## 9.2 Cardiovascular Basic Concepts

While the cardiovascular assessment most often focuses on the function of the heart, it is important for nurses to have an understanding of the underlying structures of the cardiovascular system to best understand the meaning of their assessment findings.

- For more information on the cardiovascular system, visit the "Cardiovascular and Renal System" chapter in Open RN *Nursing Pharmacology*.
- Specific sections include the following topics:
  - Review of Basic Concepts for more about the anatomy and physiology of the cardiovascular system
  - Common Cardiac Disorders for more about cardiovascular medical conditions
  - Cardiovascular and Renal System Medications for more about medications used to treat common cardiovascular conditions

## Review of Anatomy and Physiology of the Heart on YouTube[1]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=67#oembed-1*

1. Forciea, B. (2015, May 20). *Anatomy of the heart (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/d8RSvcc8koo

## 9.3 Cardiovascular Assessment

A thorough assessment of the heart provides valuable information about the function of a patient's cardiovascular system. Understanding how to properly assess the cardiovascular system and identifying both normal and abnormal assessment findings will allow the nurse to provide quality, safe care to the patient.

Before assessing a patient's cardiovascular system, it is important to understand the various functions of the cardiovascular system. In addition to the information provided in the "Review of Cardiac Basics" section, the following images provide an overview of the cardiovascular system. Figure 9.1[1] provides an overview of the structure of the heart. Note the main cardiac structures are the atria, ventricles, and heart valves. Figure 9.2[2] demonstrates blood flow through the heart. Notice the flow of deoxygenated blood from the posterior and superior vena cava into the right atria and ventricle during diastole (indicated by blue coloring of these structures). The right ventricle then pumps deoxygenated blood to the lungs via the pulmonary artery during systole. At the same time, oxygenated blood from the lungs returns to the left atria and ventricle via the pulmonary veins during diastole (indicated by red coloring of these structures) and then is pumped out to the body via the aorta during systole. Figure 9.3[3] demonstrates the conduction system of the heart. This image depicts the conduction pathway through the heart as the tissue responds to electrical stimulation. Figure 9.4[4] illustrates the arteries of the circulatory system, and Figure 9.5[5] depicts the veins of the circulatory system. The purpose of these figures is to facilitate understanding of the electrical and mechanical function of the heart within the cardiovascular system.

1. "Diagram of the human heart" by Wapcaplet is licensed under CC BY-SA 3.0
2. "Diagram of the human heart" by Wapcaplet is licensed under CC BY-SA 3.0
3. "2018 Conduction System of Heart.jpg" by OpenStax is licensed under CC-BY-3.0
4. "Arterial System en.svg" by LadyofHats, Mariana Ruiz Villarreal is in the Public Domain.
5. "Venous system en.svg" by Lady of Hats Mariana Ruiz Vilarreal is in the Public Domain.

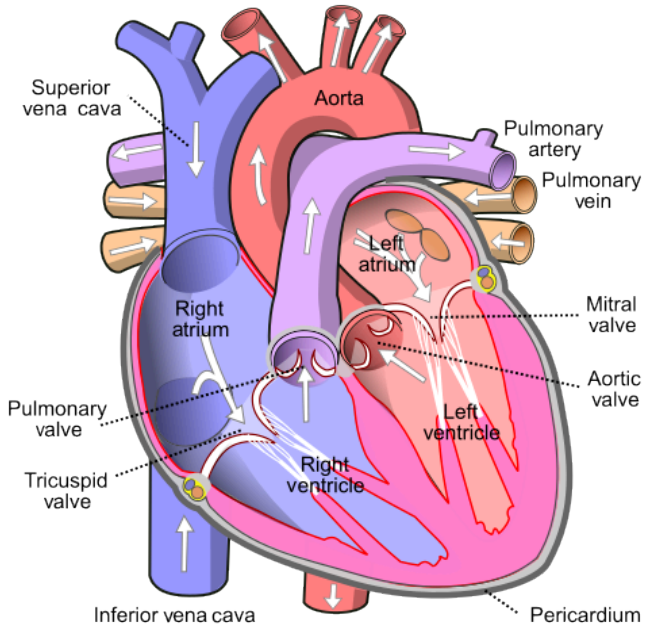



*Figure 9.1 Structure of the Heart*

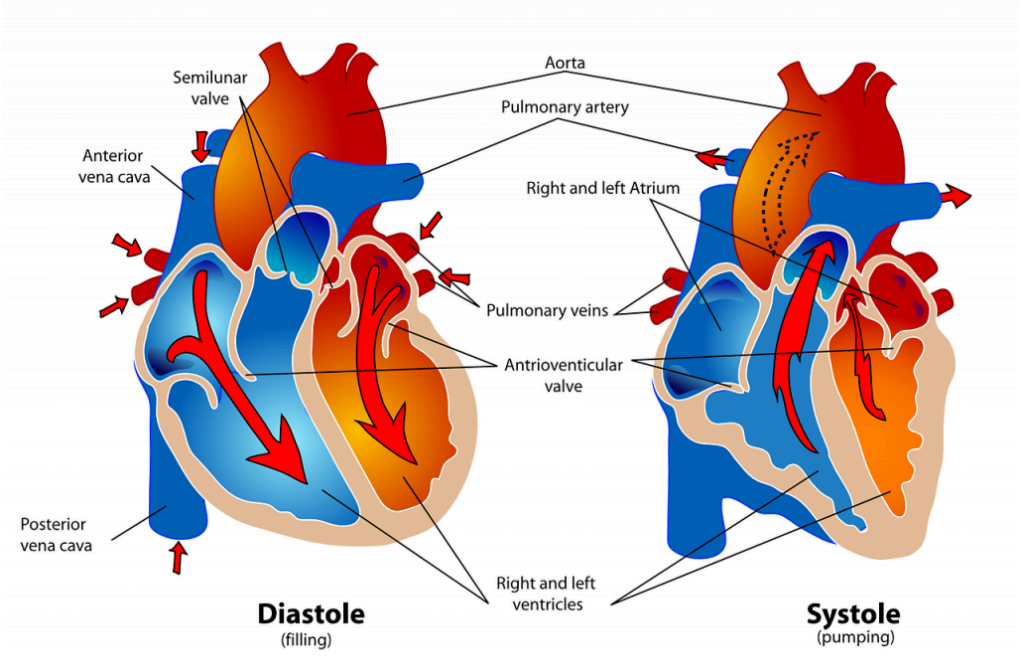



*Figure 9.2 Blood Flow Through the Heart*

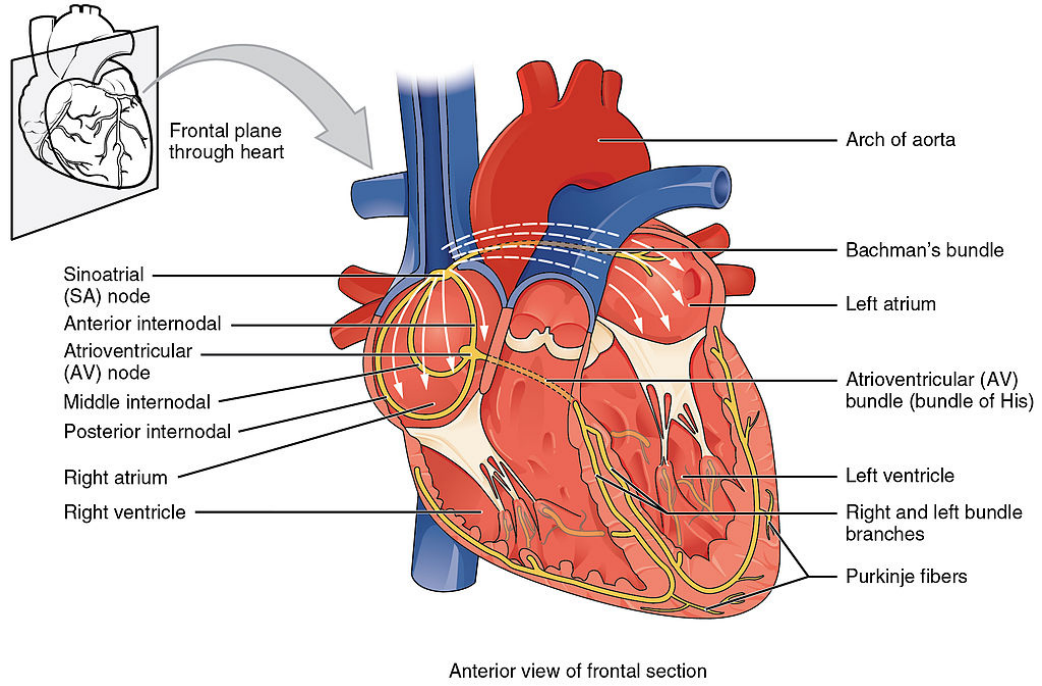



*Figure 9.3 Conduction System of the Heart*

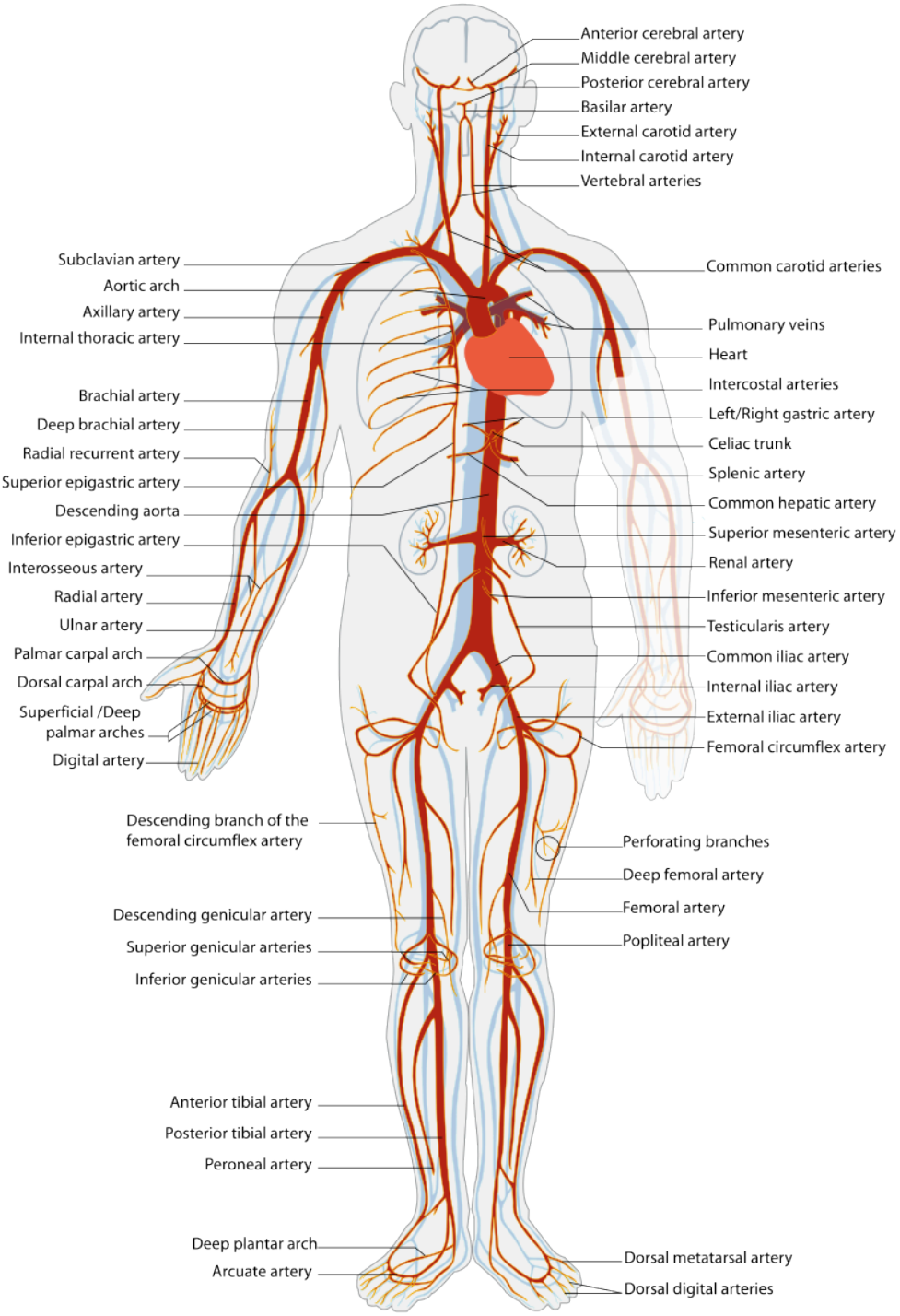



*Figure 9.4 Circulatory System: Arteries*

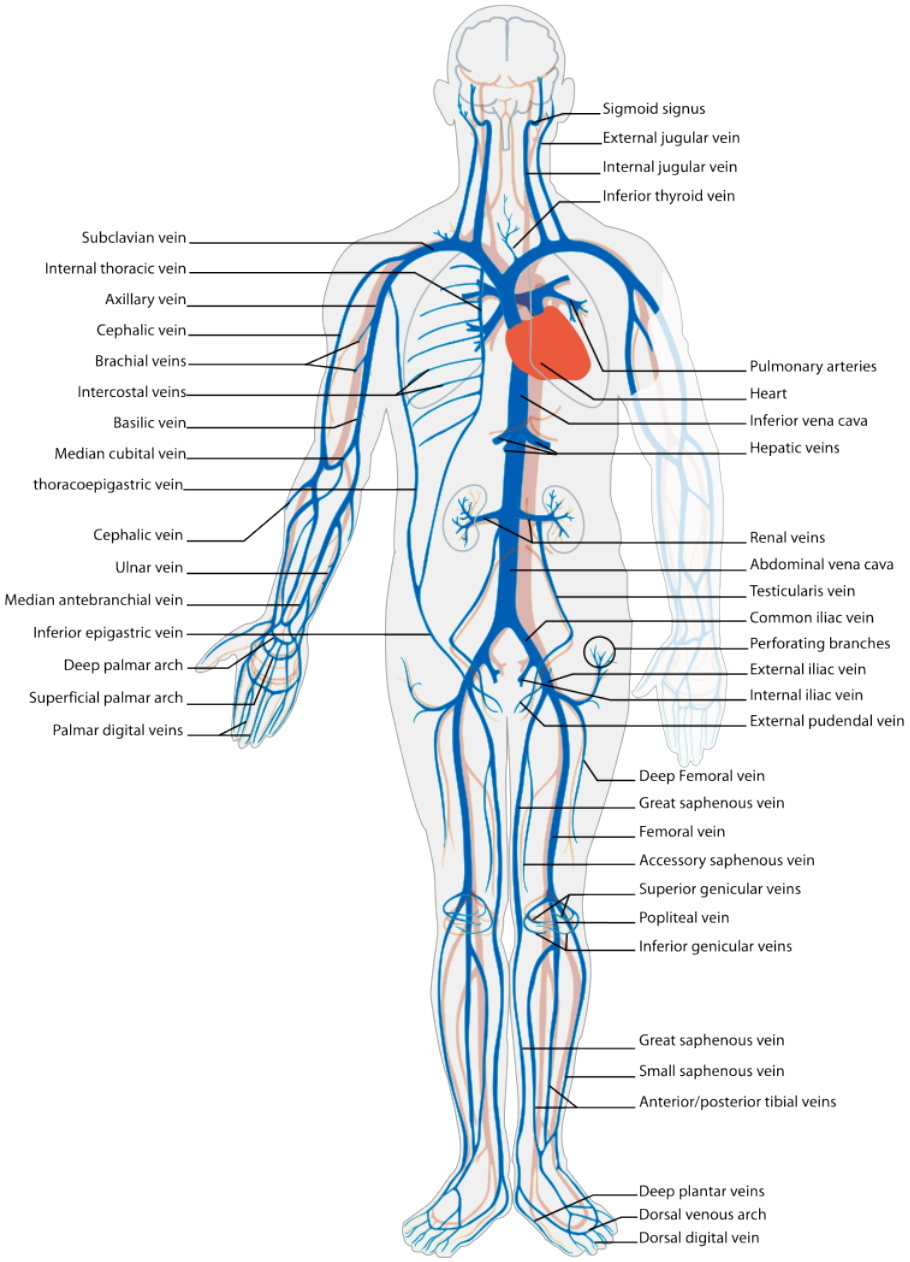



*Figure 9.5. Circulatory System: Veins*

Assessing the cardiovascular system includes performing several subjective and objective assessments. At times, assessment findings are modified according to life span considerations.

## Subjective Assessment

The subjective assessment of the cardiovascular and peripheral vascular

system is vital for uncovering signs of potential dysfunction. To complete the subjective cardiovascular assessment, the nurse begins with a focused interview. The focused interview explores past medical and family history, medications, cardiac risk factors, and reported symptoms. Symptoms related to the cardiovascular system include chest pain, peripheral edema, unexplained sudden weight gain, shortness of breath (dyspnea), irregular pulse rate or rhythm, dizziness, or poor peripheral circulation. Any new or worsening symptoms should be documented and reported to the health care provider.

Table 9.3a outlines questions used to assess symptoms related to the cardiovascular and peripheral vascular systems. Table 9.3b outlines questions used to assess medical history, medications, and risk factors related to the cardiovascular system. Information obtained from the interview process is used to tailor future patient education by the nurse.[6,7,8]

Table 9.3a Interview Questions for Cardiovascular and Peripheral Vascular Systems[9]

6. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology licensed under CC BY 4.0
7. Felner, J. M. (1990). An overview of the cardiovascular system. In Walker, H. K., Hall, W. D., & Hurst, J. W. (Eds.), *Clinical methods: The history, physical, and laboratory examinations* (3rd ed., Chapter 7). Butterworths. https://www.ncbi.nlm.nih.gov/books/NBK393/
8. Scott, C., & MacInnes, J. D. (2013, September 27). Cardiac patient assessment: putting the patient first. *British Journal of Nursing, 15*(9). https://doi.org/10.12968/bjon.2006.15.9.21091
9. Scott, C., & MacInnes, J. D. (2013, September 27). Cardiac patient assessment: putting the patient first. *British Journal of Nursing, 15*(9). https://doi.org/10.12968/bjon.2006.15.9.21091

| Symptom | Question | Follow-Up<br><br>**Safety Note:** If findings indicate current severe symptoms suggestive of myocardial infarction or another critical condition, suspend the remaining cardiovascular assessment and obtain immediate assistance according to agency policy or call 911. |
|---|---|---|
| **Chest Pain** | Have you had any pain or pressure in your chest, neck, or arm? | Review how to assess a patient's chief complaint using the PQRSTU method in the "Health History" chapter.<br><br>• P-provocation or palliation—What brings on the pain? What relieves the pain?<br>• Q-Quality or quantity—Characteristics and duration<br>• R-Region or Radiation—Where is the pain? Does it radiate anywhere?<br>• S-Severity—How would you rate the pain on a scale of 0-10?<br>• T-Timing—When did the pain start? How long does the pain last? Anything relieve the pain?<br>• U-Understanding—What do you think is causing the pain? |

| | | |
|---|---|---|
| **Shortness of Breath**<br><br>(**Dyspnea)** | Do you ever feel short of breath with activity?<br><br>Do you ever feel short of breath at rest?<br><br>Do you feel short of breath when lying flat? | What level of activity elicits shortness of breath?<br><br>How long does it take you to recover?<br><br>Have you ever woken up from sleeping feeling suddenly short of breath (**paroxysmal nocturnal dyspnea**)?<br><br>How many pillows do you need to sleep, or do you sleep in a chair (**orthopnea**)? Has this recently changed? |
| **Edema** | Have you noticed swelling of your feet or ankles?<br><br>Have you noticed your rings, shoes, or clothing feel tight at the end of the day?<br><br>Have you noticed any unexplained, sudden weight gain?<br><br>Have you noticed any new abdominal fullness? | Has this feeling of swelling or restriction gotten worse?<br><br>Is there anything that makes the swelling better (e.g., sitting with your feet elevated)?<br><br>How much weight have you gained? Over what time period have you gained this weight? |

| | | |
|---|---|---|
| **Palpitations** | Have you ever noticed your heart feels as if it is racing or "fluttering" in your chest?<br><br>Have you ever felt as if your heart "skips" a beat? | Are you currently experiencing palpitations?<br><br>When did palpitations start?<br><br>Have you previously been treated for palpitations? If so, what treatment did you receive? |
| **Dizziness (Syncope)** | Do you ever feel light-headed?<br><br>Do you ever feel dizzy?<br><br>Have you ever fainted? | Can you describe what happened?<br><br>Did you have any warning signs?<br><br>Did this occur with position change? |
| **Poor Peripheral Circulation** | Do your hands or feet ever feel cold or look pale or bluish?<br><br>Do you have pain in your feet or lower legs when exercising? | What, if anything, brings on these symptoms?<br><br>How much activity is needed to cause this pain?<br><br>Is there anything, such as rest, that makes the pain better? |
| **Calf Pain** | Do you currently have any constant pain in your lower legs? | Can you point to the area of pain with one finger? |

Table 9.3b Interview Questions Exploring Cardiovascular Medical History, Medications, and Cardiac Risk Factors

| Topic | Questions |
| --- | --- |
| **Medical History** | Have you ever been diagnosed with any heart or circulation conditions, such as high blood pressure, coronary artery disease, peripheral vascular disease, high cholesterol, heart failure, or valve problems?<br><br>Have you had any procedures done to improve your heart function, such as ablation or stent placement?<br><br>Have you ever had a heart attack or stroke? |
| **Medications** | Do you take any heart-related medications, herbs, or supplements to treat blood pressure, chest pain, high cholesterol, cardiac rhythm, fluid retention, or the prevention of clots? |

| | |
|---|---|
| **Cardiac Risk Factors** | Have your parents or siblings been diagnosed with any heart conditions?<br><br>• If yes, who has what conditions?<br><br>Do you smoke or vape?<br><br>• If yes, how many do you smoke/vape daily?<br>• For how many years have you smoked/vaped?<br><br>If you do not currently smoke, have you smoked in the past?<br><br>• If yes, what did you smoke?<br>• For how many years did you smoke?<br><br>Are you physically active during the week?<br><br>• How many times per week do you exercise and for how many minutes?<br>• What type of exercise do you usually do?<br><br>What does a typical day look like in your diet?<br><br>• How many fruits and vegetables do you normally eat in a day?<br>• Do you monitor the amount of saturated fats you eat?<br>• How many times a week do you eat a meal prepared by a restaurant?<br>• Do you pay attention to salt in your diet? Do you add salt to your foods before tasting it?<br>• Do you have caffeine during the day? If so, how much?<br><br>Do you drink alcoholic drinks?<br><br>• How many alcoholic drinks do you have on average per day? Per week? |

- Do you drink while at work?

