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INTRODUCTION

There's usually time for CPAP



A.J. Heightman, MPA, EMT-P Editor-in-Chief, *JEMS*

Two years ago, I attended a meeting where several EMS medical directors were discussing the implementation of continuous positive airway pressure (CPAP) in their systems. Many were already seeing the significant benefits of CPAP. One reported his system had already reduced the number of patients requiring endotracheal (ET) intubation in the field by 79%. He felt CPAP kept many elderly patients from becoming ventilator-dependent and from "never getting off the vent."

Another stated that nearly 50% of the patients admitted with ET tubes in one of his facilities ended up being treated for respiratory infections, particularly ventilator-associated pneumonia, and that 54% of these patients eventually died from their infections.

I hadn't considered these issues as a

field paramedic, but I quickly realized how many elderly patients with severe respiratory distress I wouldn't have intubated had CPAP been available. This would have, in turn, kept some of these patients from becoming ventilatordependent, developing a respiratory infection and dying.

But the most interesting exchange of conversation I heard that day came when a well-respected medical director from a major urban center stated that his crews weren't going to use CPAP because they could "be at an emergency department anywhere in his city in 10 minutes or less," and he felt that wasn't enough time for patients to benefit from CPAP therapy.

I could see disbelief and disagreement on many of his colleagues' faces, but it seemed no one wanted to be disrespectful by disagreeing with him. A period of silence followed, and I thought the group was going to move on without addressing his comments when, finally, one physician said she wanted to comment on his statement. All eyes turned to her.

She said, "With all due respect, most of my crews can usually reach our hospitals from anywhere in my city in less than 10 minutes, but we've documented that we've been able to give most patients an average of 28 minutes of CPAP therapy before they reach our hospitals because of the forgotten time elements inherent in our calls," she told him, pointing out the following "contact minutes" where CPAP could be beneficial:

- Initial recognition of acute respiratory distress to the start of patient packaging (five minutes);
- Patient packaging (three minutes);
- Transfer to the ambulance (five minutes);
- Loading and preparing the patient for transport (two minutes);
- Travel time to the hospital (eight minutes); and
- Off loading of the patient and transferring care to the ED staff, which might not have CPAP immediately available (five minutes).

The doubting physician left the meeting better educated, as did I.

This supplement to *JEMS* includes articles that will educate you on the important contribution CPAP can make in your system and the multiple patient conditions that can be impacted by your BLS and ALS units with CPAP use.

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POSITIVE PRESSURE

The physiology of respirations with CPAP

by Connie Mattera, MS, RN, EMT-P

Non-invasive pressure-support ventilation (NIPSV), a method of assisting a patient's respiration without intubation, was first reported in the 18th century. Used in the 1930s for patients with pulmonary edema and in the 1950s for those with polio, NIPSV is currently delivered through CPAP or bilevel positive airway pressure (BiPAP) devices.

Prior to the advent of CPAP and alternative or rescue airways, EMS providers administered ventilatory support in the field with bag-valve masks (BVMs) or the invasive intervention of intubation. CPAP helps prevent the need for mechanical ventilation and intubation by delivering positive endexpiratory pressure (PEEP) while decreasing the incidence of **barotrauma** and **volutrauma**. It also helps EMS providers avoid complications from intubation-related sedation or paralysis, in addition to such unexpected difficulties as hypoxia, lethal dysrhythmia, tissue trauma, aspiration and undetected esophageal intubation.

Provider use of CPAP helps patients avoid mandatory admission to an intensive care unit (ICU), reducing the increased morbidity and mortality associated with ventilatoracquired pneumonia (VAP) and such nosocomial infections as *Methicillin-resistant Staphylococcus aureus* (MRSA) and *Klebsiella*. Read "CPAP & VAP" on p. 22 for more about how CPAP devices reduce the instances of VAP. If CPAP isn't in your toolbox now, stay tuned because it's coming soon. But whether it's on the horizon or already in your BLS and ALS scope of practice, every EMS provider should understand the physiology of breathing and how CPAP works, so they can properly use this therapy to treat patients in respiratory distress.

PHYSIOLOGY OF VENTILATION

To understand how CPAP works, providers should begin with an understanding of the physiology of the pulmonary system. The lower airways resemble an inverted tree extending from the trachea through the bronchi to the alveolar sacs.

Alveoli form the primary constituent of lung tissue. An average adult has 300–600 million alveoli, each of which measures about 1/3 mm in diameter. Alveolar walls consist of a single layer of cells and elastin fibers that permit stretching and contracting during ventilation.

The internal surface of each alveolus is covered by a thin film of fluid containing **surfactant** that decreases surface tension and keeps alveolar walls from collapsing and sticking together on expiration. This reduces the work of reopening them with each breath.

Surfactant production diminishes when lungs are hypoperfused and hypoxic. Without adequate surfactant, alveoli collapse

GLOSSARY		
Afterload	Arterial resistance that the ventricle must overcome to empty.	
Alveoli	The functional units of the pulmonary system where gas exchange occurs.	
Atelectasis	Collapse of the expanded lung. Evidenced by severe ventilatory distress, crackles and hypoxia.	
Barotrauma	Injury of a body part or organ as a result of changes in barometric pressure.	
Bronchodilation	Decreased airway resistance.	
Surfactant	A surface-active lipoprotein mixture coating the alveoli that prevents collapse of the lungs by reducing the surface tension of pulmonary fluids.	
Tidal volume	The air moved with each breath.	
Volutrauma	Damage to the lung caused by overdistention by a mechanical ventilator set for an excessively high tidal volume; it results in a syndrome similar to adult respiratory distress syndrome.	
Sources: www.m-w.com & Dorland's Medical Dictionary		

and **atelectasis** develops. The lungs become stiff, and alveoli ultimately fill with fluid.

The alveolar-capillary surface area available for gas exchange is about 1 sq. meter/kg of body weight in the average adult. Normally, the blood-gas barrier is one cell thick. Every red blood cell circulating through the lungs spends about one second in the pulmonary capillary network. During that time, it goes through two to three alveoli and picks up its full complement of (0,) in one-fifth of a second.

The brief time each red blood cell spends in the pulmonary capillary network is normally sufficient for adequate gas exchange. However, this isn't the case in states of disease, such as emphysema and lung cancer, when the gas exchange surface area is reduced by more than two-thirds and the membranes are thicker, or interstitial or alveolar fluid is present. In this situation, O, diffusion will

be inadequate to meet the body's demands at rest, and carbon dioxide (CO₂) won't be adequately eliminated.

The relationship between pressure inside the pulmonary system and atmospheric pressure determines the direction of airflow, and the amount of air moved into the lungs depends on airway resistance and lung compliance.

AIRWAY RESISTANCE

Several factors determine airway resistance. These include airway diameter, motor nerve impulses, the length of the airway, lung volume, tissue resistance, compliance and work of breathing. We'll discuss each here.

Airway diameter: If the airway radius is narrowed by half, the resistance through it increases by 16. There's a reduction in airflow to the fourth power. Airway diameter is affected by receptors in the trachea and large bronchi that are activated by irritants or immune system responses.

Motor nerve impulses: Resistance may greatly increase due to airway secretions or bronchial constriction. The vagus nerve constricts bronchioles and sympathetic stimulation dilates bronchioles. Release of histamine causes constriction of smooth muscle resulting in bronchoconstriction.

Length of the airways: If length doubles, resistance doubles.

Lung volume: Diminished lung volume results in increased airway resistance. Small airways may close completely. Patients with increased airway resistance often breathe at high volumes to help decrease airway resistance.

Tissue resistance: Tissue resistance accounts for about 20% of the total airway resistance in young patients, although it may be increased with some diseases.

Compliance: This is the ability of the lungs and thorax to expand easily with inhalation. Good compliance means easy expansion. A normal breath of 500 mL requires a distending pressure of less than 3 cm of water (H_2 O). A child's balloon may need a pressure of 300 cm of water for the same change in volume.

