TCHP Education Consortium

Providing education for today's health care professionals
Capitol Office Building, 525 Park Street, Suite 120, St. Paul, MN 55103
612-873-2225 www.tchpeducation.com

Pulmonary Critical Care

September 7th, 2011
7:30 a.m. – 4:00 p.m.
Hennepin County Medical Center—Room OL-200

Description/Purpose Statement

The lungs are responsible for oxygenating all 50 billion cells in the body and for helping in the excretion of waste products. Primary or secondary insults to the lungs can cause a rapid decline into critical illness. The purpose of this class is to review the assessment and management of the adult experiencing pulmonary embolism, pneumonia, COPD, asthma, and ARDS using a case study and lecture approach.

Target Audience

This class is designed for primarily novice critical care or telemetry nurses, although others are welcome to attend.

Before You Come to Class

Please complete the: ① **Pulmonary Critical Care Primer** ***and*** ② **Management of the Obese Patient Home Study.** If you did not receive these primers with this cover letter, please access the primers from the TCHP website at www.tchpeducation.com under home studies. Please bring your primer post-tests to class with you for processing.

Schedule

7:30 - 7:45 a.m.	*Registration*	
7:45 - 8:45 a.m.	ABG Interpretation Pulmonary Medications	Lynn Duane
8:45 - 9:00 a.m.	*Break*	
9:00 - 11:30 a.m.	Pulmonary Pathologies (Pneumonia, COPD, ARDS)	John Gallagan
11:30 - 12:30 p.m.	*Lunch*	
12:30 - 1:30 p.m.	Pulmonary Pathologies (Asthma, Pulmonary Embolism, Pulmonary Hypertension)	Cleo Bonham
1:30 - 1:45 p.m.	*Break*	
1:45 – 3:00 p.m.	Pulmonary Pathologies (continued)	Cleo Bonham
3:00 - 4:00 p.m.	Complex Patient Problems	Cleo Bonham

Continuing Education Credit

For attending this **class**, you are eligible to receive:	**8.1 Minnesota Board of Nursing contact hours /6.75 ANCC contact hours.** **Criteria for successful completion**: **Criteria for successful completion:** All participants must attend the program and complete the evaluation form to receive contact hours. If you are an ANCC certified nurse, you must attend the ENTIRE activity to receive contact hours for it. The Twin Cities Health Professionals Education Consortium is an approved provider of continuing nursing education by the Wisconsin Nurses Association, an accredited approver by the American Nurses Credentialing Center's Commission on Accreditation.
If you complete the **primers** for this class, you are eligible to receive an additional:	**1. Pulmonary Critical Care Primers: 2.5 Minnesota Board of Nursing contact hours / 2.08 ANCC contact hours** **2. Management of the Obese Patient Home Study: 2.0 Minnesota Board of Nursing contact hours / 1.66 ANCC contact hours** **Criteria for successful completion:** You must read the primer, complete the post-test and evaluation, and submit it to TCHP for processing.

Please Read!

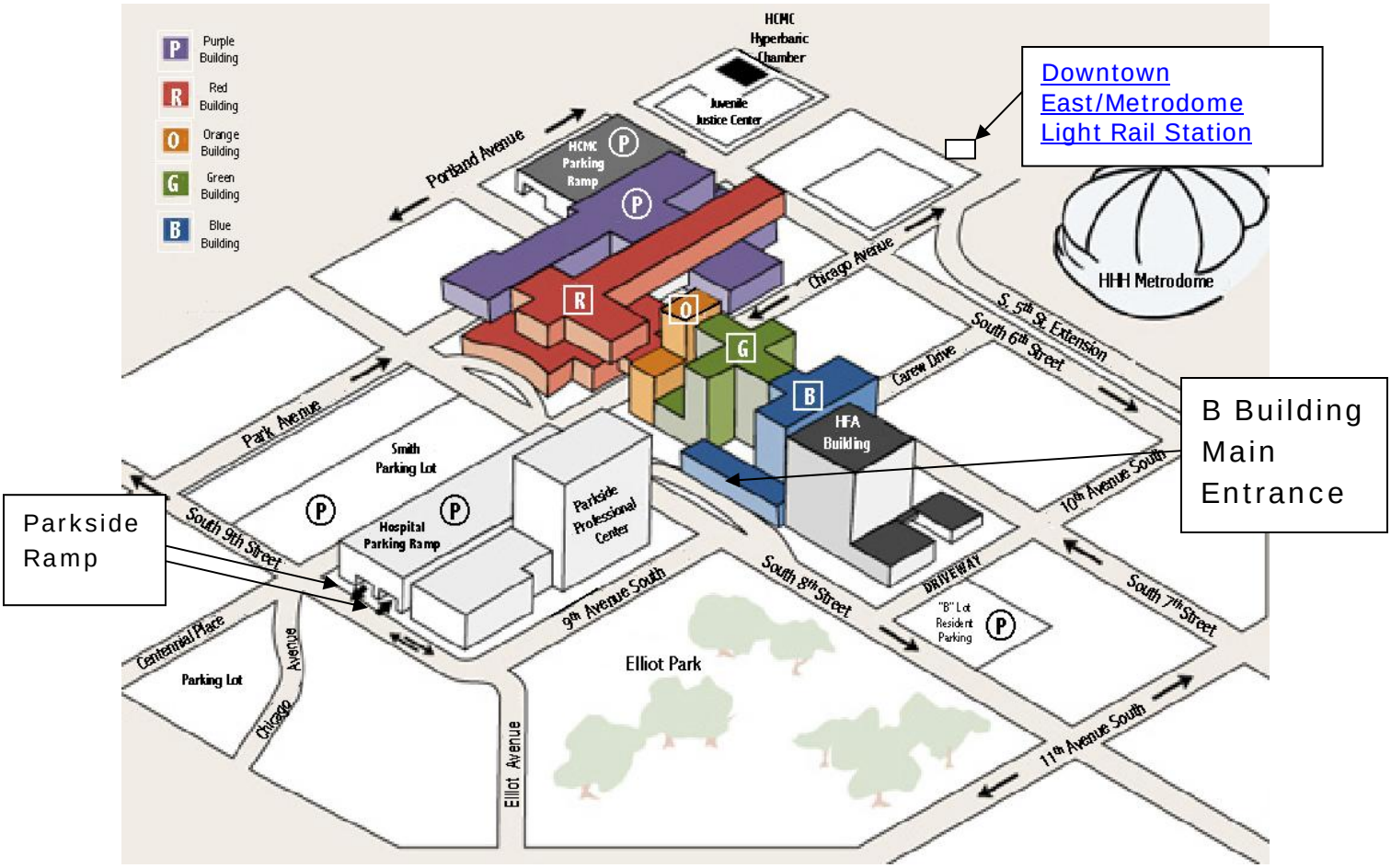
- Check the attached map for directions to the class and assistance with parking.
- Certificates of attendance will be distributed at the end of the day.
- You should dress in layers to accommodate fluctuations in room temperature.
- Food, beverages, and parking costs are your responsibility.
- If you are unable to attend after registering, please notify the Education Department at your hospital or TCHP at 612-873-2225.
- In the case of bad weather, call the TCHP office at 612-873-2225 and check the answering message to see if a class has been cancelled. If a class has been cancelled, the message will be posted by 5:30 a.m. on the day of the program.
- More complete class information is available on the TCHP website at www.tchpeducation.com.

Finding HCMC Orange Building, Room OL200

701 South 8th Street, Minneapolis, MN 55401

Finding the classroom <u>from Outside</u> the Building:
Enter the main entrance of HCMC Blue building from South 8th Street (directly across the street from the Parkside Professional Building). Once inside the door, take a right and head towards the information desk. Turn left and go past the gift shop and coffee stand to the open stairway on your right. Take the stairs to the lower level. Turn to your right at the bottom of the stairs. *Take a left at the first hallway intersection and continue straight ahead until you see a blue line on the floor. Turn left and follow the blue line until just before it ends. Room OL200 is on the right.

Finding the classroom <u>from the Parkside Ramp</u>:
Take the ramp elevators to the lower level. Follow the signs to the hospital. Follow the hallway past the stairway and vending machines. Follow directions above from *.



Driving Directions to HCMC:

From the Northeast:
Take 35W south to Exit 17C (Washington Avenue). Turn right onto Washington. Follow Washington Avenue to Chicago Avenue and turn left. Take a left onto 9th street. Turn left again to enter the Parkside Ramp. Take the ramp elevator to the lower level and follow the instructions above.*

From the Northwest: Take I-94 east to exit 230 (4th Street). Follow 4th Street through downtown to Chicago Avenue and turn right onto Chicago Avenue. Follow Chicago to 9th Street and turn left. Turn left again to enter the Parkside Ramp. Take the ramp elevators to the lower level and follow the instructions above.*

From the East: Take I-94 W to exit 234B (5th Street). Follow 5th Street around the Dome; turn left on Chicago Avenue. Follow Chicago to 9th Street and turn left. Turn left again to enter the Parkside Ramp. Take the ramp elevators to the lower level and follow the instructions on the previous page.*

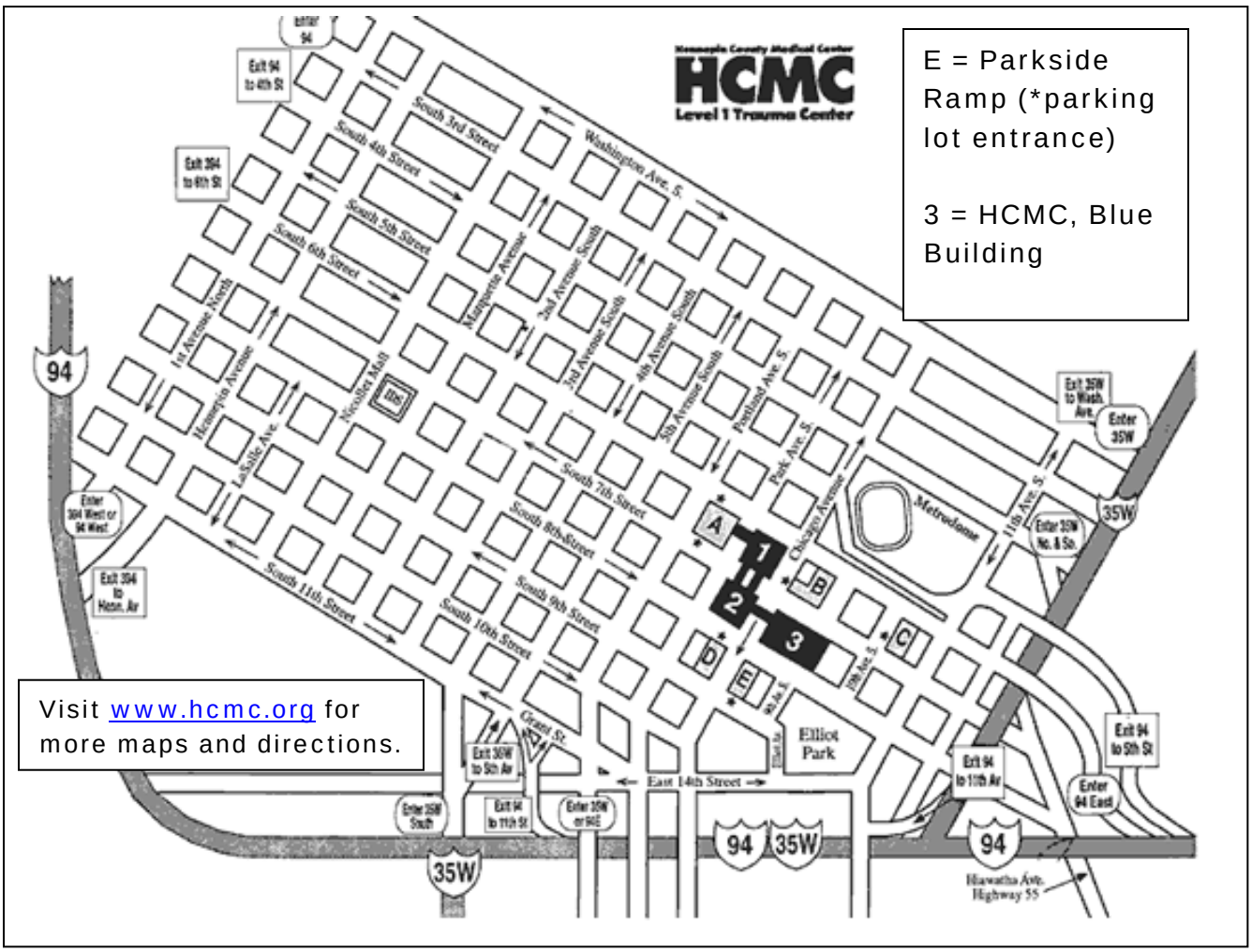
From the South: Take 35W North to exit 16A (downtown exit). Take 5th Avenue exit; follow 5th Avenue to 8th Street and turn right. Turn right on Chicago Avenue and in one block, turn left on 9th Street. Take a left to enter the Parkside Ramp. Take the ramp elevators to the lower level and follow the instructions on the previous page.*

From the West: Take 394 east to exit 9B (6th Street). Follow 6th Street to Chicago Avenue; turn right onto Chicago. Take Chicago Avenue to 9th Street and turn left. Turn left again to enter the Parkside Ramp. Take the ramp elevators to the lower level and follow the directions on the previous page.*

Public transportation is another options for getting downtown. For bus schedules and information, go to www.metrotransit.org. **Light Rail Transit to HCMC:** HCMC is located at the corner of Park Ave. and 6th Street, conveniently located just 1-1/2 blocks south of the Downtown East/Metrodome station of the Light Rail Transit line. Light Rail information is available at www.metrotransit.org/rail/index.asp.

Parking:
There are various options for parking around HCMC, but we suggest you park in the Parkside Ramp. It is closest to the classroom, and the most reasonably priced place to park at this time for the day. Therefore, directions and maps direct you to this ramp. Meters are available around the hospital but cost 75 cents/hour, so for an all-day class it gets expensive.

Parking rates are subject to change without notice, but the current cost of park in the Parkside ramp is $6.25. You must pay in cash; checks and credit cards not accepted.



TCHP Education Consortium

Pulmonary Critical Care Primer

Introduction/Purpose Statement

The lungs are responsible for oxygenating all 50 billion cells in the body and for helping in the excretion of waste products. Primary or secondary insults to the lungs can cause a rapid decline into critical illness. The purpose of this home study is to give you information on the relevant A & P, pathophysiology of the pulmonary system, ABG interpretation, and basic interventions to form a foundation for understanding the assessment and management of pulmonary embolism, pneumonia, COPD, asthma, and ARDS.

Target Audience

This home study was designed for the novice critical care or telemetry nurse; however, other health care professionals are invited to complete this packet.

Content Objectives

1. Define the process of oxygenation and ventilation.
2. Identify acid-base disturbances based on blood gas analysis.
3. Review oxygenation and ventilation modalities used for the critically ill patient.
4. Differentiate between the pathophysiologies of asthma, bronchitis, and emphysema.
5. Discuss the pathophysiology of pulmonary embolism, pneumonia, and acute respiratory distress syndrome (ARDS).

Disclosures

In accordance with ANCC requirements governing approved providers of education, the following disclosures are being made to you prior to the beginning of this educational activity:

Requirements for successful completion of this educational activity:
In order to successfully complete this activity you must read the home study, complete the post-test and evaluation, and submit them for processing.

Conflicts of Interest
It is the policy of the Twin Cities Health Professionals Education Consortium to provide balance, independence, and objectivity in all educational activities sponsored by TCHP. Anyone participating in the planning, writing, reviewing, or editing of this program are expected to disclose to TCHP any real or apparent relationships of a personal, professional, or financial nature. *There are no conflicts of interest that have been disclosed to the TCHP Education Consortium.*

Relevant Financial Relationships and Resolution of Conflicts of Interest:

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1. Writers, content reviewers, editors and/or program planners will be instructed to carefully review the materials to eliminate any potential bias.
2. TCHP will review written materials to audit for potential bias.
3. Evaluations will be monitored for evidence of bias and steps 1 and 2 above will be taken if there is a perceived bias by the participants.

No relevant financial relationships have been disclosed to the TCHP Education Consortium.

Sponsorship or Commercial Support:
Learners will be informed of:

- Any commercial support or sponsorship received in support of the educational activity,
- Any relationships with commercial interests noted by members of the planning committee, writers, reviewers or editors will be disclosed prior to, or at the start of, the program materials.

