CPAP and BiLevel patient interfaces from a mask to a hood: Why one works when the other doesn't

Captain Steven LeCroy (Ret), MA, CRT, EMTP

Conflict of Interest Disclosure
Steven C. LeCroy

I disclose the following financial relationships with a commercial entity that produces healthcare-related products or services relevant to the content I am presenting:

Company	Relationship	Content Area
Mercury Medical	Director of Clinical Support	Respiratory

Unique What If Situation

Something to Consider:
Under the current conditions and with the increase in backorders and since most medical devices are manufactured offshore are you trained to use different devices?

Bag-Valve-Mask

Hyperinflation Bag

Adult T-Piece Resuscitator

Understanding CPAP/BiLevel/BiPAP

Ignorance (noun): Lack of knowledge, experience, information or education

CPAP or BiLevel Pressure: “Which is better or are they just different?”

“CPAP or BiLevel is a means of support, the therapy doesn’t fix anything.”

Disclaimer: Bilevel pressure therapy was developed in the 1990’s and the term BiPAP™ was trademarked by the Respironics Corporation.

A Few Basic Terms

CPAP and BiLevel (sometime described as a type of CPAP) refers to continuous positive airway pressure and bilevel positive airway pressure, respectively. The important point here is that **both** therapies maintain positive airway pressure during inhalation (IPAP) and exhalation (EPAP).

IPAP – Inspiratory Positive Airway Pressure
EPAP – Expiratory Positive Airway Pressure

CPAP "maintains" the same pressure during IPAP and EPAP.

BiLevel has a higher pressure during IPAP than EPAP providing 2 levels of pressure hence the name BiLevel.

Pressure Support – The difference between IPAP and EPAP

Common Misconception: CPAP is **NOT** non-invasive ventilation even though it is often referred to as NIV

CPAP and BiLevel therapy is used to treat patients with a variety of medical conditions 'non-invasively', i.e., without an advanced airway.

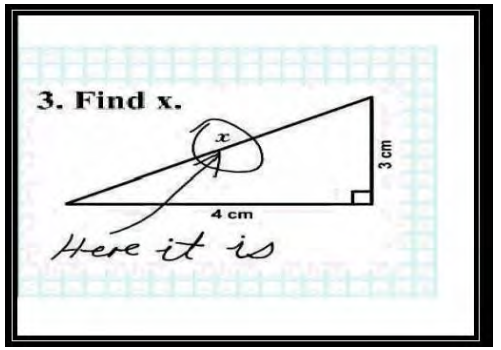
These conditions may include any medical condition that leads to respiratory distress including Congestive Heart Failure (CHF), COPD exacerbation and many others.

Respiratory Distress versus Respiratory Failure

Respiratory Distress – Patients that can maintain a close to normal pH and CO_2 level even though they are working hard. These patients are often awake and alert. Common causes: pulmonary edema (CHF), pneumonia, Adult Respiratory Distress Syndrome (ARDS), pulmonary embolism.

Respiratory Failure – Patients that can't maintain a normal pH and CO_2 level regardless of the level of work. These patient may appear sleepy (running out of gas). Common causes: opiate overdose, neuromuscular disease, status asthmaticus, severe COPD and head injuries.

It's that simple



In order to survive, a person must maintain the proper pH balance (between 7.35 and 7.45). All organs are dependent on the pH, which is to say they only operate ideally within a certain range. Only in this range is the blood ideally supplied with oxygen. If this balance cannot be maintained, the body will begin to break down and die. The body is constantly striving to maintain this balance, and there are many processes by which this is accomplished. The quickest way to adjust the pH is changing how fast we breathe.

Important Respiratory Process

CO_2 is a waste product that must be removed by the lungs. If the work of breathing can't remove the CO_2 it turns into an acid lowering the pH creating a condition called acidosis → Respiratory Failure