To demonstrate and appreciate compliance, chew some bubble gum. See how easy it is to blow a bubble after only a minute of chewing. This is great compliance. Compare that to the difficulty in blowing a bubble after an hour when gum elasticity has diminished. This demonstrates poor compliance.

CPAP raises inspiratory pressure above atmospheric pressures and then applies PEEP to exhalation.

Work of breathing: In healthy persons, the energy required for normal quiet breathing is small (only 3% of the total body expenditure). Loss of surfactant, increased airway resistance, decreased compliance, airflow obstruction and lung hyperinflation increase the work of breathing. As lungs become "stiffer," respiratory muscles become fatigued, resulting in ventilatory failure. Anything that increases functional reserve capacity (FRC) will improve lung mechanics and enable more work to be generated for the same effort.

Table 1

DISEASES THAT DECREASE COMPLIANCE

SYMPTOMS	PHYSIOLOGIC OCCURRENCE	DISEASE
Pulmonary edema	Inflation of alveoli is prevented.	Bronchitis
Atelectasis	Alveoli collapse and walls stick together.	Asthma

Table 2



Although work of breathing is difficult to measure at the bedside, it's easy to appreciate clinically. EMS providers can do this by observing the patient for tripoding, use of accessory muscles and retractions. O_2 consumption increases as ventilatory reserves decrease. As the amount of O_2 needed becomes excessive, the body becomes hypoxic. See Table 1 for symptoms and diseases that increase work of breathing.

HOW CPAP WORKS

Patients who benefit from CPAP frequently present with a chief complaint of dyspnea. Dyspnea can be caused by cardiac, pulmonary, neuromuscular, psychologic/social/spiritual etiologies or any combination of them. The severity varies widely among patients. EMS providers should get a good baseline assessment to trend improvement. See Table 2 for a modified Borg Dyspnea Scale, which rates the intensity.

CPAP gets many patients with severe inspiratory muscle fatigue through their acute crisis without the need for intubation. CPAP delivers a constant positive pressure to the airways of a spontaneously breathing patient during inspiration and expiration through a noninvasive mask. CPAP raises inspiratory pressure above atmospheric pressures and then applies PEEP to exhalation.

Intrinsic PEEP (auto-PEEP) is usually about 5 cm water. It must be overcome before negative pressure can be generated to inhale more air. If one exhales against resistance, smaller, dependent airways are "splinted" open at the end of expiration, and small bronchi and alveoli don't collapse. Keeping these structures open on exhalation allows the muscles that were working to keep them open (the ones exerting auto-PEEP) to be recruited into inspiration. When alveoli stay open, inspiratory effort doesn't have to be expended to reinflate them. This reduces inspiratory work, relieves respiratory muscle fatigue and decreases work of breathing.

Increased pressure in the airways also allows for better distribution of gases, which leads to an increase in alveolar pressure and reexpansion of collapsed alveoli. This reverses micro-atelectasis. In addition, maintaining inspiratory and expiratory pressures above normal levels results in improved functional reserve capacity, better lung compliance and **bronchodilation.** This positively affects the ventilation/ perfusion (V/Q) ratio.

As alveoli stay open, gas-exchange time can double. This increases oxygen levels in the blood and decreases CO₂ levels—as long as respiratory diffusion and pulmonary perfusion dynamics work properly. This reduces hypoxia and reverses hypercarbic ventilatory failure.¹

CPAP changes alveolar/hydrostatic pressure dynamics. An increase in alveolar pressures will counterbalance interstitial or capillary hydrostatic pressures and will slow or stop movement of fluid into the alveoli. Positive airway pressure pushes fluid out of the alveoli in pulmonary edema and will stop further influx.



CPAP decreases work of breathing in patients who present with dyspnea and severe inspiratory muscle fatigue.

It also improves cardiac output. When pulmonary capillary wedge pressures (PCWP) are less than 23, cardiac output is determined by preload (venous filling pressures). Thus, increased preload equals increased cardiac output.

In cardiogenic pulmonary edema due to heart failure, PCWP is already maxed out. If greater than 23, cardiac output is dependent on **afterload**. CPAP increases pressures throughout the thorax, including pressure surrounding the left ventricle (LV). This makes it easier to eject blood out of the heart. Similarly, pressure surrounds the thoracic cavity but not the abdominal aorta, giving the impression of reduced LV afterload outside of the thoracic cavity. This will increase cardiac output unless PEEP levels are too high. High intrathoracic pressures greatly reduce preload to the right heart and will reduce the blood pressure.

CPAP produces an increase in **tidal volume** with a subsequent reduction in the work of breathing. Stabilization of minute ventilation with an increase in FRC should improve ventilation-perfusion relationships and potentially reduce oxygen requirements. This allows for an increase in available O_2 for tissue perfusion and a decrease in CO₂ levels.

If CO_2 elimination from the lungs decreases, CO_2 levels in the blood will rise. This condition, called hypercarbia, occurs with respiratory depression or hypoventilation, which can be

caused by airway obstruction, respiratory muscle impairment or pulmonary obstructive diseases, among other pathologies. EMS providers should correct hypercarbia by increasing ventilation and attempting to correct the underlying cause. Improved ventilation and gas exchange are major benefits of CPAP.

CONCLUSION

Prehospital crews have been without the capabilities offered by CPAP and had to watch dyspneic patients decline, requiring intubation. Patients who are still awake during intubation often experience anxiety and discomfort and need to remain sedated. They can't talk with the tube passing through their vocal cords,

CPAP delivers a constant positive pressure to the airways of a spontaneously breathing patient during inspiration and expiration through a noninvasive mask.

> and the aspiration risk is high with open cords. Intubated patients are also more susceptible to VAP, MRSA and *Klebsiella* than non-intubated ones.



Most patients can relax and cope with a CPAP device over time.

CPAP should be the first line of respiratory therapy in carefully selected patients based on local protocols.

Consideration of these complications, as well as the cost of equipment and a mandatory ICU admission, makes avoiding intubation by administering CPAP an attractive option.

CPAP should be the first line of respiratory therapy in carefully selected patients based on local protocols. It relieves symptoms but should be used in concert with appropriate medications in patients with asthma, chronic obstructive pulmonary disorder (COPD) and heart failure. This will address specific underlying pathology.

Remember, CPAP isn't a ventilator. Patients must be monitored carefully (vital signs, SpO₂, capnography and clinical responses) after CPAP application to detect improvement in condition or lack of improvement that may indicate the need for intubation and assisted ventilations, as well as for signs of complications that may signal the need to remove the CPAP mask.

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MANY BENEFITS OF CPAP

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I. CPAP & CHF by Keith Wesley, MD

The primary goal of CPAP is to decrease the work of breathing so the patient doesn't deteriorate, doesn't require intubation—which is associated with increased mortality—and doesn't suffer respiratory arrest. Patients who are intubated are as much as seven times more likely to die than those who are not.¹

Several studies have demonstrated that instituting CPAP in the field reduces the need for intubation by as much as 60%.^{1,2}

In this article, we examine some of the many indications for CPAP use, including congestive heart failure (CHF), asthma/COPD, drowning, carbon monoxide (CO) poisoning and pulmonary infections, and discuss some of the physiological responses that make CPAP beneficial.

CPAP & HEART FAILURE

The primary cause of respiratory distress with heart failure is increased work of breathing.

The underlying cause: In heart failure,

the heart cannot efficiently pump the blood delivered to it. In some cases, the patient is volume overloaded, but in the majority of cases the patient's total blood volume is normal. For whatever reason, the heart fails to pump blood efficiently, and pressure in the pulmonary veins rises. Blood does not actually "back up," but the rise in pressure makes movement of blood through the lungs more difficult.

