Cardiopulmonary Anatomy and Physiology (RSPT 1207)

Credit: 2 semester credit hours (2 hours lecture, 1 hour lab)

Prerequisite: RSPT 1201

Co-requisite: RSPT 1113, RSPT 1329, RSPT 1207, RSPT 2310, RSPT 1325

Course Description

An introduction to the anatomy and physiology of the cardiovascular and pulmonary systems.

Required Textbook and Materials

1. Cardiopulmonary Anatomy and Physiology by DesJardin- 5th edition,
   a. (ISBN # 978-1-4180-4278-3)
2. #2 pencils
3. Package of #882 scantrons
4. Calculator

Course Objectives

Upon completion of the course the student will be able to:

1. Describe and explain normal cardiopulmonary anatomy and physiology. (SCANS: F1.5, F3.5, F4.5, F7.3, F10.5, F12.4, C5.4, C6.4, C7.4)
2. Describe/explain and use calculated values to assess/identify the functioning of the cardiopulmonary system.
   (PAO2, P(A-a)D02, CaO2, Cvo2, C(a-v)O2,Qs/Qt, PVR, SVR, QT, Ve, Vd/Vt)
   (SCANS: F1,F2,F3,F7,F10,C5,C7,C15,)

SCANS Skills and Competencies

Beginning in the late 1980's, the U.S. Department of Labor **S**ecretary's **C**ommission on **A**chieving **N**ecessary **S**kills (SCANS) conducted extensive research and interviews with business owners, union leaders, supervisors, and laborers in a wide variety of work settings to determine what knowledge workers needed in order to perform well on a job. In 1991 the Commission announced its findings in *What Work Requires in Schools.* In its research, the Commission determined that "workplace know-how" consists of two elements: foundation skills and workplace competencies.

Course Outline

A. Anatomy and physiology of the respiratory system
   1. Upper airway
      a. Structure
      b. Function

2. Lower airway
    a. Tracheobronchial tree (cartilaginous and non-cartilaginous)
        1. Structure
        2. Function
3. Lung segnments
4. Bronchial blood supply
5. Sites of gas exchange
6. Pulmonary vascular system
7. Lymphatic system
8. Neural control
9. The thorax
10. Muscles of ventilation
11. Accessory muscles of ventilation

B. Ventilation
1. Pressure differences
2. Diaphragm
3. Compliance
4. Hooks law
5. Surface tension
6. Poiseuille's Law
7. Airway resistance
8. Ventilatory Patterns
9. Alveolar ventilation
10. Deadspace ventilation

C. Diffusion of Pulmonary gases
1. Gas Laws
2. Atmospheric gases
3. Partial Pressure
4. PAO2
5. Movement across the alveolar-capillary membrane
6. Perfusion limited
7. Diffusion limited
8. Conditions that decrease the rate of gas diffusion

D. Anatomy and physiology of the circulatory system
1. The blood
2. The heart
    a. Structure
    b. Function
    c. Blood supply
    d. Blood flow thru
    e. Cardiac output
3. Pulmonary and systemic vascular system
    a. Neural control
    b. Receptors
    c. Blood pressure
    d. Mean arterial blood pressure

    e. Vascular resistance
  4. Distribution of blood flow

E. Oxygen transport
  1. Oxygen dissolved in blood
    a. Calculation
    b. Normal/abnormal value
  2. Oxygen bound to hemoglobin
    a. Calculation
    b. Normal/abnormal value
  3. Total oxygen content
    a. arterial
    b. venous
  4. Content difference
    a. Normal
    b. Abnormal
    c. Factors that increase and decrease C(a-v)O2
  5. Oxyhemoglobin dissociation curve
    a. Factors affecting affinity
    b. P50
  6. Oxygen consumption
    a. Calculation
    b. Factors affecting
  7. Oxygen extraction ratio
    a. Calculation
    b. Factors affecting
  8. Saturation
    a. Arterial
    b. Venous
      1. Factors increasing SvO2
      2. Factors decreasing SvO2
  9. Shunting
    a. Anatomic shunts
    b. Capillary shunts
    c. Calculation of shunts
  10. Hypoxia
    a. Types of hypoxia
    b. Causes of hypoxia
  11. Cyanosis
  12. Polycythemia

