## Research Article

# Anthropometric assessment parameters in children with disease-related malnutrition

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**ABSTRACT**

**Background**: Disease-related malnutrition (DRM) in children is frequently found in clinical practice. Nutritional status assessment and monitoring in pediatric disease-related malnutrition, especially congenital heart disease (CHD) and cancer, have certain challenges. Until now, there is no consensus regarding standard nutritional assessment parameters and monitoring for pediatric DRM.

**Objectives**: To outline the appropriate anthropometric assessment for children with DRM, specifically children with CHD and cancer.

**Review Result**: The use of weight measurement to determine nutritional status must be applied cautiously to children with CHD and cancer because it may not reflect the true body composition, considering that children with CHD may present with fluid overload and children with cancer may have organomegaly or large tumor mass. In developing nations, arm anthropometry is considered as a feasible approach for determining nutritional status of children with CHD and cancer, because it is simple, inexpensive, uniformly available and not affected by body fluid retention, organomegaly or tumor mass. The frequency and interval of nutritional status monitoring in children with CHD and cancer is adjusted according to the child's conditions.

**Conclusions**: Pediatric patients with CHD and cancer frequently suffers from malnutrition. and it is associated with poor outcomes. Weight measurement to determine nutritional status of children with CHD and cancer must be applied carefully. Arm anthropometric assessment is considered more appropriate in determining nutritional status of pediatric CHD and cancer.
Clinical significance: Anthropometric measurements of the arm are recommended to determine nutritional status in pediatric patients suffering from DRM, particularly in the cases of CHD and cancer.

**Keywords**: disease-related malnutrition; children with CHD and cancer; anthropometric assessment parameters

## INTRODUCTION

Malnutrition (undernutrition) in children is still a problem in developing nations. Based on the data from Indonesian Basic Health Research 2018, there were 6.7% moderate malnutrition and 3.5% severe acute malnutrition in under five children .1 These numbers are higher compared with the overall malnutrition prevalence in developed nations (In 2020, 0.2% moderate malnutrition and 0% severe malnutrition were reported in under five children at the United States).2 Prevalence of disease-related malnutrition varies according to the underlying disease, ranging from 23.6% in patients with gastrointestinal diseases, 27.3% in oncology patients, 28.6% in patients with cardiovascular disease, to 40% in patients with neurologic diseases.3 In developing nations, the prevalence of pediatric disease-related malnutrition (undernutrition) in regard to congenital heart disease (CHD) and cancer/malignancies keep increasing.4,5

Nutritional status assessment, monitoring and intervention are important in managing children with CHD and cancer. Malnutrition at diagnosis has been shown to be related with poor outcome and survival in these populations. However, nutritional status assessment and monitoring in children with CHD and cancer impose certain challenges. First of all, parameters for determining the child's nutritional status should not rely on weight as the only anthropometric assessment, because it could mask undernutrition and may not reflect the real weight of the child. Children with CHD may present with edema and fluid retention, and children with cancer may have organomegaly or tumor mass. In order for appropriate monitoring and management to be conducted, appropriate nutritional parameters are needed to establish correct diagnosis of the child's nutritional status. Secondly, children's nutritional status with CHD and cancer is greatly influenced by the course of their illness. Their nutritional status may change during the course of their illness and/or treatment. That is why routine nutritional assessment performed at several times in the course of illness/therapy becomes an important part of follow-up in these children. But up to date, there has been no consensus regarding the standard of nutritional monitoring frequency and interval for these children.

This systematic review aims to outline the appropriate anthropometric assessment parameters for pediatric disease-related malnutrition, specifically in the cases of CHD and cancer.

## MALNUTRITION AND DISEASE-RELATED MALNUTRITION

According to definition from the ASPEN (American Society for Parenteral and Enteral Nutrition) workgroup, malnutrition or undernutrition in children is defined as a discrepancy of necessity and consumption of nutrient, which leads to shortages of micronutrients, protein, or energy. This situation will disrupt the children's development, growth, and other significant aspects.3 In the past, overnutrition and undernutrition fell into the definition of malnutrition, but the new definition as well as this review, addresses only undernutrition.6

According to its etiopathogenesis, malnutrition is classified into the following two categories: (1) disease-related (one or additional diseases/injuries directly gives rise to nutrient discrepancy) or (2) environmental/behavioral aspects leading to diminished nutrient consumption/provision (or both).3 Diminished consumption, disrupted nutrient use, rising loss of nutrient, or hypermetabolism (rising nutrient necessity more than consumption) are among the mechanisms thought to lead to nutrient imbalance, which in turn lead to disease-related malnutrition. Those factors are also often seen in acute conditions (e.g., burn, trauma, infection) and chronic illnesses (such as congenital heart disease, malignancies, chronic kidney disease, cystic fibrosis, gastrointestinal diseases, and neuromuscular diseases).3

In this review, the discussion is limited to disease-related malnutrition (undernutrition) in children with CHD and cancer/malignancies. Disease-related malnutrition in these populations imposes particular challenges in nutritional status assessment and monitoring due to their unique conditions.