As the pressure rises, the blood, primarily the serum, moves out of the capillaries and into the tissue space between the capillaries and the alveoli. Eventually, the fluid migrates into the alveoli, causing them to collapse and become unable to exchange gases, similar to the collapse of alveoli in COPD. To counteract this, the patient must breathe out through pursed lips (a process called auto-PEEP) in an attempt to keep the alveoli open.

Unfortunately, the heart failure patient isn't accustomed to this type of reflexive breathing; as a result, their work of breathing increases quickly. The role of CPAP in the treatment of heart failure is twofold:

- The PEEP helps keep the alveoli open during exhalation, and inspiratory pressure helps to open additional alveoli, relieving the work of breathing;
- 2. The pressure generated by CPAP helps move fluid back into the vascular system.

To facilitate this second action, it's critical that the underlying myocardial dysfunction be corrected. The best method to reduce the elevated pressure in the pulmonary vasculature is the administration of nitrates.^{3,4} Once the pressure in the pulmonary arteries and veins is decreased, CPAP will be better able to move the fluid out of the lungs and into the circulatory system. The use of diuretics in heart failure

can lower the sympathetic tone of the patient and encourage diuresis.

Therefore, by reducing the work of breathing and relieving pulmonary congestion, CPAP buys time for other treatments, such as nitrates and diuretics, to work.

CONTRAINDICATION TO CPAP

If left untreated, heart failure deteriorates into cardiogenic shock with profound hypotension from low cardiac output. One side effect of CPAP, particularly at high pressures (greater than 10 cm H_2O), is that intrathoracic pressure is increased, which can result in lowering of venous blood return to the right side of the heart.

If the patient is on the verge of cardiogenic shock, this increased pressure may tip the scales. Therefore,



CPAP can reduce the work of breathing and relieve pulmonary congestion, buying time for other treatments, such as nitrates and diuretics, to work.

has come under scrutiny, and current recommendations are to avoid their use during initial treatment. *Note:* Some studies suggest that high-dose diuretic use for acute CHF increases mortality.^{5,6}

When and if diuretics are used, they will be effective only if the pulmonary interstitial fluid is in the circulatory system. This is where CPAP comes into play. Even in the absence of nitrate administration, CPAP can move fluid out of the lungs. Combined with the decrease in work of breathing, this it's best to avoid the use of CPAP in heart failure if the patient is already hypotensive.⁷ Instead, the administration of dopamine is indicated. Once the pressure is stabilized, CPAP can be started. If, after starting CPAP on the hypertensive patient, the patient becomes hypotensive, it's not likely the effect of CPAP, but instead the onset of cardiogenic shock.

TIME IS CRUCIAL

When using CPAP for heart failure, time is of the essence, and you must aggressively

treat the underlying cause. If there's a new onset of rapid atrial fibrillation, slow it down with a calcium channel blocker. If the patient is hypertensive, administer nitrates. Don't forget to obtain a 12-lead ECG and deliver the patient to a percutaneous coronary intervention center if a STelevation myocardial infarction is suspected.

CPAP has been the mainstay of heart failure treatment in the emergency department for years. The data now shows that it's just as safe and effective in the field.

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II. CPAP in asthma & COPD

by Marvin Wayne, MD, FACEP, FAAEM

It may seem counterintuitive that external pressure support (e.g., CPAP) would improve ventilation and oxygenation in an asthmatic patient, but the improvement in respiratory function offered by CPAP is impressive.

The fundamental pathophysiological change that occurs with acute exacerbation of asthma is the obstruction of expiratory air flow, leading to air entrapment, acute pulmonary distention and decreased functional reserve capacity. Secondarily, an inspiratory obstructive component may be present.

This significant increase of obstruction in inspiratory and expiratory air flow in both large and small airways is caused by inflammation, bronchoconstriction and intraluminal mucus, with development of mucous plug formations resulting in heterogeneous pulmonary ventilation. This may result in an auto-PEEP of up to +20cm H₂O and a loss in the V/Q ratio in different areas of the lung.

Under these conditions, breathing is labored. The increase in inspiratory resistance determines the need for more negative pleural pressure, which creates differential pressure between The improvement seen following CPAP administration most likely occurs through a combination of **1**) decreased work of breathing and reduction of fatigue; **2**) recruitment of alveoli and improved oxygenation; and **3**) splinting of larger airways, bronchiolar and bronchial to reduce airway collapse and mucous plugging. Current CPAP systems may allow intermittent or continuous administration of bronchodilators.

A variety of modalities exist to administer CPAP: nasal masks and partial- and full-face masks. Sedation may be necessary in some patients, but asthmatics seem to respond well to coaching and emotional support while they hold the mask on their face. Thus, CPAP may be a BLS skill when ALS isn't available or has extended response times.

INCLUSION CRITERIA

To qualify for CPAP, patients must be conscious, cooperative and hemodynamically stable (relative). The following would indicate CPAP application:

- Moderate or severe asthma/COPD;
- Respiratory failure and muscular fatigue;

CPAP provides an improvement in oxygenation & ventilation in these patients.

capillary and interstitial tissue, leading to interstitial and peribronchial edema and, thus, worsening ventilatory functions. Expiratory resistance makes active exhalations more laborious, with a further increase in the work of breathing.

During the initial decompensatory phase in asthma, hypoxemia and hypocapnia occur. In patients who are nonresponsive to traditional therapy, the condition can lead to a mixed acidosis due to CO₂ retention and lactic acidosis due to the increased work of breathing.

- Poor response to medical treatment;
- Increased end-tidal (Et) CO₂ and/or decreased SPO₂;
- Use of accessory respiratory muscles;
- Ability to wear the face mask; and/or
- Not being in obvious need of intubation.

EXCLUSION CRITERIA

The following patients exhibit exclusion criteria:

- Obvious respiratory failure who require immediate intubation;
- Decreased level of consciousness who cannot cooperate with (tolerate) the

CPAP system;

- Cardiovascular instability (SBP less than 90 or on vasopressors; relative);
- Morbid obesity (more than 200% over ideal weight; relative); and/or
- Acute abdominal processes, recent gastro-esophagus surgery, or recent facial or ENT surgery, facial deformities or facial trauma.

DISCONTINUATION CRITERIA

Discontinue CPAP if the patient exhibits the following symptoms:

- Deteriorating mental status, becomes lethargic with worsening hypercapnia or agitated with hypoxemia;
- Inability to tolerate mask due to pain or discomfort;
- Inability to improve respiratory function;
- Hemodynamic instability;
- Electric instability (with ischemia or malignant V arrhythmia); and/or
- Suspicion of pneumothorax.

Note: The patient may also request discontinuation.

COMPLICATIONS

Complications following CPAP may include abdominal distention, barotraumas, hypotension, secretion retention, facial necrosis caused by pressure and/or increasing fatigue and respiratory failure.

RESPIRATORY FAILURE

As discussed above, CPAP noninvasive positive pressure has a long history in acute heart failure and now asthma. It has also proved beneficial in COPD and other forms of respiratory failure.^{1,2} The improvement is based on the following important principles:

- 1. Reduction of inspiratory muscle recruitment and, therefore, avoidance of muscular fatigue. This effect can be observed in a slowing of respiratory rate and an increase in tidal volume. CPAP should counteract the effects of intrinsic PEEP.
- 2. *Early improvement of gas exchange.* This is due to an increase in ventilation and to a greater tolerance to higher

An-line medication nebulizer can be used with most CPAP devices.

oxygen concentrations (without hypoventilation). The shunt effect and the ventilation-perfusion mismatch secondary to CPAP also decrease.

3. *Hemodynamic effects*. These may be beneficial or harmful. In patients with fluid overload and a decrease in systolic function performance, an increase in intrathoracic pressure caused by CPAP produces a decrease in right ventricular preload and afterload. To avoid this adverse affect, avoid application of CPAP to patients with a systolic pressure below 105 mmHg. If hypotension occurs, either discontinue CPAP or use a lower pressure.

