TITLE: EXQUISITE MANAGEMENT OF PRESSURE CONTROL INVERSE RATIO VENTILATION BY A COMPUTERIZED PROTOCOL

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Pressure control inverse ratio ventilation (PCIRV) is a more complex ventilatory support mode than volume control for the following reasons: 1) The relationship between the patient's expiratory time constant, a reflection of the mechanics of the patient and circuit, and the expiratory time allowed (Te) will determine the intrinsic PEEP (PEEPi). 2)The ventilation depends on both the ventilator settings and PEEPi. 3)It is difficult to separate oxygenation from ventilation. Changes in ventilation (respiratory rate (RR) and tidal volume (Vt)) often result in changes in oxygenation due to changing PEEPi and mean airway pressure. This makes PCIRV titration complex and confusing. Many reports have been published regarding PCIRV; however, all lack a clear systematic approach to the use of PCIRV. We have developed a computerized protocol which provides a systematic approach for management of PCIRV that decouples the management of oxygenation and ventilation.

Our PCIRV protocol focuses on reducing expiratory resistance and thus the expiratory time constant while maintaining a desired level of PEEPi, tidal volume and arterial pH. Expiratory resistance is reduced dramatically (as much as 20 cm H20/l/s) by eliminating the PEEP valve. PEEPi is maintained using a short Te relative to the patient's expiratory time constant. The tidal volume is maintained by adjusting the pressure control level. The pH is maintained within a desired target zone by adjusting the minute ventilation. The optimal I:E ratio is calculated from RR and Te ([60/RR-Te]/Te). These protocols were implemented in an IBM PC/AT interfaced to a Siemens 900C ventilator. The system displays instructions on the video terminal and will automatically detect when the instructions are followed. PEEPi was measured at the end of at least a 2 second expiratory hold. Desired PEEPi is adjusted based on oxygenation needs. The PCIRV protocol effectively decouples oxygenation from ventilation by allowing the ventilation variables (RR and Vt) to be specified independent of the oxygenation variables (PEEPi and FiO2).

The PCIRV protocols were used around-the-clock by routine ICU staff to control patient care for 431 hours in 5 patients with severe ARDS. 384 instructions were generated, 360 were followed (93%). Compared with conventional therapy prior to the institution of PCIRV a reduction of peak airway pressure by 26%, of minute ventilation by 24%, and of tidal volume by 16% was noted at the same PaO2, FiO2, pH, PCO2, and mean airway pressure. Shunt fraction was reduced by 14%. No hemodynamic complications occurred; however, there was a 7% drop in cardiac index. We conclude that this computerized PCIRV protocol can be used successfully by routine staff 24 hours a day and is safe. The physicians, respiratory therapists, and nurses have all commented that this protocol has dramatically reduced the complexity of using PCIRV while assuring uniformity of care and patient safety.

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TITLE: LUNG MECHANICS AND AIRWAY PRESSURE TRANSMISSION IN INFANTS AFTER OPEN-HEART SURGERY

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To evaluate the effects of positive pressure lung inflation, lung compliance and airway pressure transmission were assessed in 11 infants undergoing open-heart surgery during their first year of life.

After closure of the sternotomy, but while the patient still was anesthetized and paralyzed, the airway was opened to ambient pressure. Thereafter, the lungs were inflated to a volume of 10 ml/kg above functional residual capacity (FRC) in steps of 2.5 ml/kg, while continuously recording airway and intrathoracic pressure. The data were analyzed using a repeated-measures analysis of variance.

In 7 of 11 patients, lung inflation to 2.5 ml/kg above FRC produced an abrupt improvement in initially low lung compliance to a level previously measured in similar patients before surgery (Figure). The corresponding elevation in airway pressure ranged from 4 to 11 cmH2O. Further lung inflation did not improve lung mechanics. In the remaining patients, initial lung compliance was high and remained unchanged throughout the range of lung inflation. Transmission of pressure into the intrathoracic space averaged 47±9% (mean±SD; range 33-61%), when airway pressure was 10-15 cmH2O, and did not change significantly with alterations in lung volume.

Open heart surgery and cardiopulmonary bypass usually result in mild postoperative lung injury with impairment in gas exchange and reduction in lung compliance. The hypoxemia and increased respiratory work resulting from the lung injury frequently can be corrected using continuous positive airway pressure. The lung pressure-volume relationships in this study show that the use of moderately elevated airway pressure abruptly corrects impaired lung distensibility, indicating a relatively narrow range of mechanical abnormality in the lung with a high degree of alveolar recruitment. Therefore, postoperative use of positive end-expiratory pressure is likely to benefit most infants after open heart operations.

Transmission of elevated airway pressure into the intrathoracic space will introduce an artifact into intrathoracic pressure measurements referenced to atmospheric pressure. Analysis of pressure transmission in this study shows that an assumption of a 50% transmission or airway pressure is appropriate for clinical purposes.

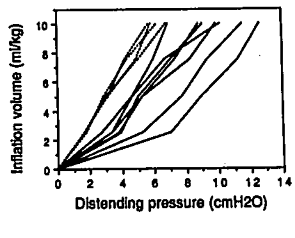

Figure. Pressure-volume curves of the lungs showing abrupt improvement in lung mechanics in 7 of 11 infants (continuous lines).