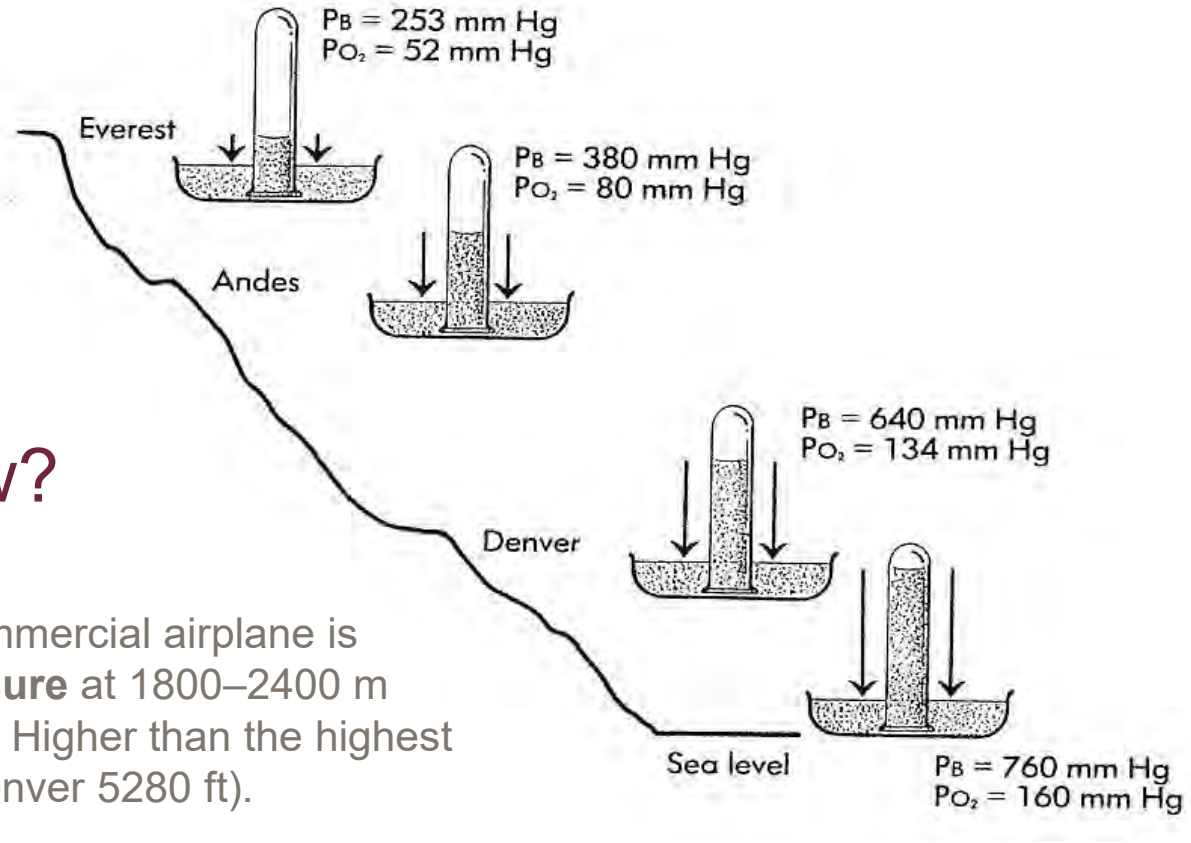
It’s that simple

CPAP is for patients that can still do the work who have low oxygen levels (hypoxia) and BiLevel is for patients that need help doing the work and have increased levels of CO_2 (hypercapnia).

Patients are often switched to Bilevel at the emergency department or as they deteriorate trying to prevent being placed on a ventilator. EMS often sees this as BiLevel is better.

BiLevel is not better the focus of the treatment is different

This explains why a patient's oxygen saturation drops in higher altitudes.



Did you know?

Air **pressure** in the **cabin** of a commercial airplane is equivalent to the outside air **pressure** at 1800–2400 m (6000–8000 feet) above sea level. Higher than the highest major city in the United States (Denver 5280 ft).

Why is this important?