Would you say you experience stress in your life?

- How would you rate the amount of stress in your life from 0-10?
- How do you cope with the stress in your life?

How many hours of sleep do you normally get each day?

- Do you have difficulty falling asleep?
- Do you have difficulty staying asleep?

# Objective Assessment

The physical examination of the cardiovascular system involves the interpretation of vital signs, inspection, palpation, and auscultation of heart sounds as the nurse evaluates for sufficient perfusion and cardiac output.

> For more information about assessing a patient's oxygenation status as it relates to their cardiac output, visit the "Oxygenation" chapter in Open RN *Nursing Fundamentals*.

Equipment needed for a cardiovascular assessment includes a stethoscope, penlight, centimeter ruler or tape measure, and **sphygmomanometer**.[10]

## Evaluate Vital Signs and Level of Consciousness

Interpret the blood pressure and pulse readings to verify the patient is stable before proceeding with the physical exam. Assess the level of consciousness; the patient should be alert and cooperative.

10. Felner, J. M. (1990). An overview of the cardiovascular system. In Walker, H. K., Hall, W. D., & Hurst, J. W. (Eds.), *Clinical methods: The history, physical, and laboratory examinations* (3rd ed., Chapter 7). Butterworths. https://www.ncbi.nlm.nih.gov/books/NBK393/

As a general rule of thumb, findings of systolic blood pressure in adults less than 100, or a pulse rate less than 60 or greater than 100, require immediate follow-up. For more information on obtaining and interpreting vital signs, see the "General Survey" chapter. Keep in mind that excessive drowsiness, restlessness, or irritability can be symptoms of hypoxia.

## Inspection

- **Skin color to assess perfusion.** Inspect the face, lips, and fingertips for **cyanosis** or pallor. Cyanosis is a bluish discoloration of the skin, lips, and nail beds and indicates decreased perfusion and oxygenation. **Pallor** is the loss of color, or paleness of the skin or mucous membranes, as a result of reduced blood flow, oxygenation, or decreased number of red blood cells. Patients with light skin tones should be pink in color. For those with darker skin tones, assess for pallor on the palms, conjunctiva, or inner aspect of the lower lip.
- **Jugular Vein Distension (JVD).** Inspect the neck for JVD that occurs when the increased pressure of the superior vena cava causes the jugular vein to bulge, making it most visible on the right side of a person's neck. JVD should not be present in the upright position or when the head of bed is at 30-45 degrees.
- **Precordium for abnormalities.** Inspect the chest area over the heart (also called **precordium**) for deformities, scars, or any abnormal pulsations the underlying cardiac chambers and great vessels may produce.
- **Extremities:**
    - **Upper Extremities:** Inspect the fingers, arms, and hands bilaterally

noting Color, Warmth, Movement, Sensation (CWMS). Alterations or bilateral inconsistency in CWMS may indicate underlying conditions or injury. Assess capillary refill by compressing the nail bed until it blanches and record the time taken for the color to return to the nail bed. Normal capillary refill is less than 3 seconds.[11]

- **Lower Extremities:** Inspect the toes, feet, and legs bilaterally, noting CWMS, capillary refill, and the presence of peripheral edema, superficial distended veins, and hair distribution. Document the location and size of any skin ulcers.
  - **Edema:** Note any presence of edema. **Peripheral edema** is swelling that can be caused by infection, thrombosis, or venous insufficiency due to an accumulation of fluid in the tissues. (See Figure 9.6[12] for an image of pedal edema.)[13]
  - **Deep Vein Thrombosis (DVT):** A deep vein thrombosis (DVT) is a blood clot that forms in a vein deep in the body. DVT requires emergency notification of the health care provider and immediate follow-up because of the risk of developing a life-threatening **pulmonary embolism**.[14] Inspect the lower extremities bilaterally. Assess for size, color, temperature, and for presence of pain in the calves. Unilateral warmth, redness, tenderness, swelling in the calf, or sudden onset of intense, sharp muscle pain that increases with dorsiflexion of the foot is an indication of a deep vein thrombosis (DVT).[15] See Figure 9.7[16] for an image of a DVT in the patient's right leg, indicated

11. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology licensed under CC BY 4.0
12. "Swollen feet at Harefield Hospital edema.jpg" by Ryaninuk is licensed under CC BY-SA 4.0
13. Simon, E. C. (2014). Leg edema assessment and management. *MEDSURG Nursing, 23*(1), 44-53.
14. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology licensed under CC BY 4.0
15. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology licensed under CC BY 4.0
16. "Deep vein thrombosis of the right leg.jpg" by James Heilman, MD is licensed under CC BY-SA 3.0

by unilateral redness and edema.

*Figure 9.6 Peripheral Edema*

*Figure 9.7 Signs of a DVT*

# Auscultation

## HEART SOUNDS

Auscultation is routinely performed over five specific areas of the heart to listen for corresponding valvular sounds. These auscultation sites are often referred to by the mnemonic "APE To Man," referring to Aortic, Pulmonic, Erb's point, Tricuspid, and Mitral areas (see Figure 9.8[17] for an illustration of cardiac auscultation areas). The aortic area is the second intercostal space

17. "Cardiac Auscultation Areas" by Meredith Pomietlo for Chippewa Valley Technical College is licensed under CC BY 4.0

to the right of the sternum. The pulmonic area is the second intercostal space to the left of the sternum. Erb's point is directly below the pulmonic area and located at the third intercostal space to the left of the sternum. The tricuspid (or parasternal) area is at the fourth intercostal space to the left of the sternum. The mitral (also called apical or left ventricular area) is the fifth intercostal space at the midclavicular line.

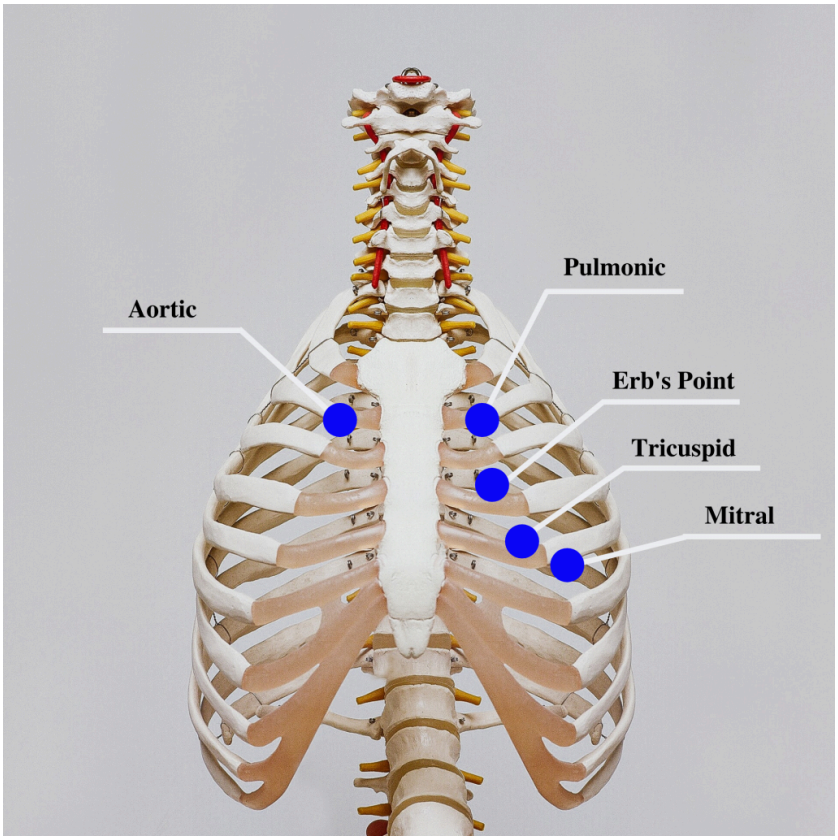



*Figure 9.8 Cardiac Auscultation Areas*

Auscultation usually begins at the aortic area (upper right sternal edge). Use the diaphragm of the stethoscope to carefully identify the S1 and S2 sounds. They will make a "lub-dub" sound. Note that when listening over the area of the aortic and pulmonic valves, the "dub" (S2) will sound louder than the "lub" (S1). Move the stethoscope sequentially to the pulmonic area (upper left sternal edge), Erb's point (left third intercostal space at the sternal border), and tricuspid area (fourth intercostal space. When assessing the mitral area for female patients, it is often helpful to ask them to lift up their breast tissue so the stethoscope can be placed directly on the chest wall. Repeat this process with the bell of the stethoscope. The

apical pulse should be counted over a 60-second period. For an adult, the heart rate should be between 60 and 100 with a regular rhythm to be considered within normal range. The apical pulse is an important assessment to obtain before the administration of many cardiac medications.

The first heart sound (S1) identifies the onset of systole, when the atrioventricular (AV) valves (mitral and tricuspid) close and the ventricles contract and eject the blood out of the heart. The second heart sound (S2) identifies the end of systole and the onset of diastole when the semilunar valves close, the AV valves open, and the ventricles fill with blood. S1 corresponds to the palpable pulse. When auscultating, it is important to identify the S1 ("lub") and S2 ("dub") sounds, evaluate the rate and rhythm of the heart, and listen for any extra heart sounds.

Listen to a normal S1/S2 sound. It may be helpful to use earbuds or a headphone:

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=71#h5p-37*

### Auscultating Heart Sounds

- To effectively auscultate heart sounds, patient repositioning may be required. If it difficult to hear the heart sounds, ask the patient to lean forward if they are able, or

lie on their left side. These positions move the heart closer to their chest wall and can increase the volume of the heart sounds heard on auscultation. This repositioning may be helpful in patients with increased adipose tissue in their chest wall or larger breasts.

- It is common to hear lung sounds when auscultating the heart sounds. It may be helpful to ask the patient to briefly hold their breath if lung sounds impede adequate heart auscultation. Limit the holding of breath to 10 seconds or as tolerated by the patient.
- Environmental noise can cause difficulty in auscultating heart sounds. Removing environmental noise by turning down the television volume or shutting the door may be required for an accurate assessment.
- Patients may try to talk to you as you are assessing their heart sounds. It is often helpful to explain the procedure such as, "I am going to take a few minutes to listen carefully to the sounds of blood flow going through your heart. Please try not to speak while I am listening, so I can hear the sounds better."

## EXTRA HEART SOUNDS

Extra heart sounds include clicks, murmurs, S3 and S4 sounds, and pleural friction rubs. These extra sounds can be difficult for a novice to distinguish, so if you notice any new or different sounds, consult an advanced practitioner or notify the provider. A midsystolic **click**, associated with mitral valve prolapse, may be heard with the diaphragm at the apex or left lower sternal border.

A click may be followed by a murmur. A **murmur** is a blowing or whooshing sound that signifies turbulent blood flow often caused by a valvular defect. New murmurs not previously recorded should be immediately communicated to the health care provider. In the aortic area, listen for possible murmurs of aortic stenosis and aortic regurgitation with the diaphragm of the stethoscope. In the pulmonic area, listen for potential murmurs of pulmonic stenosis and pulmonary and aortic regurgitation. In the tricuspid area, at the fourth and fifth intercostal spaces along the left sternal border, listen for the potential murmurs of tricuspid regurgitation, tricuspid stenosis, or ventricular septal defect.

Listen to a heart murmur caused by mitral valve regurgitation:

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=71#h5p-33*

**S3** and **S4** sounds, if present, are often heard best by asking the patient to lie on their left side and listening over the apex with the bell of the stethoscope. An S3 sound, also called a **ventricular gallop**, occurs after the S2 and sounds like "lub-dub-dah," or a sound similar to a horse galloping. An S3 can occur when a patient is experiencing fluid overload, such as during an acute exacerbation of heart failure.[18] It can also be a normal finding in pregnancy due to increased blood flow through the ventricles.

The S4 sound, also called **atrial gallop**, occurs immediately before the S1 and sounds like "ta-lub-dub." An S4 sound can occur with decreased ventricular compliance or coronary artery disease.[19]

18. Shono, A., Mori, S., Yatomi, A., Kamio, T., Sakai, J., Soga, F., Tanaka, H., & Hirata, K. I. (2019). Ultimate third heart sound. *Internal Medicine, 58(17)*, 2535–2538. https://doi.org/10.2169/internalmedicine.2731-19
19. Felner, J. M. (1990). An overview of the cardiovascular system. In Walker, H. K., Hall, W. D., & Hurst, J. W.

Listen to a S3 ventricular gallop:

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=71#h5p-36*

Listen to a S4 atrial gallop:

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=71#h5p-35*

A **pericardial friction rub** is caused by inflammation of the pericardium, with a creaky-scratchy noise generated as the parietal and visceral membranes rub together. It is best heard at the apex or left lower sternal border with the diaphragm as the patient sits up, leans forward, and holds their breath.

## CAROTID SOUNDS

The carotid artery may be auscultated for **bruits**. Bruits are a swishing sound due to turbulence in the blood vessel and may be heard due to atherosclerotic changes.

(Eds.), *Clinical methods: The history, physical, and laboratory examinations* (3rd ed., Chapter 7). Butterworths. https://www.ncbi.nlm.nih.gov/books/NBK393/

## Palpation

Palpation is used to evaluate peripheral pulses, capillary refill, and for the presence of edema. When palpating these areas, also pay attention to the temperature and moisture of the skin.

### PULSES

Compare the rate, rhythm, and quality of arterial pulses bilaterally, including the carotid, radial, brachial, posterior tibialis, and dorsalis pedis pulses. Review additional information about obtaining pulses in the "General Survey" chapter. Bilateral comparison for all pulses (except the carotid) is important for determining subtle variations in pulse strength. Carotid pulses should be palpated on one side at a time to avoid decreasing perfusion of the brain. The posterior tibial artery is located just behind the medial malleolus. It can be palpated by scooping the patient's heel in your hand and wrapping your fingers around so that the tips come to rest on the appropriate area just below the medial malleolus. The dorsalis pedis artery is located just lateral to the extensor tendon of the big toe and can be identified by asking the patient to flex their toe while you provide resistance to this movement. Gently place the tips of your second, third, and fourth fingers adjacent to the tendon, and try to feel the pulse.

The quality of the pulse is graded on a scale of 0 to 3, with 0 being absent pulses, 1 being decreased pulses, 2 is within normal range, and 3 being increased (also referred to as "bounding"). If unable to palpate a pulse, additional assessment is needed. First, determine if this is a new or chronic finding. Second, if available, use a Doppler ultrasound to determine the presence or absence of the pulse. Many agencies use Doppler ultrasound to document if a nonpalpable pulse is present. If the pulse is not found, this could be a sign of an emergent condition requiring

immediate follow-up and provider notification. See Figures 9.9[20] and 9.10[21] for images of assessing pedal pulses.

*Figure 9.9 Assessing Tibial Pedal Pulses*

20. "DSC_2277.jpg" by British Columbia Institute of Technology is licensed under CC BY 4.0. Access for free at https://opentextbc.ca/clinicalskills/chapter/2-5-focussed-respiratory-assessment/
21. "DSC_2314.jpg" by British Columbia Institute of Technology is licensed under CC BY 4.0. Access for free at https://opentextbc.ca/clinicalskills/chapter/2-5-focussed-respiratory-assessment/

*Figure 9.10 Assessing Dorsalis Pedis Pulses*

## CAPILLARY REFILL

The **capillary refill** test is performed on the nail beds to monitor **perfusion**, the amount of blood flow to tissue. Pressure is applied to a fingernail or toenail until it pales, indicating that the blood has been forced from the tissue under the nail. This paleness is called **blanching**. Once the tissue has blanched, pressure is removed. Capillary refill time is defined as the time it takes for the color to return after pressure is removed. If there is sufficient blood flow to the area, a pink color should return within 2 seconds after the pressure is removed.[22]

22. A.D.A.M. Medical Encyclopedia [Internet]. Atlanta (GA): A.D.A.M., Inc.; c1997-2020. Capillary nail refill test; [updated 2020, Aug 9] https://medlineplus.gov/ency/article/003394.htm

## Review of Capillary Refill Test on YouTube[23].

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=71#oembed-1*

## EDEMA

Edema occurs when one can visualize visible swelling caused by a buildup of fluid within the tissues. If edema is present on inspection, palpate the area to determine if the edema is pitting or nonpitting. Press on the skin to assess for indentation, ideally over a bony structure, such as the tibia. If no indentation occurs, it is referred to as nonpitting edema. If indentation occurs, it is referred to as **pitting edema**. See Figure 9.11[24] for images demonstrating pitting edema.

23. RegisteredNurseRN. (2022, March 21). *Capillary Refill Time Test: Normal vs. Abnormal - Nursing Clincial Skills.* [Video]. YouTube. Used with permission. All rights reserved. https://youtu.be/EwaDSZRH1LE
24. "Combinpedal.jpg" by James Heilman, MD is licensed under CC BY-SA 3.0

*Figure 9.11 Assessing Lower Extremity Edema*

Note the depth of the indention and how long it takes for the skin to rebound back to its original position. The indentation and time required to rebound to the original position are graded on a scale from 1 to 4. Edema rated at 1+ indicates a barely detectable depression with immediate rebound, and 4+ indicates a deep depression with a time lapse of over 20 seconds required to rebound. See Figure 9.12[25] for an illustration of grading edema. Additionally, it is helpful to note edema may be difficult to observe in larger patients. It is also important to monitor for sudden changes in weight, which is considered a probable sign of fluid volume overload.