## PEDIATRIC CONGENITAL HEART DISEASE (CHD)-RELATED MALNUTRITION

CHD is the most prevalent congenital abnormalities. Globally, this condition affects 8–11 newborns of 1000 livebirths. CHD-related malnutrition are particularly common in developing nations.7 Table 1 summarizes the prevalence of pediatric CHD-related malnutrition based on 6 studies conducted in 5 different countries. All studies used the same anthropometric parameters (weight-for-age, weight-for-length, and length-for-age z-scores). All studies used 2006 WHO child growth standards.

**Table 1. The prevalence of malnutrition in children with CHD[4,9,8,10,11,12]**

| Authors | Country | Year | Study Design | Age of Subjects | Wasting | Stunting |
|---|---|---|---|---|---|---|
| **Amelia et al.** | Indonesia | 2020 | Cross Sectional | 0 – 18 years | 56.8% | 46.6% |
| **Batte et al.** | Uganda | 2013-2014 | Cross Sectional | 0 – 15 years | 31.5% | 45.4% |
| **Abdelmoneim et al.** | Egypt | 2016 | Case Control | 0 – 60 months | 60.4% | 27.9% |
| **Hassan et al.** | Egypt | 2012-2013 | Case Control | 2 – 72 months | 23.8% | 61.9% |
| **Zhang et al.** | China | 2013 | Cohort | 1 – 3671 days | 14.3% | 23.3% |

Wasting is described as a WHO growth chart weight-for-length z-score of < -2, and stunting is described as length-for-age z-score of < -2.13

Growth patterns of children with certain cases of CHD may be impaired as reported in several previous researches. Zhang et al.12 reported that acyanotic CHD had been associated with underweight (WHO weight-for-age z-score of < -2), pulmonary hypertension had been associated with wasting, whereas cyanotic cardiac disease as well as single ventricle disease have been linked to stunting. In addition, wasting was more prevalent in acyanotic CHD and stunting was higher in cyanotic CHD.8

Genetic factors, chronic cyanosis, pulmonary hypertension, inability to feed properly resulting in decreased consumption, gastrointestinal malabsorption due to disrupted cardiac output, increase work of respiratory muscles resulting in rising energy expenditure contributes to the development of pediatric CHD-related malnutrition.7,12,14 Abdelmoneim et al.10 showed that poor dietary history, heart failure, anemia, and pulmonary hypertension were all significant contributors to malnutrition. Arodiwe et al.8 identified the following predictors for malnutrition: age, poor diet, presence of pulmonary hypertension. The associated risk factors of pediatric CHD-related malnutrition are outlined in Table 2 below.

## MALNUTRITION IN CHILDREN WITH CANCER

Low and middle income countries (LMICs) are the biggest contributors of pediatric patients with cancer in which more cases of malnutrition are reported and access to treatment is limited.[1920] Survival of pediatric patients with cancer is approximately 25%, lower than high income countries (HICs) (approximately 80).[20] Coexisting malnutrition is one of the factors that contribute to poor survival rate of pediatric cancer.[21]

Herintya et al.[5] in Yogyakarta, Indonesia, reported prevalence of undernutrition in children with acute lymphoblastic leukemia (ALL) was 45.5%. Pribnow et al.[20] in Nicaragua reported malnutrition in 67% of recently diagnosed acute myeloid leukemia (AML), ALL, Hodgkin lymphoma, Wilms tumor, or Burkitt lymphoma. Malnutrition was associated with the rising incidence of treatment abandonment, morbidity related to treatment, as well as poor event-free survival (EFS).

