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Nutritional Challenges in Pediatric Congenital Cardiac Care

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ABSTRACT

It is well documented that malnutrition significantly contributes to morbidity in children with congenital heart disease (CHD), which is influenced by type of cardiac lesion, malabsorption, hypermetabolism and poor nutrient intake. Most of the congenital heart diseases are present at birth but diagnosed and treated late due to poor resource availability in developing countries. Children with congenital heart defects may experience poor weight gain and linear growth due to several factors like increased work of breathing, increased energy demand, at the same time decreased overall calorie intake. These children need caloric supplementation before and after surgical/medical management of their cardiac condition to achieve catch up growth. So with improved supplementation of calorie, protein and side by side treating their heart failure medically and correcting their pathology surgically would be the holistic approach to deal with the situation. There are lacunae of randomised controlled trials to specify the nutritional need and feeding protocol about how to initiate and advance enteral feeding among these infants, so it is important to understand the challenges to fulfil their nutritional requirements. The purpose of this review is to discuss the nutritional challenges during preoperative and postoperative period, initiation of enteral feeding and current feeding practices among these children.

Keywords: Congenital heart disease, nutrition, feeding protocol

INTRODUCTION

Congenital heart disease (CHD) is the most common anomaly among all congenital malformations and these children are more prone to malnutrition. [1,2] Although exact figures are not available, the burden of CHD in India is likely to be very large due to a very high birth rate, approximately 180,000 children are born with CHD yearly [3] but a very small proportion get corrective intervention in the first year of life due to lack of resources and awareness, so number of cases can be seen among young adults also. The estimated birth prevalence of CHD is 9 per 1000 live births in developed countries [4] which is approximately similar to India i.e. 8.7 per 1000 live births. [5]

Cardiac surgery with cardio pulmonary bypass (CPB) generates a systemic inflammatory response syndrome, which results in organ dysfunctions. This may lead to a prolonged ventilation, inotropic support and intensive care unit (ICU) stay. Along with the cardiac defect nutrient deficiencies including macro and micronutrients can aggravate the adverse outcomes arising out of the organ dysfunctions. Children with cyanotic CHD have hypoxia; cyanotic spells which affects their nutritional status due to inadequate calorie intake that leads to stunted growth. [6] Children with acyanotic CHD have increased pulmonary blood flow, pulmonary hypertension and repeated chest infections, are more prone to develop malnutrition and

growth retardation. [7] Studies from developed countries have reported that early correction of their congenital heart defects may improve their nutritional status. [8]

A number of studies have shown nutrient deficiencies among these pediatric cardiac surgical patients as an outcome of increased requirement as well as decreased intake during the pre, intra and post-operative period. [9,9] A retrospective study has demonstrated that approximately half of the population is malnourished at the time of surgery which increases during the preoperative hospitalization and postoperatively due to the commonly observed inadequate nutrient intake and delay in starting nutritional support. [11] An observational study demonstrated that the patients undergoing cardiac surgery were at high risk of malnutrition due to various medical treatment related withholding of nutrition support during early postoperative course. [12]

Adequate nutrient supply is essential for their good recovery and health but it is very challenging to meet the nutritional requirements of these children due to several factors like feeding interruption (FI), gastroesophageal reflux, fluid restriction, swallowing difficulty, malabsorption etc. [11] Standards exist for the same age group of healthy infants but there is no standard feeding protocol or recommendations for this highly vulnerable group. Though their energy requirements are higher due to several reasons like higher catabolic stress, wound healing, growth and immune functions [13,13] but it is difficult to meet these high energy requirements (even what is recommended for healthy infants by recommended dietary allowance (RDA 2010) @92 kcal/kg/day) among these children due to various cardiac related morbidities like heart failure, cyanotic spells, chest infections, tachypnea etc. Poor nutritional status before and after surgery may result in increased morbidity and mortality. [15]

Nutritional status assessment scales though rarely used in cardiac surgery, are important component of cardiac surgical intensive care and recommended by current international nutrition guidelines. Body mass index (BMI), albumin and prealbumin levels are independent predictors of morbidity and mortality after cardiac surgery. [16,17] Studies indicate that these pediatric cardiac patients are severely malnourished, so it is essential to think about their nutritional profiles preoperatively and give due consideration to optimize their nutrition before subjecting them for surgery. [9,11] Thus the preoperative assessment may guide us to consider early nutrition interventions prior to surgery in patients at high risk of developing postoperative complications. [16]

Growth failure in infants with congenital heart disease:

Most CHD infants are born with normal weight for gestational age but develop nutritional deficiency and growth retardation during the first year of life due to physiological changes and cardiac lesions. Poor nutritional status prior to surgery is associated with longer hospital stay and it affects their weight more than the height. [18] Although early growth failure may improve to some extent as the infant grows into childhood, [19] they may still experience long term complications like poor neuromotor development, behavioral changes, social and emotional development etc. [20-23]

