Continuous Positive Airway Pressure (CPAP)

Paramedic Learner Package
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Introduction & Expectations

Welcome to the Paramedic CPAP Certification pre-course package. The information that follows reflects the specific educational needs of your service in relation to CPAP in accordance with SWORBHP practices and standards.

There are 4 components to your Learner Package – The Pre-Course Reading, Self Directed Scenarios, Self Assessment Quiz and Quiz Answer Key. You are responsible for reviewing the Learner Package and the respective protocols in detail prior to attending your certification day (see the most current Medical Directives at www.lhsc.on.ca/bhp ). The certification day will review some but not all of the information in this package. The in-class session will include an instructor-led lecture/discussion to highlight the key learning points, and will provide you with an opportunity to practice the required skills.

Incorporated into this learner package is a self-assessment quiz. Please use this quiz to challenge yourself and follow up by reviewing the provided answers. You are not required to submit your answers during your certification. During the in-class session, you will be required to successfully complete a skills review, and a written evaluation of knowledge.

If you have any questions or comments about the contents of this learner package, do not hesitate to contact the Southwest Ontario Regional Base Hospital.

Learning Objectives

Given a pre-course package, in-class lecture/discussion, and hands-on practice with a CPAP device and simulated patient, the paramedic will be able to:

1. Describe the anatomy and physiology of the adult respiratory system,
2. Relate the pathophysiology of the common causes of respiratory distress in the adult (Pulmonary Edema, COPD, Asthma and Pneumonia),
3. Explain the applications, benefits and potential complications of CPAP,
4. Identify patients who qualify for application of CPAP as per the current Medical Directive,
5. Demonstrate the appropriate application of CPAP to patients presenting with shortness of breath as per the current CPAP medical directive,

as evaluated by the educator using an in-class practical skills assessment and written evaluation of knowledge (70% pass-mark).
Review of Airway Anatomy/Physiology

The upper airway consists of the nose, mouth, pharynx and larynx, and is responsible for filtering, warming and humidifying air on inspiration. Air then travels into the lower airway which consists of the trachea, bronchi, bronchioles, and alveoli. Inhalation and exhalation are dependant on the pressure gradient between atmospheric pressure and intrathoracic pressure. When intrathoracic pressure is lower than atmospheric pressure and the diaphragm is relaxed, the pressure gradient causes inhalation. Also, when intrathoracic pressure is higher than atmospheric pressure and the diaphragm is contracted, the pressure gradient causes exhalation. The alveoli, air filled sacs that provide a flexible surface for gas exchange, are lubricated with surfactant to prevent alveolar collapse. The alveoli expand during inhalation increasing the amount of surface area available for gas exchange and contract during exhalation. Gas exchange occurs between the alveolar membrane and the pulmonary capillary beds where oxygen is delivered to red blood cells (to be carried throughout the body and delivered to tissues) and carbon dioxide is removed from systemic circulation and expelled during exhalation.

Patients complaining of shortness of breath requiring paramedic care are often experiencing the signs and symptoms of poor compliance, fluid accumulation or an obstructed airway. Compliance describes the extent to which the lungs are able to expand under the pressure of inhalation. In the case of a COPD exacerbation where a patient suffers from bronchoconstriction and alveolar collapse, increased pressure (as delivered via CPAP) can open the airways and increase compliance. Pulmonary Edema (fluid in the lungs) may be due to several etiologies including Congestive Heart Failure, drowning, aspiration and so on. This fluid inhibits air from passing through the respiratory system and reaching the alveolar membrane in order for gas exchange to occur, resulting in decreased respiration.

Overview of CPAP

Historically, CPAP (Continuous Positive Airway Pressure) has been strictly limited to use in the hospital setting, however recent literature has provided evidence of effective and successful use in the pre-hospital emergency setting. CPAP is a method of non-invasive ventilator support in which the patient breathes through a mask against positive pressure held constant throughout the respiratory cycle (in contrast to BiPAP which provides a high inspiratory positive airway pressure but a low expiratory positive airway pressure). This continuous positive airway pressure is maintained during both inhalation and exhalation and has been shown to have several benefits. This continued airway pressure is created by a flow restriction device at the exhalation port of the mask. This device acts to maintain
pressure much like Positive End Expiratory Pressure (PEEP) in patients with Acute Respiratory Distress Syndrome (ARDS).