25. "Grading of Edema" by Meredith Pomietlo for Chippewa Valley Technical College is licensed under CC BY 4.0

| | |
|---|---|
| **Grade 1** | **0–2 mm indentation; rebounds immediately.** |
| **Grade 2** | **3–4 mm indentation; rebounds in < 15 seconds.** |
| **Grade 3** | **5–6 mm indentation; up to 30 seconds to rebound.** |
| **Grade 4** | **8 mm indentation; > 20 seconds to rebound.** |

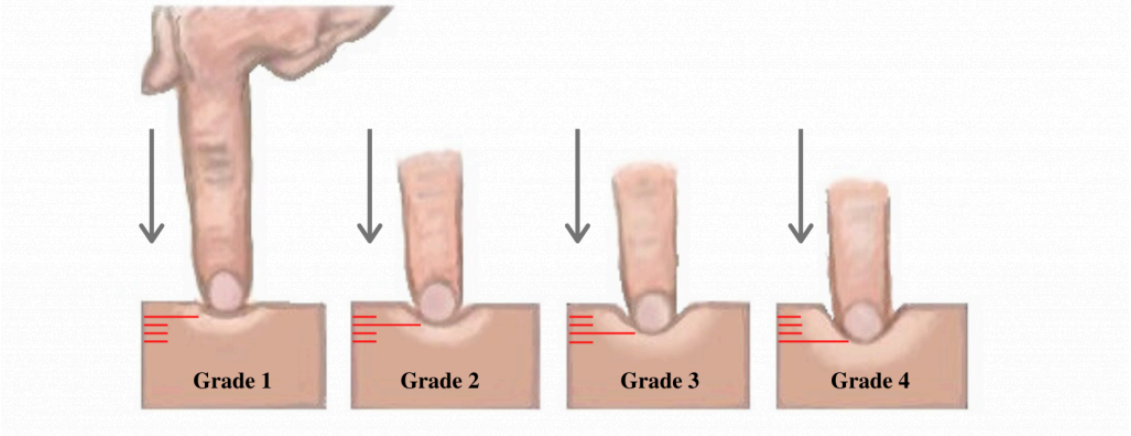



*Figure 9.12 Grading of Edema*

## HEAVES OR THRILLS

You may observe advanced practice nurses and other health care providers palpating the anterior chest wall to detect any abnormal pulsations the underlying cardiac chambers and great vessels may produce. Precordial movements should be evaluated at the apex (mitral area). It is best to examine the precordium with the patient supine because if the patient is turned on the left side, the apical region of the heart is displaced against the lateral chest wall, distorting the chest movements.[26] A **heave or lift** is a palpable lifting sensation under the sternum and anterior chest wall to the left of the sternum that suggests severe right ventricular hypertrophy. A **thrill** is a vibration felt on the skin of

26. Felner, J. M. (1990). An overview of the cardiovascular system. In Walker, H. K., Hall, W. D., & Hurst, J. W. (Eds.), *Clinical methods: The history, physical, and laboratory examinations* (3rd ed., Chapter 7). Butterworths. https://www.ncbi.nlm.nih.gov/books/NBK393/

the precordium or over an area of turbulence, such as an arteriovenous fistula or graft.

## Life Span Considerations

The cardiovascular assessment and expected findings should be modified according to common variations across the life span.

### INFANTS AND CHILDREN

A murmur may be heard in a newborn in the first few days of life until the **ductus arteriosus** closes.

When assessing the cardiovascular system in children, it is important to assess the apical pulse. Parameters for expected findings vary according to age group. After a child reaches adolescence, a radial pulse may be assessed. Table 9.3c outlines the expected apical pulse rate by age.

Table 9.3c Expected Apical Pulse by Age

| Age Group | Heart Rate |
|---|---|
| **Preterm** | 120-180 |
| **Newborn (0 to 1 month)** | 100-160 |
| **Infant (1 to 12 months)** | 80-140 |
| **Toddler (1 to 3 years)** | 80-130 |
| **Preschool (3 to 5 years)** | 80-110 |
| **School Age (6 to 12 years)** | 70-100 |
| **Adolescents (13 to 18 years)** | 60-90 |

Listen to pediatric heart tones:

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=71#h5p-32*

## OLDER ADULTS

In adults over age 65, irregular heart rhythms and extra sounds are more likely. An "irregularly irregular" rhythm suggests **atrial fibrillation**, and further investigation is required if this is a new finding. See the box below for more information about atrial fibrillation.

Listen to atrial fibrillation:

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=71#h5p-34*

- For more information on atrial fibrillation, visit the CDC Atrial Fibrillation webpage.

# Expected Versus Unexpected Findings

After completing a cardiovascular assessment, it is important for the nurse to use critical thinking to determine if any findings require follow-up.

Depending on the urgency of the findings, follow-up can range from calling the health care provider to calling the rapid response team. Table 9.3d compares examples of expected findings, meaning those considered within normal limits, to unexpected findings, which require follow-up. Critical conditions are those that should be reported immediately and may require notification of a rapid response team.

Table 9.3d Expected Versus Unexpected Findings on Cardiac Assessment

| Assessment | Expected Findings | Unexpected Findings (Document and notify the provider if this is a new finding*) |
|---|---|---|
| **Inspection** | Apical impulse may or may not be visible | Scars not previously documented that could indicate prior cardiac surgeries<br><br>Heave or lift observed in the precordium<br><br>Chest anatomy malformations |
| **Palpation** | Apical pulse felt over midclavicular fifth intercostal space | Apical pulse felt to the left of the midclavicular fifth intercostal space<br><br>Additional movements over precordium such as a heave, lift, or thrill |
| **Auscultation** | S1 and S2 heart sounds in a regular rhythm | New irregular heart rhythm<br><br>Extra heart sounds such as a murmur, S3, or S4 |

| | | |
|---|---|---|
| ***CRITICAL CONDITIONS to report immediately** | | Symptomatic tachycardia at rest (HR>100 bpm)<br><br>Symptomatic bradycardia (HR<60 bpm)<br><br>New systolic blood pressure (<100 mmHg)<br><br>Orthostatic blood pressure changes (see "Blood Pressure" chapter for more information)<br><br>New irregular heart rhythm<br><br>New extra heart sounds such as a murmur, S3, or S4<br><br>New abnormal cardiac rhythm changes<br><br>Reported chest pain, calf pain, or worsening shortness of breath |

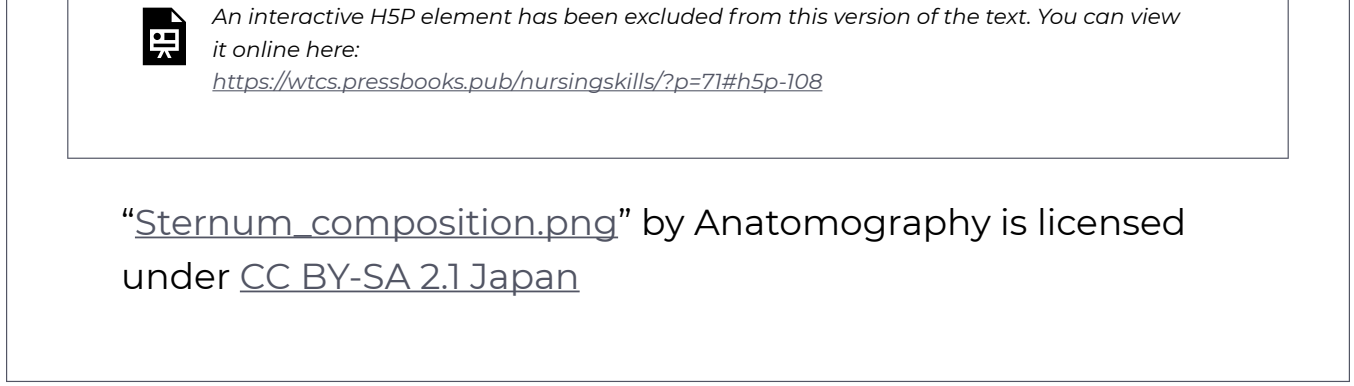
See Table 9.3e for a comparison of expected versus unexpected findings when assessing the peripheral vascular system.

Table 9.3e Expected Versus Unexpected Peripheral Vascular Assessment Findings

| Assessment | Expected Findings | Unexpected Findings (Document or notify provider if new finding*) |
|---|---|---|
| **Inspection** | Skin color uniform and appropriate for race bilaterally<br><br>Equal hair distribution on upper and lower extremities<br><br>Absence of jugular vein distention (JVD)<br><br>Absence of edema<br><br>Sensation and movement of fingers and toes intact | Cyanosis or pallor, indicating decreased perfusion<br><br>Decreased or unequal hair distribution<br><br>Presence of jugular vein distention (JVD) in an upright position or when head of bed is 30-45 degrees<br><br>New or worsening edema<br><br>Rapid and unexplained weight gain<br><br>Impaired movement or sensation of fingers and toes |
| **Palpation** | Skin warm and dry<br><br>Pulses present and equal bilaterally<br><br>Absence of edema<br><br>Capillary refill less than 2 seconds | Skin cool, excessively warm, or diaphoretic<br><br>Absent, weak/thready, or bounding pulses<br><br>New irregular pulse<br><br>New or worsening edema<br><br>Capillary refill greater than 2 seconds<br><br>Unilateral warmth, redness, tenderness, or edema, indicating possible deep vein thrombosis (DVT) |
| **Auscultation** | Carotid pulse | Carotid bruit |

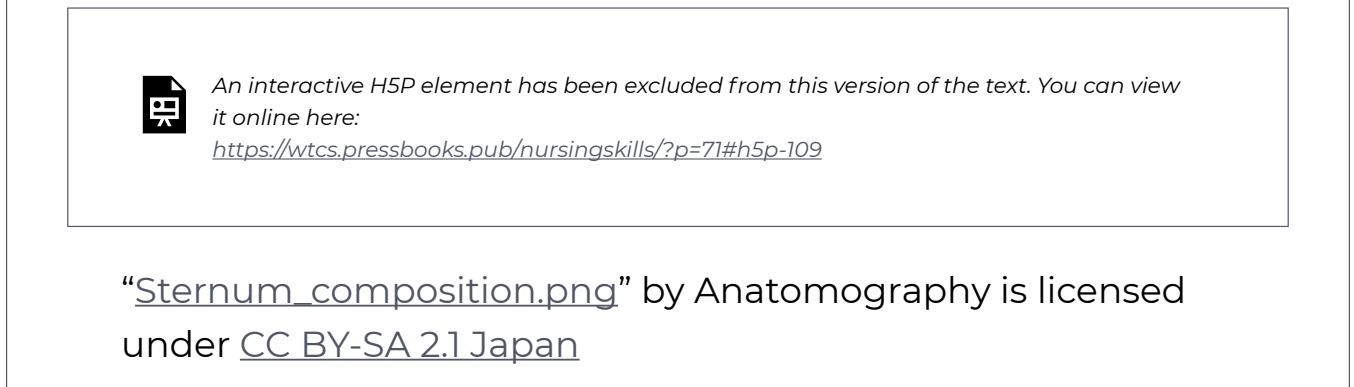
| | | |
|---|---|---|
| ***CRITICAL CONDITIONS to report immediately** | | Cyanosis<br><br>Absent pulse (and not heard using Doppler device)<br><br>Capillary refill time greater than 3 seconds<br><br>Unilateral redness, warmth, and edema, indicating a possible deep vein thrombosis (DVT) |

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=71#h5p-108*



"Sternum_composition.png" by Anatomography is licensed under CC BY-SA 2.1 Japan

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=71#h5p-109*



"Sternum_composition.png" by Anatomography is licensed under CC BY-SA 2.1 Japan

## Sample Documentation of Expected Cardiac & Peripheral Vascular Findings

*Patient denies chest pain or shortness of breath. Vital signs are within normal limits. Point of maximum impulse palpable at the fifth intercostal space of the midclavicular line. No lifts, heaves, or thrills identified on inspection or palpation. JVD absent. S1 and S2 heart sounds in regular rhythm with no murmurs or extra sounds. Skin is warm, pink, and dry. Capillary refill is less than two seconds. Color, movement, and sensation are intact in upper and lower extremities. Peripheral pulses are present (+2) and equal bilaterally. No peripheral edema is noted. Hair is distributed evenly on lower extremities.*

## Sample Documentation of Unexpected Cardiac & Peripheral Vascular Findings

*Patient reports increase in breathing difficulty and increased swelling of bilateral lower extremities over the last three days. Diminished pulses (+1) bilaterally and pitting edema (+2) in the bilateral lower extremities. Upon auscultation, an S3 heart sound is noted, and the patient has bilateral crackles in the posterior bases of the lungs. Skin is pink, warm, and dry with capillary refill of < 2 seconds. All other pulses are present (+2), and no other areas of edema are noted. JVD is absent.*

## 9.5 Checklist for Cardiovascular Assessment

Use the checklist below to review the steps for completion of a "Cardiovascular Assessment."[1]

# Steps

**Disclaimer: Always review and follow agency policy regarding this specific skill.**

1. Gather supplies: stethoscope and watch with a second hand.
2. Perform safety steps:

    - Perform hand hygiene.
    - Check the room for transmission-based precautions.
    - Introduce yourself, your role, the purpose of your visit, and an estimate of the time it will take.
    - Confirm patient ID using two patient identifiers (e.g., name and date of birth).
    - Explain the process to the patient and ask if they have any questions.
    - Be organized and systematic.
    - Use appropriate listening and questioning skills.
    - Listen and attend to patient cues.
    - Ensure the patient's privacy and dignity.
    - Assess ABCs.

3. Conduct a focused interview related to cardiovascular and peripheral vascular disease.

    - Ask relevant focused questions based on patient status. See Tables

1. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology licensed under CC BY 4.0

9.3a and 9.3b for example questions.

4. Inspect:

    - Face, lips, and extremities for pallor or cyanosis
    - Neck for jugular vein distension (JVD) in upright position or with head of bed at 30- or 45-degree angle
    - Chest for deformities and wounds/scars on chest
    - Bilateral arms/hands, noting color, warmth, movement, sensation (CWMS), edema, and color of nail beds
    - Bilateral legs, noting CWMS, edema to lower legs and feet, presence of superficial distended veins, and color of nail beds

5. Auscultate with both the bell and the diaphragm of the stethoscope over five auscultation areas of the heart. Auscultate the apical pulse at the fifth intercostal space, midclavicular line for one minute. Note the rate and rhythm. Identify the S1 and S2 sounds and follow up on any unexpected findings (e.g., extra sounds or irregular rhythm).
6. Palpate the radial, brachial, dorsalis pedis, and posterior tibialis pulses bilaterally. Palpate the carotid pulse one side at a time. Note presence/amplitude of pulse and any unexpected findings requiring follow-up.
7. Palpate the nail beds on each extremity for capillary refill. Document the capillary refill time.
8. Assist the patient to a comfortable position, ask if they have any questions, and thank them for their time.
9. Ensure safety measures when leaving the room:

    - CALL LIGHT: Within reach
    - BED: Low and locked (in lowest position and brakes on)
    - SIDE RAILS: Secured
    - TABLE: Within reach
    - ROOM: Risk-free for falls (scan room and clear any obstacles)

10. Perform hand hygiene.
11. Document the assessment findings. Report any concerns according to agency policy.

## Review Videos for Assessing the Heart and Lungs and the Apical Pulse:

### Chest Assessment – Heart and Lungs on YouTube[1]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=85#oembed-1*

### Assessing the Apical Pulse on YouTube[2]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=85#oembed-2*

1. RegisteredNurseRN. (2017, December 13). *Chest assessment nursing | Heart & lung assessment | Head-to-toe exam* [Video]. YouTube. All rights reserved. https://youtu.be/kv3B81mWc1E
2. RegisteredNurseRN. (2017, September 5). *Apical pulse assessment location nursing | Auscultate and palpate apical pulse* [Video]. YouTube. All rights reserved. https://youtu.be/RpaY7wM3QoM

## Learning Activities

*(Answers to "Learning Activities" can be found in the "Answer Key" at the end of the book. Answers to interactive activity elements will be provided within the element as immediate feedback.)*

1. As you walk into your patient's room, you notice the patient appears to be short of breath. Your patient states "I have been short of breath and tired for the past week." Upon assessment of your patient, you notice JVD, labored breathing, lung sounds with crackles in the posterior bases, and +2 edema to the lower extremities bilaterally.

**From your assessment findings, determine the most likely disease state that is being described.**

a. Hypertension
b. Pulmonary Embolism
c. Heart Failure
d. Stroke

2. Your patient puts on the call light. You enter the room and notice the patient appears to be in distress. The patient states, "I cannot catch my breath, and my heart feels as if it is going to explode." The patient's vital signs are T 98 $^{0}$F, P 148, BP 112/68, and pulse oximetry 88% on room air. You apply oxygen at 2 liters/minute via nasal cannula and notify the health care

provider (HCP). The HCP orders a stat ECG. The patient's pulse oximetry increases to 94% with the oxygen, and the patient states, "I feel less short of breath, but my heart is still racing." Upon assessment of heart sounds, the apical pulse is 134 and irregular. The ECG results indicate atrial fibrillation.

**What would be your next action?**

a. Leave the room and see your other patients.
b. Stay with the patient and notify the HCP of the ECG results.
c. Have the CNA stay with your patient as you take a break.
d. Stay with the patient and wait for them to calm down.

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=102#h5p-125*

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=102#h5p-140*

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=102#h5p-3*

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=102#h5p-110*

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=102#h5p-111*

Test your clinical judgment with an NCLEX Next Generation-style question: Chapter 9, Assignment 1.

- Test your clinical judgment with an NCLEX Next Generation-style question: Chapter 9, Assignment 2.


- Test your clinical judgment with an NCLEX Next Generation-style question: Chapter 9, Assignment 3.


- Test your clinical judgment with an NCLEX Next Generation-style question: Chapter 9, Assignment 4.

# IX Glossary

**Atrial fibrillation:** An irregular heartbeat that is often fast and increases the risk of heart attack or stroke.

**Blanching:** The whiteness that occurs when pressure is placed on tissue or a nail bed, causing blood to leave the area.

**Bruit:** A swishing sound when auscultating the carotid arteries. This indicates turbulence in the blood vessel due to atherosclerotic changes.

**Capillary refill:** The time it takes for color to return after pressure is applied to tissue causing blanching.

**Click:** Clicking sound heard on auscultation of the precordium; often heard in patients with heart valve abnormalities.

**Cyanosis:** A bluish discoloration of the skin, lips, and nail beds. It is an indication of decreased perfusion and oxygenation.

**Deep Vein Thrombosis (DVT):** A blood clot that forms in a vein deep in the body.

**Ductus arteriosus:** Shunt that connects the pulmonary artery and aorta in the developing fetus.

**Dyspnea:** A feeling of shortness of breath.

**Edema:** Swelling in tissues caused by fluid retention.

**Heave or lift:** Palpable lifting sensation under the sternum and anterior chest wall to the left of the sternum; it suggests severe right ventricular hypertrophy.

**Jugular Vein Distension (JVD):** Occurs when the increased pressure of the superior vena cava causes the jugular vein to bulge, making it most visible on the right side of a person's neck.

**Murmur:** A blowing or whooshing sound heard on auscultation of the precordium that signifies turbulent blood flow in the heart often caused by a valvular defect.

**Orthopnea:** A feeling of shortness of breath when lying flat.

**Pallor:** A reduced amount of oxyhemoglobin in the skin or mucous membranes. Skin and mucous membranes present with a pale skin color.

**Paroxysmal nocturnal dyspnea:** An attack of severe shortness of breath that generally occurs at night.

**Perfusion:** The amount of blood flow to tissue.

**Pericardial friction rub:** Uncommon heart sound caused by inflammation of the pericardium, with a creaky-scratchy noise generated as the parietal and visceral membranes rub together.

**Peripheral edema:** Swelling due to an accumulation of fluid in tissues perfused by the peripheral vascular system.

**Pitting edema:** An accumulation of fluid in tissue and causes an indentation when the area is pressed.

**Precordium:** The region of the thorax in front of the heart.

**Pulmonary embolism:** A blood clot that lodges in one of the arteries that go from the heart to the lung.

**Sphygmomanometer:** An instrument for measuring blood pressure typically consisting of an inflatable rubber cuff.

**Syncope:** A temporary loss of consciousness usually related to insufficient blood flow to the brain.

**Thrill:** A vibration felt with palpation of the precordium.

PART X

# CHAPTER 10 RESPIRATORY ASSESSMENT

# 10.1 Respiratory Assessment Introduction

## Learning Objectives

- Perform a respiratory assessment
- Differentiate between normal and abnormal lung sounds
- Modify assessment techniques to reflect variations across the life span
- Document actions and observations
- Recognize and report deviations from norms

The evaluation of the respiratory system includes collecting subjective and objective data through a detailed interview and physical examination of the thorax and lungs. This examination can offer significant clues related to issues associated with the body's ability to obtain adequate oxygen to perform daily functions. Inadequacy in respiratory function can have significant implications for the overall health of the patient.