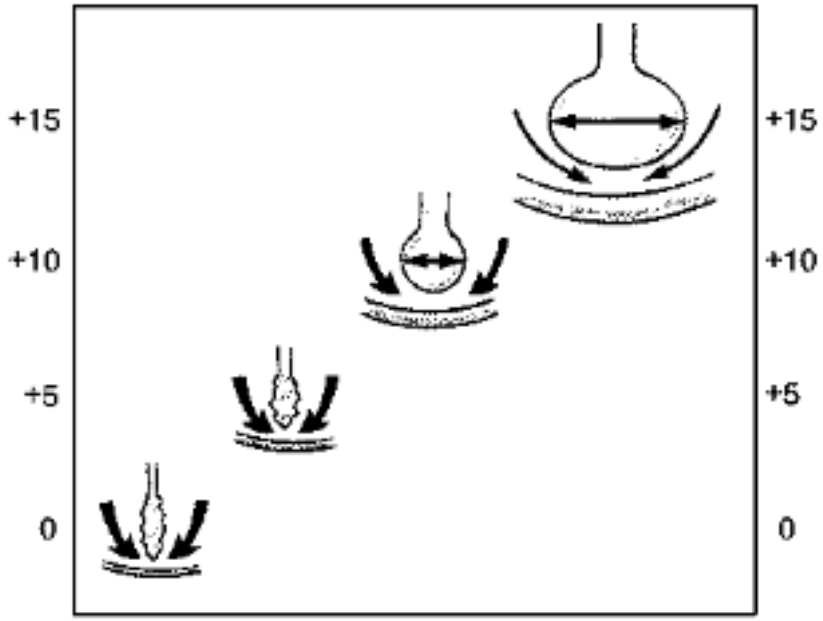
The pressure created by the oxygen in the air creates a pressure gradient from high to low (there is more oxygen in the alveoli than in the capillary). The pressure forces the oxygen into the blood stream.

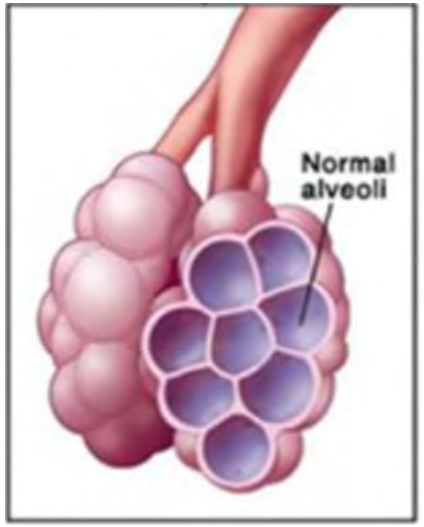
How does CPAP improve oxygenation if the pressure is set by the altitude?

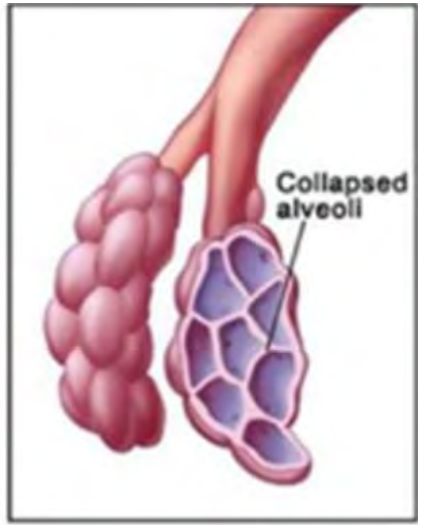
Answer: By making the lungs more efficient in 3 ways, first the pressure increases the size of the alveoli creating a larger surface area for gas exchange. Second, by recruiting alveoli that may be collapsed. Third, If the FiO_2 is increased the pressure gradient will increase improving gas exchange.

Henry's law - The amount of oxygen that dissolves into the bloodstream is directly proportional to the partial pressure of oxygen in alveolar air.

Why is this important?







Why does air go in and out?

