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Advances in  
pulmonary management of  
the critically ill infant

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INSPIRED INFANT CARE

## Inside this Issue

### Treating RDS with HFJV

### Successful Early Treatment of RDS is Strategy Dependent

Incidence of bronchopulmonary dysplasia (BPD) at 36 weeks of age was significantly lower in premature babies randomized to high frequency jet ventilation (HFJV) in a study of early ventilator treatment of respiratory distress syndrome (RDS). Incidence of severe intraventricular hemorrhage (IVH) and periventricular leukomalacia (PVL) was significantly lower in a subgroup of the HFJV-treated babies. Dr. Martin Keszler, Associate Professor of Pediatrics at Georgetown University Medical Center, reported the results from 142 patients treated at eight centers at the Annual Conference of High Frequency Ventilation of Infants at Snowbird, Utah on March 27, 1996, as well as the Pediatric Academic Societies annual meeting in Washington, DC, on May 8, 1996.<sup>1,2</sup>

The multi-center study compared infants weighing between 700 and 1500 grams treated with conventional ventilation (CV) (n=73) versus HFJV (n=69). The incidence of BPD in the conventionally treated group was 24/60 (40%) compared with 9/57 or (16%) in HFJV-treated babies.

Previous results from Thomas Jefferson Medical Center in Philadelphia (*Bunnell News*, Winter '95) prompted further examination. (The Jefferson study found an increased incidence of severe brain injury in infants treated with HFJV and "standard" PEEP of 5 cm H<sub>2</sub>O compared to conventionally treated infants.<sup>3</sup>) Sub-analysis of the multi-center data considered three treatment groups: 1) control infants treated with conventional ventilation (n=73); 2) an experimental group where PEEP was raised by at least 1 cm H<sub>2</sub>O or was maintained at 7 cm H<sub>2</sub>O or higher when the infant was switched to HFJV (n=34); and 3) an experimental group where "traditional" PEEP of 4 or 5 cm H<sub>2</sub>O was used (n=35).

Peak inspiratory pressure and airway pressure amplitude (PIP - PEEP) were lower in infants treated with HFJV. Arterial/alveolar oxygen ratio was higher in infants treated with HFJV and higher PEEP (Group 2). Hyperventilation occurred in Group 3 infants treated with HFJV and lower PEEP. (PaCO<sub>2</sub> was significantly lower over the first twelve hours post-randomization.) There was no difference in the incidence of BPD between the two HFJV treatment groups: 4/27 (15%) in Group 2 versus 5/30 (17%) in Group 3.

Group 2 infants experienced a low incidence of severe cerebral injury. Only 3/32 (9%) of these infants treated with HFJV and higher PEEP developed grade III and IV intraventricular hemorrhage (IVH) or severe periventricular leukomalacia (PVL). This incidence was significantly lower than the 12/33 (36%) Group 3 infants treated with HFJV and standard PEEP. It was not significantly lower than the 17/66 (26%) infants in the Group 1 controls statistically (p=0.11).

The relatively high incidence of cerebral injury in the Group 3 infants was consistent with the Jefferson Study.

### Discussion

While the BPD at 36 weeks results are very encouraging, data from the sub-analysis was not gathered prospectively. This study was not designed to compare the use of HFJV at higher versus standard PEEP. Therefore, drawing strong conclusions from these results is problematic.

One interpretation of the data suggests that cerebral ischemia secondary to hyperventilation led to an increased incidence of brain injury in the Group 3 babies. HFJV-treated infants in the Jefferson study were hyperventilated at 4 hours post-randomization with trends towards lower PCO<sub>2</sub> throughout the first 24

hours on HFJV. These data are consistent with the results of the larger multi-center study where mean PaCO<sub>2</sub> data from Group 3 were statistically lower during the first 24 hours of life compared to those of the other two groups. However, there were no positive correlations of low PaCO<sub>2</sub>s in individual infants with severe cerebral injury in either study.

The success of oxygen saturation monitoring via pulse oximetry appears to have led to a general decline in the use transcutaneous PCO<sub>2</sub> monitoring of premature infants over the past several years.

Concern was raised at this year's Snowbird High Frequency Meeting over this trend because high frequency ventilators can be *very* effective CO<sub>2</sub> eliminators. Consensus was that the well-known problems associated with transcutaneous monitoring are manageable.