THE BELLINGHAM (WASH.) CPAP EXPERIENCE

The primary BLS/ALS service for Bellingham and Whatcom County is Whatcom Medic One. Because of its population distribution and ALS response times, transports can take 20 minutes or more.

Approximately six years ago, Medic One trained its ALS providers to use CPAP. The initial indication was suspected acute heart failure with respiratory distress. It quickly became apparent that differentiating acute heart failure from COPD, asthma, and other forms of respiratory distress wasn't easy. Because the literature strongly suggested that CPAP provides significant respiratory support and assistance to patients with COPD, asthma and other forms of respiratory distress, those conditions were included for CPAP use.

Most of these patients would normally require significant sedation or paralysis to maintain intubation. In COPD, intubation may lead to air trapping, with subsequent barrow traumas. Even with improved oxygenation, EMS providers need to understand the longterm effect intubation has in this acute and chronic disease.

In asthma, intubation rarely treats the



primary problem, which is bronchial and bronchiolar in nature. Intubation is usually only indicated to provide relief for profound fatigue with secondary respiratory failure. Issues and concerns with intubation in these patients are obviated with the use of CPAP. Thus, CPAP has allowed us to reduce intubation in all types of acute respiratory disease by two-thirds or more.

By the numbers: Medic One has now treated more than 600 patients with CPAP—65% for presumed acute heart failure, 25% for COPD, and 20% for asthma as well as other forms of presumed respiratory distress. Sedation was needed in approximately 30% of patients, but most patients responded to coaching during CPAP use.

In spite of sedation and coaching, approximately 15% could not tolerate or failed CPAP. Only 20% of the patients who failed CPAP proximately or subsequently went on to acute intubation. In spite of these numbers, it's hard to quantify the outcome in these patients except to look at reductions in the number requiring intubation.

The overall number of patients intubated in all of these categories treated with and without CPAP fell to 30% of those intubations performed prior to the introduction of CPAP.

Clearly, CPAP has been, and continues to be, an important modality for EMS. It's generally considered as a "non-invasive" airway device and should qualify for BLS use where appropriate. It has and will continue to make a significant impact on EMS. $^{\rm 34,5}$

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CPAP may be indicated for several patient populations, including toxic inhalation.

III. Additional indications for CPAP

by Michael Richards, MD, MPA

The literature supporting the use of CPAP in the prehospital environment is almost exclusively limited to acute respiratory distress secondary to cardiogenic pulmonary edema or COPD exacerbation. Although most EMS protocols limit CPAP use to these two primary indications, it's valuable to consider other possible applications that can impact morbidity and mortality.

Given the demonstrated benefit of CPAP in cardiogenic pulmonary edema, it's particularly important for medical directors to consider how CPAP could be employed as an adjunct for managing patients with noncardiogenic pulmonary edema conditions, such as saltwater drowning or altitude-associated pulmonary edema, to achieve the same physiological effect.

Likewise, given the demonstrated ability of CPAP to clinically improve patients with COPD exacerbations, we believe EMS systems should consider application of CPAP in cases of acute lung injury that are also associated with hypoxia and hypercapnia and increased work of breathing. Even if your system isn't ready to advocate for the use of CPAP in all of these conditions, these areas are still important to monitor for new developments as well as conditions in which judiciously applying CPAP in carefully selected patients may be justified.

TOXIC INHALATION INJURIES

Many prehospital patient care protocols for hazmat feature CPAP as an important adjunct to the management of toxic inhalation injuries, particularly those associated with lower airway injury and pulmonary edema. Irritant gases are a good example of the type of agents that can cause these injuries. When these gases are inhaled, they dissolve in the water of the respiratory tract and cause inflammation and injury. Irritant gases with high water solubility dissolve quickly, with their effects typically limited to the eyes and upper airway.

However, those gases with intermediate water solubility, such as chlorine, affect both upper and lower airways, and gases with low water solubility predominantly affect the lower airways. Lower airway injury symptoms may be delayed and can include bronchorrhea, bronchospasm and noncardiogenic pulmonary edema. The use of CPAP in these types of lower airway injuries may relieve respiratory distress, improve oxygenation and decrease the need for intubation.¹

Other toxic inhalations have also been suggested as candidates for CPAP. For example, smoke inhalation injuries in the early phase are associated with bronchospasm, bronchorrhea, decreased compliance and ventilationperfusion mismatches. It has been suggested that CPAP may be an appropriate supportive measure that can help prevent the deterioration of oxygenation and intrapulmonary shunting. This concept has been demonstrated in a canine model of smoke inhalation injury where CPAP improved pulmonary function and oxygenation.²

CARBON MONOXIDE POISONING

The primary treatment for CO poisoning is the application of 100% oxygen and, in significant cases, the use of hyperbaric oxygen that requires the use of a hyperbaric chamber to place the patient under two to three atmospheres of pressure. Both treatments displace CO from hemoglobin.

No data suggests that CPAP mimics a hyperbaric chamber, but it does enhance the elimination of CO by providing 100% oxygen (if the device is so designed) via a tight-fitting mask that is superior to loosely applied 100% nonrebreather masks.

ORGANOPHOSPHATE POISONING

Exposure to organophosphates, such as the nerve agent sarin gas or certain herbicides, results in a cholinergic crisis with the classical SLUDGE (salivation, lacrimation, urination, defecation, gastrointestinal upset and emesis) presentation. When exposed to organophosphates, pulmonary edema can also occur. Therefore, it would be reasonable to presume that CPAP administration would be useful in this toxic exposure. But CPAP wouldn't take the place of the administration of antidotes, such as atropine and 2-PAM chloride, which reverse the effects of the agents. to leaking of the alveolar capillary membrane.

This may be the result of areas of vasoconstriction in the pulmonary vasculature, which causes over-perfusion and hydrostatic pulmonary hypertension in other areas of the pulmonary vasculature, ultimately leading to pulmonary edema. The application of CPAP along with supplemental oxygen has proven effective in these patients.

FLAIL CHEST

The management of patients with traumatic flail chest from blunt trauma is both challenging and controversial. These patients occasionally need endotracheal intubation and ventilator support. However, prolonged mechanical ventilation in these patients is associated with numerous complications, such as pneumonia and poor outcome. More recently, the role of CPAP by face mask with good pain control has been explored as an alternative first line of treatment for flail chest caused by blunt thoracic trauma.^{5,6} In one randomized inhospital study of CPAP compared to intubation and mechanical ventilation, the CPAP group had fewer cases of pneumonia and higher survival rate.⁷

Although the concept of "pneumatic stabilization" with CPAP is promising, it's not without its own concerns. The biggest concern likely to be raised is that of creating a pneumothorax with the positive pressure of CPAP in the setting of rib fractures. Given the relatively small numbers of cases reported in the literature in which CPAP has been used in this situation, we have to conclude that the incidence of pneumothorax is largely unknown, but it's not likely to be greater than that of mechanical ventilation in the same scenario.

DROWNING

There are numerous case reports supporting the use of CPAP in the management of submersion injuries.^{3,4} Patients suffering from near-drowning in freshwater have pulmonary injuries that are associated with atelectasis and altered surface tension in the alveoli. This sets up a ventilation perfusion mismatch leading to hypoxia.

Patients suffering from near-drowning

in saltwater are more likely to develop pulmonary edema as the inhaled hypertonic solution pulls plasma into the alveolar cavity.

In both of these cases, the application of CPAP provides an excellent way to improve oxygenation in patients who are awake and spontaneously breathing. The physiological disorders—atelectasis in the case of fresh water drowning and pulmonary edema in the case of salt water drowning, are both reversed by the application of positive pressure breathing.

ALTITUDE INJURIES

The physiological cause of high-altitude pulmonary edema (HAPE) remains controversial. The typical HAPE patient will have a history of rapid ascent to altitudes of 8,000 feet or greater, with the development of pulmonary edema and hypoxia within one to four days. It is thought that hypoxia leads

It has been suggested that CPAP may be an appropriate supportive measure that can help prevent the deterioration of oxygenation and intrapulmonary shunting.