This activity has received no commercial support outside of the TCHP consortium of hospitals other than tuition for the home study program by non-TCHP hospital participants.

If participants have specific questions regarding relationships with commercial interests reported by planners, writers, reviewers or editors, please contact the TCHP office.

Non-Endorsement of Products:
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Off-Label Use:
It is expected that writers and/or reviewers will disclose to TCHP when "off-label" uses of commercial products are discussed in enduring written materials. *Off-label use of products is not covered in this program.*

Expiration Date for this Activity:
As required by ANCC, this continuing education activity must carry an expiration date. The last day that post tests will be accepted for this edition is

December 31, 2017—your envelope must be postmarked on or before that day.

Planning Committee/Editors

Linda Checky, BSN, RN, MBA, Assistant Program Manager for TCHP Education Consortium

Lynn Duane, MSN, RN, Program Manager for TCHP Education Consortium

Author

Karen Poor, MN, RN, Former Program Manager of the TCHP Education Consortium

Content Expert

Cody Schultz, MSN, RN, Former Clinical Educator, MICU, Regions Hospital

Contact Hour Information

For completing this **Home Study and evaluation**, you are eligible to receive:	**2.5 MN Board of Nursing contact hours / 2.08 ANCC contact hours** ***Criteria for successful completion:*** You must read the home study packet, complete the post-test and evaluation and submit them to TCHP for processing. The Twin Cities Health Professionals Education Consortium is an approved provider of continuing nursing education by the Wisconsin Nurses Association, an accredited approver by the American Nurses Credentialing Center's Commission on Accreditation.

Please see the last page of the packet before the post-test for information on submitting your post-test and evaluation for contact hours.

Review of Pulmonary Anatomy and Physiology

Upper Respiratory Tract

The upper respiratory tract is comprised of the nose, mouth, pharynx, larynx, and trachea. Air enters the body through the nose or mouth and moves through the pharynx. The respiratory tract is lined with ciliated mucosal cells. These cells cleanse the airway by moving debris and mucus up and out. This mechanism is called the "mucociliary escalator." The upper respiratory tract:

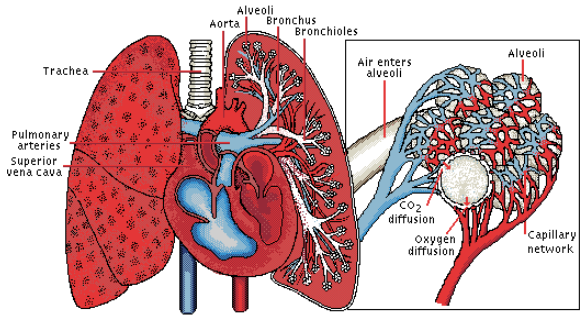
- conducts and conditions air
- protects the airways
- makes speech and smell possible

Lower Respiratory Tract

The air moves past the epiglottis, larynx, and through the trachea into the lungs. The **epiglottis** covers and protects the airway by preventing aspiration of food or foreign bodies. The **larynx** is a structure that houses the vocal cords, which are designed to produce sound through vibration and movement. The **trachea** is 10-12 cm long and consists of 16-20 C-shaped rings made of cartilage that cover its anterior side.

The lower respiratory tract begins when the trachea bifurcates into the **right and left mainstem bronchi,** at a site called the **carina**. The right mainstem bronchus is shorter, wider, and more vertical than the left. The bronchi are made of cartilage and are surrounded by muscles that run longitudinally and spirally around the bronchi. The main bronchi each branch into five lobar bronchi. The lobar bronchi branch into segmental bronchi, which divide into terminal bronchioles, which then divide into respiratory bronchioles.

At the end of the respiratory bronchioles lies a cluster of several alveoli, called an acinus. The acinus is the area where gas exchange takes place. Adults have 200-600 million alveoli with a total surface area of 40-100 square meters. The alveolar membrane is about 0.2 microns thick.



The lungs themselves are air-filled, spongy structures that are divided into lobes. The right lung has three lobes and normally accounts for 55% of total ventilation. The left lung has two lobes and accounts for 45% of ventilation.

The Mechanics of Ventilation

Inspiration is an active process -- muscles have to contract to cause air to flow into the lungs. The **diaphragm** is the major muscle of inspiration. This large muscle is located just underneath the rib cage and contracts to pull the rib cage down and out. This produces a negative pressure (vacuum) inside the thorax, which pulls air in. Nerves coming from the spinal cord at the C3-C5 level innervate the diaphragm. Seventy percent of the tidal volume is provided by the action of the diaphragm.

Another group of muscles that is normally used in inspiration is the **internal intercostal** group. These muscles are located between the ribs and elevate the ribs when contracted, increasing the antero-posterior diameter. If you place your hand on your ribs and deeply inspire, you will note that your ribs come up and out. These muscles are innervated at the T1-T11 level of the spinal cord.

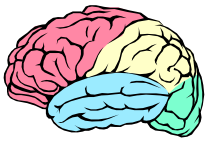
The third group of muscles is not used in normal inspiration. The **scalene and sternocleidomastoid** muscles are called "accessory muscles," and pull up the sternum and ribs when used. Think of a long distance runner after a race. The runner will stand with his hands on his knees and breathe deeply, so that you can see the sternocleidomastoid bulge and the clavicles rise. These muscles are used when additional volume of inspiration is needed (as in exercise), when the body's demand for oxygen is greater than the supply, when the airway is obstructed, or there are lung compliance problems.

Exhalation is a passive process. The relaxation of the inspiratory muscles will "push" air out of the thorax. In the event of difficulty in breathing, the abdominal muscles and external intercostal muscles can contract to push up and back, which will press the air out of the lung.

Control of Ventilation

There are several mechanisms that control ventilation:

1. **The cerebral cortex** controls voluntary breathing, which makes holding breath and hyperventilation possible.



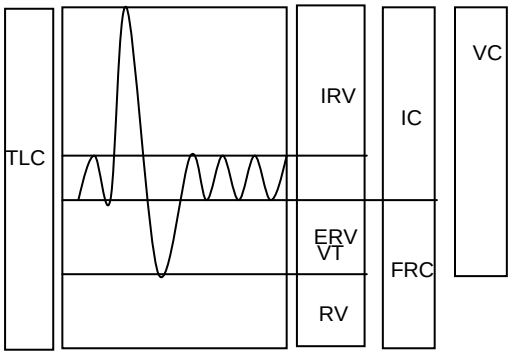
2. **Brain stem**:
   - The lower pons (pacemaker or apneustic center) produces sustained inspiration when stimulated.
   - The upper pons (pneumotaxis center) initiates expiration when stimulated by the apneustic center.
   - The medulla (the "manager") receives messages from the chemoreceptors to stimulate inspiration.

3. **Chemoreceptors** are receptors that are sensitive to hydrogen ion and oxygen concentration. They are located in the aorta and carotid arteries, and medulla. Changes in the $PaCO_2$, pH, and PaO_2 cause the respiratory rate and tidal volume to change to maintain adequate oxygenation and acid-base balance. The central chemoreceptors in the medulla are most sensitive to hydrogen ions and CO_2. Those in the aorta and the carotid bodies (peripheral chemoreceptors) are most sensitive to oxygen.

Lung Volumes and Capacities

The amount of air moving in and out of the lungs can be broken down into specific volumes. Two or more volumes combine to form a capacity. Many of these volumes and capacities, called Pulmonary Function Tests (PFT's), can be measured for diagnostic purposes.

The following chart shows the volumes and capacities and describes what each one measures.



TLC = Total Lung Capacity
- air in lungs after full inspiration ~ 6,000 ml

IRV = Inspiratory Reserve Volume
- air forcibly inhaled above VT

VT = Tidal Volume
- air inhaled or exhaled with each breath

ERV = Expiratory Reserve Volume
- air forcibly exhaled above VT

RV = Residual Volume
- air that always remains in lung

IC = Inspiratory Capacity
- max amount of air inhaled after a normal exhalation

FRC = Functional Residual Capacity
- amount of air in lungs after tidal breath

VC = Vital Capacity
- amount of air that can be forcibly inhaled and exhaled with one breath

Physiology of Ventilation

There are two parts to gas exchange: ventilation (V) and perfusion (Q). Ventilation refers to the movement of **air** in the pulmonary airways; perfusion refers to the movement of **blood** in the pulmonary vasculature. The pulmonary arteries, veins, and capillaries, a low-pressure system, together contain about 500-750 ml of blood, 10-15% of the cardiac output.

The capillary bed in the lung is a network of very thin, fine vessels that enclose each alveolus. The alveolar-capillary membrane is approximately 2 microns thick. This extremely fine membrane allows the easy diffusion of gases. Gases move from areas of high pressure to areas of lower pressure.

The amount of ventilation (V) and perfusion (Q) is expressed by the ratio V/Q. The normal amount of ventilation is 4 LPM, and normal amount of perfusion is about 5 LPM, so V/Q overall = 4/5 or 0.8. There are, however, regional differences in the different parts of the lung depending on position. With normal lung function, ventilation and perfusion is greater in the bases of the lungs when the person is in an upright position.

Changes in the V/Q ratio occur when perfusion does not match ventilation. There are two reflexes that work to keep V/Q normal:

1. **Pulmonary vasoconstriction:** when there are alveoli not helping with gas exchange, the blood vessels supplying those alveoli constrict (e.g., pneumonia, COPD)

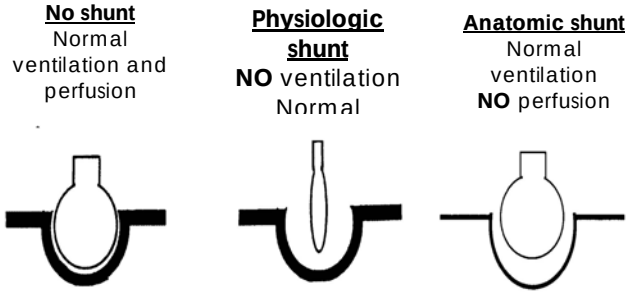
2. **Terminal bronchiole constriction:** When blood is not flowing past the alveoli, the smooth muscle in that area constricts (e.g., pulmonary embolism)

Alterations in the VQ ratio can occur from one of two physiologic mechanisms: shunting or increased dead space.

Shunting

A "shunt" occurs when a portion of the cardiac output **(blood)** does not participate in gas exchange. An "anatomical shunt" occurs when a portion of the cardiac output bypasses the alveolar-capillary unit. This is normal with bronchial, pleural, and thesbian vasculature.

Abnormal shunting occurs with structural abnormalities, such as pulmonary AV fistula (intrapulmonary), Tetralogy of Fallot (intracardiac), or shunts related to neoplasms. In a "physiological shunt," blood is circulating through non-ventilated alveoli, as is seen with atelectasis, pleural effusions, pulmonary edema, or pneumonia.



Dead Space

Dead space is the volume of **air** not participating in gas exchange. Dead space is normally 2 ml/kg. In **anatomical dead space**, a portion of each breath fails to reach the alveoli for perfusion. This is normal in the trachea and large airways, such as the bronchi. Anatomical dead space is increased in persons with large airways or long ventilator tubing. **Physiological dead space** exists when the alveoli receive air but do not connect with the capillary membrane. An example of increased physiologic dead space is emphysema -- the alveolar walls and capillary beds have been destroyed, leaving a large amount of air space that doesn't connect with a capillary.

Compliance

Compliance is to the ability of the lungs to stretch (elasticity or distensibility) and recoil. It is measured as the volume of air per unit of pressure change (i.e., ml/cm H_20). Normal lung compliance is 200 ml/cmH_2O. ***Increased compliance*** indicates that the **pressure** needed to stretch the lungs is **less** than normal, from:

- "stretched out" lungs (as is seen in emphysema) -- leading to increased expiratory work
- the patient assisting the pressure-controlled ventilator

Decreased compliance means greater inspiratory work because of "stiff" lungs (e.g. ARDS). As compliance decreases, the **pressure** required to deliver the same volume **increases**.

Resistance

Resistance is the pressure inside the airways as air flows into the lungs. To a certain extent, the normal airway "resists" the entrance of air, simply because the airways become smaller. Resistance is measured in terms of cm H_2O/liters of flow. An increase in the resistance to air flow can be measured with a **peak pressure**. Factors that influence resistance include:

Airway:
- flow rate of the gas: noninvasive oxygen delivery, CPAP, or mechanical ventilation
- size/diameter: bronchospasm
- obstruction: kinks, H_2O in tubing, secretions

Lung:
- chest size
- volume of gas
- elasticity

Chest wall:
- deformities
- position of patient
- external compression of chest wall or diaphragm (ascites, obesity, pregnancy)

Neuromuscular disorders:
- Guillain-Barré
- ALS (amyotrophic lateral sclerosis/Lou Gehrig's disease)

Work of Breathing

The work of breathing (WOB) refers to the how much energy the ventilatory muscles require. At rest, the work of breathing consumes 1-3% of the cardiac output. The work of breathing can be either increased or decreased;

however, we are more concerned about increases in the work of breathing. Work of breathing can be increased by a variety of factors:

1. Hypoxemia, acidosis, hypercarbia
2. Airway resistance problems: secretions, bronchospasm, artificial airway
3. Lung compliance problems: ARDS
4. Increased metabolic work: hyperthermia, hyperthyroidism

Increased WOB may lead to respiratory muscle fatigue and decompensation. If the oxygen demands of the body continue to be higher than the supply, the patient may exhibit hypoxemia, tissue hypoxia, acidosis, and hypercarbia, resulting in arrhythmias and cardiac arrest.

Oxygenation

The amount of oxygen can be measured three different ways in the blood: the partial pressure of oxygen (PaO_2), O_2 content, and O_2 saturation.

1. The **PaO_2** is the pressure (P) exerted by oxygen (O_2) dissolved in the arterial blood (a).
2. **Oxygen content** (CaO_2) is the number of milliliters of oxygen carried by 100 ml of whole blood.
3. **Oxygen saturation** (SaO_2) is the percent (%) of oxygen that the hemoglobin is carrying.

PaO_2

The PaO_2 (pO_2) represents the amount of oxygen that is physically dissolved in the blood -- about 3% of the total oxygen. The greater portion of oxygen (about 97%) is chemically bound to hemoglobin as **oxyhemoglobin**. The PaO_2 reflects gas exchange in the lung and is the driving force behind hemoglobin saturation.

A normal range for PaO_2 on room air is 70-100 mm Hg. This measurement can be affected by:

- **age**: as people age, their "normal" PaO_2 decreases
- **altitude**: the higher the altitude, the lower the pressure to push oxygen into the blood
- **FiO_2**: the **F**raction of **i**nspired **o**xygen (FiO_2) is the amount of oxygen that is being inhaled. Decreases in the amount of oxygen will lead to a decrease in the PaO_2.

Oxygen Saturation and Oxyhemoglobin

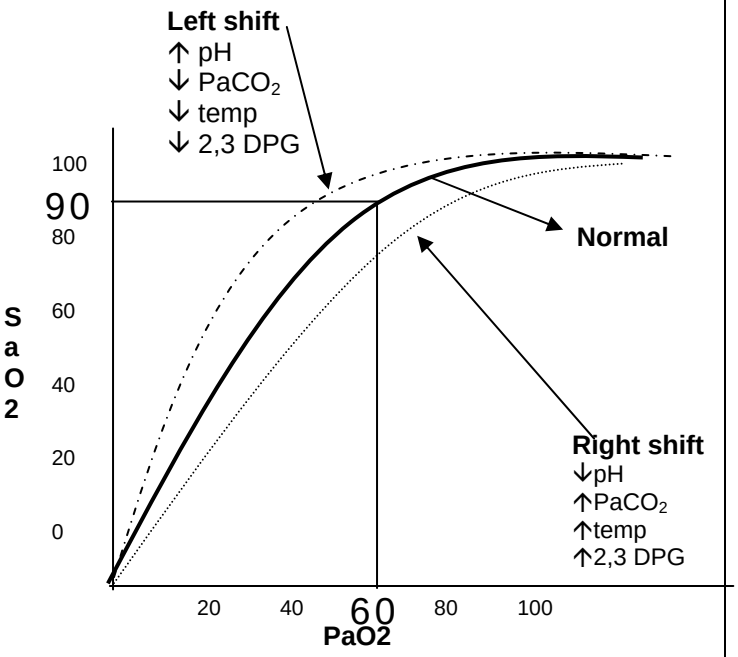
Oxygen saturation (SaO_2) calculates the percentage of oxygen that hemoglobin is transporting. Each gram of hemoglobin can carry 1.34 ml of oxygen. **Oxyhemoglobin** can be determined when the hemoglobin (Hgb), SaO_2, and the cardiac output (CO) are known. The formula is:

Oxyhemoglobin saturation =
(1.34 X Hgb X SaO_2) X CO/100

Pulse oximetry uses light-emitting devices to detect the saturated hemoglobin and non-saturated hemoglobin. The percentage of saturated hemoglobin is usually 90-100%. Because it is a percentage, the SaO_2 can never be more than 100%. The SaO_2 reflects oxygenation status, not ventilation status (pH, $PaCO_2$).