Critical illness and surgery in the infants result in high catabolic stress, inflammation, suboptimal myocardial function leading to high catecholamine secretion, high pulmonary artery pressure(PAP) and increased respiratory work load. All these factors increase the demand for carbohydrate, protein, fat and micronutrients including trace elements and immunonutrients due to increased resting energy expenditure, but these requirements are difficult to meet in these children postoperatively. Lack of specified guidelines for nutrition supplementation in these children with CHD leads to energy imbalance and growth failure. [20,24]

Preoperative malnutrition:

Predictable severe inflammatory response occurs in these malnourished children with CHD post cardiac surgery. Therefore preoperative period may be considered as a good time to optimize the nutritional status, especially to act upon modifiable risk factors and potentially lower the risk of intra and post-operative complications arising out of malnutrition. The majority of the literature available deals with the intra and immediate post-operative nutrition management, when it may be too late to intervene and alter the outcome. [25] Though realising the importance of a preoperative nutrition intervention is necessary, it must be acknowledged that, timely intervention before surgery is hindered by logistical difficulties, as majority of patients who undergo cardiac surgery are admitted within 12–24 hours before surgery in developing countries. A well-nourished patient shows better outcomes postoperatively so it is important to ensure that well-nourished patient is subjected to cardiac surgery so as to have better recovery with shorter duration of ICU and hospital stay. [11]

Most of the infants with CHD are not growth retarded; their birth weight and height fall within appropriate range of gestational period. However the chances of malnutrition increase after birth. [26] Poor preoperative nutrition influences the metabolic response to injury after corrective cardiac intervention. [27,6] Among the various studies it can be inferred that acute malnutrition is more prevalent than chronic malnutrition, underweight and wasting is more prevalent than stunting.

Vaidyanathan B and colleagues in their prospective study found that 59% patients had weight for age z score <-2 and 26% had height for age z score <-2 before surgery but this score improved after the corrective intervention of cardiac anomaly. [28] In a prospective cohort study, Ratanachu et al demonstrated that 40% of infants admitted to the hospital for cardiac repair had malnutrition preoperatively. Among the infants who were admitted to the hospital, 28% were underweight, 22% wasted and 16% stunted. [29]

According to Toole Benjamin et al, the prevalence of acute and chronic malnutrition among infants with CHD was 51.2% and 40% at the time of surgery respectively. [11] As per Tokel K et al, 51 patients (85%) in their cohort had malnutrition preoperatively in which 58.3 % had acute, 13.3 % chronic and 13.3 % acute on chronic malnutrition. Preoperative z score for weight were correlated with the postoperative number of complications and infection ($p<0.05$). However, they were not correlated with length of ICU and hospital stay. [30]

It is well perceived that the increased total energy expenditure among CHD infants is a result of increased work of heart, increased work for breathing and diminished myocardial efficiency. [9] In a prospective study by Van der Kuip M et al, infants with CHD had 35% increased total daily energy expenditure and 7% higher total body water as compared to the healthy infants and they have observed that presence of cardiac failure does not affect the total energy expenditure among CHD infants. [31] Nydegger A et al showed that the early corrective intervention of CHD showed decline in energy requirements up to the levels of healthy infants and the poor preoperative growth was associated with the increased hospital length of stay. [32]

Post-operative nutrition and growth:

Only very few clinical studies have reported the effects of postoperative nutrition interventions in cardiac surgical patients. In these patients malnutrition have been reported to increase morbidity and mortality after cardiac surgery. [33,34] Some patients experience a complicated postoperative course, requiring pharmacological and/or mechanical cardiac support, as well as prolonged mechanical ventilation. These patients are frequently hypercatabolic, not able to feed themselves and are in need of intense nutrition support. [35,36] Moreover it was shown that weight

loss in these patients after cardiac surgery was associated with a persistent inflammatory response leading to a decreased physical functioning. [37]
Malnutrition among hospitalized infants with CHD remain common and it affects 60% of patients with left to right shunt and 53% of patient with complex heart disease. [38] The age and time of corrective intervention and delivery of adequate nutrition also affects the potential for nutritional recovery and normalization of somatic growth. [30, 39-41]

An observational study has demonstrated that infants with biventricular physiology undergoing corrective cardiac repair had a positive effect on weight for age z score at the time of discharge. [42] Another similar study have demonstrated that the anthropometric z score for weight, length and head circumference were lower in CHD infants at 3 months of follow up but the resting energy expenditure(REE) was normal as healthy infants. [43] Similarly, a prospective study reported that half of the infants with CHD had low weight for age and one quarter had low height for age and the maximum recovery for weight and weight for height was achieved in first year of life after corrective intervention of CHD whereas the variation in height score was not significant. [44]