> It's important to note that although there may be value for CPAP use in traumatic chest injuries, the FDA currently lists such injuries as a contraindication to CPAP administration.

PULMONARY INFECTIONS

It's well known that pulmonary infections, such as communityacquired pneumonia (CAP), are associated with the complications of hypoxia and acute respiratory dysfunction. Because the infections alter alveolar structure and function, supplemental oxygen alone may not be enough to correct the hypoxia in these patients.

In one "proof-of-concept" type study of CPAP in CAP, patients with moderately severe respiratory failure showed rapid improvement in oxygenations with CAP.⁸ It's hypothesized that CPAP improves gas exchange by recruiting collapsed alveoli,



Capnography can be used in conjunction with CPAP via a dual nasal oxygen/ capnography sensor applied under the mask, as shown here.

CPAP could be employed as an adjunct for managing patients with noncardiogenic pulmonary edema conditions.

decreasing "flooding" in the interstitial space and alveoli associated with inflammation, and ultimately decreasing the ventilation perfusion mismatch.

CPAP has been used successfully in other pulmonary infections, too—most notably *Pneumocystis carinii* pneumonia. There are also numerous case studies claiming clinical improvement with the use of CPAP in respiratory failure from H1N1 influenza and case controlled studies showing improved outcomes in pediatric patients with bronchiolitis that receive CPAP as compared to intubation.⁹

SUMMARY

CPAP has been used successfully in hospital and prehospital settings for CHF, asthma/COPD, drowning, CO poisoning, pulmonary infections and other conditions. It helps avoid the need for intubation and may, therefore, reduce mortality. If

your EMS agency has not yet purchased CPAP devices and is invested in training your providers, you should consider it now.

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	PULMONARY EDEMA Assessment Findings	RESPIRATORY DISTRESS Assessment Findings
Chief Complaint	Difficulty breathing or shortness of breath	Difficulty breathing or shortness of breath
OPQRST	Assess onset, duration, progression, subjective severity, possible triggering events and response to treatments before EMS arrival.	Assess onset, duration, progression, subjective severity, possible triggering events and response to treatments before EMS arrival.
Associated Signs	Chest pain, fever or chills, and a productive cough	Chest pain, fever or chills, and a productive cough
AMPLE	Check for allergen exposure, medications and compliance, history of myocardial infarction, cardiomyopathy or hypertension, acute respiratory distress syndrome, infection, disseminated intravascular coagulation, aspiration, high-altitude pulmonary embolism (HAPE), PE, overdose or cardiogenic disorders.	Check for possible exposure to known allergens, medications and compliance, progressive exercise intolerance, recent lung infection, or a cough (either productive or nonproductive)
Initial Exam	Check airway, breathing and cardiovascular. Correct immediately life-threatening problems.	Check airway, breathing and cardiovascular. Correct immediately life-threatening problems.
Physical Exam	General Appearance: Patient exhibits tripod positioning, purse-lipped breathing or severe distress. Neck: Check for jugular venous distention. Skin: Is skin cool, moist and pale, or warm, dry and flushed? Could it be uticaria, cyanosis or diaphoresis? Respiratory Effort: Uses accessory muscles shows signs of fatigue, speaks in two-word sentences or has tachypnea. Lung Sounds: You notice wheezes, rales, rhonchi or stridor, or a pink, frothy sputum. Lower Extremities: Patient has pitting edema of the ankles. Neuro: Patient has altered LOC, lethargy, somnolence or anxiety	General Appearance: Patient exhibits tripod positioning, purse-lipped breathing or severe distress. Neck: Check for jugular venous distention. Skin: Is skin cool, moist and pale, or warm, dry and flushed? Could it be uticaria or cyanosis? Respiratory Effort: Uses accessory muscles, shows signs of fatigue or speaks in two-word sentences. Lung Sounds: You notice wheezes, rales, rhonchi or stridor, or a pink, frothy sputum. Lower Extremities: Patient has pitting edema of the ankles. Neuro: Patient has altered LOC, lethargy or somnolence.
Data/Monitoring	<i>Vital Signs:</i> BP, HR, RR, SpO ₂ , ECG, 12-lead ECG, blood sugar (if diabetic), altered loss of consciousness, $EtCO_2$, $EtCO_2$ or temperature	<i>Vital Signs:</i> BP, HR, RR, SpO ₂ , ECG, 12-lead ECG, blood sugar (if diabetic) altered loss of consciousness, EtCO ₂ or temperature.
Goals of Therapy	Improve oxygenation and ventilation Reduce the work of breathing Treat underlying conditions	Improve oxygenation and ventilation Reduce the work of breathing Treat underlying conditions.
Documentation	Pertinent positives and negatives Previous responses to treatment Critical thinking	Pertinent positives and negatives Previous response to treatment
Quality Improvement	Maximize nitro administration Early CPAP use Monitor ${\rm EtCO_2}$	Monitor EtCO ₂ Early CPAP use

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BRING IT TO BLS

EMT-B success with CPAP requires education & training

by Keith Wesley, MD

For many years, EMT-Bs have been taught how to manually provide positive-pressure ventilation using the BVM, and routinely use this skill during respiratory and cardiac arrest situations. They've also been taught to use it for the patient in respiratory distress with inadequate ventilation, including patients suffering from COPD, asthma and heart failure.

But positive-pressure ventilation in this manner is difficult to perform because it requires carefully squeezing the bag, timing the squeeze with the patient's inhalation and ensuring the squeeze is of the right volume. If the bag is squeezed too forcibly, the patient may gag or vomit. This results not only in respiratory distress but also in airway patency issues.

Nothing is more frightening than seeing a patient struggle to breathe and then suffer respiratory arrest when your only tools are the BVM and a non-visualized airway. When these

CPAP performs the same mechanics as positive-pressure ventilations in a spontaneously breathing patient, but without the accompanying downsides.

Wisconsin was the first state to examine this issue. Officials first developed a training program, and then they began to implement a pilot project involving BLS services in 2005.

The primary question asked at the time was whether patients who received CPAP by BLS personnel would suffer greater complications than those given CPAP by paramedics. After a year of study, officials found no difference, and actually found that BLS use of CPAP helped reduce the need for ALS for these patients.

In several cases during the pilot program, BLS agencies that used CPAP transported patients with COPD without an ALS intercept. This was because, despite being in their scope of practice, many ALS agencies didn't have CPAP, and the patients had improved to such a degree that an ALS intercept and intervention was no longer needed. This also freed up

ALS resources to respond to additional or more critical calls.

The result was that Wisconsin became the first state in the nation to add CPAP to the BLS scope of practice. The pilot project also resulted in widespread adoption of CPAP by Wisconsin ALS services as well.

According to a recent survey of the National Association of State EMS Officials at www.

nasemso.org, more than three quarters of the states in the U.S. now allow CPAP at the BLS level.

As you read this section and others throughout this supplement, you will realize the significant patient impact CPAP will have in those states where every BLS and ALS unit is capable of delivering this effective treatment modality in the field.

MAKE IT BASIC

So, what's necessary to bring this skill to the BLS provider?

patients quit breathing, they often continue to have a gag reflex that makes non-visualized airway insertion virtually impossible. CPAP performs the same mechanics as positivepressure ventilations in a spontaneously breathing patient, but without the accompanying downsides.

Therefore, five years ago, several states began to consider the value of having EMT-Bs use CPAP. The potential disadvantages of manual positive-pressure ventilation, coupled with an increased risk of respiratory arrest in the absence of ALS interventions, tilted the risk-benefit ratio in favor of CPAP use by BLS providers.



Nebulized medication should be used in concert with CPAP.

First, BLS providers must be educated about the mechanism of CPAP and have a better understanding of the disease processes for which it's indicated. The current National Standard Curriculum for EMTs currently doesn't include CPAP, nor does it provide the required level of education in pathophysiology. However, that shouldn't deter states from implementing CPAP for BLS providers.