CPAP has been shown not only to improve patient outcome but also to decrease the need for intubation and therefore the multitude of complications associated with ETI\(^2\). The ability to assess a patient accurately and quickly to determine the need for CPAP is a key point to ensuring positive patient outcomes. Those patients presenting with signs and symptoms consistent with an exacerbation of COPD or acute pulmonary edema have the potential for significant improvement if CPAP is applied correctly. It is vitally important that paramedics be able to differentiate between the most common causes of respiratory distress in the adult: COPD, pulmonary edema, pneumonia, and asthma\(^2\). Patients presenting with signs and symptoms consistent with a COPD exacerbation or pulmonary edema due to CHF will be treated with CPAP, whereas those patients presenting with signs and symptoms consistent with pneumonia and/or asthma will not be treated with CPAP.

Continuous Positive Airway Pressure effectively improves lung mechanics, gas exchange and oxygenation by recruiting atelectatic alveoli (forcing alveoli open, thereby increasing surface area and preventing alveolar collapse), improving pulmonary compliance (by splinting airways open to increase gas exchange), increasing functional residual volume, and reducing the work of breathing\(^3\). At the same time, and particularly in patients with Congestive Heart Failure, CPAP reduces preload and afterload by reducing venous return to the left ventricle. An increase in intrathoracic pressure and diminished transpulmonary blood flow, results in enhanced left ventricular function\(^4\)\(^3\)\(^5\). The effect of CPAP on the patient suffering from respiratory distress is a decrease in respiratory rate, heart rate and blood pressure\(^2\), an elevation of SpO\(_2\), and relief of anxiety, stress and work of breathing\(^3\). As stated above, it is crucial to differentiate between the common causes of respiratory distress in order to determine whether CPAP is the appropriate treatment plan for a patient. A brief review of each of the common causes of shortness of breath is found below.

**Causes of Respiratory Distress**

**COPD**

Chronic Obstructive Pulmonary Disease is a term used to describe either, or a combination of two respiratory diseases: Chronic Bronchitis and Emphysema. COPD is most often caused by repeated exposure to a respiratory irritant such as cigarette smoke, environmental pollutants, or recurring infections. Chronic Bronchitis is evidenced by chronic inflammation of the bronchi as a result of scarring and increased mucous production. Patients exhibiting signs and symptoms consistent with Chronic Bronchitis
present with a chronic cough, low blood oxygen levels and crackles on auscultation. These patients are labeled ‘blue bloaters’ due to their commonly overweight and cyanotic appearance. Emphysema is an abnormal increase in the size of the alveoli and destruction of alveolar walls resulting in a loss of surface area and therefore a decrease in gas exchange. Emphysemic patients are thin, have barrel chests and often hyperventilate in an attempt to maintain normal SpO₂ levels. These patients are labeled ‘pink puffers’ and lung sounds seem distant upon auscultation. In either of the above two conditions, it is often a common respiratory infection that will trigger an exasperation of COPD and possibly respiratory failure. During a COPD exacerbation, terminal bronchioles collapse during exhalation leading to air trapping in the alveoli. CPAP will force these collapsed bronchioles to open and return to the function of gas exchange.

**Pulmonary Edema (as associated with CHF)**

Left ventricular failure is most often caused by heart disease related to hypertension and ischemia. The left ventricle fails to pump blood effectively to the body resulting in increased end diastolic volume and pressure. This excess pressure is forced back through the left atrium, pulmonary veins and pulmonary capillaries. The increased pressure in the pulmonary capillaries forces the plasma portion of blood into the alveoli causing the accumulation of fluid in the lungs. Pulmonary edema effectively reduces gas exchange resulting in hypoxia. Clinical signs and symptoms associated with acute pulmonary edema include the acute onset of shortness of breath, SpO₂ < 90%, crackles on auscultation and the typical upright sitting positioning. Patients presenting with acute pulmonary edema will benefit from treatment with CPAP as the constant pressure causes fluids to be ‘pushed back’ into systemic circulation.

**Pneumonia**

Pneumonia is another potential cause of respiratory distress and is attributed to an infection in the lungs; bacterial, fungal or viral in origin. The alveoli affected may become pus filled resulting in decreased gas exchange. As well, bronchioles may become inflamed causing pain. Patients suffering from pneumonia may present with tachypnea, fever, localized chest pain, or productive cough. These patients will not be treated with CPAP.

**Asthma**

Asthma is the result of an adverse reaction to a stimulus resulting in the contraction of smooth muscle and mucous production in the bronchioles. Stimuli such as an allergen, stress, exercise, and cold weather may cause this increased responsiveness of the bronchi and bronchioles, resulting in bronchoconstriction and mucosal edema. Patients experiencing an asthma attack will present with high pitch wheezing on expiration,
tachycardia, tachypnea, positional breathing and in severe cases, cyanosis and Status Asthmaticus (severe asthma attack that is unresponsive to bronchodilators lasting several hours). The use of CPAP for acute asthma has not been well documented in the pre-hospital setting. CPAP in the treatment of an asthma attack may cause increased air trapping and increased intra thoracic pressure, or irritation of the bronchioles further potentiating signs and symptoms. A patient suffering from asthma is in need of treatment with Salbutamol or Epinephrine depending on severity and treatment should not be delayed. As such, CPAP is not indicated for asthma, and is absolutely contraindicated in the presence of asthma exacerbation.