## 10.2 Respiratory Basic Concepts

The main function of our respiratory system is to provide the body with a constant supply of oxygen and to remove carbon dioxide. To achieve these functions, muscles and structures of the thorax create the mechanical movement of air into and out of the lungs called **ventilation**. **Respiration** includes ventilation and gas exchange at the alveolar level where blood is oxygenated and carbon dioxide is removed. When completing a respiratory assessment, it is important for the nurse to understand the external and internal structures involved with respiration and ventilation. See Figure 10.1[1] for an illustration of the upper and lower respiratory system structures. Notice the lobular division of the lung structures and the bronchial tree.

1. "Respiratory_system_complete_en.png" by British Columbia Institute of Technology is licensed under CC BY 4.0. Access for free at https://opentextbc.ca/clinicalskills/chapter/2-5-focussed-respiratory-assessment/

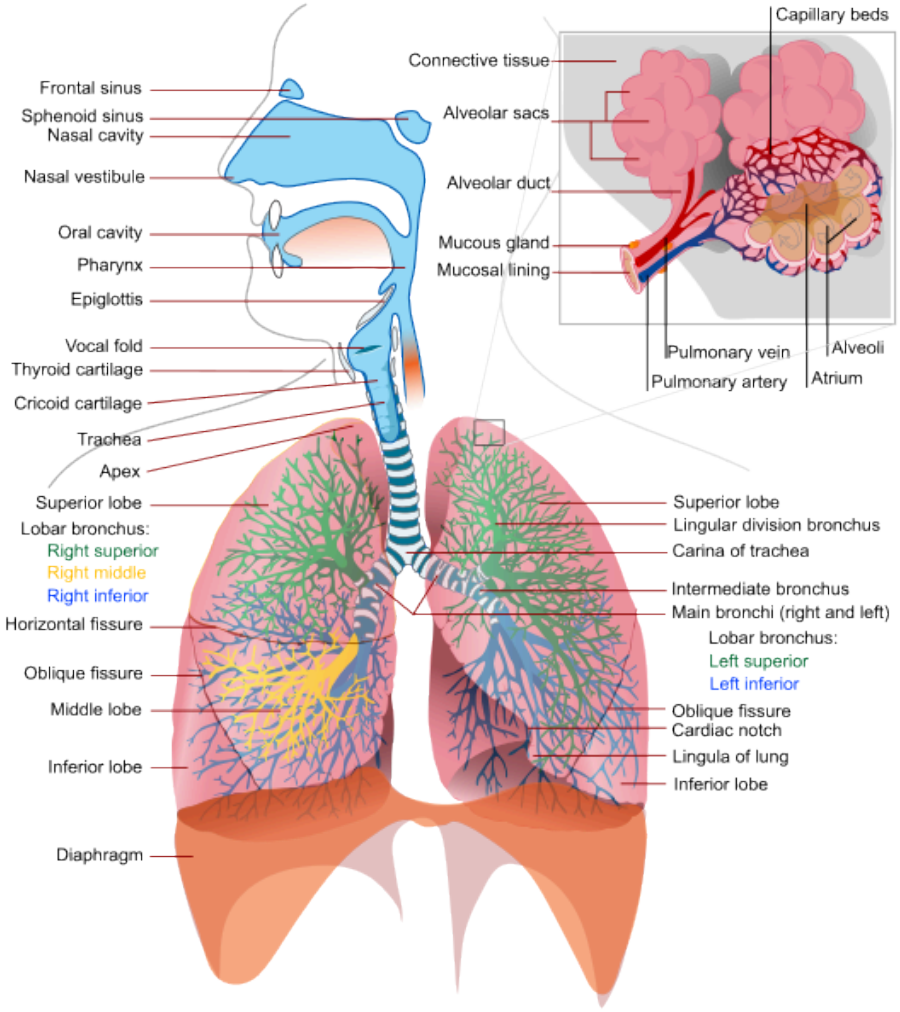



*Figure 10.1 Respiratory System Structures*

For more information on basic oxygenation concepts, visit the "Oxygen Therapy" chapter of this book.

- For more information about applying the nursing process to patients experiencing decreased oxygenation, visit the "Oxygenation" chapter in Open RN *Nursing Fundamentals*.
- For a detailed review of the respiratory system, common respiratory disorders, and related medications, visit the

- "Respiratory" chapter of the Open RN *Nursing Pharmacology* textbook. Specific sections of this chapter include the following:
  - Respiratory Basics
  - Diseases of the Respiratory System
  - Respiratory Medication Classes

## Review Videos of the Anatomy of the Respiratory System and Breathing Mechanics:

### Respiratory System Anatomy on YouTube[2]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=276#oembed-1*

2. Forciea, B. (2015, May 13). *Respiratory system anatomy (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/aqTwrdMS6CE

## Respiratory System: Breathing Mechanics on YouTube[3]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=276#oembed-2*

3. Forciea, B. (2015, May 12). *Anatomy and physiology: Respiratory system: Breathing mechanics (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/X-J5Xgg3l6s

## 10.3 Respiratory Assessment

With an understanding of the basic structures and primary functions of the respiratory system, the nurse collects subjective and objective data to perform a focused respiratory assessment.

# Subjective Assessment

Collect data using interview questions, paying particular attention to what the patient is reporting. The interview should include questions regarding any current and past history of respiratory health conditions or illnesses, medications, and reported symptoms. Consider the patient's age, gender, family history, race, culture, environmental factors, and current health practices when gathering subjective data. The information discovered during the interview process guides the physical exam and subsequent patient education. See Table 10.3a for sample interview questions to use during a focused respiratory assessment.[1]

**Table 10.3a Interview Questions for Subjective Assessment of the Respiratory System**

1. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology and is licensed under CC BY 4.0

| Interview Questions | Follow-up |
| --- | --- |
| **Have you ever been diagnosed with a respiratory condition, such as asthma, COPD, pneumonia, or allergies?**<br><br>**Do you use oxygen or peak flow meter?**<br><br>**Do you use home respiratory equipment like CPAP, BiPAP, or nebulizer devices?** | Please describe the conditions and treatments. |
| **Are you currently taking any medications, herbs, or supplements for respiratory concerns?** | Please identify what you are taking and the purpose of each. |

| | |
|---|---|
| **Have you had any feelings of breathlessness**<br><br>(**dyspnea**)? | Note: If the shortness of breath is severe or associated with chest pain, discontinue the interview and obtain emergency assistance.<br><br>Are you having any shortness of breath now? If yes, please rate the shortness of breath from 0-10 with "0" being none and "10" being severe?<br><br>Does anything bring on the shortness of breath (such as activity, animals, food, or dust)? If activity causes the shortness of breath, how much exertion is required to bring on the shortness of breath?<br><br>When did the shortness of breath start?<br><br>Is the shortness of breath associated with chest pain or discomfort?<br><br>How long does the shortness of breath last?<br><br>What makes the shortness of breath go away?<br><br>Is the shortness of breath related to a position, like lying down? Do you sleep in a recliner or upright in bed?<br><br>Do you wake up at night feeling short of breath? How many pillows do you sleep on?<br><br>How does the shortness of breath affect your daily activities? |

| | |
|---|---|
| **Do you have a cough?** | When you cough, do you bring up anything? What color is the phlegm?<br><br>Do you cough up any blood (**hemoptysis**)?<br><br>Do you have any associated symptoms with the cough such as fever, chills, or night sweats?<br><br>How long have you had the cough?<br><br>Does anything bring on the cough (such as activity, dust, animals, or change in position)?<br><br>What have you used to treat the cough? Has it been effective? |

| | |
|---|---|
| **Do you smoke or vape?** | What products do you smoke/vape? If cigarettes are smoked, how many packs a day do you smoke?<br><br>How long have you smoked/vaped?<br><br>Have you ever tried to quit smoking/vaping? What strategies gave you the best success?<br><br>Are you interested in quitting smoking/vaping?<br><br>If the patient is ready to quit, the five successful interventions are the "5 A's": Ask, Advise, Assess, Assist, and Arrange.<br><br>**Ask** – Identify and document smoking status for every patient at every visit.<br><br>**Advise** – In a clear, strong, and personalized manner, urge every user to quit.<br><br>**Assess** – Is the user willing to make a quitting attempt at this time?<br><br>**Assist** – For the patient willing to make a quitting attempt, use counseling and pharmacotherapy to help them quit.<br><br>**Arrange** – Schedule follow-up contact, in person or by telephone, preferably within the first week after the quit date.[2] |

## Life Span Considerations

Depending on the age and capability of the child, subjective data may also need to be retrieved from a parent and/or legal guardian.

2. Massey, D., & Meredith, T. (2011). Respiratory assessment 1: Why do it and how to do it? *British Journal of Cardiac Nursing, 5*(11), 537–541. https://doi.org/10.12968/bjca.2010.5.11.79634

### PEDIATRIC

- Is your child up-to-date with recommended immunizations?
- Is your child experiencing any cold symptoms (such as runny nose, cough, or nasal congestion)?
- How is your child's appetite? Is there any decrease or change recently in appetite or wet diapers?
- Does your child have any hospitalization history related to respiratory illness?
- Did your child have any history of frequent ear infections as an infant?

### OLDER ADULT

- Have you noticed a change in your breathing?
- Do you get short of breath with activities that you did not before?
- Can you describe your energy level? Is there any change from previous?

## Objective Assessment

A focused respiratory objective assessment includes interpretation of vital signs; inspection of the patient's breathing pattern, skin color, and respiratory status; palpation to identify abnormalities; and auscultation of lung sounds using a stethoscope. For more information regarding interpreting vital signs, see the "General Survey" chapter. The nurse must have an understanding of what is expected for the patient's age, gender, development, race, culture, environmental factors, and current health condition to determine the meaning of the data that is being collected.

### Evaluate Vital Signs

The vital signs may be taken by the nurse or delegated to unlicensed assistive personnel such as a nursing assistant or medical assistant. Evaluate the respiratory rate and pulse oximetry readings to verify the

patient is stable before proceeding with the physical exam. The normal range of a respiratory rate for an adult is 12-20 breaths per minute at rest, and the normal range for oxygen saturation of the blood is 94–98% ($SpO_2$).[3] **Bradypnea** is less than 12 breaths per minute, and **tachypnea** is greater than 20 breaths per minute.

As a general rule of thumb, respiratory rates outside the normal range or oxygen saturation levels less than 95% indicate respiration or ventilation is compromised and requires follow-up. There are disease processes, such as chronic obstructive pulmonary disease (COPD), where patients consistently exhibit below normal oxygen saturations; therefore, trends and deviations from the patient's baseline normal values should be identified. A change in respiratory rate is an early sign of deterioration in a patient and failing to recognize such a change can result in poor outcomes. For more information on obtaining and interpreting vital signs, see the "General Survey" chapter.

## Inspection

Inspection during a focused respiratory assessment includes observation of level of consciousness, breathing rate, pattern and effort, skin color, chest configuration, and symmetry of expansion.

- Assess the level of consciousness. The patient should be alert and cooperative. **Hypoxemia** (low blood levels of oxygen) or **hypercapnia** (high blood levels of carbon dioxide) can cause a decreased level of consciousness, irritability, anxiousness, restlessness, or confusion.
- Obtain the respiratory rate over a full minute. The normal range for the respiratory rate of an adult is 12-20 breaths per minute.

3. This work is a derivative of Nursing Pharmacology by Open RN licensed under CC BY 4.0

- Observe the breathing pattern, including the rhythm, effort, and use of **accessory muscles**. Breathing effort should be nonlabored and in a regular rhythm. Observe the depth of respiration and note if the respiration is shallow or deep. Pursed-lip breathing, nasal flaring, audible breathing, intercostal **retractions**, anxiety, and use of accessory muscles are signs of respiratory difficulty. Inspiration should last half as long as expiration unless the patient is active, in which case the inspiration-expiration ratio increases to 1:1.
- Observe the pattern of expiration and patient position. Patients who experience difficulty expelling air, such as those with emphysema, may have prolonged expiration cycles. Some patients may experience difficulty with breathing specifically when lying down. This symptom is known as **orthopnea**. Additionally, patients who are experiencing significant breathing difficulty may experience most relief while in a "tripod" position. This can be achieved by having the patient sit at the side of the bed with legs dangling toward the floor. The patient can then rest their arms on an overbed table to allow for maximum lung expansion. This position mimics the same position you might take at the end of running a race when you lean over and place your hands on your knees to "catch your breath."
- Observe the patient's color in their lips, face, hands, and feet. Patients with light skin tones should be pink in color. For those with darker skin tones, assess for pallor on the palms, conjunctivae, or inner aspect of the lower lip. **Cyanosis** is a bluish discoloration of the skin, lips, and nail beds, which may indicate decreased perfusion and oxygenation. **Pallor** is the loss of color, or paleness of the skin or mucous membranes and usually the result of reduced blood flow, oxygenation, or decreased number of red blood cells.
- Inspect the chest for symmetry and configuration. The trachea should be midline, and the clavicles should be symmetrical. See Figure 10.2[4]

4. "Anterior_Chest_Lines.png," "Posterior_Chest_Lines.png," and "Lateral_Chest_Lines.png" by Meredith Pomietlo for Chippewa Valley Technical College are licensed under CC BY 4.0

for visual landmarks when inspecting the thorax anteriorly, posteriorly, and laterally. Note the location of the ribs, sternum, clavicle, and scapula, as well as the underlying lobes of the lungs.

- Chest movement should be symmetrical on inspiration and expiration.
- Observe the anterior-posterior diameter of the patient's chest and compare to the transverse diameter. The expected anteroposterior-transverse ratio should be 1:2. A patient with a 1:1 ratio is described as **barrel-chested**. This ratio is often seen in patients with chronic obstructive pulmonary disease due to hyperinflation of the lungs. See Figure 10.3[5] for an image of a patient with a barrel chest.
- Older patients may have changes in their anatomy, such as **kyphosis**, an outward curvature of the spine.

- Inspect the fingers for clubbing if the patient has a history of chronic respiratory disease. **Clubbing** is a bulbous enlargement of the tips of the fingers due to chronic hypoxia. See Figure 10.4[6] for an image of clubbing.

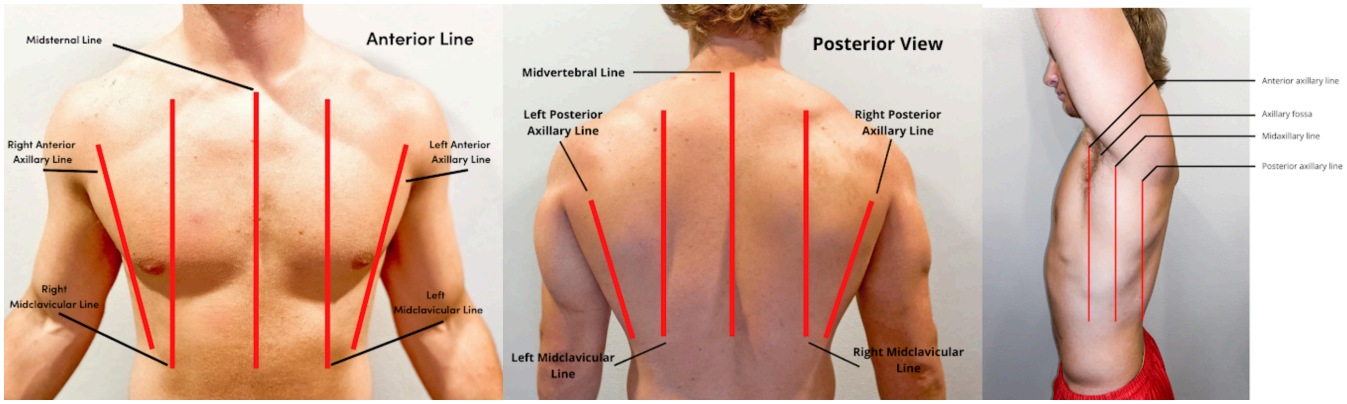



*Figure 10.2 Landmarks of the Anterior, Posterior, and Lateral Thorax*

5. "Normal A-P Chest Image.jpg" and "Barrel Chest.jpg" by Meredith Pomietlo for Chippewa Valley Technical College are licensed under CC BY 4.0
6. "Clubbing of fingers in IPF.jpg" by IPFeditor is licensed under CC BY-SA 3.0

*Figure 10.3 Comparison of Chest with Normal Anterior/Posterior Diameter (A) to a Barrel Chest(B)*

*Figure 10.4 Clubbing of the Fingers*

## Palpation

- Palpation of the chest may be performed to investigate for areas of

abnormality related to injury or procedural complications. For example, if a patient has a chest tube or has recently had one removed, the nurse may palpate near the tube insertion site to assess for areas of air leak or crepitus. **Crepitus** feels like a popping or crackling sensation when the skin is palpated and is a sign of air trapped under the subcutaneous tissues. If palpating the chest, use light pressure with the fingertips to examine the anterior and posterior chest wall. Chest palpation may be performed to assess specifically for growths, masses, crepitus, pain, or tenderness.

- Confirm symmetric chest expansion by placing your hands on the anterior or posterior chest at the same level, with thumbs over the sternum anteriorly or the spine posteriorly. As the patient inhales, your thumbs should move apart symmetrically. Unequal expansion can occur with pneumonia, thoracic trauma, such as fractured ribs, or pneumothorax.

## Auscultation

Using the diaphragm of the stethoscope, listen to the movement of air through the airways during inspiration and expiration. Instruct the patient to take deep breaths through their mouth. Listen through the entire respiratory cycle because different sounds may be heard on inspiration and expiration. Allow the patient to rest between respiratory cycles, if needed, to avoid fatigue with deep breathing during auscultation. As you move across the different lung fields, the sounds produced by airflow vary depending on the area you are auscultating because the size of the airways change.

Listen to normal breath sounds on inspiration and expiration.

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=279#h5p-31*

Correct placement of the stethoscope during auscultation of lung sounds is important to obtain a quality assessment. The stethoscope should not be placed over clothes or hair because these may create inaccurate sounds from friction. The best position to listen to lung sounds is with the patient sitting upright; however, if the patient is acutely ill or unable to sit upright, turn them side to side in a lying position. Avoid listening over bones, such as the scapulae or clavicles or over the female breasts to ensure you are hearing adequate sound transmission. Listen to sounds from side to side rather than down one side and then down the other side. This side-to-side pattern allows you to compare sounds in symmetrical lung fields. See Figures 10.5[7] and 10.6[8] for landmarks of stethoscope placement over the anterior and posterior chest wall.

