Usefulness of extracorporeal membrane oxygenation using double roller pumps in a low body weight newborn: A novel strategy for mechanical circulatory support in an infant

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ABSTRACT

Extracorporeal membrane oxygenation (ECMO) with a centrifugal pump requires a certain flow rate; therefore, its application for low body weight infants is frequently accompanied by oxygenator membrane malfunction and/or inadequate perfusion. To prevent low-flow associated complications, we report a case in which a novel system of dual roller pumps was used. A baby girl with a body mass index 0.25 m^2, who experienced difficulty weaning from cardiopulmonary bypass after a Norwood-like operation, required an ECMO. Concerns for the tube lifespan reduction due to roller pump friction led to the use of a double roller pump circulation. The termination of ECMO during tube exchange is not needed, because circulation is maintained by another roller pump. The novel strategy of ECMO with double roller pumps will allow low perfusion rate to provide adequate circulatory support for low body weight patients.

Keywords: Centrifugal pump, extracorporeal membrane oxygenation, postoperative care, roller pump

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) requires a certain flow rate when it is used with a centrifugal pump system. Therefore, its use in low body weight infants is associated with a high risk of oxygenator membrane malfunction, clot formation, and inadequate perfusion.[1] On the other hand, ECMO circulation using a roller pump may also be associated with several problems such as tubing wear, spallation, and air embolization induced by tube friction and overly negative pressure.[2,3] In this report, we present a case of ECMO used with double roller pumps [Figure 1]. This setup allows physicians to adequately and accurately control the ECMO-derived perfusion flow rate.

CASE REPORT

A baby girl was delivered by emergency cesarean section at 38 weeks' gestation (birth weight, 2,960 g; body mass index, 0.25 m^2). She was diagnosed with hypoplastic left heart syndrome and aortic atresia by fetal echocardiography. Although, preoperative heart failure was controlled with mechanical ventilation and hypo-oxygenation therapy, urgent surgical intervention was performed 4 days after birth. Aortic arch reconstruction and right ventricular outflow conduit anastomosis were performed under hypothermic circulatory arrest. The patient had difficulty weaning from cardiopulmonary bypass after the Norwood-like operation, and mechanical circulatory support by ECMO was required. An adequate perfusion rate was estimated to be 500 mL/min. Double roller pump ECMO with an air trapping system and intra-tube pressure monitoring was applied to maintain an adequate flow rate. The patient successfully weaned from ECMO support without any

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Quick Response Code:

Website: www.annalspc.com

DOI: 10.4103/0974-2069.171403

How to cite this article: Nakanishi K, Kato T, Kawasaki S, Amano A. Usefulness of extracorporeal membrane oxygenation using double roller pumps in a low body weight newborn: A novel strategy for mechanical circulatory support in an infant. Ann Pediatr Card 2016;9:85-6.

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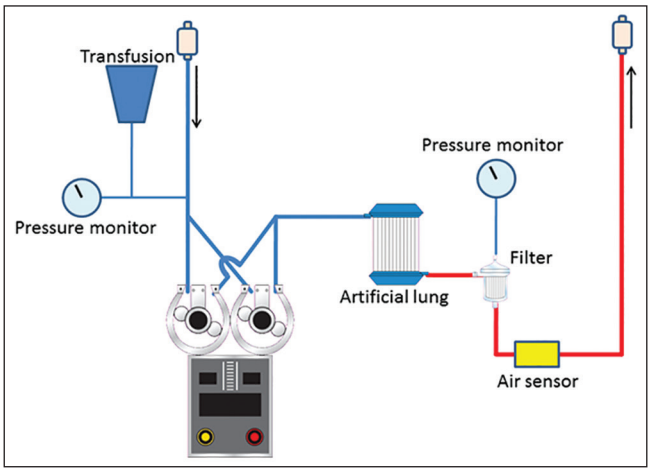

Figure 1: Depiction of the extracorporeal membrane oxygenation circulation system with double roller pumps. The double roller pumps had a master–slave relationship. To avoid air embolization, a pressure monitor, air sensor, and trapping filter were inserted into the system

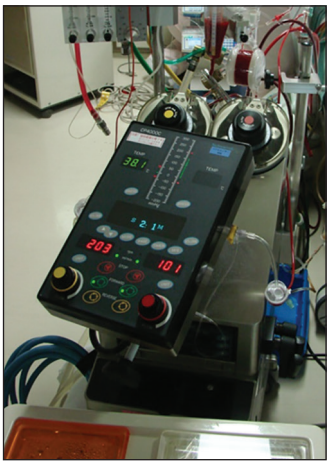

Figure 2: The management of two pumps with different rotation rates (2:1) with a master–slave relationship. The difference in rotation rates provides a different tube lifespan for each pump

complications or technical trouble on the postoperative day 2. The total support time was 44 h and 50 min.

DISCUSSION

Neonates supported with venoarterial ECMO using centrifugal pumps are at increased risk of ECMO-related complications, including hemolysis, hyperbilirubinemia, hypertension, and renal failure. These complications are likely interrelated, as hemolysis is associated with renal injury.[3] The leakage flow within the clearance gap between the rotating impeller and volute housing of a shrouded centrifugal blood pump is a key factor for the occurrence of thrombosis or hemolysis in the pump.[1] Patients with low body weight including newborns require a low perfusion rate; therefore, roller pumps are more appropriate in these patients.[4] Although this double roller pump circulatory system can cause double amount of hemolysis, tubing wear, spallation, and cytokine release compared to the single roller pump system, the patient can be continuously supported by an adequate ECMO flow rate from another circulatory route even at the time of tube exchange. Furthermore, the management of two pumps with different rotation rates and a master–slave relationship [Figure 2] provides a different tube lifespan and lower revolutions per minute for each pump, which avoids simultaneous tube exchange. Additionally, we used an air trapping system and monitored the intra-tube pressure to avoid air embolization caused by overly negative pressure. The strategy may lack any evidence, and an experimental model examination will be needed to verify further its safety and efficacy. However, this is a preliminary report of on a novel strategy, which we believe is worth reporting.

A novel strategy of ECMO circulatory system with double roller pumps shown in the present case allows safe maintenance of a sufficiently low perfusion rate for low body weight patients.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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