F. Ventilation/ perfusion relationships
  1. Normal pulmonary capillary blood flow
  2. Normal alveolar ventilation
  3. Ventilation perfusion ratio
    a. Increased ratio
    b. Decreased ratio

4. How the V/Q ratio affects capillary gases
5. How respiratory disorders affect the V/Q ratio

G. Control of Ventilation
   1. The medulla oblongata
      a. Dorsal respiratory groups
      b. Ventral respiratory groups
   2. The pontine respiratory centers on the medulla oblongata
   3. Central Chemoreceptors
      a. Location
      b. Stimulation
   4. Peripheral Chemoreceptors
      a. Location
      b. Stimulation
   5. Reflexes
      a. Hering-breur
      b. Deflation
      c. Irritant
      d. Juxtapulmoanry-capillary receptors
      e. Peripheral proprioceptor reflexes
      f. Hypothalamic control
      g. Cortical control
      h. Aortic and carotid sinus baroreceptors

H. Carbon dioxide transport and acid- base balance
   1. Carbon dioxide transport in the plasma
   2. Carbon dioxide transport in the red blood cell
   3. Carbon dioxide elimination at the lungs
   4. Carbon dioxide dissociation curve
   5. Acid base balance
   6. Buffer systems
   7. The respiratory system effects on acid base balance
      a. Respiratory acidosis
         1. Interpretation
         2. Causes
         3. Compensation
      b. Respiratory alkalosis
         1. Interpretation
         2. Causes
         3. Compensation
   8. The renal system effects on the acid base balance
      a. Metabolic acidosis
         1. Interpretation
         2. Causes
         3. Compensation
      b. Metabolic alkalosis
         1. Interpretation
         2. Causes

3. Compensation

I. Renal failure and it's effects of the cardiopulmonary system
   1. The kidneys
      a. Function
      b. Structure
      c. Urine formation
   2. Regulation of electrolytes
   3. Renal failure
      a. Causes
      b. Classification
      c. Cardiopulmonary disorders caused by renal failure

Grade Scale

93 – 100	A
85 – 92	B
77 – 84	C
68 – 76	D
0 – 67	F

Course Evaluation

Final grades will be calculated according to the following criteria:

4 Exams	85%
Lab(assignments and homework)	15%

Course Requirements

1. Egan Workbook
   a. Chapters:
      i. 8 The Respiratory System
      ii. 9 The Cardiovascular System
      iii. 10 Ventilation
      iv. 11 Gas Exchange and Transport
      v. 13 Acid-Base balance
      vi. 14 Regulation of breathing

Course Policies

1. No food or drink, or use of tobacco products in class
2. Beepers, telephones, headphones, and other electronic devices must be turned off while in class
3. No children allowed in the classroom
4. No late assignments will be accepted
5. Abide by LIT policies

6. Abide by policies within the Respiratory Care Handbook
7. Abide by instructor specific policies; this will be distributed on the first class day.
8. Exam dates will be distributed the first class day.

Disabilities Statement

The Americans with Disabilities Act of 1992 and Section 504 of the Rehabilitation Act of 1973 are federal anti-discrimination statutes that provide comprehensive civil rights for persons with disabilities. Among other things, these statutes require that all students with documented disabilities be guaranteed a learning environment that provides for reasonable accommodations for their disabilities. If you believe you have a disability requiring an accommodation, please contact the Special Populations Coordinator at (409) 880-1737 or visit the office in Student Services, Cecil Beeson Building.