Employing a lifesaving treatment not only requires an in-depth knowledge of pathophysiology, but it also requires an astute awareness of the potential complications of the given procedure. Providers must also be given the tools to correct any unforeseen complications, such as tension pneumothorax. Monitoring EtCO₂ is critical to observing how your treatment is helping your patient and should be considered on any BLS unit that would initiate CPAP.

Once Wisconsin officials decided to make CPAP a basic EMS skill, they created their own CPAP education program. This curriculum, which can be provided in two hours, includes hands-on scenarios with the service's CPAP device. Additionally, regular and frequent refresher training should be undertaken to ensure BLS providers maintain competency in the use of CPAP and reinforce that there's little downside to its implementation—even if administered to a patient who may not actually require it.

INDICATIONS

So, what are the indications for BLS CPAP? That's a difficult guestion. There aren't many objective physiological criteria, except for increased work of breathing. Diagnosis is often seen as outside the realm of BLS. However, the new education standards encourage a greater level of critical thinking. If this critical thinking is applied correctly, it can provide sufficient clues as to who will benefit from CPAP.

BLS providers should consider CPAP for a hemodynamically stable patient with respiratory distress and a blood pressure greater than 90 who is alert and able to follow commands. They should also consider it in the scenarios below.

To successfully implement basic CPAP, the BLS provider must be educated to look for

CPAP & NEBULIZERS

Many states and BLS medical directors allow BLS providers to use nebulized bronchodilators. This is occurring effectively in BLS and ALS systems throughout the U.S., such as the Fire Department of New York EMS, enabling BLS crews to treat patients not yet in acute respiratory distress with nebulized bronchodilators, as well as enabling ALS units to be triaged to higher priority cases.

For the majority of CPAP indications, such as COPD and asthma, the combination of CPAP with nebulizers appears to improve their effectiveness. However, it isn't uncommon for BLS providers who first start using CPAP to be wary of the device because it's new.

To overcome this hesitancy, it's reasonable to advocate that, for a short period of time, all nebulizers be administered with CPAP. Once the providers have become comfortable with the device, it's appropriate to develop more stringent guidelines for its use just as a separate treatment modality.

Download the Wisconsin CPAP education program at www.dhs.wisconsin.gov/ ems/EMSsection/Protocols/ CPAP/CPAP.htm

CPAP & VAP

CPAP is changing the landscape of prehospital airway and ventilatory management by reducing the number of patients who require intubation. This can help EMS agencies better deploy providers by giving EMT-Bs one more tool to manage airways and free ALS providers for more critical calls. An example of this is that the 2005 Wisconsin pilot program determined BLS administration of CPAP often allowed patients with COPD to be transported without an ALS intercept.

CPAP can also help hospitals avoid costly VAP, a significant and common complication of intubation. The average cost to hospitals to treat a single patient's VAP is \$56,000, which might not be paid for by Medicare. If prehospital CPAP can reduce intubation by 60–75%, which saves hospitals money. See "Purchasing Power: Consider these 10 tips when choosing a CPAP device" on p. 24 for more tips on how to convince hospitals to help fund EMS implementation of CPAP.

Both of these ultimately help patients who can be successfully treated by CPAP instead of intubation because they don't have to experience the discomfort, expense or possible illness they might have otherwise.



Patient anxiety can be eased when the patient holds their CPAP device in place because they feel in control of their breathing.

signs of increased work of breathing, such as orthopnea, use of accessory muscles, diaphoresis and speaking in short, one- or two-word sentences. They must also be able to assess for rales and/or wheezes to differentiate heart failure from COPD.

CASE EXAMPLES

For the patient with bronchospasm, many situations indicate the potential value of CPAP:

Example 1: The patient has used their own nebulizer without response. An in-line nebulizer used in conjunction with CPAP should be the next step.

Example 2: While administering a nebulizer with a T-piece, it's obvious the patient isn't breathing in deeply enough to inhale the bronchodilator. CPAP is indicated.

Many patients with heart failure may exhibit wheezes due to fluid accumulating outside of the bronchi causing airway narrowing ("cardiac asthma"). This may lead EMS providers to believe the patient has COPD and apply CPAP with in-line bronchodilators.

The application of CPAP with in-line bronchodilators is often instituted with the understanding that the patient is suffering from COPD. This occurs just as often with ALS providers who aren't guided by capnography waveforms as it does with BLS providers.

The administration of beta agonists to patients with acute heart failure is discouraged due to the increased oxygen demand they place on the heart. However, the value of CPAP here is enormous and may outweigh the possible complications of beta agonist administration.

CONCLUSION

CPAP is a useful therapy that can be safely initiated by EMTs after appropriate education. A majority of the U.S. states have recognized this fact and now allow BLS personnel to administer CPAP. This simple therapy can provide huge benefits for patients who rely on BLS services for their EMS care. BLS providers should consider CPAP for a hemodynamically stable patient with respiratory distress and a blood pressure greater than 90 who is alert and able to follow commands.

It can also offer earlier care and relief

of respiratory distress in rural areas or regions where ALS resources are limited, and it can free up valuable ALS units to respond to other patients who need advanced care and medications.

RESOURCE

Salpeter SR, Ormiston TM & Salpeter EE. Cardiovascular effects of β-agonists in patients with asthma and COPD: A meta-analysis. *Chest.* 2004;125;2309–2321.

Discuss whether CPAP should be within the BLS scope at http://connect. jems.com/forum/topics/ cpap-within-emtb-scope

EMT-initiation of CPAP can be helpful in rural areas where ALS resources are limited.



PURCHASING POWER

Consider these 10 tips when choosing a CPAP device

by Keith Wesley, MD

When it comes to choosing a CPAP device, there are a host of designs and options available.

1_TYPE OF FLOW

CPAP devices are one of two types: those that run constantly and those that flow only when the pressure drops below a certain level. The constantflow devices provide CPAP by ensuring that there's more air/oxygen flow than the circuit and mask can accommodate. The excess is vented through the PEEP valve.

Constant-flow devices require that the system has no leaks in the circuit or at the mask/face seal. Otherwise, flow escapes through the leak and the predetermined level of pressure may not be attained.

Demand-type CPAP devices generate air/oxygen flow only when the pressure within the breathing circuit drops below a set threshold. This occurs when the system has a leak and, of course, when the patient breathes in.

2 _ OXYGEN CONSUMPTION

The rate of oxygen consumption will affect how long you'll be able to provide CPAP on a cylinder. It also will affect your budget. The rate at which a CPAP device consumes O_2 depends on its design. Constant-flow devices consume oxygen at a faster rate than demand-type devices. In addition, some constant-flow devices, such as the Bousignac and OxyPeep, the desired CPAP pressure depends on the oxygen flow rate from the cylinder.

Some constant-flow and demand-type devices can be set to provide less than 100% oxygen, which will result in decreased oxygen consumption.

$3_{\rm OXYGEN}$ concentration

The primary benefit of CPAP is that it improves ventilation, which is dependent on work of breathing and not on oxygen delivery. Choosing a device that provides less than 100% oxygen is acceptable as it's always possible to administer additional supplemental oxygen to the patient by applying a nasal cannula under the mask.

4_pressures

CPAP devices deliver pressure through one of two means. Either the flow rate is in excess of the patient's need—in which case a PEEP valve is attached to the exhalation port—or the desired amount of pressure is selectable from a control and flow is generated until that level of pressure is reached.

Devices in the first group may use a single valve or include an additional PEEP valve to ensure the pressure listed on them won't be exceeded. Devices in the second group have a variable PEEP selector that allows for titration of the desired amount of pressure.

There's no magic number for the proper amount of PEEP, although adverse events tend to occur with pressures exceeding 20 cm H_2O . Some patients may tolerate and even improve clinically at levels of 2 cm H_2O .