7. "Anterior Respiratory Auscultation Pattern.png" by Meredith Pomietlo for Chippewa Valley Technical College is licensed under CC BY 4.0
8. "Posterior Respiratory Auscultation Pattern.png" by Meredith Pomietlo for Chippewa Valley Technical College is licensed under CC BY 4.0

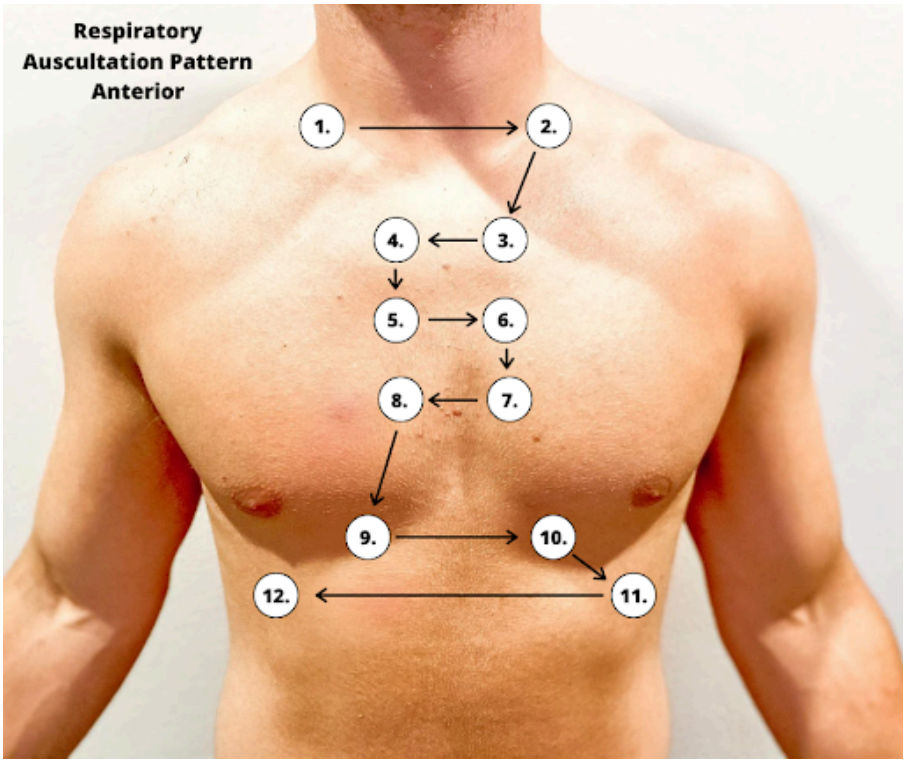



*Figure 10.5 Anterior Auscultation Areas*

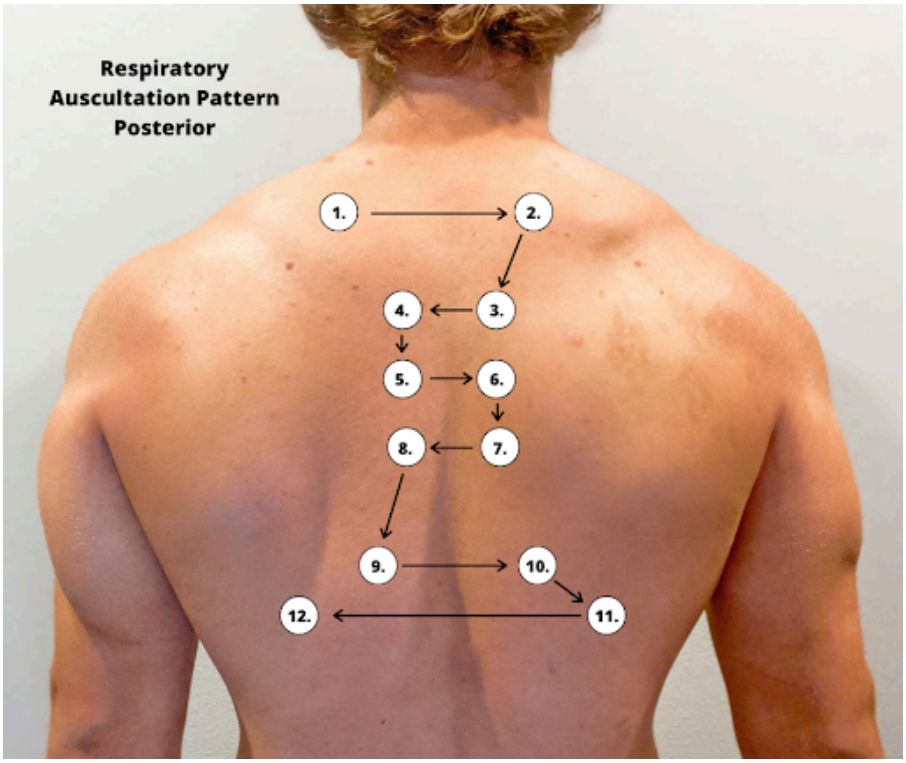



*Figure 10.6 Posterior Auscultation Areas*

When assessing patients who are experiencing shortness of breath (or fatigue easily), it may be helpful to begin auscultation in the bases and progress upward to other lung fields as tolerated by the patient. This ensures that assessment of the vulnerable lower lobes is achieved prior to patient fatigue.

## EXPECTED BREATH SOUNDS

It is important upon auscultation to have awareness of expected breath sounds in various anatomical locations.

- **Bronchial breath sounds** are heard over the trachea and larynx and are high-pitched and loud.
- **Bronchovesicular sounds** are medium-pitched and heard over the major bronchi.
- **Vesicular breath sounds** are heard over the lung surfaces, are lower-pitched, and often described as soft, rustling sounds.

## ADVENTITIOUS LUNG SOUNDS

Adventitious lung sounds are sounds heard in addition to normal breath sounds. They most often indicate an airway problem or disease, such as accumulation of mucus or fluids in the airways, obstruction, inflammation, or infection. These sounds include rales/crackles, rhonchi/wheezes, stridor, and pleural rub:

- **Coarse crackles**, also called **rhonchi**, are low-pitched, loud, continuous sounds frequently heard on expiration. They are a sign of turbulent airflow through secretions in the large airways.

## Rhonchi Lung Sounds on YouTube [9]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=279#oembed-1*

- **Fine crackles**, also called **rales**, are popping or crackling sounds heard on inspiration. They occur in association with conditions that cause fluid to accumulate within the alveolar and interstitial spaces, such as heart failure or pneumonia. Fine crackles are soft, high-pitched, and very brief. For this reason, it is essential to listen to lung sounds with the stethoscope placed on the patient's skin and not over their clothing or hospital gown. The sound is similar to that produced by rubbing strands of hair together close to your ear.

Listen to fine crackles:

*An interactive H5P element has been excluded from this version of the text. You can view it online here: https://wtcs.pressbooks.pub/nursingskills/?p=279#h5p-28*

9. RegisteredNurseRN. (2023, April 10). Rhonchi Lung Sounds Nursing NCLEX | Adventitious Lung Sounds. [Video]. YouTube. Used with permission. All rights reserved. https://youtu.be/7cIEXfqnYRQ

- **Wheezes** are whistling-type noises produced during expiration (and sometimes inspiration) when air is forced through airways narrowed by bronchoconstriction or associated mucosal edema. For example, patients with asthma commonly have wheezing.

Listen to wheezes:

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=279#h5p-29*

- **Stridor** is heard only on inspiration. It is associated with mechanical obstruction at the level of the trachea/upper airway.

Listen to stridor:

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=279#h5p-30*

- **Pleural rub** may be heard on either inspiration or expiration and sounds like the rubbing together of leather. A pleural rub is heard when there is inflammation of the lung pleura, resulting in friction as the surfaces rub against each other.[10]

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## Life Span Considerations

### CHILDREN

There are various respiratory assessment considerations that should be noted with assessment of children.

- The respiratory rate in children less than 12 months of age can range from 30-60 breaths per minute, depending on whether the infant is asleep or active.
- Infants have irregular or periodic newborn breathing in the first few weeks of life; therefore, it is important to count the respirations for a full minute. During this time, you may notice periods of **apnea** lasting up to 10 seconds. This is not abnormal unless the infant is showing other signs of distress. Signs of respiratory distress in infants and children include nasal flaring and sternal or intercostal retractions.
- Up to three months of age, infants are considered "obligate" nose-breathers, meaning their breathing is primarily through the nose.
- The anteroposterior-transverse ratio is typically 1:1 until the thoracic muscles are fully developed around six years of age.

### OLDER ADULTS

As the adult person ages, the cartilage and muscle support of the thorax becomes weakened and less flexible, resulting in a decrease in chest expansion. Older adults may also have weakened respiratory muscles, and breathing may become shallower. The anteroposterior-transverse ratio may be 1:1 if there is significant curvature of the spine (kyphosis).

## Percussion

Percussion is an advanced respiratory assessment technique that is used by advanced practice nurses and other health care providers to gather

additional data in the underlying lung tissue. By striking the fingers of one hand over the fingers of the other hand, a sound is produced over the lung fields that helps determine if fluid is present. Dull sounds are heard with high-density areas, such as pneumonia or **atelectasis**, whereas clear, low-pitched, hollow sounds are heard in normal lung tissue.

- Because infants breathe primarily through the nose, nasal congestion can limit the amount of air getting into the lungs.
- Attempt to assess an infant's respiratory rate while the infant is at rest and content rather than when the infant is crying. Counting respirations by observing abdominal breathing movements may be easier for the novice nurse than counting breath sounds, as it can be difficult to differentiate lung and heart sounds when auscultating newborns.
- Auscultation of lungs during crying is not a problem. It will enhance breath sounds.
- The older patient may have a weakening of muscles that support respiration and breathing. Therefore, the patient may report tiring easily during the assessment when taking deep breaths. Break up the assessment by listening to the anterior lung sounds and then the heart sounds and allowing the patient to rest before listening to the posterior lung sounds.
- Patients with end-stage COPD may have diminished lung sounds due to decreased air movement. This abnormal assessment finding may be the patient's baseline or normal and might also include wheezes and

fine crackles as a result of chronic excess secretions and/or bronchoconstriction.[11,12]

## Expected Versus Unexpected Findings

See Table 10.3b for a comparison of expected versus unexpected findings when assessing the respiratory system.[13]

**Table 10.3b Expected Versus Unexpected Respiratory Assessment Findings**

11. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology and is licensed under CC BY 4.0
12. Honig, E. (1990). An overview of the pulmonary system. In Walker, H. K., Hall, W. D., Hurst, J. W. (Eds.), *Clinical methods: The history, physical, and laboratory examinations* (3rd ed.). Butterworths. https://www.ncbi.nlm.nih.gov/books/NBK356/
13. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology and is licensed under CC BY 4.0

| Assessment | Expected Findings | Unexpected Findings (Document and notify provider if a new finding*) |
|---|---|---|
| **Inspection** | Work of breathing effortless<br><br>Regular breathing pattern<br><br>Respiratory rate within normal range for age<br><br>Chest expansion symmetrical<br><br>Absence of cyanosis or pallor<br><br>Absence of accessory muscle use, retractions, and/or nasal flaring<br><br>Anteroposterior: transverse diameter ratio 1:2 | Labored breathing<br><br>Irregular rhythm<br><br>Increased or decreased respiratory rate<br><br>Accessory muscle use, pursed-lip breathing, nasal flaring (infants), and/or retractions<br><br>Presence of cyanosis or pallor<br><br>Asymmetrical chest expansion<br><br>Clubbing of fingernails |
| **Palpation** | No pain or tenderness with palpation. Skin warm and dry; no crepitus or masses | Pain or tenderness with palpation, crepitus, palpable masses, or lumps |
| **Percussion** | Clear, low-pitched, hollow sound in normal lung tissue | Dull sounds heard with high-density areas, such as pneumonia or atelectasis |
| **Auscultation** | Bronchovesicular and vesicular sounds heard over appropriate areas<br><br>Absence of adventitious lung sounds | Diminished lung sounds<br><br>Adventitious lung sounds, such as fine crackles/rales, wheezing, stridor, or pleural rub |

| | | |
|---|---|---|
| ***CRITICAL CONDITIONS to report immediately** | | Decreased oxygen saturation <92%[14]<br><br>Pain<br><br>Worsening dyspnea<br><br>Decreased level of consciousness, restlessness, anxiousness, and/or irritability |

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=279#h5p-7*

14. Hill, B., & Annesley, S. H. (2020). Monitoring respiratory rate in adults. *British Journal of Nursing, 29*(1), 12–16. https://doi.org/10.12968/bjon.2020.29.1.12

## Sample Documentation of Expected Findings

*Patient denies cough, chest pain, or shortness of breath. Denies past or current respiratory illnesses or diseases. Symmetrical anterior and posterior thorax. Anteroposterior-transverse ratio is 1:2. Respiratory rate is 16 breaths/minute, unlabored, regular, and inaudible through the nose. No retractions, accessory muscle use, or nasal flaring. Chest rise and fall are equal bilaterally. Skin is pink, warm, and dry. No crepitus, masses, or tenderness upon palpation of anterior and posterior chest. Lung sounds clear bilaterally in all lobes anteriorly and posteriorly. No adventitious sounds. SpO2 saturation 99% on room air.*

## Sample Documentation of Unexpected Findings

*Patient reports shortness of breath for five to six hours. Patient has labored breathing at rest. Nail beds are cyanotic. Respiratory rate is tachypneic at 32/minute with neck and abdominal accessory muscle use. Lung expansion is symmetrical. Pursed-lip breathing noted with intermittent productive cough. Reports coughing up blood-tinged green sputum for two days. Anterior and posterior chest walls have no tenderness, masses, or crepitus upon palpation. On auscultation bilateral coarse crackles over lung bases. Expiratory wheezes are audible and heard with stethoscope scattered throughout lung fields. Pulse oximetry 93% on room air.*

## 10.5 Checklist for Respiratory Assessment

Use the checklist below to review the steps for completion of a "Respiratory Assessment."[1]

# Steps

**Disclaimer: Always review and follow agency policy regarding this specific skill.**

1. Gather supplies: stethoscope and pulse oximeter.
2. Perform safety steps:

    - Perform hand hygiene.
    - Check the room for transmission-based precautions.
    - Introduce yourself, your role, the purpose of your visit, and an estimate of the time it will take.
    - Confirm patient ID using two patient identifiers (e.g., name and date of birth).
    - Explain the process to the patient and ask if they have any questions.
    - Be organized and systematic.
    - Use appropriate listening and questioning skills.
    - Listen and attend to patient cues.
    - Ensure the patient's privacy and dignity.
    - Assess ABCs.

3. Obtain subjective data related to history of respiratory diseases, current symptoms, medications, and history of smoking using the suggested interview questions in Table 10.3a.

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4. Obtain and analyze vital signs, including the pulse oximetry reading. Act appropriately on unexpected findings outside the normal range.
5. Assist the patient to a seated position if tolerated. Provide privacy while exposing only those areas of assessment.

    - Assess level of consciousness for signs of hypoxia/hypercapnia
    - Count respiratory rate for one minute
    - Observe respirations for rhythm pattern, depth, symmetry, and work of breathing
    - Observe configuration and symmetry of the chest. Compare anterior-posterior diameter to the transverse diameter
    - Inspect skin color lips, face, hands, and feet

    Note that early signs of hypoxia may include anxiety, confusion, restlessness, change in mental status, and/or level of consciousness (LOC).
6. Palpate:

    - Inspect anterior/posterior chest wall for areas of tenderness, crepitus, lumps, or masses
    - Compare for bilaterally equal chest expansion

7. Auscultate: Use correct stethoscope placement directly on the skin over designated auscultation areas. Identify any adventitious sounds.
8. Assist the patient back to a comfortable position, ask if they have any questions, and thank them for their time.
9. Ensure safety measures when leaving the room:

    - CALL LIGHT: Within reach
    - BED: Low and locked (in lowest position and brakes on)
    - SIDE RAILS: Secured
    - TABLE: Within reach
    - ROOM: Risk-free for falls (scan room and clear any obstacles)

10. Perform hand hygiene.
11. Document the assessment findings. Report any concerns according to agency policy.

# 10.6 Supplementary Video on Respiratory Assessment

## Review of Heart & Lung Assessment | Head-to-Toe Exam on YouTube[1]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=287#oembed-1*

1. RegisteredNurseRN. (2017, December 17). *Chest assessment nursing | Heart & lung assessment | Head-to-toe exam* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/kv3B81mWc1E

## Learning Activities

*(Answers to "Learning Activities" can be found in the "Answer Key" at the end of the book. Answers to interactive activity elements will be provided within the element as immediate feedback.)*

1. An elderly patient is admitted to the medical floor with increased shortness of breath, new productive cough, and low-grade fever. The nurse begins the physical examination of the respiratory system.

**What is the best position for the patient to assume for the physical exam?**

a. Supine
b. Sitting upright
c. Semi-Fowlers
d. Left-lateral

2. During the course of the preceding patient's physical exam, auscultation of the lungs reveals rhonchi in the upper airways and coarse crackles in the right lower base. The nurse knows that rhonchi and crackles may indicate _____ or _____ in the airways.

3. A patient has pneumonia, which is currently being treated with antibiotics, and reports feeling better since being hospitalized. The nurse assesses the patients oxygen saturation

using a pulse oximeter by placing the probe on the patient's finger. The reading is 89%.

**Which of the following actions should the nurse perform first?**

a. Assess the pulse oximeter probe site to ensure an accurate reading.
b. Administer oxygen and monitor the pulse oximetry until it reaches 95 percent.
c. Raise the head of the bed and ask the patient to take several deep breaths.
d. Contact the provider and recommend prescribing a chest X-ray.

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=291#h5p-126*

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=291#h5p-98*

*An interactive H5P element has been excluded from this version of the text. You can view it online here:*
*https://wtcs.pressbooks.pub/nursingskills/?p=291#h5p-6*

NEXT GEN RN

- Test your clinical judgment with an NCLEX Next Generation-style question: Chapter 10, Assignment 1.

NEXT GEN RN

- Test your clinical judgment with an NCLEX Next Generation-style question: Chapter 10, Assignment 2.

# X Glossary

**Accessory muscles:** Muscles other than the diaphragm and intercostal muscles that may be used for labored breathing.

**Apnea:** Absence of respirations.

**Atelectasis:** Alveoli or an entire lung is collapsed, allowing no air movement.

**Barrel-chested:** An equal AP-to-transverse diameter that often occurs in patients with COPD due to hyperinflation of the lungs.

**Bradypnea:** Decreased respiratory rate or slow breath less than normal range according to the patient's age.

**Bronchial breath sounds:** High-pitched hollow sounds heard over trachea and the larynx.

**Bronchovesicular sounds:** Mixture of low- and high-pitched sounds heard over major bronchi.

**Clubbing:** A change in the configuration where the tips of the nails curve around the fingertips, usually caused by chronic low levels of oxygen in the blood.

**Crackles:** Also referred to as "rales"; sound like popping or crackling noises during inspiration. Associated with inflammation and fluid accumulation in the alveoli.

**Crepitus:** Air trapped under a subcutaneous layer of the skin; creates a popping or crackling sensation as the area is palpated.

**Cyanosis:** Bluish discoloration of the skin, lips, and nail beds. It is an indication of decreased perfusion and oxygenation.

**Dyspnea:** A subjective feeling of breathlessness.

**Hemoptysis:** Blood-tinged mucus secretions from the lungs.

**Hypercapnia:** Increased carbon dioxide levels in the blood.

**Hypoxemia:** Decreased levels of oxygen in the blood.

**Kyphosis:** Outward curvature of the back; often described as “hunchback.”

**Orthopnea:** Breathlessness or a feeling of shortness of breath when lying in a reclined position.

**Pallor:** A reduced amount of oxyhemoglobin in the skin or mucous membranes and causes skin and mucous membranes to present with a pale skin color.

**Pleural rub:** An uncommon sound heard when there is inflammation of the lung pleural membranes.

**Rales:** Another term used for crackles.

**Respiration:** Includes ventilation and gas exchange at the alveolar level where blood is oxygenated and carbon dioxide is removed.

**Retractions**: The “pulling in” of muscles between the ribs or in the neck when breathing, indicating difficulty breathing or respiratory distress.

**Stridor:** High-pitched crowing sounds heard over the upper airway and larynx indicating obstruction.

**Tachypnea:** Rapid and often shallow breathing greater than normal range according to the patient’s age.

**Ventilation:** The mechanical movement of air into and out of the lungs.

**Vesicular sounds:** Low-pitched soft sounds like “rustling leaves” heard over alveoli and small bronchial airways.

**Wheeze:** High-pitched sounds heard on expiration or inspiration associated with bronchoconstriction or bronchospasm.

PART XI

# CHAPTER 11 OXYGEN THERAPY

# 11.1 Oxygen Therapy Introduction

## Learning Objectives

- Implement interventions to improve a patient's oxygenation status
- Correctly apply oxygen equipment
- Set flow rate using fixed and portable equipment
- Survey the environment for potential safety hazards
- Use pulse oximetry
- Assess patient response to oxygen therapy
- Adapt procedures to reflect variations across the life span
- Document actions and observations
- Recognize and report significant deviations from norms

The air we breathe contains 21% oxygen and is crucial for life. Several body systems must work collaboratively during the oxygenation process to take in oxygen from the air, carry it through the bloodstream, and adequately oxygenate tissues. First, the airway must be open and clear. The chest and lungs must mechanically move air in and out of the lungs. The bronchial airways must be open and clear so that air can reach the alveoli, where oxygen is absorbed into the bloodstream and carbon dioxide is released during exhalation. The heart must effectively pump this oxygenated blood to and from the lungs and through the systemic arteries. The hemoglobin in the blood must be in adequate amounts to sufficiently carry the oxygen to the tissues, where it is released, and carbon dioxide is absorbed and carried back to the lungs.

