Cardiology in the Young

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Use of exclusive human milk diet in a neonate with single ventricle physiology supported on a ventricular assist device as a bridge to heart transplantation: case report

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Brief Report

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Abstract

Malnutrition is common among paediatric heart failure patients, with nutritional rehabilitation critical for survival and optimal health outcomes. Ventricular assist devices have been associated with improved growth, though additional nutritional support may be needed. Here, we report the use of human milk-based fortifiers to avoid severe malnutrition in a neonate supported on a ventricular assist device until transplantation.

Introduction

Malnutrition is common in paediatric heart failure patients, often worsening during the waitlist period, and linked to poor outcomes and mortality.[1–4] Nutritional rehabilitation during this period is critical for survival and optimal health outcomes. Ventricular assist devices have emerged as an effective intervention for nutritional rehabilitation. We and others have found that ventricular assist devices were associated with improved nutritional status, including improved weight-for-age or BMI-for-age z scores among paediatric patients.[3–5] Combining these devices with additional nutritional interventions may further improve nutritional status among paediatric patients awaiting heart transplant. Nevertheless, experiences describing the use of combined nutritional rehabilitation strategies are limited, particularly for neonates. Herein, we detail our experience with adding human milk-based fortifiers to enteral feeds of human milk for a neonate with single ventricle physiology supported by a ventricular assist device while awaiting heart transplant. Nutritional status was improved, and full enteral feeds were achieved during the waitlist period.

Case presentation

A di-di male twin born at 38 weeks' gestation and weighing 3.03 kg, with a prenatal diagnosis of pulmonary atresia with intact ventricle septum and possible coronary sinusoids, was admitted to the cardiac ICU after birth. Upon arrival, prostaglandins (0.01 mcg/kg/min) were initiated. A patent ductus arteriosus stent was placed by cardiac catheterisation on day of life 3, and upon return, remained intubated with new concerns for right coronary atresia. Perfusion, oxygenation, and gas exchange were notable for metabolic acidosis, poor cardiac output with low mixed venous saturation (as low as 30%), and diastolic hypotension. Bicarbonate and fluid bolus were given with escalated inotropic support using vasopressin (0.5 mU/kg/min) and epinephrine (0.02 mcg/kg/min). He also had concerns for rhythm changes and elevated troponin (reaching >10,000 pg/mL). The heart transplant team was consulted and decided to place a systemic ventricular assist device while awaiting heart transplantation. A CentriMag™ (Abbott Cardiovascular, Plymouth, MN, USA) was placed on day of life 11, with a 14 Fr venous cannula in the right atrium and a 10 Fr arterial cannula in the ascending aorta. However, due to subsequent acute desaturations, hypotension, and bleeding, there was concern for shunt thrombus and platelet consumption. Four days later, the CentriMag™ was exchanged with a PediMag™ (Thoratec Corporation, Pleasanton, CA, USA) to decrease the extracorporeal blood volume. Over the next 2 months, he experienced acute periods of haemodynamic instability that led to patent ductus arteriosus stent replacement; episodes of pulmonary haemorrhage; stent dilation; and bronchoscopy to remove blood clots from the trachea. He was stabilised and returned to baseline with no further interventions until heart transplant on day of life 72. See Figure 1 for a complete timeline of clinical course and enteral feeding changes.

Nutrition

Intravenous nutrition was initiated upon admittance to the cardiac ICU. Trophic feeds of human milk were attempted before exchange to PediMag™ but were not sustained.

