Extracorporeal life support for nonimmune hydrops fetalis

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Abstract. A Down syndrome female born at 35 wk estimated gestational age with non-immune hydrops fetalis associated with a complete atrioventricular septal defect and large patent ductus arteriosus with hypoxemia, severe anasarca and hypotension was treated successfully with extracorporeal life support for severe cardiopulmonary failure leading to eventual hospital discharge and elective repair of her cardiac defect. The case demonstrates that extracorporeal life support may be an effective therapy when initiated early in patients with non-immune hydrops fetalis associated with significant cardiac abnormalities.

Keywords: Cardiac anatomy, pathologic anatomy, congenital heart disease, septal defect, extracorporeal membrane oxygenation

1. Introduction

Hydrops fetalis is a devastating condition characterized by fluid accumulation throughout the body in extravascular compartments resulting in ascites, pericardial and pleural effusions. Prior to the use of Rh immunoglobulin, isoimmune hydrops was the primary cause of hydrops but with improved obstetrical care, nonimmune hydrops is now the most prevalent, accounting for between 76–87% of all cases [1]. Of the numerous causes of nonimmune hydrops, congenital cardiac abnormalities carry the highest mortality rate [2]. In 90% of infants who do not survive with congenital cardiac abnormalities, the primary cause of death is hypoxia from their anatomical defects and fluid overloaded state [3,4].

Extracorporeal life support (ECLS) is an established therapy for the treatment of acute heart or lung

failure [5]. In the case of nonimmune hydrops, there is little published data on ECLS efficacy but the limited data suggests that early ECLS treatment may significantly improve survival in patients with nonimmune hydrops [6]. Here we report a case of nonimmune hydrops associated with complete atrioventricular septal defect (AVSD) treated with early ECLS.

2. Case report

A female infant with Down syndrome was delivered at an estimated gestational age of 35 wk with a birth weight of 2,500 g following a pregnancy complicated by poor prenatal care, premature rupture of membranes, proteinuria and hypertension. A prenatal ultrasound demonstrated polyhydramnios and a fetus with bilateral pleural effusions and ascites with no signs of pulmonary hypoplasia. The mother underwent emergency cesarean section for progressive hydrops. The APGAR scores were 2 and 7 at 1 and 5 min, respectively. The infant was intubated for respiratory distress and underwent placement of bilateral chest tubes. Initial blood gas

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showed a pH of 7.32, $p\text{CO}_2$ of 47 mmHg, and $p\text{O}_2$ of 40 mmHg and oxygen saturation of 70%. A total of 115 mL of ascites was removed from the abdomen and the infant was placed on high frequency oscillatory ventilation with inhaled nitric oxide for pulmonary hypertension. An initial echocardiogram demonstrated a balanced, complete AVSD with right to left shunting and ejection fraction of 79%. On day 2 of life, due to progressive respiratory failure and hypotension, the infant was given multiple fluid boluses, started on milrinone, dopamine and epinephrine infusions, administered broad spectrum antibiotics and transferred to our facility for consideration of ECLS.

On arrival, the infant was hypotensive (mean arterial pressure 20 mmHg), diffusely edematous with ascites and had a 3/6 systolic ejection murmur. Arterial blood gas on arrival was notable for a pH of 7.39, $p\text{O}_2$ of 26 mmHg, $p\text{CO}_2$ of 39 mmHg and lactic acid level was 5.9 mEq/L. The patient was stabilized with epinephrine, sodium bicarbonate and 5% albumin. Afterwards, mean arterial pressure increased to 40 mmHg; however, the patient continued to have significantly poor oxygenation with an oxygen index of 104. A chest X-ray revealed a right-sided pneumothorax, a left-sided pleural effusion and a normal cardiac silhouette (Fig. 1). The patient was maintained on high frequency

oscillatory ventilation with a FiO_2 of 100%, rate of 60 and interval time of 0.3 sec and inhaled nitric oxide of 20 ppm.

Placement of a second chest tube was performed shortly after with subsequent resolution of the right-sided pneumothorax. Venoarterial ECLS cannulation was then initiated for persistent profound hypoxia and hemodynamic instability. After initiation of ECLS, the patient's pre-ductal oxygen saturation was 100% with post-ductal saturation ranging from 88–95%. Mean arterial pressure improved immediately after ECLS support to approximately 50 mmHg. A follow-up echocardiogram demonstrated a balanced AVSD with unrestricted bidirectional shunting from a moderate ventricular septal defect, leaflet attachments to the crest of the interventricular septum, pulmonary artery dilation, moderate common atrioventricular valve regurgitation and a large patent ductus arteriosus (PDA) with mainly right to left shunting. On day 3 of life, inhaled nitric oxide was discontinued, furosemide infusion was initiated and a peritoneal catheter was placed to drain the ascites. The patient had progressive improvement in oxygen saturation and hemodynamics with improvement in her fluid overload state and ECLS was discontinued on day 5 of life without any subsequent instability.