Several medical conditions, such as asthma, chronic obstructive

pulmonary disease (COPD), pneumonia, heart disease, and anemia can impair a person's ability to sufficiently complete this oxygenation process, thus requiring the administration of supplemental oxygen. This chapter will review basic concepts related to oxygenation, provide an overview of oxygenation equipment, and apply the nursing process to the administration of supplemental oxygen. Oxygen is considered a medication and, therefore, requires a prescription and continuous monitoring by the nurse to ensure its safe and effective use.

## 11.2 Basic Concepts of Oxygenation

When assessing a patient's oxygenation status, it is important for the nurse to have an understanding of the underlying structures of the respiratory system to best understand their assessment findings.

- Visit the "Respiratory Assessment" chapter for more information about the structures of the respiratory system.

- For more information about common respiratory conditions and medications used to treat them, visit the "Respiratory" chapter in Open RN *Nursing Pharmacology*.

## View supplementary YouTube videos on oxygenation basics:

### TED-Ed video on Oxygen's Journey[1]

### Breathing Mechanics[2]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=629#oembed-1*

### Gas Exchange[3]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=629#oembed-2*


1. TED-Ed. (2017, April 13). *Oxygen's surprisingly complex journey through your body - Edna Butler* [Video]. YouTube. All rights reserved. https://youtu.be/GVU_zANtroE
2. Forciea, B. (2015, May 12). *Anatomy and physiology: Respiratory system: Breathing mechanics (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/X-J5Xgg3l6s
3. Forciea, B. (2015, May 12). *Respiratory system: Gas exchange (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/uVWko7_v7MM

### Carbon Dioxide Transport[4]

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=629#oembed-3*

## Assessing Oxygenation Status

A patient's oxygenation status is routinely assessed using pulse oximetry, referred to as **SpO2**. SpO2 is an estimated oxygenation level based on the saturation of hemoglobin measured by a pulse oximeter. Because the majority of oxygen carried in the blood is attached to hemoglobin within the red blood cell, SpO2 estimates how much hemoglobin is "saturated" with oxygen. The target range of SpO2 for an adult is 95-100%.[5] For patients with chronic respiratory conditions, such as COPD, the target range for SpO2 is often lower at 88% to 92%.

Although SpO2 is an efficient, noninvasive method to assess a patient's oxygenation status, it is an estimate and not always accurate. For example, decreased peripheral circulation can also cause a misleading low SpO2 level due to lack of blood flow to the area in which the pulse oximeter is attached. Another example of an inaccurate reading is if the patient is severely anemic with a decreased hemoglobin level. They may have a normal SpO2 reading because their existing hemoglobin is saturated with

4. Forciea, B. (2015, May 12). *Respiratory system: C02 transport (v2.0)* [Video]. YouTube. All rights reserved. Video used with permission. https://youtu.be/BmrvqZoxHYI
5. Hill, B., & Annesley, S. H. (2020). Monitoring respiratory rate in adults. *British Journal of Nursing, 29*(1), 12–16. https://doi.org/10.12968/bjon.2020.29.1.12

oxygen, even though the available oxygen is not enough to meet the metabolic demands of their body.

A more specific measurement of oxygen and carbon dioxide in the blood is obtained through an **arterial blood gas (ABG)**. ABG results are often obtained for patients who have deteriorating or unstable respiratory status requiring urgent and emergency treatment. An ABG is a blood sample that is typically drawn from the radial artery by a respiratory therapist, emergency or critical care nurse, or health care provider. ABG results evaluate oxygen, carbon dioxide, pH, and bicarbonate levels. The partial pressure of oxygen in the blood is referred to as **PaO2**. The normal PaO2 level of a healthy adult is 80 to 100 mmHg. The PaO2 reading is more accurate than a SpO2 reading because it is not affected by hemoglobin levels. The **PaCO2** level is the partial pressure of carbon dioxide in the blood. The normal PaCO2 level of a healthy adult is 35-45 mmHg. The normal range of pH level for arterial blood is 7.35-7.45, and the normal range for the bicarbonate **(HCO3)** level is 22-26. The **SaO2** level is also obtained, which is the calculated arterial oxygen saturation level. See Table 11.2a for a summary of normal ranges of ABG values.[6]

Table 11.2a Normal Ranges of ABG Values

| Value | Description | Normal Range |
|---|---|---|
| **pH** | Acid-base balance of blood | 7.35-7.45 |
| **PaO2** | Partial pressure of oxygen | 80-100 mmHg |
| **PaCO2** | Partial pressure of carbon dioxide | 35-45 mmHg |
| **HCO3** | Bicarbonate level | 22-26 mEq/L |
| **SaO2** | Calculated oxygen saturation | 95-100% |

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Read more information about interpreting ABG results in the "Acid Base" section of the "Fluids and Electrolytes" chapter in Open RN *Nursing Fundamentals, 2e*.

## Hypoxia and Hypercapnia

**Hypoxia** is defined as a reduced level of tissue oxygenation. Hypoxia has many causes, ranging from respiratory and cardiac conditions to anemia. **Hypoxemia** is a specific type of hypoxia that is defined as decreased partial pressure of oxygen in the blood (PaO2), measured by an arterial blood gas (ABG).

Early signs of hypoxia are anxiety, confusion, and restlessness. As hypoxia worsens, the patient's level of consciousness and vital signs will worsen, with increased respiratory rate and heart rate and decreased pulse oximetry readings. Late signs of hypoxia include bluish discoloration of the skin and mucous membranes called **cyanosis**. Cyanosis is most easily seen around the lips and in the oral mucosa. A sign of chronic hypoxia is **clubbing**, a gradual enlargement of the fingertips (see Figure 11.1[7]). See Table 11.2b for symptoms and signs of hypoxia.[8]

7. "Acopaquia.jpg" by Desherinka is licensed under CC BY-SA 4.0
8. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology and is licensed under CC BY 4.0

*Figure 11.1 Clubbing of Fingertips*

**Hypercapnia** is an elevated level of carbon dioxide in the blood. This level is measured by the PaCO2 level in an ABG test and is indicated when the PaCO2 level is higher than 45. Hypercapnia is typically caused by hypoventilation or areas of the alveoli that are ventilated but not perfused. In a state of hypercapnia or hypoventilation, there is an accumulation of carbon dioxide in the blood. The increased carbon dioxide causes the pH of the blood to drop, leading to a state of respiratory acidosis.

> You can read more about respiratory acidosis in the "Fluids and Electrolytes" chapter of the Open RN *Nursing Fundamentals* book.

Patients with hypercapnia can present with tachycardia, **dyspnea**, flushed skin, confusion, headaches, and dizziness. If the hypercapnia develops gradually over time, such as in a patient with chronic obstructive pulmonary disease (COPD), symptoms may be mild or may not be present at all. Hypercapnia is managed by addressing its underlying cause. A noninvasive positive pressure device such as a BiPAP may provide support to patients who are having trouble breathing normally, but if this is not sufficient, intubation may be required.[9]

Table 11.2b Symptoms and Signs of Hypoxia

9. This work is a derivative of StatPearls by Patel, Miao, Yetiskul, and Majmundar and is licensed under CC BY 4.0

| Signs & Symptoms | Description |
|---|---|
| **Restlessness** | Patient may become increasingly fidgety, move about the bed, demonstrate signs of anxiety and agitation. Restlessness is an early sign of hypoxia. |
| **Tachycardia** | An elevated heart rate (above 100 beats per minute in adults) can be an early sign of hypoxia. |
| **Tachypnea** | An increased respiration rate (above 20 breaths per minute in adults) is an indication of respiratory distress. |
| **Shortness of breath (Dyspnea)** | Shortness of breath is a subjective symptom of not getting enough air. Depending on severity, dyspnea causes increased levels of anxiety. |
| **Oxygen saturation level (SpO2)** | Oxygen saturation levels should be above 94% for an adult without an underlying respiratory condition. |
| **Use of accessory muscles** | Use of neck or intercostal muscles when breathing is an indication of respiratory distress. |
| **Noisy breathing** | Audible noises with breathing are an indication of respiratory conditions. Assess lung sounds with a stethoscope for adventitious sounds such as wheezing, rales, or crackles. Secretions can plug the airway, thereby decreasing the amount of oxygen available for gas exchange in the lungs. |
| **Flaring of nostrils or pursed-lip breathing** | Flaring is a sign of hypoxia, especially in infants. Pursed-lip breathing is a technique often used in patients with COPD. This breathing technique increases the amount of carbon dioxide exhaled so that more oxygen can be inhaled. |
| **Position of patient** | Patients in respiratory distress may sit up or lean over by resting arms on their legs to enhance lung expansion. Patients who are hypoxic may not be able to lie flat in bed. |
| **Ability of patient to speak in full sentences** | Patients in respiratory distress may be unable to speak in full sentences or may need to catch their breath between sentences. |
| **Skin color (Cyanosis)** | Changes in skin color to bluish or gray are a late sign of hypoxia. |
| **Confusion or loss of consciousness (LOC)** | This is a worsening sign of hypoxia. |

| | |
|---|---|
| **Clubbing** | Clubbing, a gradual enlargement of the fingertips, is a sign of chronic hypoxia. |

## Treating Hypoxia

Acute hypoxia is a medical emergency and should be treated promptly with oxygen therapy. Failure to initiate oxygen therapy when needed can result in serious harm or death of the patient. Although oxygen is considered a medication that requires a prescription, oxygen therapy may be initiated without a physician's order in emergency situations as part of the nurse's response to the "ABCs," a common abbreviation for airway, breathing, and circulation. Most agencies have a protocol in place that allows nurses to apply oxygen in emergency situations. After applying oxygen as needed, the nurse then contacts the provider, respiratory therapist, or rapid response team, depending on the severity of hypoxia. Devices such high-flow oxymasks, CPAP, BiPAP, or mechanical ventilation may be initiated by the respiratory therapist or provider to deliver higher amounts of inspired oxygen. Various types of oxygenation devices are further explained in the "Oxygenation Equipment" section.

Prescription orders for oxygen therapy will include two measurements of oxygen to be delivered – the oxygen flow rate and the fraction of inspired oxygen (FiO2). The oxygen flow rate is the number dialed up on the oxygen flow meter between 1 L/minute and 15 L/minute. **Fio2** is the concentration of oxygen the patient inhales. Room air contains 21% oxygen concentration, so the FiO2 for supplementary oxygen therapy will range from 21% to 100% concentration.

In addition to administering oxygen therapy, there are several other interventions the nurse should consider implementing to a hypoxic patient. Additional interventions used to treat hypoxia in conjunction with oxygen therapy are outlined in Table 11.2c.[10]

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Table 11.2c Interventions to Manage Hypoxia

| Interventions | Additional Information |
|---|---|
| **Raise the Head of the Bed** | Raising the head of the bed to high Fowler's position promotes effective chest expansion and diaphragmatic descent, maximizes inhalation, and decreases the work of breathing. Patients with COPD who are short of breath may gain relief by sitting upright or leaning over a bedside table while in bed. |
| **Encourage Enhanced Breathing and Coughing Techniques** | Enhanced breathing and coughing techniques such as using pursed-lip breathing, coughing and deep breathing, huffing technique, incentive spirometry, and flutter valves may assist patients to clear their airway while maintaining their oxygen levels. See the following "Enhanced Breathing and Coughing Techniques" subsection for additional information regarding these techniques. |
| **Manage Oxygen Therapy and Equipment** | If the patient is already on supplemental oxygen, ensure the equipment is turned on, set at the required flow rate, correctly positioned on the patient, and properly connected to an oxygen supply source. If a portable tank is being used, check the oxygen level in the tank. Ensure the connecting oxygen tubing is not kinked, which could obstruct the flow of oxygen. Feel for the flow of oxygen from the exit ports on the oxygen equipment. In hospitals where medical air and oxygen are used, ensure the patient is connected to the oxygen flow port. Hospitals in America follow the national standard that oxygen flow ports are green and air outlets are yellow. |
| **Assess the Need for Respiratory Medications** | Pharmacological management is essential for patients with respiratory disease such as asthma, COPD, or severe allergic response. Bronchodilators effectively relax smooth muscles and open airways. Glucocorticoids relieve inflammation and also assist in opening air passages. Mucolytics decrease the thickness of pulmonary secretions so that they can be expectorated more easily. |
| **Provide Oral Suctioning if Needed** | Some patients may have a weakened cough that inhibits their ability to clear secretions from the mouth and throat. Patients with muscle disorders or those who have experienced a cerebral vascular accident (CVA) are at risk for aspiration pneumonia, which is caused by the accidental inhalation of material from the mouth or stomach. Provide oral suction if the patient is unable to clear secretions from the mouth and pharynx. See the chapter on "Tracheostomy Care and Suctioning" for additional details on suctioning. |
| **Provide Pain Relief If Needed** | Provide adequate pain relief if the patient is reporting pain. Pain increases anxiety and may inhibit the patient's ability to take in full breaths. |

| | |
|---|---|
| **Consider the Side Effects of Pain Medications** | A common side effect of pain medication is sedation and respiratory depression.<br><br>For more information about interventions to manage respiratory depression, see the "Oxygenation" chapter in the Open RN *Nursing Fundamentals* textbook. |
| **Consider Other Devices to Enhance Clearance of Secretions** | Chest physiotherapy and specialized devices assist with secretion clearance, such as handheld flutter valves or vests that inflate and vibrate the chest wall. Consider requesting a consultation with a respiratory therapist based on the patient's situation. |
| **Plan Frequent Rest Periods Between Activities** | Patients experiencing hypoxia often feel short of breath and fatigue easily. Allow the patient to rest frequently, and space out interventions to decrease oxygen demand in patients whose reserves are likely limited. |
| **Consider Other Potential Causes of Dyspnea** | If a patient's level of dyspnea is worsening, assess for other underlying causes in addition to the primary diagnosis. Are there other respiratory, cardiovascular, or hematological conditions such as anemia occurring? Start by reviewing the patient's most recent hemoglobin and hematocrit lab results. Completing a thorough assessment may reveal abnormalities in these systems to report to the health care provider. |
| **Consider Obstructive Sleep Apnea** | Patients with obstructive sleep apnea (OSA) are often not previously diagnosed prior to hospitalization. The nurse may notice the patient snores, has pauses in breathing while snoring, or awakens not feeling rested. These signs may indicate the patient is unable to maintain an open airway while sleeping, resulting in periods of apnea and hypoxia. If these apneic periods are noticed but have not been previously documented, the nurse should report these findings to the health care provider for further testing and follow-up. Testing consists of using continuous pulse oximetry while the patient is sleeping to determine if the patient is hypoxic during these episodes and if a CPAP device should be prescribed. See the box below for additional information regarding OSA. |
| **Anxiety** | Anxiety often accompanies the feeling of dyspnea and can worsen it. Anxiety in patients with COPD is chronically undertreated. It is important for the nurse to address the feelings of anxiety and dyspnea. Anxiety can be relieved by teaching enhanced breathing and coughing techniques, encouraging relaxation techniques, or administering antianxiety medications. |

**Obstructive Sleep Apnea (OSA)** is the most common type of sleep apnea. See Figure 11.2[11] for an illustration of OSA. As soft tissue falls to the back of the throat, it impedes the passage of air (blue arrows) through the trachea and is characterized by repeated episodes of complete or partial obstructions of the upper airway during sleep. The episodes of breathing cessations are called "apneas," meaning "without breath." Despite the effort to breathe, apneas are associated with a reduction in blood oxygen saturation due to the obstruction of the airway. Treatment for OSA often includes the use of a CPAP device.

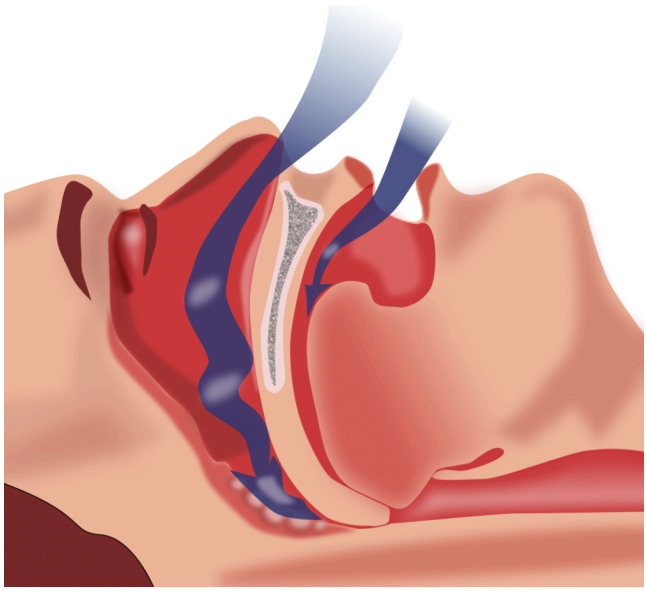

*Figure 11.2 Obstructive Sleep Apnea*

11. "Obstruction ventilation apnée sommeil.svg" by Habib M'henni is in the Public Domain.

## Enhanced Breathing and Coughing Techniques

In addition to oxygen therapy and the interventions listed in Table 11.2c to implement for a patient experiencing dyspnea and hypoxia, there are several techniques a nurse can teach a patient to use to enhance their breathing and coughing. These techniques include pursed-lip breathing, incentive spirometry, coughing and deep breathing, and the huffing technique.

### Pursed-Lip Breathing

Pursed-lip breathing is a technique that allows people to control their oxygenation and ventilation. The technique requires a person to inspire through the nose and exhale through the mouth at a slow controlled flow. See Figure 11.3[12] for an illustration of pursed-lip breathing. This type of exhalation gives the person a puckered or pursed appearance. By prolonging the expiratory phase of respiration, a small amount of positive end-expiratory pressure (PEEP) is created in the airways that helps to keep them open so that more air can be exhaled, thus reducing air trapping that occurs in some conditions such as COPD. Pursed-lip breathing often relieves the feeling of shortness of breath, decreases the work of breathing, and improves gas exchange. People also regain a sense of control over their breathing while simultaneously increasing their relaxation.[13]

12. This work is derivative of "aid611002-v4-728px-Live-With-Chronic-Obstructive-Pulmonary-Disease-Step-8.jpg" by unknown and is licensed under CC BY-NC-SA 3.0. Access for free at https://www.wikihow.com/Live-With-Chronic-Obstructive-Pulmonary-Disease
13. This work is a derivative of StatPearls by Nguyen and Duong and is licensed under CC BY 4.0


*Figure 11.3 Pursed-Lip Breathing*

View a supplementary YouTube video on pursed-lip breathing from the COPD Foundation called *Breathing Techniques*.[14]

## Incentive Spirometry

An incentive spirometer is a medical device often prescribed after surgery to prevent and treat atelectasis. Atelectasis occurs when alveoli become deflated or filled with fluid and can lead to pneumonia. See Figure 11.4[15] for an image of a patient using an incentive spirometer. While sitting upright, the patient should breathe in slowly and deeply through the tubing with the goal of raising the piston to a specified level. The patient should

14. COPD Foundation. (2020, April 17). *Breathing techniques* [Video]. YouTube. All rights reserved. https://youtu.be/ZJPJjZRHmy8
15. "Incentive Spirometer.pngsommeil.svg" by BruceBlaus is licensed under CC BY-SA 4.0

attempt to hold their breath for 5 seconds, or as long as tolerated, and then rest for a few seconds. This technique should be repeated by the patient 10 times every hour while awake.[16] The nurse may delegate this intervention to unlicensed assistive personnel, but the frequency in which it is completed and the volume achieved should be documented and monitored by the nurse.


*Figure 11.4 Using an Incentive Spirometer*

16. Cleveland Clinic. (2018, May 2). *Incentive spirometer.* https://my.clevelandclinic.org/health/articles/4302-incentive-spirometer

## Coughing and Deep Breathing

Teaching the coughing and deep breathing technique is similar to incentive spirometry but no device is required. The patient is encouraged to take deep, slow breaths and then exhale slowly. After each set of breaths, the patient should cough. This technique is repeated 3 to 5 times every hour.

