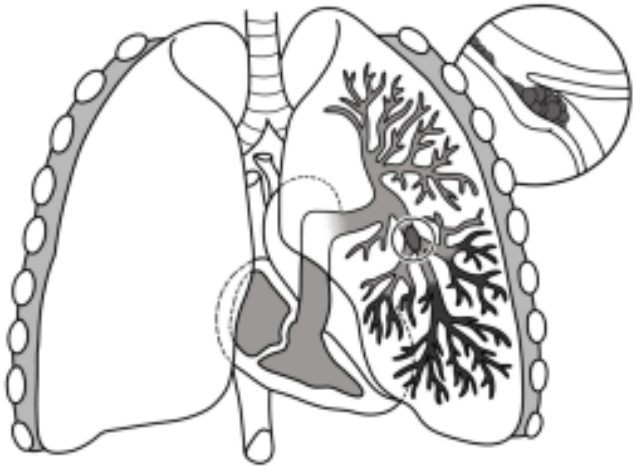


Fig. 7.7

Thrombocytopenia: This condition results from an insufficient number of platelets. Because of this, the blood may not clot properly, resulting in excessive bleeding (Betts et al., 2013).

Thrombocytosis: This disorder occurs when the patient has too many platelets, which may trigger the formation of unwanted blood clots and can be potentially fatal (Betts et al., 2013).

Transient ischemia attack (TIA): A patient may experience a TIA if an embolus moves to the brain. The embolus interrupts blood flow, sometimes for just a few seconds, resulting in loss of consciousness or temporary loss of neurological function. The difference between a TIA and a CVA is that the symptoms of a TIA only last for a short period of time and would likely resolve on their own.

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/ licensed under CC BY 4.0

References

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology licensed under CC BY 4.0

Mayo Clinic. (2022). *Anemia*. https://www.mayoclinic.org/diseases-conditions/anemia/symptoms-causes/syc-20351360

UCLA Health. (2022). *Hemophilia*. https://healthinfo.uclahealth.org/Library/DiseasesConditions/Pediatric/Blood/90,P02313

Image Credits (images are listed in order of appearance)

Signs_of_Stroke_(49948546186) by NIH Image Gallery, Public domain

Deep_vein_thrombosis_of_the_right_leg by James Heilman, CC BY-SA 3.0

Heart_attack-NIH by NIH: National Heart, Lung and Blood Institute, Public domain

Pulmonary-embolism by Baedr-9439, CC0 1.0

7.4 Hematological Medications

Hematological medications are used to treat various forms of the blood disorders that were discussed on the previous page (Mount Sinai, 2022). The medications listed below are some of the more common ones prescribed both in the hospital and in the community for patients with a history of clotting issues or who may be at risk for developing a blood clot. These medications are also often given to patients following an injury or treatment such as surgery, which might increase the patient's chance of a blood clot. Long periods of immobility can also increase the chance of a blood clot developing, so patients may be given some of these medications if they will be spending a long period of time on bedrest, for example.

Heparin Sodium

Heparin sodium was the first anticoagulant developed and can be given either **subcutaneously** or **intravenously**. Heparin inhibits the activated coagulation factor X, which is involved in the clotting cascade. Heparin does not have fibrinolytic activity, so it will not break down existing clots. Only 20% to 30% of the dose exerts a therapeutic effect, which means that the dose must be higher than for other anticoagulants. Heparin is always measured in units and will only be seen measured as such in doctors' orders and prescriptions. Fig. 7.8 below shows a vial of heparin and a syringe that would be used to draw up the medication. Often, heparin comes in a prefilled syringe because this decreases the chance of medication errors.

Fig. 7.8

Intravenous heparin is commonly used to treat deep vein thrombosis (DVT) or a pulmonary embolism (PE). It is also indicated for use during an acute myocardial infarction. Subcutaneous heparin can be administered to prevent DVT or PE caused by atrial fibrillation and post-operatively to reduce the risk of the patient developing a blood clot. Because heparin is a **high-alert medication**, hospitals use several processes for storing and labelling the medication to help prevent errors. These processes can include an independent double-check of all orders and medications before they are given to the patient and having labels on the medication that indicate it is a high-alert medication.

Low-Molecular-Weight Heparin (LMWH)

As indicated by the name, **low-molecular-weight heparin (LMWH)** is related to heparin in that it is created by breaking apart the heparin molecule. Unlike heparin, where only 20% to 30% of the dose has a therapeutic effect, almost the whole dose of LMWH exerts that therapeutic effect. As a result, a lower dose is needed to see the same therapeutic effect as a larger dose of heparin. LMWH also works by inhibiting clotting factor X in the blood. It is always given **subcutaneously** and is measured in either units or milligrams. For example, dalteparin (Fragmin) and tinzaparin (Innohep) are measured in units, and enoxaparin (Lovenox) is measured in milligrams. If a patient is given an overdose of LMWH, protamine sulphate will reverse the effects.

An LMWH is often given for the prevention and treatment of deep vein thrombosis (DVT) and pulmonary embolism (PE). It can also be given to patients post-operatively or to those are hospitalized and at risk for developing a blood clot. In most cases, LMWH comes in a prefilled syringe, as can be seen in Fig. 7.9.

Fig. 7.9

Key Concept

A common **suffix** seen in low-molecular-weight heparin medications is **-parin.**

Examples: dalte**parin** (Fragmin) and enoxa**parin** (Lovenox)

Both heparin and LMWH are often given in the hospital, and if the patient is required to continue on an anticoagulant after they are discharged, they are often switched to an oral form of anticoagulant such as warfarin.

Warfarin

Warfarin (Coumadin) is an oral anticoagulant and is measured in milligrams (mg). It is available in various strengths, and each of these strengths comes in a different colour to help prevent errors when patients self-administer different dosages at home (Fig. 7.10). Close monitoring of **prothrombin time (PT)** or **international normalized ratio (INR)** is required when patients are taking warfarin. It acts by inhibiting the synthesis of vitamin-K-dependent clotting factors, which include factors II, VII, IX, and X, and other anticoagulant proteins.

Patients may take warfarin to prevent and treat venous thrombosis, such as DVT, and pulmonary embolus (PE). Patients with atrial fibrillation may take the medication to prevent blood clots from forming and to reduce the risk of death associated with recurrent myocardial infarctions.

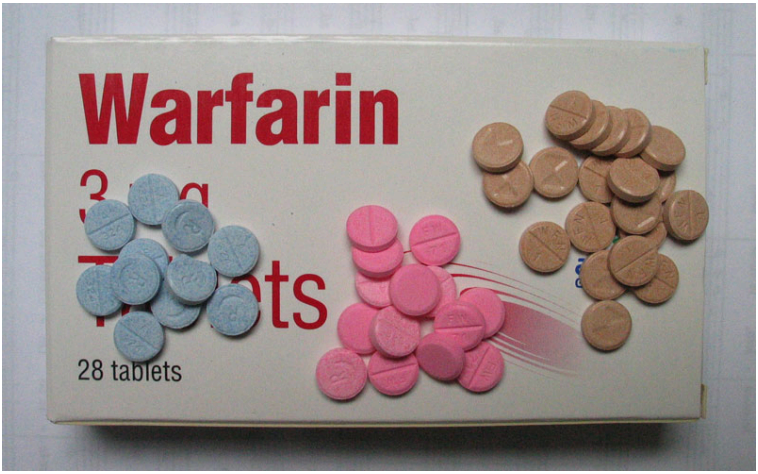


Fig. 7.10

Key Concept

Certain foods and vitamins can either increase or decrease the effects of **warfarin**. For example, vitamin K can produce an effect referred to as **antagonism**, whereby ingesting vitamin K can decrease the effects of the medication. As a result, a patient's risk of blood clots could increase because the effects of warfarin are decreased.

On the other hand, cranberries, garlic, and grapefruit can increase the effects of warfarin. This is known as **synergism** because these foods increase the effects of this particular medication. This could result in an increased risk of

hemorrhage because the patient's blood would not clot when it should.

Platelet Aggregation Inhibitor (Antiplatelet) Drugs

Medications in this category prevent platelets from clumping together (aggregating), adhering to the site of an injury, and beginning to form a clot. They are given to patients with peripheral arterial disease or a history of recent myocardial infarction (MI) or cerebrovascular accident (CVA), and to those at risk of having an MI or CVA. They are also given if a patient is having heart surgery such as a valve or stent replacement or an angioplasty.

Acetylsalicylic acid (aspirin) and clopidogrel (Plavix) are common examples of antiplatelet medications. Low-dose aspirin (81 mg) is taken daily by many patients for its antiplatelet effect. However, aspirin can also be taken for other reasons because of its anti-inflammatory, analgesic, and anti-pyretic effects.

Selective Xa Inhibitor and Thrombin Inhibitor Medications

Selective inhibitors of factor Xa indirectly inhibit platelet aggregation induced by thrombin. **Selective Xa inhibitors** are used to prevent blood clots in patients with unstable angina and those having angioplasty or a joint replacement. These medications are also given to patients to prevent or treat deep vein thrombosis and pulmonary embolism. **Thrombin inhibitor** medications are similar

to selective Xa inhibitors and are indicated for the same patient population, but they inhibit thrombin instead of factor Xa. Rivaroxaban is an example of a selective Xa inhibitor, and dabigatran is a thrombin inhibitor.

Thrombolytic Medications

Anticoagulants will not dissolve or break apart a clot that has already developed. **Thrombolytic** medication is required in the acute treatment of a myocardial infarction (MI), cerebrovascular accident (CVA), or pulmonary embolism (PE). Thrombolytics will break apart clots rapidly once administered. Alteplase (tPA) is a common thrombolytic that is used for the above-mentioned pathologies. Fig. 7.11 is an image of a patient's hand before and after treatment with a **thrombolytic** for a blood clot in the hand. You can see circulation returning to the patient's hand in the second part of the image.

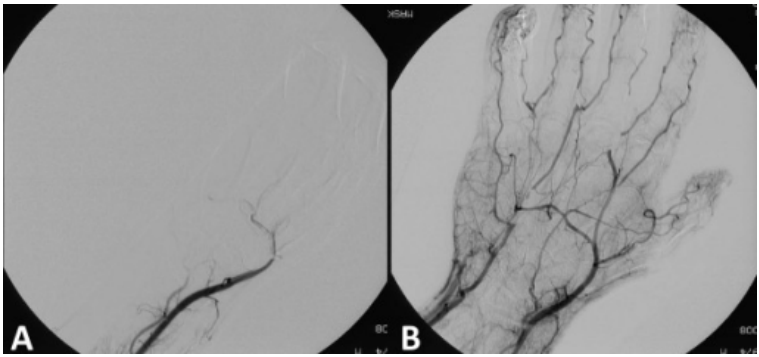


Fig. 7.11

Anemia

As previously mentioned, there are a number of causes for anemia, and treatment will depend on the causative factor. For example, iron-deficiency anemia can be treated with supplemental iron. Fig. 7.12 shows an example of an oral form of supplemental iron medication that can be given for this type of anemia. Medications with "Fe" or "ferrous" in the name are often used to treat iron-deficiency anemia and examples are listed in Table 7.1.

Fig. 7.12

Table 7.1. Common Medications for Iron-Deficiency Anemia

Generic Name	Trade Name
ferrous fumarate	Ferro-Sequels
ferrous sulfate	Feosol, Fer-In-Sol, Slow FE
ferrous gluconate	Fergon

(WebMD, 2022)

Because **vitamin B_{12}–deficiency anemia** and **folate-deficiency anemia** often occur together, they are usually treated in a similar manner (John Hopkins Medicine, 2022). Vitamin B_{12}–deficiency anemia is a condition in which the body lacks enough vitamin B_{12}, which is necessary for the development of healthy red blood cells. Folic acid, also called folate, is another B vitamin that is needed for red blood cell development (John Hopkins Medicine, 2022). These vitamin deficiencies cause red blood cells to be oval and very large rather than developing normally. This results in the bone marrow making fewer red blood cells, and the red blood cells often die sooner than normal. Treatment typically includes vitamin B_{12} injections and oral folic acid supplements (John Hopkins Medicine, 2022).

Table 7.2. Common Hematologic Medications

Generic Name	Trade Names
heparin sodium, heparin	Heparin
dalteparin	Fragmin
tinzaparin	Innohep
enoxaparin	Lovenox
warfarin	Coumadin, Jantoven
acetylsalicylic acid (ASA)	aspirin, Bayer, Ecotrin
clopidogrel	Plavix
rivaroxaban	Xarelto
dabigatran	Pradaxa
alteplase (tPA)	Alteplase

(WebMD, 2022)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/ licensed under CC BY 4.0

References

John Hopkins Medicine. (2022). *Vitamin B12 deficiency anemia.* https://www.hopkinsmedicine.org/health/conditions-and-diseases/vitamin-b12-deficiency-anemia

Mount Sinai. (2022). *Hematologic disorders.* https://www.mountsinai.org/care/surgery/services/pediatric-surgery/conditions-we-treat/hematologic-disorders

WebMD. (2022). *Drugs and medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

Heparin_1 by Sixflashphoto, CC BY-SA 4.0

Thrombosespritze_04_(fcm) by Frank C. Müller, CC BY-SA 4.0

Warfarintablets5-3-1 by Gonegonegone, CC BY-SA 3.0

Angiograph_before_and_after_thrombolytic_therapy_in_a_case_of_thrombosis_on_the_hand by Ipaktchi K, CC BY 2.0

Retafer+ by Styroks, CC BY-SA 4.0

7.5 Review

Chapter Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=78#h5p-3

Chapter Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=78#h5p-2

Trade and Generic Name Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=78#h5p-1

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/ licensed under CC BY 4.0

CHAPTER VIII

ENDOCRINE SYSTEM AND MEDICATIONS

8.1 Introduction to the Endocrine System and Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Describe the endocrine system, its components, and common pathologies
2. Define the purpose of endocrine system medications
3. Describe the differences between type 1 and type 2 diabetes
4. Identify different types of insulin
5. Explain the purpose of oral diabetic agents
6. Identify the most common oral diabetic medications
7. Explain the difference between hypo- and hyperthyroidism

8. Identify the most common drugs used to treat hypo- and hyperthyroidism, both trade and generic names

9. Describe the purpose and common types of corticosteroid medications

Chapter Overview

The endocrine system is constantly working and regulating numerous organs by releasing hormones to obtain homeostasis within our bodies. This chapter will discuss three major endocrine glands: the adrenal glands, the pancreas, and the thyroid. How these glands work, the hormones they release, and common pathologies that can occur when things go wrong will all be discussed. Then medications that may be prescribed to treat these endocrine system pathologies will be discussed.

8.2 The Endocrine System

The complex **endocrine system** consists of many glands, including the **pituitary**, **thyroid**, **parathyroid**, **pineal**, and **adrenal glands**, as well as the **pancreas**, **ovaries**, and **testes**. Fig 8.1 provides an overview of the endocrine system and its components. This chapter will focus on a discussion of the characteristics of and the pathologies that affect three major endocrine glands and their hormones: the adrenal glands, the pancreas, and the thyroid gland.

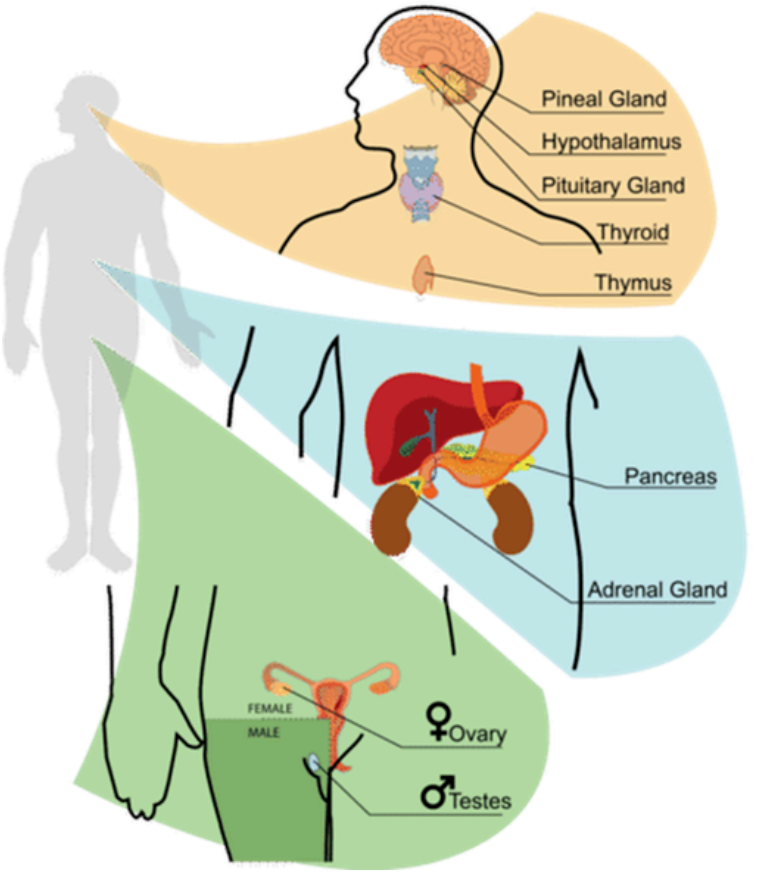


Fig. 8.1

The endocrine system uses **hormones** for chemical signalling, similar to how the nervous system uses neurotransmitters to communicate. These hormone signals are sent by the endocrine organs and transported mostly through the bloodstream to other areas of the body. They then bind to receptors on target cells to induce a particular response. Hormone levels are tightly controlled by the body to prevent levels from becoming to high or too low, and **feedback loops** are the manner in which the endocrine system

accomplishes this. Feedback loops govern the initiation and maintenance of hormone secretion in response to a variety of stimuli. The most common feedback loop in this system is the **negative feedback loop**. Negative feedback is characterized by the inhibition, or stopping, of further secretion of a hormone in response to adequate levels of that hormone. This allows blood levels of the hormone to be maintained within a narrow range. Fig. 8.2 shows an example of a negative feedback loop that governs the levels of thyroxine (T3) and triiodothyronine (T4) in the blood.

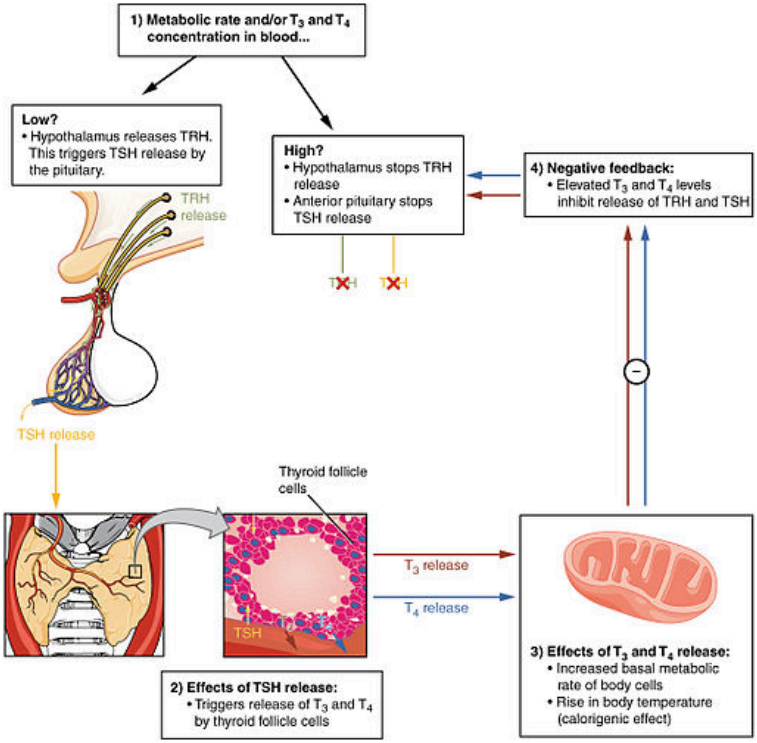


Fig. 8.2

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=162#oembed-1

(TED-Ed, 2018)

The Adrenal Glands

There are two **adrenal glands**, one on each kidney, as shown in Fig. 8.3. Each adrenal gland consists of the **adrenal cortex**, which is composed of glandular tissue, and the **adrenal medulla**, which is made up of nervous tissue. The adrenal cortex and medulla each secrete its own set of hormones. One of the major functions of the adrenal glands is to respond to stress. The body responds in different ways to short-term stress and long-term stress. The reaction to short-term stress, also called the **fight-or-flight response**, is mediated by the hormones epinephrine and norepinephrine secreted by the adrenal medulla. Their function is to prepare the body for physical exertion. But if the stress continues for a longer time, the adrenal cortex hormone cortisol then mediates body responses such as depression, suppressed immune response, or severe fatigue.

The adrenal cortex also produces steroid hormones, which are important for regulating blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation. Adrenal hormones also have several non-stress-related functions, including the increase of blood sodium and glucose levels.

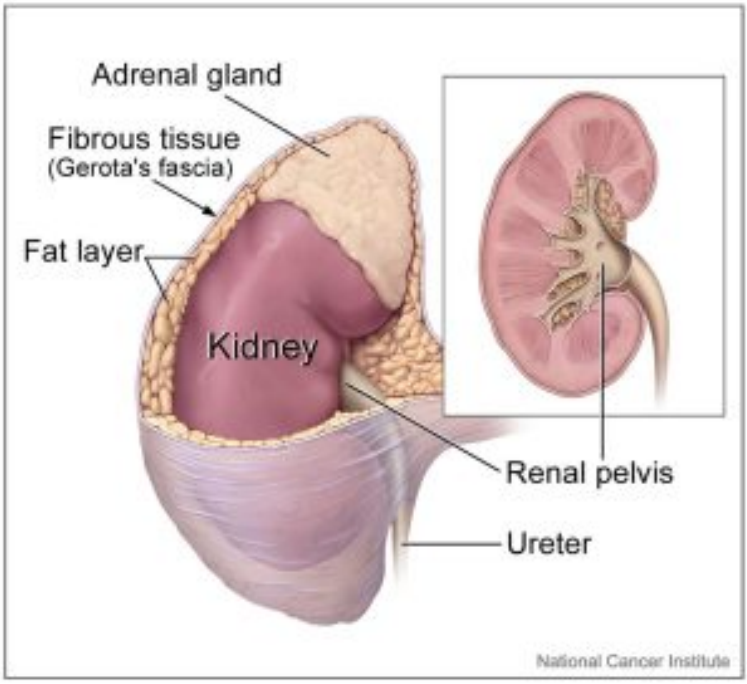


Fig. 8.3

The Pancreas

The **pancreas**, shown in Fig. 8.4, is a long, slender organ located near the stomach. **Pancreatic islets**, which are a group of cells that produce hormones, secrete glucagon and insulin. Glucagon plays an important role in blood glucose regulation because low blood glucose levels stimulate its release. On the other hand, elevated blood glucose levels stimulate the release of insulin.

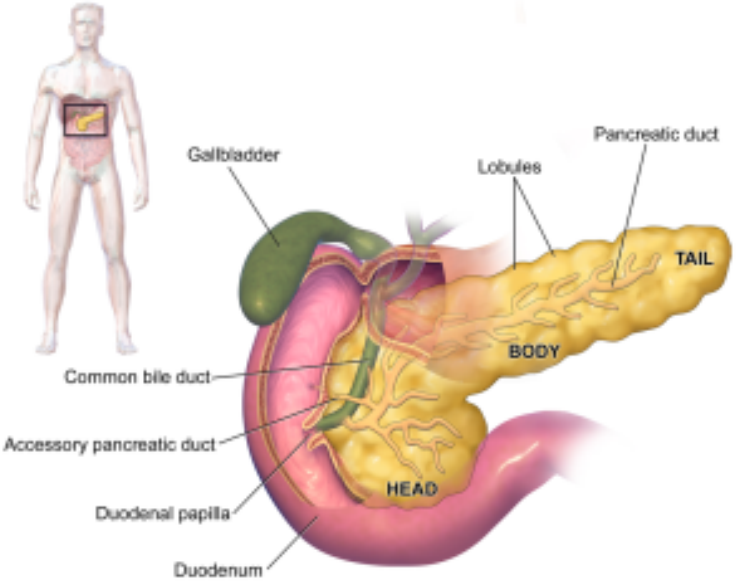


Fig. 8.4

Glucagon

Receptors in the pancreas can sense a decrease in blood glucose levels, which may occur during periods of fasting or prolonged exercise. In response, the alpha cells of the pancreas secrete the hormone **glucagon**, which eventually results in an increase in glucose levels. The activity of glucagon is regulated through a negative feedback loop whereby rising blood glucose levels inhibit further glucagon production and secretion.

Insulin

Insulin facilitates the uptake of glucose into skeletal and adipose

body cells. The presence of food in the intestines triggers the release of various gastrointestinal tract hormones, which then trigger insulin production and secretion by the beta cells of the pancreas. Once nutrient absorption begins to occur in the digestive tract, blood glucose levels increase, which further stimulates insulin secretion. The release of insulin is also regulated through a negative feedback loop—as blood glucose levels decrease, further insulin release is inhibited.

The Thyroid Gland

The **thyroid gland**, shown in Fig. 8.5, is a butterfly-shaped organ located anterior to the trachea, just below the larynx. Each lobe of the thyroid is embedded with **parathyroid glands**. The thyroid secretes the hormones thyroxine (T4) and triiodothyronine (T3), which are often referred to as metabolic hormones because their levels influence the body's basal metabolic rate, the amount of energy used by the body at rest. A negative feedback loop controls the regulation of thyroid hormone levels. Low blood levels of T3 and T4 stimulate the release of thyrotropin-releasing hormone (TRH) from the **hypothalamus**, which triggers the secretion of thyroid-stimulating hormone (TSH) from the anterior **pituitary**. In turn, TSH stimulates the thyroid gland to secrete T3 and T4.

Thyroid hormones are critical for the normal development of the nervous system both in utero and in early childhood, and they support neurological function in adults. When levels of T3 and T4 hormones are high, the heart rate accelerates, the heartbeat strengthens, and blood pressure increases. Because thyroid hormones regulate metabolism, heat production, protein synthesis, and many other body functions, thyroid disorders can have severe and widespread consequences.

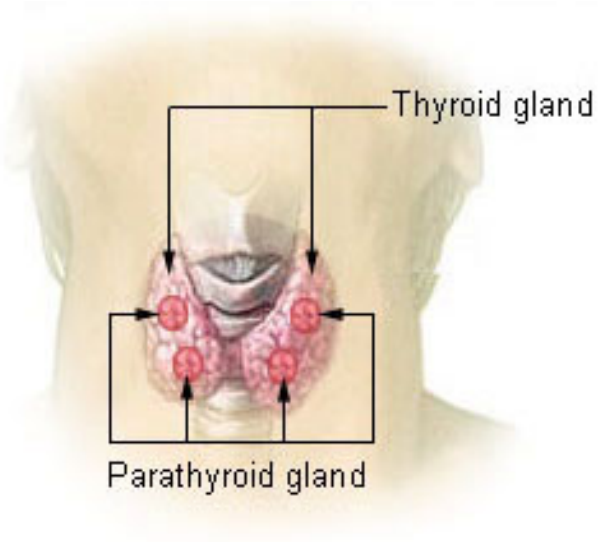


Fig. 8.5

The thyroid gland also secretes another hormone called calcitonin. Calcitonin is released in response to elevated blood calcium levels. It decreases blood calcium concentrations by doing the following:

- It inhibits the activity of osteoclasts (bone cells that break down bone matrix and release calcium into blood circulation).
- It decreases calcium absorption in the intestines.
- It increases calcium loss in the urine.

Calcium is critical for many biological processes and is essential for muscle contraction, nerve impulse transmission, and blood clotting.