Course Schedule:

Week	Topic	Required Reading
1	Anatomy and Physiology of the Respiratory System	DesJardin Chapter 1 Egan Chapter 8
2	Anatomy and physiology of the Respiratory System	DesJardin Chapter 1 Egan Chapter 8
3	Ventilation	DesJardin Chapter 2 Egan Chapter 10
4	Test #1- Homework Ch8,10 due/ Diffusion	DesJardin Chapter 3
5	Diffusion / Oxygen transport	DesJardin Chapter 6
6	Oxygen transport	DesJardin Chapter 6
7	Oxygen transport /Test #2-	DesJardin Chapter 6
8	Ventilation and perfusion	DesJardin Chapter 8
9	Control of ventilation	DesJardin Chapter 9 Egan Chapter 14
10	Anatomy and physiology of the circulatory system	DesJardin Chapter 5 Egan Chapter 9 Egan Chapter 14
11	Test #3-Egan Chapter 9 and 14 due/ Kidneys	DesJardin Chapter 16 Egan Chapter 11 and 13
12	Renal failure	DesJardin Chapter 16
13	Carbon Dioxide transport	DesJardin Chapter 7 Egan Chapter 11 and 13
14	Acid base Balance	DesJardin Chapter 7 Egan Chapter 11
15	Acid base Balance	DesJardin Chapter 7 Egan Chapter 11
16	Review and Final (Test #4)-Egan Chapter 11and 13 due	

Exact exam dates will be distributed on the first class day. This scheduled may be adjusted to facilitate student learning.

Lab schedule:

Week	Topic	Assignment
1	Round table discussion of upper airway problems. PP over upper airway	DesJardin Chapter 1 Egan Chapter 8
2	Identifying the lobes and segnments of the lungs	DesJardin Chapter 1 Egan Chapter 8
3	Calculation of PAo2, P(A-a) O2	DesJardin Chapter2 Egan Chapter 10
4	Calculate Cao2, Cvo2, C(a-v) O2	DesJardin Chapter 3
5	Calculate compliance (Cs, Cd)	DesJardin Chapter 6
6	Calculate RAW	DesJardin Chapter 6
7	Calculate Qt, Qs/Qt	DesJardin Chapter 6
8	Calculate V/QVe,	DesJardin Chapter 8
9	Calculate Ve, Vd/Vt	DesJardin Chapter 9 Egan Chapter 14
10	Identifying blood flow and coronary vessels	DesJardin Chapter 5 Egan Chapter 9 Egan Chapter 14
11	Calculate Qt,MAP,PVR,SVR	DesJardin Chapter 16 Egan Chapter 11 and 13
12	Calculate aniongap	DesJardin Chapter 16
13	Ph	DesJardin Chapter 7 Egan Chapter 11 and 13
14	ABG interpretation	DesJardin Chapter 7 Egan Chapter 11
15	ABG interpretation	DesJardin Chapter 7 Egan Chapter 11
16	ABG interpretation	DesJardin Chapter 7 Egan Chapter 11

SPECIFIC OBJECTIVES:
The Anatomy of the Respiratory System
Upon completion of this course the student will be able to:

1. List/identify the three major components of the upper airway: Nose, oral cavity and pharynx.
2. Identify/list the three primary functions of the upper airway: Conductor of air, prevent aspiration and the area for speech and smell.
3. Identify/ list the three primary functions of the nose
4. Identify the structures that form the outer portion of the nose.
5. Identify the structures that the internal portion of

6. Identify the structures that form the oral cavity.
7. Identify the location/ structure/function of the nasopharynx, oropharynx and laryngopharynx.
8. Identify the cartilages of the larynx.
9. Identify the structure and function of the interior portion of the larynx.
10. Identify the structure and function of the laryngeal muscles.
11. Describe the ventilatory functions of the larynx.
12. Describe/identify/label the histology of the tracheobronchial tree.
13. Identify the location (generation) and the structure of the cartilaginous airways.
14. Identify the location (generation) and the structure of non-cartilagionous airways.
15. Describe how the cross-sectional area of the tracheobronchial tree changes from the trachea to the terminal bronchioles.
16. Describe the structure and function of the following components of the bronchial blood supply.
17. Describe the structure and function of the sites of gas exchange.
18. Discuss/describe the structure and function of the alveolar epithelium.
19. Describe the structure and function of the components of the pulmonary vascular system.
20. Describe the structure and function of the components of the lymphatic system.
21. Describe how the following components of the autonomic nervous system relate to the neural control of the lungs.
22. Identify the effect the sympathetic and parasympathetic nervous system have on the following: heart, bronchial smooth muscle, bronchial glands, stomach, intestines, and eyes.
23. Identify the structure of the lungs.
24. Identify the lung segments from the anterior, posterior, lateral, and medial views.
25. Identify the components of the mediastinum.
26. Identify the components of the pleural membranes.
27. Identify the components of the thorax.
28. Describe/identify the structure and function of the diaphragm.
29. Describe the structure and function of the following accessory muscles of the inspiration.
30. Describe the structure and function of the accessory muscles of expiration.

