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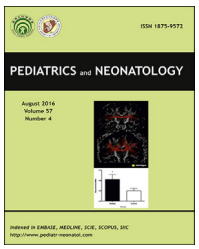

ORIGINAL ARTICLE

Extracorporeal Membrane Oxygenation Support in Neonates: A Single Medical Center Experience in Taiwan

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Key Words
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Background: Extracorporeal membrane oxygenation (ECMO) was used in neonates with severe cardiopulmonary failure who failed to respond to conventional therapy. We started to apply neck venoarterial ECMO (VA-ECMO) in neonatal patients from 2000. In this study, we have focused on neonates who received ECMO support and described the current status of ECMO in neonates for both cardiac and pulmonary support and the risk factors associated with their outcomes.
Methods: Data were retrieved from our ECMO database for the neonates (age < 28 days) who received neck VA-ECMO support from January 2005 to June 2015.
Results: In total, 27 neonates, including 21 with respiratory support and six with cardiac support, were enrolled in this study. Sixteen (59.2%) patients survived to hospital discharge, and only one patient had a poor neurological outcome. The survival rate for respiratory support was 61.9% in which meconium aspiration syndrome with persistent pulmonary hypertension of a newborn had a superior outcome (11/13, 84.6%) and congenital diaphragmatic hernia had the worst outcome (4/7, 57.1%). The survival rate in the cardiac support group was only 50%. The median ECMO duration and hospital stay were 6 (1 ~ 35.8) days and 37 (23 ~ 232) days, respectively, for survivors. Furthermore, 11 (52.3%) neonates of 21 outborn patients were put on ECMO in other hospitals by our mobile ECMO team for respiratory support, and their survival (81.8%) was significantly better than those from in-house ECMO institution (40%).

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Conclusion: This is the first report for ECMO in neonatal disease in Taiwan. We achieved an overall survival rate of 59.2% with good neurological outcomes in this 10-year experience. ECMO could be a useful transportation tool for critical neonates who have a poor response to ventilator support.

1. Introduction

Extracorporeal membrane oxygenation (ECMO) is a temporary support of lung-heart function for patients with reversible cardiac and pulmonary diseases. Although it is used in both adult and pediatric populations, the neonatal respiratory population has been most successfully treated by ECMO. Since the first successful ECMO application in a newborn with respiratory failure in 1975,[1] two prospective randomized trials have been conducted, and they showed the effectiveness of ECMO in neonatal respiratory failure, targeting on congenital diaphragmatic hernia (CDH), meconium aspiration syndrome (MAS), sepsis, and persistent pulmonary hypertension of newborn (PPHN).[2,3] In 1982, Bartlett et al[4] described its use in 45 neonatal respiratory patients who had failed to respond to conventional therapies; 55% of those neonates survived. Since then, the number of ECMO centers has increased throughout the world.[5] By 1992, this support therapy became a mainstay in many pediatric hospitals throughout the United States with up to 100 ECMO centers. Over the past several years, the numbers of neonatal respiratory ECMO cases have begun a downward trend as fewer patients are requiring ECMO support as frequently as in the past.[6] This decline is most likely attributable to the newer respiratory therapies now available such as surfactant, high-frequency oscillatory ventilation (HFOV), and inhaled nitric oxide (iNO).[7] Since the past decade, ECMO has increased gradually in neonatal cardiac support and showed certain benefits.[8,9] The indications of ECMO in cardiac support for neonates include postoperative care after congenital heart surgery, cardiogenic shock, cardiomyopathy, and myocarditis.[10–12] Our hospital is a tertiary referral center in Taiwan and started ECMO program from early 1994 and attempted to rescue neonates with severe cardiopulmonary failure from 2000. We also established inter-facility ECMO transport. In this study, we studied neonates who received ECMO support. We excluded ECMO support after open heart surgery because these patients had complex cardiac anatomy and underwent many surgeries. We tried to describe the current status of ECMO in neonates for both cardiac and pulmonary support and the risk factors associated with their outcomes.

2. Materials and methods

2.1. Study population

The Institutional Review Board of National Taiwan University Hospital, Taipei, Taiwan approved the study. In our institution, data from all ECMO patients, including diagnosis, indication for ECMO, treatment course, and outcomes, have been prospectively collected for quality assurance since 1999. Data from neonates (age $<$ 28 days) who received ECMO support from January 2005 to June 2015 were retrieved from our database for this study. Patients who received cardiac surgery and ECMO support for postoperative care were excluded from this study.

2.2. ECMO criteria

In this study, neonates with severe cardiopulmonary failure with the following criteria were supported with ECMO: (1) gestational age (GA) $\geq$ 31 weeks; (2) oxygen index (OI) $>$ 25 in two or more arterial blood gases, or persistent PaO_2 $<$ 40 mmHg for 2–12 hours that failed to respond to maximal intensive treatment, including iNO and/or HFOV; (3) no congenital heart disease except a patent arterial duct (PDA) or atrial septal defects by echocardiography; and (4) acidosis and shock: pH $<$ 7.20 for 2 hours or with hypotension, and oliguria, even under escalation of catecholamines.

2.3. Criteria for second course ECMO

We monitored the vital signs and blood gas after weaning off ECMO. If the condition deteriorated and did not improve under conservative treatment, ECMO was set up again if they fulfilled ECMO criteria mentioned above.

We excluded newborns with multiple life-threatening congenital anomalies and who had mechanical ventilation for more than 14 days or severe cerebral lesions.

2.4. ECMO technique and mobile ECMO

Our ECMO technique was described in previous reports.[13,14] Pediatric cardiovascular surgeons cannulated patients for ECMO in our institution. The ECMO technicians were in-house for day and evening shifts and on-call during the night shift. The ECMO chart was modified and included pediatric cannulas, ECMO accessories, surgical instruments, suture materials, surgical drapes, and other supplies. For neonates, we applied venoarterial ECMO (VA-ECMO) support in neck vessels, with centrifugal pumps and hollow-fiber membrane oxygenators (all from Medtronic Inc., Anaheim, CA, USA). Surgeons chose adequate size of the cannula, usually 8–10 Fr for arterial cannulation and 10–12 Fr for vein. We also applied venous, arterial saturation and hemoglobin monitor, and a flow meter during ECMO runs. These patients underwent cannulation through the right internal jugular vein and common carotid artery. Some

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