Table 8.1. Hormones Associated with the Adrenal Glands, Pancreas, and Thyroid

Endocrine gland	Hormone(s)	Effect
Adrenal (cortex)	Aldosterone	Increases blood sodium levels
Adrenal (cortex)	Cortisol	Increases blood sugar levels
Adrenal (medulla)	Epinephrine, norepinephrine	Stimulates fight-or-flight response
Pancreas	Insulin	Reduces blood glucose levels
Pancreas	Glucagon	Increases blood glucose levels
Thyroid	Thyroxine (T4), triiodothyronine (T3)	Stimulates basal metabolic rate
Thyroid	Calcitonin	Reduces blood calcium levels

(Ernstmeyer & Christman, 2020)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

TED-Ed. (2018, June 21). *How do your hormones work? – Emma Bryce* [Video] YouTube. https://www.youtube.com/watch?v=-SPRPkLoKp8

Image Credits (images are listed in order of appearance)

Endocrine system glands by Mariana Ruiz Villarreal, CC BY-SA 3.0

1813 A Classic Negative Feedback Loop by OpenStax, CC BY 3.0

Kidney and adrenal gland by National Cancer Institute, Public domain

Blausen 0699 PancreasAnatomy2 by BruceBlaus, CC BY 3.0

Illu thyroid parathyroid by National Cancer Institute, Public domain

8.3 Endocrine Pathologies

A number of pathologies can affect the endocrine system; however, the primary focus for this section will be the pathologies that result from issues with the three major endocrine glands that are the focus of this chapter: the adrenal glands, the pancreas, and the thyroid gland. A few other common endocrine pathologies that do not involve these three glands are also included in this section.

Common Pathologies

Acromegaly: This disorder affects adults and is caused by abnormally high levels of growth hormone that result in increased growth of the bones in the face, hands, and feet (Betts et al., 2013).

Addison's disease: This condition is caused by the hyposecretion of corticosteroids, which also results in low blood glucose levels and low blood sodium levels. An **Addisonian crisis** is a life-threatening condition that presents with severely low blood pressure as a result of low corticosteroid levels (Betts et al., 2013). Addison's disease is a type of **adrenal insufficiency** and is characterized by the adrenal glands releasing too little cortisol.

Cushing's syndrome: This pathology results from excessive production of the hormone cortisol. The signs and symptoms are rapid weight gain, depression, anxiety, high blood sugar, a moon-shaped face, and fatigue. Individuals also experience weak muscles and bone pain (Betts et al., 2013).

Diabetes mellitus: Dysfunction of insulin production and secretion, as well as the target cells' responsiveness to insulin, can result in this condition. It is a common disease that affects the ability of the body to produce and use insulin. When diabetes

mellitus goes untreated or is uncontrolled, blood glucose levels are consistently elevated. This can eventually lead to complications such as diabetic **retinopathy**, **neuropathy**, **arteriosclerosis**, increased risk of infections, **ketoacidosis**, and even death. Fig. 8.6 is an illustration of the beta cells and the pancreatic islets in the pancreas, both of which play an integral role in the regulation of blood glucose levels.

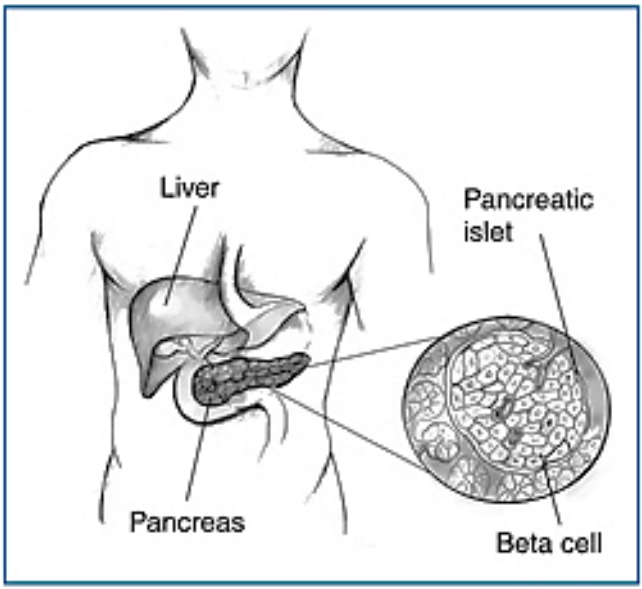


Fig. 8.6

There are two main forms of diabetes mellitus:

- **Type 1 diabetes** is an autoimmune disease that affects the beta cells of the pancreas. The beta cells in people with type 1 diabetes do not produce insulin, so these individuals require synthetic insulin, which is administered by injection or

infusion. The most common means of administering insulin is through a **subcutaneous** injection. This form of diabetes is often diagnosed in childhood and was previously known as **insulin dependent diabetes mellitus (IDDM)**.

- **Type 2 diabetes** accounts for approximately 95% of all cases of diabetes. It is acquired later in life, and factors such as poor diet and inactivity greatly increase a person's risk of developing this condition. In type 2 diabetes, the body's cells become resistant to the effects of insulin. In response, the pancreas increases its insulin secretion, but over time, the beta cells become exhausted. In many cases, type 2 diabetes can be controlled by moderate weight loss, regular physical activity, and a healthy diet. However, if blood glucose levels cannot be controlled, oral diabetic medication is prescribed, and eventually those with type 2 diabetes may even require insulin. This type of diabetes used to be referred to as **non-insulin dependent diabetes mellitus (NIDDM)**.

Table 8.2. Symptoms of Hypoglycemia and Hyperglycemia

Hypoglycemia	**Hyperglycemia**
Shaky or jittery	Blurred vision
Sweaty	Increased thirst and frequent urination
Hungry	Feeling weak and tired
Headache	Fruity-smelling breath
Blurred vision	Dry mouth
Dizzy or lightheaded	Nausea and vomiting
Confused or disoriented	Abdominal pain
Fast or irregular heartbeat	Shortness of breath
Seizures or convulsions (jerky movements)	Confusion
Unconsciousness	Unconsciousness

Hypothyroidism: This condition is marked by low levels of thyroid hormones, which can result from different causes. Treatment varies depending on the causative factors contributing to the patient's condition. Hypothyroidism is characterized by a low metabolic rate, weight gain, cold extremities, constipation, reduced libido, menstrual irregularities, and reduced mental activity. This condition requires long-term thyroid hormone replacement therapy. Some of the potential causes include the following:

- **Dietary iodine deficiency** can result in the impaired ability to synthesize T3 and T4, which can then lead to a number of severe disorders. For much of the world's population, foods do not provide adequate levels of iodine because the amount varies according to the level in the soil in which the food was grown, as well as irrigation and the fertilizers used. Therefore, the primary source of dietary iodine in many countries is iodized salt. When the body cannot produce T3 and T4, thyroid-stimulating hormone (TSH) is secreted in increasing amounts. As a result, the thyroid gland increases in size, resulting in a **goiter**, which is shown in Fig. 8.7. Iodine deficiency can also result in impaired growth and development, decreased fertility, and prenatal and infant death.

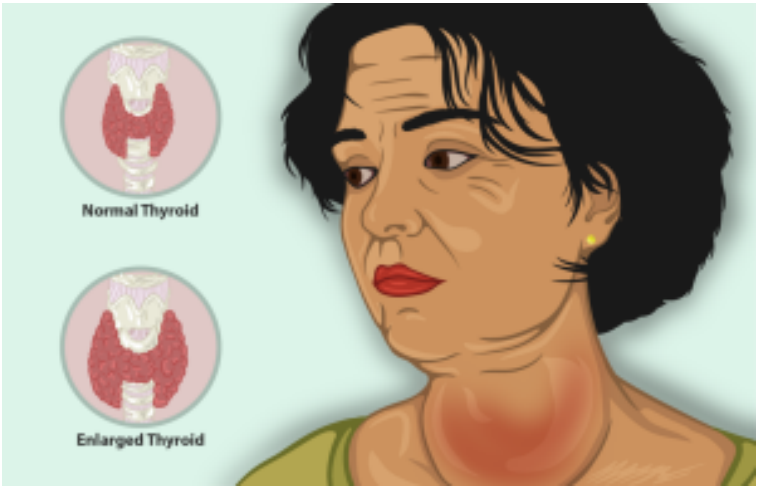


Fig. 8.7

- In areas of the world with access to iodized salt, dietary deficiency of iodine is rare. Instead, inflammation of the thyroid gland or low blood levels of thyroid hormones is a common cause of hypothyroidism.

Hyperthyroidism: This condition is characterized by abnormally elevated blood levels of thyroid hormones and is often caused by a pituitary or thyroid tumour. It can also result from an autoimmune reaction referred to as **Graves' disease**, in which antibodies overstimulate the follicle cells of the thyroid gland. Hyperthyroidism can lead to an increased metabolic rate, excessive body heat and sweating, diarrhea, weight loss, tremors, and increased heart rate. The person's eyes may bulge, called an **exophthalmic goiter** (Fig. 8.8) because antibodies produce inflammation in the soft tissues of the eye orbits.

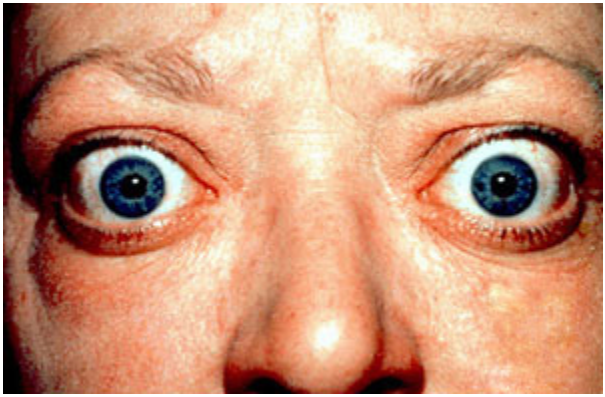


Fig. 8.8

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology, licensed under CC BY 4.0

Image Credits (images are listed in order of appearance)

Pancreas insulin beta cells by National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK): Health Information, Public domain

A woman suffering from Goiter by myUpchar, CC BY-SA 4.0

Proptosis and lid retraction from Graves' Disease by Jonathan Trobe, CC BY 3.0

8.4 Endocrine System Medications

This section will discuss some of the more common medications that are used to treat hypothyroidism, hyperthyroidism, and diabetes mellitus, as well as common uses for corticosteroids. The mechanism of action of many of these medications is complicated, so we will only provide a basic overview of the medications in the categories below. Similarly to other chapters, a summary of all the medications discussed will be provided in a table at the end of the page.

Thyroid Replacement Medications

Levothyroxine (Synthroid) is a thyroid replacement medication used to treat **hypothyroidism**. Oral levothyroxine, shown in Fig. 8.9, is a synthetic T4 hormone that exerts the same physiological effect as **endogenous** T4, which means this medication can maintain normal T4 levels when a deficiency is present. Another medication available is **liothyronine (Cytomel, Triostat)**, which also contains T4 and is a common medication for treating hypothyroidism (WebMD, 2023).

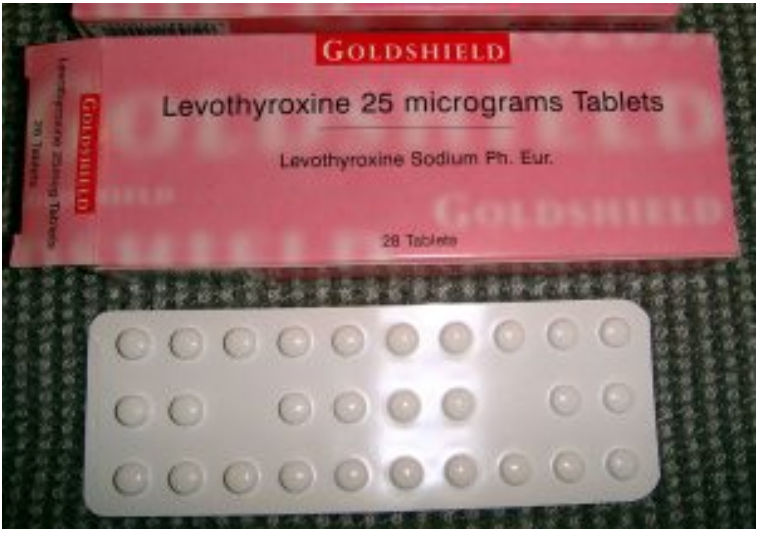


Fig. 8.9

Thyroid replacement medications do not cure hypothyroidism, but rather supplement the lack, or low level of, T4, which means that treatment is lifelong. It is important to also monitor serum TSH levels before and during treatment to determine the effectiveness of the drug. Note that drug interactions may occur with several other medications, including **anticoagulants** and diabetic medications.

Anti-Thyroid Medications

Hyperthyroidism is often treated by thyroid surgery or with **radioactive iodine (RAI) therapy**. Patients are often given a radioactive oral medication, such as **sodium iodide 131 (Iodotope)**, which collects in the thyroid cells and destroys the thyroid gland. This has little effect on the rest of body, but also destroys cancer cells if they are present in the thyroid. The patient must follow

radiation precautions for a three-day period after RAI treatment to limit radiation exposure to others. This often includes staying in the hospital or away from others in the home. The end result of thyroid surgery or RAI treatment is often hypothyroidism, which is treated with thyroid hormone replacement therapy.

Propylthiouracil (PTU) is an anti-thyroid medication used to treat **hyperthyroidism** or to mimic the symptoms of hyperthyroidism in preparation for a **thyroidectomy** or radioactive iodine therapy. Propylthiouracil works by inhibiting the synthesis of thyroid hormones. This medication is administered orally, and the total daily dosage is usually given in three equal doses at approximately eight-hour intervals. Propylthiouracil can cause hypothyroidism, which makes it necessary to routinely monitor serum TSH levels and adjust the dose as needed to maintain optimal levels.

Adrenal Medications: Corticosteroids

Corticosteroids are common medications that are used to treat many different pathologies that have already been discussed in other chapters in this book. They are often used as a replacement therapy for **adrenal insufficiency**, as well as for the management of various dermatologic, rheumatologic, hematologic, and gastrointestinal (GI) disorders. Systemic corticosteroids are also often given for respiratory conditions and acute exacerbations of chronic obstructive pulmonary disease (COPD) and severe asthma.

There are various forms of corticosteriods and routes that corticosteroids can be given. Oral **prednisone** is the most widely used of the systemic corticosteroids and is generally used as an anti-inflammatory and immunosuppressive agent. Topical creams, such as **hydrocortisone**, are commonly used for itching, and its oral formulation is used to treat Addison's disease. There are also various forms of injectable corticosteroids, such as **methylprednisolone**,

which is used to treat inflammation associated with pathologies such as arthritis.

Some other examples of pathologies for which corticosteroids are administered:

- Adrenocortical insufficiency
- Rheumatoid arthritis
- Lupus erythematosus
- Psoriasis
- Contact dermatitis or drug hypersensitivity reactions
- Optic neuritis
- Asthma/COPD
- Ulcerative colitis
- Multiple sclerosis

Despite their beneficial effects, long-term systemic use of corticosteroids is associated with well-known adverse events, including osteoporosis and fractures, adrenal suppression, hyperglycemia and diabetes, cardiovascular disease and dyslipidemia, dermatological and GI events, psychiatric disturbances, and immunosuppression. Therefore, the lowest possible dose of corticosteroid should be used to control the condition requiring treatment to avoid the development of these adverse effects.

Fig. 8.10

When a patient is taken off an oral dose of corticosteroids it is necessary to slowly reduce the dose. This is referred to as a **tapered dosage**, whereby the dose is slowly decreased over a number of days. Tapering the dosage is necessary to allow the adrenal cortex, which is suppressed by the large medication dose, to gradually begin to secrete its own cortisol again. Fig. 8.10 shows a common corticosteroid medication being given in a tapered dose, where the dosage and number of tablets decreases every day.

Key Concept

A few common **suffixes** seen with **corticosteroids** are **-sone, -lone, -solone**.

Examples: betamethasone, dexamethasone, hydrocortisone, prednisone

Diabetic Medication Classes: Insulins

Because patients with type 1 diabetes have absent, or near-absent, beta cell function in the pancreas, **insulin** treatment is essential. A number of different types of insulin and methods for administration are available. New technology is always evolving as it relates to the monitoring of blood sugars and administering insulin to patients to with type 1 diabetes. It is important to note that lifestyle modifications that improve health should also be emphasized, along with prescribing and administering insulin. Lifestyle modifications include healthy food choices to stabilize blood glucose levels, as well as daily exercise.

Fig. 8.11

Insulin is most often given via the **subcutaneous** route, but in some cases in the hospital, it may be given **intravenously** if the patient's condition requires it. Insulin, when administered subcutaneously, is given using a specialized insulin syringe that measures insulin in **units** (Fig. 8.11). This helps decrease errors and provides a more specific measurement of the amount of insulin being given to the patient. These insulin syringes are used to draw up insulin from vials of insulin, which are stored at the nursing station, elsewhere in the hospital, or in the patient's home if the insulin is being self-administered.

Another option is an **insulin pen**, shown in Fig. 8.12, which is often used in the hospital setting, as well as for self-administration, to facilitate safe and accurate self-administration of insulin. The advantage of an insulin pen is that the insulin is pre-measured and stored in the pen and does not have to be drawn up from a vial.

Fig. 8.12

There are also **continuous computerized glucose monitors and pumps** that provide automatic delivery of insulin to the patient. A number of these are available on the market, and Figs. 8.13 and 8.14 show some possible options. These devices decrease the need to regularly take blood glucose samples, and they administer insulin throughout the day and night.

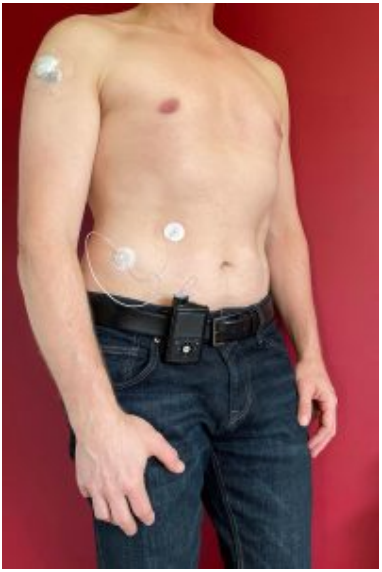


Fig. 8.13

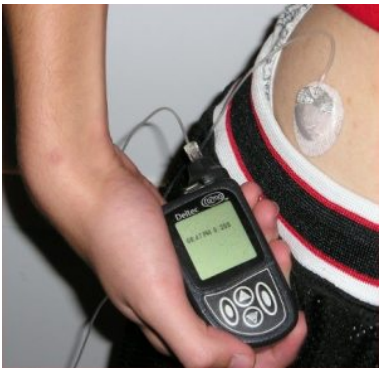


Fig. 8.14

Insulin is a high-alert medication that can be associated with significant patient harm when used incorrectly. In most healthcare settings, it is necessary for extra safety precautions to be taken, such as a double-check by two nurses before administering insulin to any patient. Patients on insulin therapy are at risk for **hypoglycemia**. It is essential for the healthcare provider, or the patient themself if at home, to monitor for signs of hypoglycemia and to intervene appropriately.

Types of Insulin

There are several different types of insulin that vary in terms of onset, peak, and duration.

Rapid-Acting Insulin

Rapid-acting insulins are administered with meals to mimic the effects of **endogenous** insulin release when food is eaten. Dosages of rapid-acting insulin vary greatly depending on individual patient factors as well as carbohydrate intake, premeal glucose levels, and anticipated activity during the day.

Rapid-acting insulins include **insulin lispro (Humalog)** and **insulin aspart (Novolog)** and are also available via inhalation **(Afrezza)**. Because insulin lispro and insulin aspart act so quickly, as well as the potential for hypoglycemia, these insulins should be administered within 15 minutes before or right after eating a meal. Peak serum levels are seen 30 to 90 minutes after dosing. Inhaled insulin enters the bloodstream even faster, and effects are seen within one minute and peak in 30 to 60 minutes. Inhaled insulin is contraindicated in many patients, especially those with chronic lung disease such as asthma or COPD.

Short-Acting Insulins

Short-acting insulins are also given with meals to mimic the effects of **endogenous** insulin release when food is eaten. Dosages are individualized based on carbohydrate intake, premeal glucose levels, and activity levels. Short-acting inulin is often also referred to as **regular insulin**, and this is reflected in the abbreviation **R** found in many drug names, such as **Humulin R** and **Novolin R**.

Regular insulin, similar to other insulins, is generally administered **subcutaneously**, but it is the only insulin that can be administered intravenously as well. It is available in vials, as shown in Fig. 8.15, and insulin pens. Subcutaneous doses should be administered approximately 30 minutes before meals because this is when the onset of therapeutic action generally occurs. Peak effects occur in three hours, and the duration of effect is eight hours.

Fig. 8.15

Intermediate-Acting Insulin

Intermediate-acting insulins are administered once or twice daily to mimic **endogenous** insulin levels. **NPH insulin**, also known as **isophane insulin**, is an example of an intermediate-acting insulin. Brand names include **Humulin N** or **Novolin N**. Mixtures of intermediate- and short-acting insulins are available in such mixes as **Humulin 70/30** or **Novolin 70/30**. Not all insulins can come

mixed, but it is possible with these forms of insulin. The onset, duration, and details of all the insulins discussed here, including some of the options for mixed insulins, are listed in Table 8.3 below.

Long-Acting Insulin

For those with type 1 diabetes, **long-acting insulin** should be combined with rapid- or short-acting insulin at mealtimes. **Insulin glargine (Lantus)** and **insulin devemir (Levemir)** are long-acting insulins given once or twice daily. Long-acting insulin has a relatively constant therapeutic effect over 24 hours, with no pronounced peak in comparison to NPH insulin. This can be seen in Fig. 8.16, which provides an illustration of the different types of insulin, their onset of action, and duration of effects within the body. Long-acting insulin should only be administered subcutaneously and is available in vials and insulin pens.

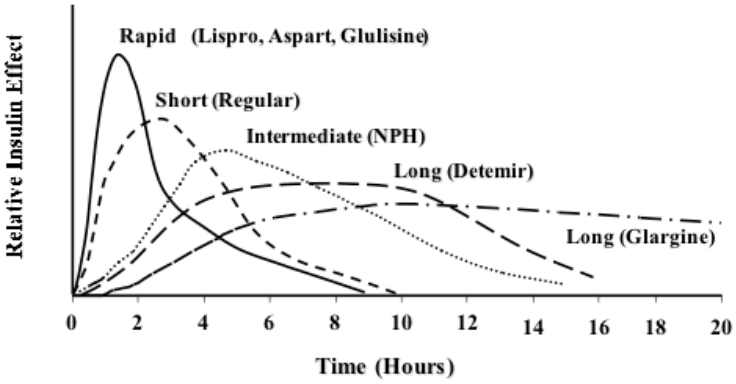


Fig. 8.16

Table 8.3. Types of Insulin

Class	Generic/Trade	Onset/Peak Effect/Duration
Rapid-Acting Insulin	insulin lispro (Humalog) insulin aspart (Novolog) inhaled insulin (Afreeza)	Onset: 15–30 minutes Peak effect: 1–3 hours Duration: 3–5 hours
Short-Acting Insulin	Humulin R Novolin R	Onset: 30 minutes Peak effect: 3 hours Duration: 8 hours
Intermediate-Acting Insulin	Humulin N Novolin N	Onset: 1-2 hours Peak effect: 6 hours Duration: up to 24 hours
Combination: Intermediate-Acting/ Rapid-Acting	Humalog Mix 50/50 Humalog Mix 75/25 Novolog Mix 70/30 *First number is % of intermediate-acting insulin, second number is % of rapid-acting	Onset: 15-30 minutes Peak effect (50/50): 1–5 hours Duration: 11–22 hours
Combination: Intermediate-Acting/ Short-Acting	Humulin 70/30 Novolin 70/30	Onset: 30–90 minutes Peak effect: 1.5–6.5 hours Duration: 18–24 hours

Long-Acting Insulin	insulin glargine (Lantus) insulin detemir (Levemir)	Onset: 3–4 hours Peak effect: none Duration: >24 hours

(Ernstmeyer & Christman, 2020)

Glucagon

Glucagon (Glucagen) is indicated as a treatment for severe **hypoglycemia**, which may occur in patients with diabetes mellitus. Glucagon injections are used for patients who are unable to safely swallow carbohydrates to treat hypoglycemia because of the effects of severe hypoglycemia or possibly other medical conditions. Glucagon increases blood glucose concentration during an episode of hypoglycemia. It may be administered **subcutaneously**, **intramuscularly**, or **intravenously**. Peak therapeutic effects and glucose levels are seen within 13 to 20 minutes of subcutaneous or intramuscular injection. Fig. 8.17 shows an example of an emergency glucagon kit that can be used if a patient becomes hypoglycemic and cannot swallow carbohydrates to increase blood sugar.

Fig. 8.17

Oral Antihyperglycemics

There are several different classes of oral antihyperglycemic drugs that are used in conjunction with a healthy diet and exercise for the management of type 2 diabetes.

Glipizide

Glipizide (Glucotrol) is an antihyperglycemic medication that works by stimulating insulin secretion from the beta cells of pancreatic islet tissue and is therefore dependent on functioning beta cells in the pancreatic islets. Peak plasma concentrations occur 1 to 3 hours after a single oral dose. It is important that patients understand that the medication, and other oral antidiabetic medications, help control episodes of hyperglycemia but do not cure diabetes.

Metformin

Metformin (Glucophage), shown in Fig. 8.18, is a antihyperglycemic that works by decreasing hepatic glucose production, decreasing the intestinal absorption of glucose, and improving insulin sensitivity by increasing peripheral glucose uptake and utilization. Metformin should be given in divided doses with meals with the therapeutic goal of decreasing both fasting plasma glucose and glycosylated hemoglobin levels to near normal by using the lowest effective dose.

Fig. 8.18

Sitagliptin

Sitagliptin (Januvia) is an oral antihyperglycemic medication that works to increase insulin release and decrease glucagon levels in the blood. it is taken once daily, at the same time each day, and can be taken with or without food.

Glyburide

Glyburide (Diabeta) is an oral antihyperglycemic that used along

with diet and exercise in Type 2 diabetes (WebMD, 2023). It belongs to the category of medications know as sulfonylureas. The drugs mechanism of action is to increase the bodies production of insulin and therefore lowers the blood sugar. Glyburide comes in various doses and it is important to only take what is prescribed. The best time to take glyburide is with your first morning meal daily (WebMD, 2023).

Table 8.4. Common Endocrine Medications

Generic Name	Trade Name(s)	Reason for Administering
levothyroxine	Synthroid	Hypothyroidism
liothyronine	Cytomel, Triostat	Hypothyroidism
methimazole	Tapazole	Hyperthyroidism, Graves' disease
propylthiouracil	Propacil	Hyperthyroidism
sodium iodide 131	Iodotope	Hyperthyroidism, thyroid cancer
betamethasone	Celestone	Rheumatic disorders
dexamethasone	Decadron	Rheumatic problems, asthma, COPD
fludrocortisone	Florinef	Adrenal insufficiency
hydrocortisone	Cortef, Solu-Cortef	Adrenocortical insufficiency, rheumatoid arthritis, COPD, asthma
methylprednisolone	Medrol, Solu-Medrol	Inflammatory conditions, arthritis, lupus, ulcerative colitis

prednisolone	Pediapred, Prelone	Inflammatory conditions, autoimmune disorders
prednisone	Deltasone, Meticorten	Suppresses the immune system, decreases inflammation
triamcinolone	Aristocort, Kenalog	Skin diseases, allergies, rheumatic disorders
glucagon	Glucagen	Hypoglycemia
glipizide	Glucotrol	Type 2 diabetes
metformin	Glucophage	Type 2 diabetes
sitagliptin	Januvia	Type 2 diabetes
glyburide	Diabeta	Type 2 diabetes

*Insulin is not included in this table.
(WebMD, 2023)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

WebMD. (2023). *Drugs & medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

Levothyroxine 25mcg Tablets by Ash, Public domain

Sandoz.Methylprednisolone.4mg by Anonymous, Public domain

Insulin syringe foto by Rehab Center Parus, CC BY-SA 4.0

Human insulin 100 IU-1ml pen yellow background by Wesalius, CC BY 4.0

Diabetic Type 1 adult man with insulin pump and CGM sensor by Medtd1, CC BY-SA 4.0

Insulin pump with infusion set by Mbbradford, Public domain

Human insulin 100IU-ml vial yellow background by Wesalius, CC BY 4.0

Insulin short-intermediate-long acting by Anne Peters, CC BY 3.0

Glucagon emergency rescue kits image by Mizi m, CC0 1.0 Universal

Metformin 500mg Tablets by Ash, Public domain

8.5 Review

Chapter Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=166#h5p-5

Chapter Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=166#h5p-6

Trade and Generic Name Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=166#h5p-4

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

CHAPTER IX

NERVOUS SYSTEM AND MEDICATIONS

9.1 Introduction to the Nervous System and Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Describe the purpose of the nervous system, its key components, and how they work
2. Describe common pathologies that affect the nervous system
3. Identify common medications used to treat seizure disorders
4. Identify common medications used to treat dementia and Alzheimer's disease
5. Identify the most common medications used to treat Parkinson's disease
6. Identify common medications used to treat insomnia

Chapter Overview

The nervous system is a very complex body system. Even though there have been continual advancements in the scientific discipline of neuroscience, our understanding of the intricacies in this area are limited. Simply put, the nervous system may be too complex for us to completely understand. The complexity of the nervous system and difficulty understanding the brain can make treating and preventing diseases that affect this system complicated; however, there are a number of common medications that are important to be familiar with when treating pathologies that affect the nervous system. This chapter will provide an overview of the nervous system, its common pathologies, and medication options for patients with these pathologies.