Benefits of SaO2 Monitoring

- Noninvasive
- Accurate with an SaO2 > 70%



- Can have continuous monitoring

Limitations of SaO2 Monitoring

- Affected by a poor pulsatile signal (hypotension, shock, vasopressors)
- Affected by high bilirubin levels (such as in liver failure)
- Excessive movement will limit accuracy of monitor

Oxygen Content (CaO_2)

The CaO_2 represents the total amount of oxygen in the body - both dissolved and bound to hemoglobin. Some intensive care units and physicians calculate this figure to determine how well oxygenated the patient is. The calculation for the CaO_2 is:

1.34 ml O_2/gm Hgb X gm/Hgb X SaO_2 + 0.003 X PaO_2

The normal CaO_2 is 20 ml/100 ml blood. Here are some examples:

1. A patient with hemoglobin of 14.6, an SaO_2 of 98%, and PaO_2 of 99 would have a CaO_2 of:
   1.34 X 14.6 X .98 + 0.003 X 99 = 19.99

2. A patient with a hemoglobin of 11, an SaO_2 of 90%, and PaO_2 of 65 would have a CaO_2 of:
   1.34 X 11 X .90 + 0.003 X 65 = 13.47

The CaO_2 is affected by changes in the amount of hemoglobin, changes in the saturation of hemoglobin with oxygen, and the PaO_2.

Oxyhemoglobin Dissociation Curve

The oxyhemoglobin dissociation curve defines the relationship between dissolved oxygen (PaO_2) and the oxygen actually carried by the hemoglobin (oxyhemoglobin). This curve reflects how easily Hgb gives up oxygen to the tissues.

The flat upper portion of the curve illustrates that if the PaO_2 drops from 100 to 70, the saturation decreases only slightly. Adequate amounts of oxygen will be carried to the tissues even with a lower PaO_2. The steep midportion of the curve demonstrates that slight reductions in PaO_2 result in large reductions in the saturation of Hgb.

Many physicians write orders to keep the SaO_2 > 90%. This is because an SaO_2 of 90% is roughly equal to a PaO_2 of 60. A PaO_2 of 60 will keep tissues alive.

The relationship between PaO_2 and SaO_2 is affected by alterations in the pH, temperature, CO_2, and 2,3 DPG (a substance that facilitates dissociation of O_2 from hemoglobin at the tissues). If the hemoglobin-oxygen affinity is high, oxygen is easily bound to hemoglobin and does not want to release to the tissues. This is called a "**shift to the left**". When the hemoglobin-oxygen affinity is low, oxygen is not easily bound to hemoglobin; however, the hemoglobin readily unloads its O_2 at the tissue level. This is called a "**shift to the right**".

Hypoxemia/Hypoxia

The terms "hypoxia" and "hypoxemia" are sometimes used interchangeably, but they represent different concepts.

- **Hypoxia** is an inadequate amount of oxygen available at the tissue level *(We **can't** measure this)*
- **Hypoxemia** is an inadequate amount of oxygen in the blood *(We **can** measure this)*

Hypoxia occurs for a variety of reasons:

- Pulmonary causes:
  1. Alveolar hypoventilation
  2. Diffusion defects at the alveolar-capillary level
  3. Right to left shunt
  4. V/Q mismatch (the most common cause)

- Nonpulmonary causes:
  1. Reduced blood flow: myocardial infarction, shock, or dysrhythmias
  2. Anemia
  3. Nonfunctioning hemoglobin: Hgb is bound to other substances, such as CO poisoning
  4. Mitochondrial failure: cyanide poisoning

Compensatory Mechanisms to Prevent Hypoxia

The body has a number of compensatory mechanisms that it uses to correct hypoxia.

1. The respiratory system will increase the minute ventilation by increasing the respiratory rate and/or the tidal volume, and will change the blood flow to optimize the VQ ratio.

2. The heart rate and contractility will increase, and selective vasoconstriction and vasodilation will take place to pump oxygenated blood to the priority organs.

3. The kidneys will excrete erythropoietin, which increases red blood cell production in the bone marrow (erythrocytosis).

With the exception of the kidneys' response, all of the compensatory mechanisms to correct hypoxemia increase the tissue demand for oxygen, thus increasing workload.

Measures to Increase Oxygenation

Administration of Oxygen

The fastest way to increase oxygenation is to administer oxygen! Oxygen therapy is used to treat hypoxemia, to decrease the work of breathing, and to decrease the work of the heart.

Nasal Prongs (Cannula)

Nasal prongs (cannula) are used when an exact concentration of oxygen does not need to be guaranteed.

Adults and pediatric patients are put on a flow of 1-6 liters per minute (LPM), while infants can be put on up to 2 LPM. Nasal prongs are indicated for supplemental oxygen, not patients in acute distress. The approximate concentrations of oxygen per liter of flow per minute are:

1 L = 24%	2 L = 28%	3 L = 32%
4 L = 36%	5 L = 40%	6 L = 44%

A "bubbler" humidifier can be used for flow rates of 4 liters or higher. **CAUTION:** a bubbler humidifier should not be used with any device other than a nasal cannula, as it may cause harm to the patient.

Simple mask

The simple mask can be used to deliver 6 - 10 LPM of oxygen, which approximates 35-55% fraction of inspired oxygen (FiO2). The actual amount of oxygen delivered can vary greatly with changes in the patient's ventilatory pattern.

Non-rebreather (partial) mask

The mask of choice for emergency situations is the non-rebreather mask. This mask delivers nearly 100% oxygen as long as the following criteria are met:

1. The mask fits the patients face snugly
2. The flow to the reservoir bag is adjusted so that the bag does not totally collapse when the patient inhales (the bag is always partially inflated)

The partial non-rebreather mask consists of a pliable mask with a reservoir bag and two one-way valves. For safety's sake, there is only one valve on the side of the mask so if the source of the oxygen fails, the patient can entrain room air. The second one-way valve is located on the reservoir bag so the patient cannot "rebreathe" exhaled gas.

Venturi mask

The Venturi mask is considered a "high flow system." This mask is used when a consistent FiO_2 is needed and the patient does not require added humidity. The mask has either an adjustable Venturi, or individual Venturis that can be changed to allow different oxygen concentrations. Be sure to set the flowmeter to the appropriate liter flow. Each Venturi requires different flows; this is usually stamped with the concentration of oxygen it will deliver; e.g. 50% FiO_2/15 LPM.

High flow humidifiers

A high flow humidifier is indicated for patients who natural mechanism for heating and humidifying inspired gas has been bypassed (i.e. intubated or tracheostomy patients). It can also be used for patients whose natural mechanism is not sufficient to prevent retention of secretions due to mucosal drying. The tubing, reservoir, sterile water, and "mask" must be changed at the frequency required by Infection Control policies and prn. Heated humidity devices will cause condensation in the tubing; this condensate must be drained from the circuit and not drained back into the reservoir to prevent contamination.

Aerosol (nebulizers)

Aerosol therapy is indicated for the following conditions:

- The presence of upper airway edema; i.e. laryngotracheobronchitis, subglottal edema, post-extubation edema, post-operative management of the upper airway.
- The presence of one or more of the following: stridor, brassy croup-like cough, hoarseness following extubation, upper airway irritation (smoke inhalation) or airway insult.

Continuous aerosol therapy may be delivered via face mask, face tent, hood, or blow-by. An oxygen analyzer **must** be used on all infant hoods. Condensate must be drained frequently from tubing to avoid contamination. Contamination with an aerosol can cause the contaminates to become airborne.

Ventilation

Ventilation is the movement of air, both into and out of the lungs. Ventilation is dependent on:

- Respiratory effort
- Respiratory rate
- The distance between the blood and the gas exchanging part of the alveolus

Ventilation is measured by the $PaCO_2$ on the ABG and by end-tidal CO_2 monitoring (capnography).

$PaCO_2$

Measurement of the $PaCO_2$ is done on the arterial blood gas. Like the PaO_2, the $PaCO_2$ is measured as a pressure, in mm of Hg. The normal $PaCO_2$ is between 35 and 45 mm Hg.

End-Tidal CO_2 Monitoring

End-tidal CO_2 monitoring or "capnography" is useful for determining that tracheal, rather than esophageal,

intubation has taken place. Capnography can also be used to evaluate the efficiency of mechanical ventilatory support and for monitoring the severity of pulmonary disease and response to therapy.

Ways to Improve Ventilation

Effective Coughing Techniques

In the old days, we were taught to have the patient cough with every deep breath, and to have patients blow up balloons in an effort to prevent pneumonia. We know now that those techniques are not helpful. Coughing is effective only when there is something to cough out. Deep exhalation and needless coughing cause the alveoli to collapse, causing more atelectasis. Coughing also causes an increase in the intracranial pressure and pain in surgery patients.
There are several methods of coughing that are effective in clearing the smaller airways of mucous. They are:

1. *Cascade cough*: have the patient inhale deeply through the nose, hold for 1-3 seconds, then cough forcefully several times.
2. *Huff cough*: have the patient inhale deeply through the nose, hold for 1-3 seconds, then say "huff" forcefully several times.
3. *End-expiratory cough*: have the patient take a normal breath, then at the end of a normal exhalation, have the patient cough once. Follow by a cascade or huff cough.

Deep Breathing and Incentive Therapy

Effective deep breathing and incentive therapy will aid in alveolar expansion, will help to clear the smaller airways, and will improve stress. The patient should be encouraged to breathe deeply at least ten times every hour. For patients who cannot breathe and are on the ventilator, the "sigh" button can be used to give them a breath that is 1 1/2 times the normal tidal volume. Check with the physician before doing this.

Chest Physiotherapy

Often done by respiratory therapists, chest physiotherapy is designed to mobilize secretions by a sequential application of "cupping" or "thumping" the posterior, and sometimes anterior, chest.

Nasal Pharyngeal Airway (Trumpet)

The trumpet is an excellent ventilation and suctioning aid. It can be used in conscious or unconscious patients. The trumpet is placed, using a water-soluble lubricant, into the patient's nare, using a gentle back and forth motion. Optimally, the trumpet should be moved from nare to nare every 24 hours to prevent skin breakdown.

Oral Airway

The oral airway is a good tool to keep the tongue out of the airway. It can be used only for patients who are unconscious and who are not gagging. The oral airway can be dangerous to use in patients who may vomit, as it provides a more open channel for aspiration. Generally, an oral airway is used as a temporary measure until the patient wakes up or is intubated.

Tracheostomy

The ultimate in invasive ventilation techniques, the tracheostomy is used for a wide variety of purposes. Patients may require a tracheostomy for long-term mechanical ventilation or as a result of neck, throat, or mouth surgery.

CPAP or BiPAP

Another way of improving oxygenation and ventilation is by using non-invasive positive pressure, such as CPAP or BiPAP. CPAP stands for "Continuous Positive Airway Pressure," and BiPAP stands for "Bilevel Positive Airway Pressure." Both will provide positive pressure or "PEEP" for spontaneously breathing people. It is important to differentiate between CPAP and BiPAP. BiPAP is essentially "Bi-level" ventilation - or CPAP with pressure support. BiPAP is for spontaneously breathing patients who require additional positive pressure for their inspiratory cycle.

Indications for positive airway pressure are to:

1. Reduce air trapping in patients with asthma and/or COPD.
2. Help mobilize retained secretions in patients with cystic fibrosis or chronic bronchitis.
3. To prevent or reverse atelectasis.
4. Optimize bronchodilator delivery in patients receiving bronchial medication therapies.
5. Help redistribute extra-vascular water, such as in pulmonary edema.
6. Assist with breathing for those with ventilatory muscle weakness, but who do not wish to be intubated.

CPAP can be delivered a number of ways, either with a nasal or full-face mask or with a mechanical ventilator via

an endotracheal tube or tracheostomy. Patients, such as those with obstructive sleep apnea (OSA), may also have a small bedside CPAP machine for the home care setting. These patients use the CPAP at night and when napping.

One of the major complications of CPAP and BiPAP use relates to skin breakdown because of the tight-fitting nasal or facial mask. For this reason, these machines have been designed to have a small leak when placed on the patient.

In the critical care setting, patients who are alert and cooperative may benefit greatly from this type of ventilation. Patients who are at risk for vomiting, who have facial trauma, or who are not able to comply with the treatment should not be on CPAP/BiPAP treatment.

Arterial Blood Gas Analysis

Arterial blood gases (ABG's) provide information about oxygenation and acid-base balance. Acid-base status reflects physiologic processes and chemical reactions. Acid-base balance refers specifically to the regulation of hydrogen ion concentration in the body.

Obtaining an ABG

1. Identify the pulsating arterial site.
2. Perform the Allen's test.
3. Thoroughly cleanse area with Betadine solution and let dry for three minutes (can also scrub area for one minute with alcohol prep).
4. Stabilize the artery by pulling the skin taut and bracketing the pulsating area with the first two fingers of your non-dominant hand.
5. Holding the syringe like a pencil, puncture the skin slowly (at about a 45 degree angle). Advance the needle with the bevel up.
6. Wait for flash of arterial blood to occur.
7. If no flash occurs, withdraw slowly until the needle is almost out, and redirect.
8. When flash occurs, allow syringe to fill with at least one ml of blood.
9. Withdraw needle and apply pressure to the site for five minutes. While holding pressure, carefully rotate the syringe to mix the blood and heparin.
10. Using universal precautions, remove the needle from the syringe and place cap (see your unit policy). Immediately place on ice and send to the lab. The ABG is no longer valid after 30 minutes.

Do's and Don'ts

- **DO** document the SaO_2 at the exact time the ABG is drawn. The SaO_2 is calculated on the ABG from the pH and HCO_3- and should correspond closely with the oximeter measurement.
- **DO** document the respiratory rate, effort, and use of accessory muscles.
- **DO** document patient temperature
- **DO** document amount of oxygen the patient is on.

∅ **DON'T** draw ABG's if patient just suctioned.
∅ **DON'T** draw ABG's if patient receiving nebulizer treatment.
∅ **DON'T** draw ABG's if patient became short of breath doing an activity (or if SaO_2 dropped while YOU were doing something to the patient).
∅ **DON'T** draw ABG's if patient is not on the amount of oxygen you want to assess (wait 20 minutes after any O_2 change).

Acid-Base Balance and the ABG

pH

The pH on the ABG is inverse logarithmic number of hydrogen ions in the blood. **Normally, the pH should be 7.35-7.45**. If the number of hydrogen ions rises, the blood is more acidotic. If the number of hydrogen ions falls, the blood is more alkalotic.

Maintaining a Normal pH

The body really likes to keep a normal pH. In order to maintain the blood pH between 7.35-7.45, the body has a buffering system. There are two major chemical buffers, regulated by the respiratory and renal systems, in the body:

- carbon dioxide (CO_2): **the normal PaCO2 on the ABG is 35 - 45 mm/Hg**
- bicarbonate (HCO_3^-): **the normal HCO3- level on the ABG is 22 - 26 mEq/L**

The respiratory system responds within 1-3 minutes to changes in acid-base balance. If the chemo-receptors sense too many hydrogen ions (acidosis), it will stimulate the respiratory center to breathe faster and deeper – to "**blow off" CO_2**. If the chemoreceptors sense too few hydrogen ions (alkalosis), it will depress the respiratory center to **keep CO_2**.

The kidneys compensate over 24-48 hours to correct imbalances. If the kidneys see acidosis, they will retain, regenerate or synthesize HCO_3^- and excrete H^+. If the

kidneys see alkalosis, they will excrete HCO_3^- and retain H^+.