**Conclusion**

Studies have shown that a patient’s risk of intubation and its associated complications was reduced by 16.34% when CPAP was applied in the pre-hospital setting. A 6.6% reduction in mortality rate of these patients was also noted with the use of CPAP as compared to the use of ETI\(^2\). Keep in mind that the success of CPAP may be dependent on the paramedic’s ability to coach the patient to initially cooperate. The initial application of CPAP can easily frighten a patient, but is well tolerated with proper coaching\(^4\). If treating a patient with CPAP, administer high flow oxygen while CPAP equipment is prepared. Preparation of equipment will be demonstrated during the in class session of certification. Monitor the patient as per BLS standards while administering CPAP and discontinue use if any contraindications arise (as per in class discussion). Please refer to your EMS Service for specific CPAP equipment and its usage.
Self Directed Scenarios

Use the following scenarios to self assess your ability to differentiate between the common causes of respiratory distress and determine whether or not you would apply CPAP.

Scenario 1

You are treating a 29 year old female patient who reports she started coughing a couple hours ago and thought she was getting a cold. While walking, she became short of breath and still is, even after sitting down. She is able to talk only in three and four word sentences and her nose is flaring. Lung sounds are absent in the bases with expiratory wheezing in the upper fields; her skin is pink, warm and dry. She called EMS because she was getting tired of working so hard to breathe. Vital signs: HR 120, RR 36, BP 138/88, SpO2 95%.

- Which respiratory emergency is this patient experiencing?
- Based on your assessment, are there any contraindications for the use of CPAP?
- What is your treatment plan for this patient?

Scenario 2

You are on scene with a 70 year old female patient complaining of shortness of breath. She is sitting in a kitchen chair, leaning forward with her hands on her knees. Upon assessment, her skin is pale and diaphoretic; lung sounds are diminished in the bases with crackles present in all fields. The patient has a history of an MI, angina and HTN. She says she has pain in her back but denies any other pain. Vital signs: HR 96, RR 40, BP 182/104, SpO2 93%.

- Which respiratory emergency is this patient experiencing?
- How does CPAP affect left ventricular function?
- How is venous return affected by the use of CPAP?
- Based on your assessment, are there any contraindications for the use of CPAP?
- What is your treatment plan for this patient?

Scenario 3

You are treating a 60 year old male patient complaining of shortness of breath. He is sitting at the end of his bed, leaning forward with his hands on his knees. He is on home O2 at 2L/min. Upon assessment, his skin is pink, warm and dry; lung sounds are diminished in the bases with wheezes in all fields; his chest has equal expansion and appears barrel-shaped. He reports smoking a pack of cigarettes a day for 35 years. Vital signs: HR 88, RR 36, BP 142/88, SpO2 94%.

- Which respiratory emergency is this patient experiencing?
- What effect does CPAP have on the alveoli of this patient?
- Based on your assessment, are there any contraindications for the use of CPAP?
- What is your treatment plan for this patient?
**Scenario 4**

You are treating a 20 year old male with a history of severe asthma. He is a tall, thin track and field athlete who was exercising when he suddenly became short of breath. He is complaining of pain on his right side, and using his rescue inhaler has not improved his breathing. Upon assessment, the patient’s skin is pink, warm and dry; lung sounds are absent on the right and clear in the left upper and lower fields. Vital signs: HR 112, RR 32, BP 128/64, SpO₂.

- Which respiratory emergency is this patient experiencing?
- Based on your assessment, are there any contraindications for the use of CPAP?
- What is your treatment plan for this patient?

**Scenario 5**

You are treating a 62 year old female patient in severe respiratory distress. She has a history of CHF, COPD, hyperlipidemia and hyperthyroidism. She is sitting at the table with her hands on her knees and is leaning forward. Her skin is pale and diaphoretic; lung sounds are diminished in the bases with loud audible crackles in the upper fields; her chest is equal on expansion and she is using her accessory muscles to breathe. Vital signs: HR 100, RR 40, BP 208/110, SpO₂ 92%. While you are preparing the patient for transport, the patient’s condition worsens and she deteriorates into respiratory arrest.