9.2 The Nervous System

The nervous system, shown in Fig. 9.1, is a very complex system and is responsible for controlling much of the body, including both voluntary and involuntary functions. It receives information about the environment around us, then creates responses to that information. This system is also responsible for taking sensory input and integrating it with other sensations, memories, emotional states, and learning. The nervous system can be divided into two main components: the **central nervous system** and the **peripheral nervous system**. From there, it is subdivided even further by functions and components.

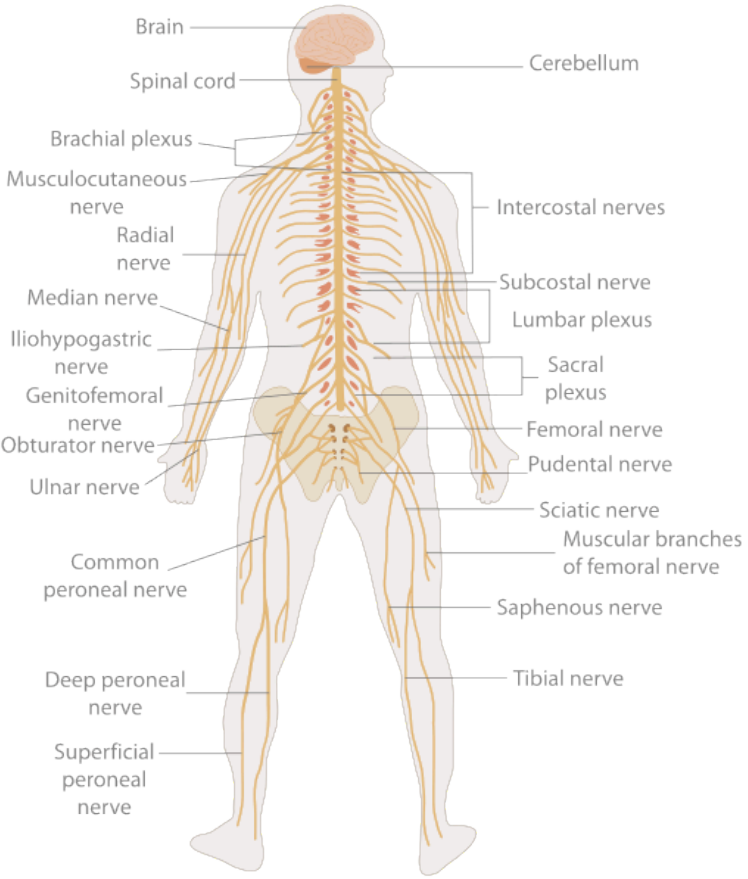


Fig. 9.1

Components of the Nervous System

As mentioned above, the two main components of the. nervous system are the central nervous system (CNS) and the peripheral nervous system (PNS).

Central nervous system (CNS): The brain and the spinal cord make up the central nervous system. The brain is

described in terms of its major regions, which include the cerebrum, diencephalon, brain stem, and cerebellum. The regulation of homeostasis and conscious experiences are controlled in the brain. Reflexes and the integration of sensory and motor pathways are handled in the spinal cord.

Peripheral nervous system (PNS): This part of the nervous system connects the central nervous system with the rest of the body. The nerves, axons, and ganglia that make up the PNS are found throughout the body in other organs and even in other systems, such as the digestive system, as well as the eyes, ears, nose, and various other locations. Messages travel back and forth from the CNS to the muscles, organs, and senses in peripheral areas of the body. When **sensory neurons** carry messages and various forms of sensory information towards the CNS, they are considered **afferent fibres**. When the CNS uses **motor neurons** to carry instructions from the CNS to the muscles, they are called **efferent fibres**. Messages constantly travel back and forth along neurons between the CNS and the periphery.

The PNS is subdivided into two components: the **somatic nervous system** and the **autonomic nervous system**.

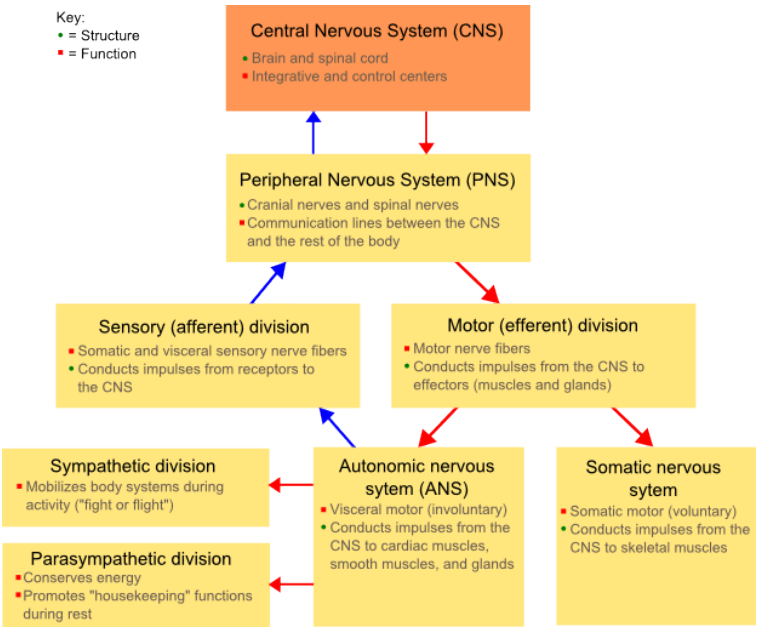


Fig. 9.2

Somatic nervous system: This part of the PNS is responsible for conscious perception of the environment and for voluntary responses to that perception through the use of skeletal muscles.

Autonomic nervous system: This part of the PNS handles involuntary responses that the brain controls without the need for conscious thought. It consists of the **sympathetic** and **parasympathetic nervous systems** and uses a balance of the two to regulate the body's involuntary functions, including heart rate, respiratory rate, digestion, and sweating:

- **Sympathetic nervous system:** Associated with the fight-or-flight response

- **Parasympathetic nervous systems:** Focuses on what could be called “rest and digest”

, and Fig. 9.3 discusses the differences between the parasympathetic and sympathetic nervous systems.

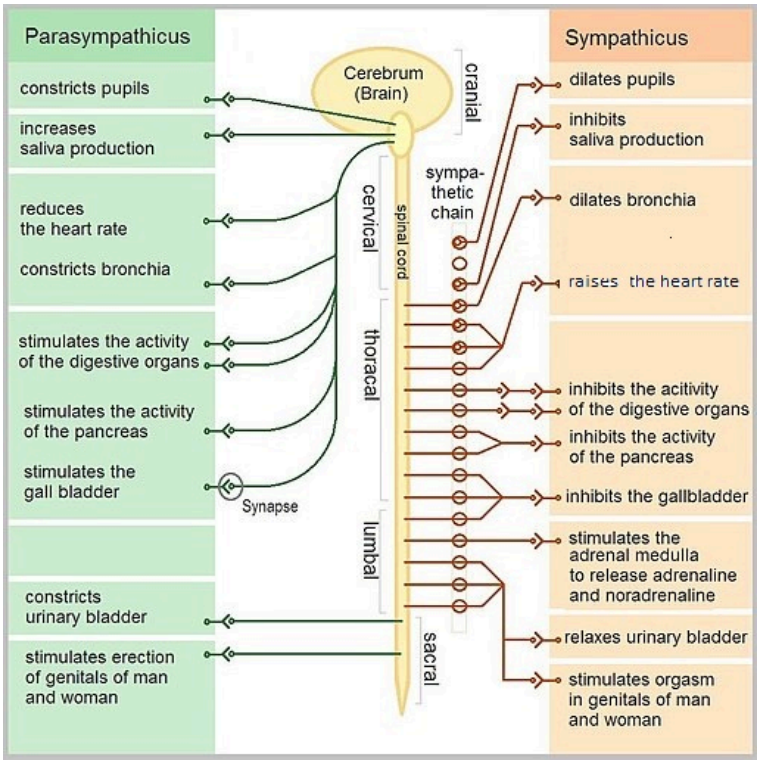


Fig. 9.3

Neurons

Neurons are the cells considered to be the basis of nervous tissue within the body (Betts et al., 2013). They are responsible for the

electrical signals that communicate information about sensations and produce movements in response to those stimuli, along with starting thought processes in the brain. An important part of the function of neurons is in their unique structure. The shape and the parts of these cells are what make the numerous connections within the nervous system possible (Betts et al., 2013).

Parts of a Neuron

The main part of a neuron is the **cell body**, which contains the **nucleus** and most of the major **organelles** (Betts et al., 2013). The **axon** is a fibre that emerges from the cell body and projects to **target cells**. A single axon can branch repeatedly to communicate with many target cells (Betts et al., 2013). It is the axon that continues the **nerve impulse**, or electrical signal, which is then communicated to one or more cells. The neurons also have **dendrites**, which receive information from other neurons at specialized areas of contact called **synapses**. The dendrites are usually highly branched, providing locations for other neurons to communicate with the cell body. Information flows through a neuron from the dendrites, across the cell body, and down the axon (Betts et al., 2013). Fig. 9.4 provides a diagram of all the main components of a neuron.

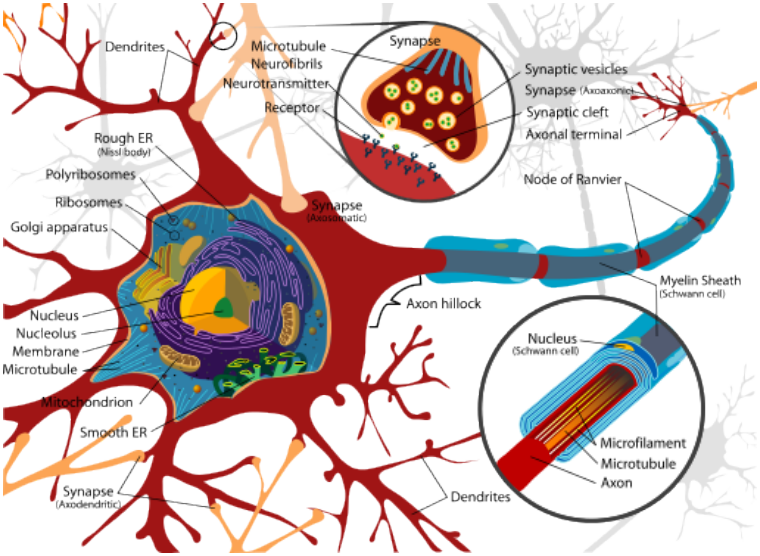


Fig. 9.4

Axons are wrapped by an insulating substance called **myelin**, which is made from **glial cells** (Betts et al., 2013). Myelin acts as insulation but there are also gaps in the myelin covering of an axon (Betts et al., 2013). Each gap is called a **node of Ranvier** and is important to the way electrical signals travel down the axon. At the end of the axon is the **axon terminal**, where there are usually several branches extending toward the target cells; each branch ends in an enlargement called a **synaptic end bulb**. These bulbs are what make the connections with the target cells at the synapse (Betts et al., 2013). The axon terminal is also where the electrical signals are changed to chemical signals called **neurotransmitters**, which are used to communicate with the next group of nerve cells. The video below provides a quick overview of the neuron and how it functions.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=354#oembed-1

(Neuroscientifically Challenged, 2014)

Communication in the Nervous System

Understanding how communication occurs within the nervous system will help you understand the mechanism of action of medication that works by influencing the neurotransmitters. There are two types of connections between electrically active cells: chemical synapses and electrical synapses. In an **electrical synapse**, there is a direct connection between two cells so that ions can pass from one cell to the next. In a **chemical synapse**, electrical impulses signal the release of a chemical signal, a neurotransmitter, that then travels to, and binds with, a target cell. We will be focusing on the communication of a neurotransmitter in a chemical synapse because most of the medications discussed affect this form of connection.

Once in the **synaptic cleft**, the space between two neurons, the neurotransmitter diffuses the short distance to the **postsynaptic membrane** and can interact with **neurotransmitter receptors** (Fig. 9.5). Receptors are specific for the neurotransmitter, and the two fit together like a key and lock. A neurotransmitter binds to its receptor and will not bind to receptors for other neurotransmitters, making the binding a specific chemical event.

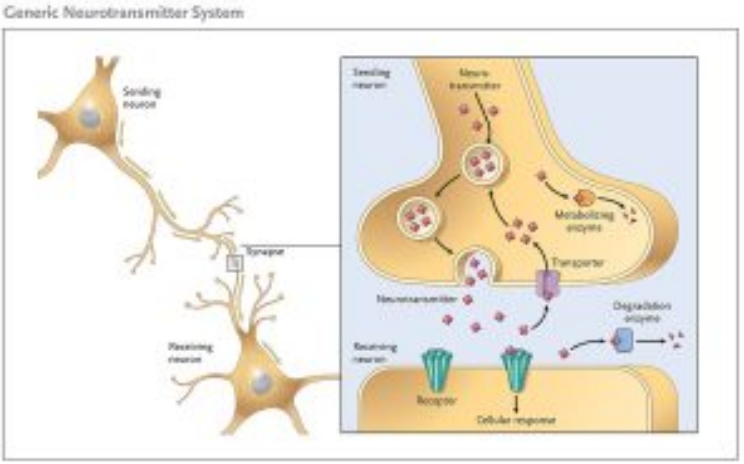


Fig. 9.5

When the neurotransmitter binds to the receptor, the cell membrane of the target neuron changes its electrical state, and a new, graded potential begins. If that graded potential is strong enough to reach threshold, the next neuron generates an action potential and continues the message, or electrical signal. This continues over and over until the message reaches its destination in the brain.

Neurotransmitters

Neurotransmitters are chemical messengers that our body cannot work without. An important thing to remember about neurotransmitters and signalling chemicals is that the effect is entirely dependent on the receptor. There are a number of different types of neurotransmitters in the body:

- Dopamine

- Serotonin
- Histamine
- Norepinephrine
- Epinephrine
- Glutamate
- Acetylcholine

Examples of Neurotransmitter Functions

Any alteration in central nervous system (CNS) function can be related to abnormal impulse transmission and can result from an imbalance of neurotransmitters. A person with an imbalance of neurotransmitters may have the signs and symptoms of a CNS disorder or pathology. The medications used to treat CNS disorders do so by mimicking or blocking the neurotransmitter based on the imbalance caused by the condition. Medications can also be used to either stimulate or depress the effect of the neurotransmitter. For example, **CNS depressants** alter the brain by decreasing the excitability of neurotransmitters, blocking their receptor site or increasing the inhibitory neurotransmitter. Conversely, **CNS stimulants** increase brain activity by increasing the excitability of neurotransmitters, decreasing the inhibitory neurotransmitters or blocking their receptor sites.

Examples:

- **Norepinephrine** is often associated with the fight-or-flight response. Abnormal levels of this neurotransmitter are also associated with depression and decreased alertness and interest, along with possible palpitations, anxiety, and panic attacks.
- **Dopamine** is strongly linked to motor movement and cognition. It influences movement and can be associated with ADHD, paranoia, and schizophrenia.

- **Serotonin** is heavily involved in many bodily processes. Abnormal levels of serotonin can affect sleep, libido, mood, and temperature regulation. Alterations of this neurotransmitter have been linked to many mental health issues such as depression, bipolar disorder, anxiety, and body disorders.

References

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology licensed under CC BY 4.0

Neuroscientifically Challenged. (2014, July 22). *2-minute neuroscience: The neuron* [Video]. YouTube. https://www.youtube.com/watch?v=6qS83wD29PY

Image Credits (images are listed in order of appearance)

TE-Nervous_system_diagram by The Emirr, CC BY 3.0

NSdiagram by Fuzzform, CC BY-SA 3.0

The_Autonomic_Nervous_System by Geo-Science-International, CC0 1.0

Complete_neuron_cell_diagram_en by LadyofHats, Public domain

Generic_Neurotransmitter_System by National Institute on Drug Abuse (NIDA), Public domain

9.3 Nervous System Pathologies

This section examines some of the more common pathologies associated with the nervous system. Some of the rarer pathologies are also discussed because of their severity.

Alzheimer's disease: This is a form of dementia that is characterized by the accumulation of beta-amyloid plaque, a type of dense protein found in the cerebral cortex. It is a degenerative disease in which individuals experience memory loss and confusion. The brain atrophies (shrinks) as the condition progresses. Alzheimer's disease accounts for 60% to 80% of all dementia diagnoses, which makes it the most common type of dementia (Alzheimer Society, 2022). It is a fatal disease that affects all aspects of someone's life. Although it is a progressive degenerative disease, it affects everyone differently and progresses at varying rates among individuals (Alzheimer Society, 2022). Fig. 9.6 shows the differences between the brain of someone who has Alzheimer's disease compared to someone who does not. The sooner this disease is diagnosed and treated, the better the quality of life the patient will have as they progress through this condition (Alzheimer Society, 2022).

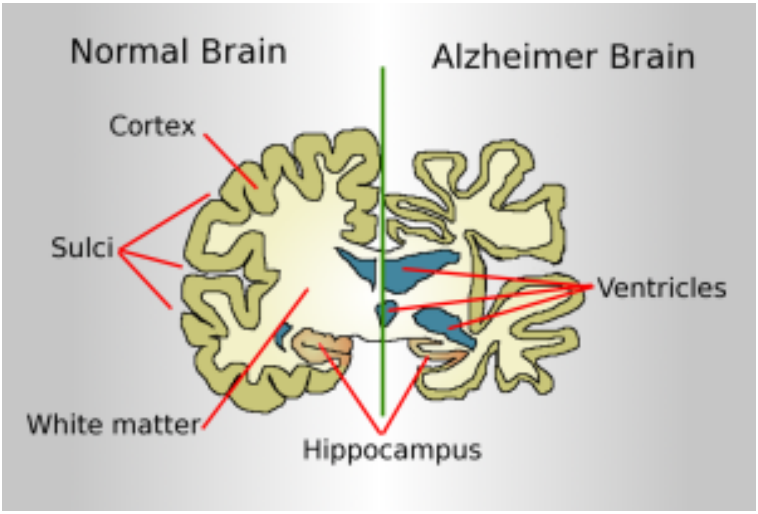


Fig. 9.6

Amyotrophic lateral sclerosis (ALS): A rare neurological disease, ALS mostly affects the nerve cells (neurons) responsible for controlling the voluntary muscles (NINDS, 2022). Voluntary muscles are the ones we choose to move. This disease is progressive, which means it will continue to worsen, and there is no cure (NINDS, 2022). The signs and symptoms of ALS begin with muscle weakness or stiffness, then progress to affect all the voluntary muscles. Eventually, patients lose their strength and the ability to speak, eat, move, and even breathe. Respiratory failure is usually the eventual cause of death, which typically occurs within three to five years after the onset of symptoms (NINDS, 2022).

Huntington's disease: This rare and inherited disease causes the progressive breakdown of nerve cells in the brain (Mayo Clinic, 2022). Symptoms generally appear in middle life and affect movement, cognition, and mental health (Mayo Clinic, 2022). They include involuntary movements, muscle rigidity, impaired gait and balance, and difficulty with speech. The disease also causes

cognitive deficits such as difficulty focusing, behaviour changes, lack of impulse control, and lack of awareness of one's own behaviours (Mayo Clinic, 2022). Depression and mania are also common symptoms for those with Huntington's disease. Medications can be used to manage many of the symptoms, but they will not prevent the progression of this condition (Mayo Clinic, 2022).

Parkinson's disease: A progressive disease of the nervous system, Parkinson's impairs a person's ability to move. The typical onset for symptoms is in the middle to later stages of life; there is no cure, and once symptoms develop, they will continue to worsen. The exact cause of this disease is unknown, but it is widely accepted that an imbalance of dopamine and acetylcholine play a role. Fig. 9.7 provides a list of the common motor- and non-motor-related symptoms that those with Parkinson's disease experience.

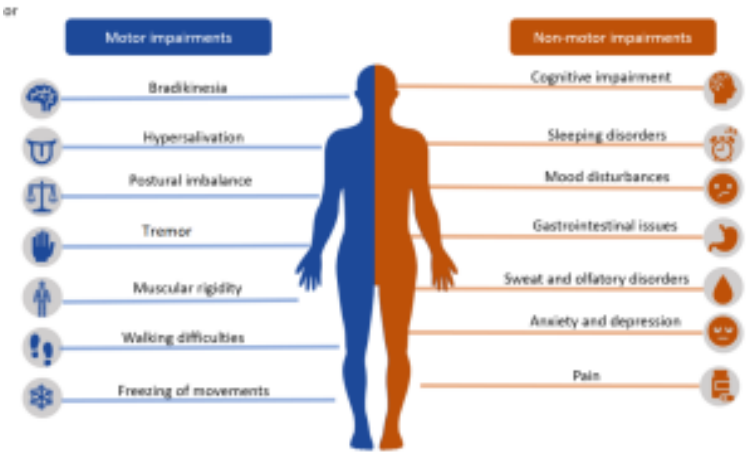


Fig. 9.7

Meningitis: This is an inflammation of the meninges—the three layers of fibrous membrane that surround the central nervous system (Betts et al., 2013). Meningitis can be caused by infection

by bacteria or viruses, and the particular pathogen that causes meningitis is not necessarily specific to the disease, so the bacteria or virus can also cause other infections in the body (Betts et al., 2013).

The symptoms associated with meningitis include fever, chills, nausea, vomiting, light sensitivity, neck soreness, and severe headache (Betts et al., 2013). There are also neurological symptoms such as changes in mental state, including confusion, memory deficits, and other dementia-like symptoms (Betts et al., 2013).

Bacterial meningitis is fatal in about 5% to 40% of children and 20% to 50% of adults (Betts et al., 2013); antibiotics are used to treat bacterial meningitis. Viral meningitis cannot be treated with antibiotics (Betts et al., 2013), but often, the symptoms are not as severe as for bacterial meningitis.

Multiple sclerosis (MS): This autoimmune disease is characterized by an abnormal response of the body's immune system directed against the central nervous system (CNS). The immune system causes inflammation within the CNS that damages **myelin**, as well as the nerve fibres themselves and the specialized cells that make myelin. When myelin or nerve fibres are damaged or destroyed, messages travelling through the CNS are altered or stopped completely. Damage to areas of the CNS produce a variety of neurological symptoms that will vary among people with MS. The damaged areas develop scar tissue that gives the disease its name—multiple areas of scarring, or multiple sclerosis. The cause of MS is not known, but it is believed to involve genetic susceptibility, abnormalities in the immune system, and environmental factors that combine to make MS symptoms variable and unpredictable. No two people have exactly the same symptoms, and each person's symptoms can change or fluctuate over time. One person might experience only one or two of the possible symptoms, whereas another person might experience several symptoms of the disease. Fig. 9.8 provides a summary of the common symptoms that those with multiple sclerosis may experience.

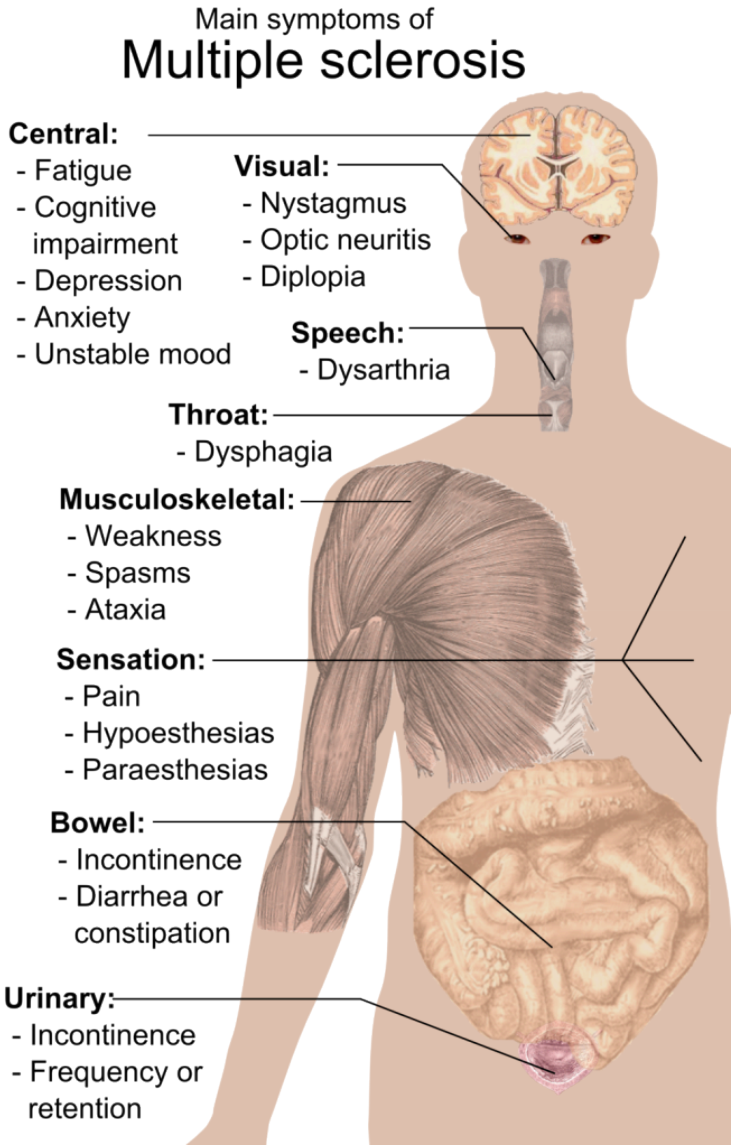

Main symptoms of
Multiple sclerosis
Central:
- Fatigue
- Cognitive impairment
- Depression
- Anxiety
- Unstable mood
Visual:
- Nystagmus
- Optic neuritis
- Diplopia
Speech:
- Dysarthria
Throat:
- Dysphagia
Musculoskeletal:
- Weakness
- Spasms
- Ataxia
Sensation:
- Pain
- Hypoesthesias
- Paraesthesias
Bowel:
- Incontinence
- Diarrhea or constipation
Urinary:
- Incontinence
- Frequency or retention

Fig. 9.8

At this time, there are no symptoms, physical findings, or laboratory tests that can, by themselves, be used to diagnose whether a person has MS. Several strategies are used to determine whether a person meets the criteria for a diagnosis of MS and to rule out other possible causes of whatever symptoms they are experiencing. These strategies include a detailed medical history, a neurological exam, and various tests, including magnetic resonance imaging (MRI), spinal fluid analysis, and blood tests.

Seizures: This condition is defined as the transient occurrence of signs and symptoms caused by abnormally excessive or synchronous neuronal activity in the brain. This means that during a seizure, large numbers of brain cells are activated abnormally at the same time. It is similar to an electrical storm in the brain and is shown in Fig. 9.9. Seizures may alter consciousness and produce abnormal motor activity. There are different classifications of seizures based on the severity of symptoms. Seizures can be diagnosed and identified based on a test called an **electroencephalogram** (EEG).