If the body sees acidosis, it will:
Increase the respiratory rate to blow off CO_2
Retain, regenerate or make bicarbonate
Excrete hydrogen ions

If the body sees alkalosis, it will:
Decrease the respiratory rate to keep CO_2
Excrete bicarbonate
Retain hydrogen ions

When there is an acid-base disturbance and either the lungs or kidneys react, it is called **compensation**. **Compensation** can be complete or partial. The body will compensate so that the pH reaches the edges of normal. For example, if the pH is 7.10 (acidosis), the body will try to compensate so that the pH will reach 7.35, not greater than 7.35. Partial compensation means that the pH has not reached a normal level.

Respiratory Acidosis

In **acute** respiratory acidosis, the lungs don't get rid of enough CO_2.

Causes: oversedation, head trauma, respiratory and cardiac arrest

What to look for: ↑ **$PaCO_2$,** ↓ **pH, normal HCO_3^-**

Examples:
- pH 7.29, $PaCO_2$ 57, HCO_3^- 28
- pH 7.06, $PaCO_2$ 98, HCO_3^- 28

In **compensated** respiratory acidosis, the lungs still don't get rid of enough CO2, but the kidneys have had enough time to save bicarbonate.

Causes: COPD, spinal cord injury, respiratory muscle paralysis

What to look for: ↑ **$PaCO_2$,** ↓ **pH,** ↑ **HCO_3^-**

Examples:
- pH 7.31, $PaCO_2$ 76, HCO_3^- 39
- pH 7.34, $PaCO_2$ 60, HCO_3^- 33

Respiratory Alkalosis

In **acute** respiratory alkalosis, the lungs are "blowing off" too much CO_2, leading to an increased pH.

Causes: stress, pain, fever, and hypoxemia

What to look for: ↓ **$PaCO_2$,** ↑ **pH, normal HCO_3^-**

Examples:
- pH 7.52, $PaCO_2$ 27, HCO_3^- 22
- pH 7.65, $PaCO_2$ 23, HCO_3^- 24

Compensated respiratory alkalosis occurs when the lungs "blow off" too much CO_2, but the kidneys have time to excrete bicarbonate and save hydrogen ions.

Causes: uncommon, but can occur in the patient with neurological damage

What to look for: ↓ **$PaCO_2$,** ↑ **pH,** ↓ **HCO_3^-**

Examples:
- pH 7.49, $PaCO_2$ 16, HCO_3^- 11
- pH 7.45, $PaCO_2$ 23, HCO_3^- 16

Metabolic Acidosis

Metabolic acidosis occurs where there is either too much acid (such as in shock, hypoxemia, diabetes, overdose, renal failure) in the system, or when there is a loss of bicarbonate (diarrhea, NG suction, renal tubular acidosis).

Acute metabolic acidosis without compensation may be seen in the mechanically ventilated, sedated, or comatose patient. Because of the altered mental status, there is no compensatory response by the respiratory system.

What to look for: **normal $PaCO_2$,** ↓ **pH,** ↓ **HCO_3^-**

Examples:
- pH 7.05, $PaCO_2$ 37, HCO_3^- 7
- pH 7.23, $PaCO_2$ 40, HCO_3^- 12

Compensated metabolic acidosis is much more common. The respiratory rate and depth increases to blow off CO2. There is a limit to how much the respiratory system can compensate. The $PaCO_2$ may be quite low, but it is still not able to bring the pH back to normal.

What to look for: ↓ **$PaCO_2$,** ↓ **pH,** ↓ **HCO_3^-**

Examples:
- pH 7.19, $PaCO_2$ 22, HCO_3^- 8
- pH 6.96, $PaCO_2$ 9, HCO_3^- 2

Metabolic Alkalosis

In metabolic alkalosis, there is a gain of base or increased loss of acid, resulting in an increased pH. If there is a gain of base, such as in sodium bicarbonate (baking soda) ingestion or administration of $NaHCO_3$ during CPR, the HCO_3- will be elevated. If there is loss of an acid, such as in vomiting or NG suction, the HCO_3- will be normal in the acute phase.

Acute metabolic alkalosis is uncommon, but can been seen if the patient is not neurologically intact and is unable to increase the respiratory rate.

What to look for: **normal $PaCO_2$, ↑ pH, ↑ HCO_3^-**

Examples:

- Gain of a base: pH 7.55, $PaCO_2$ 40, HCO_3^- 42
- Loss of acid: pH 7.52, $PaCO_2$ 37, HCO_3^- 28

Compensated metabolic alkalosis can look like:

What to look for: **↑ $PaCO_2$, ↑ pH, ↑ HCO_3^-**

Examples:

- Gain of a base: pH 7.47, $PaCO_2$ 46, HCO_3^- 42
- Loss of acid: pH 7.46, $PaCO_2$ 44, HCO_3^- 26

There is also a limit to the compensation of the respiratory system in metabolic alkalosis. The body will not tolerate CO_2 levels over 50-55 mm Hg, and will increase the rate and depth of breathing after that point.

Now, you might notice that metabolic alkalosis from loss of an acid and respiratory acidosis look a lot alike. Here's how to tell the difference. There is an increase in CO_2 in both metabolic alkalosis and respiratory acidosis, but the pH will be relatively normal. In compensated respiratory acidosis, though, the pH will be on the **low** side of normal, not the high, and the HCO_3^- level will be high, not normal.

Analyzing the ABG

1. Look at the PaO_2.

2. Look at the pH.

a) Is it normal?
b) Is it low normal or high normal? Look for changes in the $PaCO_2$ and HCO_3- to see if there is compensation for a problem.
c) If it is low (less than 7.35), the patient is in acidosis.
d) If it is high (more than 7.45), the patient is in alkalosis.

3. Look at the $PaCO_2$.

a) The pH and $PaCO_2$ have a "teeter-totter" relationship. If the problem is **respiratory**, one will be up, and the other will be down.
b) If the pH and $PaCO_2$ are both up or both down, the problem is **metabolic**. The teeter-totter isn't there, so it can't be a primary respiratory problem, instead, it is a metabolic problem with respiratory compensation.

4. Look at the HCO_3-.

a) The pH and HCO_3- go up and down together in a **metabolic** problem.
b) If the pH and the HCO_3- are opposite (one is up and the other is down), the problem is primarily respiratory, and the HCO_3- is trying to compensate.

Examples:

1) pH 7.01; $PaCO_2$ 69; HCO_3- 24
a) The pH is very low, so it is acidosis.
b) The $PaCO_2$ is high, making a teeter-totter with the pH, so it is a respiratory problem.
c) The HCO_3- is normal, so there is no compensation.
d) Respiratory acidosis without compensation.

2) pH 7.33; $PaCO_2$ 72; HCO_3- 36
a) The pH is low, so it is acidosis.
b) The $PaCO_2$ is high, making a teeter-totter with the pH, so it is a respiratory problem.
c) The HCO_3- is high, so there is compensation, but not enough to bring the pH to normal.
d) Respiratory acidosis with partial compensation.

3) pH 6.99; $PaCO_2$ 20; HCO_3- 2
a) The pH is very low, so it is acidosis.
b) The PaCO2 is low; it is not a teeter-totter with the pH, so it is a metabolic problem with respiratory compensation.
c) The HCO3- is low, confirming a metabolic problem.
d) Metabolic acidosis with partial compensation.

4) pH 7.35; PaCO2 65; HCO3- 32
a) The pH is low normal.
b) The PaCO2 is high, making a teeter-totter with the pH, so it is a respiratory problem.
c) The HCO3- is high, so there is compensation.
d) Respiratory acidosis with compensation.

5) *pH 7.51; $PaCO_2$ 15; HCO_3- 8*
   a) The pH is high, so it is alkalosis.
   b) The PaCO2 is low, making a teeter-totter with the pH, so it is a respiratory problem.
   c) The HCO3- is low, so there is compensation.
   d) Respiratory alkalosis with partial compensation.

6) *pH 7.78; $PaCO_2$ 59; HCO_3- 40*
   a) The pH is very high, so it is alkalosis.
   b) The PaCO2 is high; it is not a teeter-totter with the pH, so it is a metabolic problem with respiratory compensation.
   c) The HCO3- is high, confirming a metabolic problem.
   d) Metabolic alkalosis with partial compensation.

7) *pH 7.45; $PaCO_2$ 37; HCO_3- 24*
   a) The pH is normal.
   b) The PaCO2 is normal
   c) The HCO3- is normal.
   d) Normal acid-base balance.

Acute Respiratory Distress Syndrome (ARDS)

Larry Leakey is a 21-year-old man who was involved in a severe car accident. He underwent emergency surgery to repair a lacerated liver, perforated bowel, and tension hemopneumothorax. He received 15 units of blood during surgery. He was rapidly extubated after surgery and sent to the ICU.

The next day, Larry became increasingly short of breath and was using all accessory muscles. He had O_2 saturations in the 80's. His PaO_2 on blood gases was 34 mm Hg. His heart rate was 180 beats/min. Jeremy's chest x-ray showed diffuse, patchy infiltrates throughout his lung fields. His diagnosis was ARDS.

What is ARDS?

Acute Respiratory Distress Syndrome (ARDS) and its less severe cousin Acute Lung Injury (ALI) have been documented in medical history for at least two thousand years. It became better known during the Viet Nam War, when soldiers would develop respiratory failure and die after being wounded. Although over twenty years of extensive research and study have been given to ARDS and its treatment, the mortality for ARDS remains high.

What happens in ARDS?

ARDS always occurs as a secondary problem. Four hours to 48 hours after the initial insult, the immune system is activated, causing inflammation in the lung. The white blood cells (particularly neutrophils) release chemical mediators which cause increased vascular permeability. In the lung, this becomes disastrous.

Fluid and proteins enter into and around the alveoli through the very thin vascular membrane, causing pulmonary edema. This fluid damages the Type II alveolar cells, destroying the capacity to make surfactant. This damage, combined with the "washing out" action of the fluid, decreases the amount of surfactant, which then leads to alveolar collapse and atelectasis.

The combination of pulmonary edema and atelectasis leads to intrapulmonary shunting, decreased compliance, and increased work of breathing. The patient begins to become more and more hypoxemic, even on high levels of oxygen.

As a result of hypoxemia, the pulmonary vasculature constricts through the capillary beds. This causes pulmonary hypertension. As the pressure builds in the pulmonary artery, more and more fluid is forced out into the alveoli and interstitium. The lung becomes even less compliant, causing an increased work of breathing and an increased oxygen demand.

What causes ARDS?

There are certain injuries, diseases, and interventions that are more likely to cause ARDS. The most common causes are listed below.

Most Common
1) Sepsis
2) Gastric aspiration
3) Pneumonia
4) Trauma

Other
- Drug overdose (e.g., ASA)
- Near-drowning
- Massive blood transfusion/transfusion reaction
- Inhalation of toxic gases and vapors
- Pancreatitis

Asthma exacerbation

Batt Atsma is a 37-year-old mother of two who has had asthma for many years. She is classified as a Step 3 - moderate persistent asthmatic. She enters the hospital with shortness of breath and wheezing unrelieved by her usual asthma medications.

What is asthma?

One of the diseases that can be considered both acute and chronic is asthma. People with asthma always have the underlying disease, but have exacerbations of asthma.

The conducting airways (bronchi, bronchioles) of the pulmonary system are hyperreactive in persons with asthma. With a precipitating factor, the smooth muscle of the airways constrict, causing decreased air conduction and increased breathing difficulty. With the smooth muscle contraction comes increased mucous production, mucosal cell swelling, and ventilation-perfusion abnormalities.

Because of the pressure dynamics in the chest, air will flow into the patient with an asthma exacerbation much more easily than it will flow out. Air becomes "trapped" inside the lungs, causing hyperinflation of the lungs. The resistance to airflow increases, causing the patient to work harder at breathing. The pressure inside the alveoli becomes greater (because of the air trapping) than the pressure in the airways, so more air becomes trapped in the alveoli.

What are the causes of asthma?

- Respiratory infection
- Allergic reaction to inhaled antigen
- Inappropriate bronchodilator management
- Idiosyncratic reaction to aspirin or other nonsteroidal anti-inflammatory agents
- Emotional stress
- Exercise
- Environmental exposure
- Occupational exposure
- Nonselective beta blocking agents
- Mechanical stimulation (coughing, laughing, cold air inhalation)
- Reflux esophagitis
- Sinusitis

Batt Atsma has been classified as a Step Three - moderate persistent asthmatic. She is on multiple inhalers through the day, and typically has two to three asthma "attacks" per week. She is no longer able to do many of the sporting activities that she used to do with her children.

Is there a classification system for how bad asthma is?

The National Asthma Education and Prevention Program, which is sponsored by the National Heart Lung and Blood Institute, has published guidelines to determine the severity of illness for adults and children older than 5 years. This classification helps clinicians determine what treatments would best suit the patient.

Step One - Mild Intermittent

In this level, patients have symptoms more than twice a week, but are asymptomatic with a normal PEF between exacerbations. The exacerbations last from a few hours to a few days, and the intensity may vary. They have symptoms at night less than twice a month. The FEV_1/PEF is greater than 80% of predicted.

Step Two - Mild Persistent

Patients at a step two have symptoms more than twice a week but less than once per day. Exacerbations of their asthma may interfere with activities. They are prone to having nighttime symptoms more than twice a month, but still have an FEV_1/PEF ratio of greater than 80% of predicted.

Step Three - Moderate Persistent

These patients have symptoms every day and use inhaled short-acting $beta_2$-agonists every day. When they have exacerbations (>2 times/week), they affect the patients activities and may last for days. They have nighttime symptoms more than once a week, and have an FEV_1/PEF ratio of >60% and < 80% of predicted.

Step Four - Severe Persistent

The most severe of all of the steps, patients who are at a step four experience continual symptoms, have limited physical activity, and have frequent exacerbations. They have frequent nighttime symptoms and have a FEV_1/PEF ratio of less than 60% of predicted.

Pulmonary Function Assessment

One of the best indicators of asthma symptom severity is the FEV_1 on the spirometer. Standing for "Forced Expiratory Volume" in one second, it measures how much the patient is able to exhale forcibly after a normal inhalation. The amount exhaled in one second in normal lungs is approximately 80% of the total exhaled amount - that's where the 80% of predicted value comes from on the classification above.

Another measure of day to day function is the PEFR - the peak expiratory flow rate. This is the fastest rate at which air can move through the airways in a forced exhalation. The day to day rate is measured against the patient's

personal best, and should be > 80% of what it optimally is. Measurements of the PEF can and should be done by the patient on a daily basis. Typically, a PEF >80% of the personal best is in a "green" zone - which indicates that the asthma is stable. A PEF of 60-80% is in the "yellow" zone and indicates that the patient should take extra caution or medications. A PEF of <60% is in the "red" zone and indicates that the patient is having a significant exacerbation.

What is status asthmaticus?

This is the term used to describe an asthma exacerbation that is refractory to bronchodilator therapy, including aminophylline IV and beta-adrenergic agents (epinephrine). It often needs further treatment, such as intubation and mechanical ventilation.

Chronic obstructive pulmonary disease

Joe Chroniclung is a 60 year-old male with end stage COPD. He was recently hospitalized for pneumonia and a COPD exacerbation and was sent to a transitional care facility for rehabilitation. Joe was a long-time smoker, but has not smoked since his last hospitalization.

In chronic obstructive pulmonary disease (COPD), there is an obstruction to air flow either into or out of the lungs. Chronic bronchitis and emphysema are the major diseases that cause COPD. Although the pathophysiology for each is discussed separately, please be aware that the two most commonly appear together.

What is chronic bronchitis?

In chronic bronchitis, persistent injury to the alveoli causes an overstimulation of mucus production, accompanied by a persistent cough. As the disease progresses, the bronchial walls thicken, causing the airway resistance to increase. The results of the bronchial wall thickening and excessive mucus production are:

- Hypoxemia and hypercapnia
- Chronic cough with sputum production
- Pulmonary hypertension from hypoxemia, leading to cor pulmonale

The diagnosis of chronic bronchitis is made when there is a history of a chronic productive cough for three months of the year in each of two successive years.

What is emphysema?

In emphysema, the alveolar walls are destroyed, causing the very small air sacs to enlarge into large air sacs, called blebs. During the wall destruction, the capillary beds are also destroyed. The results of this are:

- Hypercapnia without hypoxemia (in the early stages)
- Bleb formation with potential for pneumothorax
- Air trapping within the blebs with constriction of the smooth muscle of the bronchioles

What are the causes of COPD?

