

MECONIUM ASPIRATION AND HIGH-FREQUENCY JET VENTILATION

A BRIEF CLINICAL REPORT

Stephen J. Boros, M.D., Mark C. Mammel, M.D.

J. Michael Coleman, M.D., and Dennis R. Bing, R.R.T.

From the Infant Pulmonary Research Center

Children's Hospital of St. Paul, and

the Department of Pediatrics

University of Minnesota, Minneapolis, MN

Presented at the Ross Conference: Two Great Debates in Neonatology,
ECMO and HFJV. December 8, 1987.

Laboratory studies of high-frequency ventilation (HFV) and meconium aspiration syndrome (MAS) are controversial, at times contradictory. In 1983, we compared high-frequency jet ventilation (HFJV) and conventional mechanical ventilation (CMV) in cats with MAS. In this study, CMV was unequivocally superior.¹ Since that time, there have been three similar studies comparing various forms of HFV to CMV using different animal models. Two studies showed some advantage to HFV. One study did not.^{2,3,4}

Recently, we treated three neonates with severe MAS with HFJV in an effort to avert the need for extracorporeal membrane oxygenation (ECMO). All three patients met established ECMO criteria. None required ECMO. All survived and were eventually discharged on good health.

METHODS

Our high-frequency jet ventilator was the Bunnell Life Pulse (Bunnell, Inc.). This ventilator system has been described in detail elsewhere.⁵ Our conventional ventilator was a standard pressure-preset, time-cycled infant ventilator (Bourns BP200, Bourns, Inc.)

CASE REPORTS

Case 1:

G.T., a 3680-gram girl, was delivered by emergency cesarean section through thick meconium. She was immediately intubated and large amounts of thick meconium suctioned from her airway. Despite immediate pulmonary toilet, G.T. required mechanical ventilation shortly after birth. Her chest x-ray showed bilateral coarse infiltrates consistent with severe MAS.

By 20 hours of age, she was paralyzed with pancuronium bromide and her blood pressure supported with dobutamine. CMV settings were: FiO_2 1.0; rate 100 bpm; peak inspiratory pressure (PIP) 40 cm H_2O ; PEEP 6 cm H_2O ; I:E ratio 1:1.2; and mean airway pressure (Paw) 16.2 cm H_2O . Concomitant arterial blood gas values were: pH 7.14; PaCO_2 70 torr, PaO_2 39 torr, AaDO_2 585 torr, oxygenation index 42. The mean AaDO_2 for the preceding 8 hours was 586 torr. The mean oxygenation index for those 8 hours was 27. Because of the steady progression of her respiratory failure, G.T. received a trial of HFJV as a prelude to possible ECMO. Initial HFJV settings were: FiO_2 1.0; rate 400 bpm; PIP 46 cm H_2O ; I:E ratio 1:6.6; and Paw 13.0 cm H_2O . Arterial blood gas values one hour following HFJV were: pH 7.25; PaCO_2 40 torr, PaO_2 48 torr.

Four hours following HFJV, blood gas values were: pH 7.64; PaCO_2 14 torr, PaO_2 103 torr. After 48 hours of HFJV, G.T. was returned to CMV and successfully extubated 12 hours later. She was discharged in good health at 15 days of age.

Case 2:

G.S., a 3010-gram girl, was delivered vaginally through thick meconium. Her nose and mouth were suctioned prior to the delivery of her shoulders. However, she was not intubated until one hour of age when she required mechanical ventilation. At that time, thick meconium was recovered from her endotracheal tube. Her initial chest x-ray showed bilateral course infiltrates consistent with MAS.

By five hours of age, she was paralyzed and her blood pressure supported with dobutamine. CMV settings were FiO_2 1.0; rate 91 bpm; PIP 47 cm H_2O ; PEEP 5 cm H_2O ; I:E 1:1.1; Paw 21 cm H_2O . Concomitant arterial blood gas values were: pH 7.34; PaCO_2 42 torr; PaO_2 42 torr; oxygen saturation 70%; AaDO_2 612 torr; oxygenation index 50. The mean AaDO_2 for the preceding five hours was 610 torr. The mean oxygenation index for those five hours was 37.

Persistent hypoxemia and a progressive deterioration in the infant's general condition prompted a trial of HFJV as a prelude to possible ECMO. Initial HFJV settings were: FiO_2 1.0; rate 420 bpm; PIP 45 cm H_2O ; PEEP 6 cm H_2O ; I:E ratio 1:6, Paw 17 cm H_2O . Arterial blood gas values one hour following HFJV were little changed (pH 7.44; PaCO_2 31 torr; PaO_2 32 torr). However, the infant's general condition had improved significantly.

Four hours following HFJV, arterial blood gas values were: pH 7.65; PaCO_2 21 torr; PaO_2 47 torr; oxygen saturation 89%. After 66 hours of HFJV, G.S. was returned to CMV and successfully extubated eight hours later. She was discharged in good health at 14 days of age.

Case 3:

B.S., a 3510-gram boy, was delivered by emergency cesarean section through thick meconium. Unfortunately, he received positive pressure ventilation before either his trachea or endotracheal tube was suctioned. His initial chest x-ray showed extensive bilateral infiltrates consistent with severe MAS.