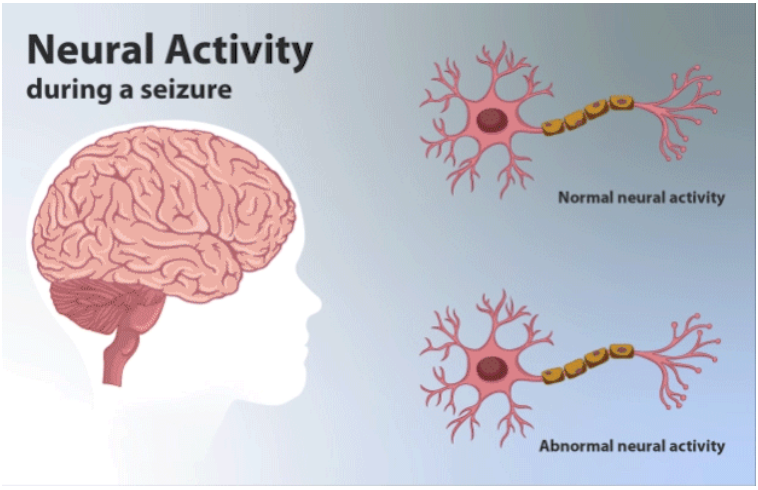


Fig. 9.9

Classification of Seizures

Seizures are classified in many ways, beginning with whether they are **focal** or **generalized**.

- **Focal seizures:** Onset is on one side of the brain, and these seizures are classified as simple, complex, or secondarily generalized.
    - **Simple partial seizures** are the most common and may affect both sensory and autonomic systems. These seizures may cause twitching or changes in sensation (CDC, 2022).
    - **Complex partial seizures** cause impairment of consciousness, with or without motor activity or other signs. The individual may appear dazed or confused (CDC, 2022).
    - Simple or complex partial seizures may become **secondarily generalized**, producing a **tonic-clonic** seizure (CDC, 2022).
- **Generalized seizures:** Onset is bilateral, on both sides of the brain, and these seizures are classified as absence or tonic-clonic.
    - **Absence seizures**, sometimes called **petit mal seizures**, can cause rapid blinking or a few seconds of staring into space.
    - **Tonic-clonic seizures**, also called **grand mal seizures**, can make a person exhibit the following symptoms(CDC, 2022):
        - Loss of consciousness
        - Muscle jerking (clonic)
        - Muscles becoming limp or weak (atonic)
        - Tense or rigid muscles (tonic)
- **Status epilepticus** is a state of repeated or continuous seizures and is often defined as a single seizure lasting more than 20 minutes or repeated seizures without recovery of consciousness. Prolonged status epilepticus can lead to

irreversible brain injury and has a very high rate of mortality. The goal of therapy should be to achieve control of a seizure within 60 minutes or less.

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/ licensed under CC BY 4.0

References

Alzheimer Society. (2022). *What is Alzheimer's disease?* https://alzheimer.ca/en/about-dementia/what-alzheimers-disease

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology licensed under CC BY 4.0

Centers for Disease Control and Prevention (CDC). (2022). *Types of seizures.* https://www.cdc.gov/epilepsy/about/types-of-seizures.htm

Mayo Clinic. (2022). *Huntington's disease.* https://www.mayoclinic.org/diseases-conditions/huntingtons-disease/symptoms-causes/syc-20356117#:~:text=Huntington's%20disease%20is%20a%20rare,(cognitive)%20and%20psychiatric%20disorders

National Institute for Neurological Disorders and Stroke (NINDS). (2022). *Amyotrophic lateral sclerosis (ALS) fact sheet.*

https://www.ninds.nih.gov/amyotrophic-lateral-sclerosis-als-fact-sheet#:~:text=get%20more%20information%3F-,What%20is%20amyotrophic%20lateral%20sclerosis%3F,chewing%2C%20walking%2C%20and%20talking

Image Credits (images are listed in order of appearance)

Brain-ALZH by Garrondo, Public domain

Parkinson_disease_symtpoms by CarrotsMitHummus, CC BY-SA 4.0

Symptoms_of_multiple_sclerosis by Mikael_Häggström, Public domain

Depiction_of_neural_activity_during_a_seizure by myUpchar, CC BY-SA 4.0

9.4 Nervous System Medications

The most common medications and medication categories for conditions of the nervous system are discussed below. Some conditions, such as multiple sclerosis, are very complex to treat and involve many medications, and as such, those pathologies and the medications used to treat them are not included below.

Anticonvulsants

Medications used for seizures are called **anticonvulsants**. Anticonvulsant medications stabilize cell membranes and suppress the abnormal electric impulses in the cerebral cortex. These medications prevent seizures but do not provide a cure. Anticonvulsants are classified as **central nervous system depressants**. There are many types of medications used to treat seizures, including phenytoin (Dilantin), phenobarbital (Luminal), benzodiazepines, carbamazepine (Tegretol), valproate (valproic acid), and levetiracetam (Keppra).

There are three main pharmacological effects of anticonvulsant medications. First, they increase the threshold of activity in the motor cortex, making it more difficult for nerves to become excited. Second, they limit the spread of a seizure discharge from its origin by suppressing the transmission of impulses from one neuron to the next. Third, they decrease the speed of nerve impulse conduction within a given neuron.

Hydantoin Medications

Phenytoin (Dilantin), which was discovered in 1938, is categorized as a **hydantoin medication**. It was the first anti-seizure medication and is still being used to control seizures. Phenytoin lessens the incidence of seizures by interfering with sodium channels in the brain, resulting in a reduction of sustained high-frequency neuronal discharges.

Phenytoin has a narrow therapeutic drug level, usually 10–20 mcg/mL, so serum drug monitoring is required. Serum levels of phenytoin sustained above the therapeutic range may produce delirium, psychosis, and encephalopathy, which means it is important, at the first sign of acute toxicity, for serum levels to be immediately checked.

Key Concept

A common **suffix** for hydantoin medications for epilepsy is **-toin**.

Examples: ethotoin (Peganone), fosphenytoin (Cerebyx), phenytoin (Dilantin)

Benzodiazepine Medications

Benzodiazepine medications exert an anticonvulsant effect on receptors in the brain stem. These medications can also be administered for other therapeutic reasons and for many other

pathologies that have been, or will be covered, in this book. Lorazepam, a benzodiazepine with anti-anxiety, sedative, and anticonvulsant effects, is available for oral, intramuscular, or intravenous routes of administration. Some of the various medication forms that lorazepam is offered in are shown in Figs. 9.10 and 9.11. Benzodiazepines are a controlled Schedule IV substance because they have the potential for abuse and may lead to dependence.

Key Concept

A common **suffix** for benzodiazepines is **-azepam**.
Examples: clonazepam (Klonopin), diazepam (Valium), lorazepam (Ativan)

*Fig.*9.10

Fig. 9.11

Barbiturate Medications

The therapeutic actions of **barbiturate medications** include long-acting sedative and anticonvulsant effects. Phenobarbital is an example of a barbiturate primarily used as a sedative and to treat seizure disorders. In high doses, it can be used to induce anesthesia, and overdose can cause death. In the 1960s and 1970s, barbiturates were used to treat anxiety and insomnia but are no longer used for these purposes because of the serious adverse effects of these drugs.

Key Concept

A common **suffix** for barbiturate medications is **-barbital**. **Examples:** mephobarbital (Mebaral), phenobarbital (Luminal)

Levetiracetam

Levetiracetam is indicated as **adjunctive therapy** in the treatment of partial onset seizures in patients with epilepsy and is generally

well tolerated. The exact mechanism of action is unknown, but this medication may interfere with sodium, calcium, potassium, or GABA transmission. Withdrawal seizures may occur if levetiracetam is stopped abruptly.

Gabapentin

Gabapentin is indicated as an **adjunctive treatment** for partial seizures, but it is most commonly used to treat neuropathic pain. An example of neuropathic pain is tingling or burning in the lower extremities that often occurs in patients with diabetes. The exact mechanism of action is unknown.

Antiparkinson Medications

Parkinson's disease is believed to be related to an imbalance of dopamine and acetylcholine and a deficiency of dopamine in certain areas of the brain, so drug therapies are aimed at increasing levels of dopamine and/or antagonizing the effects of acetylcholine. Drug therapy does not cure the disease but is used to slow the progression of symptoms. Common medications used to treat Parkinson's disease are carbidopa/levodopa, selegiline, and amantadine.

Carbidopa/Levodopa

Carbidopa/levodopa, shown in Fig. 9.12, is the most common drug used to treat Parkinson's disease and is usually started as soon as the patient becomes functionally impaired. The administration of dopamine is ineffective in the treatment of Parkinson's disease

because it does not cross the blood-brain barrier, but levodopa, the metabolic precursor of dopamine, does cross the blood-brain barrier and presumably is converted to dopamine in the brain. Carbidopa is combined with levodopa to help stop the breakdown of levodopa. Additionally, the incidence of levodopa-induced nausea and vomiting is less when levadopa is combined with carbidopa.

Fig. 9.12

Selegiline

Selegiline is often used in conjunction with carbidopa/levodopa when patients demonstrate a deteriorating response to that treatment; it is helpful for controlling symptom fluctuations. Selegiline inhibits MAO-B, blocking the breakdown of dopamine. There is no evidence from controlled studies that selegiline has any beneficial effect in the absence of concurrent levodopa therapy.

Amantadine

Amantadine is used in the early stages of Parkinson's disease, but it can be effective in moderate or advanced stages in reducing tremors and muscle rigidity. The exact mechanism of action is unknown, but it is an antiviral drug that acts on dopamine receptors.

None of these medications can cure Parkinson's, and over time, it is not uncommon for tolerance to these medications to increase, so the dose often needs to be increased to maintain the same therapeutic effect. Eventually, the side effects also become worse, so at a certain point, the physician may place the patient on a "drug holiday." This means the patient stops taking medications for a few days, then restarts at a lower dose.

Alzheimer's Medications

The most common medication given for Alzheimer's disease is **donepezil (Aricept)** (WebMD, 2022). Although this medication, and all others, will not prevent the progression of this disease, they will often slow the development and enable patients to have better standard of living. Other common medications are **galantamine**

(Razadyne) and **tacrine (Cognex)** (WebMD, 2022). **Rivastigmine (Exelon)** is another option and can be given via a transdermal patch that only needs to be changed once a day (WebMD, 2022). This is ideal when Alzheimer's, or other types of dementia, become advanced, and patients are uncooperative when taking oral medications.

Insomnia Medications

Many patients with neurological disorders also have insomnia. Although anyone can experience insomnia, those with any of the nervous system pathologies discussed in this chapter are more susceptible (Betts et al., 2013). Insomnia is generally characterized by difficulty falling asleep, difficulty staying asleep, or difficulty getting back to sleep. There are many factors that can make insomnia worse, including stress, anxiety, and pain (Betts et al., 2013). Typically, medications used to treat insomnia are classified as hypnotics or sedatives.

Nonbarbiturate Hypnotic or Sedative Medications

Nonbarbiturate hypnotic or sedative medications work by depressing the central nervous system in order to produce sedation and sleep. They are regulated because they have the potential for addiction. Some examples of these types of medications include the following:

- Chloral hydrate (Somnote)
- Zopiclone (Imovane)
- Zolpidem (Ambien, Intermezzo, Zopimist)

Anti-Anxiety (Benzodiazepines) and Antidepressant Medications

Certain medications, which can also be prescribed for anxiety or depression, may also be given for insomnia. Some of them are listed below:

- Anti-anxiety medications:
  - Flurazepam (Dalmane)
  - Temazepam (Restoril)
  - Triazolam (Halcion)

- Antidepressant drugs for insomnia:
  - Doxepin (Silenor)
  - Trazodone (Oleptra)

Melatonin

The hormone **melatonin** is secreted by the pineal gland and regulates the 24-hour wake-sleep cycle (Betts et al., 2013). Melatonin, shown in Fig. 9.13, can be purchased over the counter (OTC) and used to stimulate the melatonin receptors, resulting in an increased desire to sleep. It is one of the few non-prescription sleep aids available (Betts et al., 2013).

Fig. 9.13

Table 9.1. Common Nervous System Medications

Generic	Trade	Reason For Administering
carbamazepine	Tegretol	seizure disorders
valproate	Valproic acid	seizure disorders
ethotoin	Peganone	seizure disorders
fosphenytoin	Cerebyx	seizure disorders
gabapentin	Neurontin	seizure disorders
levetiracetam	Keppra	seizure disorders
mephobarbital	Mebaral	seizure disorders
phenobarbital	Luminal	seizure disorders
phenytoin	Dilantin	seizure disorders
amantadine	Gocovri	Parkinson's disease
carbidopa/levodopa	Sinemet	Parkinson's disease
selegiline	Eldepryl, Emsam	Parkinson's disease
donepezil	Aricept	Alzheimer's disease/dementia
razadyne	Galantamine	Alzheimer's disease/dementia
rivastigmine	Exelon	Alzheimer's disease/dementia
tacrine	Cognex	Alzheimer's disease/dementia

chloral hydrate	Somnote	Insomnia
zopiclone	Imovane	Insomnia
zolpidem	Ambien, Intermezzo, Zopimist	Insomnia
flurazepam	Dalmane	Insomnia/anxiety
temazepam	Restoril	Insomnia/anxiety
triazolam	Halcion	Insomnia/anxiety
doxepin	Silenor	Insomnia/depression
trazodone	Oleptra	Insomnia/depression

(WebMD, 2022)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/ licensed under CC BY 4.0

References

Betts, J. G., Young, K. A., Wise, J. A., Johnson, E., Poe, B., Kruse, D. H., Korol, O., Johnson, J. E., Womble, M., & DeSaix, P. (2013). *Anatomy and physiology*. OpenStax. https://openstax.org/details/books/anatomy-and-physiology licensed under CC BY 4.0

WebMD. (2022). *Drugs & medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

Loratsepaamiin_perustuvia_lääkkeitä by Melissan, Public domain
Lorazepam2mgmLvial by Stickpen, Public domain
Medicationlevodopa by Revion101, CC BY-SA 4.0
Melatonin_prescription by Murrur, CC BY-SA 3.0

9.5 Review

Chapter Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=362#h5p-14

Chapter Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=362#h5p-15

Trade and Generic Name Review

An interactive H5P element has been excluded from

this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=362#h5p-13

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/ licensed under CC BY 4.0

CHAPTER X

PSYCHIATRIC CONDITIONS & MEDICATIONS

10.1 Introduction to Psychiatric Conditions and Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Explain the term “anxiety”
2. Identify common medications to treat anxiety
3. Explain the term “depression”
4. Identify common medications used to treat depression
5. Describe other common psychiatric pathologies
6. Identify common medications used to treat other common psychiatric pathologies
7. Define common medication terms related to addiction and the medications used to treat it

Chapter Overview

Psychiatric medications are commonly prescribed within the hospital setting and for patients in the community as well. As you will see while going through this chapter, there are a number of different medications that can be given for the same pathologies. Many work in similar or just slightly different ways, but some patients respond better to one versus another. A very basic review of neurotransmitters, similar to Chapter 9, will be covered, followed by a thorough discussion of some of the more common psychiatric pathologies. Treatment options, specifically medications, will be discussed, and then an introduction to the topic of addiction will be provided. Considering how common these medications are within the medical system, this chapter will help provide the foundation needed by new healthcare professionals.

10.2 Psychiatric Pathologies

This chapter is a little different from the others in that it does not focus on a whole body system, but rather deals specifically with psychiatric pathologies and medications. Also, because **neurotransmitters** and concepts such as **synapses** were discussed in the nervous system chapter, this chapter will simply provide a basic review of these topics before delving into pathologies. When discussing psychiatric pathologies and medications, many of the potential causes and treatments revolve around neurotransmitters—either too much or too little of a certain neurotransmitter.

For example, as discussed in Chapter 9, **dopamine** is strongly linked to motor and cognition. This neurotransmitter influences movement and can be associated with ADHD, paranoia, and schizophrenia. **Serotonin** is also heavily involved in many body processes, and abnormal levels of serotonin can affect sleep, libido, mood, and temperature regulation. Alterations of serotonin have been linked to many mental health issues such as depression, bipolar disorder, anxiety, and body function disorders. **Gamma-aminobutyric acid (GABA)** also assists with communication in the brain, and low levels of this neurotransmitter have been linked to issues such as anxiety, seizures, mania, and impulse control.

Although there are numerous potential psychiatric pathologies, only the most common and prevalent will be discussed below. Often the treatments and medications for many of these, and some not discussed here, are very similar, so this chapter provides a good overview of psychiatric pathologies and treatment options.

Anxiety: This is a group of conditions marked by pathological or

extreme anxiety or dread. Individuals with anxiety experience disturbances of mood, behaviour, and most systems in the body, making them unable to continue with everyday activities. The psychiatric disorder of anxiety also occurs when the intensity and duration of anxiety does not match the potential for harm or threat to the affected person.

Common signs and symptoms of anxiety:

- Aches
- Pains
- Stomachache
- Headache
- Heart racing or pounding
- Trembling
- Sweating
- Difficulty concentrating
- Increased agitation

Depression: This frequently occurring pathology affects up to 5% of the population. To be diagnosed with depression, five of the symptoms listed below must be present during the same two-week period and represent a change from previous functioning. The symptoms cause clinically significant distress or impairment in social, occupational, or other important areas of functioning.

Common signs and symptoms of depression:

- Depressed mood
- Diminished interest
- Weight gain or weight loss when not dieting
- Insomnia or hypersomnia
- Agitation
- Fatigue or loss of energy
- Feeling of worthlessness
- Inappropriate guilt
- Diminished ability to concentrate

- Thoughts of death, suicidal ideation, or suicide attempt

The video below provides an overview of anxiety and depression, as well as the potential causes for such pathologies.

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=796#oembed-1*

(SciShow Psych, 2019)

Bipolar disorder: This disorder is marked by extreme mood swings. Typically, patients experience extreme highs (called **mania** or **hypomania**) alternating with extreme lows (depression). Often those with this pathology will have periods without symptoms between the periods of extreme highs and lows.

Common signs and symptoms of mania:

- Rapid speech
- Hyperactivity
- Reduced need for sleep
- Flight of ideas
- Grandiosity
- Poor judgement
- Aggression or hostility
- Risky sexual behaviour
- Neglect of basic self-care

Schizophrenia: This pathology refers to a group of severe, disabling psychiatric disorders marked by withdrawal from reality, illogical thinking, **delusions**, **hallucinations**, and **flat affect**. Fig. 10.1 provides an overview of some of the changes that may occur in the brain of someone with schizophrenia.

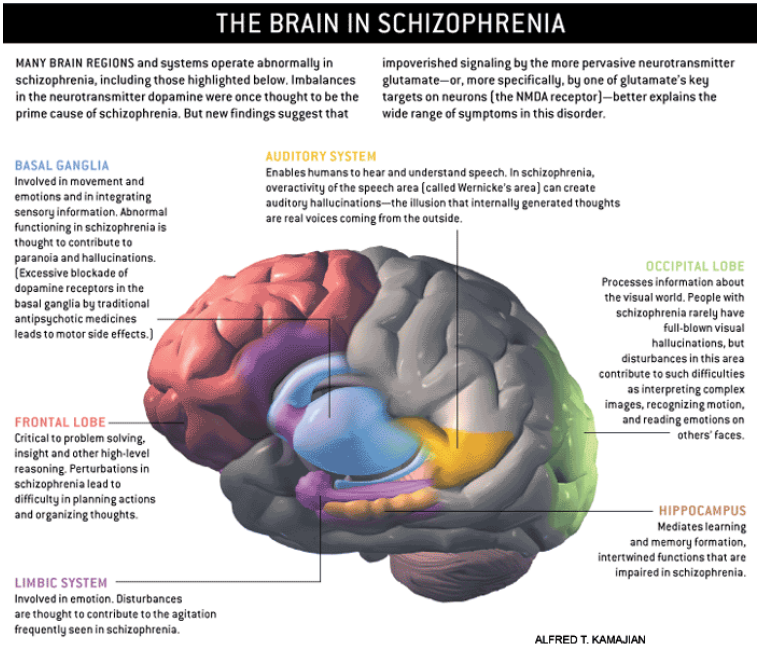


Fig. 10.1

Schizophrenia affects people from all walks of life and usually first appears between the ages of 15 and 30. Not everyone will experience the same symptoms, but many symptoms are common, such as withdrawing, hearing voices, talking to oneself, seeing things that are not there, neglecting personal hygiene, and showing low energy.

Common signs and symptoms of schizophrenia:

> There are three types of symptoms related to schizophrenia: **positive**, **negative**, and **cognitive**. Note that in this context, the word *positive* is not the same as "good." Rather, positive symptoms demonstrate how the individual has lost touch with reality.

- **Positive symptoms:**
    - **Delusions**
    - **Hallucinations**
    - Disorganized thinking and behaviour
- **Negative symptoms:**
    - Apathy (lack of interest in people, things, activities)
    - Lack of motivation
    - Blunted affect
    - **Poverty of speech**
    - **Anhedonia**
    - Avoidance of relationships
- **Cognitive symptoms:**
    - Poor decision making
    - Loss of memory
    - Distracted
    - Difficulty focusing

The video below describes some of the more complex aspects of schizophrenia:

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=796#oembed-2

(Neuroscientifically Challenged, 2022)

Attention-deficit hyperactivity disorder (ADHD): This condition is characterized by hyperactivity, lack of impulse control, and lack of attention that interferes with how a person functions. ADHD is

often diagnosed during childhood, but the signs and symptoms can last through adulthood.

Common signs and symptoms of ADHD:

- Hyperactivity
- Inability to concentrate
- Difficulty with self-control
- Lack of emotional control

A child with ADHD may have difficulty sitting still and focusing at school or have emotional outbursts. These behaviours often impact their life.

Post-traumatic stress disorder (PTSD): This mental health pathology is often triggered by either experiencing or witnessing a terrifying or traumatic event. Symptoms can vary but may include flashbacks, nightmares, and severe anxiety, as well as uncontrollable thoughts about the event (Mayo Clinic, 2023).

It is common for most people who experience a traumatic event to have temporary difficulty adjusting and coping, but with time and good self-care, they can get better (Mayo Clinic, 2023). If the symptoms worsen, last for longer periods of time, or interfere with day-to-day functioning, the individual may have developed PTSD (Mayo Clinic, 2023). This pathology was originally referred to as "shell shock" in the First World War and was applied to soldiers who had difficulty adjusting to everyday life after fighting in a war. Since then, the definition has evolved and extended to other situations.

Common signs and symptoms of PTSD (Mayo Clinic, 2023):

- Recurrent, unwanted, distressing memories of a traumatic event
- Flashbacks—reliving the traumatic event as if it were happening again
- Upsetting dreams or nightmares about the traumatic event
- Severe emotional distress or physical reactions to

something that reminds the person of the traumatic event
    - Trying to avoid thinking or talking about the traumatic event
    - Avoiding places, activities, or people that remind the person of the traumatic event
    - Negative thoughts about oneself, other people, or the world
    - Memory problems

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Mayo Clinic. (2023). *Post-traumatic stress disorder (PTSD)*. https://www.mayoclinic.org/diseases-conditions/post-traumatic-stress-disorder/symptoms-causes/syc-20355967#:~:text=Post%2Dtraumatic%20stress%20disorder%20(PTSD)%20is%20a%20mental%20health,uncontrollable%20thoughts%20about%20the%20event

Neuroscientifically Challenged. (2022, 3 June). *2-minute neuroscience: Schizophrenia* [Video]. YouTube. https://www.youtube.com/watch?v=pjTmZqBNB78

SciShow Psych. (2019, February 28). *Why do depression and anxiety go together?* [Video]. YouTube. https://www.youtube.com/watch?v=xdAjGRvxGPM

Image Credits (images are listed in order of appearance)

Schizophrenia brain large by Jurgitta, CC BY-SA 4.0

10.3 Antidepressant and Anti-Anxiety Medications

Many of the medications that will be discussed here can be used to treat a few different pathologies. For example, antidepressants may also be given to patients with anxiety. This may possibly be because the patient suffers from both pathologies or because it is effective for long-term treatment for either pathology. Treatment of depression, and most other pathologies that have been discussed, may include medication, but also ideally a mix of **psychotherapy**, **cognitive behavioural therapy** (CBT), possibly **electroconvulsive therapy** (ECT), and maybe even group therapy.

Antidepressant Medications

Antidepressants, also known as **mood-elevating medications**, are used to treat depression and other mental health disorders, as well as other medical conditions such as migraine headaches, chronic pain, and premenstrual syndrome. Antidepressants increase levels of **neurotransmitters** in the central nervous system, including serotonin, dopamine, and norepinephrine.

Four classes of antidepressants will be discussed, including **tricyclic antidepressants (TCAs)**, **selective serotonin reuptake inhibitors (SSRIs)**, **serotonin norepinephrine reuptake inhibitors (SNRIs)**, and **monoamine oxidase inhibitors (MAOIs)**. TCAs and MAOIs are referred to as first-generation antidepressants because they were first marketed in the 1950s. SSRIs and SNRIs are called second-generation antidepressants and are popular because they have fewer side effects.

Black Box Warnings are in place for all classes of antidepressants used with children, adolescents, and young adults because of a higher risk of suicide. All patients receiving antidepressants should be monitored for signs of worsening depression or changes in behaviour, especially when the medication is started or dosages are changed.

Monoamine Oxidase Inhibitors (MAOI)

Monoamine oxidase inhibitors (MAOIs) are a first-generation antidepressant. A significant disadvantage to MAOIs is their potential to cause a **hypertensive** crisis when taken with stimulant medications or foods containing **tyramine**.

Tranylcypromine (Parnate) is an example of an MAOI. The mechanism of action of tranylcypromine is not fully understood but is presumed to be linked to the potentiation of monoamine **neurotransmitter** activity in the central nervous system resulting from its irreversible **inhibition** of the enzyme monoamine oxidase (MAO). MAO inactivates norepinephrine, dopamine, epinephrine, and serotonin. Tranylcypromine is indicated for the treatment of major depressive disorder in adult patients who have not responded to other antidepressants. It may also be used to treat Parkinson's disease.

MAOs must be used with caution due to the risks of a hypertensive crisis, serotonin syndrome, and increased suicidality. A hypertensive crisis is defined by severe hypertension (blood pressure greater than 180/120 mmHg) with evidence of organ dysfunction. Symptoms may include a headache (which may radiate frontally), chest palpitations, neck stiffness or soreness, nausea and/or vomiting, sweating, dilated pupils, **photophobia**, shortness of breath, and/or confusion. Either **tachycardia** or **bradycardia** may be present and may be associated with chest pain.

Other potential side effects include **mania**, **orthostatic hypotension**, seizures, **hypoglycemia** in diabetic patients,

decreased appetite and weight loss, dizziness, headache, drowsiness, and restlessness.
Examples of monoamine oxidase inhibitors:

- bupropion (Aplenzin, Wellbutrin)
- nefazodone (Oleptro)
- trazodone (Brintellix)

Tricyclic Antidepressants

Tricyclic antidepressants (TCAs) were one of the original first-generation antidepressants and were named for the triple-ring configuration in their chemical structure. Owing to the popularity of SSRIs and SNRIs, TCAs are now more commonly used to treat **neuropathic** pain and insomnia.

Amitriptyline (Elavil) is an antidepressant that also has sedative effects. Its mechanism of action is not known. Amitriptyline inhibits the membrane pump mechanism responsible for the uptake of norepinephrine and serotonin in neurons. This interference with the reuptake of norepinephrine or serotonin is believed to cause the antidepressant activity of amitriptyline.

Potential side effects of TCA include the following:

- **Tachycardia**
- Urinary retention
- Constipation
- Dry mouth
- Blurred vision
- Exacerbation of narrow-angle glaucoma
- Cognitive impairment
- Psychomotor slowing
- Confusion
- Sedation
- Delirium

If the physician decides to stop the medication after prolonged use, it is important to gradually decrease the dosage to avoid symptoms such as nausea, headache, and malaise.