- Which respiratory emergencies is this patient experiencing?
- Based on your assessment, are there any contraindications for the use of CPAP?
- What is your treatment plan for this patient?
Self Assessment Quiz

1. Which of the following is the primary pulmonary abnormality involved in congestive heart failure?
   a. Loss of elasticity of the alveoli
   b. Bronchospasm of the terminal bronchioles
   c. Fluid collection in the alveoli
   d. Poor perfusion of the lung

2. Which of the following patients may benefit from the application of CPAP?
   a. 67 year old female who suddenly became short of breath while walking to get a glass of water in the middle of the night. She is overweight, sleeps propped up on a number of pillows, has a history of MI, NIDDM and CHF. Vitals: HR 112, RR 36, BP 180/98, SpO2 93%, Auscultation: Crackles in the bases.
   b. 28 year old female who is short of breath after walking outside on a very cold winter day. She has a history of asthma but forgot her inhaler at home. Vitals: HR 102, RR 36, BP 146/96, SpO2 96%, Auscultation: Expiratory wheezing throughout.
   c. 59 year old male complaining of localized chest pain and shortness of breath. He claims he saw his family Dr. today who gave him an antibiotic. Vitals: HR 90, RR 26, BP 150/90, SpO2 96%, Auscultation: Crackles mid-left lobe.
   d. 14 year old female who was playing soccer and can’t seem to catch her breath. Her mother states she has been undergoing tests for asthma but nothing is yet confirmed. HR 120, RR 36, BP 130/86, SpO2 97%, Auscultation: Wheezing throughout.

3. CPAP works primarily by which of the following mechanisms?
   a. Reversing bronchospasm
   b. “Splinting” the lung by keeping the alveoli expanded
   c. Forcing oxygen into the blood stream
   d. Maintaining an open airway

4. As ventilation worsens, which of the following describes the differences in Oxygen and Carbon Dioxide concentrations?
   a. Oxygen saturation and carbon dioxide concentrations go up
   b. Carbon dioxide concentration and oxygen saturation go down
   c. Oxygen saturation goes up and carbon dioxide concentration gradually goes down
   d. Carbon dioxide concentration goes up and oxygen saturation gradually goes down

5. Which of the following is the primary pulmonary abnormality involved in Emphysema?
   a. Bronchospasm of the terminal bronchioles
   b. Fluid collection in the alveoli
   c. Loss of elasticity of the alveoli
   d. Poor perfusion of the lung
6. Which of the following is a potential complication associated with the treatment of asthma using CPAP?
   a. Increased gas exchange due to splinting of the alveoli
   b. Alveolar collapse leading to decreased surface area for gas exchange
   c. Increased mucous production
   d. Increased air trapping and intra thoracic pressure.

7. Which of the following represents the potential assessment findings of a patient with pneumonia?
   a. Patient complains of shortness of breath, refuses to lay down on your stretcher and auscultation reveals crackles in both bases and mid-lobes.
   b. Patient complains of shortness of breath, localized chest pain, pain on inspiration, and a productive cough; auscultation reveals crackles in the right lower lobe (near the pain).
   c. Patient complains of acute onset shortness of breath while bringing in the groceries from the car, she has tried to use her inhaler but it isn't working. Auscultation reveals wheezing in all fields.
   d. Patient complains of shortness of breath and localized chest pain. Incident history reveals signs and symptoms began immediately after sneezing. Auscultation reveals absent air entry to the left lower lobe (near the pain).

8. Which of the following indicates the primary reason for application of CPAP to patients in severe respiratory distress?
   a. Patients who receive CPAP treatment in the pre-hospital setting are less likely to require intubation.
   b. CPAP enables the paramedic to deliver a higher amount of oxygen in a shorter amount of time to patients needing high concentration oxygen.
   c. The use of CPAP enables the paramedic to be hands free as opposed to using a BVM for those patients to require assisted ventilations.
   d. CPAP treatment is faster and more effective than BVM ventilation for patients with CHF.

9. Which of the following indicates the correct path of air through the respiratory system?
   a. Nose, Larynx, Pharynx, Trachea, Bronchi, Bronchioles, Alveoli
   b. Nose, Pharynx, Larynx, Trachea, Bronchioles, Bronchi, Alveoli
   c. Nose, Larynx, Pharynx, Trachea, Bronchioles, Bronchi, Alveoli
   d. Nose, Pharynx, Larynx, Trachea, Bronchi, Bronchioles, Alveoli

10. Which of the following causes of shortness of breath would occur due to a decrease in perfusion?
    a. Pulmonary Embolism
    b. Asthma Attack
    c. Pneumonia
    d. Pulmonary Edema
Quiz Answer Key

1. C
2. A
3. B
4. D
5. C
6. D
7. B
8. A
9. D
10. A
References