Fig. 1. Initial chest X-ray after extracorporeal life support cannulation. Right-sided pneumothorax with two right sided and one left sided chest tubes in place, left-sided pleural effusion in the apical and basilar segments of the lung and significant body wall edema. A 6-French arteriolar cannula is located in the right common carotid artery and an 8-French cannula in the right internal jugular vein for venoarterial extracorporeal life support.

Fig. 2. Chest X-ray prior to discharge showing resolution of pneumothorax and body wall edema with stable cardiomegaly and pulmonary congestion.

On day 8 of life, bedside PDA ligation was performed. Respiratory status slowly improved and the patient was extubated on day 36 of life and transitioned to continuous positive airway pressure. She was transitioned to high flow nasal cannula on day 71 of life. The patient was discharged at 3 mo after resolution of her body wall edema and pulmonary congestion (Fig. 2). Brain magnetic resonance imaging performed prior to discharge showed evidence of early periventricular leukomalacia, no intraparenchymal hemorrhage or infarct, and an extra-axial posterior fossa hemorrhage most likely related to birth. She returned at 6 months of age for a repair of her complete AVSD and remains stable at 10 mo of age while currently appearing neurologically intact.

3. Discussion

Hydrops fetalis can be caused by a number of cardiovascular associated abnormalities including arrhythmias, anemia, infection, cardiomyopathy, arteriovenous malformations, sacrococcygeal teratomas and structural cardiac abnormalities. Malformations of cardiac structure or vasculature are the most common cardiovascular cause of nonimmune hydrops [7]. Structural defects and physiological derangements that create significant atrio-ventricular valve regurgitation, such as the AVSD and severe pulmonary hypertension described in this case,

lead to an unsustainable increase in intracardiac pressures. Furthermore, the over-aggressive fluid resuscitation and large PDA may have contributed to the progressive fluid overload state. As right sided heart failure develops from increased cardiac pressures, central venous pressure increases and eventually leads to generalized edema and hydrops.

ECLS may be an effective therapy in neonates with cardiac abnormalities. The use of ECLS among this population has been steadily increasing with patients surviving to discharge in approximately one third of cases [8]. It is conceivable that neonatal patients with severe cardiac abnormalities and a poor prognosis would benefit from early ECLS intervention as a bridge to more definitive surgical treatment, particularly patients with associated hydrops. There have been only a few published reports describing the use of ECLS with success for hydrops in various settings including cystic adenomatoid malformation of the lung, teratoma resection, and abdominal compartment syndrome [9–11]. Our case is an example of ECLS rescue of severe nonimmune hydrops, which allowed for diuresis and achievement of a euvolemic state followed by definitive surgical intervention. Further studies regarding the specific indications for ECLS and outcomes would provide clinicians a better guide for when to use ECLS aggressively as current studies have generalized indications as either cardiac or pulmonary causes.

References

- [1] Bellini C, Hennekam RC, Fulcheri E, Rutigliani M, Morcaldi G, Boccardo F, et al. Etiology of nonimmune hydrops fetalis: a systematic review. *Am J Med Genet A* 2009;149A(5):844–51.
- [2] Lequier L. Extracorporeal life support in pediatric and neonatal critical care: a review. *J Intensive Care Med* 2004;19(5):243–58.
- [3] Poeschmann RP, Verheijen RH, Van Dongen PW. Differential diagnosis and causes of nonimmunological hydrops fetalis: a review. *Obstet Gynecol Surv* 1991;46(4):223–31.
- [4] Harahan D, Murphy JF, O'Brien N, Gorman W, Kelehan P, Cullinane C, et al. Clinico-pathological findings in non-immune hydrops fetalis. *Ir Med J* 1991;84(2):62–3.
- [5] Bartlett RH, Roloff DW, Custer JR, Younger JG, Hirschl RB. Extracorporeal life support: the University of Michigan experience. *JAMA* 2000;283(7):904–08.
- [6] Bealer JF, Mantor PC, Wehling L, Tunell WP, Tuggle DW. Extracorporeal life support for nonimmune hydrops fetalis. *J Pediatr Surg* 1997;32(11):1645–47.
- [7] Knilans TK. Cardiac abnormalities associated with hydrops fetalis. *Semin Perinatol* 1995;19(6):483–92.
- [8] Hintz SR, Benitz WE, Colby CE, Sheehan AM, Rycus P, Van Meurs KP; ELSO Registry. Utilization and outcomes of neonatal cardiac extracorporeal life support: 1996–2000. *Pediatr Crit Care Med* 2005;6(1):3–8.
- [9] Etches PC, Tierney AJ, Demianczuk NN. Successful outcome in a case of cystic adenomatoid malformation of the lung complicated by fetal hydrops, using extracorporeal membrane oxygenation. *Fetal Diagn Ther* 1994;9(2):88–91.
- [10] Burdis L, Koch DD. The use of cardiopulmonary bypass and extracorporeal membrane oxygenation for support during removal of two teratomas and hydrops fetalis. *J Extra Corpor Technol* 2004;36(2):182–84.
- [11] Prodhan P, Imamura M, Garcia X, Byrnes JW, Bhutta AT, Dyamenahalli U. Abdominal compartment syndrome in newborns and children supported on extracorporeal membrane oxygenation. *ASAIO J* 2012;58(2):143–47.