- Cigarette smoking
- Environmental pollution or occupational exposure
- $Alpha_1$-antitrypsin deficiency (genetic marker for familial emphysema)

What type of tests can be done to assess Joe's pulmonary function?

Joe's last documented FVC was 3.12 and FEV_1 was 1.29. The FEV_1 was 32% of predicted.

Pulmonary function tests can be very useful in determining the function of the lungs in COPD, just as they can in asthma. The FEV_1 is the same test as for COPD as it is for asthma - the amount of air that can be forcibly exhaled in one second. In people with normal lungs, the FEV_1 should be > 80%. The FVC (Forced Vital Capacity) is also measured. Where the FEV_1 was the amount of air exhaled in one second, the FVC is the total amount of air that is exhaled quickly. It should be $\geq$ 15 L. This volume represents the patient's ability to breathe deeply and cough. This number is reduced in people with obstructive disease.

Pneumonia

S.A. Pneumo is a 47 year-old male who enters the hospital with shortness of breath, a cough, and a 1½ week history of flu-like symptoms. He is diagnosed with pneumonia.

What causes pneumonia?

Pneumonia has a number of causes. It can be caused by **microorganisms** such as bacteria, viruses, and fungi. Streptococcus pneumoniae, Mycoplasma pneumoniae, and Histoplasma capsulatum may all cause pneumonia in a normally healthy person. Pneumococcus, Escherichia coli, Pseudomonas aeruginosa, Serratia, Proteus, and Acinetobacter usually occur as pneumonias in patients who have a chronic disease, poor nutrition, trauma, surgery, or who are immunosuppressed.

Aspiration is one of the most common causes of pneumonia. Gastric contents contain caustic substances and bacteria. Entry into the airway causes the conducting airways to be blocked and the alveoli to be "burned" and become inflamed.

Chemical inhalation is another cause of pneumonia. Inhalation of smoke, cleaning chemicals and industrial chemicals causes caustic damage to the airways and alveoli. Inflammation and formation of exudate results, blocking the airways and alveoli.

What is the pathophysiology of pneumonia?

Once the foreign substance has entered the lungs, the immune response is initiated. First, certain alveolar cells begin to produce large amounts of mucous to try to coat the foreign substance. Second, white blood cells will attempt to "wall off" the foreign substance. Third, the inflammation triggered by the immune system will cause blood flow to the area to increase, as well as to increase capillary permeability.

If these normal mechanisms don't work, the patient becomes progressively more ill. Mucus and fluid from the capillaries fill the alveoli, increasing the space through which gas must travel. At the same time, the increased blood flow goes past alveoli that aren't contributing to gas exchange (physiologic shunting). And last, if the patient has a bacterial pneumonia, the bacteria may produce exudates that further clog the alveoli. These problems culminate in hypoxemia. Hypoxemia will cause the patient to breathe faster, leading to hypocapnia (blowing off CO2).

What's the difference between a "community" and "nosocomial" pneumonia?

Pneumonias that begin outside of the hospital setting are called "community acquired" and pneumonias that start in health care facilities are known as "nosocomial" pneumonias. People who are at risk for acquiring pneumonia in the hospital are those who:

- are > 70 years old
- are intubated and/or on mechanical ventilation
- have a depressed level of consciousness
- have an underlying chronic lung disease
- have had a previous large volume aspiration
- are being given cimetidine for stress-bleeding prophylaxis
- are being given antimicrobials
- have an NG tube
- have had a recent bronchoscopy

Pulmonary embolism

Clottia Breathless is a 28 year-old woman who was admitted at 0500 for shortness of breath and chest pain. She has right calf tenderness, and her right leg is swollen and warm. The Homan's sign is positive on the right. Her tentative diagnosis is pulmonary embolism.

What is the most likely cause of Ms. Breathless' illness?

Perfusion to the lung may be disturbed by an embolus in the pulmonary vasculature. Pulmonary emboli may be made up of fat, air, or amniotic fluid. Pulmonary emboli are generally made of blood, which may form in the vasculature in the:

- Popliteal vein
- Ileofemoral vein
- Right side of the heart
- Pelvic area

What will favor the development of a pulmonary embolus?

The three factors, called Virchow's triad, favoring the development of venous thrombosis include:

- Blood stasis
- Blood coagulation abnormalities
- Vessel wall abnormalities

Emboli may also be formed from other substances that enter into the blood stream. Fat emboli can form when the long or flat bones of the body are broken; air emboli can occur with traumatic injury (pneumothorax) or leak in a central line; and amniotic fluid emboli may occur with an abruptio placentae.

How does blood normally flow in the lung?

Ninety-nine percent of the blood in the body goes through the pulmonary circulation to be re-oxygenated. The remaining 1% feeds the pulmonary tissues with oxygenated blood through the bronchial circulation. De-oxygenated blood enters into the lung through the pulmonary artery and travels to the capillary bed. The capillary bed is a network of very thin, fine vessels that enclose each alveolus (think of a spider web around a grape), which is optimal for gas exchange.

Oxygen, CO_2, and other waste products are exchanged between the alveolus and capillary through a pressure gradient system. Re-oxygenated blood travels out of the

capillary system, through the pulmonary vein and into the left heart.

A feature vital to efficient gas exchange is called "autoregulation," that refers to the ability of the arteries in the lung to constrict when blood is flowing by alveoli which are not contributing to gas exchange (i.e., an atelectatic alveolus), and to dilate when stimulated by the sympathetic nervous system. Vasoconstriction in response to non-gas exchanging alveoli is important to prevent shunting, which is blood moving from the venous to arterial side without receiving oxygen.

Ms. Breathless is experiencing hypoxemia as the blood supply to some of her alveoli is shut off. Although she is ventilating appropriately, the gases cannot diffuse into the blood stream. Ms. Breathless is experiencing autoregulation at this point to stop more blood from flowing to the blocked area.

What is the pathophysiologic process of a pulmonary embolism?

The embolus forms, enters into the venous system and travels through the right heart into the pulmonary vasculature. A large embolus tends to lodge in the upper part of the lung and causes rapid and severe deterioration, leading to cardiac arrest and death. Small, or micro, emboli tend to lodge in the lower part of the lung. Deterioration is slower and less severe; in some cases, a subtle problem.

What caused Ms. Breathless' symptoms?

The patient entered the ER with labored respirations (dyspnea) and a rapid respiratory rate (tachypnea). As the embolus blocked perfusion to a large number of alveoli, it decreased the amount of gas exchange. The resulting hypoxemia and hypercapnia triggered the chemoreceptors in the aortic arch, medulla, and carotid bodies to increase respiratory rate and effort to attempt to keep the body tissues oxygenated.

As the chemoreceptors trigger an increased respiratory rate and effort, the sympathetic nervous system is also stimulated to force the heart to pump the limited amount of oxygen faster. The increased heart rate and increased blood pressure are compensatory responses to hypoxemia.

Skin color may be a late indicator of oxygenation status. Cyanosis indicates that there are more desaturated hemoglobin molecules (blue) than saturated hemoglobin molecules (red). If the patient is anemic, there will be no cyanosis; rather, the patient will be pale.

What are the potential complications?

Pulmonary vascular pressure rises because of the mechanical blockage of a blood vessel. This elevation is called pulmonary hypertension. As the hypertension increases, the work of the right heart increases. This increased workload can lead to angina, myocardial infarction, or heart failure.

Summary

Without the lungs and proper lung function, every organ in the body would cease to function in minutes. The respiratory system is responsible for oxygenating the bloodstream and for removing excess gases from the circulation. Understanding how oxygenation and ventilation occur and how to interpret ABG's can help you determine how best to assess and manage your critically ill patient. Knowing the causes, pathophysiology, and some of the tests for selected pulmonary illnesses provides you with a foundation of knowledge for managing the acutely and critically ill pulmonary patient.

Recommended Reading

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Directions for Submitting Your Post Test for Contact Hours

To obtain a certificate of completion for this home study program, please complete the post-test and evaluation on the next few pages. If you are completing this home study as pre-reading for a TCHP class, please bring your post-test and evaluation to class with you for processing. The date on your certificate of completion will be the date that your home study is received. **Any materials received with a postmark after the expiration will be discarded.**

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Pulmonary Critical Care Primer Post Test

Please print all information clearly and sign the verification statement:

Name_____
(please print legal name above)

Birth date (required)
Format: 01/03/1999

M	M	D	D	Y	Y	Y	Y

For HealthEast, HCMC, or MVAMC, employees only:
Hospital _____ Unit_____

Personal verification of successful completion of this educational activity (required):
I verify that I have read this home study and have completed the post-test and evaluation.

_____
Signature

1) The chemoreceptors are sensitive to:
   a) CO_2 and O_2 levels
   b) CO_2 and CO levels
   c) O_2 and Hgb levels
   d) O_2 and He levels

2) The tidal volume is the:
   a) amount of air exhaled forcibly
   b) the amount of air that is always in the lung
   c) the amount of air present in the airways but not participating in gas exchange
   d) the amount of air inhaled or exhaled with each breath

3) Pulmonary compliance may be increased in patients with:
   a) ARDS
   b) congestive heart failure
   c) emphysema
   d) asthma

4) What is the PaO2 if the SaO2 is 90%?
   a) 50
   b) 60
   c) 70
   d) 90

5) An oral airway is appropriate for:
   a) an unconscious person
   b) a nauseated person
   c) a combative person
   d) permanent placement

6) What does the following ABG show? pH 7.10, PaCO2 60, HCO3- 22
   a) respiratory alkalosis
   b) respiratory acidosis
   c) metabolic alkalosis
   d) metabolic acidosis

7) What does this ABG show? pH 6.99, PaCO2 20, HCO3- 2
   a) respiratory alkalosis
   b) respiratory acidosis
   c) metabolic alkalosis
   d) metabolic acidosis

8) Acute Respiratory Distress Syndrome can result from:
   a) sepsis
   b) near-drowning
   c) gastric aspiration
   d) all of the above

9) Which of the following part(s) of the lung are hyperreactive in asthma?
   a) bronchioles
   b) alveoli
   c) capillaries
   d) alveolar junction

10) Pathophysiologic changes that occur with emphysema include:
   a) wall thickening
   b) chronic cough with sputum production
   c) chronic air trapping with bleb formation
   d) pulmonary hypotension

11) What is the most common cause of pneumonia?
   a) inhalation of smoke
   b) fungal infections
   c) aspiration of stomach contents
   d) none of the above

12) The three factors that are "Virchow's triad" are:
   a) blood stasis
   b) blood coagulation abnormalities
   c) vessel wall abnormalities
   d) all of the above

13) Pulmonary hypertension results in:
   a) right heart failure
   b) hypoxemia
   c) pulmonary hypertension
   d) lactic acid production

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Evaluation: Pulmonary Critical Care Primer

Please complete the evaluation form below by placing an "X" in the box that best fits your evaluation of this educational activity. Completion of this form is required to successfully complete the activity and be awarded contact hours.

At the end of this home study program, I am able to:	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
1. Define the process of oxygenation and ventilation.					
2. Identify acid-base disturbances based on blood gas analysis.					
3. Review oxygenation and ventilation modalities used for the critically ill patient.					
4. Differentiate between the pathophysiologies of asthma, bronchitis, and emphysema.					
5. Discuss the pathophysiology of pulmonary embolism, pneumonia, and acute respiratory distress syndrome (ARDS).					
6. The teaching / learning resources were effective. *If not, please comment:*					

The following were disclosed in writing prior to, or at the start of, this educational activity (please refer to the first 2 pages of the booklet).		
	Yes	**No**
7. Notice of requirements for successful completion, including purpose and objectives		
8. Conflict of interest		
9. Disclosure of relevant financial relationships and mechanism to identify and resolve conflicts of interest		
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Management of the Obese Patient

Management of the Obese Patient

Introduction/Purpose Statement

According to the National Center for Health Statistics, more than 60 percent of adults in the United States are considered to be overweight or obese.(1,1) A sizable number of these adults are morbidly obese or bariatric, leading to a number of medical and nursing challenges. Bariatrics is a field of medicine that studies obesity; its causes, prevention, and treatment.

The purpose of this home study packet is to define obesity using current guidelines, look at health problems that can occur (especially in relationship to the ICU environment), give some tips on how to manage the nursing care of these patients, and briefly review common bariatric surgery procedures.

Target Audience

This home study was designed for health care professionals with little to no familiarity with management of the obese patient.

Content Objectives

1. Define the terms overweight, obese, and morbidly obese.
2. Identify health conditions common to those who are overweight.
3. Describe nursing interventions specific to the obese patient.
4. Identify common bariatric surgical procedures.

Disclosures

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In order to successfully complete this activity you must read the home study, complete the post-test and evaluation, and submit them for processing.

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Planning Committee/Editors

Linda Checky, BSN, RN, MBA, Assistant Program Manager for TCHP Education Consortium.

Lynn Duane, MSN, RN, Program Manager for TCHP Education Consortium.

Author

Linda Checky, BSN, RN, MBA, Assistant Program Manager for TCHP Education Consortium.

Content Experts

Patty Hoffman, RN, Clinical Educator, Surgical Bariatric Unit at Regions Hospital.

Patricia Johnson, RN, Staff Nurse at the Minneapolis VA Medical Center.

Frank Jirik, RN, Staff Nurse in the SICU at Hennepin County Medical Center.

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The Size of the Problem

The National Institutes of Health define being overweight as a body mass index (BMI) of 25 to 29.9 kg per m^2. (2,10) BMI describes the relationship between height and weight and is calculated using one of the two formulas below:

$$BMI = \frac{\text{Weight in kilograms}}{\text{Height in meters squared}}$$

$$BMI = \frac{\text{Weight in pounds} \times 703}{\text{Height in inches squared}}$$

With BMI, the higher the number, the more weight there is for that given height. Obesity is defined as a BMI of 30 or more and morbid obesity as a BMI more than 40. (3,1) The term bariatric most often refers to the study and care of patients who are morbidly obese, with a BMI more than 40. If you are wondering where you stack up in all this, a Body Mass Index Chart is provided in the appendix.

As you've heard in the media, obesity rose dramatically during the late 1990's for Americans of all ages.(17,1) The data show that 31 percent of adults 20 years of age and older (nearly 59 million people) have a BMI of 30 or more, compared with 23 percent in 1994. (17,1) The prevalence of overweight children and adolescents has also risen. Children who are at or above the 95th percentile of their BMI for age according to the CDC growth charts are considered overweight.(1,1) Ten percent of preschool children (2-5 years of age) are overweight (up from 7 percent in 1994), and 15% of children and teens (6-19 years of age) are overweight according to 1999-2000 data (nearly triple the rate from 1980) (17,2) This is concerning because overweight children often grow up to be obese adults and obese adults are at risk for significant health problems.(17,2) Researchers at the 2003 American Heart Association's Scientific Sessions reported that about 1 in 8 school children have 3 or more risk factors of the metabolic syndrome, a precursor of cardiovascular disease. (20,1)

Obesity does not strike everyone equally. In adults, more women are obese (33%) than men (28%), with the problem greatest among non-Hispanic black women (50%) compared to Mexican-American women (40%), and non-Hispanic white women (30%) (17,2) There was no significant difference in obesity rates among men based on race/ethnicity. In children ages 6-11 years, more Mexican-American (24%) and non-Hispanic black (20%) children are overweight compared to non-Hispanic white children (12%). By adolescence, more non-Hispanic black and Mexican-American children (24%) are likely to be overweight than non-Hispanic white adolescents (13%).(17,2)

What all this means is that no matter what type of client you serve in the health care community, obesity is a significant problem.

Assessment of Risk

What's the big deal about obesity, you might ask. Being overweight or obese substantially increases the risk of morbidity from hypertension; dyslipidemia; type-2 diabetes; coronary heart disease; stroke; gallbladder disease; osteoarthritis; sleep apnea and respiratory problems; and endometrial, breast, prostate, and colon cancers. Higher body weights are also associated with an increase in all-cause mortality.(2,1)

When assessing risk in your clients, there is more to worry about than the degree of obesity. It is necessary to also look at overall health status and the waist circumference. Excess abdominal fat is an important, independent risk factor for disease. Central obesity (excessive fat tissue around the abdomen) ties into the whole concept of metabolic syndrome. Metabolic syndrome is a cluster of disorders that increase the likelihood of developing diabetes, heart disease, peripheral vascular disease, or a stroke.