The ability to titrate the amount of

pressure provides greater flexibility in CPAP use. Devices that allow variable pressures should include an accurate pressure gauge to allow appropriate monitoring of CPAP pressures.

5_circuits

Some CPAP devices use proprietary circuits that only function with a specific device, while others allow the circuit to be interchanged with other systems. This issue has caused many agencies to choose the non-proprietary circuits.

However, there are two reasons to favor proprietary circuits. First, these circuits are most often used with demand-type CPAP devices. Demand-type devices usually require some form of pressure monitoring within the circuit, and the circuits are specifically designed for this reason.

Second, although it may be tempting to think that non-proprietary circuits will be used on other systems, the reality is that once most patients arrive at the hospital, the respiratory therapist will most likely switch out the entire circuit for one designed for the hospital's CPAP/ BiPAP machine.

Another issue to consider when examining CPAP circuits is whether a filter can be placed on the exhalation port. This is essential when using CPAP on a patient with a suspected infectious condition, such as influenza or tuberculosis. This filter shouldn't alter the CPAP dynamics of the pressures generated.

6_MASKS

The key to successful CPAP application is to not have leaks in the system. Tight-fitting straps can help, but they may be uncomfortable for the patient, increasing their anxiety. When evaluating CPAP masks, make sure the mask will provide a comfortable—yet effective—fit to the patient's face.

7_IN-LINE NEBULIZATION OF BRONCHODILATORS

CPAP use with COPD and asthma patients should be combined with the administration of bronchodilators. To facilitate the process, the CPAP circuit and/or mask should allow for the easy introduction of a T-piece nebulizer set that doesn't require significant and timeconsuming modifications.

8_CPAP/VENTILATOR COMBINATIONS

The number of inexpensive transport ventilators that also provide CPAP is growing. The same issues regarding the CPAP component apply. However, agencies can realize significant cost savings by combining the two functions.

ADDITIONAL RESOURCES

Memorial Hermann Hospital. Largest hospital system in Texas and local EMS launch unique partnership to provide non-invasive intervention in congestive heart failure patients: Memorial Hermann healthcare system and Houston Fire Department EMS collaboration to serve as a model for the nation. www.memorialhermann.org/ newsroom/content.aspx?id=268

The rate of oxygen consumption will affect how long you will be able to provide CPAP on a cylinder of a given size.

Excellent data is available to support the use of transport ventilators during and following cardiac arrest resuscitation. For more information, see the 2010 AHA Guidelines on CPR and ECC at http:// static.heart.org/eccguidelines/2010-guidelines-for-cpr.html

9_EASE OF USE

It's important for a CPAP device to be easily assembled and used in the field. Involve your providers in field testing prospective units.

$10_{\rm FUNDING \, OPTIONS}$

Cheaper isn't always better. If a device doesn't meet your clinical criteria for reliable CPAP delivery, any savings are offset by the fact that more patients might require intubation and ICU admission.

Some hospitals have agreed to purchase CPAP units and/or generators for all EMS services. Although one such program in Houston cost the hospital system more than \$250,000 to implement, they were able to recoup this cost within six months by decreasing ICU admissions.¹

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GO WITH THE FLOW

How to apply CPAP with patient comfort in mind

by Connie Mattera, MS, RN, EMT-P, & Keith Wesley, MD

No CPAP device will accomplish its goal if the patient can't tolerate its application. To facilitate successful use, consider the following tips.

DON'T START WITH THE HEAD STRAPS

Patients in respiratory distress often feel claustrophobic when a tight-fitting mask is applied, particularly with straps. *One option:* Ask the patient to hold the mask to their face. Keep your hand on the mask and provide verbal encouragement. This allows you to assess compliance with the procedure and evaluate their mental status, level of consciousness and ability to breathe spontaneously.

Another advantage of holding the mask: It requires you to stay close to the patient and coach them to breathe in through their nose and out through their mouth. This prevents incoming air/oxygen from hitting the back of the throat, minimizing the gag reflex, and it reduces the likelihood of gastric distension, which can result in vomiting. In addition, one of the side effects of CPAP with a higher level of PEEP is a decrease in blood pressure. Close contact and monitoring reapply it when they feel more comfortable. Intermittent CPAP is better than no CPAP at all.

USE COACHING TO IMPROVE COMPLIANCE

"CPAP virgins" are often fearful and anxious, particularly if they're also hypoxic. It's therefore vital that, before starting CPAP, you explain to the patient what to expect.

Don't approach the severely short-of-breath patient with mask in hand, telling them you're going to apply a tight-fitting mask to their face to help them breathe. Instead, refer to the device like you do any oxygen-delivery system, saying, "I'm going to give you some oxygen to breathe. Once it starts, it may be difficult for you to talk to me, so I want you to listen to me and follow my instructions. This will feel odd at first and it will be loud. But if you breathe through your nose and out through your mouth, you'll feel better." Try calling it a special mask that will help them breathe more easily.

Tip: Don't tell the patient the procedure may make them gag or vomit; this can result in a self-fulfilling prophecy.

CONSIDER SEDATIVES

ALS providers should consider administering a small dose of an anxiolytic drug, such as lorazepam, in conjunction with CPAP. A dose of 0.5 to 1 mg IV lorazepam (or 2 mg IV pyelogram midazolam) is usually sufficient to reduce the anxiety associated with CPAP administration or respiratory distress, without decreasing the patient's

Don't approach the severely short-ofbreath patient with mask in hand, telling them you're going to apply a tight-fitting mask to their face to help them breathe.

will lessen the possibility of side effects going undetected.

If the patient is tolerating the therapy well and the clinical condition is clearly improving, apply straps per local protocol.

Tip: If the patient doesn't tolerate CPAP well, allow them to remove the mask and breathe normally, then have them

ventilator drive. Repeat doses may be administered as needed as long as the patient continues to follow directions.

Diazepam may be used, but with caution, because it's more likely to cause respiratory depression. Start with 1 mg IV; titrate as needed.



Coaching can help patients new to CPAP overcome their initial unease with the mask.

APPLY NITRATES VIA AN IV

The primary medication for the treatment of heart failure is nitrates, usually delivered via sublingual tabs or spray. Tablets require temporary lifting of the CPAP mask to administer. Some patients in respiratory distress have a dry mouth, and the sublingual tabs may not be efficiently absorbed under the tongue.

If tablets are the only choice, place a drop of water or saline on the tablet when placed sublingually, or have the patient suck on the tablet. Use of the spray may be accomplished with minimal breaking of the mask/face seal by sliding the dispenser straw under the mask and spraying the nitrate directly into the open mouth. Don't forget to follow this with transdermal nitrates in the field.

The most effective means of nitrate administration for heart failure, however, is IV, because it allows more judicious titration. Even in services with relatively short transport times, the use of IV nitrates has proved very effective, particularly if started early.

USE A NASAL CANNULA FOR CAPNOGRAPHY

Capnography, the standard of care for the intubated patient, should also be used with CPAP. Many CPAP devices have ports or connectors to the circuit that are used to monitor EtCO₂. However, the use of ports or connecting sites in the circuit can result in significant blunting of the graph and

washout of the reading.

A recent study performed by HealthEast Medical Transportation in St. Paul, Minn., demonstrated that the only reliable method of using capnography with CPAP is the application of a nasal cannula that has both oral and nasal sampling ports.

A FINAL BIT OF ADVICE

When using CPAP in the field, there's no need to reinvent the wheel. Consult with other agencies and resources for other best practices and tips. By keeping your patient's comfort in mind, you'll ensure better results and build confidence to regularly tap the benefits of this powerful therapy.

CPAP BEST PRACTICES

Sample BLS/ALS protocols & quality improvement

by Keith Wesley, MD, & Marvin Wayne, MD, FACEP, FAAEM

Every EMS service should have patient care protocols and procedures in place that clearly outline the role of CPAP in their care of patients. The following are examples of indications, contraindications, precautions and procedures that you may be able to use for your service. These examples should be modified to meet your scope of practice and approved by your medical director. To obtain the actual EMS system protocols, go online to www. jems.com/CPAPprotocols.