Both suspected causative effects of poor oxygen delivery to the brain, hyperventilation and atelectasis, are preventable by the proper administration of PEEP. Raising PEEP reduces tidal volume delivery when PIP is kept constant while also increasing mean airway pressure. The infants treated with PEEP of  $\geq 7$  cm H<sub>2</sub>O during HFJV in this study maintained mean PaCO<sub>2</sub>s above 35 torr and were significantly better oxygenated than those babies in either of the other two groups.

To paraphrase Dr. Alison Froese from her address at this year's Snowbird Meeting: "We humans seemed destined to keep rediscovering history." The organizing committee for this multi-center study using HFJV agreed that the use of higher PEEP was essential to the success of the study based upon the very positive animal studies of Drs. Froese and Sugiura<sup>4</sup>, numerous baboon studies out of San Antonio reported at previous Snowbird meetings by Dr. Robert deLemos and his associates<sup>5</sup>, and a pilot

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study conducted by Dr. Keszler at Georgetown. Why then, did some participants at *every* participating hospital fail to follow this protocol consistently?

Use of HFJV, unlike HFOV, has always been associated with the use of lower mean airway pressures. The power of the conventional "sigh" breaths to recruit collapsed alveoli with adequate PEEP to support them during HFJV has yet to be fully appreciated by many clinicians who are otherwise perfectly comfortable using the Jet to treat active pulmonary air leaks. Is this what led so many clinicians to use the more conservative "low-volume" strategy?

It is quite predictable that successful HFJV treatment of air leaks using the appropriate "low-volume" strategy may well lead to atelecta-

sis. ***Your choice is then either to switch back to conventional ventilation and risk the reappearance of air leaks, or to raise PEEP and properly treat your patient's new problem.*** The importance of improving both PO<sub>2</sub> and PCO<sub>2</sub> by using HFJV with higher PEEP, versus acceptance of marginal blood gases using "traditional" PEEPs and lower mean airway pressures has heretofore never been so clearly illustrated.

The prevailing disappointment over the results of the HiFi Study in 1989 (increased IVH and airleaks in infants randomized to high-frequency oscillatory ventila-

tion)<sup>6</sup> slowly gave way to increased understanding of the need for optimization of lung volume during treatment with the small tidal volumes and low distending pressures of HFOV. It took many years for the community of HFOV users to appreciate the importance of using a "high-volume" ventilator strategy in surfactant deficient babies.

Data from this study, as well as from those that have come before, strongly suggest that the use of proper strategy can prevent chronic lung injury in premature infants. In this study, strategy also greatly influenced the odds of producing brain injury. Proper blood gas monitoring, including the use of transcutaneous PCO<sub>2</sub> monitors, and the appropriate application of PEEP seem essential to proper HFJV treatment of premature infants.

<sup>1</sup> Keszler M, *et al.* High-frequency jet ventilation reduces chronic lung disease; strategy affects the incidence of adverse outcomes. *Pediatr Res* 1996;39(Part 2):336A. Abstract #1999.

<sup>2</sup> Keszler M, *et al.* High-frequency jet ventilation and conventional ventilation: gas exchange and airway pressures. *Pediatr Res* 1996;39(Part 2):336A. Abstract #2000.

<sup>3</sup> Wiswell TE, Graziani LJ, Kornhauser MS, Cullen J, Spitzer AR. Early initiation of high-frequency jet ventilation in the management of respiratory distress syndrome is associated with a greater risk for adverse outcomes: a perspective. *Pediatr Res* 1996;39(Part 2):356A. Abstract #2118

<sup>4</sup> Sugiura M, *et al.* Lung volume maintenance during high frequency jet ventilation improves physiological and biochemical outcome of lavaged rabbit lung. *Physiologist* 1990;33:A123. Abstract.

<sup>5</sup> deLemos RA, Coalson JJ, Gerstmann DM, *et al.* Ventilatory management of infant baboons with hyaline membrane disease: the use of high frequency ventilation. *Pediatr Res* 1987;21:594-602.

<sup>6</sup> Rigatto H, Davi M, Frantz III ID, *et al* (HiFi Study Group). High-frequency oscillatory ventilation compared with conventional mechanical ventilation in the treatment of respiratory failure in preterm infants. *New Engl J Med* 1989;320:88-93.