Central Obesity (high waist circumference)

Waist circumference is a useful tool to use in patients who are categorized as normal or overweight, but adds little to the predictive power of the disease risk classification of BMI in individuals with BMIs ≥ 35 kg/m^2. Men who have a waist circumference more than 40 inches and women more than 35 inches, are at greater risk for diabetes, dyslipidemia, hypertension, and cardiovascular disease. Individuals with a waist circumference above these values should be considered one risk category above that defined by their BMI (see figure 1).

Overall Health Status

Some types of diseases or conditions associated with obesity place patients at a high risk of mortality and require aggressive treatment. Established coronary

heart disease (or other atherosclerotic disease), type-2 diabetes, and sleep apnea all increase a patient's risk of death. Osteoarthritis, gallstones, stress incontinence, and gynecological abnormalities such as amenorrhea and menorrhagia also increase risk but are not life-threatening. Risk factors such as hypertension, cigarette smoking, high low-density lipoprotein cholesterol (LDLs) and low high-density lipoproteins (HDLs), impaired fasting glucose, and a family history of early cardiovascular disease, and age (male ≥45 years and female ≥55 years) also create a high absolute risk in the obese patient. The following table is offered as a way of classifying risk, according to the NIH. (2,10)

Figure 1: Classification of Overweight and Obesity by BMI, Waist Circumference, and Disease Risk*

	BMI	Obesity Class	Disease Risk* (relative to normal weight and waist circumference)	
			Normal waist circum.	High** waist circum.
Under-weight	<18.5		-	-
Normal	18.5-24.9		-	***
Over-weight	25-29.9		Increased	High
Obesity	30-34.9 35-39.9	I II	High Very high	Very high Very high
Extreme Obesity	≥40	III	Extremely high	Extremely high

*Disease risk for type-2 diabetes, hypertension, and cardiovascular disease
**Waist circumference >40 inches in men and >35 inches in women
***Increased waist circumference can also be a marker for increased risk even in persons of normal weight
(Source: NIH)

Metabolic Syndrome

Metabolic syndrome is a term used to describe a group of disorders of your body's metabolism that make you more likely to develop diabetes, heart disease, peripheral vascular disease, or a stroke. These disorders include:

- Central obesity (waist circumference more than 40 inches in men and more than 35 inches in women)
- Blood fat disorders (mainly high triglycerides and low HDL's)
  - ◊ Fasting triglycerides 150 mg/dL or more
  - ◊ Blood HDL cholesterol less than 40mg/dL in men and less than 50 mg/dL in women
- Elevated blood pressure (130/85 mmHg or higher)
- Improper use of insulin or blood sugar (insulin resistance or glucose intolerance)
  - ◊ Fasting glucose 110 mg/dL or more
- Prothrombotic state (high fibrinogen or plasminogen activator inhibitor [-1] in the blood)
- Proinflammatory state (elevated high-sensitivity C-reactive protein in the blood)

While each of these disorders is a risk factor in itself, the combination of the disorders greatly increases the chance of potentially life-threatening illnesses. While this cluster of disorders is not new (formally known as syndrome X, the deadly quartet, and insulin resistance syndrome), it is becoming increasingly common. It's estimated that 47 million U.S. adults have it. (18,1) The underlying causes are thought to be lack of physical activity, being overweight/obese, and genetic factors.

The Critically Ill / Injured Obese Patient

Robert is a 30 year-old male with a history of hypertension and depression. At a height of 70 inches and a weight of 400 lbs., Robert is well above a BMI of 40. Robert has been involved in a motor vehicle accident. The main problem the ambulance crew is having at the moment is just getting Robert from the scene to the hospital. The ambulance crew is not only having trouble extricating and moving Robert, but they cannot get a cervical collar on him to stabilize his neck. Robert is tachycardic, tachypneic, diaphoretic, and in pain.

Once Robert reaches the emergency room, the problems posed by his size will continue to challenge staff. Equipment won't fit, moving him will be a challenge, "road trips" for testing and unit transfers will be risky, and obesity will complicate his treatment in a myriad of ways. What can be done to give Robert the quality care he deserves? What

potential problems/complications should we be on the lookout for?

Airway Management

Airway management problems in obese patients can be extremely difficult. They tend to have large, immobile necks, are prone to obstruction, and are difficult to intubate. The first intubation attempt should be made by the most experienced person available, working under optimal conditions whenever possible. It is a good idea to have back-up help present. Each subsequent attempt to intubate will worsen swelling and cause airway trauma, making it harder to visualize the area and insert the endotrachial tube.

Be sure to have a properly fitted mask available and the ability to mask ventilate, if intubation should prove difficult or impossible (i.e., *before* sedation and paralysis deprives the patient of the ability to breathe on their own). Facial anatomy, increased soft tissue mass, and a large tongue may all make bagging by mask difficult. Alternative "rescue" airway devices such as a Laryngeal Mask Airway (LMA) and fiber-optic laryngoscope/bronchoscope should be close at hand in case they are needed.

Be conscious of the fact that percutaneous cricothyrotomy or surgical tracheostomy may be very difficult due to additional tissue in the neck area. It is hard to identify landmarks and there is an increased likelihood of false passage of the tracheostomy tube into other planes of tissue. Once intubated or trached, stabilization of the tube will be very tricky (especially tracheostomy tubes). Be extremely careful when turning or moving the patient to prevent accidental extubation.

Many patients who are obese also suffer from obstructive sleep apnea (either diagnosed or undiagnosed). Patients may need CPAP or BiPAP to keep their airways open. If the sleep apnea has not been treated or was not identified early on, the patient may have pulmonary hypertension and right-sided heart failure as a result.

Pulmonary Issues

The lungs and airways didn't grow in size or function as the patient's weight increased. In simple obesity, respiratory resistance is 3 times normal and compliance is half of normal. (4,104) This doubles the work of breathing. The ventilatory drive changes to meet the demands of breathing by shifting to a higher respiratory rate and a smaller tidal volume. The bariatric patient is even more impaired, with a respiratory resistance 8 times normal and a work of breathing 4 times normal.(4,104) A "normal" respiratory drive may not be adequate to meet demand and can eventually lead to retention of CO_2. It may be "normal" for a bariatric patient to have resting hypoxia and hypercarbia. These patients are on the edge to begin with and have no reserves to draw on if there is an insult to the pulmonary system.

Respiratory expansion is restricted in the bariatric patient by the weight of the chest wall. An enlarged abdomen presses up on the diaphragm, restricting its movement and crowds the thoracic cavity. This causes a reduction in functional residual capacity, a reduced expiratory volume, and ventilation is diminished at the lung bases causing a ventilation-perfusion abnormality with arterial hypoxemia, especially when in the supine position. (7,1995) The mechanics of breathing are further impaired by fat deposits in the diaphragm and intercostal muscles (.6,86; 7,1995) All of these make the bariatric patient more susceptible to rapid desaturation and progression to respiratory failure. Monitor the patient closely for fatigue of respiratory muscles and becoming somnolent—it could be a sign of hypercapnia. Pulse oximetry may be used post-surgically for the first 24 hours or if the respiratory status of the patient is unstable.

A vigorous pulmonary toilet that encourages coughing, deep breathing, and incentive spirometry is essential to prevent atelectasis and pneumonia. Pneumonia is poorly tolerated by the obese patient and should be avoided whenever possible. Raise the head of the bed 30-45 degrees to help reduce the pressure of the abdominal contents on the diaphragm. A 45 degree upright and reverse Trendelenburg position are usually better tolerated than a 90 degree upright or supine position. (3,4)

While proper pain management is necessary for the patient to be able to cough and deep breathe, patients must be awake to be able to perform the necessary pulmonary toilet. The goal is to have the pain controlled with the patient awake enough to cough and deep breathe and/or participate in cares.

Cardiac and Fluid Issues

Obese patients have a higher incidence of pulmonary hypertension and right-sided heart failure. Watch for

inotropic failure via PA catheter and echo. Fluid volume will need to be managed very carefully.

Be watchful for third spacing of fluids. Signs of decreased circulating volume are persistent tachycardia over baseline, decreased urine output, decreased blood pressure, and an increased need for oxygen.

Deep Vein Thrombosis and Pulmonary Embolism

All obese patients require prophylaxis for DVT early on. Obese patients are at a higher risk for DVTs because of the lack of mobility, stasis, and polycythemia related to chronic respiratory insufficiency. Administer low dose molecular weight heparin subcutaneously and apply sequential compression devices whenever the patient is at rest. If the patient has been immobile prior to their hospitalization, they should have venous leg studies prior to using compression devices. (13,109) Foot devices may provide a better fit and patient tolerance if the patient's calves and thighs are too big for more traditional equipment. Staff should prepare for getting the patient up and moving as soon as possible.

Pharmacological Issues

There is very little published research in the area of dosing regimens for obese patients. The question is, do you keep going up on the dosage because dosing is usually done in milligrams per kilogram? Or would it be better to use Ideal Body Weight (IDW) versus Total Body Weight (TBW) to figure medication dosages. The issue gets even more muddied when the patient is third spacing fluids, which is a problem in critically ill obese patients.

What is known is that the obese patient has a higher percentage of adipose tissue and a lower percentage of water and lean body mass and that medications will be absorbed differently because of this. Some drugs are lipophilic and distribute mostly in the adipose tissue (carbamazepine, diazepam, propofol, and opiate analgesics). Dosages of these types of medications tend to be calculated using TBW. Other drugs tend to distribute mostly in lean muscle (acetaminophen and digoxin) and are usually dosed using IBW. (6,88) Some medications may be dosed using an Adjusted Body Weight (ABW) calculation. Medications that use an ABW calculation are those that appear to have an increased distribution pattern because of the excess weight (presumed to be about 20-50% of the excess weight). This means that these types of drugs tend to spread out more in the body when there is excess weight. The recommended calculation to make the ABW is:

Adjusted Body Weight=(TBW-IBW) 0.4 + IBW (5,19)

Here are some recommendations for a few selected medications frequently used in the ICU setting:

Opioids

Like any other patient, factors such as severity of the pain, ventilatory support, age, underlying illness, etc. will all impact analgesic requirements. While there is some evidence that obese patients may require smaller morphine-equivalent doses to relieve pain due to increased endogenous opioid concentrations, there is wide variability in requirements. (5,20) Dosing of opioids should be based on the pain assessment. The best approach is to give smaller IV doses frequently (every 10-15 minutes) until the pain is controlled at the right level. For continuous IV infusions of opioids, rate increases can be determined by frequent pain assessments. If an intermittent schedule is desired, there must be additional orders written for breakthrough pain.

Heparin

There is no consensus on whether to use unfractionated or low molecular weight heparin (LMWH) and little information about how to dose them in morbidly obese patients. Recommendations are that obese patients receive early prophylaxis for deep vein thrombosis (DVT) and pulmonary embolism, and that the regimen should err on the side of using the higher end of the range for initial dosing of heparin. Institutions may choose to cap dosing at a certain weight or use an adjusted weight that mimics plasma volume for the initial loading and maintenance infusion. Adjustments can be made after the initial dosing by following the appropriate labs (APTT or anti-/Xa). (5,21)

Antibiotics

Recommendations for antibiotics are specific to the type of medication. In general, it is recommended that aminoglycosides (gentamycin, tobramycin, amikacin) be avoided to reduce the likelihood of ototoxicity and nephrotoxicity that can come with their use. If an aminoglycoside is indicated, there are 2 dosing options recommended, assuming that renal function is normal (5,24):

1. Use an adjusted body weight with a 12 hour dosing interval. This would provide a good concentration-killing effect while avoiding the high doses that would be necessary with once a day dosing.
2. Use an adjusted body weight together with once a day dosing but limit the total daily dose. This method takes advantage of the concentration-dependent killing effect, but may sacrifice a portion of the high peak concentration.

Either of these dosing regimens require therapeutic drug monitoring if therapy is given for more than 3-5 days.

For penicillins, cephalosporins, and quinolones, it is suggested that dosing be at the higher end of recommended treatment ranges—especially in morbidly obese patients that have severe infections. Cefazolin, particularly, should be given in higher doses for surgical prophylaxis. (5,24)

Sedatives
Recommendations vary as to whether total body weight (TBW) or ideal body weight (IBW) should be used as the basis for dosing. There is agreement that it is preferable and safer to use a series of "mini loading doses" or an infusion rather than a single IV dose, and to titrate to the desired effect.

Anesthetics
Patients that have received anesthesia are at risk for "resedation." Because most anesthetics are lipophilic, patients may "resedate" when the anesthetic is released from the fat cells into the bloodstream.(13,107)

Oral and Transdermal Medications
Dosing and administration schedules of oral and transdermal medications may also need adjustment. (6,88) Bariatric patients often have a lower gastric pH, which may alter the absorption of medications. Cutaneous tissue is not perfused as well in the obese patient because adipose tissue is less vascularized. Absorption rates for medications are based on persons of average weight. Subcutaneously given drugs may also be absorbed inappropriately. Dosages may need to be increased because they are less well absorbed, or the drug may need to be given more frequently.

General Guidelines
There are many other medications given in the ICU setting and few of them have been studied sufficiently in morbidly obese patients to make any firm recommendations. Because most studies exclude morbidly obese subjects, there is a lack of information available about patients that are more than 135 kg. Some institutions elect to cap dosing at a weight of 135 kg. for this reason.

Because the dosing calculation will vary depending on how the drug distributes in the adipose and lean tissues of the body, you should consult your pharmacist for dosing recommendations in bariatric patients.

Physical Assessment

When listening for breath sounds in the bariatric patient, be sure to displace skin folds over the area you are listening to, place the diaphragm of the stethoscope firmly on the spot, and have the patient inhale deeply. Auscultation is most effective in spots where the lung tissue is closest to the chest wall. Be sure to listen over dependent areas of the lung where fluid is more likely to collect.

Heart sounds can be heard more readily over the aortic and pulmonic areas to the left or right of the sternal border at the 2nd intercostal space, or listen with the patient in a left lateral side-lying position. Bowel sounds may take longer to detect.

Be sure to use the correct cuff sizes on the blood pressure cuff. The width of the cuff should be 40-50% of the arm's circumference. The cuff should be long enough for the bladder to go around the arm almost completely (80% of the arm circumference).

Nutrition

When a bariatric patient enters the ICU, the temptation is to place them on an immediate, strict diet to try to take some pounds off. While weight reduction is a good goal, proper nutrition is essential for healing. Bariatric patients in the ICU should have a comprehensive assessment of their nutritional status as they are often protein deficient. (6,86)

While weight loss during a critical illness is usually not recommended, carefully controlled weight loss in the bariatric patient may be beneficial in certain instances. (3,3) In patients who are not critically ill, short periods of permissive underfeeding have been

associated with lower rates of infection and reduced insulin requirements. (3,3) A dietitian's expertise is necessary to prepare the nutritional formula and help manage the permissive underfeeding.

Solving Practical Problems

Nurses in the ER do not currently have a bed big enough to accommodate Robert. They improvise by strapping two gurneys together while they wait for a special bed to arrive. This will make it difficult to transport Robert because most doors and elevators do not allow for double-width. The wheels also need to be aligned so they track correctly. The first problem they encounter is getting a weight, as the scale cannot handle someone Robert's size. The alternative is to order an oversized bed with weighing capability or to take Robert to the loading dock to use the freight scale. The doctor would like a CT but Robert is too big to fit in the scanner. The nurse must use a thigh cuff on Robert's arm to get a blood pressure. A Doppler probe is brought to the bedside because the nurse and doctor both have had no success in placing an IV due to the excessive subcutaneous fat.

As you can see, all kinds of practical problems need to be solved with a larger patient. Every hospital should have quick access to larger beds, preferably with weighing capability to 400 lbs. or more. A proper bed is the first step in being able to safely and comfortably move and care for a patient. If the patient cannot fit into the CT scanner, it may be necessary to transport the patient to a specialized radiology suite. If the patient is not stable enough to transport, practitioners will be limited to bedside exam and portable diagnostic equipment to aid diagnosis.

Road Trips

"Road trips" with the bariatric patient are inherently dangerous and need to be carefully planned whenever possible. Avoid after-hours movement of the patient to ensure adequate staffing. Be sure to call ahead to the receiving department and clearly communicate the patient's weight so that an adequate bed/table is available. Use a HoverMatt® or other transfer device. Constant presence of a Respiratory Therapist is recommended for intubated bariatric patients when they are outside of their department.