Ventilation

Upon completion of this course the student will be able to:

1. Define ventilation.
2. Differentiate between the pressure differences across the lungs.
3. Describe/identify the role of the diaphragm in ventilation.
4. Explain how the excursion of the diaphragm effects the intrapleural pressure, intra-alveolar pressure, and bronchial gas flow during inspiration, end-inspiration, expiration and end-expiration.
5. Define/calculate and interpret static lung compliance.
6. Define/calculate and interpret lung compliance
7. Explain how Hooke's law can be applied to the elastic properties of the lungs.
8. Define surface tension.

9. Describe the physical principles of Laplace's law.
10. Describe how Laplace's law can be applied to the alveolar fluid lining.
11. Explain how pulmonary surfactant offsets alveolar surface tension.
12. Define the term dynamic.
13. Describe how Poiseuille's law can be rearranged to simple proportionalities.
14. Describe how Poiseuille's law arranged for pressure relates to the radius of the bronchial airways.
15. Describe how Poiseuille's law can be rearranged to simple proportionalities.
16. Define/calculate airway resistance and explain how it relates to laminar flow and turbulent flow.
17. Define time constants and explain how they relate to alveolar units with increased airway resistance and decreased compliance.
18. Define dynamic compliance and explain how it relates to increased airway resistance and frequency dependence.
19. Define dynamic compliance and explain how it relates to increased airway resistance and frequency dependence.
20. Differentiate between alveolar ventilation and deadspace ventilation, and include an explanation of deadspace.
21. Describe how deep breathing and the rate of breathing affects the total alveolar ventilation.
22. Calculate an individual's total alveolar ventilation in one minute when given alveolar ventilation, deadspace ventilation and breaths per minutes.
23. Describe how the normal intrapleural pressure differences cause regional differences in normal ventilation.
24. Describe how decreased lung compliance and increased airway resistance alters the ventilatory pattern (i.e., the respiratory rate and tidal volume).
25. Define specific ventilatory patterns.

The Diffusion of Pulmonary Gases

Upon completion of this course the student will be able to:

1. Define diffusion.
2. Identify the percentage and partial pressure of the gases that compose the barometric pressure.
3. Identify the partial pressure of the gases in the air, alveoli, and blood.
4. Name/ label the nine major structures of the alveolar-capillary membrane that a gas molecule must diffuse through.
5. Describe how oxygen and carbon dioxide normally diffuse across the alveolar-capillary membrane.
6. Explain how Fick's law relates to gas diffusion.
7. Describe how Henry's law and Graham's law relate to the diffusion constants in Fick's law.
8. Describe how Fick's law can be applied to certain clinical conditions.
9. Define the meaning of perfusion limited, and explain how it relates to a gas like nitrous oxide.
10. Define the meaning of diffusion limited, and explain how it relates to a gas like carbon monoxide

11. Describe how oxygen can be classified as perfusion or diffusion limited.
12. Describe the effects of high pressure, low pressure (altitude), Fio2, Paco2 levels have on the PAO2

The Circulatory System

Upon completion of this course the student will be able to:

1. Describe the function of the following specialized cells of the plasma: Erythrocytes, Leukocytes, Thrombocytes.
2. List/ identify the chemical components of plasma.
3. Describe the structure and function of the following components of the heart: Inferior and Superior Venae Cavae, Right and Left Atria, Right and Left Ventricles, Pulmonary Trunk, Pulmonary Arteries, Pulmonary Veins, Tricuspid Valve, Bicuspid Valve (mitral valve), Pulmonary Semilunar Valve, Aortic Semilunar Valve, Chordae Tendinea, Papillary Muscles.
4. Describe/trace/identify blood flows through the heart.
5. Identify the major blood vessels that nourish the heart.
6. Describe the location and function of the following components of the conduction system of the heart: Sinoatrial node, Atrioventricular node, Bundle of his, Right and Left bundle branches, Purkinje fibers.
7. Explain how the following components of the autonomic nervous system coordinate the moment-to-moment rhythmicity of the heart: Cardio-inhibitor center, Cardio-accelerator center.
8. Describe the following components of the pulmonary and systemic vascular systems: Arteries, Arterioles, Capillaries, Venules, Veins.
9. Explain the neural control of the vascular systems.
10. Describe the function of the baroreceptors.
11. Define the following types of pressures: Intra-vascular pressure, Transmural pressure, Driving pressure.
12. Describe how the following relate to the cardiac cycle and blood pressure: Ventricular systole, Ventricular diastole.
13. List the intra-luminal blood pressures throughout the pulmonary and systemic vascular systems.
14. Describe how blood volume affects blood pressure, and include the following: Stroke volume, Heart rate, Cardiac output.
15. Identify the percentage of blood found throughout the various parts of the pulmonary systemic systems.
16. Describe the influence of gravity on blood flow, and include how it relates to: Zone 1, Zone 2, and Zone 3.
17. Define the following determinants of cardiac output: Ventricular preload, Ventricular afterload, Myocardial contractility.
18. Define vascular resistance.
19. Describe how the following affect of the pulmonary vascular resistance: Active mechanisms and Passive mechanisms.
20. List the abbreviations and normal ranges of the following hemodynamic values directly measured by means of the pulmonary artery catheter: Central venous

pressure, Right atrial pressure, Mean pulmonary artery pressure, Pulmonary capillary wedge pressure, Cardiac output.

21. List the abbreviations and normal ranges of the following computed hemodynamic values: Stroke volume, stroke volume index, Cardiac index, Right ventricular stroke work index, Left ventricular stroke work index, Pulmonary vascular resistance, Systemic vascular resistance.
22. List factors that increase and decrease the following: Stroke volume, Stroke volume index, Cardiac output, Cardiac index, Right ventricular stroke work index, Left ventricular stroke work index.
23. List the factors that increase and decrease the pulmonary vascular resistance.
24. List the factors that increase and decrease the systemic vascular resistance.

Oxygen Transport

Upon completion of this course the student will be able to:

1. Calculate the quantity of oxygen that dissolves in the plasma of the blood.
2. Describe the major features of hemoglobin.
3. Calculate the quantity of oxygen that combines with hemoglobin.
4. Calculate the total amount of oxygen in the blood.
5. Identify the abbreviations for oxygen content of arterial blood, oxygen content of mixed venous blood and oxygen content of capillary blood.
6. Describe how the following relate to the oxygen dissociation curve: oxygen pressure, percentage of hemoglobin bound to oxygen and oxygen content.
7. Describe the clinical significance of the flat portion of the oxygen dissociation curve and P50.
8. Identify the factors that shift the oxygen dissociation curve to the right.
9. Identify the factors that shift the oxygen dissociation curve to the left.
10. Explain the clinical significance of a right or left shift of the oxygen dissociation curve in regard to the loading of oxygen in the lungs and unloading of oxygen at the tissues.
11. Calculate /interpret the following oxygen transport studies: Total oxygen delivery, arterial-venous oxygen content difference, oxygen consumption, oxygen extraction ration and pulmonary shunting.
12. Identify the factors that increase and decrease the oxygen transport studies.
13. Differentiate between the following forms of pulmonary shunting: Anatomic shunt, Capillary shunt and shunt-like effect.
14. Describe the clinical significance of intrapulmonary shunting.
15. Define the following four main types of tissue hypoxia: Hypoxic hypoxia, anemic hypoxia, Circulatory hypoxia and Histotoxic hypoxia.
16. Explain the meaning of cyanosis and polycythemia.