Examples of tricyclic antidepressants:

- amoxapine (Asendin)
- desipramine (Norpramin)
- doxepin (Sinequan)
- imipramine (Tofranil)
- nortriptyline (Aventyl, Pamelor)

Key Concept

Common **suffixes** for **tricyclic antidepressants** is
-triptyline
Examples: Amitriptyline (Elavil)

Selective Serotonin Reuptake Inhibitors (SSRIs)

Selective serotonin reuptake inhibitors (SSRIs) are second-generation antidepressants and have fewer side effects than TCAs and MAOIs. SSRIs inhibit the reuptake of serotonin. They are primarily used to treat depression, but are also used to treat obsessive compulsive disorder, bulimia, panic disorder, post-traumatic stress disorder, some forms of anxiety, premenstrual syndrome, and migraines.

The development of potentially life-threatening serotonin syndrome or neuroleptic malignant syndrome (NMS)–like reactions have been reported with SNRIs and SSRIs. Symptoms of serotonin syndrome may include mental status changes (e.g., agitation,

hallucinations, and coma), autonomic instability (e.g., **tachycardia** and hyperthermia), and gastrointestinal symptoms (nausea, vomiting, and diarrhea). Serotonin syndrome, in its most severe form, can resemble neuroleptic malignant syndrome (NMS), which includes hyperthermia, muscle rigidity, possible rapid fluctuation of vital signs, and mental status changes.

Examples of SSRIs:

- citalopram (Celexa)
- escitalopram (Lexapro)
- fluoxetine (Prozac) (Fig. 10.2)
- fluvoxamine (Luxor)
- proxetine (Paxil)
- sertraline (Zoloft)

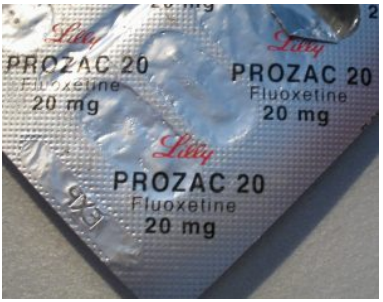


Fig. 10.2

Key Concept

Common **suffixes** for **SSRIs** are **-pram, -oxamine,** and **-oxetine**.
Examples: citalopram (Celexa), fluvoxamine (Luxor), paroxetine (Paxil)

Serotonin Norepinephrine Reuptake Inhibitors (SNRIs)

Serotonin norepinephrine reuptake inhibitors (SNRIs) are indicated for the treatment of major depressive disorders. SNRIs work by inhibiting the reuptake of serotonin and norepinephrine, with weak **inhibition** of dopamine reuptake.

Examples of SNRIs:

- desvenlafaxine (Pristiq)
- duloxetine (Cymbalta)
- levomilnacipran (Fetzima)
- venlafaxine (Effexor) (Fig. 10.3)

Fig. 10.3

The video below provides an overview of antidepressants and how they can be treated with antidepressants:

> *One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=798#oembed-1*

(Miller, 2015)

Anti-Anxiety Medications

Anxiety treatment can include non-pharmacological interventions as well as medications. Non-pharmacological interventions to decrease anxiety include relaxation techniques such as deep breathing, exercise, **psychotherapy**, support groups, or **cognitive behavioural therapy** (CBT). **Anti-anxiety medications**, also referred

to as **anxiolytics**, can also be used to help patients feel more at ease and can be used as needed (PRN). Many anti-anxiety medications are classified as minor tranquilizers and include benzodiazepines.

Benzodiazepines

Benzodiazepines are given for acute, or sometimes ongoing, anxiety. They are a controlled **Schedule IV** substance because they have the potential for abuse and may lead to dependence. As discussed in previous chapters, benzodiazepines can also be used for their sedative and anticonvulsant effects.

Examples of benzodiazepines:

- alprazolam (Xanax) (Fig. 10.4)
- chlordiazepoxide (Librium)
- diazepam (Valium)
- lorazepam (Ativan)

Fig. 10.4

Key Concept

A common **suffix** for **benzodiazepines** is **-azepam**.
Examples: diazepam (Valium), lorazepam (Ativan)

Antidepressants for Anxiety

Patients experiencing anxiety may also be prescribed the antidepressant medications discussed above. It is not uncommon for patients to be on tricyclic antidepressants (TCAs), selective serotonin reuptake inhibitors (SSRIs), or serotonin and norepinephrine reuptake inhibitors (SNRIs).

Table 10.1. Common Psychiatric Medications

Generic Name	Trade Name	Reason for Administering
tranylcypromine	Parnate	Depression, Parkinson's disease
bupropion	Aplenzin, Wellbutrin	Depression
nefazodone	Oleptro	Depression
trazodone	Brintellix	Depression
amitriptyline	Elavil	Depression, insomnia, neuropathic pain
amoxapine	Asendin	Depression, insomnia, neuropathic pain
desipramine	Norpramin	Depression, insomnia, neuropathic pain
doxepin	Sinequan	Depression, insomnia, neuropathic pain
imipramine	Tofranil	Depression, insomnia, neuropathic pain
nortriptyline	Aventyl, Pamelor	Depression, insomnia, neuropathic pain
citalopram	Celexa	Depression
escitalopram	Lexapro	Depression
fluoxetine	Prozac	Depression

fluvoxamine	Luxor	Depression
paroxetine	Paxil	Depression
sertraline	Zoloft	Depression
desvenlafaxine	Pristiq	Depression
duloxetine	Cymbalta	Depression
levomilnacipran	Fetzima	Depression
venlafaxine	Effexor	Depression
diazepam	Valium	Anxiety
chlordiazepoxide	Librium	Anxiety
alprazolam	Xanax	Anxiety
lorazepam	Ativan	Anxiety

(WebMD, 2022)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Miller, B. (2015, August 28). *Treating depression with antidepressants* [Video]. YouTube. https://www.youtube.com/watch?v=pGEQILM7C7Y&t=2s&ab_channel=BrookeMiller

WebMD. (2023). *Drugs and medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

Prozac by Maksim, CC BY-SA 3.0

Venlafaksiiniin perustuvia lääkkeitä by Anniina Järvelä, Public domain

Boites de Xanax et d'alprazolam en ce moment dans les pharmacies by Gotgot44, CC BY-SA 4.0

10.4 Other Psychiatric Medications

Antipsychotic Medications

Antipsychotic medications are used to treat psychosis, schizophrenia, extreme **mania**, depression that is resistant to other therapy, and other central nervous system conditions. The symptoms of psychosis generally include **delusions**, **hallucinations**, bizarre behaviour, and inappropriate moods. Schizophrenia is the most common form of psychosis, though there are other types and causes, such as drug-induced psychosis. Antipsychotics are sometimes referred to as **major tranquilizers** because they produce a state of tranquility. Although the medications that were discussed in the section on anti-anxiety medications are referred to as **minor tranquilizers**, it is important to note that they are actually unrelated to major tranquilizers and work very differently within the body.

All antipsychotics block dopamine receptors in the brain; however, the precise mechanism of action is not clearly known. Conventional antipsychotics, such as **haloperidol** (Fig. 10.5), block dopamine receptors in certain areas of the central nervous system. These areas are associated with emotions, cognitive function, and motor function, and blockage produces a tranquilizing effect in patients suffering from psychosis. However, several adverse effects are also caused by this dopamine blockade.

Fig. 10.5

Table 10.2. Potential Adverse Effects of Antipsychotic Medications

Adverse Effect	Definition
Tardive dyskinesia	Involuntary contraction of the oral and facial muscles (such as tongue thrusting) and wavelike movements of the extremities
Neuroleptic malignant syndrome (NMS)	A potentially life-threatening adverse effect that includes high fever, unstable blood pressure, and **myoglobinemia**
Extrapyramidal symptoms	Involuntary motor symptoms similar to those associated with Parkinson's disease; includes symptoms such as **akathisia** and acute **dystonia**

(Ernstmeyer & Christman, 2020)

Second-generation antipsychotics, also referred to as **atypical antipsychotics**, have fewer adverse effects. An example of an atypical antipsychotic is **risperidone (Risperdal)** (Fig. 10.6). Second-generation, or atypical, antipsychotics block specific dopamine 2 receptors and specific serotonin 2 receptors, resulting in fewer adverse effects. Atypical antipsychotics may also cause metabolic changes such as **hyperglycemia**, **hyperlipidemia**, and weight gain.

Fig. 10.6

ADHD Medications

Methylphenidate (Ritalin) and **amphetamine (Adderall)** are examples of central nervous system stimulants that are often used to treat ADHD. Both are thought to block the reuptake of norepinephrine and dopamine into the presynaptic neurons. They can also stimulate the brain and act similarly to **amphetamines**. These medications have a high potential for abuse and dependence, so they are highly controlled.

Anti-Mania Medications

Mood stabilizers are used to treat bipolar disorder. **Lithium (Lithobid)** was the first medication used to treat this disorder and is sometimes referred to as an **anti-mania drug** because it can help control the mania that occurs in bipolar disorder. Lithium alters sodium transport in nerve and muscle cells, but the specific mechanism of action is unknown.

Lithium must be closely monitored and has a narrow therapeutic serum range. Serum sodium levels should also be monitored for potential **hyponatremia**.

Addiction

Addiction is a substance-related disorder characterized by an intense urge and use of a substance (University of Toledo, 2022). It often results from ongoing use, and abuse, of drugs or chemicals to achieve a desired physical or emotional effect (a "high," sedation, or

hallucination). Eventually, an individual develops a tolerance to the substance and requires more of it to achieve the same effect they once had (University of Toledo, 2022). As such, more of a given substance may be used, and the frequency of use increases. Common drugs or medications that are abused include heroin, cocaine, narcotics, barbiturates, anti-anxiety medications, and alcohol.

Over a period of time and with use of the substance, physical dependence on the substance develops and withdrawal symptoms are experienced if substance use is not continued (University of Toledo, 2022).

Withdrawal symptoms include the following (University of Toledo, 2022):

- Irritability
- Sleeplessness
- Depressed mood
- Anger
- Cravings
- Sweating
- Nausea and vomiting
- Tremors
- Confusion
- Emotional and physical pain

Medications Used to Assist Withdrawal

Some medications can be given to assist with the withdrawal process from certain substances. For example, **buprenorphine (Buprenex, Subutex)** can be given to lessen the withdrawal symptoms from addiction to heroin, cocaine, and narcotic medications (WebMD, 2023). **Methadone (Diskets, Dolophine)** is another, often more common medication that is prescribed to assist with withdrawal. It can be given on a long-term basis to prevent

re-addiction as well. Methadone is highly controlled, so when it is taken long term, individuals must go to a clinic daily to obtain their dose. Fig. 10.7 shows someone receiving their daily dose of methadone in liquid form. Methadone prevents withdrawal symptoms but does so in such a way that it does not produce the **euphoria** that was once achieved with substances such as heroin, cocaine, or narcotics.

Fig. 10.7

There are also certain medications that can be used to treat withdrawal from alcohol. **Acamprosate (Camprol)** and **disulfiram (Antabuse)** are commonly prescribed but work quite differently than those medications discussed above (Web MD, 2023). Acamprosate helps to reduce cravings, and disulfiram produces nausea, chest pain, and sweating if someone ingests alcohol. Because of the unpleasant symptoms that result when mixing alcohol and disulfiram, those on the medication are inclined to avoid alcohol.

Table 10.3. Common Psychiatric Medications

Generic Name	Trade Name	Reason for Administering
haloperidol	Haldol	Schizophrenia, mania, psychosis, Tourette's syndrome
risperidone	Risperdal	Schizophrenia, bipolar disorder, psychosis
methylphenidate	Ritalin, Concerta	ADHD
amphetamine	Adderall	ADHD
lithium	Lithobid	Mania (bipolar disorder)
buprenorphine	Buprenex, Subutex	Withdrawal from heroin, cocaine, or narcotic drugs
methadone	Diskets, Dolophine	Withdrawal from heroin, cocaine, or narcotic drugs
acamprosate	Camprol	Alcohol withdrawal
disulfiram	Antabuse	Alcohol withdrawal

(WebMD, 2023)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

University of Toledo Counseling Center. (2023). *Tolerance and withdrawal.* https://www.utoledo.edu/studentaffairs/counseling/selfhelp/substanceuse/marijuanatolerancewithdrawal.html#:~:text=tolerance%20is%20a%20physical%20effect,no%20longer%20having%20the%20substance

WebMD. (2023). *Drugs and medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

Haloperidol 2 by Intropin (Mark Oniffrey), CC BY-SA 4.0

Risperdal tablets by Housed, CC BY-SA 3.0

HIV in Indonesia (10701445183) by Department of Foreign Affairs and Trade, CC BY 2.0

10.5 Review

Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=804#h5p-19

Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=804#h5p-20

Trade and Generic Name Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=804#h5p-18

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

CHAPTER XI

ANALGESIC MEDICATIONS

11.1 Introduction to Analgesic Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Describe the two main analgesic medication categories
2. List the four therapeutic effects of aspirin
3. Describe two therapeutic effects of acetaminophen
4. Define nonsteroidal anti-inflammatory drugs (NSAIDs)
5. List common narcotic and non-narcotic analgesic medications
6. Identify common adverse and side effects to analgesic medications

Chapter Overview

Complaints of pain are one of the most common reasons that individuals seek out medical care. Pain indicates that something in the body is not right and potentially requires medical treatment. Whether it is a headache, a broken bone, labour pain, chest pain, or another condition, pain medications are commonplace in healthcare facilities and in the general community. Although this may be a shorter chapter compared to some others, it is nonetheless important content and includes knowledge that can be applied to your day-to-day work in any healthcare profession and facility.

11.2 Physiology of Pain

Before learning about the medications that are used to treat a patient's pain, it is important to review the physiology of pain, the types of pain, the means of assessing pain, and the reasons for administering analgesics.

Physiology of Pain

Pain occurs when there is tissue damage in the body. Tissue damage activates the pain receptors of the **peripheral nerves**. **Nociceptors**, which are the nerve endings that respond to painful stimuli, are located in arterial walls, joint surfaces, muscle fascia, periosteum, skin, and soft tissue. The cause of tissue damage may be physical, such as heat or pressure, or chemical, which results from pain-producing substances being released into the extracellular fluid surrounding the nerve fibres. These pain-producing substances activate pain receptors, increase the sensitivity of pain receptors, or possibly stimulate the release of inflammatory substances, such as **prostaglandins**.

For a person to feel pain, the signal from the **nociceptors** in peripheral tissues must be transmitted to the spinal cord and then to the hypothalamus and cerebral cortex of the brain. The signal is transmitted to the brain by two types of nerve cells—A-delta and C fibres. The **dorsal horn of the spinal cord** is the relay station for information from these fibres. In the brain, the **thalamus** is the relay station for incoming sensory stimuli, including pain. From the thalamus, the pain messages are relayed to the **cerebral cortex**, where they are perceived. This complex pathway can be seen in Fig. 11.1 below.

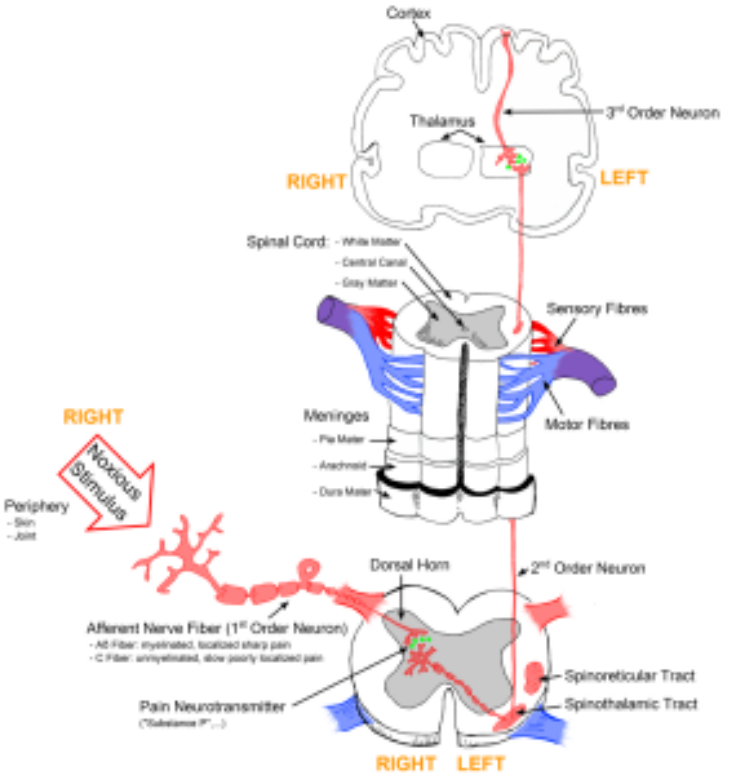


Fig. 11.1

Endogenous Analgesia

The **central nervous system (CNS)** actually has its own **endogenous** analgesia system for relieving pain. The CNS suppresses pain signals from peripheral nerves. **Opioid peptides** interact with **opioid receptors** to inhibit the perception and transmission of pain signals. These opioid peptides are **endorphins**, **enkephalins**, and **dynorphins**.

See the video below for more information about how the body perceives pain and an overview of how pain relievers work within

the body. This will introduce you to some of the discussion that you will find in this chapter.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=1108#oembed-1

(TED-Ed, 2012)

Types of Pain

Acute Pain

Acute pain comes on suddenly and is caused by something specific, such as a trauma. It is sharp in quality and usually does not last longer than a month. It goes away when there is no longer an underlying cause for the pain, either because the body has corrected the issue or medical treatment has relieved the causative factor.

Causes of acute pain include the following:

- Surgery
- Broken bones
- Dental work
- Burns or cuts
- Labour and childbirth

Chronic Pain

Chronic pain is pain that is ongoing and usually lasts longer than a couple of months. This type of pain can continue even after the injury or illness that caused it has healed or gone away. Pain signals remain active in the nervous system for weeks, months, or years. Some people suffer chronic pain even when there is no past injury or apparent body damage.

Chronic pain is linked to some health conditions:

- Arthritis
- Cancer
- Nerve pain
- Back pain
- Fibromyalgia pain

People who have chronic pain can have physical effects that are stressful on the body. These include tense muscles, limited ability to move around, lack of energy, and appetite changes. It is common to also have emotional effects of chronic pain, which can include depression, anger, anxiety, and fear of reinjury.

Pain Assessment

Analgesic medications are given to alleviate pain. However, pain can

be subjective and vary from person to person, so it is important to have ways of measuring someone's level of pain. This is accomplished by using different forms of a **pain scale**. Pain can be assessed according to a number of mnemonics (memory aids), such as **PQRST (Provoking factors, Quality, Region/Radiation, Severity, Time)** or simply measured according to a **scale from 1 to 10**, with 10 being the worst pain the patient has ever felt and 1 being no pain at all (Fig. 11.3). **Visual pain scales** have been developed as tools for communicating about pain with children through to patients at the end of life (Fig. 11.2). Visual pain scales are also helpful if the healthcare provider and the patient speak different languages or there are other communication issues.

Fig. 11.3

Fig. 11.2

The Ideal Analgesic

Throughout this chapter, we will discuss many common analgesics that can be used to relieve mild, severe, chronic, and acute pain. Pain is a phenomenon that unfortunately is seen on a daily basis within the community and throughout health care. This makes an "ideal analgesic" something that is greatly sought after and needed. In order for an analgesic to be "ideal," it would have to have certain qualities, including maximum pain relief, no side effects, and no possibility for addiction. Sadly, this ideal analgesic does not exist, as none of the medications that will be discussed have all of these qualities.

Types of Analgesics

Analgesics used to treat pain are categorized as **non-narcotic (non-opioid)**, **narcotic (opioid)**, and **adjuvant** medications. **Non-narcotic medications** include acetaminophen and nonsteroidal anti-inflammatory drugs (NSAIDs). There are several types of **narcotics**, and because of the possibility of abuse and addiction, they are all highly controlled. **Adjuvants** are defined as medications with a primary use other than pain relief, though they have analgesic properties in some painful conditions. This group includes numerous medications in various classes such as **gabapentin** (an anticonvulsant), **amitriptyline** (a tricyclic antidepressant), and certain muscle relaxants. We will discuss all these types of analgesics later in the chapter.

References

TED-Ed. (2012, June 26). *How do pain relievers work? – George Zaidan* [Video]. YouTube. https://youtu.be/9mcuIc5O-DE

Image Credits (images are listed in order of appearance)

Sketch colored final by Bettina Guebeli, CC BY-SA 4.0
Children's pain scale by Robert Weis, CC BY-SA 4.0
Pain scale with words by MissLunaRose12, CC BY-SA 4.0

11.3 Non-Narcotic Analgesics

Non-narcotic analgesics, often referred to as **non-opioid analgesics**, include **acetaminophen** and **nonsteroidal anti-inflammatory drugs (NSAIDs)**. These are only effective for mild to moderate pain and are often the first step for pain control. The advantages of these medications is that they are inexpensive, not addictive, and often available over the counter, which means that a prescription is not required.

Acetaminophen

Acetaminophen (Tylenol) inhibits the synthesis of **prostaglandins**, which may serve as mediators of pain and fever primarily in the central nervous system. It is used to treat mild pain and fever but does not have anti-inflammatory properties. Acetaminophen also does not have some of the side effects common to NSAIDs, such as stomach upset. It is not related to aspirin, which will be discussed later, so can be taken by individuals who are allergic to aspirin. There are a number of different types of acetaminophen available on the market, and two of those are shown in Fig. 11.4.

Fig. 11.4

Nonsteroidal Anti-Inflammatory Drugs (NSAIDs)

Nonsteroidal anti-inflammatory drugs (NSAIDs) have an analgesic effect, as well as **antipyretic** and anti-inflammatory actions. Some, such as aspirin, also have an **antiplatelet** effect. Aspirin and other NSAIDs relieve pain by inhibiting the biosynthesis of **prostaglandins** by different forms of the **COX enzyme**. COX-2 inhibitors, which are listed below, are different in that they are selective and only inhibit the COX-2 enzyme.

There are also possible side effects to taking NSAIDs, and these can vary depending on the type of NSAID, duration of use, and the patient's current condition. As a result of the inhibition of COX by NSAIDs, there is also decreased protection of the stomach lining, and gastric irritation and bleeding may occur when these

medications are taken. All NSAIDs except aspirin also increase the risk of heart attack, heart failure, and stroke. These can be fatal, and the risk is higher if the patient takes more of the medication than is directed or takes it for longer periods of time.

NSAIDs are used to treat various conditions, including the following:

- Osteoarthritis
- Rheumatoid arthritis
- Bursitis
- Tendinitis
- **Gout**
- Migraine headaches
- **Dysmenorrhea**

Key Concept

Common **suffixes** for **NSAIDs** are **–profen** and **–coxib**.
Examples: celecoxib (Celebrex), ibuprofen (Advil, Motrin)

Examples of NSAIDs (WebMD, 2023):

- celecoxib (Celebrex)
- diclofenac (Cataflam, Flector, Voltaren)
- etodolac (Lodine)
- fenoprofen (Nalfon)
- ibuprofen (Advil, Motrin)
- indomethacin (Indocin)
- ketoprofen (Ketofen, Anafen)

- ketorolac (Toradol)
- naproxen sodium (Aleve)

Ibuprofen

Ibuprofen (Advil, Motrin) inhibits **prostaglandin** synthesis. It is used for mild to moderate pain and is also an **antipyretic** with anti-inflammatory effects. Ibuprofen is used to treat common disorders, including rheumatoid arthritis and osteoarthritis, and pain associated with **dysmenorrhea**. It is safe for adults and for infants six months of age or older. Ibuprofen is sold under different trade names and is available in combination with other medications as well, such as cold medications. One option is shown in Fig. 11.5.

Fig. 11.5

Ketorolac

The NSAID **ketorolac (Toradol)** is commonly used for "breakthrough" pain that occurs during the treatment of severe acute pain being treated with opioids. It is often given in conjunction with certain narcotic medications when those alone do not relieve the patient's pain, and the pain "breaks through" the analgesic effect of the narcotic. Ketorolac inhibits **prostaglandin** synthesis and is indicated for the short-term management (up to five days in adults) of moderate to severe acute pain that requires narcotic analgesic medication.

Celecoxib

Celecoxib (Celebrex) is a COX-2 inhibitor and specifically inhibits the enzyme COX-2 that is required for the synthesis of **prostaglandins**. Celecoxib is often used to treat the pain associated with osteoarthritis, rheumatoid arthritis, and **ankylosing spondylitis**. It also relieves the pain associated with dysmenorrhea.

Acetylsalicylic acid and Other Salicylates

Acetylsalicylic acid (Bayer Aspirin, Ecotrin, Empirin) falls under a subcategory of NSAIDs called **salicylates** (Healthline, 2022). In some counties the generic name is also know as aspirin. Salicylates, which are derived from salicylic acid, are a group of chemicals that can be found naturally in plants and synthetically in medications such as aspirin (Healthline, 2022).

Fig. 11.6

Other salicylate medications:

- diflunisal (Dolobid)
- magnesium salicylate (Doan's)
- salsalate (Salsitab)

All salicylates have three therapeutic functions: analgesic, anti-inflammatory, and **antipyretic**. Aspirin shares these therapeutic functions by inhibiting the production of **prostaglandins**, but it also has a fourth therapeutic action that is unique and not shared by other salicylates—an **antiplatelet** function. This means it decreases platelet aggregation and can be taken daily to reduce the risk of heart attack and stroke. Aspirin is safe for adults and children older than 12 years of age.

The video below discusses the development of aspirin, how it was historically used, and how we currently use it in health care.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=1110#oembed-1

(TED-Ed, 2017)

Key Concept

Children and teenagers should not take aspirin to treat chickenpox or flu-like symptoms because of the risk of **Reye's syndrome**. Reye's syndrome primarily occurs in children in conjunction with a viral illness. It can cause symptoms such as persistent vomiting, confusion, or loss of consciousness, and requires immediate medical attention.

Table 11.1. Common Non-Narcotic Medications

Generic Name	Trade Name	Reason for Administering
acetaminophen	Tylenol	Mild to moderate pain, fever
celecoxib	Celebrex	Mild to moderate pain, inflammatory conditions
diclofenac	Cataflam, Flector, Voltaren	Mild to moderate pain, inflammatory conditions
etodolac	Lodine	Mild to moderate pain, inflammatory conditions
fenoprofen	Nalfon	Mild to moderate pain, inflammatory conditions
ibuprofen	Advil, Motrin	Mild to moderate pain, inflammatory conditions, fever
indomethacin	Indocin	Mild to moderate pain, inflammatory conditions
ketoprofen	Ketofen, Anafen	Mild to moderate pain, inflammatory conditions
ketorolac	Toradol	Mild to moderate pain, inflammatory conditions
naproxen	Aleve	Mild to moderate pain, inflammatory conditions

acetylsalicylic acid	Bayer Aspirin, Ecotrin, Empirin	Mild to moderate pain, inflammatory conditions, fever, blood clots
diflunisal	Dolobid	Mild to moderate pain, inflammatory conditions, fever
magnesium salicylate	Doan's	Mild to moderate pain, inflammatory conditions, fever
salsalate	Salsitab	Mild to moderate pain, inflammatory conditions, fever

(WebMD, 2023)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Healthline. (2022). *Salicylate sensitivity: Causes, symptoms, and foods to avoid.* https://www.healthline.com/nutrition/salicylate-sensitivity#TOC_TITLE_HDR_2

TED-Ed. (2017, October 2). *How aspirin was discovered – Krishna Sudhir* [Video]. YouTube. https://www.youtube.com/watch?v=uRhkDN2WjzI

WebMD. (2023). *Drugs & medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

Extra Strength Tylenol and Tylenol PM by Ragesoss, CC BY-SA 4.0

Bottle of Ibuprofen tablets with cap removed and tablets in front by Derrick Coetzee, CC0 1.0

Big Aspirin Bottle by Grantmidnight, CC BY-SA 4.0

11.4 Narcotic and Adjuvant Analgesics

Narcotics, also called **opioids**, are analgesics prescribed for moderate to severe pain. They work by binding to **opiate receptor sites** in the brain, and then block pain impulses coming to the brain from the nerves in the body. Narcotics also produce a level of sedation and a sense of well-being, also know as euphoria.