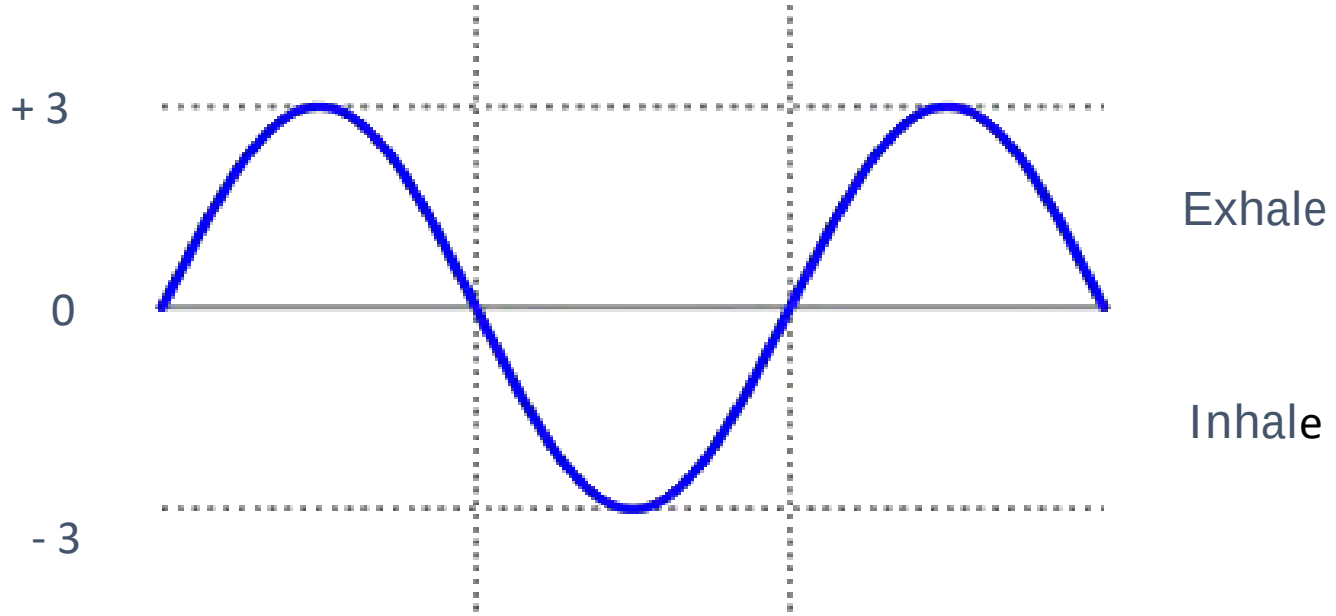
We breathe by contracting respiratory muscles (mainly the diaphragm) and expanding our chest and thereby create a slightly negative pressure inside the airway *relative to ambient (outside) pressure*.

This slightly negative pressure -- about -3 cm H_2O at rest -- allows fresh air to enter our lungs and supply the alveoli with oxygen. Then we relax the respiratory muscles, and in so doing exhale to create a slightly positive pressure (inside the lungs) relative to ambient (+3 cm H2O); this allows stale air full of carbon dioxide to leave our lungs and enter the atmosphere.

When it comes to breathing (and to make the math easier) ambient pressure is always written as zero. As long as a person can make slight pressure changes (+/- 3 cm H2O) air will move in and out.

Boyle's law - As the lungs expands, the volume inside the lungs increases and the pressure inside decreases causing air to enter the lungs.

Normal Healthy Breathing



"CPAP is NOT NIV the patient still has to be able to move the air"

Why CPAP Works
(Key Concept)

"CPAP does not do the work it makes the work easier and makes oxygenation more efficient"

How:

1. Dilates the airway for easier exhale
2. Overcomes Auto-PEEP for easier inhale
3. Recruits collapsed alveoli
4. Reduces the amount of fluid in the alveoli
5. More efficient gas exchange