By 20 hours of age, B.S. was paralyzed, and his blood pressure was supported with dobutamine. CMV settings were: FiO_2 1.0; rate 90 bpm; PIP 38 cm H_2O ; PEEP 5 cm H_2O ; I:E ratio 1:1.7; Paw 16 cm H_2O . Concomitant arterial blood gas values were: pH 7.22; PaCO_2 72 torr; PaO_2 25 torr; oxygen saturation 60%; AaDO_2 583 torr; oxygenation index 64. The mean AaDO_2 for the preceding 16 hours was 607 torr. The mean oxygenation index for those 16 hours was 53.

The infant received a trial of HFJV while ECMO facilities were being readied. Initial HFJV settings were: FiO_2 1.0; rate 400 bpm; PIP 55 cm H_2O ; I:E ratio 1:6.5; Paw 19 cm H_2O . One hour following HFJV, arterial blood gas values were pH 7.43; PaCO_2 33 torr; PaO_2 44 torr; oxygen saturation 95%.

Four hours after HFJV, arterial blood gases were: pH 7.56; PaCO_2 26 torr; PaO_2 46 torr; oxygen saturation 92%. After nine days of HFJV, B.S. was returned to CMV. He was successfully extubated ten days later. The infant's hospital course was complicated by moderate residual lung disease treated with diuretics and a short course of corticosteroids. B.S. was discharged at 43 days of age in good health, receiving no medications of supplemental oxygen.

DISCUSSION

Not long ago, we compared HFJV (IDC 6000) and CMV in adult cats who aspirated a mixture of 25% human meconium saline. This double cross-over study showed that pulmonary artery pressures, pulmonary vascular resistances, intrapulmonary shunts, and AaDO₂ values were consistently worse during HFJV with the IDC device. CMV was clearly the superior therapy.¹

Trindade *et al* examined HFJV (Bunnell Life Pulse) and CMV in piglets following the aspiration of 20% human meconium in saline. In this four-hour longitudinal study, HFJV using the Bunnell device was the more effective form of ventilation. It provided better ventilation and oxygenation using lower airway pressures.²

Karlson and DuRant compared HFV, using a "home-made" flow-interrupter type device, and CMV in rabbits following the aspiration of a 25% mixture of human meconium. This two-hour longitudinal study showed no particular advantage to either HFJV or CMV.³

Keszler *et al* evaluated the effectiveness of HFJV, CMV, and the combination of HFJV and a slow background CMV rate in puppies with MAS. The experiment, a six-hour longitudinal study, involved the aspiration of a 20% mixture of human meconium. In this model, HFJV provided comparable oxygenation and better ventilation than CMV. The combination of HFJV and CMV proved to be superior to both other techniques.⁴

The only reasonable conclusion we draw from these seemingly contradictory data is that, as yet, there is no good animal model of MAS. The Bunnell HFJV device may also perform differently than the other devices tested in these animal studies. Different animal models and different experimental designs produce different results.

Recently, Cornish and co-workers successfully treated five neonates with severe MAS with a combination of high-frequency ventilation and ECMO. Based on this experience and similar laboratory experiences, these authors now recommend HFJV as an intermediate step between CMV and ECMO in MAS.⁶ Our recent clinical experience supports these recommendations.

Despite our own previous animal data to the contrary, we, too, believe HFJV can be useful in the treatment of severe MAS and should be used as an intermediate measure between CMV and ECMO. When successful, HFJV avoids the risks, expense, and potential long-term morbidity associated with ECMO. ECMO should be reserved for those who fail a trial of HFJV.

REFERENCES

1. Mammel MC, Gordon MJ, Connett JE, Boros SJ. Comparison of high-frequency ventilation and conventional mechanical ventilation in a meconium aspiration model. *J Pediatr* 1983; 103:630-634.
2. Trinidad O, Goldberg RN, Bancalari E, Dickstein P, Ellison J, Gerhardt T. Conventional vs. high-frequency jet ventilation in a piglet model of meconium aspiration: Comparison of pulmonary and hemodynamic effects. *J Pediatr* 1985; 107:115-120.
3. Karlson KH, DuRant RH. High-Frequency positive pressure ventilation in experimental meconium aspiration syndrome. *Am J Med Soc* 1986; 29:92-96.
4. Keszler M, Molina B, Butterfield AB, Subramanian KNS. Combined high-frequency jet ventilation in a meconium aspiration mode. *Crit Care Med* 1986; 14:34-38.
5. Boros SJ, Mammel MC, Coleman JM, Lewallen PK, Gordon MJ, Bing DR, Ophoven JP. Neonatal high-frequency jet ventilation: Four years' experience. *Pediatrics* 1985; 75:657-663.
6. Cornish JD, Gerstmann DR, Clark RH, Carter JM, Null DM, DeLemos RA. Extracorporeal membrane oxygenation and high-frequency oscillatory ventilation: Potential therapeutic relationships. *Crit Care Med* 1987; 15:831-834.