## Huffing Technique

The huffing technique is helpful for patients who have difficulty coughing. Teach the patient to inhale with a medium-sized breath and then make a sound like "Ha" to push the air out quickly with the mouth slightly open.

## Vibratory PEP Therapy

Vibratory positive expiratory pressure (PEP) therapy uses handheld devices such as "flutter valves" or "Acapella" devices for patients who need assistance in clearing mucus from their airways. These devices (see Figure 11.5[17]) require a prescription and are used in collaboration with a respiratory therapist or advanced health care provider. To use vibratory PEP therapy, the patient should sit up, take a deep breath, and blow into the device. A flutter valve within the device creates vibrations that help break up the mucus so the patient can cough it up and spit it out. Additionally, a small amount of positive end-expiratory pressure (PEEP) is created in the airways that helps to keep them open so that more air can be exhaled.

17. "Flutter Valve Breathing Device 3I3A0982.jpg" by Deanna Hoyord, Chippewa Valley Technical College is licensed under CC BY 4.0

*Figure 11.5 Flutter Valve Device*

View a supplementary YouTube video on using a flutter valve device from NHS University Hospitals Plymouth Physiotherapy called Acapella[18]

18. NHS University Hospitals Plymouth Physiotherapy. (2015, May 12). *Acapella* [Video]. YouTube. All rights reserved. https://youtu.be/XOvonQVCE6Y

## 11.3 Oxygenation Equipment

There are several types of equipment a nurse may use when providing oxygen therapy to a patient. Each device is described in detail below.

# Pulse Oximeter

A pulse oximeter is a commonly used portable device used to obtain a patient's oxygen saturation level at the bedside or in a clinic. See Figure 11.6[1] for an image of a portable pulse oximeter. The pulse oximeter, commonly referred to as a "Pulse Ox," is an electronic device that noninvasively measures the oxygen saturation of hemoglobin in a patient's red blood cells, referred to as SpO2. The normal range for SpO2 for an adult without an underlying respiratory condition is above 92%. The pulse oximeter analyzes light produced by the probe as it passes through the finger to determine the saturation level of the hemoglobin molecule.

Pulse oximetry readings can be inaccurate for several reasons and must be interpreted using the nurse's clinical judgment. The most common cause of inaccuracy with pulse oximeters is motion artifact. Patient movement can cause pulsatile venous flow to be incorrectly measured as arterial pulsations, thus producing false oximetry and pulse-rate readings. Another common cause of inaccuracy is poor peripheral perfusion. Poor peripheral perfusion can be caused by conditions such cardiac and vascular disease. In these situations, use a specific pulse oximeter probe for the forehead, bridge of nose, or earlobe to obtain the reading. In any clinical situation where the patient's fingertips are cool or cold, attempt to warm them by using moist heat or a warm blanket, and then apply the pulse oximetry probe when the fingers are warmed for a more accurate reading. Nail polish can also cause an inaccurate pulse oximetry reading and must be removed before placing the probe. Finally, in emergency situations such as carbon monoxide poisoning, other molecules besides

1. "OxyWatch_C20_Pulse_Oximeter.png" by Thinkpaul is licensed under CC BY-SA 3.0

oxygen can attach to hemoglobin and cause a falsely high SpO2 reading even though the patient doesn't have enough oxygen to meet metabolic demands.[2]


*Figure 11.6 Portable Pulse Oximeter*

## Oxygen Flow Meter

In inpatient settings, rooms are equipped with wall-mounted oxygen supply outlets that are nationally standardized in a green color, whereas air outlets are standardized with a yellow color. Oxygen flow meters are attached to the green oxygen outlets, and then the oxygenation device is attached to the flow meter. See Figure 11.7[3] for an image of an oxygen flow

2. American Lung Association. (2020, May 27). *Pulse oximetry*. https://www.lung.org/lung-health-diseases/lung-procedures-and-tests/pulse-oximetry
3. "Oxygen Regulator3I3A1063.jpg" by Deanna Hoyord, Chippewa Valley Technical College is licensed under CC BY 4.0

meter. An oxygen flow meter consists of a glass cylinder containing a steel ball with an opening through which oxygen from the supply source is injected through an adapter. This adapter is commonly referred to as a "tree" because of its appearance. Oxygen is turned on, and the flow rate of oxygen is controlled by turning the green valve on the side of the glass cylinder. The flow rate is set according to the location of a steel ball inside the cylinder and the numbered lines on the glass cylinder. The line corresponding to the ordered liter flow rate should intersect the middle of the metal ball in the flow meter. For example, in Figure 11.7 the flow rate is currently set at 2 liter per minute (L/min). It is essential to implement safety precautions whenever oxygen is used. Read more about "Safety with Oxygen Therapy" later in this section.


*Figure 11.7 Oxygen Flow Meter*

## Portable Oxygen Supply Devices

Portable oxygen tanks are commonly used when transporting a patient to procedures within the hospital or to other agencies. See Figure 11.8[4] for an

4. "RECALLED_–_Portable_oxygen_cylinder_units_(8294127015).jpg" by The U.S. Food and Drug Administration is in the Public Domain.

image of a portable oxygen tank. Oxygenation devices are connected to the tank in a similar manner as the wall-mounted oxygen flow meter. It is crucial for nurses and transporters to ensure the tank has an adequate amount of oxygen for use during transport, is turned on, and the appropriate flow rate is set.


*Figure 11.8 Portable Oxygen Tank*

Instead of oxygen tanks, oxygen concentrators are commonly used by patients in their home environment. See Figure 11.9[5] for an image of a home oxygen concentrator. Oxygen concentrators are also produced in portable sizes that are lightweight and easy for patient use while travelling and mobile in the community. See Figure 11.10[6] for an image of a portable oxygen concentrator. Oxygen concentrators work by taking the 21% concentration of oxygen in the air, running it through a molecular sleeve to remove the nitrogen and concentrating the oxygen to a 96% level, thus producing between 1 and 6 liters per minute of oxygen. Oxygen

5. "Invacare Perfecto 2 Oxygen Concentrator.JPG" by BrokenSphere / Wikimedia Commons is licensed under CC BY-SA 3.0
6. "Portable Oxygen Concentrator by Inogen.jpg" by Oxystore is licensed under CC BY-SA 4.0

concentrators may provide pulse flow or continuous flow. Pulse flow only occurs on inhalation, whereas continuous flow delivers oxygen throughout the entire breath cycle. Pulse versions are the most lightweight because oxygen is provided only as needed by the patient.[7]


*Figure 11.9 Home Oxygen Concentrator*

7. Gibson, C. M. (Ed.). *Portable oxygen concentrator.* WikiDoc. https://www.wikidoc.org/index.php/Portable_oxygen_concentrator


*Figure 11.10 Portable Oxygen Concentrator*

## Nasal Cannula

A nasal cannula is the simplest oxygenation device and consists of oxygen tubing connected to two short prongs that are inserted into the patient's nares. See Figure 11.11[8] for an image of a nasal cannula. The tubing is connected to the flow meter of the oxygen supply source. To prevent drying out the patient's mucus membranes, humidification may be added for hospitalized patients receiving oxygen flow rates greater than 4 L/minute or for those receiving oxygen therapy for longer periods of time.[9]

Nasal cannulas are the most common type of oxygen equipment. They are used for short- and long-term therapy (i.e., COPD patients) and are best used with stable patients who require low amounts of oxygen.

**Flow rate:** Nasal cannulas can have a flow rate ranging from 1 to 6 liters

8. "Image00011.jpg" by British Columbia Institute of Technology is licensed under CC BY 4.0. Access for free at https://opentextbc.ca/clinicalskills/chapter/5-5-oxygen-therapy-systems/
9. Duck, A. (2009, December 14). *Does oxygen need humidification?* https://www.nursingtimes.net/clinical-archive/respiratory-clinical-archive/does-oxygen-need-humidification-14-12-2009/

per minute (L/min), with a 4% increase in FiO2 for every liter of oxygen, resulting in range of fraction of inspired oxygen (FiO2) levels of 24-44%.

**Advantages:** Nasal cannulas are easy to use, inexpensive, and disposable. They are convenient because the patient can talk and eat while receiving oxygen.

**Limitations:** The nasal prongs of nasal cannula are easily dislodged, especially when the patient is sleeping. The tubing placed on the face can cause skin breakdown in the nose and above the ears, so the nurse must vigilantly monitor these areas. Based on agency policy, the nurse should add padding to the oxygen tubing as needed to avoid skin breakdown and may apply a water-based lubricant to prevent drying. However, petroleum-based lubricant should not be used due to the risk of flammability. Nasal cannulas are not as effective if the patient is a mouth breather or has blocked nostrils, a deviated septum, or nasal polyps.[10]

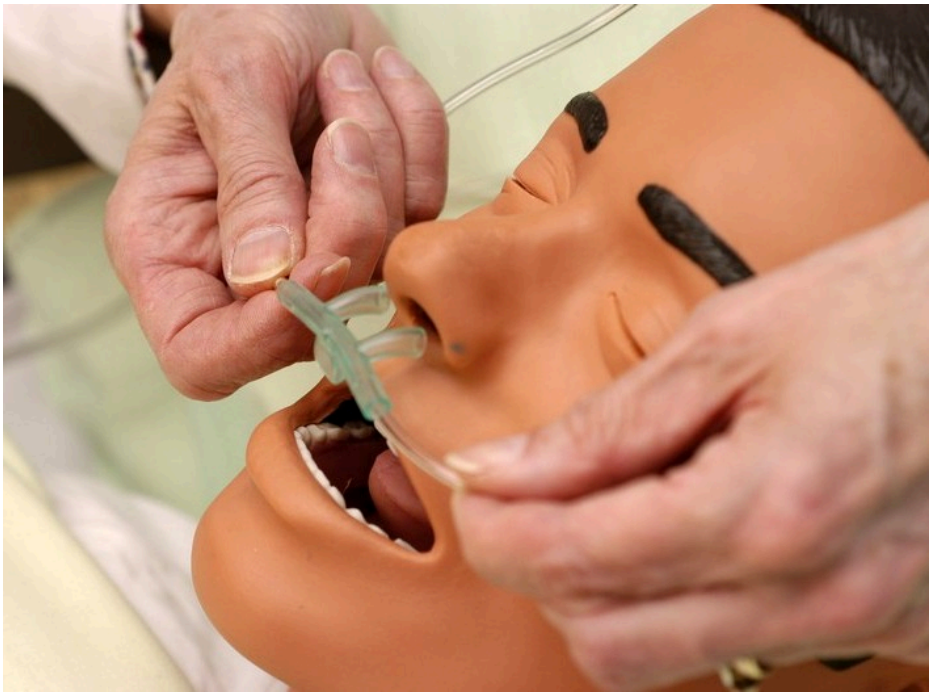

*Figure 11.11 Nasal Cannula*

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## High-Flow Nasal Cannula

High-flow nasal cannula therapy is an oxygen supply system capable of delivering up to 100% humidified and heated oxygen at a flow rate of up to 60 liters per minute.[11] Patients with high-flow nasal cannulas are generally in critical condition and require advanced monitoring. See Figure 11.12[12] for an illustration of a high-flow nasal cannula system that is initially set up by a respiratory therapist and then maintained by a nurse.

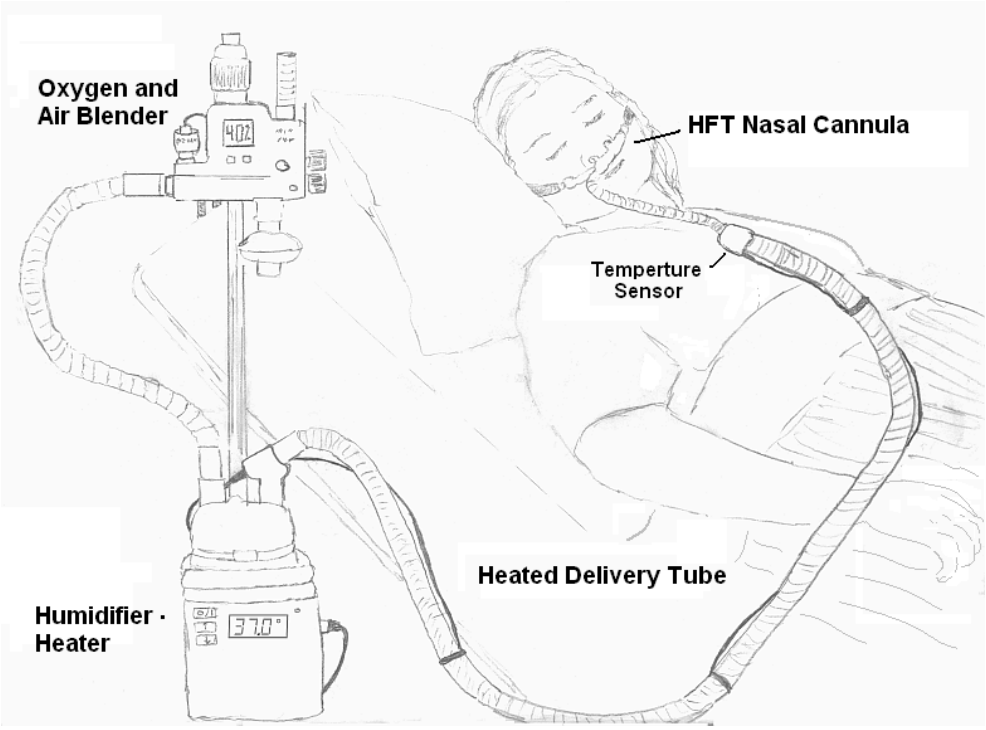


*Figure 11.12 High-Flow Nasal Cannula System*

## Simple Mask

A simple mask fits over the mouth and nose of the patient and contains exhalation ports (i.e., holes on the side of the mask) through which the patient exhales carbon dioxide. These holes should always remain open.

11. This work is a derivative of StatPearls by Sharma, Danckers, Sanghavi, and Chakraborty and is licensed under CC BY 4.0
12. "HFT diagram.png" by Strangecow is in the Public Domain.

The mask is held in place by an elastic band placed around the back of the head. It also has a metal piece near the top that can be pinched and shaped over the patient's nose to create a better fit. Humidified air may be attached if the oxygen concentrations are drying for the patient. See Figure 11.13[13] for an image of a simple face mask.

**Flow Rate:** Simple masks should be set to a flow rate of 6 to 10 L/min, resulting in oxygen concentration (FiO2) levels of 35%-50%. The flow rate should never be set below 6 L/min because this can result in the patient rebreathing their exhaled carbon dioxide.

**Advantages:** Face masks are used to provide moderate oxygen concentrations. Their efficiency in oxygen delivery depends on how well the mask fits and the patient's respiratory demands.

**Disadvantages:** Face masks must be removed when eating, and they may feel confining for some patients who feel claustrophobic with the mask on.[14]

13. "DSC_2086.jpg" by British Columbia Institute of Technology is licensed under CC BY 4.0. Access for free at https://opentextbc.ca/clinicalskills/chapter/5-5-oxygen-therapy-systems/
14. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology and is licensed under CC BY 4.0

*Figure 11.13 Simple Face Mask*

## Non-Rebreather Mask

A non-rebreather mask consists of a mask attached to a reservoir bag that

is attached with tubing to a flow meter. See Figure 11.14[15] for an image of a non-rebreather mask. It has a series of one-way valves between the mask and the bag and also on the covers on the exhalation ports. The reservoir bag should never totally deflate; if the bag deflates, there is a problem and immediate intervention is required. The one-way valves function so that on inspiration, the patient only breathes in from the reservoir bag; on exhalation, carbon dioxide is directed out through the exhalation ports. Non-rebreather masks are used for patients who can breathe on their own but require higher concentrations of oxygen to maintain satisfactory blood oxygenation levels.

**Flow rate:** The flow rate for a non-rebreather mask should be set to deliver a **minimum** of 10 to 15 L/minute. The reservoir bag should be inflated prior to placing the mask on the patient. With a good fit, the non-rebreather mask can deliver between 60% and 80% FiO2.

**Advantages:** Non-rebreather masks deliver high levels of oxygen noninvasively to patients who can otherwise breathe unassisted.

**Disadvantages:** Due to the one-way valves in non-rebreather masks, there is a high risk of suffocation if the gas flow is interrupted. The mask requires a tight seal and may feel hot and confining to the patient. It will interfere with talking, and the patient cannot eat with the mask on.

15. "DSC_2083.jpg" by British Columbia Institute of Technology is licensed under CC BY 4.0. Access for free at https://opentextbc.ca/clinicalskills/chapter/5-5-oxygen-therapy-systems/

*Figure 11.14 Non-Rebreather Mask*

## Partial Rebreather Mask

The partial rebreather mask looks very similar to the non-rebreather mask. The difference between the masks is a partial rebreather mask does not contain one-way valves, so the patient's exhaled air mixes with their inhaled air. A partial rebreather mask requires 10-15 L/min of oxygen, but only delivers 35-50% FiO2.

## Venturi Mask

Venturi masks are indicated for patients who require a specific amount of supplemental oxygen to avoid complications, such as those with chronic obstructive pulmonary disease (COPD). Different types of adaptors are attached to a face mask that set the flow rate to achieve a specific FiO2 ranging from 24% to 60%. Venturi adapters are typically set up by a respiratory therapist, but in some facilities, they may be set up by a nurse according to agency policy.

**Flow rate:** The flow rate depends on the adaptor and does not correspond to the flow meter. Consult with a respiratory therapist before changing the flow rate.

**Advantages:** A specific amount of FiO2 is delivered to patients whose breathing status may be affected by high levels of oxygen.

## Oxymask

An oxymask is an oxygen delivery device that has an open design that eliminates the need for valves and reservoirs. O2 flow is directed towards the nose and mouth. Large openings in the mask allow CO2 to escape, decrease claustrophobia, increase ability to communicate, and allow for delivery of PO fluids and medications without removing the mask.

**Flow rate:** An oxymask can deliver 24-90% oxygen concentration on 1-15 LPM oxygen, which increases flexibility and safety of the product.

**Advantages:** The oxymask increases flexibility and safety due to variable oxygen flow rates. It also can decrease claustrophobia and increase the ability to communicate without removing the mask.

## Oxymizer

An oxymizer is a special nasal cannula that provides a larger luminal diameter in combination with an oxygen reservoir. The oxymizer is

designed as either a moustache or pendant style. Some patients don't like the weight of the device, which is greater due to the oxygen reservoir and tubing size.

**Flow rate:** The flow rate is 1/4 to 1/2 of the previous flow rate required. The oxymizer can deliver up to 15 LPM.

**Advantages:** The oxymizer is able to help maintain adequate O2 saturations in hypoxic patients with a lower flow rate, resulting in reduced O2 costs, longer portable O2 sources, and decreased nasal irritation and dryness.

## Continuous Positive Airway Pressure (CPAP)

A continuous positive airway pressure (CPAP) device is used for people who are able to breathe spontaneously on their own but need help in keeping their airway unobstructed, such as those with obstructive sleep apnea. (See Table 11.2c in the "Basic Concepts of Oxygenation" section for more information about obstructive sleep apnea.) The CPAP device consists of a special mask that covers the patient's nose, or nose and mouth, and is attached to a machine that continuously applies mild air pressure to keep the patient's airways from collapsing.

A prescription is required for a CPAP device in the hospital or patient's home environment. In the hospital, the FiO2 is set up with the CPAP mask by the respiratory therapist. In a home setting, an adapter is added so that oxygen is attached using a flow meter with preprogrammed settings so the patient and/or nurse are only required to turn the machine on before sleeping and off upon awakening. It is important to keep the mask and tubing clean to prevent infection, so be sure to follow agency policy for cleaning the equipment regularly. If a humidifier is attached, distilled water or sterile water should be used to fill it, but never tap water. See

Figure 11.15[16] for an illustration of a patient wearing a CPAP device while sleeping.