Moving the Patient

While early mobilization is clearly a goal, it must be done safely—both for the sake of staff and the patient. Be sure that there is adequate manpower to move the patient safely. Usually 5 are needed to turn an intubated patient. Use an air mattress (HoverMatt®) for transfers and a lift for lifting the patient up off the bed. See if a bed/chair conversion is available from your equipment representative (see capital equipment list in the appendix).

Just moving the patient around in bed can be a challenge. It's always best to have adequate help when turning, ambulating, or moving an obese patient. Besides the obvious hazards of a patient falling or the caregiver injuring themselves, there is a risk that the patient will inadvertently dislodge wires, IVs, and/or catheters when they have to lurch around in bed to turn.

Go slowly and carefully with mobilization because the obese patient will be more sensitive to orthostatic changes and may have sensory neuropathies. Obese patients often have chronic back pain from increased load pressure, foot pain from flattening feet, and transient parasthesias of the arms from circulation impairment in the axilla. Stress fractures may be present, as well as degenerative joint disease. All can make ambulation difficult and painful. The gait is typically wide-based for balance, with a rolling motion. Arms are often held out from the body due to girth or parasthesias and the back is often arched to counterbalance the abdomen. Address the issue of pain management and assess the need for assistive equipment such as a quad-cane or walker. Consider ordering occupational and physical therapy consults for assistance with daily activities and ambulation.

Make sure the patient can stand with their own strength before ambulating. It is unlikely that staff would be able to help the patient if they start to fall. If a patient fall occurs, give them care on the floor until enough help arrives to safely get them up. Bring a strong footstool or chair nearby as a resting spot for the patient. If the patient is not able to help lift themselves, blankets or a stretcher can be used to lift the patient. If necessary, call emergency services, fire or ambulance crew for help in moving the patient. They have experience lifting and moving patients of all sizes.

Blood Specimens

Since obtaining ABGs may be difficult, a cannula should be placed if repeated sampling is expected. The arterial line will also provide a means for monitoring blood pressure. If it is impossible to get an ABG, respiratory status can be assessed by using pulse oximetry alone or combined with capnography (a close fitting mask is used to determine expired CO_2 levels). Venous or capillary sampling for blood gases can also be done. Venus sampling uses a different range of normal for the O_2 and CO_2 because a peripheral venous sample mostly reflects the skin and muscle extraction of oxygen. A venous sample is not a good reflection of a patient's oxygenation but will at least give insight into their blood pH. A capillary sample is generally only run on neonates but can, in a pinch, be done on an adult. A special heparinized tube will be needed to collect and run the sample and it should be iced after collection, just like an ABG.

If the patient does not have an access for drawing specimens and they are a difficult draw, be sure to check with the laboratory to see if capillary specimens or pediatric tubes can be sent for analysis. Most laboratories are capable of running these types of specimens.

Intravenous Access, LPs, and Injections

Subcutaneous fat can make it difficult to locate veins for cannulation. Ultrasonography may be needed to help find the veins. Tourniquets may not work well or may cut into the flesh if tied too tightly. Try using a large blood pressure cuff instead to more comfortably distend the veins. Choose cannula size carefully. Use a smaller cannula (22 or 24 gauge) whenever possible to spare veins for future use.

An external jugular line may be difficult to impossible to insert due to a short, thick neck. A longer cannula may be needed, which may make the line "positional." Try to minimize Trendelenburg's position during line insertion because it causes the abdominal contents to press against the diaphragm, restricting breathing. Supplemental oxygen may be needed.

Femoral vein access will be complicated by difficulty in locating landmarks, lifting the abdomen away from the operative site, and moisture/yeast infections in groin area.

Longer needles will be needed for injections and lumbar punctures. It may be necessary to conduct lumbar puncture with the patient safely braced in a sitting position. Remember that the "opening pressure" measurement is not valid from a sitting position.

Medications given by IM injection often miss the muscle in bariatric patients because the needle is too short. A standard 1-1.5 inch needle is generally too short. Either use a longer needle or change the route of administration.

Toileting

Stress incontinence is a common problem for bariatric patients due to increased intra-abdominal pressure. Difficulty getting out of bed can magnify this problem. Wall-mounted toilets may not be able to support the weight of the patient and standard commodes are too small. Patient rooms for obese patients should have floor mounted toilets or an extended size commode should be ordered. Be aware that the patient may need assistance with cleansing the perineal and perianal area. These areas are very difficulty for the patient to reach. Occupational therapy can offer devices to assist with bathing and cleansing.

Catheterizing, or even applying a condom catheter, can be difficult in the bariatric patient. Suprapubic adipose tissue may need to be retracted in male patients (either by an assistant or by using tape) in order to visualize the perineum. It may be necessary to use a portable light to be able to see the perineum and introitus in a female. The side-lying position with the upper leg flexed or lifted by an assistant can help with female catheterization. The drainage tubing may be relatively short and extension tubing may be needed to secure it properly. Tape adhesion can be a problem, too, due to warmth and moisture in the perineal area.

Skin Care

Skin care in the obese patient can be quite a challenge, but is extremely important. Obese patients have many skin folds and those folds hold onto moisture. Hygiene may be impaired because they cannot see or reach areas that need cleaning. Rashes are often found in the groin, perineum, axilla, breast area, and in large skin folds. These areas offer warm and moist conditions that encourage the growth of yeast and fungi. Carefully cleanse and dry all skin folds during bathing and toileting. Apply ointments as needed to areas where yeast and fungus is a

problem. For areas that are very difficult to dry, using a hairdryer on low may help. Powder applied to skin folds may help to reduce moisture and chafing. A fan may help to keep the patient cool and dry. The umbilicus may be deep and difficult to clean; gentle use of cotton swabs may helpful. The coccyx/ischial area is very vulnerable to skin breakdown and needs to be monitored carefully.

Cellulitis can be a problem in the obese patient due to poor circulation and/or in conjunction with diabetes. Patients may not be able to care for wounds themselves because they cannot adequately see and reach the affected area.

Daily inspection of the skin should include incisions, IV sites, pressure areas (gluteal, sacral, heel and the head), the abdomen, breasts, back folds, thighs, posterior neck, and perineal areas. Follow a rigid schedule of turning and re-positioning (including manual turning of the head) every two hours to prevent decubitus ulcer formation. Do not rely on a rotational mattress to do this for you. While specialty beds can be helpful, they do not provide enough movement to prevent ulcer formation. Assess that skin folds are clean and dry with each re-positioning. The back of the neck is often overlooked when an airway assistance device is in place—check this spot often as secretions can accumulate there. Be sure that lines and tubes do not get trapped in skin folds.

Vasopressors increase the likelihood of decubitus ulcer formation, so be especially watchful in these patients. Adipose tissue is poorly vascularized and may cause delayed healing of open wounds. Diabetes can compound the problem by increasing the incidence of infection and delayed healing. Watch for potential wound dehiscence due to high skin tension (increased adipose tissue and edema). An abdominal binder may help relieve tension on abdominal wounds and add support. Consult a wound or ostomy nurse for complex wound or skin care needs.

ICU Course

The ICU course for bariatric patients is often full of complications, setbacks, and challenges. It is also very difficult to predict how the patient will do.

Bariatric patients have a higher incidence of cardiac, pulmonary, and endocrine problems than non-obese patients. (7,1981) They are also more prone to have hypertension and sleep-related disorders, require more oxygen, a longer weaning time from mechanical ventilation, and a longer hospital stay. (7,1981-1982) Critically ill bariatric patients have a higher ICU mortality rate, and it is difficulty to predict the outcome for these patients using conventional means. The APACHE II scoring system, which is used extensively to predict mortality in ICU patients, does not work well with bariatric patients. The predicted mortality of survivors is not statistically different from the nonsurvivors in bariatric patients. Neither the length of ICU stay nor duration of mechanical ventilation predicted in-hospital mortality to a significant degree. Multiple organ failure remains the best predictor of ICU mortality in the critically ill bariatric patient (7,1995)

Bariatric Surgery

There are literally thousands of treatments for obesity ranging from prayer to herbal medicine to diets to surgery. Many of us have tried these programs and, if the statistics can be believed, have struggled (usually unsuccessfully) to keep the weight off.

While the number of patients who are morbidly obese or bariatric, are low compared to the number of adults who are overweight or obese, it is estimated that 5 million people meet the criteria for clinically severe obesity. (8,86) Weight loss options for the bariatric patient are somewhat limited, with bariatric surgery being more effective in facilitating and maintaining weight loss.(8,86)

Bariatric surgery promotes weight loss by making the stomach smaller and delaying emptying of the stomach and/or by shortening or bypassing the small intestine, causing food to be poorly digested and absorbed. Patients selected for bariatric surgery usually have: (9,32)

- BMI of 40 or more (or BMI 35 or higher with comorbidities)
- Absence of a correctable cause for the obesity
- Absence of a major psychiatric disorder or history of substance abuse
- Are an adult with a long-standing history of obesity (5 or more years)
- Have been unsuccessful with weight loss using non-surgical means
- Able to follow the dietary and behavioral changes recommended post-surgically

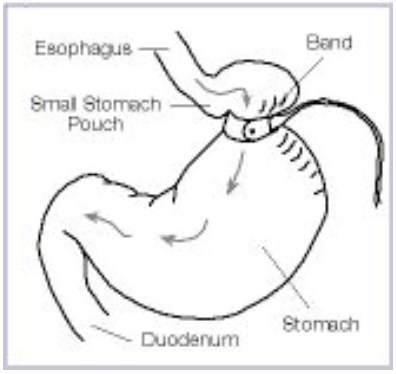
There are 4 main types of procedures that are performed:

- Laparoscopic Adjustable Gastric Banding (Lap-Band)
- Vertical Banded Gastroplasty (VBG)
- Roux-en-Gastric Bypass (RNYGBP)
- Biliopancreatic Diversion (BD)

Laparoscopic Adjustable Gastric Banding (Lap-Band)

The Lap-Band procedure restricts food intake by placing an inflatable silicone band around the upper part of the stomach, giving it an "hour glass"-shape.

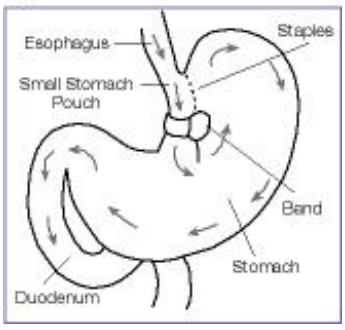
Figure 2



This produces a small upper stomach and a narrow passage to the lower stomach. This will cause an early and longer feeling of fullness, resulting in a smaller intake of food. The band can be inflated or deflated through an access port just under the skin. This will increase or decrease the diameter of the narrow passageway from the upper stomach to the lower stomach, which will directly impact the amount of food the person can consume. It is the least invasive bariatric surgery available and is completely reversible. However, it is a relatively new procedure and may not be covered by insurance.

Vertical Banded Gastroplasty (VBG)

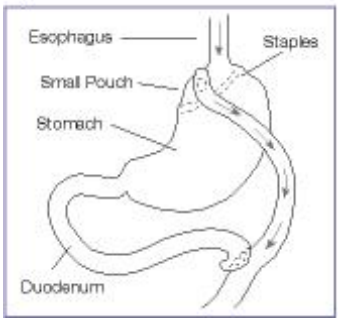
Figure 3



VBG restricts food intake by creating a small (30 ml capacity) pouch at the top of the original stomach. The smaller stomach or pouch is made by using a circular stapling instrument. The circular stapling instrument simultaneously cuts a "window" in the stomach as it staples around the window to close it. The window is created to slip the band through. A vertical stapler is then used to staple vertically above where the window has been cut, forming a small pouch. The pouch initially holds about 30 ml or 1 oz. of food, but will slowly expand to hold 2-4 oz. over time. This procedure does not bypass or impair the stomach or small intestine so it does not result in vitamin or mineral deficiencies. The procedure also involves placing a band of either Marlex or Gore-Tex to make the passageway from the small upper stomach to the lower stomach narrow. This slows the rate of gastric emptying which helps the person feel full longer. A slightly different procedure places a silicone band to narrow the smaller stomach outlet into the lower stomach rather than the circular stapling with Marlex band (Siliastic Ring Vertical Gastroplasty).

Roux-en-Gastric Bypass (RNYGBP)

Figure 4

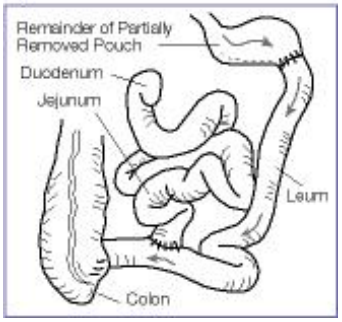


The RNYGB procedure, which can be done with a surgically opened abdomen or through laparoscopy, was developed in the 1960's and is considered by many surgeons to be the "gold standard" to which all other procedures are compared. The surgery involves stapling of the stomach to restrict the intake of food. Most bariatric surgeons today will actually divide the stomach after stapling to reduce the risk of the staple line from breaking down or splitting.(10,94) Physically dividing the stomach causes a very strong seal to form along the staple line, much like a weld. The small intestine (jejunum) is then anastomosed to the smaller stomach. The anastomosis is deliberately made narrow to delay emptying of the small stomach pouch, which will prolong the feeling of fullness after eating. This anastomosis bypasses the distal stomach, duodenum, and proximal jejunum, causing a slight malabsorption of food. Because of this malabsorption, weight loss with RNYGBP is greater than with restrictive procedures but may cause nutritional deficiencies (especially iron, calcium, and vitamin B12). Taking a daily multiple vitamin to prevent nutritional deficiencies is part of the patient's

postoperative self-care. Another problem that can occur with this procedure is dumping syndrome. Because the pylorus is bypassed, food can rapidly enter the small intestine from the small stomach pouch, pulling water into the intestine along with it. This propels food through the intestine more rapidly. The increase in peristalsis can cause diarrhea, nausea, abdominal cramping, rapid heart rate, sweating, and weakness or dizziness. Eating sugary foods is a secondary (and preventable) cause of dumping syndrome in patients with RNYGBP. Patients are discouraged from eating high calorie, sugary foods postsurgically.

Biliopancreatic Diversion (BPD)

Figure 5

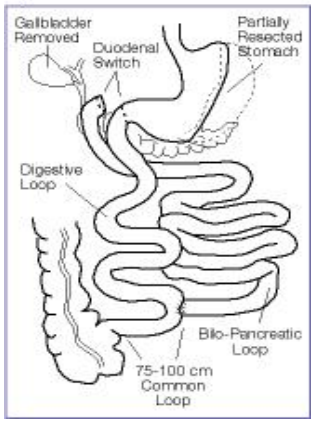


BPD is the most drastic of all obesity surgeries available and is rarely performed in the United States due to the serious long-term complications that can result and because a superior hybrid of this procedure (Duodenal Switch or DS) exists. With BPD, 65-75% of the stomach is removed; intestines are rerouted and shortened so that 60% no longer carries food but only bile and pancreatic juices. This delays food mixing with digestive juices until the last 50-100 cm of small bowel—most fats and proteins don't have a chance to digest and pass through the colon undigested. This increases the possibility of losing more weight than with any other bariatric procedure.

Duodenal Switch

Duodenal switch (DS), a hybrid of the BPD procedure, involves disconnecting the small intestine between the pyloric sphincter and the common bile duct and reattaching it close to the colon. The surgeon then cuts the small intestine to about 50-60% of its full length and attaches the lower end to the open end of the duodenum. This causes food to come in contact with digestive juices only a short way before it enters the colon. All sections of the intestines remain functioning; they are just rearranged and not removed. The stomach size is also reduced by removal of about 75% of the stomach along the greater curvature. An appendectomy and gall bladder removal are performed at the same time to prevent future surgeries. DS offers the advantage of greater weight loss through restriction and malabsorption like BPD, but preserves the pylorus and prevents dumping syndrome. By removing the greater curvature of the stomach where the majority of stomach acid is produced, the risk of developing a marginal ulcer is eliminated. The procedure is also functionally reversible by lengthening the bowel to absorb more calories.

Figure 6



Why Have Surgery?

