

The use of CPAP for the pre-hospital treatment of acute respiratory distress

Overview:

Continuous Positive Airway Pressure (CPAP) has become a standard treatment for congestive heart failure (CHF) and a number of other respiratory distress situations and has significantly reduced the need for endotracheal intubation (ETI) in these patient groups. CPAP devices work by providing a constant positive airway pressure to the patient to splint open the airways during exhalation and, to reduce the patient's work of breathing (WOB) (work of breathing is the energy expended by the patient to breathe). CPAP is designed to reduce that WOB by "over delivering" a flow of air or oxygen during the inspiratory phase. Increased WOB leads to exhaustion and respiratory depression. The PEEP pressure during the expiratory phase is supplied to splint open the airways and to force accumulated fluid back into the interstitial spaces. In addition to the improvement in the patient's condition and the reduction in the need for intubation and drug interventions, it has been shown that the use of CPAP with these patients' (in the prehospital environment) also reduces the length of hospital stay and the need for admittance to the Intensive Care Unit (ICU).

Discussion:

The efficacy of the delivery of CPAP pressures by the devices offered for the prehospital market differs significantly. To deliver a "*continuous*" (and this is the key word in CPAP) positive airway pressure, during the inspiratory phase, the device must deliver a flowrate in excess of the flowrate demanded by the patient. Some

devices on the market, while being very novel in their approach to delivering a PEEP pressure, do not provide a continuous positive pressure by providing the flow demanded by the patient during the inspiratory phase and therefore may be incorrectly classified as CPAP devices.

Other devices utilize a constant gas flow and a pressure balancing valve on the facemask to maintain the CPAP pressure. These tend to produce high sound levels which can be annoying to the patient. Their efficacy is considered to be good.

The last group of CPAP devices use an internal pressure control circuit to actuate a demand valve and supply CPAP pressure. Some of these devices however have a significant delay in delivery of flow when the patient initiates the inspiratory cycle. This is due to the high triggering pressure of the demand valve which generates the inspiratory flow and creates a "hiccup" in flow delivery which can be disturbing for the patient. In addition some have a high peak pressure at the commencement of the inspiratory phase. Any significant drop below the CPAP baseline during inspiration and airway pressure spike at the beginning of expiration reduce the efficacy of the CPAP and adds to the patient's WOB.

As can be seen from the following graph, the volume of the shaded area indicates when the pressures are above or below the baseline CPAP pressured set during one respiratory cycle. This indicates the additional work imposed on the patient (Fig. 1).

Gas consumption is an important issue in the pre-hospital emergency

market. On a “D” size oxygen cylinder of the gas flow/pressure balancing valves ranges between 35 - 45 minutes while the internal pressure control devices last between 45 - 55 minutes. The novel PEEP devices have a significantly shorter operating time of between 15 - 20 minutes (based on a CPAP pressure of 7.5 cmH₂O) (Fig. 2).

Conclusion:

Prehospital CPAP has been clinically proven to assist patients in respiratory distress from CHF and a number of other conditions. The following statements are taken from the conclusions drawn during a number of clinical studies. These comments validate the use of CPAP in the prehospital environment.