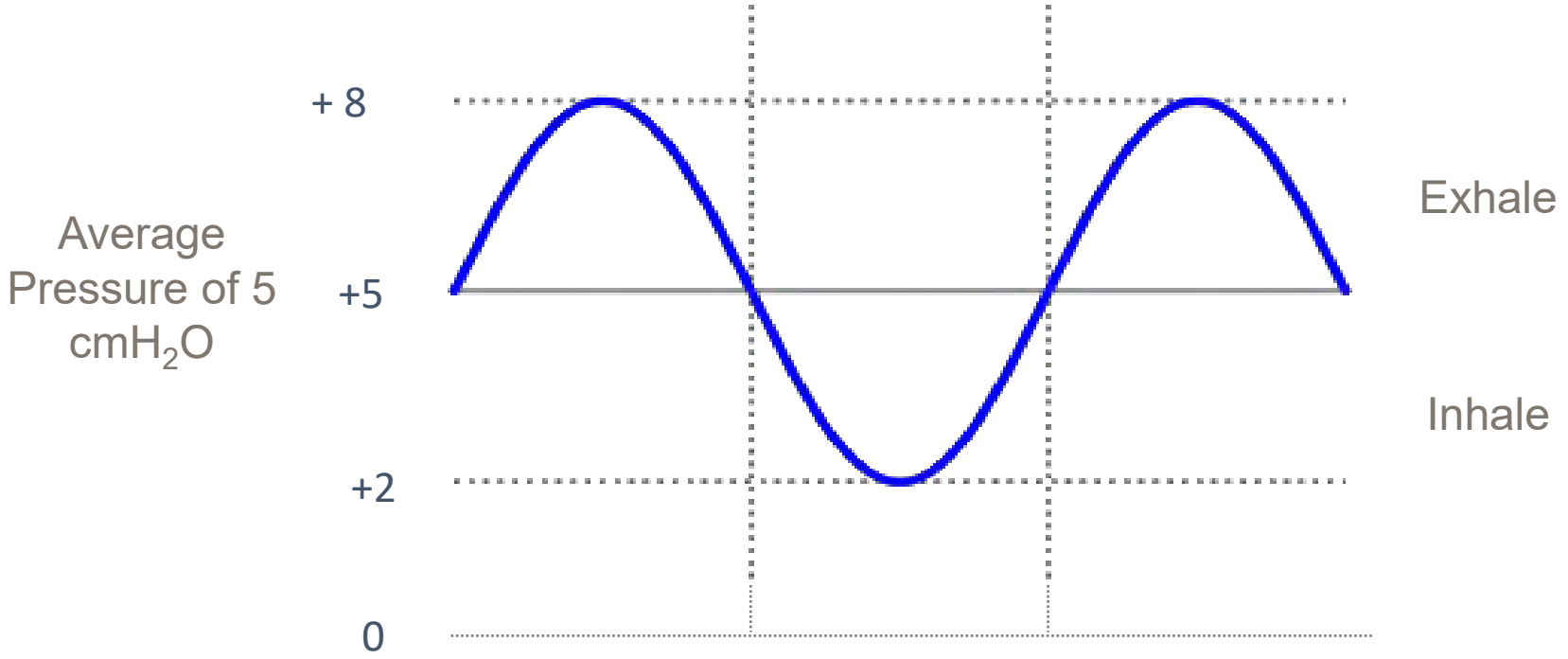
Did you know?

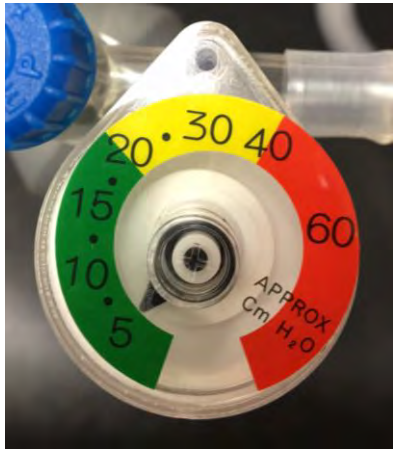
If the diameter of the airway is reduced in size by ½ the work of breathing increase 16 times.

What type of problems effect the diameter of the airway? Asthma, COPD, foreign body, allergic reaction, mucus plugs etc.

Poiseuille's Law – Involves the relationship between airway resistance and the diameter of the airway. Therefore, a small change in diameter has a huge effect on the resistance of an airway.

Breathing with 5 cmH_2O CPAP





"All CPAP devices will have fluctuations in pressure, however the pressure should never go to zero"

CPAP Indications

CPAP is indicated for patients in respiratory distress that have signs of hypoxemia without signs of CO_2 retention.

Normal $EtCO_2$ 35 – 45 mmHg

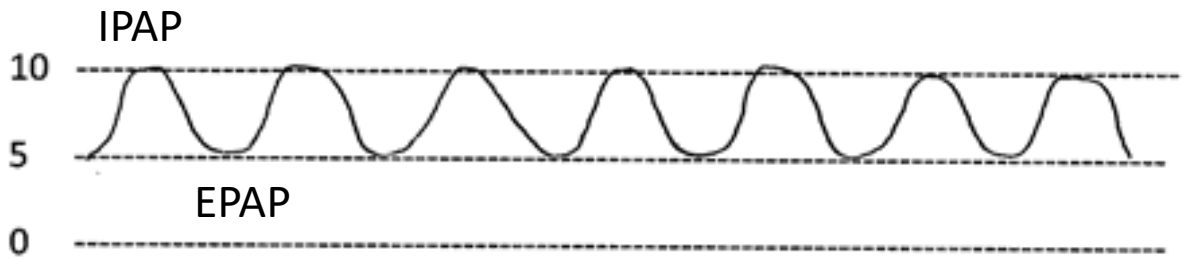
Normal Oxygen Saturation (SPO_2) > 92 %

CPAP is often used for the wrong patients.