After reading how invasive bariatric surgery is, one might wonder why a doctor would ever recommend it. When you look at the complications and self-care needed post-surgically (too many to cover here), one might wonder why anyone would agree to have it done, especially considering the high morbidity and mortality compared to other elective procedures. The answer lies in the obesity related conditions that can threaten the quality and quantity of life and the lack of other alternatives. Those that meet the criteria for surgery have tried other means to lose weight and the weight either did not come off or stay off. Bariatric surgery remains the most effective method for long-term weight loss. When the weight is lost, most obesity-related conditions abate or even completely resolve (most notably, Type 2 diabetes, obstructive sleep apnea, hypoventilation of obesity, gastroesophageal reflux, and peripheral edema). There is also usually an immediate reduction in the incidence of hypertension, but these benefits diminish over time. (11-booklet 7,7) The need for medications for diabetes, and cardiovascular disease may be reduced or even eliminated.

Psychosocial Issues

Providing compassionate emotional support for the bariatric patient and their families is essential. Keep in mind that the patient has experienced significant social disapproval prior to today. Obesity has long been associated with failure, laziness, lack of

willpower, low intellect, social ineptness, poor hygiene, and psychological dysfunction. These negative stereotypes cross all levels of age, education, and profession. (12,140) Persistent, strong, negative attitudes towards obesity occur even in physicians and nurses who *specialize* in the treatment of obesity. (12,140) These attitudes can be conveyed without conscious intention. It is not surprising that obese patients who receive medical care report embarrassment, humiliation, and insults. Some sources cite an increased incidence of depression and anti-depressant usage in the obese, other sources negate these differences. (12,140; 19) Most have tried to lose weight numerous times, without lasting success. Body language and facial expressions can easily transmit a nurse's discomfort in caring for the patient. Grunts and groans with patient transfers underscore to the patient the burden that they represent to their caregivers. Keep in mind that the intubated patient can still hear you. Bariatric patients often avoid regular medical care because the appointments involve being weighed and counseled about their weight and the lack of appropriately sized equipment. Many feel they are being judged harshly by those in charge of their care. Bariatric patients want to and should receive the same professional, respectful care as any other patient.

Conclusion

Obesity has become one of the most important public health issues worldwide, affecting both developed countries (Canada, United States, United Kingdom) and Third World areas such as Latin America, China, Asia, and Africa. (8,84) It affects both adult and pediatric populations and there are multiple reasons why the problem continues to grow (genetics, cultural influences, lifestyle, and environmental factors). Health care facilities and providers must become better equipped to manage obese patients. Hopefully this home study has helped to further your education in this area.

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References in the book have a two-number format. The first number indicates the source the information is taken from (as listed below). The second number indicates the page number where that information was taken from.

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Figures

- Figure 1: Taken from the National Institutes of Health website: www.nhlbi.nih.gov/guidelines/obesity/ob_home.htm, page 10.
- Figures 2-6 Taken from the National Institutes of Health website: http://win.niddk.nih.gov/publications/gastric.htm, pages 3-6.

Appendix List

1. Body Mass Index Table NIH Website (reference 2), click on link.
2. Where to measure waist circumference, NIH (reference 2, pg 9).
3. Capital Equipment list, source: www.ormanager.com.

Appendix 1

Body Mass Index Table

for BMI greater than 35, go to Table 2 on next page

To use the table, find the appropriate height in the left-hand column labeled Height. Move across to a given weight (in pounds). The number at the top of the column is the BMI at that height and weight. Pounds have been rounded off.

BMI	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Height (inches)	Body Weight (pounds)																
58	91	96	100	105	110	115	119	124	129	134	138	143	148	153	158	162	167
59	94	99	104	109	114	119	124	128	133	138	143	148	153	158	163	168	173
60	97	102	107	112	118	123	128	133	138	143	148	153	158	163	168	174	179
61	100	106	111	116	122	127	132	137	143	148	153	158	164	169	174	180	185
62	104	109	115	120	126	131	136	142	147	153	158	164	169	175	180	186	191
63	107	113	118	124	130	135	141	146	152	158	163	169	175	180	186	191	197
64	110	116	122	128	134	140	145	151	157	163	169	174	180	186	192	197	204
65	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210
66	118	124	130	136	142	148	155	161	167	173	179	186	192	198	204	210	216
67	121	127	134	140	146	153	159	166	172	178	185	191	198	204	211	217	223
68	125	131	138	144	151	158	164	171	177	184	190	197	203	210	216	223	230
69	128	135	142	149	155	162	169	176	182	189	196	203	209	216	223	230	236
70	132	139	146	153	160	167	174	181	188	195	202	209	216	222	229	236	243
71	136	143	150	157	165	172	179	186	193	200	208	215	222	229	236	243	250
72	140	147	154	162	169	177	184	191	199	206	213	221	228	235	242	250	258
73	144	151	159	166	174	182	189	197	204	212	219	227	235	242	250	257	265
74	148	155	163	171	179	186	194	202	210	218	225	233	241	249	256	264	272
75	152	160	168	176	184	192	200	208	216	224	232	240	248	256	264	272	279
76	156	164	172	180	189	197	205	213	221	230	238	246	254	263	271	279	287

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Table 2: Body Mass Index for BMI over 35

To use the table, find the appropriate height in the left-hand column labeled Height. Move across to a given weight. The number at the top of the column is the BMI at that height and weight. Pounds have been rounded off.

BMI	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**
Height (inches)	**Body Weight (pounds)**																		
58	172	177	181	186	191	196	201	205	210	215	220	224	229	234	239	244	248	253	258
59	178	183	188	193	198	203	208	212	217	222	227	232	237	242	247	252	257	262	267
60	184	189	194	199	204	209	215	220	225	230	235	240	245	250	255	261	266	271	276
61	190	195	201	206	211	217	222	227	232	238	243	248	254	259	264	269	275	280	285
62	196	202	207	213	218	224	229	235	240	246	251	256	262	267	273	278	284	289	295
63	203	208	214	220	225	231	237	242	248	254	259	265	270	278	282	287	293	299	304
64	209	215	221	227	232	238	244	250	256	262	267	273	279	285	291	296	302	308	314
65	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324
66	223	229	235	241	247	253	260	266	272	278	284	291	297	303	309	315	322	328	334
67	230	236	242	249	255	261	268	274	280	287	293	299	306	312	319	325	331	338	344
68	236	243	249	256	262	269	276	282	289	295	302	308	315	322	328	335	341	348	354
69	243	250	257	263	270	277	284	291	297	304	311	318	324	331	338	345	351	358	365
70	250	257	264	271	278	285	292	299	306	313	320	327	334	341	348	355	362	369	376
71	257	265	272	279	286	293	301	308	315	322	329	338	343	351	358	365	372	379	386
72	265	272	279	287	294	302	309	316	324	331	338	346	353	361	368	375	383	390	397
73	272	280	288	295	302	310	318	325	333	340	348	355	363	371	378	386	393	401	408
74	280	287	295	303	311	319	326	334	342	350	358	365	373	381	389	396	404	412	420
75	287	295	303	311	319	327	335	343	351	359	367	375	383	391	399	407	415	423	431
76	295	304	312	320	328	336	344	353	361	369	377	385	394	402	410	418	426	435	443

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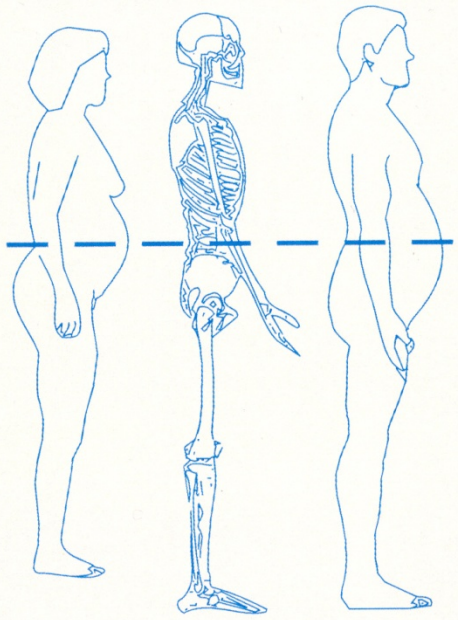
Appendix 2

Waist Circumference Measurement

To measure waist circumference, locate the upper hip bone and the top of the right iliac crest. Place a measuring tape in a horizontal plane around the abdomen at the level of the iliac crest. Before reading the tape measure, ensure that the tape is snug, but does not compress the skin, and is parallel to the floor. The measurement is made at the end of a normal expiration.



Measuring-Tape Position for Waist (Abdominal) Circumference in Adults

(Source: NIH, reference 2, page 9)

Appendix 3

Capital equipment related to obesity

Bariatric beds
Burke Bariatric
800/255-4147
www.burkebariatric.com
Tri-Flex II bariatric bed with 1,000-lb capacity has integrated scales and trapeze option.
Hill-Rom Company, Inc
800/445-3730
www.hill-rom.com
Magnum II bariatric patient care system holds patients up to 800 lb and functions as a bed, chair, and transport vehicle. Total Care bariatric bed system has a 500-lb weight limit.
Invacare
800/333-6900
www.invacare.com
Bariatric and heavy-duty products include beds, wheelchairs, lifts, slings, and trapezes.
KCI
210/255-6364
www.kci1.com
BariMaxx II bed system with pressure reduction environment for patients up to 1,000 lbs.

Bariatric bedside commodes
Gendron
800/537-2521
www.gendroninc.com
Bariatric shower and commode chairs, patient lifts, wheelchairs, beds, stretchers.

Bariatric patient transfer devices
Air Pal
800/633-4725
www.airpal.com
Inflatable patient transfer mattress creates less friction for moving patients.
Allen Medical Systems
800/433-5774
www.allenmedical.com
Products for bariatric patients up to 1,000 pounds (450+ kilograms) including long patient Transfer Boards.
HoverTech International
800/471-2776
www.hovermatt.com
Inflatable HoverMatt patient transfer mattress has no weight limit and can be used with x-ray and MRI.
Inventive Products Inc
800/336-6911
www.apc.net/ipi/slippinfo.htm
The Slipp is a two-layer vinyl patient transfer sheet that is not air powered.
KCI
800/275-4524
www.kci1.com
EZ Lift battery-powered electric patient lift/transfer system with 1,000 lb capacity.
Liko Inc

888/545-6671
www.liko.com
The UltraTwin FreeSpan patient lifting device for patients up to 880 lbs.

Bariatric scales
Scale-Tronix
800/873-2001
www.scale-tronix.com
Stand-on scale for patients up to 1,000 lb.

Bariatric stretchers
Steris Corporation
800/548-4873
www.steris.com
Hausted Horizon electric powered stretcher with extra wide litter top and pressure care mattress has 625-lb capacity
Stretchair
800/787-9537
www.stretchair.com
Combination wheelchair-stretchers for bariatric patients with capacities up to 1,000 lb.
Stryker
800/787-9537
www.strykermedical.com
Bariatric stretchers.

Bariatric surgical tables
Getinge USA
800/475-9040
www.getingeusa.com
Maquet Alphamaxx surgical table with 1000-lb patient weight capacity designed for patient ergonomics with full articulation in normal and reverse orientation.
Skytron
800/759-8766
www.skytron.us/
Hercules 6500HD bariatric/general purpose surgical table provides full body imaging capability for advanced procedures, including 1,000-lb lift, 850-lb articulation, and 180-degree top rotation. Optional table side extensions.
Steris Corporation
800/548-4873
www.steris.com
Bariatric table extensions for Amsco 3080/3085 SP surgical tables rated for patients up to 1000 lb.
Stryker
800/787-9537
www.strykermedical.com
Bariatric surgical tables.
Trumpf Medical Systems
843/534-0606
www.us.trumpf-med.com
Titan surgical table has a 1,000-lb capacity. It is fully articulated, modular, split leg, and mobile with complete longitudinal movement and extreme low-height adjustment.

Bariatric wheelchairs
Gendron
800/537-2521

www.gendroninc.com
The Regency XL 2000 wheelchairs hold patients from 600-lbs to 850-lbs and have seat configurations from 20 inches to 32 inches wide and from 18 inches to 22 inches deep. The chairs also are available in a bariatric recliner modes featuring power assist manual recline. Gendron also has bariatric beds, stretchers, shower and commode chairs, and patient lifts.
Wheelchairs of Kansas
800/537-6454
www.wheelchairsofkansas.com
Bariatric products such as wheelchairs, beds, lifts, and walkers.

Source: OR Manager, Inc. www.ormanager.com. 800/442-9918, used with permission.

Directions for Submitting Your Post Test for Contact Hours

To obtain a certificate of completion for this home study program, please complete the post-test and evaluation on the next few pages. The date on your certificate of completion will be the date that your home study is received. **Any materials received with a postmark after the expiration will be discarded.**

HealthEast, HCMC, & MVAMC Employees

If you are an employee of HealthEast, HCMC, or MVAMC, you may send the post-test and evaluation to TCHP for processing. Your post-test will be returned to you through your hospital. It cannot be mailed to your home.

Paid Participants

If you are not an employee of one of the TCHP hospitals, please send the post-test and evaluation to TCHP with a check for $12.00. Please make check payable to **TCHP Education Consortium** and mail to:

TCHP Education Consortium
Capitol Office Building
525 Park Street, Suite 120
St. Paul, MN 55103

Your post-test will be returned to you with the certificate of completion.

Management of the Obese Patient Post- Test

Please print all information clearly and sign the verification statement:

Name_____
(please print legal name above)

Birth date (required)								
Format: 01/03/1999	**M**	**M**	**D**	**D**	**Y**	**Y**	**Y**	**Y**

For HealthEast, HCMC, or MVAMC, employees only:
Hospital _____Unit_____

Personal verification of successful completion of this educational activity (required):
I verify that I have read this home study and have completed the post-test and evaluation.

_____
Signature

1) Morbid obesity is defined as:
   a) BMI more than 40
   b) Greater than 40 lbs. overweight
   c) Waist circumference more than 40
   d) Death caused by being overweight

2) The term bariatric refers to:
   a) A field of medicine that studies obesity
   b) A patient who has taken barium in x-ray
   c) The study and care of patients who are morbidly obese.
   d) Both A & C

3) Obesity increases the risk of morbidity from all of the following *except*:
   a) Type-2 diabetes
   b) Osteoarthritis
   c) Bunions
   d) Coronary artery disease

4) Waist circumference is a useful tool to measure in people who are:
   a) Normal weight
   b) Overweight (BMI <35)
   c) Morbidly obese
   d) Both A & B
   e) All of the above

5) The metabolic syndrome is a term used to describe a group of disorders including:
   a) HDLs more than 40 mg/dL
   b) Low blood sugar
   c) High waist circumference
   d) All of the above

6) Which statement about airway management in the obese patients is false?
   a) Bagging by mask may be difficult
   b) A tracheostomy will make it much easier to manage the patient's airway
   c) Obstructive sleep apnea is a common problem

7) Which statement about medications in the obese patient is false?
   a) Obese patients who have had anesthesia are at risk for resedation
   b) Opioids and sedatives should be titrated to the desired effect
   c) Dosing is always done in mg/kg

Expiration date: The last day that post tests will be accepted for this edition is **December 31, 2017**—your envelope must be postmarked on or before that day.

Management of the Obese Patient Evaluation

Please complete the evaluation form below by placing an "X" in the box that best fits your evaluation of this educational activity. Completion of this form is required to successfully complete the activity and be awarded contact hours.

At the end of this home study program, I am able to:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Define the terms overweight, obese and morbidly obese.					
2. Identify health conditions common to those who are overweight.					
3. Describe nursing interventions specific to the obese patient.					
4. Identify common bariatric surgical procedures.					
5. The teaching / learning resources were effective. *If not, please comment:*					

The following were disclosed in writing prior to, or at the start of, this educational activity (please refer to the first 2 pages of the booklet).	Yes	No
6. Notice of requirements for successful completion, including purpose and objectives		
7. Conflict of interest		
8. Disclosure of relevant financial relationships and mechanism to identify and resolve conflicts of interest		
9. Sponsorship or commercial support		
10. Non-endorsement of products		
11. Off-label use		
12. Expiration Date for Awarding Contact Hours		
13. Did you, as a participant, notice any bias in this educational activity that was not previously disclosed? *If yes, please describe the nature of the bias:*		

14. How long did it take you to read this home study and complete the post test and evaluation:
_____hours and _____minutes.

15. Did you feel that the number of contact hours offered for this educational activity was appropriate for the amount of time you spent on it?
____Yes
____No, more contact hours should have been offered
____No, fewer contact hours should have been offered.

Expiration date: December 31, 2017