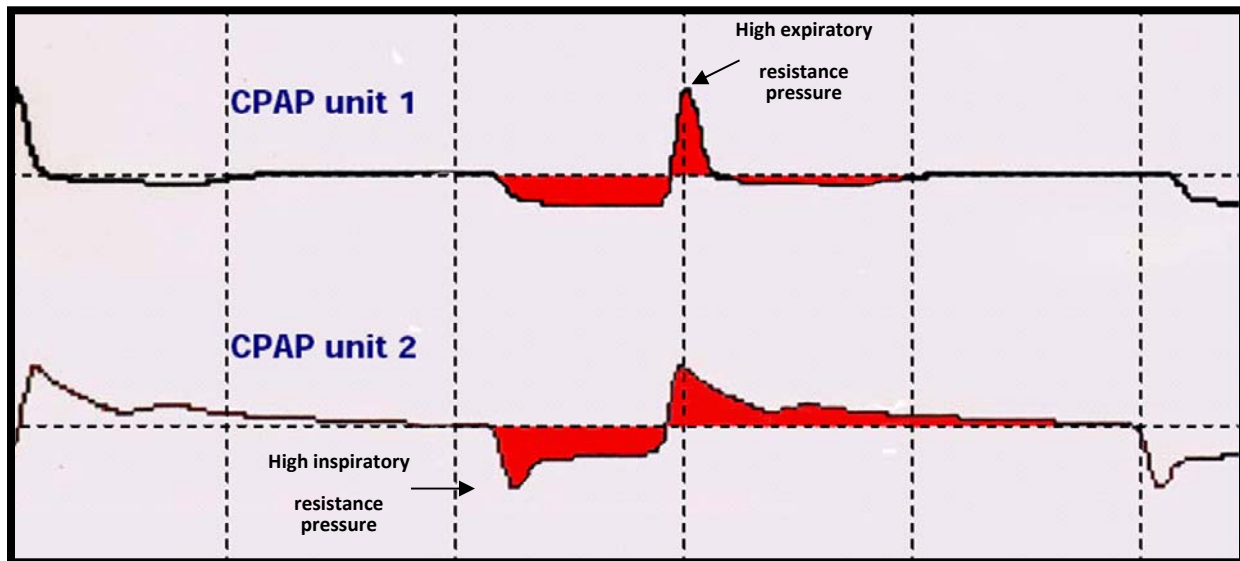


Fig.1. Pressure waveform showing high inspiratory and expiratory pressures of two, commonly available, pressure control/demand valve devices - CPAP pressure 7.5 cm H₂O

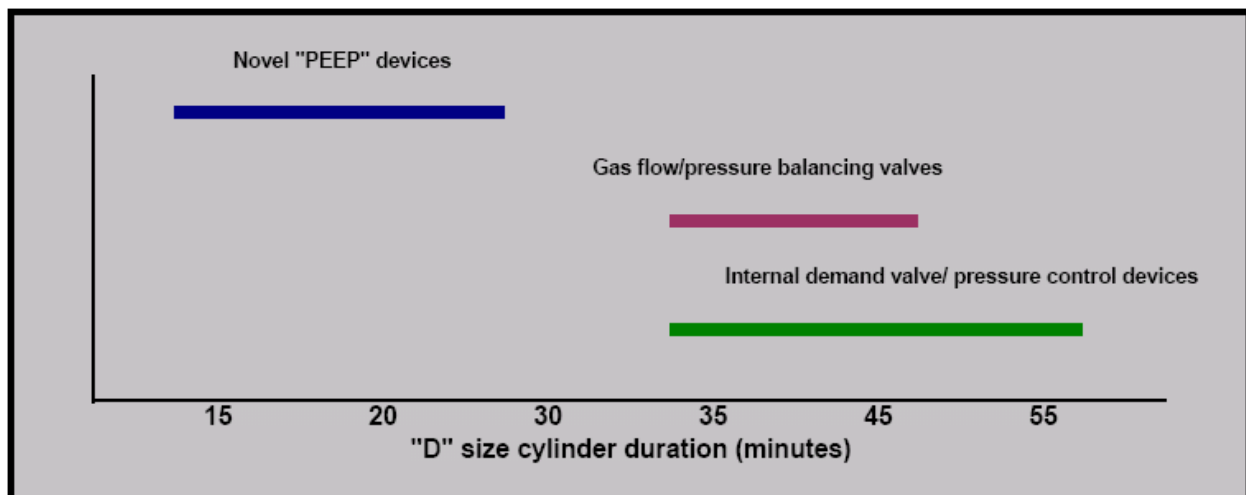


Fig. 2. Cylinder duration on a standard “D” size Oxygen Cylinder

STUDY COMMENTS

“NIV clearly improves outcomes for patients with chronic obstructive pulmonary disease and acute cardiogenic pulmonary edema when instituted as a first-line therapy”.

Noninvasive ventilation in acute care: Controversies and emerging concepts. Kallet RH. San Francisco General Hospital, San Francisco, CA 94110, USA. *Respir Care*. 2009 Feb;54(2):259-63.

“Prehospital NIPSV is feasible and able to improve emergency management of ACPE”.