	ABUSE POTENTIAL	MEDICAL USE	SAFETY/DEPENDENCE	EXAMPLES
SCHEDULE I	High	⊗ Not currently accepted	Lack of accepted safety for use of the substance under medical supervision[1]	Marijuana,[2] heroin, lysergic acid diethylamide (LSD), 3,4 methylenedioxymethamphetamine (MDMA), peyote[3]
SCHEDULE II	High	✓ Currently accepted	Abuse may lead to severe psychological or physical dependence[4]	Cocaine, methamphetamine, oxycodone, fentanyl,[5] Adderall[6]
SCHEDULE III	**Less than** the substances in Schedules I and II	✓ Currently accepted	Abuse may lead to moderate or low physical dependence or high psychological dependence[7]	Ketamine, anabolic steroids, testosterone, Tylenol with codeine[8]
SCHEDULE IV	**Low potential** for abuse relative to the substances in Schedule III	✓ Currently accepted	Abuse may lead to limited physical dependence or psychological dependence relative to the substances in Schedule III[9]	Xanax, Valium, Ambien[10]
SCHEDULE V	**Low potential** for abuse relative to the substances in Schedule IV	✓ Currently accepted	Abuse may lead to limited physical dependence or psychological dependence relative to the substances in Schedule IV[11]	Cough medicines with codeine, certain antidiarrheal medicines, FDA-approved drugs containing the marijuana extract cannabidiol (CBD)[12]

Fig. 11.7

Narcotics are schedule medications (Schedule II to IV) because they have a high potential for abuse and addiction; therefore, they are highly controlled. The symbol C that is found on narcotic medications indicates that they are controlled substances (schedule medications), and the Roman numeral (II, III, or IV) indicates the assigned schedule based on how addicting the medication is. Fig. 11.7 shows the different schedule categories (I to V) for narcotics, other medications, and some illegal drugs.

A number of side effects are common to all narcotics because of the existence of different opiate receptors, which they also affect. These side effects include constipation, respiratory depression, sedation, euphoria, and **antitussive** effects. Often patients in a hospital who are prescribed narcotics are also given a laxative medication to prevent constipation. This is also done because these patients are already at an increased risk of constipation because of lack of mobility, surgical procedures, and other factors.

Much of the discussion on this page will focus on **morphine sulphate**, but there are a vast number of other narcotics that can be used to treat moderate to severe pain.

Some examples of narcotic medications include the following (WebMD, 2023):

- codeine
- fentanyl (Abstral, Actiq, Duragesic)
- hydrocodone (Zohydro ER)
- hydromorphone (Dilaudid)
- meperidine (Demerol)
- methadone (Dolophine, Methadose)
- morphine sulphate (Astramorph, Duramorph, MS Contin)
- oxycodone (OxyContin, Roxicodone)
- oxymorphone (Numorphan, Opana)
- tramadol (Ultram)

Key Concept

Methadone is also used in the treatment of drug addiction such as heroin (WebMD, 2022). It is often prescribed as part of a treatment program where patients will have to go and get the medication from a healthcare provider (WebMD, 2022). Methadone is used in addiction treatment as it does not provide a high like some other narcotics and prevents the symptoms of withdrawal and cravings. The term for this treatment if often referred to as replacement therapy (WebMD, 2022).

Morphine

Morphine (Astramorph, Duramorph, MS Contin) is an example of a narcotic used to treat moderate to severe pain. It binds to opioid receptors in the central nervous system (CNS) and alters the perception of and response to painful stimuli while also producing generalized CNS depression. Morphine is more accurately known as **morphine sulfate**, and this can be seen in the abbreviation MS found in the trade name MS Contin, as shown in Fig. 11.9 (Murphy et al., 2022). Morphine, similarly to **codeine**, is derived from the natural opium poppy (Murphy et al., 2022). Most other narcotics available, and listed above, are made synthetically.

Morphine (Fig. 11.8) is also commonly used to treat cancer pain and for pain at the end of life because there is no "ceiling effect,"

meaning that the higher the dose, the higher the level of analgesia. Morphine is also commonly used in **patient-controlled analgesia (PCA)**; other medications administered via PCA include hydromorphone and fentanyl. PCAs are common in the hospital setting and allow the patient to control the administration of their analgesic medications. The medications are connected to the patient's intravenous line, and when the patient feels the need for more pain medication, they push a button that releases a specific dose of the drug but also has a lockout mechanism to prevent an overdose.

Fig. 11.8

Combination

Fig. 11.9

Narcotic–Non-Narcotic Medications

Non-narcotic and narcotic medication are often given in combination because the non-narcotic medication provides a foundation of pain relief upon which the narcotic can build. As a

result, less narcotic medication is needed to effectively control the pain (Li, 2019).
Examples of combination medications (WebMD, 2023):

- Empirin-Codeine No. 3 (aspirin + codeine)
- Empirin-Codeine No. 4 (aspirin + codeine)
- Percodan (aspirin + oxycodone)
- Tylenol-Codeine No. 2 (acetaminophen + 15 mg of codeine)
- Tylenol-Codeine No. 3 (acetaminophen + 30 mg of codeine)
- Tylenol-Codeine No. 4 (acetaminophen + 60 mg of codeine)
- Percocet (oxycodone and acetaminophen)

Naloxone (Narcan)

Naloxone (Narcan) reverses pain relief and the CNS and respiratory depression caused by narcotics. It competes with opioid receptor sites in the brain and prevents the opioids from binding with the receptors or displaces opioids already occupying receptor sites. It is indicated for the complete or partial reversal of narcotic or opioid depression, which includes respiratory depression. Naloxone can be used in the case of an overdose and is widely available in most pharmacies and other locations across Canada. Fig. 11.10 provides an image of a common naloxone medication kit that can be obtained from pharmacies, clinics, and hospitals, and used to treat overdoses that occur outside the hospital setting.

Fig. 11.10

Adjuvants

Adjuvant analgesics are medications that were developed for other purposes but were later found to be effective to treat pain. Examples of adjuvant medications include **gabapentin** (an anticonvulsant) and **amitriptyline** (a tricyclic antidepressant). Muscle relaxants are also considered to be adjuvant analgesics and are used for various musculoskeletal disorders such as multiple sclerosis (MS). Three different types of muscle relaxants will be discussed below: **baclofen (Lioresal)**, **cyclobenzaprine (Flexeril, Amrix)**, and **tizanidine (Zanaflex)**. Although there are other types of

adjuvants available, the ones discussed in this section are the more common types used in health care.

Baclofen

Baclofen (Lioresal) inhibits reflexes at the spinal level. It is used to treat muscle symptoms, such as spasm, pain, and stiffness, which are often caused by multiple sclerosis, spinal cord injuries, or other spinal cord disorders.

Cyclobenzaprine

Cyclobenzaprine (Flexeril, Amrix) reduces **tonic** muscle activity at the level of the brain stem. It is a muscle relaxant that is structurally similar to tricyclic antidepressants and is most often used to treat acute muscle spasms.

Tizanidine

Tizanidine (Zanaflex) acts as an agonist at central alpha-adrenergic receptor sites. It reduces **spasticity** by increasing the presynaptic inhibition of motor neurons. Tizanidine is used to treat increased muscle tone, spasms, and spasticity.

Bringing It All Together

A number of analgesic medications have been covered in this chapter, and as a means of summarizing this topic, watch the video below. It discusses the considerations, as suggested by the World

Health Organization (WHO), for which analgesic medications are prescribed to patients. Note that the video discusses Paracetamol, which is another trade name for acetaminophen.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=1112#oembed-1

(Rhesus Medicine, 2020)

Table 11.2. Common Narcotic Medications

Generic Name	Trade Name	Reason for Administering
morphine sulphate	Astramorph, Duramorph, MS Contin	Moderate to severe pain
codeine	–	Moderate to severe pain
fentanyl	Abstral, Actiq, Duragesic	Moderate to severe pain
hydrocodone	Zohydro ER	Moderate to severe pain
hydromorphone	Dilaudid	Moderate to severe pain
meperidine	Demerol	Moderate to severe pain
methadone	Dolophine, Methadose	Moderate to severe pain
oxycodone	OxyContin, Roxicodone	Moderate to severe pain
oxymorphone	Numorphan, Opana	Moderate to severe pain
tramadol	Ultram	Moderate to severe pain
aspirin + codeine	Empirin-Codeine No. 3, Empirin-Codeine No. 4	Moderate to severe pain
aspirin + oxycodone	Percodan	Moderate to severe pain
oxycodone + acetaminophen	Percocet	Moderate to severe pain
acetaminophen + codeine	Tylenol-Codeine, Tylenol-Codeine No. 3, Tylenol-Codeine No. 4	Moderate to severe pain
nalaxone	Narcan	Narcotic (opioid) overdose

baclofen	Lioresal	Multiple sclerosis, muscle spasms, moderate to severe pain (adjuvant)
cyclobenzaprine	Flexeril, Amrix	Muscle spasm, moderate to severe pain (adjuvant)
tizanidine	Zanaflex	Muscle spasms, moderate to severe pain (adjuvant)

(WebMD, 2023)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Li, J.-X. (2019). Combining opioids and non-opioids for pain management: Current status. *Neuropharmacology*, *158*, 107619. https://doi.org/10.1016/j.neuropharm.2019.04.025

Murphy, P. B., Bechmann, S., & Barrett, M. J. (2022, June 20). *Morphine*.https://www.ncbi.nlm.nih.gov/books/NBK526115/

Rhesus Medicine. (2020, September 14). *WHO analgesic ladder – Pain management | World Health Organisation analgesic ladder (+ side effects)* [Video]. YouTube. https://www.youtube.com/watch?v=x-ntxFpTK3g

WebMD. (2023). *Drugs & medications* A–Z. https://www.webmd.com/drugs/2/index

WebMD. (2022). *Methadone*. https://www.webmd.com/mental-health/addiction/what-is-methadone

Image Credits (images are listed in order of appearance)

CRS Controlled Substance Act Schedules by Joanna R. Lampe, Public domain

Morphine 1mL Vial by DanielTahar, CC BY-SA 4.0

Morphine DOJ by U.S. Department of Justice, Public domain

NaloxoneKit by James Heilman, CC BY-SA 4.0

11.5 Review

Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=1114#h5p-27

Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=1114#h5p-28

Generic and Trade Name Review

An interactive H5P element has been excluded from

this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=1114#h5p-26

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

CHAPTER XII

ANTIMICROBIAL MEDICATIONS

12.1 Introduction to Antimicrobial Medications

Learning Objectives

By the end of this chapter, you should be able to

1. Describe the terms “antimicrobial medications,” “antibiotic medications,” and “antiviral medications”
2. Identify the suffixes and prefixes used to identify categories of antibiotics
3. Identify common antimicrobial medications by both generic and trade names
4. Identify common antibiotic-resistant organisms (AROs)
5. Explain basic concepts relating to antimicrobials and the emergence of AROs

Chapter Overview

Have you ever been prescribed an antibiotic for an infection and asked, "Why do I have to finish taking all these pills when I already feel better"? Or, perhaps you wondered why the healthcare provider chose a certain medication over another or why the pharmacist told you to avoid certain foods when taking a particular antibiotic.

You may have had these questions in your own healthcare experiences. It is important to remember that if you have these questions, many patients will as well. Learning about the various types of antimicrobials and how they work will help you provide better understanding of these medications to others.

12.2 Antimicrobial Basics

Before we learn about medications that are used to treat infections in patients, we must first understand the basics of microbiology. Let's begin with a review of bacteria. **Bacteria** are found in nearly every habitat on earth, including within and on humans. Most bacteria are harmless or considered helpful, but some are pathogens. A **pathogen** is defined as an organism causing disease to its host. Pathogens, when overgrown, can cause significant health problems or even death for patients.

The term **antimicrobial** most often refers to medications used to treat bacteria, but it also includes medications used to treat viruses and fungi. We will discuss some important concepts concerning antimicrobials throughout this chapter. These include the fact that bacteria may be identified when a patient has an infection by using a **culture and sensitivity test** or a **gram stain test**. Antimicrobials may be classified as **broad-spectrum** or **narrow-spectrum**, based on the variety of bacteria they treat effectively. Additionally, antibiotics may be **bacteriostatic** or **bactericidal** in terms of how they target bacteria. Finally, the mechanism of action is also considered in the selection of an antibiotic to treat a particular infection.

Culture and Sensitivity

When a patient presents signs or symptoms of an infection, healthcare providers will begin the detective work needed to identify the source of the infection. A **culture** is a test performed to examine different body substances for the presence of bacteria or fungi (Parker et al., 2016). These culture samples are commonly

collected from a patient's blood, urine, sputum, feces, or wound bed. Nurses are typically responsible for the collection of culture samples and must be conscientious about collecting the sample prior to the administration of antibiotics. Antibiotic administration prior to a culture being taken can result in delayed identification of the organism and complicate the patient's recovery. Once culture samples are collected, they are then incubated in a solution that promotes bacterial or fungal growth and spread onto a special culture plate (Fig. 12.1) (Parker et al., 2016). Specialists then monitor the culture for signs of organism growth to aid in the diagnosis of the infectious pathogen. A **sensitivity analysis** is often performed to select an effective antibiotic to treat the microorganism. If the organism shows resistance to the antibiotic used in the test, that antibiotic will not provide effective treatment for the patient's infection.

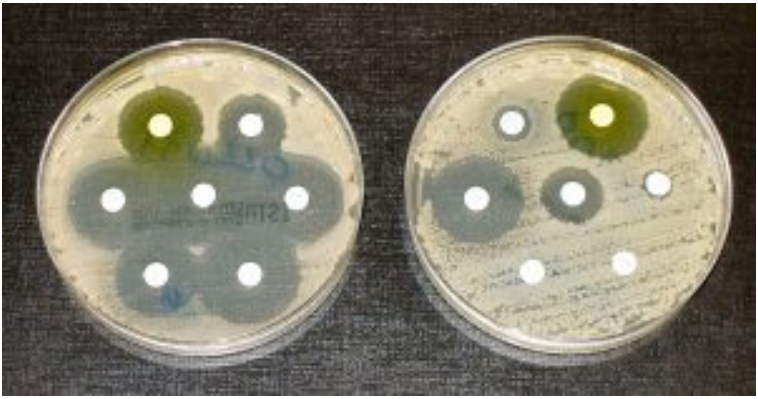


Fig. 12.1

Gram Positive vs. Gram Negative

A **gram stain** is another type of test used to help classify pathogens

(Fig. 12.2). Gram stains are useful for quickly identifying whether bacteria are **gram positive** or **gram negative**, based on the staining patterns of their cellular walls. Identification of bacteria as gram positive or gram negative helps the healthcare provider quickly select an appropriate antibiotic to treat an infection.

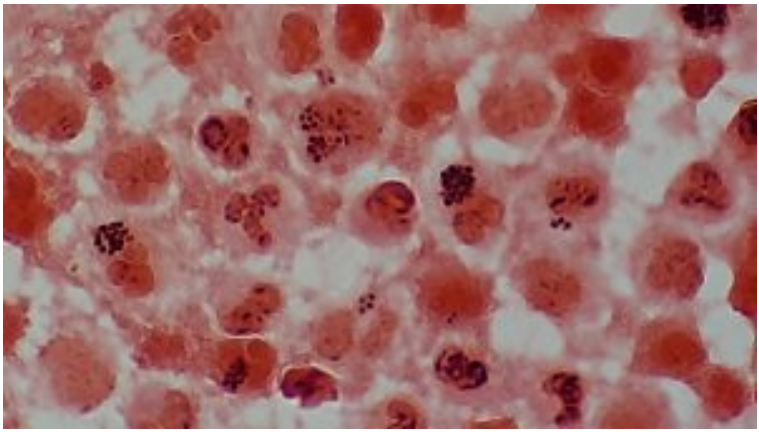


Fig. 12.2

Broad-Spectrum vs. Narrow-Spectrum Antimicrobials

Spectrum of activity is one of the factors that healthcare providers use when selecting antibiotics to treat a patient's infection. A **narrow-spectrum antibiotic** targets only specific types of bacterial pathogens (Parker et al., 2016). For example, some narrow-spectrum medications only target **gram-positive bacteria**, but others target only **gram-negative bacteria**. If the pathogen causing the infection has been identified in a culture and sensitivity test, it is best to use a narrow-spectrum antimicrobial and minimize collateral damage to the normal microbacteria.

A **broad-spectrum antibiotic** targets a wide variety of bacterial pathogens, including both gram-positive and gram-negative species, and is frequently used to cover a wide range of potential pathogens while waiting for laboratory identification of the infecting pathogen. Broad-spectrum antibiotics are also used for **polymicrobial infections** (a mixed infection with multiple bacterial species) or as **prophylactic prevention** of infections with surgery or invasive procedures. Finally, broad-spectrum antibiotics may be selected to treat an infection when a narrow-spectrum drug fails because of the development of medication resistance by the target pathogen (Parker et al., 2016).

One risk associated with using **broad-spectrum** antibiotics is that they also target a broad spectrum of normal microbacteria, which can cause diarrhea. They also increase the risk of a **superinfection**, a secondary infection in a patient who has a pre-existing infection. A superinfection develops when the antibacterial intended for the pre-existing infection kills the protective microbiota, allowing another pathogen that is resistant to the antibacterial to proliferate and cause a secondary infection. Common examples of superinfections that develop as a result of antibiotic use include yeast infections (candidiasis) and pseudomembranous colitis caused by *Clostridium difficile* (*C. diff*), which can be fatal (Parker et al., 2016).

Antibacterial Actions

When a provider selects an antibacterial medication, it is important to consider how and where the medication will target the bacteria. **Antibacterial medications** can be either **bacteriostatic** or **bactericidal** in their interactions with the offending bacteria. **Bacteriostatic medications** cause bacteria to stop reproducing; however, they may not ultimately kill the bacteria. In contrast, **bactericidal medications** kill their target bacteria.

The decision about whether to use a bacteriostatic or bactericidal drug often depends on the type of infection and the overall immune status of the patient. In a healthy patient with strong immune defences, both bacteriostatic and bactericidal medications can be effective in achieving a clinical cure. However, when a patient is immunocompromised, a bactericidal medication is essential for the successful treatment of infections. Regardless of the immune status of the patient, life-threatening infections such as acute endocarditis require the use of a bactericidal medication to eliminate all the offending bacteria (Parker et al., 2016).

Medication Resistance

Although there are numerous medications available to treat infections, greater limitations in effectiveness are being seen. This is because some bacteria have developed resistant strains that are immune to certain antibiotic medications. This happens because antibiotic medications have been so widely prescribed, and they are often prescribed for conditions that do not warrant antibiotic medication use. For example, **methicillin-resistant *Staphylococcus aureus* (MRSA)** causes serious and sometimes fatal infections in hospitalized patients, and now has been found in patients who are in other types of healthcare facilities and even in homes and in the community. Other **antibiotic-resistant organisms (AROs)** include bacteria such as **vancomycin-resistant *Enterococcus* (VRE)**, which is resistant to the antibiotic vancomycin (Fig. 12.3).

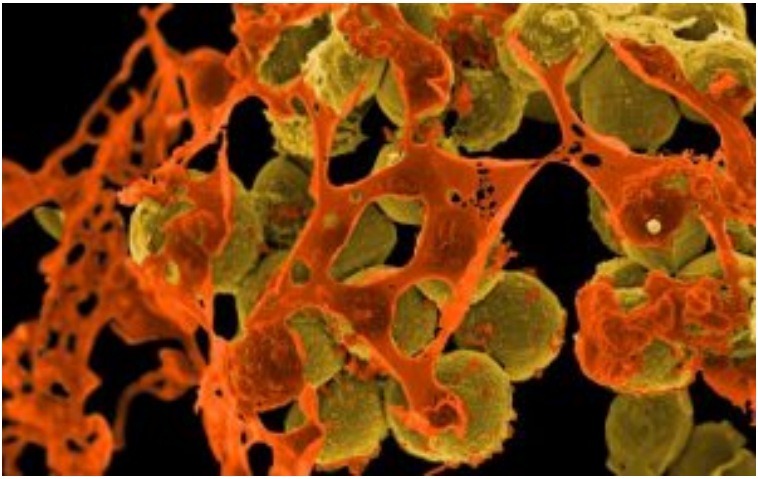


Fig. 12.3

In many countries around the world, antibiotics are self-administered by patients at home. Unfortunately, many patients stop taking antibiotics once their symptoms go away and they feel better. If a 10-day course of treatment is prescribed, many patients only take the medication for five or six days, unaware of the negative consequences of not completing the full course of treatment.

The problem: A shorter course of treatment not only fails to kill the target organisms to the expected levels but also helps create drug-resistant variants within the body. A patient's **nonadherence** amplifies drug resistance when the recommended course of treatment is long.

For example, treatment for tuberculosis (TB) has a recommended treatment regimen lasting from six months to a year. The Centers for Disease Control (CDC) estimates that about one-third of the world's population is infected with TB, most living in underdeveloped or underserved regions where antimicrobial medications are available over the counter. In such countries, there may be even lower rates of adherence than in developed areas.

Nonadherence leads to antibiotic resistance and more difficulty in controlling pathogens. As a direct result, the emergence of **multidrug-resistant** strains of TB is becoming a huge problem.

The overprescription of antimicrobials also contributes to antibiotic resistance. Patients often demand antibiotics for diseases that do not require them, such as viral colds and ear infections. Pharmaceutical companies aggressively market medications to physicians and clinics, making it easy for them to give free samples to patients, and some pharmacies even offer certain antibiotics free to low-income patients with a prescription.

In recent years, various initiatives have aimed to educate patients, parents, and clinicians about the use of antibiotics. However, previous studies have shown that the parental expectations for antimicrobial prescriptions for children has actually increased.

This is a complex issue with no clear, easy solution. However, what is clear is that extensive education regarding the judicious and complete use of medications to increase adherence and decrease the opportunity for antimicrobial resistance is required (Parker et al., 2016).

The video below provides an overview of antibiotic resistance and the increase in "superbugs."

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://openeducationalberta.ca/medicalterminologyii/?p=1323#oembed-1

(Be Smart, 2015)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Be Smart. (2015, April 15). *Antibiotic resistance and the rise of superbugs* [Video]. YouTube. https://www.youtube.com/watch?v=fyRyZ1zKtyA

Parker, N., Schneegurt, M., Thi Tu, A.-H., Lister, P., & Forster, B. M. (2016). *Microbiology*. OpenStax. https://openstax.org/details/books/microbiology?Book%20details, licensed under CC BY 4.0

WebMD. (2023). *Drugs & medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance

antibiotic sensitivity and resistance by Dr Graham Beards, CC BY-SA 4.0

Plenty of Gram positive cocci in singles, pair and clusters in Gram stained smear of wound drainage by Ajay Kumar Chaurasiya, CC BY-SA 4.0

Methicillin-resistant Staphylococcus aureus (MRSA) Bacteria by NIAID/NIH, Public domain

12.3 Antibiotic Medications

Now that we have reviewed antimicrobial basics, we will take a closer look at specific antimicrobial classes. Each of the following sections of this chapter is based on a class or subclass of anti-infective medications. This page will focus on antibiotics and the different classes of antibiotics available. Although some classes are similar, there are still important differences between antibiotics and considerations for when and why they are prescribed.

Penicillins

Penicillin was the first antibiotic discovered, and its detection was a bit of an accident (Fig. 12.4). In 1928, Alexander Fleming, a professor of bacteriology at St. Mary's Hospital in London, England, discovered penicillin growing in a petri dish in his lab. The penicillin was the result of "mould juice" that had grown there inadvertently. Fleming noted that this "mould juice" inhibited the growth of *Staphylococcus* bacteria that was previously growing in the petri dish, thereby discovering the first antibiotic (Parker et al., 2016).

Fig. 12.4

Penicillins are prescribed to treat a variety of infectious processes such as streptococcal infections, pneumococcal infections, and staphylococcal infections. They can also be used to treat various forms of gram-positive and gram-negative bacteria, and they all share the common molecular structure of a **beta-lactam ring**. Penicillins may be administered orally, **intravenously**, or **intramuscularly**. They are **bactericidal** and kill bacteria by interfering with the synthesis of proteins needed in their cellular walls (Parker et al., 2016). When the bacterial cell wall is impaired, the cell rapidly breaks down and is destroyed. Penicillin antibiotics are considered **broad-spectrum** antibiotics because they can be used to treat a wide variety of bacterial infections.

Examples of penicillin antibiotics (WebMD, 2023):

- amoxicillin (Amoxil)

- ampicillin (Principen)
- penicillin V (Penicillin VK, Veetids)
- piperacillin (Pipracil)

Key Concept

A common **suffix** found with **penicillin antibiotics** is **-cillin.**

Examples: amoxicillin (Amoxil), piperacillin (Pipracil)

Cephalosporins

Cephalosporins are slightly modified chemical "twins" to penicillins owing to their beta-lactam chemical structure. Because of these similarities, some patients who are allergic to penicillins may experience cross-sensitivity to cephalosporins. Cephalosporins are used to treat skin and skin-structure infections, bone infections, genitourinary infections, otitis media, and community-acquired respiratory tract infections. They are typically **bactericidal** and are similar to penicillin in their action within the cell wall. Cephalosporins are sometimes grouped into "generations" by their antimicrobial properties. First-generation medications are effective mainly against gram-positive organisms. Subsequent generations are generally also effective against aerobic gram-negative bacilli. Fifth-generation cephalosporins are active against methicillin-resistant *Staphylococcus aureus* (MRSA) and other complicated infections.
Examples of cephalosporin antibiotics (WebMD, 2023):

- cefazolin (Ancef)
- cephalexin (Keflex)
- cefuroxime (Ceftin, Zinacef)
- ceftriaxone (Rocephin)

Key Concept

Common **prefixes** found with **cephalosporin antibiotics** are **cef-** and **ceph-**.

Examples: cephalexin (Keflex), ceftriaxone (Rocephin)

Carbapenems

Carbapenems are a beta-lactam "cousin" to penicillins and cephalosporins. Cross-sensitivity may occur in patients allergic to penicillin or cephalosporins. Carbapenems are useful for treating life-threatening, multidrug-resistant infections owing to their **broad spectrum** of activity (Parker et al., 2016). These antibiotics are effective in treating gram-positive and gram-negative infections and are especially useful for treating complex hospital-acquired infections or for patients who are immunocompromised. Carbapenems are typically **bactericidal** and work by inhibiting the synthesis of the bacterial cell wall.

Key Concept

A common **suffix** found with **carbapenem antibiotics** is **-penem**.

Example: meropenem (Merrem IV)

Monobactams

Like penicillins, cephalosporins, and carbapenems, **monobactams** also have a beta-lactam ring structure. They are **narrow-spectrum** antibacterial medications that are used primarily to treat gram-negative bacteria such as *Pseudomonas aeruginosa*. Monobactams are **bactericidal** and work to inhibit bacterial cell wall synthesis (Parker et al., 2016).

Sulfonamides

Sulfonamides are one of the oldest **broad-spectrum** antimicrobial agents that work by competitively inhibiting the bacterial metabolic enzymes needed for bacterial function. Sulfonamides are used to treat urinary tract infections, otitis media, meningitis, acute exacerbations of chronic bronchitis, and travellers' diarrhea. This mechanism of action provides **bacteriostatic** inhibition of growth against a wide spectrum of gram-positive and gram-negative pathogens.

Examples of sulfonamide antibiotics (WebMD, 2023):

- sulfadiazine (Silvadene)
- sulfisoxazole (Gantrisin Pediatric)
    - Often combined with generic trimethoprim (TMP) to

become SMZ/TMP (Bactrim, Septra)

Key Concept

Sulfonamides are often also referred to as **sulfa drugs.**

Fluoroquinolones

Fluoroquinolones are synthetic antibacterial medications that work by inhibiting bacterial DNA replication. They are **bactericidal** owing to the action they take against the DNA of the bacterial cell wall. Many fluoroquinolones are **broad spectrum** and are effective against a wide variety of both gram-positive and gram-negative bacteria.

Fluoroquinolones have been associated with disabling and potentially irreversible serious adverse reactions, including the following:

- Tendinitis and tendon rupture
- Peripheral **neuropathy**
- Central nervous system effects
- Exacerbation of muscle weakness in patients with myasthenia gravis

Patients who experience any of these serious adverse reactions should discontinue the medication immediately and avoid the use of fluoroquinolones.