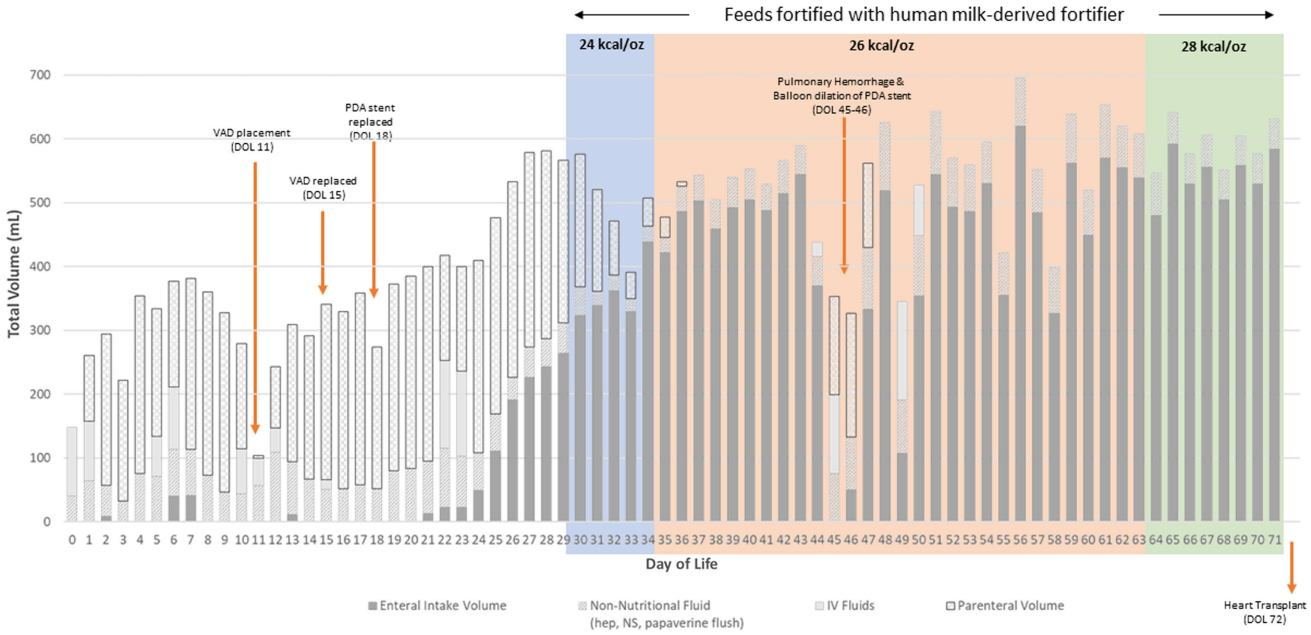

Figure 1. Clinical course and enteral feeding. DOL = day of life; PDA = patent ductus arteriosus; NS = normal saline; VAD = ventricular assist device.

Approximately 1 week after the PediMag™ exchange, nasoduodenal feeds of human milk were started at 1 mL/h and held here until extubation 3 days later. Once extubated, feeds advanced by 1 mL/h every 12 h with a goal targeted enteral volume of 125 mL/kg/d (21 mL/h) based on 4 kg. Around 50% goal rate, he presented symptoms of agitation, fussiness, desaturations with "bearing down", believed to be associated with slow motility and constipation so advancement was paused for 24 h. Stool softener was increased, and prune juice was added to his regimen. His gastrointestinal symptoms improved, so feed advancement resumed.

At 2 weeks after PediMag™ placement, he reached two-thirds of goal volume (85 mL/kg) and the team fortified human milk feeds to 24 kcal/ounce using a human milk-based fortifier to improve nutrient intake (Prolacta Bioscience®, Duarte, CA, USA). Parenteral nutrition was discontinued at this time but Intralipids™ (Fresenium Kabi AB, Uppsala, Sweden) were continued for additional calories. Targeted goal enteral feed rate was achieved approximately 3 weeks post-PediMag™ placement at 35 d old. When at goal volume, calories were increased to 26 kcal/ounce to provide 110kcal/kg/day. All intravenous nutrition was stopped by day of life 36, 33 days after PediMag™ placement.

Over the next month, feeds continued at this concentration with weekly increases in rate to maintain growth velocity. Average daily intakes of volume, calories, and protein over the next 2 weeks were 468 mL (104 mL/kg), 406 calories (90 kcal/kg), and 10 g of protein (2.3 g/kg) based on a weight of 4.5 kg. Due to ongoing fluid restriction, fortification of feeds was increased to 28 kcal/ounce to further improve caloric intake. He remained on this regimen until heart transplant with one exception. At 1.5 months of age, a pulmonary haemorrhage led to feeding interruption and a brief re-initiation of total parenteral nutrition. Once stabilised and recovered, feeds resumed, and the goal rate was achieved again.

Growth

Table 1 highlights his anthropometric measurements and changes to them at three time points, namely birth, initial device placement, and heart transplant. At the time of CentriMag™ placement, he weighed 3.65 kg, up 620 g from birth, likely some of this gain a reflection of fluid overload. From CentriMag™ placement to transplant, he demonstrated positive weight gain of 1.16 kg, average of 19 g/d, and increased 7 cm, average of 0.8 cm/wk in linear growth, not meeting any indicators of malnutrition for weight gain velocity or linear gain velocity.[6] His change in weight-for-age *Z* score from device to transplant was –1.33 SD, indicating moderate malnutrition (decline of 1.2–2 SD).[6] Overall, from birth to transplant, he gained 1.78 kg, an average of 25 g/d with no malnutrition indicators met. He showed a decline in weight-for-age *Z* score of –0.85 SD, suggesting mild malnutrition (decline of 0.8–1.2 SD) based on neonatal indicators.[6] Additionally, he gained 6.7 cm in length and 4 cm in head circumference from birth to transplant.