Prehospital noninvasive pressure support ventilation for acute cardiogenic pulmonary edema Weitz G, Struck J, Zonak A, Balnus S, Perras B, Dodt C. Department of Internal Medicine I, Conservative Intensive Care and Emergency Medicine, University Hospital Schleswig-Holstein, Campus Lübeck, Lübeck, Germany. *Eur J Emerg Med*. 2007 Oct;14(5):276-9

“CPAP is safe, portable and easy to apply”.

Prehospital use of CPAP: Positive pressure = Positive patient outcomes. Sullivan R. New Castle County EMS, DE, USA. *Emerg Med Serv*. 2005 Aug;34(8):120, 122-4, 126.

“Both Intubation and mortality were decreased in the CPAP group”.

“Effectiveness of prehospital continuous positive airway pressure in the management of acute pulmonary edema.” Michael H^a, Michael R^b, et al: ^aEmergency Medical Care Program, Western Carolina University, Cullowhee, NC. ^bDepartment of Emergency Medicine, University of New Mexico, Albuquerque, NM *Prehospital Emergency Care*. 10(4):430-439, 2006

“The addition of CPAP to standard therapy was advantageous and significantly reduced both mortality and intubation rates”.

“The use of noninvasive ventilation in emergency department patients with acute cardiogenic pulmonary edema: A systematic review.” Collins S, Mielniczuk L, Whittingham H, et al. Department of Emergency Medicine, University of Cincinnati, Cincinnati, OH 45267-0769, USA. *Annals of Emergency Medicine*. 48(3):260-269, 2006

“The prehospital use of CPAP is feasible, may avert the need for endotracheal intubation, and may reduce short-term mortality”.

Effectiveness of prehospital continuous positive airway pressure in the management of acute pulmonary edema. Hubble MW, Richards ME, Jarvis R, Millikan T, Young D. Emergency Medical Care Program, Western Carolina University, Cullowhee, NC

28723, USA. *Prehosp Emerg Care*. 2006 Oct-Dec;10(4):430-9.

“Previous studies have demonstrated the clinical effectiveness of CPAP in the management of acute pulmonary edema. prehospital CPAP appears to be a cost-effective treatment”

Estimates of cost-effectiveness of prehospital continuous positive airway pressure in the management of acute pulmonary edema. Hubble MW, Richards ME, Wilfong DA. Emergency Medical Care Program, Western Carolina University, Cullowhee, North Carolina 28723, USA. *Prehosp Emerg Care*. 2008 Jul-Sep;12(3):277-85.

“For patients with acute respiratory failure and presumed pulmonary edema, the prehospital use of CPAP is feasible and may avert the need for ETI”.

Prehospital use of continuous positive airway pressure (CPAP) for presumed pulmonary edema: a preliminary case series. Kosowsky JM, Stephanides SL, Branson RD, Sayre MR. Department of Emergency Medicine, Brigham and Women’s Hospital, Boston, Massachusetts 02115, USA. *Prehosp Emerg Care*. 2001 Apr-Jun;5(2):190-6.

“Prehospital CPAP treatment in patients with acute severe pulmonary edema improved oxygenation significantly and lowered respiratory rate, heart rate, and systolic blood pressure”.

The use of prehospital continuous positive airway pressure treatment in presumed acute severe pulmonary edema Kallio T, Kuisma M, Alaspää A, Rosenberg PH. Department of Anesthesiology and Intensive Care, Helsinki University Hospital, Helsinki, Finland. *Prehosp Emerg Care*. 2003 Apr-Jun;7(2):209-13

“Understanding CPAP devices’ performance capabilities is also important because performance of individual units can vary”

Comparison of three CPAP systems used in EMS. McCoy RW, Diesem R. Valley Inspired products. White Paper

“A small but not significant percentage of patients are optimal candidates for a prehospital trial of CPAP”

EMS transports for difficulty breathing: is there a potential role for CPAP in the prehospital setting? Kosowsky JM, Gasaway MD, Stephanides SL, Ottaway M, Sayre MR. University of Cincinnati, Cincinnati, OH. *Acad Emerg Med*. 2000 Oct;7(10):1165.