Nutritional intervention can also alter the immediate morbidity outcomes. Recent observational studies have reported that poor nutrition before and after surgery are associated with longer ventilation duration and increased length of ICU and hospital stay. Higher z score for weight to age was a protective factor for intubation period (p=0.012), so the early prevention of malnutrition and optimal timing of surgery is important to improve the post-operative outcomes. [45] Early enteral feeding after cardiac surgical repair improves the immunity and reduces oxidative stress and infections. [46,47] And provision of adequate nutrition during the critical illness may improve the function of the host microbiome. [48]

Postoperatively, fluid restriction leads to suboptimal nutritional delivery so, the feeding algorithm or nutrition protocol may be used for initiation or advancement of nutrition support to achieve the nutritional goal in a shorter duration of time without compromising patient's safety. [49-51]

Timing of initiation of enteral nutrition and delivery of calorie after surgery:

The ideal timing for initiation of enteral nutrition and advancement of feeding remains unclear. An observational study has reported that the median time for initiation of enteral feeding was 3 days (range 2-30 days), median calorie intake was 93 kcal/kg/day (43-142). The goal of 100 kcal/kg/day was achieved in 48.4% of infants on 341 feeding day and goal of 120 kcal/kg/day was achieved only in 19.7 % on 139 feeding day. [27] A similar study reported that the median time for initiation of enteral nutrition was 4 days (IQR 3-6) and median calorie intake was below the recommended daily allowance. [52]

A pilot study demonstrated that early enteral feeding is feasible and delivery of supplemented expressed breast milk helped in achieving the nutritional goal among infants with congenital cardiac repair because the fluid restriction makes the delivery of nutrients very challenging among this vulnerable group. In their study the intervention group had shorter ventilation duration, length of ICU and hospital stay as compared to the control group. Though the energy goal was not achieved as per the recommendation but the intervention group consumed up to 40 kcals /kg /day more than the control group. [53]

Standard feeding protocols:

The infants with CHD usually require mechanical ventilation, vasoactive infusions for variable duration after open heart surgery. Some of them with severe myocardial dysfunction post-surgery may require mechanical circulatory support like extra corporeal membrane oxygenation (ECMO) for their recovery. Also the sternum is kept open in some complex

surgeries because of inadequate relaxation and severe diastolic dysfunction. These factors delay initiation of enteral nutrition in this subset of patients due to low cardiac output situation with poor gastro intestinal (GI) perfusion. They may experience several complications such as respiratory failure, chylothorax, renal failure and neurological impairment postoperatively. These issues make it more challenging to feed them as per their resting energy expenditure (REE).

There is paucity of literature regarding recommendation/ practice of postoperative nutritional support in a standardised manner in infants after cardiac repair. And also we did not find any prospective studies, (randomised controlled ones including) pertaining to initiation of enteral nutrition and achieving the required amount of calorie target in post cardiac surgical repair infants. Initiation of enteral feeding postoperatively varies from hours to few days and from centre to centre, and there is no uniform recommendation. Also there is no recommended daily required calorie and the mode of supplementation of the needed energy enterally under such critical situations when the child is undergoing high catabolic phase.

A pilot study reported that they initiated enteral feeding to infants <6 months, after 6 hours of cardiac surgery after their initial hemodynamic stabilisation, with expressed breast milk (EBM) and supplemented EBM. The test dose was 5 ml of EBM, frequency and volume of feed was gradually increased as per the fluid restrictions and tolerance of the infants. They found that the ventilation duration, ICU stay and hospital stay was less in intervention group as compared to the control group, and also they observed that early enteral feeding is feasible in post cardiac surgery children with better convalescence. [53]

Several studies have documented frequent feeding interruption (FI) in cardiac surgical patients, due to routine procedures such as cardiac catheterization, MRI, echocardiogram, planned extubations and placement of chest tube or central lines. Feedings are often withheld for clinical deterioration, hypoperfusion, ileus, gastro esophageal reflux etc. [21] Fluid restriction also plays a major role in under-delivery of nutrients. [40,54] Another study has reported that many a time the reasons for FI were not clear, as FI was ill defined and was associated with mechanical problems of feeding tube. Thus to obtain maximum benefits of a nutrition intervention there should be a standard feeding protocol and clear, medically sound reasons for withholding the feed.

CONCLUSION

Providing adequate nutrition is very much essential for the infants with CHD, the highly vulnerable group for malnutrition. Improved strategies for nutritional support and standard feeding regimen have been associated with increased survival and decreased overall morbidity. Preoperative optimization of nutritional status and early initiation of postoperative nutritional supplementation enterally may improve the clinical outcome. Further clinical trials are required to identify the specific nutrient composition, timing of initiation of feeding and optimal mode to deliver maximum nutrition.

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