Why:

1. Misdiagnosed: Patient may be in respiratory failure and not a candidate for CPAP.
2. Trying to avoid intubation and CPAP is the only option.
3. BiLevel might be a better option, may be expensive and not always available especially pre-hospital.

BiLevel CPAP IS Non-invasive Ventilation

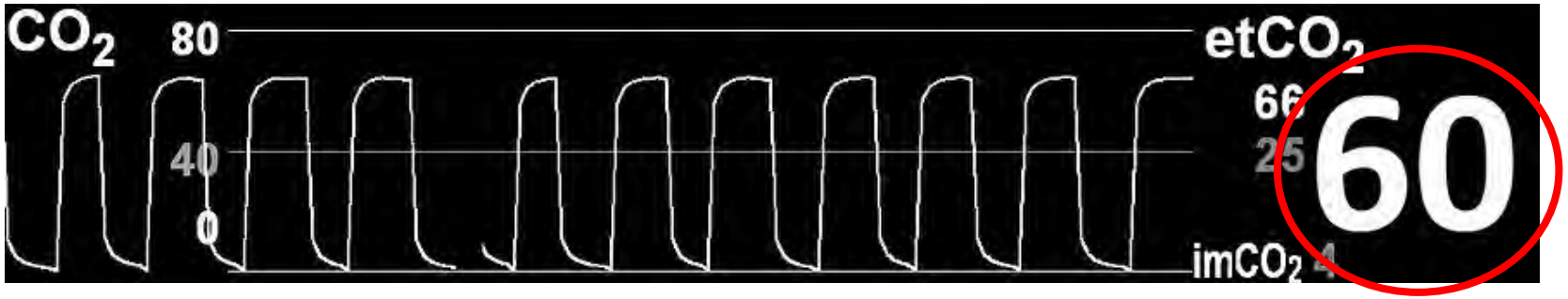


Pressure stays above zero

With BiLevel there are 2 numbers, inspiratory pressure (IPAP) and expiratory pressure (EPAP) often written as BiLevel 10/5. The patient will inhale with the help of 10 cmH_2O and exhale against a less resistance of 5 cmH_2O. The bump in pressure for inhalations helps the patient inhale (sometimes referred to as pressure support) while the lower resistance to exhale against reduces the work of breathing.

BiLevel Indications

BiLevel is indicated for patients in respiratory distress (heading toward respiratory failure) that have signs of CO_2 retention, the patient is tiring and the goal is to avoid intubation.



Normal CO2 – 35 – 45 mmHg

BiLevel is not better than CPAP it's different

What's the value of NIV over CPAP?

For some patients there's little value to use NIV over CPAP, for others the value is priceless. The question is which patients get which therapy?

Research Supporting the Use of NIV

"As compared with CPAP, NIPPV produces greater improvements in oxygenation and carbon dioxide clearance and a greater reduction in the work of breathing in patients with pulmonary edema"

Noninvasive Ventilation in Acute Cardiogenic Pulmonary Edema
N Engl J Med 2008

"NIPPV has also been shown to reduce complications associated with treatment and length of hospital stay."

Non-invasive positive pressure ventilation for treatment of respiratory failure due to exacerbations of chronic obstructive pulmonary disease

First published: 19 July 2004
Editorial Group: Cochrane Airways Group

Research Supporting the Use of NIV

"In this population, response to initial ED management of bronchospasm, as measured by PEFR, was better with aerosols delivered by BiPAP than with those delivered by SVN."

Treatment of acute bronchospasm with beta-adrenergic agonist aerosols delivered by a nasal bilevel positive airway pressure circuit.
Ann Emerg Med. 1995 Nov;26(5):552-7.