**Table 2.** The associated risk factors of pediatric CHD-related malnutrition[9,12,14,15,16,17,18]

| | |
|---|---|
| Increased energy requirement | Increased basal metabolic rate (BMR)/ hypermetabolism<br>Increased total energy expenditure (TEE)<br>Increased nutritional requirement of cardiac and respiratory muscles<br>Infection<br>Prematurity |
| Decreased food intake | Anorexia<br>Early satiety<br>Dysphagia<br>Gastroesophageal reflux |
| Increased loss of nutrients | Gastrointestinal malabsorption<br>Hyperosmolarity<br>Protein-losing enteropathy<br>Electrolyte loss from kidney |
| Inefficient utility of nutrients | Acidosis<br>Cellular hypoxia<br>Increased pulmonary pressure |
| Others | Chromosome disorder<br>Nutritional impairment during pregnancy<br>Low birth weight |

## PEDIATRIC CHD AND CANCER'S NUTRITIONAL STATUS AND PROGNOSIS

Nutritional status greatly influences outcome and prognosis of children with CHD and cancer. According to the literature, well-nourished children have higher prevalence of survival in pediatric cancer[20,22] and lower complication rates in children with CHD that underwent surgical intervention therapy.[14,23]

Poor critical care outcomes were linked to small weight-for-height and weight-for-age ratio. Mitting et al.[14] reported that small weight-for-age z-score (WAZ) at admission had been significantly associated with protracted respiratory failure as well as increasing mortality outcomes of surgery in neonates with CHD neonates. Radman et al.[23] reported that acute-and-chronic malnourishment and lower total body fat mass tend to be associated with worse clinical outcomes and worse myocardial performance in children undergoing surgery for CHD.

Pediatric cancer patients with malnutrition have been linked to poor prognosis, specifically increasing morbidity rate in addition to decreased survival.[20] The effect of impaired nutritional status on patient's prognosis and outcome is linked to poor tolerance to the therapy due to diminished nutrient and disruption of immune system. In addition, a correlation between undernutrition during treatment and a greater number of complications, increasing treatment-related morbidity, as well as decreasing EFS has also been reported.[22] A prospective cohort study by Iniesta et al.[24] showed that riskier therapy influenced the incidence undernutrition during the initial three months and malnutrition at diagnosis had been significantly linked to recurrence, becoming palliative or mortality. In addition, malnourished patients had fourteen times more risk to develop an event.

## ANTHROPOMETRIC ASSESSMENT PARAMETERS IN CHILDREN WITH CHD AND CANCER

Growth becomes the principal measurement of nutritional status in children. It has to be measured regularly throughout childhood and adolescence. In children aged less than 36 months, growth measurements include head circumference-for-age, length-for-age, weight-for length, and weight-for-age. In children ages 2–20 years, the recommended growth measurement includes standing weight-for-age, body mass index (BMI)-for-age, as well as height-for-age.[25] Nutritional status is commonly classified based on weight for length/height.[13]

To assess pediatric malnutrition, Mehta et al.[3] advised 2006 WHO growth reference[26] for children aged under 2 years old and 2000 CDC growth charts[27] for age 2-20 years. The definition of malnutrition is recommended to rely on the declining z-score as well as negative z-score over the use of percentiles because z-score can better describe how far off a child's anthropometric value is compared to children of the same age. On the other hand, this cannot be use as the only diagnostic tool. Other clinical signs suggesting malnutrition should also be taken into account in diagnosing pediatric malnutrition, such as the presence of edema, condition of the hair and nails, etc.[25]

Nutritional status assessment in certain children with CHD and cancer cannot rely only on weight measurement because it may not reflect the true body composition. The typically used anthropometric measurements to determine nutritional status cannot assess the major composition of human's body: water content, fat, as well as lean body mass.[23,28] Children with cancer sometimes present late with large tumor mass or organomegaly, which makes weight measurement inaccurate to assess nutritional status in these children.[28,29] Body weight may increase in the cases of severe CHD in which there is excessive fluid, thereby covering the decreasing fat mass and occurring cachexia.[23] Other nutritional assessment parameters are needed to determine nutritional status in certain cases of children with CHD (e.g. children presenting with edema and fluid retention) and children with cancer that have organomegaly or tumor mass.

At the moment, no "gold standard" is established to assess nutritional status of pediatric patients. Misclassification of nutritional status can occur should the BMI, body weight, and length/height are utilized in isolation.[21,30] Several methods are available for the clinical assessment of nutritional status. Among these, dual-energy X-ray absorptiometry (DXA) is considered the gold standard for determining human body constituents. However, DXA is not widely available in LMICs and even in many HICs, it is not readily available enough to be used in routine clinical settings.[19]