All patients on fluoroquinolone therapy should be instructed to avoid direct and indirect sunlight because of the photosensitivity

that can be experienced while on these medications. Patients should take measures to ensure that dosages are spaced evenly throughout the day and that fluid balance is maintained. It is important to maintain a fluid intake of 1,500 mL to 2,000 mL per day while taking the medication.

Examples of fluoroquinolone antibiotics (WebMD, 2023):

- ciprofloxacin (Cipro)
- levofloxacin (Levaquin)

Key Concept

A common **suffix** found with **fluoroquinolone antibiotics** is **-floxacin**.

Examples: ciprofloxacin (Cipro), levofloxacin (Levaquin)

Macrolides

Macrolides are complex antibacterial **broad-spectrum** medications that are effective against both gram-positive and gram-negative bacteria. Macrolides inhibit RNA protein synthesis and suppress bacterial reproduction. They are **bacteriostatic** because they do not actually kill bacteria but inhibit additional growth, allowing the body's immune system to kill the offending bacteria (Parker et al., 2016).

Macrolides are often used to treat respiratory infections, otitis media, pelvic inflammatory infections, and chlamydia. They can have a significant impact on liver function and should be used

cautiously in patients with liver disease or impairment. Gastrointestinal upset is common, and patients should be advised to take the medication with food. Patients should also be advised to avoid excessive sunlight and to wear protective clothing and use sunscreen when outside.

- azithromycin (Zithromax)
- clarithromycin (Biaxin)
- erythromycin (E-Mycin)

Aminoglycosides

Aminoglycosides are potent **broad-spectrum** antibiotics that are useful for treating severe infections. They are **bactericidal** and inhibit protein synthesis in the cell wall, which results in bacterial death.

Many aminoglycosides are poorly absorbed in the gastrointestinal tract; therefore, the majority are given **intravenously** or **intramuscularly**. All aminoglycoside antibiotic medications have the potential to cause toxic effects to the auditory nerve (ototoxicity) or to the kidneys (nephrotoxicity). They should be administered cautiously, and patients receiving aminoglycoside antibiotics must be carefully monitored with hearing tests (audiograms) and blood tests (BUN and creatinine) for kidney function.

Examples of aminoglycoside antibiotics (WebMD, 2023):

- gentamicin (Cidomycin)
- neomycin (Neosporin)
- tobramycin (TOBI, Tobrex)

Key Concept

A common **suffix** found with **aminoglycoside antibiotics** is **-micin** and **-mycin**.

Examples: gentamicin (Cidomycin), neomycin (Neosporin), tobramycin (TOBI, Tobrex)

Tetracyclines

Tetracyclines are **broad-spectrum** antibiotics that are **bacteriostatic**, inhibiting bacterial growth. They stop the growth of bacteria by preventing protein synthesis in the cell wall. Tetracycline medications are useful for treating many gram-positive and gram-negative infectious processes, yet their use is limited because of the significant side effects experienced by many patients.

The side effects of tetracycline medications include photosensitivity, discolouration of developing teeth, and renal and liver impairment. Patients should be instructed to avoid direct sunlight exposure and wear sunscreen to prevent skin reactions. Also, patients who are on oral contraceptives should be educated that tetracyclines may impede the effectiveness of oral contraceptives and an alternative measure of birth control should be used while on the antibiotic.

Examples of tetracycline antibiotics (WebMD, 2023):

- demeclocycline (Declomycin)
- doxycycline (Vibramycin, Vibra-Tabs)

- minocycline (Dynacin, Minocin)
- tetracycline (Sumycin)

Key Concept

A common **suffix** found with **tetracycline antibiotics** is **-cycline**.

Examples: minocycline (Dynacin, Minocin), tetracycline (Sumycin)

Combination Antibiotics

Combination antibiotic medications are also available. These include combinations of anti-infectives and antibiotics that work together within bacteria and affect the areas within the organisms needed to build cellular proteins. These medications are often used against methicillin-resistant *Staphylococcus aureus* (MRSA) bacterial infections of the skin.

Some of the antibiotics that are often combined include the following (WebMD, 2023):

- sulfamethoxazole/trimethoprim (Bactrim Septra)
- clindamycin (Cleocin)
- vancomycin (Vancocin)

Key Concept

Metronidazole (Flagyl) is a very common antibiotic and antiprotozoal. It doe snot fall under the categories of antibiotics already discussed as it is categorized as a nitroimidazole type of antibiotic. It is commonly used to treat sexually transmitted diseases, parasites in the intensities, and bacterial infection of the vagina, stomach, brain and respiratory tract. This medication will be commonly seen within hospitals in Alberta and the rest of Canada.

Table 12.1. Common Antibiotic Medications

Generic Name	Trade Name	Reason for Administering
amoxicillin	Amoxil	Bacterial infection
ampicillin	Principen	Bacterial infection
cefazolin	Ancef	Bacterial infection
ceftriaxone	Rocephin	Bacterial infection
cefuroxime	Ceftin, Zinacef	Bacterial infection
cephalexin	Keflex	Bacterial infection
ciprofloxacin	Cipro	Bacterial infection
clindamycin	Cleocin	Bacterial infection
demeclocycline	Declomycin	Bacterial infection
doxycycline	Vibramycin, Vibra-Tabs	Bacterial infection
gentamicin	Cidomycin	Bacterial infection
levofloxacin	Levaquin	Bacterial infection
azithromycin	Zithromax	Bacterial infection
clarithromycin	Biaxin	Bacterial infection
erythromycin	E-Mycin	Bacterial infection
meropenem	Merrem IV	Bacterial infection

minocycline	Dynacin, Minocin	Bacterial infection
neomycin	Neosporin	Bacterial infection
penicillin V	Penicillin VK, Veetids	Bacterial infection
piperacillin	Pipracil	Bacterial infection
sulfadiazine	Silvadene	Bacterial infection
sulfisoxazole	Gastrinsin Pediatric	Bacterial infection
sulfisoxazole/trimethoprim (SMZ/TMP)	Bactrim, Septra	Bacterial infection
tetracycline	Sumycin	Bacterial infection
tobramycin	TOBI, Tobrex	Bacterial infection
vancomycin	Vancocin	Bacterial infection
metronidazole	Flagyl	Bacterial Infection or parasites in the intestines.

(WebMD, 2023)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Parker, N., Schneegurt, M., Thi Tu, A.-H., Lister, P., & Forster, B. M. (2016). *Microbiology*. OpenStax. https://openstax.org/details/books/microbiology?Book%20details, licensed under CC BY 4.0

WebMD. (2023). *Drugs and medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credit

Penicillin treatment (45905411884) by Owen Massey McKnight, CC BY-SA 2.0

12.4 Other Antimicrobial Medications

Antiviral Medications

Similar to antibacterial medications, **antiviral medications** directly impact the interaction and reproduction of the invading microorganisms. Antibacterial medications are required for treating bacterial infections, whereas antivirals treat specific viral infections. For example, **oseltamivir (Tamiflu)** is commonly prescribed to treat influenza. Unlike antibiotics, antiviral medications do not kill the offending virus, but they work to reduce the replication and development of the virus (Parker et al., 2016).

Unlike the complex structure of fungi or protozoa, viral structure is simple. There are several subclasses of antiviral medications: **anti-influenza**, **anti-herpes**, **anti-hepatitis**, and **antiretrovirals**.

Anti-Influenza Medications

Oseltamivir (Tamiflu) targets the influenza virus by blocking the release of the virus from infected cells (Fig. 12.5). This medication does not cure influenza but can decrease influenza symptoms and shorten the duration of illness if taken in a timely manner. Patients are prescribed the medication as prophylaxis against infection or known exposure, or to shorten the course of the illness. If patients experience flu-like symptoms, it is critical that they start treatment within 48 hours of symptom onset.

Fig. 12.5

The following are medications used to treat influenza virus infections (influenza A or influenza B) (WebMD, 2023):

- amantadine (Symmetrel)
- influenza virus vaccine (Fluarix, FluMist)
- oseltamivir (Tamiflu)
- rimantadine (Flumadine)
- zanamivir (Relenza)

Key Concept

Flu vaccinations are given prophylactically to prevent influenza. The vaccine uses either the whole virus, part of

the virus, or a surface antigen from the virus to provoke the body's immune response and create temporary immunity. Annual revaccination is necessary to provide protection against the most current strains of the two most common and dangerous flu families—influenza A and influenza B viruses.

Anti-Herpes Medications

Acyclovir (Zovirax) and its derivatives are frequently used to treat herpes and varicella virus infections, including genital herpes, chickenpox, shingles, Epstein-Barr virus infections, and cytomegalovirus infections (Fig. 12.6). Acyclovir causes termination of the DNA chain during the viral replication process. It can be administered either topically or systemically, depending on the infection.

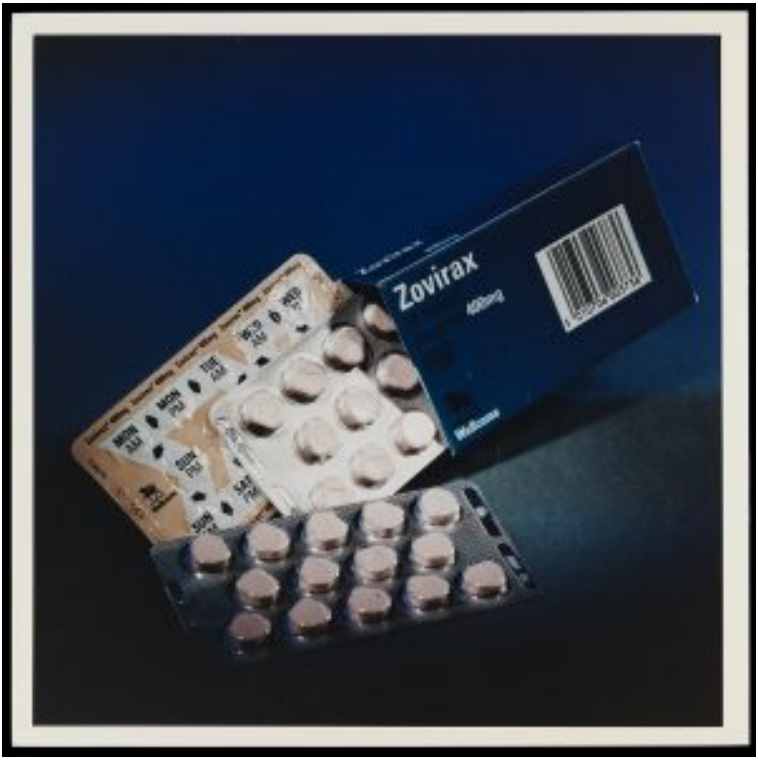


Fig. 12.6

Anti-Hepatitis Medications

Hepatitis, or inflammation of the liver, can be complicated to treat, and the choice of treatment will vary depending on the causative factor (A, B, or C). Hepatitis can be caused by toxins, medications, and viruses.

Medications for hepatitis virus infections (hepatitis A, hepatitis B, or hepatitis C) include the following (WebMD, 2023):

- adefovir (Hepsera)
- entecavir (Barclude)

- interferon alfa-2b (Intron A)
- interferon alfacon-1 (Infergen)
- lamivudine (Epivir)

Antiretroviral Medications

Viruses with complex life cycles, such as **human immunodeficiency virus (HIV)** and the condition it can result in, **acquired immunodeficiency syndrome (AIDS)**, can be difficult to treat. These types of viruses require the use of **antiretroviral medications** that block viral replication. Many antiretrovirals may impact renal function; therefore, the patient's urine output and renal labs should be monitored carefully for signs of decreased function.

Antifungal and Yeast Infection Medications

Antifungals, or **antimycotic agents**, are medications used to treat fungal infections. They work by killing the cells of the fungus or inhibiting cell reproduction. Unlike antibacterial and antiviral medications, many antifungals are applied topically to the affected area. Fungal infections commonly affect surface areas of the body, including the toes, nails (**onychomycosis**) , mouth, and groin, as well as the skin. For example, *Candida albicans* is a type of fungus that when overgrown in the mouth produces oral thrush. Patients experiencing thrush may be prescribed an oral antifungal "swish and spit" medication such as **nystatin**.

Imidazoles are synthetic fungicides commonly used in medical applications, but they are also used in agriculture to keep seeds and harvested crops from moulding. Examples include **miconazole (Monistat)**, **ketoconazole (Nizoral)**, and **clotrimazole (Lotrimin)**, which are used to treat fungal skin infections such as ringworm,

tinea pedis (athlete's foot), tinea cruris (jock itch), and **tinea corporis** (Fig. 12.7).

Fig. 12.7

Triazole medications, including **fluconazole (Diflucan)**, can be administered orally or intravenously for the treatment of several types of systemic yeast infections, including oral thrush and cryptococcal meningitis, both of which are prevalent in patients with AIDS (Parker et al., 2016).

Fig. 12.8

Key concept

A common **suffix** found with a couple of the antifungal medications is **-conazole.**

Examples: ketoconazole (Nizoral), fluconazole (Diflucan)

Allylamines, a structurally different class of synthetic antifungal drugs, are most commonly used topically for the treatment of skin

infections like athlete's foot, ringworm, and jock itch (Fig. 12.8). Oral treatment with **terbinafine (Lamisil)** is also used for fingernail and toenail fungus (onychomycosis) (Parker et al., 2016).

Polyenes are another class of antifungal agents and are naturally produced by certain soil bacteria. Common examples include **nystatin (Mycostatin)** and **amphotericin B (Fungizone)**. Nystatin is typically used as a topical treatment for yeast infections of the skin, mouth, and vagina, but may also be used for intestinal fungal infections. Amphotericin B is used for systemic fungal infections such as aspergillosis, cryptococcal meningitis, histoplasmosis, blastomycosis, and candidiasis. It was the only antifungal medication available for several decades, but its use has serious side effects, including renal toxicity (Parker et al., 2016).

Medications for systemic fungal infections (WebMD, 2023):

- amphotericin B (Fungizone)
- capofungin (Cancidas)
- terbinafine (Lamisil)

Medications for yeast infections (WebMD, 2023):

- fluconazole (Diflucan)
- nystatin (Mycostatin, Nystatin Cream)
- flucytosine (Ancobon)

Table 12.2. Common Anti-Viral & Anti-fungal Yeast Medications

Generic Name	Trade Name	Reason for Administering
amantadine	Symmetrel	Influenza virus infection
influenza virus vaccine	Fluarix, FluMist	Influenza virus infection
oseltamivir	Tamiflu	Influenza virus infection
rimantadine	Flumadine	Influenza virus infection
zanamivir	Relenza	Influenza virus infection
acyclovir	Zovirax	Herpes infection
adefovir	Hepsera	Hepatitis infection
entecavir	Barclude	Hepatitis infection
interferon alfa-2b	Intron A	Hepatitis infection
interferon alfacon-1	Infergen	Hepatitis infection
lamivudine	Epivir	Hepatitis infection
clotrimazole	Lotrimin	Fungal skin infection
miconazole	Monistat	Fungal skin infection
amphotericin B	Fungizone	Systemic fungal infection
capofungin	Cancidas	Systemic fungal infection
ketoconazole	Nizoral	Systemic fungal infection

terbinafine	Lamisil	Systemic fungal infection
fluconazole	Diflucan	Yeast and fungal infections
flucytosine	Ancobon	Yeast infection
nystatin	Mycostatin, Nystatin Cream	Yeast infection

(WebMD, 2023)

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

References

Parker, N., Schneegurt, M., Thi Tu, A.-H., Lister, P., & Forster, B. M. (2016). *Microbiology*. OpenStax. https://openstax.org/details/books/microbiology?Book%20details, licensed under CC BY 4.0

WebMD. (2023). *Drugs & medications* A–Z. https://www.webmd.com/drugs/2/index

Image Credits (images are listed in order of appearance)

A Tamiflu (oseltamivir) capsule by Mk2010, CC BY-SA 4.0

Zovirax, packaging Wellcome L0067161 by Wellcome Images, CC BY-SA 4.0

Canesten by Editor182, Public domain

Terbinafine spray by Whispyhistory, CC BY-SA 4.0

12.5 Review

Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=1329#h5p-31

Review

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=1329#h5p-32

Generic and Trade Name Review

An interactive H5P element has been excluded from

this version of the text. You can view it online here: https://openeducationalberta.ca/medicalterminologyii/?p=1329#h5p-30

Attribution

Unless otherwise indicated, material on this page has been adapted from the following resource:

Ernstmeyer, K., & Christman, E. (Eds.). (2020). *Nursing pharmacology*. Chippewa Valley Technical College. https://wtcs.pressbooks.pub/pharmacology/, licensed under CC BY 4.0

Glossary

absorption

when food that is broken down enters the bloodstream and its nutrients are put to work

actuation

the action of causing a device to deliver medication, such as pressing the top of the canister or twisting an inhaler to prepare the dose

adjunctive therapy

when another medication is given alongside or in addition to a primary medication used to treat a particular condition

adjuvant

medications with a primary use other than pain relief that have analgesic properties in some painful conditions

adrenal insufficiency

a disorder that occurs when the adrenal glands do not produce enough of certain hormones, such as cortisol

afterload

the pressure that the heart needs to contract to eject blood

akathisia

distressing motor restlessness and the need to move

amphetamines

stimulant drugs that speed up the central nervous system

aneurysm

ballooning of a blood vessel caused by weakening of the vessel wall

angina

chest pain caused by lack of blood flow (and oxygen) to cardiac cells

angina pectoris

chest pain caused by inadequate supply of blood and oxygen to an area of the heart

anhedonia

lack of interest in activities once enjoyed

ankylosing spondylitis

an inflammatory disease that can cause some of the bones in the spine to fuse

antagonism

a decrease in the therapeutic effects of a medication

anticoagulant

a substance that opposes or prevents coagulation

antiemetic

medication used to treat nausea and vomiting

antiemetics

medications used to treat nausea and vomiting

antiplatelet

medication used to prevent platelets from adhering to each other and forming blood clots

antipyretic

medication used to reduce fevers

antitussive

medication used to treat a cough

arrhythmia

irregular heart rhythm

arteriosclerosis

hardening of the arteries

arthroplasty

joint replacement surgery

atherosclerosis

hardened with plaque

atrial fibrillation

irregular and fast heartbeat that can lead to other pathologies

bactericidal

antibiotics that kill bacteria

bacteriostatic

antibiotics that fight off bacteria by slowing their growth

Black Box Warnings

the strictest labeling requirements the FDA can mandate for prescription medications, often because of potential adverse effects that can occur when a medication is taken

blood clots

gel-like clumps of blood

bradycardia

slow heart rate

brand names

drug names that are created by drug companies; vary worldwide

broad spectrum

antibiotics that work for many types of bacterial infections

broad-spectrum

antibiotics that work for many types of bacterial infections

bronchoconstriction

narrowing of the bronchioles

bronchoconstrictive

narrowing of the bronchioles

bronchodilation

opening or widening of the bronchioles

bronchospasm

when the muscles that surround the bronchi tighten

bronchospasms

when the muscles that surround the bronchi tighten

carcinogenic

cancer causing or producing

cardiac arrest

heart stops beating suddenly

cerebrovascular accident

a stroke; often abbreviated as CVA

chemical digestion

when digestive secretions break down complex food molecules into their chemical building blocks

chronic kidney disease

the kidneys are damaged and no longer work properly

coagulation

the formation of a thrombus or blood clot

cognitive behavioural therapy

a form of structured, time-limited, problem-focused, and goal-oriented therapy

Compendium of Pharmaceuticals and Specialties (CPS)

a resource for referencing drug information

conjunctivitis

an inflammation of the conjunctiva, causing watery, red, and swollen eyes; also known as "pink eye"

coronary artery disease

disease caused by plaque buildup in the arteries

COX enzyme

an enzyme that helps create the chemical prostaglandin

defecation

when undigested materials are removed from the body as feces

delusions

fixed false beliefs that cannot be changed through reasoning

diaphoresis

sweating

Diskus device

a type of inhaler device that contains medication in powder form that is inhaled into the lungs

diuresis

increase in urine output

diuretic

medication that promotes polyuria (increased urine output)

dysmenorrhea

painful menstruation

dyspnea

shortness of breath or difficulty breathing

dystonia

painful muscle spasms

ECG

electrocardiogram

edema

swelling in the body, often in the lower limbs

electroconvulsive therapy

a procedure, done under general anesthesia, in which small electric currents are passed through the brain to intentionally trigger a brief seizure

electroencephalogram

a record of the electricity in the brain; abbreviated as EEG

emboli

small pieces of a blood clot that break off; singular form is **embolus**

embolus

small piece of a blood clot that breaks off; plural form is **emboli**

endogenous

originating from within an organism

euphoria

a feeling or state of intense excitement and happiness

fat

also known as a lipid

fibrillation

an uncoordinated beating of the heart

flat affect

lack of observable expressions of emotions, monotone voice, expressionless face, and immobile body

generic names

standard drug names known worldwide

glial cells

a type of cell that provides physical and chemical support to neurons and maintains their environment

gout

the build-up of uric acid within a joint

H. pylori

a type of bacteria that can cause peptic ulcers

hallucinations

hearing, seeing, smelling, tasting, or feeling touched by things that are not there

HandiHaler

an egg-shaped inhaler device used to deliver medication into the lungs; the medication is inserted into the inhaler in capsule form

heart attack

myocardial infarction; abbreviated as MI

heart failure

failure of the heart to pump well; the heart becomes weakened and can't supply the cells with enough blood

Helicobacter pylori

a type of bacteria that can cause peptic ulcers

hematocrit

the percentage of red blood cells in blood

hematopoiesis

the formation of blood cellular components

hemoglobin

the oxygen-carrying compound in erythrocytes (red blood cells)

hemorrhagic

bleeding caused by blood vessel rupture

homeostasis

the steady state of body systems that living organisms maintain

hyperglycemia

high blood sugar

hyperlipidemia

high lipid levels in the blood

hypertension

high blood pressure

hypertensive

having high blood pressure

hyperthyroidism

a condition in which the thyroid gland produces too much of certain hormones (T3 and T4)

hypoglycemia

low blood sugar

hypokalemia

low potassium levels

hyponatremia

low sodium levels in the blood

hypothyroidism

a condition in which the thyroid gland doesn't produce enough of certain hormones (T3 and T4)

hypoxia

decreased supply of oxygen to the tissues

incontinence

the inability to hold urine or control urination

ingestion

entry of food into the alimentary canal through the mouth

inhibition

the action of restricting or hindering a process

international normalized ratio

a test that measures the time required for blood to clot; abbreviated as INR

intramuscularly

injected into the muscle

intravenous

pertaining to within the vein

intravenously

pertaining to within the vein

ischemia

reduced blood flow to the tissue region "downstream" of a narrowed vessel

ketoacidosis

a serious complication from diabetes that results from the body

breaking down fat as fuel, which causes a build-up of acids called ketones in the bloodstream and can be life threatening

lymphocyte

a type of white blood cell involved in immune function

lymphocytes

white blood cells involved in immune function

mania

extreme emotional highs; often associated with bipolar disorder

mastication

chewing

mechanical digestion

the purely physical process of breaking food down

medulla oblongata

lower part of the brain that controls such functions as heart rate, breathing, and blood pressure

metered dose inhaler

an inhaler that delivers medication by inhalation into the lungs; sometimes called a "puffer"

myelin

the fatty substance that surrounds and insulates the nerve fibres

myocardial infarction

heart attack

myoglobinemia

the presence of myoglobin in the blood; often seen with excessive exercise

narcotic

a type of analgesic medication that is available with a prescription, is highly regulated, and is used to treat moderate to severe pain

narcotics

analgesic medications that are available with a prescription, are highly regulated, and are used to treat moderate to severe pain

narrow-spectrum

antibiotics that target only specific types of bacterial pathogens

nausea

the feeling of being sick to your stomach

nebule

a small ampoule of liquid medication that is used with a nebulizer

nebulizer

a device that turns liquid medication into a mist that is inhaled into the lungs using a facemask

neuropathic

disease caused by damage or injury to the nerves

neuropathy

disease of the nerves

neurotransmitters

chemical messengers in the body

nociceptors

nerve endings that respond to painful stimuli

non-narcotic

analgesic medications that are often available without a prescription and are used to treat mild to moderate pain

nucleus

a membrane-enclosed organelle within a cell that contains the chromosomes

onychomycosis

fungal infection of the nail

organelles

small structures in a cell that are surrounded by a membrane and have a specific function

orthostatic hypotension

a decrease in blood pressure when moving from a sitting to a standing position

osteoblasts

bone-building cells

osteoclasts

cells that eat away bone

paroxysmal supraventricular tachycardia

a type of arrhythmia that presents with a regular but rapid heartbeat that starts and stops abruptly

partial thromboplastin time

a blood test that looks at how long it takes for blood to clot; abbreviated as PTT

pathogen

an organism that causes disease to its host

pathogens

organisms that cause disease to their host

peripheral arterial disease

obstruction of the vessels in peripheral regions of the body

peripheral artery disease

obstruction of blood vessels in peripheral regions of the body

peripheral edema

swelling of the limbs, usually the legs

peristalsis

the contraction and relaxation of muscles that move in a wave down a tube, for example, in the intestines

peritonitis

inflammation of the peritoneum

pharmacology

the science that deals with the actions of medications on the body

photophobia

eye discomfort in bright light; sensitivity to light

platelet aggregation

blood clotting

polyuria

urinating more than usual or producing an abnormal amount of urine

poverty of speech

a psychological condition in which a person speaks minimally or makes only brief replies

priapism

prolonged erection of the penis

PRN

abbreviation for "as needed"

propulsion

the movement of food through the digestive tract

prostaglandins

a group of lipids that are made at sites of tissue damage or infection

prothrombin time

a test that evaluates blood clotting

psychotherapy

also known as "talk therapy"; a way to help people with a broad variety of mental illnesses and various emotional difficulties

pulmonary edema

excess fluid in the lungs

pulmonary embolism

a blood clot in the lungs

retinopathy

disease of the retina

SA node

sinoatrial node, which is responsible for the contraction of the atria

Schedule IV

a medication with a low potential for abuse

sinus rhythm

normal sinus rhythm is a regular heartbeat

spacer

a plastic device attached to an inhaler that holds the medication while the patient inhales the entire dose

spasticity

increase in muscle tone or stiffness

stroke

a cerebrovascular accident (CVA)

subcutaneously

under all the layers of the skin

sublingual

under the tongue

sublingually

under the tongue

supraventricular tachycardia

irregular heart rhythm

synapse

the point of contact between neurons where information is passed from one neuron to the next

syncope

fainting

synergism

an increase in the therapeutic effects of a medication

tachycardia

increased heart rate

tapered

slowly lowering the dose of a medication

thrombolytic

medications used to dissolve a major clot quickly

thrombus

a blood clot that forms in a vein or artery

thyroidectomy

removal of the thyroid

tinea corporis

superficial skin infection

tonic

a state of continuous activity

tonic-clonic

a seizure characterized by a jerking (clonic) phase followed by the muscles becoming tense or rigid (tonic)

transient ischemic attack

also know as a mini-stroke; often abbreviated as TIA

Turbuhaler

an inhaler device that contains a powdered medication that is inhaled into the lungs

tyramine

an amino acid that helps regulate blood pressure; found in dried fruit such as raisins, apricots, and prunes, as well as in oranges, grapefruit, lemons, limes, and pineapples

vasculitis

inflammation of the blood vessels

vasodilation

widening of the blood vessels

ventricular dysrhythmia

irregular heartbeat in the ventricles

viscosity

thickness or consistency

viscous

having a thick, sticky consistency between solid and liquid

Abbreviations

Activity Orders

ABBREVIATION	MEANING
AAT	activity as tolerated
ad lib	freely, as desired
ADL	activities of daily living
BR	bedrest
BRP	bathroom privileges
PWB	partial weight-bearing

Nutrition Orders

ABBREVIATION	MEANING
CDA	Canadian Diabetes Association
Cl. flds	clear fluids
DAT	diet as tolerated
FDA	Food and Drug Administration
H2O	water
NPO	nothing by mouth
WDW	when drinking well