CONCLUSION: In patients with severe acute asthma, the addition of NIV to standard medical therapy probably accelerates the improvement in lung function, decreases the inhaled bronchodilator requirement, and shortens the ICU and hospital stay

A Prospective Randomized Controlled Trial on the Efficacy of Noninvasive Ventilation in Severe Acute Asthma
Respiratory Care, May 2010 Vol 55 No 5

PEFR – Peak Expiratory Flow Rate (Breathing Test)

Peak Inspiratory Flow Rates & Dyssynchrony

If the peak flow rate (volume and velocity of the oxygen or air) coming from the device toward the patient is too low what is described as device asynchrony an increase in work of breathing will result.

Everyone has experience flow starvation during the pandemic. This occurs when we inhale through a mask. The increase in work even in the most healthy people will give a sensation of shortness of breath, air hunger and anxiety. Flow rates must be titrated to meet the patient's inspiratory demands.

The peak inspiratory flow rates needed by patients with Acute Respiratory Distress or failure is a mean 30–40 L/min, and can exceed 60 and even reach 120 L/min in more severe patients.

Key question: Does your device meet the Peak Inspiratory Flow Rates needed by the patient? Or are you contributing to the problem?

DIFFERENT TYPES OF PATIENT INTERFACES

The most common CPAP/BiLevel patient interface is the Oral Nasal Mask. All of the others with the exception of the Hood and Nasal Prongs are used for sleep apnea. The Nasal Prongs/Cannulas are commonly used with High Flow therapy.

Hoods

Full Facemask

Oral Nasal Mask

Nasal Mask

Nasal Prongs/Cannulas

BLEEP

PROPER FIT FOR AN ORAL NASAL MASK

"If the mask does not have a good seal and is comfortable the therapy will fail"

- Most manufactures offer from 3 - 5 different sizes of mask from pediatrics to extra large adults.
- Mask Designs
  - Double Seal
  - Cushion (inflatable/non-inflatable)
  - Gel
  - Head harness vs Head strap
  - Forehead support to take pressure off the bridge of the nose
  - Easy access to the face and airway
  - Vented or Non-vented

PROPER FIT FOR AN ORAL NASAL MASK

"Selecting the proper mask is part guess and part experience"

- In EMS the options are almost always limited
- Taking the time to explain what you are doing goes a long way
- Have the gas/air flowing before placing the mask on the patient's face (Let them hear and feel the gas flow)
- If possible have the patient hold the mask in place and then add the harness/strap
- Mask should not be too tight (not skin-tight, only air-tight)
- Try not to pull the patient's hair or pin their ears in the strap.
- Once the harness/strap is in place check the manometer (if available) to modify the pressure, check for a seal and check for Dyssynchrony with the flowrate.

WHY CPAP/BILEVEL FAILS

“Some patients just can’t tolerate a mask”

- Wrong therapy/Wrong patient
- Inspiratory flowrate is too low (by far the most common)
- Provider doesn’t explain what’s going to happen
- Mask too big or too small – Can’t get a good seal
- Mask too tight or too loose
- Expiratory resistance makes it too difficult to breathe (BiLevel might be a better option)
- Provider ignores the patient once therapy started
- Patient having difficulty communicating
- Claustrophobic
- Can’t wear their glasses

NEW CPAP/BILEVEL INTERFACE TECHNOLOGY HOOD/HELMET

Technology has been around for over 20 years

Was not approved in the US as a respiratory interface until the pandemic

Can be used for both CPAP and Bilevel

Patients can talk, read and watch TV

Some have access for oral medication, water & food

CPAP and BiLevel hoods are slightly different

Eliminates skin breakdown on the face

Can be quite noisy

Requires a minimum gas flow of 40 LPM to washout the CO_2

NEW CPAP/BILEVEL INTERFACE TECHNOLOGY BLEEP

"Even though primarily used with sleep apnea with the current pandemic and long-term use of CPAP/BiLevel nothing is off the table"

Works well in any position

One size fits all

Gives providers an additional option

Patient can talk, eat and take medication

With proper connectors should be able to be used with any CPAP/BiLevel device

"All CPAP/Bilevel interfaces can work and all can fail. It's a matter of the four **R**'s: the **R**ight patient, **R**ight therapy, **R**ight application and **R**ight interface"

Questions?

Should a question arise regarding CPAP and/or BiLevel, feel free to contact:

Captain Steve LeCroy (Ret.), MA, CRT, EMTP
paraexp@aol.com
(727) 412-4153