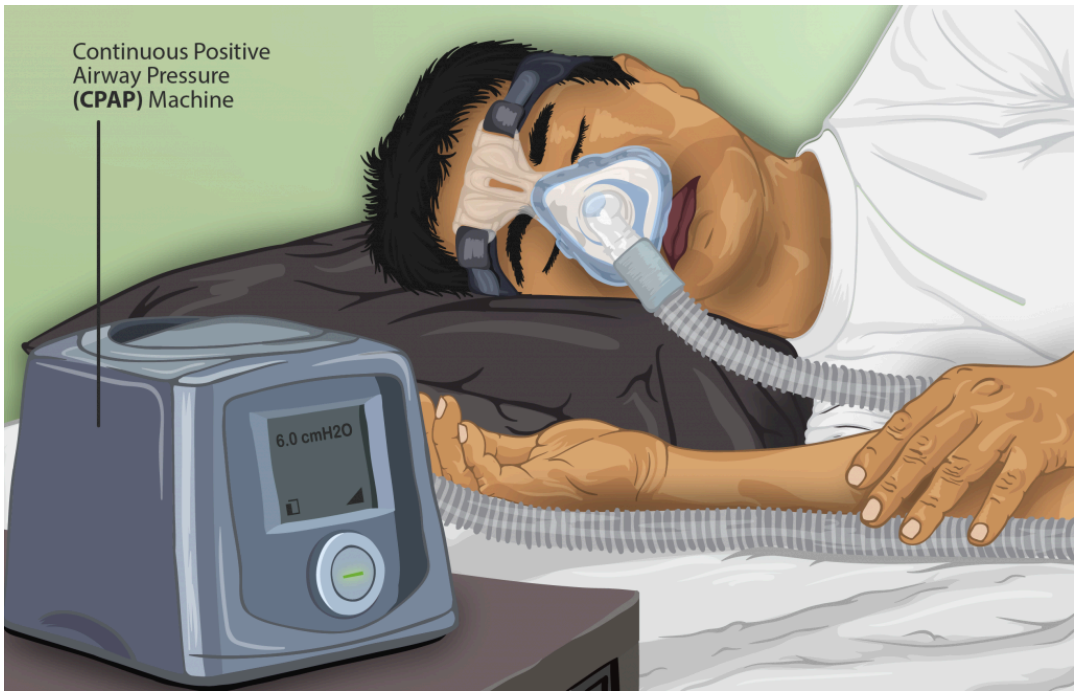


*Figure 11.15 CPAP Machine*

**View a supplementary YouTube video from the FDA on CPAP Tips**[17]

16. "Depiction of a sleep apnea patient using a CPAP machine" by https://www.myupchar.com/en is licensed under CC BY 4.0
17. U.S. Food and Drug Administration. (2012, December 12). *CPAP tips from FDA* [Video]. YouTube. All rights reserved. https://youtu.be/B10ABypyGOo

*One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wtcs.pressbooks.pub/nursingskills/?p=714#oembed-1*

## BiPAP

A bilevel positive airway pressure (BiPAP) device is similar to a CPAP device in that it is used to prevent airways from collapsing, but BiPAP devices have two pressure settings. One setting occurs during inhalation and a lower pressure setting is used during exhalation. Patients using BiPAP devices in their home environment for obstructive sleep apnea often find these two pressures more tolerable because they don't have to exhale against continuous pressure. In acute-care settings, BiPAP devices are also used for patients in acute respiratory distress as a noninvasive alternative to intubation and mechanical ventilation and are managed by respiratory therapists. BiPAP devices in home settings are set up in a similar manner as CPAP machines for ease of use. See Figure 11.16[18] for an image of a simulated patient wearing a BiPAP mask in a hospital setting with continuous pulse oximetry monitoring.

18. "Simulated patient wearing a BiPAP mask" by Chippewa Valley Technical College is licensed under CC BY 4.0

*Figure 11.16 Simulated Patient Wearing a BiPAP Mask*

## Bag Valve Mask (Ambu Bag)

A bag valve mask, commonly known as an "Ambu bag," is a handheld device used in emergency situations for patients who are not breathing (respiratory arrest) or who are not breathing adequately (respiratory failure). In this manner, this device is different from the other devices because it assists with **ventilation**, the movement of air into and out of the lungs, as well as oxygenation. See Figure 11.17[19] for an image of a bag valve mask. Bag valve masks are produced in different sizes for infants, children, and adults to prevent lung injury, so it is important to use the correct size for the patient.

19. "Ballon ventilation 1.jpg" by Rama is licensed under CC BY-SA 2.0 FR

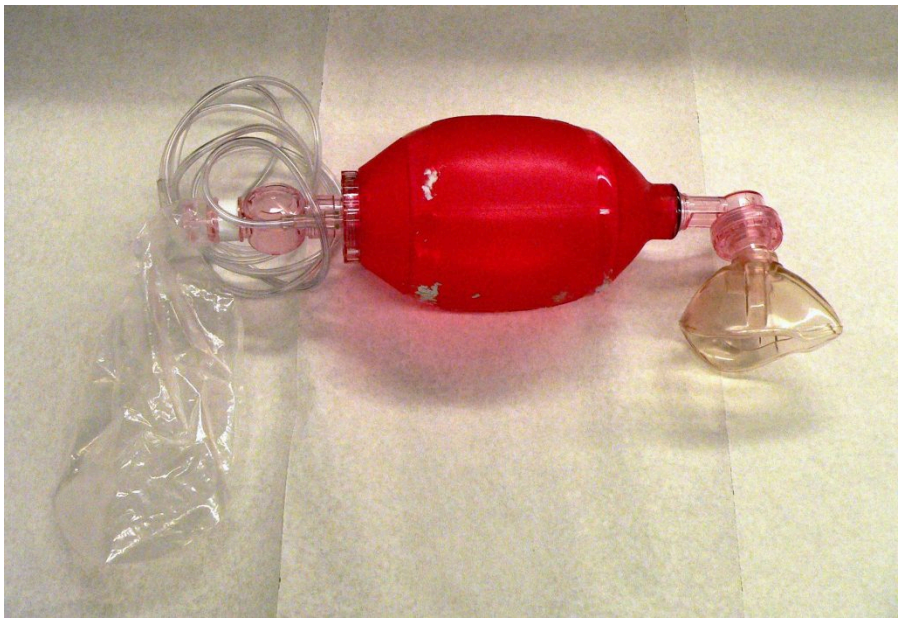

*Figure 11.17 Bag Valve Mask*

When using a bag mask valve, the rescuer manually compresses the bag to force air into the lungs. Squeezing the bag once every 5 to 6 seconds for an adult or once every 3 seconds for an infant or child provides an adequate respiratory rate. In inpatient settings, the bag mask valve is attached to an oxygen supply to increase the concentration of oxygenation provided with each breath. See Figure 11.18[20] for an illustration of operating a bag valve mask.

It is vital to obtain a tight seal of the mask to the patient's face, but this is difficult for a single rescuer to achieve. Therefore, two rescuers are recommended; one rescuer performs a jaw thrust maneuver, secures the mask to the patient's face with both hands, and focuses on maintaining a leak-proof mask seal, while the other rescuer squeezes the bag and focuses on the amount and the timing.

20. "Resuscitator 3 - Operation (PSF).png" by Pearson Scott Foresman is in the Public Domain.

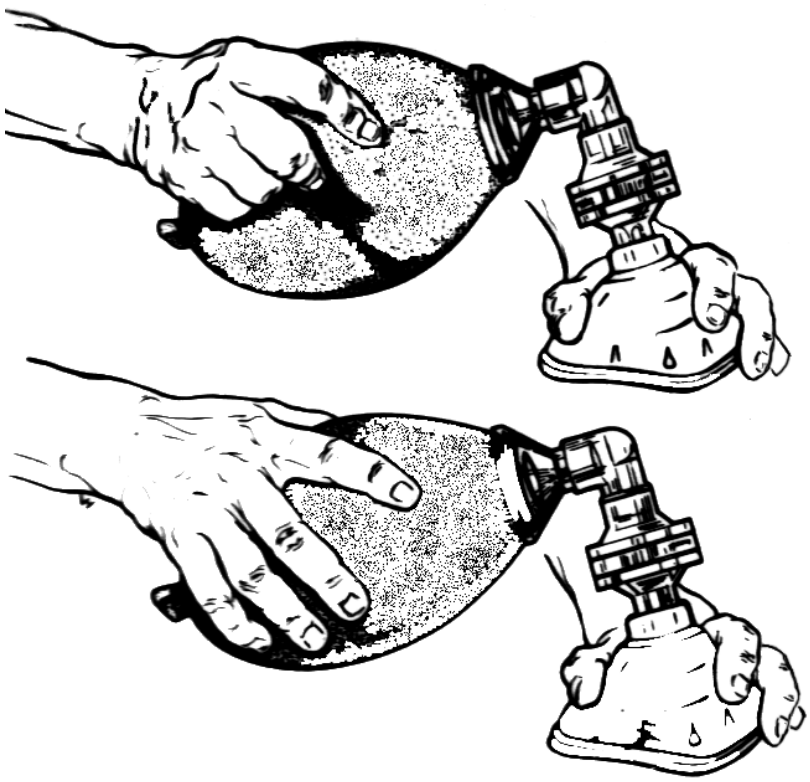

*Figure 11.18 Operation of a Bag Valve Mask*

**Flow rate:** The flow rate for a bag valve mask attached to an oxygen source should be set to 15 L/minute, resulting in FiO2 of 100%.

**Advantages:** A bag valve mask is portable and provides immediate assistance to patients in respiratory failure or respiratory arrest. It also can be used to hyperoxygenate patients before procedures that can cause hypoxia, such as tracheal suctioning.

**Disadvantages:** The rate and depth of compression of the bag must be closely monitored to prevent injury to the patient. In the event of respiratory failure when the patient is still breathing, the bag compressions must be coordinated with the patient's inhalations to ensure that oxygen is delivered, and asynchrony of breaths is prevented. Complications may also result from overinflating or overpressurizing the patient. Complications include lung injury or the inflation of the stomach that can lead to aspiration of stomach contents. Additionally, rescuers may tire after a few minutes of manually compressing the bag, resulting in less-than-optimal ventilation. Alternatively, an endotracheal tube (ET) can

be inserted by an advanced practitioner to substitute for the mask portion of this device. See more information about endotracheal tubes below.

## Endotracheal Intubation

When a patient is receiving general anesthesia prior to a procedure or surgery or is experiencing respiratory failure or respiratory arrest, an endotracheal tube (ET) is inserted by an advanced practitioner, such as a respiratory therapist, paramedic, or anesthesiologist, to maintain a secure airway. The ET tube is sealed within the trachea with an inflatable cuff, and oxygen is supplied via a bag valve mask or via mechanical ventilation. See Figure 11.19[21] for an image of a cuffed endotracheal tube.

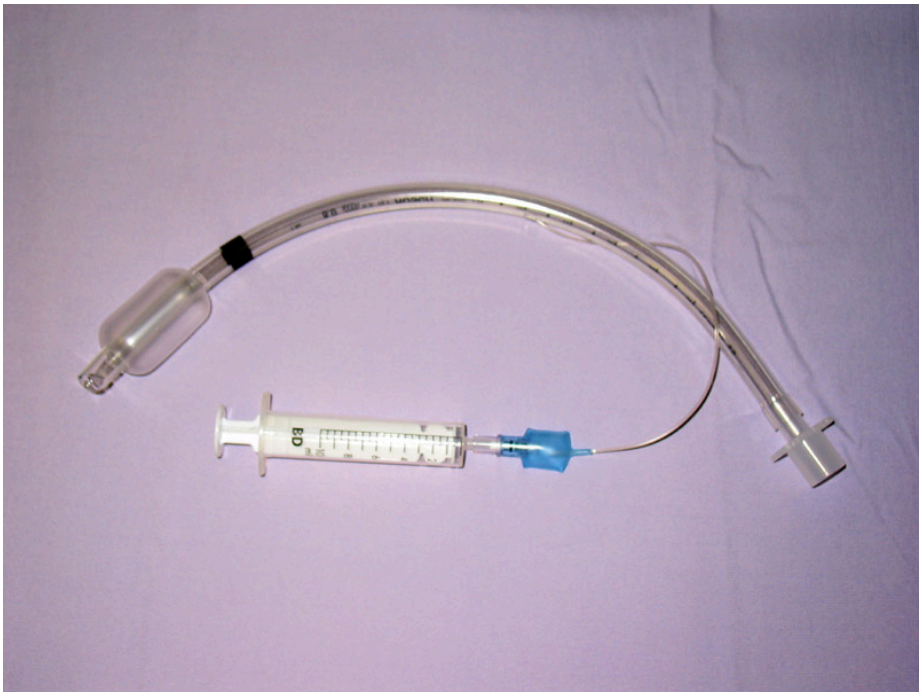

*Figure 11.19 An Endotracheal Tube*

## Mechanical Ventilator

A mechanical ventilator is a machine attached to an endotracheal tube to assist or replace spontaneous breathing. Mechanical ventilation is termed

21. "Sondeintubation.jpg" by bigomar2 is licensed under CC BY-SA 3.0

invasive because it requires placement of a device inside the trachea through the mouth, such as an endotracheal tube. Mechanical ventilators are managed by respiratory therapists via protocol or provider order. FiO2 can be set from 21-100%. Nurses collaborate with respiratory therapists and the health care providers regarding the overall care of the patient on a mechanical ventilator. See Figure 11.20[22] for an image of a simulated patient who is intubated with an endotracheal tube and attached to a mechanical ventilator.

22. "Simulated intubated patient on a mechanical ventilator" by ARISE project is licensed under CC BY 4.0

*Figure 11.20 Simulated Intubated Patient on a Mechanical Ventilator*

## Tracheostomy

A tracheostomy is a surgically made hole called a stoma that goes from the front of the patient's neck into the trachea. A tracheostomy tube is placed through the stoma and directly into the trachea to maintain an open (patent) airway and to administer oxygen. A tracheostomy may be performed emergently or as a planned procedure. Read more about tracheostomies in the "Tracheostomy Care and Suctioning" chapter.

## Flow Rates and Oxygen Percentages

When administering oxygen to a patient, it is important to ensure that oxygen flow rates are appropriately set according to the type of administration device. Review Table 11.3a to review appropriate settings for various types of oxygenation devices.

Table 11.3a Settings of Oxygenation Devices

| Device | Flow Rates and Oxygen Percentage |
|---|---|
| **Nasal Cannula** | Flow rate: 1-6 L/min<br><br>FiO2: 24% to 44% |
| **High-Flow Nasal Cannula** | Flow rate: up to 60 L/min<br><br>FiO2: Up to 100% |
| **Simple Mask** | Flow rate: 6-10 L/min<br><br>FiO2:  28% to 50% |
| **Non-Rebreather Mask** | Flow rate: 10 to 15 L/min<br><br>FiO2: 60-80%<br><br>Safety Note: The reservoir bag should always be partially inflated. |
| **CPAP, BiPAP, Venturi Mask, Mechanical Ventilator** | Use the settings provided by the respiratory therapist and/or provider order. |
| **Bag Valve Mask** | Flow rate: 15 L/min<br><br>FiO2: 100%<br><br>Squeeze the bag once every 5 to 6 seconds for an adult or once every 3 seconds for an infant or child. |

## Safety With Oxygen Therapy

Oxygen therapy supports life, but it also supports fire. While there are many benefits to oxygen therapy, there are also many hazards. Oxygen must be administered cautiously and according to the safety guidelines in Table 11.3b.[23]

Table 11.3b Oxygen Therapy Safety Guidelines

23. This work is a derivative of Clinical Procedures for Safer Patient Care by British Columbia Institute of Technology and is licensed under CC BY 4.0

| Guideline | Additional Information |
|---|---|
| **Remember that oxygen is a medication.** | Oxygen is a medication and should not be adjusted without consultation with a physician or respiratory therapist. |
| **Store oxygen cylinders correctly.** | When using oxygen cylinders, store them upright, chained, or in appropriate holders so that they will not fall. Full oxygen tanks should be stored separately from partially full or empty oxygen tanks. |
| **Use tank holders appropriately.** | When transporting a patient, proper tank holders must be used per The Joint Commission guidelines. Tanks should never be placed on the patient's bed. |
| **Do not allow smoking near the oxygen devices.** | Oxygen supports combustion. No smoking is permitted around any oxygen delivery devices in the hospital or home environment. |
| **Keep oxygen cylinders away from heat sources.** | Keep oxygen delivery systems at least 5 feet from any heat source. |
| **Check for electrical hazards in the home or hospital prior to use.** | Determine that electrical equipment in the room or home is in safe working condition. A small electrical spark in the presence of oxygen will result in a serious fire. The use of a gas stove, kerosene space heater, or smoker is unsafe in the presence of oxygen. Avoid items that may create a spark (e.g., electrical razor, hair dryer, synthetic fabrics that cause static electricity, or mechanical toys) with nasal cannula in use. Petroleum-based lubricants should not be used on the lips or around the nasal cannula. |
| **Check levels of oxygen in portable tanks.** | Check oxygen levels of portable tanks before transporting a patient to ensure that there is enough oxygen in the tank. |

## 11.4 Nursing Process Related to Oxygen Therapy

When administering oxygen therapy, it is important for the nurse to assess the patient before, during, and after the procedure and document the findings.

### Subjective Assessment

Prior to initiating oxygen therapy, if conditions warrant, the nurse should briefly obtain a history of respiratory conditions and collect data regarding current symptoms associated with the patient's feeling of shortness of breath. The duration of this focused assessment should be modified based on the severity of the patient's dyspnea. See Table 11.4 for focused interview questions related to oxygen therapy. This information is used to customize the oxygen delivery device and flow rate for the patient. For example, supplemental oxygen is typically initiated in nonemergency situations with a nasal cannula at 1-2 liters per minute (L/min), but a patient with a history of chronic obstructive pulmonary disease (COPD) may require a different device such as a Venturi mask.

Table 11.4 Focused Interview Questions for Subjective Assessment of Dyspnea

| Interview Questions | Follow-up |
|---|---|
| Please rate your current feeling of shortness of breath from 0-10, “0” being no shortness of breath and “10” being the worst shortness of breath you have ever experienced. | Note: If the shortness of breath is severe, associated with chest pain, or if there are imminent signs of respiratory failure, discontinue the subjective assessment and obtain emergency assistance. |
| Are you experiencing any additional symptoms such as chest pain, cough, or a feeling of swelling in your throat or tongue? | Please describe.<br><br>Note: If the patient describes severe symptoms that could indicate imminent blockage of the airway, obtain emergency assistance.<br><br>When did it start?<br><br>Is the cough productive of phlegm? If yes, what color and what is the amount?<br><br>Does the chest pain radiate elsewhere? |
| Have you ever been diagnosed with respiratory conditions such as asthma or COPD? | Please describe. |
| Are you currently taking any medications, herbs, or supplements to help you breathe? | Please identify what you are taking and the dosage.<br><br>If you are using inhalers on an as-needed basis, how often are you using them and has the frequency increased lately? |
| Have you received oxygen therapy previously? | Please describe.<br><br>Do you use oxygen therapy at home? What is your normal flow rate?<br><br>Do you use CPAP or BiPAP devices at home? |
| Do you smoke? | Have you considered quitting? |

## Objective Assessment

Prior to applying supplemental oxygen, objective data regarding patient status should quickly be obtained such as airway clearance, respiratory rate, pulse oximetry, and lung sounds. Signs of cyanosis in the skin or nail bed assessment should also be noted. Within a few minutes after initiating oxygen administration, the nurse should evaluate for improvement of these indicators, and if no improvement is noted, then additional actions should be taken. At any point, if the nurse feels that the patient's condition is deteriorating, emergency action should be taken such as calling the rapid response team or 911.

Depending upon the severity of patient condition, serial ABG results may also be monitored to determine effectiveness of oxygenation interventions.

After oxygen therapy is initiated, it is important to closely monitor for skin breakdown at pressure points. For example, nasal cannula tubing often causes skin breakdown in the nares or over the ears, so protective foam dressings may need to be applied.

## Life Span Considerations

### CHILDREN

Different sized oxygen equipment is used for infants and children. Additionally, oxygen tubing may need to be secured to a child's face with tape to prevent them from pulling it off. For infants, the pulse oximeter probe is usually attached to the palm or foot.

### OLDER ADULTS

If a patient is oxygen-dependent, ensure that extension tubing is applied so the patient is able to reach the bathroom with the oxygen device in