Diagnostic Tests

ABBREVIATION	MEANING
Angio	angiography
A&P	auscultation and percussion
Alb	albumin
Alk phos	alkaline phosphatase
Ba	barium
BaE	barium enema
BMR	basal metabolic rate
bs	blood sugar
BUN	blood urea nitrogen

ABBREVIATION	MEANING
C&S	culture and sensitivity test
Ca	calcium
CBC	complete blood count
CO2	carbon dioxide
CSF	cerebrospinal fluid
C-spine	cervical spine films
CT	computerized tomography
CXR	chest X-ray
DI	diagnostic imaging
diff	differential

ABBREVIATION	MEANING
DRE	digital rectal exam
ECG	electrocardiogram
Echo	echocardiogram
EEG	electroencephalogram
EMG	electromyogram
ERCP	endoscopic retrograde cholangiopancreatography (test of the pancreas and gallbladder)
ESR	erythrocyte sedimentation rate
ESWL	extracorporeal shock wave lithotripsy
ETOH	ethyl alcohol (level of alcohol consumption)
ETT	exercise tolerance test

ABBREVIATION	MEANING
FBS	fasting blood sugar
Fe	iron
Ga scan	gallium scan
GTT	glucose tolerance test
H	hydrogen
HCG	human chorionic gonadotropin (pregnancy test)
Hct	hematocrit
HDL	high-density lipoprotein
Hg	mercury
Hgb	hemoglobin

ABBREVIATION	MEANING
I	iodine
IVC	intravenous cholangiogram
IVP	intravenous pyelogram
K	potassium
KUB	kidneys, ureters, bladder
lab	laboratory
LDL	low-density lipoprotein
LFT	liver function test
Lymphs	lymphocytes
Lytes	electrolytes

ABBREVIATION	MEANING
Mg	magnesium
MRI	magnetic resonance imaging
MUGA	multigated acquisition scan (heart function test)
N	nitrogen
Na	sodium
O2	oxygen
P	phosphate
PCV	packed cell volume
PET	positron emission tomography

ABBREVIATION	MEANING
PFT	pulmonary function test
PSA	prostate-specific antigen
PT/INR	prothrombin time/international normalized ratio
PTT	partial thromboplastin time
rbc	red blood cell
RBC	red blood cell count
Sed rate	sedimentation rate
spec	specimen
T	temperature
TENS	transcutaneous electrical nerve stimulation

ABBREVIATION	MEANING
U/A	urinalysis
U/O	urine output
UGI	upper gastrointestinal
US	ultrasound
VQ scan	ventilation-perfusion scan of the lungs
wbc	white blood cell
WBC	white blood cell count

Procedures

ABBREVIATION	MEANING
AB	abortion
BP	blood pressure
BSE	breast self-exam
BSO	bilateral salpingo-oophorectomy
Bx	biopsy
cath	catheter
chemo	chemotherapy

ABBREVIATION	MEANING
CPR	cardiopulmonary resuscitation
cysto	cystoscopy
D&C	dilation and curettage
drsg	dressing
E	enema
ECT	electroconvulsive therapy
H&P	history and physical
HD	hemodialysis

ABBREVIATION	MEANING
HRT	hormone replacement therapy
I&D	incision and drainage
I&O	intake and output
lap	laparotomy
LP	lumbar puncture
SBFT	small bowel follow-through
T&A	tonsillectomy and adenoidectomy

ABBREVIATION	MEANING
TAB	therapeutic abortion
TAH-BSO	total abdominal hysterectomy–bilateral salpingo-oophorectomy
TPR	temperature, pulse, respirations
TURP	transurethral resection of the prostate gland
VS	vital signs
XRT	radiation therapy

Medications

ABBREVIATION	MEANING
2/3-1/3	2/3 dextrose, 1/3 saline
ac	before meals
am	morning
ASAP	as soon as possible
bid	twice a day
C	Celsius
caps	capsule(s)
cm	centimetre

ABBREVIATION	MEANING
D/S	dextrose in saline
D/W	dextrose in water
D5W	5% dextrose in water
g	gram
gtt	drop or drops
h, hr	hour
h.s.	at bedtime
H20	water
i, ii, iii, iv	one, two, three, four
ID	initial dose
IM	intramuscular

ABBREVIATION	MEANING
INH	Isoniazid (medication used to treat tuberculosis)
IV	intravenous
kg	kilogram
kJ	kilojoule
L	litre
Lax	laxative
LD	last dose
m	metre

ABBREVIATION	MEANING
MAR	medication administration record
mcg	microgram
mg	milligram
mL	millilitre
mm	millimetre
NG	nasogastric
NKA	no known allergies
NS	normal saline
NSAID	nonsteroidal anti-inflammatory drug

ABBREVIATION	MEANING
pc	after a meal
pm	evening
po	orally, by mouth
PPN	partial parenteral nutrition
pr	per rectum
prn	as necessary
pv	per vagina
qh.s.	every night at bedtime

ABBREVIATION	MEANING
q1h, q2h, q3h, …	every hour, every two hours, every three hours, …
qam	every morning
qid	four times a day
RL	Ringer's lactate
Rx	prescription
sc	subcutaneous
sl	sublingual (under the tongue)

ABBREVIATION	MEANING
STAT	immediately
supp	suppository
tab	tablet
tid	three times a day
TKVO	to keep vein open
TPN	total parenteral nutrition
ungt	ointment
v/o	verbal order

Diseases and Symptoms

ABBREVIATION	MEANING
ASHD	arteriosclerotic heart disease
BPH	benign prostatic hypertrophy
CA	cancer
CF	cystic fibrosis
CHF	congestive heart failure
COPD	chronic obstructive pulmonary disease
CP	cerebral palsy
CVA	cerebrovascular accident

ABBREVIATION	MEANING
DT	delirium tremens
DVT	deep vein thrombosis
GERD	gastroesophageal reflux disease
HBV	hepatitis B virus
HCV	hepatitis C virus
HIV	human immunodeficiency virus
HPV	human papilloma virus
HTN	hypertension

ABBREVIATION	MEANING
IBD	inflammatory bowel disease
IBS	irritable bowel syndrome
MI	myocardial infarction
MS	multiple sclerosis
N&V	nausea and vomiting
NYD	not yet diagnosed
OA	osteoarthritis
OP	osteoporosis
ORIF	open reduction internal fixation

ABBREVIATION	MEANING
PVD	peripheral vascular disease
SARS	severe acute respiratory syndrome
SIDS	sudden infant death syndrome
SOB	shortness of breath
Staph	bacterial infection (*Staphylococcus*)
STD/STI	sexually transmitted disease/infection
Strep	bacterial infection (*Streptococcus*)
TB	tuberculosis
TIA	transient ischemic attack
UTI	urinary tract infection
VT, V tach	ventricular tachycardia

Common Medical Terms

ABBREVIATIONS	MEANING
Ab	antibody
abd	abdomen
BM	bowel movement, bone marrow
C1, C2, …	cervical vertebra 1, cervical vertebra 2, …
CCU	coronary care unit
CNS	central nervous system

ABBREVIATIONS	MEANING
DNA	deoxyribonucleic acid
DOB	date of birth
Dr.	doctor
Dx	diagnosis
EENT	eye, ear, nose, and throat
ENT	ear, nose, and throat
ER	emergency room
Fx	fracture

ABBREVIATIONS	MEANING
GI	gastrointestinal
GU	genitourinary
GYN	gynecology
HCA	healthcare aide
Ht	height
Hx	history
ICU	intensive care unit
JP	Jackson-Pratt drain
Kx	Kardex
L	left

ABBREVIATIONS	MEANING
L1, L2, …	lumbar vertebra 1, lumbar vertebra 2, …
lat	lateral
LLQ	left lower quadrant
LPN	licensed practical nurse
LUQ	left upper quadrant
MBA	motorbike accident
MD	medical doctor
meds	medications
mets	metastasis
mm Hg	millimetres of mercury

ABBREVIATIONS	MEANING
MVA	motor vehicle accident
NICU	neonatal intensive care unit
OPD	outpatient department
OR	operating room
Ortho	orthopedics
PA	posteroanterior
PAC	pre-admission clinic
PCA	patient-controlled analgesic
post-op	after surgery
pre-op	before surgery

ABBREVIATIONS	MEANING
prep	preparation
Pt	patient
qt	quart
req	requisition
RLQ	right lower quadrant
RN	registered nurse
ROM	range of motion
RR	recovery room
RT	respiratory therapist
R	right

ABBREVIATIONS	MEANING
RUQ	right upper quadrant
S1, S2, …	sacral vertebra 1, sacral vertebra 2, …
T1, T2, …	thoracic vertebra 1, thoracic vertebra 2, …
Tx	treatment
UV	ultraviolet
VAX	computerized medical system
W/C	wheelchair
wt	weight
yr	year

Common Suffixes

Common Suffix	Category
-pril	ACE inhibitors (hypertension
-azosin	alpha-1 blockers (hypertensio
-losin	alpha-1 receptor blockers
-micin, -mycin	aminoglycoside antibiotics
-sartan	angiotensin II receptor block
-tropium	anticholinergic bronchodilat
-conazole	antifungals
-barbital	barbiturates (for epilepsy)
-azepam	benzodiazepines
-terol	beta-agonist bronchodilators
-olol	beta-blockers (hypertension)
-dronate, -dronic	bone resorption inhibitors
-dipine	calcium channel blockers (hy
-penem	carbapenem antibiotics
-lone, -sone	corticosteroids
-lone, -sone, -solone	corticosteroids (more comm

-methasone, -metasone, -solide, -solone	corticosteroids (respiratory)
-floxacin	fluoroquinolone antibiotics
-tidine	H2 blockers
-statin	HMB-CoA reductase inhibito
-toin	hydantoin anticonvulsants
-parin	low-molecular-weight hepar
-profen, -coxib	NSAIDs
-cillin	penicillins
-prazole	proton pump inhibitors (PPIs
-pram, -oxamine, -oxetine	SSRIs
-cycline	tetracycline antibiotics
-thiazide	thiazide diuretics
-triptyline	tricyclic antidepressants
-phylline	xanthine bronchodilators

Complete Medication List

Below is a complete list of all medications from this book (insulins not included).

Generic Name	Trade Name	Reason for Administering
abatacept	Orencia	rheumatoid arthritis (RA)
acamprosate	Camprol	alcohol withdrawal
acebutolol	Sectral	hypertension (HTN), myocardial infar
acetaminophen	Tylenol	osteoarthritis (OA), rheumatoid arthr
acetaminophen	Tylenol	mild to moderate pain, fever
acetaminophen + codeine	Tylenol-Codeine, Tylenol-Codeine No. 3, Tylenol-Codeine No. 4	moderate to severe pain
acetylsalicylic acid	Aspirin	osteoarthritis (OA), tendinitis
acetylsalicylic acid	Bayer Aspirin, Ecotrin, Empirin	mild to moderate pain, inflammatory
acyclovir	Zovirax	herpes infection
adalimumab	Humira	rheumatoid arthritis (RA)
adefovir	Hepsera	hepatitis infection
adenosine		arrhythmias
albuteral	Ventolin	asthma
albuteral/ipratropium	Combivent	COPD
alendronate	Fosamax	osteoporosis (OP)

alginate, magnesium	Gaviscon	GERD
allopurinol	Zyloprim	gout
alprazolam	Xanax	anxiety
alteplase (tPA)	Alteplase	dissolving blood clots
aluminum hydroxide	Maalox	GERD
aluminum hydroxide gel	Amphojel	GERD
amantadine	Gocovri	Parkinson's disease
amantadine	Symmetrel	influenza virus infection
amiloride	Midamor	hypertension (HTN), congestive heart
amiodarone	Cordarone	arrhythmias
amitriptyline	Elavil	depression, insomnia, neuropathic pa
amlodipine	Norvasc	hypertension (HTN)
amoxapine	Asendin	depression, insomnia, neuropathic pa
amoxicillin	Amoxil	bacterial infection
amphetamine	Adderall	ADHD
amphotericin B	Fungizone	systemic fungal infection
ampicillin	Principen	bacterial infection

antiphlogistine	Rub A535	osteoarthritis (OA)
aspirin + codeine	Empirin-Codeine No. 3, Empirin-Codeine No. 4	moderate to severe pain
aspirin + oxycodone	Percodan	moderate to severe pain
atenolol	Tenormin	hypertension (HTN), myocardial infar
atorvastatin	Lipitor	high cholesterol
azithromycin	Zithromax	bacterial infection
baclofen	Lioresal	multiple sclerosis (MS), muscle spasm (adjuvant)
benazepril	Lotensin	hypertension (HTN), heart failure
betamethasone	Celestone Soluspan	osteoarthritis (OA)
betamethasone	Celestone	rheumatic disorders
betapace	Sotalol	arrhythmias
bisacodyl	Dulcolax	constipation
bismuth subsalicylate	Pepto-Bismol	GERD
bisoprolol	Monocor	hypertension (HTN), myocardial infar
budesonide	Pulmicort	preventing asthma attacks
buprenorphine	Buprenex, Subutex	withdrawal from heroin, cocaine, or r

bupropion	Zyban	smoking cessation
bupropion	Aplenzin, Wellbutrin	depression
calcium carbonate	Tums	GERD
calcium carbonate	Rolaids	GERD
candesartan	Atacand	hypertension (HTN), prevention of a h failure
capofungin	Cancidas	systemic fungal infection
captopril	Capoten	hypertension (HTN), heart failure
carbamazepine	Tegretol	seizure disorders
carbidopa/levodopa	Sinemet	Parkinson's disease
carvedilol	Coreg	hypertension (HTN), myocardial infar
cefazolin	Ancef	bacterial infection
ceftriaxone	Rocephin	bacterial infection
cefuroxime	Ceftin, Zinacef	bacterial infection
celecoxib	Celebrex	osteoarthritis (OA), rheumatoid arthr
celecoxib	Celebrex	mild to moderate pain, inflammatory
cephalexin	Keflex	UTI

cephalexin	Keflex	bacterial infection
cetirizine	Zyrtec	cold and allergy symptoms
chloral hydrate	Somnote	insomnia
chlordiazepoxide	Librium	anxiety
ciclesonide	Alvesco	preventing asthma attacks
cilazapril	Inhibace	hypertension (HTN), heart failure
cimetidine	Tagamet	GERD
ciprofloxacin	Cipro	bacterial infection
citalopram	Celexa	depression
clarithromycin	Biaxin	bacterial infection
clindamycin	Cleocin	bacterial infection
clonidine	Catapres	hypertension (HTN)
clopidogrel	Plavix	blood clot, risk of blood clots (will not
clotrimazole	Lotrimin	fungal skin infection
codeine	–	moderate to severe pain
colchicine	Colchicine-Odan	gout
cyclobenzaprine	Flexeril, Amrix	muscle spasm, moderate to severe pa

dabigatran	Pradaxa	blood clot, risk of blood clots (will not
dalteparin	Fragmin	blood clot, risk of blood clots (will not
demeclocycline	Declomycin	bacterial infection
denosumab	Prolia	osteoporosis (OP)
desipramine	Norpramin	depression, insomnia, neuropathic pa
desvenlafaxine	Pristiq	depression
dexamethasone	Decadron	rheumatic problems, asthma, COPD
dextromethorphan	Robitussin	suppresses cough
diazepam	Valium	anxiety
diclofenac	Voltaren	osteoarthritis (OA)
diclofenac	Cataflam, Flector, Voltaren	mild to moderate pain, inflammatory
diflunisal	Dolobid	mild to moderate pain, inflammatory
digoxin	Lanoxin	heart failure, atrial fibrillation
diltiazem	Cardiazem	hypertension (HTN), arrhythmia
dimenhydrinate	Gravol	nausea and vomiting
diphenhydramine	Benadryl	cold and allergy symptoms
disulfiram	Antabuse	alcohol withdrawal

docusate	Colace	constipation
donepezil	Aricept	Alzheimer's disease/dementia
doxepin	Silenor	insomnia/depression
doxepin	Sinequan	depression, insomnia, neuropathic pa
doxycycline	Vibramycin, Vibra-Tabs	bacterial infection
duloxetine	Cymbalta	depression
enalapril	Vasotec	hypertension (HTN), heart failure
enoxaparin	Lovenox	blood clot, risk of blood clots (will not
entecavir	Barclude	hepatitis infection
erythromycin	E-Mycin	bacterial infection
escitalopram	Lexapro	depression
esomeprazole	Nexium	GERD
estrogen/progesterone	–	osteoporosis (OP)
etanercept	Enbrel	rheumatoid arthritis (RA)
ethacrynic acid	Edecrin	hypertension (HTN), congestive heart
ethotoin	Peganone	seizure disorders
etidronate	Didrocal	osteoporosis (OP)

etodolac	Lodine	mild to moderate pain, inflammatory
ezetimibe	Zetia	high cholesterol
famotidine	Pepcid	GERD
felodipine	Plendil	hypertension (HTN)
fenoprofen	Nalfon	mild to moderate pain, inflammatory
fentanyl	Abstral, Actiq, Duragesic	moderate to severe pain
ferrous fumarate	Ferro-Sequels	iron supplement
ferrous gluconate	Fergon	iron supplement
ferrous sulfate	Feosol, Fer-In-Sol, Slow FE	iron supplement
fexofenadine	Allegra	cold and allergy symptoms
finasteride	Proscar	benign prostatic hypertrophy (BPH)
flecainide acetate	Tambocor	arrhythmias
fluconazole	Diflucan	yeast and fungal infections
flucytosine	Ancobon	yeast infection
fludrocortisone	Florinef	adrenal insufficiency
fluoxetine	Prozac	depression
flurazepam	Dalmane	insomnia/anxiety

flurbiprofen	Ansaid	osteoarthritis (OA)
fluticasone	Flovent	preventing asthma attacks
fluticasone/salmeterol	Advair	asthma, COPD, bronchitis, and emphy
fluvastatin	Lescol	high cholesterol
fluvoxamine	Luxor	depression
fosfomycin	Monurol	UTI
fosinopril	Monopril	hypertension (HTN), heart failure
fosphenytoin	Cerebyx	seizure disorders
furosemide	Lasix	hypertension (HTN), congestive heart
gabapentin	Neurontin	seizure disorders
gentamicin	Cidomycin	bacterial infection
glipizide	Glucotrol	type 2 diabetes
glucagon	Glucagen	hypoglycemia
glyburide	Diabeta	type 2 diabetes
guaifenesin	Mucinex	productive cough
guanfacine	Tenex	hypertension (HTN)
haloperidol	Haldol	schizophrenia, mania, psychosis, Tou

heparin sodium, heparin	Heparin	blood clot, risk of blood clots (will not
hydrochlorothiazide	HCTZ	hypertension (HTN), congestive heart
hydrochlorothiazide, propranolol	Inderide LA	hypertension (HTN)
hydrocodone	Zohydro ER	moderate to severe pain
hydrocortisone	Cortef, Solu-Cortef	adrenocortical insufficiency, rheumat
hydromorphone	Dilaudid	moderate to severe pain
hydroxychloroquine	Plaquenil	rheumatoid arthritis (RA)
hyoscyamine	Levsin	peptic ulcers, decreases gastric secre
ibuprofen	Advil, Motrin	osteoarthritis (OA), gout
ibuprofen	Advil, Motrin	mild to moderate pain, inflammatory
imipramine	Tofranil	depression, insomnia, neuropathic pa
indapamide	Lozide	hypertension (HTN), CHF, edema
indomethacin	Indocid	osteoarthritis (OA)
indomethacin	Indocin	mild to moderate pain, inflammatory
influenza virus vaccine	Fluarix, FluMist	influenza virus infection
interferon alfa-2b	Intron A	hepatitis infection
interferon alfacon-1	Infergen	hepatitis infection

ipratropium	Atrovent	asthma, chronic bronchitis, and empl
irbesartan	Avapro	hypertension (HTN), prevention of a h failure
ketoconazole	Nizoral	systemic fungal infection
ketoprofen	Ketofen, Anafen	mild to moderate pain, inflammatory
ketorolac	Toradol	osteoarthritis (OA), gout
ketorolac	Toradol	mild to moderate pain, inflammatory
ketotifen	Zaditor	cold and allergy symptoms
lactulose	Cephulac	constipation
lamivudine	Epivir	hepatitis infection
lansoprazole	Prevacid	GERD
levetiracetam	Keppra	seizure disorders
levofloxacin	Levaquin	UTI
levofloxacin	Levaquin	bacterial infection
levomilnacipran	Fetzima	depression
levothyroxine	Synthroid	hypothyroidism
lidocaine	Xylocaine	arrhythmias

liothyronine	Cytomel, Triostat	hypothyroidism
lisinopril	Zestril	hypertension (HTN), heart failure
lithium	Lithobid	mania (bipolar disorder)
loperamide	Imodium	diarrhea
loratadine	Claritin	cold and allergy symptoms
lorazepam	Ativan	anxiety
losartan	Cozaar	hypertension (HTN), prevention of a h failure
magnesium hydroxide	Milk of Magnesia	GERD, constipation
magnesium salicylate	Doan's	mild to moderate pain, inflammatory
menthol topical	BenGay	osteoarthritis (OA)
meperidine	Demerol	moderate to severe pain
mephobarbital	Mebaral	seizure disorders
meropenem	Merrem IV	bacterial infection
metformin	Glucophage	type 2 diabetes
methadone	Diskets, Dolophine	withdrawal from heroin, cocaine, or r
methadone	Dolophine, Methadose	moderate to severe pain

methimazole	Tapazole	hyperthyroidism, Graves' disease
methotrexate	Metoject	rheumatoid arthritis (RA)
methyldopa	Aldomet	hypertension (HTN)
methylphenidate	Ritalin, Concerta	ADHD
methylprednisolone	Depo-Medrol	osteoarthritis (OA)
methylprednisolone	Medrol, Solu-Medrol	inflammatory conditions, arthritis, lu
metoclopramide	Maxeran	nausea and vomiting
metolazone	Zaroxolyn	hypertension (HTN), congestive heart
metoprolol	Lopressor	hypertension (HTN), myocardial infar
metoprolol, hydrochlorothiazide	Dutoprol	hypertension (HTN)
metronidazole	Flagyl	bacterial infection, intestinal parasite
miconazole	Monistat	fungal skin infection
mineral oil enema	Fleet	constipation
minocycline	Dynacin, Minocin	bacterial infection
mometasone	Asmanex	preventing asthma attacks
montelukast	Singulair	allergies, preventing asthma attacks
morphine sulphate	Astramorph, Duramorph, MS Contin	moderate to severe pain

nalaxone	Narcan	narcotic (opioid) overdose
naproxen	Aleve	osteoarthritis (OA), gout
naproxen	Aleve	mild to moderate pain, inflammatory
nefazodone	Oleptro	depression
neomycin	Neosporin	bacterial infection
nicotine	Nicorette	smoking cessation
nicotine inhaler system	Nicotrol	smoking cessation
nifedipine XL	Adalat XL	hypertension (HTN)
nitrofurantoin	Macrobid	UTI
nitroglycerine	Nitro-Bid	angina
nortriptyline	Aventyl, Pamelor	depression, insomnia, neuropathic pa
nystatin	Mycostatin, Nystatin Cream	yeast infection
omeprazole	Prilosec	GERD
ondansetron	Zofran	nausea and vomiting
oseltamivir	Tamiflu	influenza virus infection
oxybutynin	Ditropan	overactive bladder
oxycodone	OxyContin, Roxicodone	moderate to severe pain

oxycodone + acetaminophen	Percocet	moderate to severe pain
oxymorphone	Numorphan, Opana	moderate to severe pain
pantoprazole	Pantoloc	GERD
paroxetine	Paxil	depression
penicillin V	Penicillin VK, Veetids	bacterial infection
perindopril	Coversyl	hypertension (HTN), heart failure
phenobarbital	Luminal	seizure disorders
phenytoin	Dilantin	seizure disorders
piperacillin	Pipracil	bacterial infection
polyethylene glycol (PEG)	Miralax	constipation
pravastatin	Lipostat	high cholesterol
prednisolone	Pediapred, Prelone	inflammatory conditions, autoimmun
prednisone	Winpred	rheumatoid arthritis (RA)
prednisone	Deltasone, Meticorten	immune system suppression, inflamm
prochlorperazine	Stemetil	nausea and vomiting
propranolol	Inderal	hypertension (HTN), myocardial infar
propylthiouracil	Propacil	hyperthyroidism

psyllium	Metamucil	constipation
quinapril	Accupril	hypertension (HTN), heart failure
quinapril, hydrochlorothiazide	Accuretic	hypertension (HTN)
quinidine	no brand name	arrhythmia
raloxifene	Evista	osteoporosis (OP)
ramipril	Altace	hypertension (HTN), heart failure
ranitidine	Zantac	GERD
razadyne	Galantamine	Alzheimer's disease/dementia
rimantadine	Flumadine	influenza virus infection
risedronate	Actonel	osteoporosis (OP)
risperidone	Risperdal	schizophrenia, bipolar disorder, psycl
rivaroxaban	Xarelto	blood clot, risk of blood clots (will not
rivastigmine	Exelon	Alzheimer's disease/dementia
rosuvastatin	Crestor	high cholesterol
salmeterol	Serevent	asthma
salsalate	Salsitab	mild to moderate pain, inflammatory
scopolamine	Scopace, Maldemar	nausea related to motion sickness

selegiline	Eldepryl, Emsam	Parkinson's disease
senna	Senokot	constipation
sertraline	Zoloft	depression
sildenafil	Viagra	erectile dysfunction
simethicone	Oval	antiflatulent
simvastatin	Zocor	high cholesterol
sitagliptin	Januvia	type 2 diabetes
sodium iodide 131	Iodotope	hyperthyroidism, thyroid cancer
spironolactone	Aldactone	hypertension (HTN), congestive heart
sucralfate	Sulcrate	ulcers
sulfadiazine	Silvadene	bacterial infection
sulfisoxazole	Gastrinsin Pediatric	bacterial infection
sulfisoxazole/trimethoprim (SMZ/TMP)	Bactrim, Septra	bacterial infection
tacrine	Cognex	Alzheimer's disease/dementia
tadalafil	Cialis	erectile dysfunction
telmisartan	Micardis	hypertension (HTN), prevention of a h failure

temazepam	Restoril	insomnia/anxiety
terbinafine	Lamisil	systemic fungal infection
tetracycline	Sumycin	bacterial infection
theophylline	Elixophyllin	asthma and COPD
timolol	Blocadren	hypertension (HTN), myocardial infar
tinzaparin	Innohep	blood clot, risk of blood clots (will not
tiotropium	Spiriva	asthma, chronic bronchitis, and emph
tizanidine	Zanaflex	muscle spasms, moderate to severe p
tobramycin	TOBI, Tobrex	bacterial infection
tolterodine	Detrol	overactive bladder
tramadol	Ultram	moderate to severe pain
trandolapril	Mavik	hypertension (HTN), heart failure
tranylcypromine	Parnate	depression, Parkinson's disease
trazodone	Oleptra	insomnia/depression
trazodone	Brintellix	depression
triamcinolone	Kenalog, Aristospan	osteoarthritis (OA)
triamcinolone	Aristocort, Kenalog	skin diseases, allergies, rheumatic dis

triazolam	Halcion	insomnia/anxiety
trimethoprim-sulfamethoxazole	Bactrim, Septra	UTI
trolamine salicylate	Aspercreme	osteoarthritis (OA)
valproate	Valproic acid	seizure disorders
valsartan	Diovan	hypertension (HTN), prevention of a h failure
valsartan, hydrochlorothiazide	Diovan HCT	hypertension (HTN)
vancomycin	Vancocin	bacterial infection
varenicline	Chantix	smoking cessation
venlafaxine	Effexor	depression
verapamil	Isoptin	hypertension (HTN), arrhythmia
warfarin	Coumadin, Jantoven	blood clot, risk of blood clots (will not
zanamivir	Relenza	influenza virus infection
zolpidem	Ambien, Intermezzo, Zopimist	insomnia
zopiclone	Imovane	insomnia