Carbon Dioxide Transport and Acid-Base Balance

Upon completion of this course the student will be able to:

1. List the three ways in which carbon dioxide is transported in the plasma.
2. List the three ways in which carbon dioxide is transported in the red blood cells.
3. List how carbon dioxide is converted to HCO3 at the tissue sites and transported in the plasma to the lungs.

4. Explain how carbon dioxide is eliminated at the lungs.
5. Describe how the carbon dioxide dissociation curve differs form, the oxygen dissociation curve.
6. Explain how the Haldan effects relates to the carbon dioxide dissociation curve.
7. Define the meaning of: electrolytes, buffer, strong acid, weak acid, weak base, strong base, dissociation constant and pH.
8. List the three major mechanisms that maintain the narrow pH range.
9. Describe the components of the Henderson-Hasselbalch equation.
10. Explain how the Pco2, HCO3, and pH levels change in the following respiratory acid-base imbalances: Acute ventilatory failure, Chronic ventilatory failure and Renal compensation, Acute alveolar hyperventilation, and Chronic Alveolar hyperventilation and Renal compensation.
11. Describe how the Pco2, HCO3, and pH levels change in the following metabolic acid-base imbalances: Metabolic acidosis, Chronic metabolic acidosis and Respiratory compensation, and Metabolic alkalosis.

Ventilation-Perfusion Relationships
Upon completion of this course the student will be able to:

1. Define ventilation-perfusion ration.
2. Describe the overall ventilation-perfusion ration in the normal upright lung.
3. Explain how the ventilation-perfusion ratio progressively changes from the upper to the lower lung regions in the normal, upright lung.
4. Describe how an increased and decreased ventilation-perfusion ratio affects the alveolar gases.
5. Describe how the ventilation-perfusion ratio affects the end-capillary gases and the pH level.
6. Define the respiratory quotient and respiratory exchange ratio.
7. Identify respiratory disorders that increase the ventilation-perfusion ratio.
8. Identify respiratory disorders that decrease the ventilation-perfusion ratio.

Control of Ventilation
Upon completion of this course the student will be able to:

1. Describe the function of the following respiratory neurons of medulla oblongata: The dorsal respiratory group and the ventral respiratory group.
2. Describe the influence of the following pontine respiratory centers on the respiratory neurons of the medulla oblongata: Apneustic center and Pneumotaxic center.
3. List conditions that can depress the respiratory neurons.
4. Describe how the following regulate the respiratory neurons: Central chemoreceptors, peripheral chemoreceptors and reflexes that influence ventilation.

Renal Failure and its Effects on the Cardiopulmonary System
Upon completion of this course the student will be able to:

1. Describe how the following relate to the kidneys: Hilum, ureters, cortex, medulla, renal pelvis, major calyces, minor calyces, renal papillae, renal pyramid and nephron.
2. Describe how the following relate to the nephron: Glomerulus, Bowman's capsule, renal corpuscle, proximal convoluted tubule, descending limb of the loop of Henle, ascending limb of the loop of Henle, Distal convoluted tubule and collecting duct.
3. Describe how the following blood vessels relate to the nephron: Renal arteries, interlobular arcuate arteries, afferent arterioles, efferent arterioles, peritubular capillaries, interlobularveins, and renal vein.
4. Describe the role of the following in the formation of urine: Glomerular filtration, tubular reabsorption and tubular secretion.
5. Describe the role of the following in the control of urine concentration and volume: Countercurrent mechanism and selective permeability.
6. Describe the role of the kidneys in the regulation of the following: Sodium, potassium, calcium, magnesium, phosphate and acid-base balance.
7. Describe the role of capillary fluid shift system and the renal system in controlling the blood volume.
8. Identify common causes of renal disorders, including congenital disorders, infections, obstructive disorders, inflammation and immune responses and neoplasms.
9. Identify the causes of renal disorders of pre-renal conditions, intra-renal conditions and post-renal conditions.
10. Describe how mechanical ventilation alters urinary output.
11. Describe cardiopulmonary problems that can develop with renal failure including the following: Hypertension and edema, metabolic acidosis, electrolyte abnormalities, anemia, bleeding and cardiovascular problems.

Contact Information:

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