HEALTHEAST (MINN.) MEDICAL TRANSPORTATION PROCEDURE

CPAP has been shown to rapidly improve vital signs, gas exchange, work of breathing, decrease the sense of dyspnea and the need for endotracheal intubation in patients who suffer shortness of breath from asthma, COPD, pulmonary edema, CHF and pneumonia. In patients with CHF, CPAP improves hemodynamics by reducing preload and afterload.

INDICATIONS

- Has shortness of breath (for reasons other than trauma)
- Is awake and able to follow commands
- Is of an age able to fit the CPAP mask
- Has a respiratory rate greater than 26 breaths per minute
- Has a systolic blood pressure above 90 mmHg (CPAP may raise intrathoracic pressures, reducing preload, therefore reducing blood pressure even further)

- Has been using accessory muscles during respirations
- Presented signs and symptoms consistent with asthma, COPD, pulmonary edema, CHF or pneumonia.

CONTRAINDICATIONS

- 1. Patient is in respiratory arrest
- 2. Patient is suspected of having a pneumothorax
- Patient has a tracheostomy
- 4. Patient is vomiting

PRECAUTIONS

Use care if patient:

- Has impaired mental status and is not able to cooperate with the procedure
- Has failed at past attempts at noninvasive ventilation
- Has active upper gastrointestinal bleeding or history of recent gastric surgery
- Complains of nausea or vomiting
- Has inadequate respiratory effort
- Has excessive secretions
- Has a facial deformity that prevents
 the use of CPAP

PROCEDURE

- 1. Explain the procedure to the patient.
- 2 Ensure adequate oxygen supply to ventilation device.
- Place the patient on continuous pulse oximetry, continuous EtCO₂ and cardiac monitoring.
- 4. Place the delivery device over the mouth and nose.
- 5. Secure the mask with provided straps or other devices.
- 5. Use 5.0 cm H_2O of PEEP (pressure

may be titrated up to $15 \text{ cmH}_2\text{O}$ as needed.)

- 7. Check for air leaks.
- 8. Monitor and document the patient's respiratory response to treatment.
- 9. Monitor vital signs at least every five minutes. CPAP can cause BP to drop.
- 10. Continue to coach patient to keep mask in place and readjust as needed.
- Remove device and consider intermittent positive pressure ventilation with or without endotracheal intubation if respiratory status deteriorates.

REMOVAL PROCEDURE

- CPAP therapy needs to be continuous and shouldn't be removed unless the patient can't tolerate the mask or experiences continued or worsening respiratory failure.
- Intermittent positive pressure ventilation and/or intubation should be considered if the patient is removed from CPAP therapy.

PEDIATRIC CONSIDERATIONS

CPAP should be used with caution in children under 12 years of age and should start with lower pressures (2 cm H_20) .

SPECIAL NOTES

- An in-line bronchodilator nebulizer may be placed in CPAP circuit if needed.
- Don't remove the CPAP device until hospital therapy is ready to be placed on patient.
- Most patients will improve in

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QUALITY IMPROVEMENT

The use of CPAP is a potentially lifesaving procedure and is performed on patients in respiratory distress. The care rendered to this group of patients should be examined closely to ensure therapy is maximized and to determine the extent to which CPAP improves patient outcome. To facilitate continuous quality improvement, it's vital that providers understand what elements must be monitored and documented. The following are examples of the data that should be collected:

MONITORING

- 1. Indication for CPAP usage
- 2. Absence of contraindications for CPAP
- 3. Level of consciousness
- Vital signs: blood pressure, heart rate, respiratory rate, 0₂ saturation and EtCO₂
- 5. Subjective dyspnea scores
- 6. Level of CPAP used
- 7. Accompanying therapies, including nebulizers and nitrates
- 8. Need for anxiolytics
- 9. Complications

OUTCOMES

- 1. Failure to tolerate CPAP
- Advanced airway management: intubation, non-visualized airway, rapid sequence intubation a. Prehospital b. Hospital
- 3. ICU admission
- 4. Mortality
- 5. Correlation of hospital admission diagnosis with prehospital primary impression

To facilitate this, many services have developed separate data collection sheets to be used when CPAP is used on the patient. See the graphs, which are designed specifically for BLS providers. The only addition for ALS providers would be the use of EtCO₂ detection.

Adult Respiratory Distress Protocol





five to 10 minutes. If there's no improvement within this time, consider increasing pressure and preparing for drug-facilitated airway management.

- Watch patient for gastric distention (often presents as vomiting in conscious patient).
- Use nitroglycerin infusion rather than spray to prevent breaking CPAP seal or dispersal of medication on rescuers.
- Remember that CPAP application doesn't violate "do not resuscitate" or "do not intubate" orders.
- Consider the ALS administration of Ativan for anxiety associated with CPAP use, bearing in mind that Ativan may result in respiratory suppression.

BELLINGHAM, WASH., PROCEDURE

SETTING UP THE CPAP SYSTEM

 Connect the generator to the oxygen source (tank or wall outlet) via quick connect. Don't attach to a flow meter; it must be a 50-psi source.

- 2. Attach the filter on the air entrainment (air intake) port.
- 3. Attach the corrugated tubing to the WhisperFlow generator.
- Select the appropriately sized mask (large for most adults, small for very small adults and children), and attach the mask to corrugated tubing.
- 5. Attach the CPAP valve to the center hole of the mask.
- 6. Attach the strap to the mask.

ADJUSTING FLOW AND FI0₂ ON THE WHISPERFLOW GENERATOR

- 1. Turn all three control knobs fully clockwise to the "off" position.
- 2. Turn the flow adjustment valve counter-clockwise to the completely open position (about five complete turns) to provide full flow (140 liters per minute).
- Turn the oxygen control valve to the fully closed position (28%). If after five minutes, the patient's SpO₂ isn't

at the desired level, you may deliver higher oxygen concentrations (up to 100%) by turning the valve farther counter-clockwise. The FiO₂ should be increased judiciously to preserve O_{2} . Then evaluate the Sp O_{2} .

- 4. Turn the on/off valve to the "on" position.
- 5. Verify that air is flowing to the mask.
- 6. Leave the oxygen and flow controls as you've set them. Then turn the on/off valve fully off (clockwise).

APPLY THE MASK

- 1. When you're ready to apply the mask to the patient, turn the on/off valve fully on (counter-clockwise 1/2 turn), be sure the gas is flowing, and then hold the mask on the patient's face. It will help to put one hand on the back of the patient's head and one on the mask to be sure you are applying just enough pressure to keep a good air seal.
- 2. Within a few minutes, when the

patient is comfortable, use the head strap to hold the mask in place. Ensure that it isn't too tight. Some air leakage is acceptable unless it's in the eye area.

- 3. Make sure you are providing flow in excess of the patient's inspiratory flow rate in order to maintain continuous pressure throughout the breathing cycle. This should be checked frequently during transport, as the patient's needs may change. There are three ways to determine whether your flow is set high enough:
 - The CPAP valve should remain slightly open during the entire respiratory cycle.
 - The anti-asphyxia valve on the mask shouldn't open during normal operation.
 - You should be able to feel some gas escaping from the exhalation port of the CPAP valve even during inspiration.

- 4. For patient comfort and to preserve oxygen, turn the flow adjustment knob down to maintain the flow just above the patient's flow rate.
- 5. Normally, the patient should improve in the first five minutes with CPAP, as evidenced by the following:
 - · decreased heart rate;
 - decreased respiratory rate;
 - decreased blood pressure; and •
 - increased O₂ sat.

CONCLUSION

Well-written protocols, which clearly state the point in care at which CPAP should be administered—combined with close monitoring-will ensure that CPAP is used in the most appropriate manner and that patients in severe respiratory distress will reap the benefits of this wonderful life-saving skill.

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