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Extracorporeal membrane oxygenation in infants with meconium aspiration syndrome: a decade of experience with venovenous ECMO

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Abstract

Background: Despite the emergence of new therapies for respiratory failure of the newborn with meconium aspiration syndrome (MAS), extracorporeal membrane oxygenation (ECMO) has a significant role as a rescue modality in these infants. Our objective was to compare the use of venovenous (VV) vs venoarterial (VA) ECMO in newborns with MAS who need ECMO and to ascertain the impact of new therapies in these infants during the last decade. We also evaluated how disease severity or time of ECMO initiation affected mortality and morbidity.

Methods: A report of 12 years experience (1990-2002) of a single center, comparing VV and VA ECMO, is given. Venovenous ECMO was the preferred rescue modality for respiratory failure unresponsive to maximal medical therapy. Venoarterial ECMO was used only when the placement of a VV ECMO 14-F catheter was not possible; 128 patients met ECMO criteria, 114 were treated with VV ECMO, and 12 with VA ECMO. Two patients were converted from VV to VA ECMO.

Results: Venovenous and VA ECMO patients had comparable birth weight (mean ± SEM, 3.48 ± 0.05 vs 3.35 ± 0.15 kg) and gestational age (40.3 ± 0.1 vs 40.7 ± 0.3 weeks). Before ECMO, there was no difference between VV and VA ECMO patients in oxygenation index (60 ± 3 vs 63 ± 8), mean airway pressure (19.5 ± 0.4 vs 20.8 ± 1.5 cm H_2O), alveolar-arterial O_2 gradient (630 ± 2 vs 632 ± 4 torr), ECMO cannulation age (median [25th-75th percentiles], 23 [14-47] vs 26 [14-123] hours), or in the % of patients who needed vasopressors/inotropes (98% vs 100%). From November 1994, inhaled nitric oxide (NO) was available. Before VV ECMO, 67% of the patients received NO, 24% received surfactant, and 48% were treated with high-frequency ventilation (HFV). There was no significant

Abbreviations: ECMO, extracorporeal membrane oxygenation; VV, venovenous; VA, venoarterial; MAS, meconium aspiration syndrome; NO, inhaled nitric oxide; HFV, high-frequency ventilation; A-a O_2 gradient, alveolar-arterial O_2 gradient; MAP, mean airway pressure; OI, oxygenation index.

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difference between VV and VA ECMO patients in survival rate (94% vs 92%), ECMO duration (88 [64-116] vs 94 [55-130] hours), time of extubation (9 [7-11] vs 14 [9-15] days), age at discharge (23 [18-30] vs 27 [15-41] days), or incidence of short-term intracranial complications (5.3% vs 16.7%). For the total cohort of 126 infants, indices of disease severity (oxygenation index, alveolar-arterial O_2 gradient, mean airway pressure) did not correlate with outcome measures. Delay in ECMO initiation (>96 hours) was associated with prolonged mechanical ventilation and hospitalization ($P < .01$). New therapies (NO, HFV, surfactant) in the second part of the decade were associated with a longer ECMO duration (98 [80-131] vs 87 [60-116] hours; $P < .05$), no delay in ECMO initiation time (23 [10-40] vs 24 [14-52] hours), and no significant change in survival (97% vs 92.5%). No patient was treated with VA ECMO after 1994.

Conclusions: Venovenous ECMO is as reliable as VA ECMO in newborns with MAS in severe respiratory failure who need ECMO. Delay in ECMO initiation may result in prolonged mechanical ventilation and increased length of hospital stay. The emergence of new conventional therapies (NO, HFV, surfactant) and particularly increased experience enable sole use of VV ECMO with no significant change in survival in infants with MAS.

Meconium-stained amniotic fluid is observed in 10% to 15% of pregnancies at the time of delivery; meconium aspiration syndrome (MAS), a common form of neonatal respiratory distress, occurs in about 5% of infants born through meconium-stained amniotic fluid [1]. Important therapeutic advances have emerged in the last decade in the management of neonatal respiratory failure, including high-frequency ventilation, inhaled nitric oxide (NO), and surfactant. These measures have decreased the number of infants requiring extracorporeal membrane oxygenation (ECMO) [2-6], but resulted in a longer pre-ECMO course. This in turn may lead to higher mortality and to prolonged ECMO course and post-ECMO ventilation [5,7,8].

The UK collaborative neonatal ECMO trial showed that for every 4 infants receiving ECMO for MAS, there was one extra survivor [9]. The worldwide survival rate for over 6000 neonates with MAS receiving ECMO support is 94% [10]; the highest survival rate for any neonatal condition suitable for ECMO. In terms of morbidity, ECMO survivors do not appear to have any increased rate of disability or neurological damage compared to other severely hypoxic, conventionally treated neonates with MAS, despite a greater proportion of survivors [11]. Thus, the use of ECMO in severe MAS should be regarded not as a "last resort" when other treatments failed, but more as an extension of conventional treatment [12,13].

Venoarterial (VA) ECMO is the traditional and most common ECMO mode as a rescue therapy for newborns with respiratory failure [2,5,8,9]. Venovenous (VV) ECMO does not provide circulatory support, is limited in the maximal achievable oxygen delivery, and is more dependent on optimal venous drainage. In the last decade, the thin-walled, 14-F, double-lumen catheter which enables a single-site cannulation of the internal jugular vein was introduced [14]. Anderson et al [15] have published a multicenter study concluding that VV ECMO can provide the same level of support as VA ECMO to newborns with adequate cardiac function. Few reports were published in which the only patients treated with VA ECMO were those who could not accommodate the VV double-lumen 14-F catheter (no cardiovascular exclusion criteria were used). They found that VV ECMO may be as effective as VA ECMO in respiratory failure of the newborn [16,17]. Venovenous ECMO offers a few theoretical advantages over VA ECMO. Ligation of the carotid artery is avoided, pulsatile flow and perfusion of well oxygenated blood to the pulmonary circulation and coronary arteries are maintained, increased left ventricular afterload associated with VA ECMO is avoided, and there is entrapment of particulate emboli from the ECMO circuit (gaseous or thromboembolic) in the pulmonary vascular bed.

In view of these reports, we present the 12-year experience of a single center, comparing the use of VV vs VA ECMO in newborns with MAS where VV ECMO was the preferred mode, and the only patients placed on VA ECMO were those who could not accommodate the VV double-lumen 14-F catheter. We also tried to ascertain the impact of new therapies in these infants during the last decade and to evaluate how disease severity or time of ECMO initiation affected mortality and morbidity.

1. Methods

Venovenous ECMO was introduced at Huntington Memorial Hospital (Pasadena, Calif) in October 1990. Only infants with intractable respiratory failure unresponsive to maximal medical therapy who met ECMO criteria [13] and whose parents gave informed consent were placed on ECMO. Venovenous ECMO was the preferred mode of ECMO. An attempt was made to place a 14-F double-lumen VV catheter (Kendall Infant ECMO Catheter, catalog No. 5914; Kendall Healthcare Products Co, Mansfield, Mass) in all infants who met ECMO criteria. The technical inability to place the catheter was the sole criterion for choosing VA ECMO.