Mehta et al.[3] recommended the use of clinical parameters along with anthropometric measurement to assess pediatric nutritional status. Iniesta et al.[24] highly recommended measurement of body constituents and growth with arm anthropometry or bioelectrical impedance (BIA) in children with cancer. Comprehensive assessment can be achieved through this combined measurements.[31] In clinical practice, combination of arm anthropometry, such as triceps skinfold thickness (TSFT) and mid-upper arm circumference (MUAC) with BIA can evaluate body composition changes more efficiently as well as diagnose pediatric cancer related malnutrition, in which the patients' weight can be compromised by the metabolic disruption, presence of tumor, and stunting.[21,22,30]

When there is an inadequate energy supply, the first constituents used are the reserves in the muscle fat and protein, represented by the declining MUAC and TSFT. Previous studies agreed that MUAC represents lean body mass and TSFT represents fat mass because these parameters are not influenced by race, tumor's weight, also associated with body constituents.[20] Furthermore, using TSFT is superior since it represents peripheral fat mass, thereby reducing the confounding factor, e.g. fluid buildup.[23]

In developing nations where body composition assessment methods, such as DXA and BIA, are not easily available, arm anthropometry measurements are considered as more appropriate and feasible measures for determining nutritional status in pediatric CHD and cancer. Arm anthropometry measurements are simple, inexpensive, uniformly available, and not influenced by organomegaly or large tumor mass as sometimes seen in children with cancer, and also not affected by body fluid retention that may be seen in certain cases of CHD. Malnutrition stratification based on MUAC has been recommended for children aged 3 to 60 months using the standards developed by WHO.[25] Meanwhile, determination of MUAC z-score for children over the age of 5 years may use the 2006 WHO MUAC-for-age z-score.[32] Abdel-Rahman et al.[33] generated the MUAC Lambda, Mu, Sigma (LMS) values for age 2 months to 18 years which were based on the CDC National Health and Nutrition Examination Survey.

Limitations of the use of MUAC and TSFT measurements to assess pediatric disease-related malnutrition are the WHO's MUAC and TSFT reference charts are only available for children from the age of 3 months, and the MUAC LMS values are only provided for children from 2 months old.[26] Aside from that, MUAC has shown a known bias towards identifying stunted children and also younger and smaller infants as malnourished in children aged 6 to 60 months. To date, MUAC is not advised to be used in infants aged younger than 6 months due to scarce evidence for the interpretation.[34] However, a more recent study by Mwangome et al.[35] in 2017 concluded that MUAC was superior than weight-for-length z-score in predicting mortality of hospitalized infants under 6 months old, suggesting that MUAC measurement may have a role in nutritional status assessment for this particular population. Further researches are encouraged in order to establish a standardized approach for determining nutritional status in pediatric disease-related malnutrition, especially for younger infants under 6 months old.

## MONITORING OF NUTRITIONAL STATUS IN PEDIATRIC CHD AND CANCER

Due to the highly prevalent pediatric CHD and cancer-related malnutrition, and as nutritional status represents an adjustable risk, determination of nutritional status is a must since the patient was diagnosed to getting therapy and beyond.[22] During the course of illness, Mehta et al.[3] suggested that serial anthropometric measurements be performed to assess optimal growth. Improvement of outcomes and reducing readmission rate are expected from this nutritional monitoring. However, determining ideal frequency and interval for nutritional monitoring is difficult because of the wide range of nutritional behaviors, degree of failure to thrive, chronic illnesses, concomitant morbidities, socioeconomic conditions, and so on. Like any other medical condition, the interval of follow-up visit in this population, should be individualized.[25]

In children with disease-related malnutrition, whose chronic illnesses should be monitored, optimizing nourishment to alleviate the malnutrition will lead to better prognosis.[6] The nutritional goal for children with CHD is to maintain their weight throughout the critical conditions as well as to gain adequate weight throughout recovery stage.[36] The primary nutritional goals in pediatric cancer comprise the maintenance of ideal body stores, reduction of wasting, promotion of proper growth and development, as well as provision of a better quality of life.[29]

## CONCLUSION

Pediatric patients with CHD and cancer commonly present with malnutrition. Malnutrition at diagnosis is associated with unfavorable outcome. Nutritional assessment and monitoring are important for the management of diseases. To date, no "gold standard" of nutritional assessment exist for pediatric disease-related malnutrition. Measurement of weight as representation of nutritional status of children with CHD and cancer must be done with caution. In certain cases of children with CHD and cancer, arm anthropometric assessment is deemed appropriate and feasible in determining nutritional status. The frequency and interval of nutritional status monitoring in children with chronic illnesses, such as CHD and cancer, should be tailored according to the conditions of the child. Further research is needed to establish a more suitable standard of nutritional assessment parameters in pediatric disease-related malnutrition.

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