Use of Noninvasive Positive Pressure Ventilation in Acute Respiratory Failure

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For more than 50 years, mechanical support of patient's respiration has been mainly achieved by the use of intermittent positive pressure ventilation (IPPV) through a cuffed endotracheal or tracheostomy tube. In this time, there have been important advances and improvements to these machines - such as the development of positive end expiratory pressure (PEEP) and pressure support ventilation (PSV). These advances have had a significant positive impact on the management of patients with acute respiratory failure.

For the past 10 years, there has been increased interest in the use of noninvasive methods of ventilation for the management of acute and long-term ventilatory insufficiency. This is due, in part, to increased recognition of the high rate of complications specially related to intubation.

The first machines developed for use in patients with respiratory failure delivered continuous positive airway pressure (CPAP). With CPAP, a single pressure that is greater than atmospheric is applied to the patient's airway throughout the inspiratory and expiratory cycles of respiration. There are multiple reasons why CPAP improves breathing.

1. Counteracts intrinsic PEEP
2. Decreases preload and afterload in congestive heart failure (CHF)
3. Improves lung compliance in CHF
4. Decreases the work of breathing

Intrinsic PEEP is the concept, that in patients with severe chronic obstructive pulmonary disease (COPD) or asthma, the lung does not fully empty due to the obstruction of the airway resulting in a positive pressure in the airways at the end of expiration. Therefore, to breathe in, the COPDer must first overcome this positive airway pressure before he can generate a negative pressure to inhale more air. This is called intrinsic PEEP and, in patients with respiratory failure due to COPD, it is often about 5cm$H_2$0. But it can be higher.

NIPPV also applies positive pressure to the airway. The mode of ventilation most commonly used is bilevel positive airway pressure (BiPAP). This involves the delivery of two different pressures: an inspiratory positive airway pressure (IPAP) and an expiratory positive airway pressure (EPAP), which is lower than the IPAP. The machine senses the change in flow as the patient begins to inhale and will cycle up to the preset IPAP. This pressure is maintained until the machine senses a decrease in inspiratory flow as the patient reaches maximum inhalation. It then cycles down to the EPAP and maintains that pressure until the patient again begins to initiate a breath, when it again cycles up to the IPAP.

This mode of ventilation requires that the patient breathe spontaneously; it is the initiation of the inspiration that triggers the machine to cycle up to the IPAP.

In patients with respiratory failure, a common technique is to begin with the expiratory level at 5 and the inspiratory level at 15. The levels are adjusted based on patient comfort, tidal volume achieved and blood gases.

Other ventilators and mode of ventilation have also been used with a nose or facemask. These ventilators are set as they would be for an intubated patient using common modes of ventilation such as assist-control

There are now multiple randomized, prospective studies showing the benefit of noninvasive ventilation in respiratory failure (1-3).

Furthermore, not only has it been shown to be an effective therapy, but there is also evidence that it contributes to less time in hospital, fewer complications and decreased mortality compared to immediate intubation and ventilation. Antonelli et al (4) showed in their study that there is a reduction of intubation from 74% to 16%, major complications were decreased from 48% to 16% and length of stay from 35 days to 23 days. Brochard et al (3) showed in their series that the mortality decreased from 29% to 9%. It should be noted that only 1/3 of the patients could be randomized and only between 50-80% of patients are compliant with treatment. Still there is certainly Level 1 evidence to support the use of BiPAP in patients with a $PCO_2 > 50$, a $pH < 7.35$, and a respiratory rate > 30.

There is also evidence from randomized, controlled trials to show that CPAP improves oxygenation, hypercapnia and reduces the rate of endotracheal intubation in pulmonary edema (5-7). If tolerated, BiPAP seems even more effective with faster reduction of PCO_2, improved PO_2, pH and RR. Unfortunately, there were an increased number of myocardial infarctions in the patients on BiPAP compared to CPAP. Until further studies are done, it is recommended that CPAP be tried first, and if BiPAP is attempted, it should be initiated cautiously, watching for hypotension (8).

There is still controversy on how and why CPAP works in CHF. There is no dispute that it reduces the work of breathing by improving atelectasis and V/Q ratios. Some studies have suggested it also improved preload and afterload and that there is actually an improvement in cardiac index. Of even more interest, Bradley et al suggest that up to 50% of patients with CHF have sleep apnea. In these patients, the use of CPAP not only improves sleep, but also leads to improvement in ejection fraction that lasts into the daytime hours when they are awake. It is postulated that CPAP reduces preload and also afterload. It is possible that obstructive sleep apneas can put a severe strain on the heart by markedly increasing afterload and leading to hypertension.

In conclusion, for those patients who present to the emergency department with acute respiratory failure but with normal levels of consciousness, no major secretion problems and who are hemodynamically stable, a trial of BiPAP or CPAP should be attempted prior to considering intubation and mechanical ventilation.

References

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