Discussion

This case demonstrates that human milk-based fortifiers can be safely added to human milk for enteral feeding of a term neonate on a ventricle assist device awaiting heart transplant. In addition, this case provides evidence that enteral nutrition can be increased to higher concentrations to further optimise intake and wean from parenteral nutrition in a fluid restricted patient. The combination of ventricular assist device and fortification of enteral feeds with human milk-based fortifiers allowed this cardiac patient to achieve full enteral autonomy by 1 month of age, wean from parenteral nutrition, and avoid severe gastrointestinal complications. Additionally, severe malnutrition was avoided while awaiting transplant, despite all the complex inter-related cardiorespiratory and nutritional challenges. These achievements are ideal for this patient population; however, they are often very difficult to achieve, especially with medical management of heart failure.[7]

The choice of fortifier in this case relied heavily on our centre's experience, focusing primarily on reducing risks for feeding intolerance and necrotising enterocolitis. Several factors shaped

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Table 1. Growth outcomes in a term neonate with ventricular assist device awaiting heart transplantation

Anthropometric	Birth	CentriMag™ Placement (DOL 11)	Transplant (DOL 72)	Change birth to CentriMag™	Change CentriMag™ to transplant	Change birth to transplant
Weight, kg	3.03	3.65	4.81	0.62	1.16	1.78
Weight-for-age, Z score	−0.67	−0.19	−1.52	+ 0.48	−1.33	−0.85
Length, cm	48.5	48.2	55.2	−0.3	+ 7.0	+ 6.7
Length-for-age, Z score	−0.73	−1.79	−2.05	−1.06	−0.26	−1.32
Head Circumference, cm	34.5	36.6	38.5	+ 2.1	+ 1.9	+ 4.0
Head circumference-for-age, Z score	0.03	0.91	−0.89	+0.88	−1.8	−0.92

DOL = day of life.
*Z scores based on the 2006 World Health Organization growth standard charts.[8] *Z* scores represent the number of standard deviations (SD) from the mean value of the reference population

our decision-making process. First, we observed bloody stools in previous single ventricle and heart failure patients given cow milk-based fortifiers. Second, we participated in a randomised trial where in a human milk-based fortifier utilised in infants with single ventricle physiology was well tolerated with improved growth after Stage 1 surgical palliation.[9] This trial's overall finding of decreased necrotising enterocolitis risk with a human milk-based fortifier compared to cow milk-based fortifiers,[9] influenced our decision. Moreover, the current patient's early clinical instability and delayed enteral feeding necessitated an approach prioritising low-volume fortification with lowest possible risk for gastrointestinal complications to improve nutrient intake. The American Academy of Pediatrics considers mother's milk as medical therapy for very low birthweight infants and recommends pasteurised donor milk as the best alternative as both diets have been shown to be protective against necrotising enterocolitis.[8–10]

This case highlights the importance and success of lower volume (<100mL/kg/d) fortification. Newborn patients in heart failure may often demonstrate tolerance to minimal enteral nutrition and depend on parenteral nutrition supplementation throughout the waitlist period.[7] Remarkably, however, this patient received lower volume fortification with adequate tolerance and high-calorie achievement for 6 weeks reaching a max of 28 kcal/ounce. Despite the complexity of his medical and surgical course, his caloric concentration was safely initiated at 85 mL/kg/d and continued to be increased to goal feeding volume without any need to reduce caloric concentration of fortified feeds.

The patient overall demonstrated a satisfactory trajectory in all anthropometrics while on this regimen. Using the neonatal malnutrition indicators by Goldberg and colleagues, his weight gain and linear velocity were greater than 75% expected for age from device to transplant.[6,11] Though he met the minimum criteria for moderate malnutrition in weight-for-age *Z* score change from initial device placement to transplant (−1.33 SD), he improved to mild malnutrition when comparing weight-for-age *Z* score change from birth to transplant (−0.85 SD). Overall, his change in length-for-age Z score did not show any malnutrition from device to transplant, though he met moderate malnutrition from birth to transplant (−1.32 SD). The most reliable method for length measurement (length board) was utilised from device to transplant. However, the birth length method was not able to be confirmed. It is possible the initial birth length measurement could represent a less accurate method. His head circumference gains met less than 50% of goal for both intervals, with a max decline of −1.8 SD *Z* score. These findings align with those from a recent randomised trial in which neonates who received human milk-based fortifiers had improved short-term growth following cardiac surgery compared to those who received standard-of-care diets, including cow milk-based fortification.[12]

Conclusion

In summary, this case report demonstrates that full enteral feeds can be achieved safely using an exclusive human milk diet including a human milk-based fortifier in a term single ventricle neonate supported by a ventricular assist device. Additionally, this may also prevent further worsening of nutritional status while awaiting transplantation. For this patient, lower volume fortification was achieved and tolerated before the goal volume was met, despite fluid restriction. Given these results, more studies are warranted to further understand the impact of an exclusive human milk diet in neonates on a ventricular assist device.

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Ethical standard. None.

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