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Estimating nutritional needs in paediatric heart failure: beyond the equations

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Abstract

Background: Nutrition optimisation is imperative in paediatric patients with heart failure. Energy needs can be assessed using indirect calorimetry. *Methods:* Presented are two cases of children with clinical heart failure who benefited from indirect calorimetry. *Results:* Using indirect calorimetry, it was determined both cases were hypermetabolic. *Conclusion:* These cases demonstrate the impact of heart failure on metabolic rate and growth. Energy requirements were up to two times higher than estimations from predictive equations.

There is a high prevalence of growth difficulties in paediatric patients with heart failure.[1–3] Nutrition optimisation is imperative in order to prevent increased morbidity and mortality in this vulnerable population.

An integral part of every nutrition assessment is determining energy requirements. Predictive equations are frequently used due to their practical nature. However, these are over-simplified estimations and do not take disease-specific considerations into account.[4] Indirect calorimetry can be used as an alternative and provides an individualised measurement of resting energy expenditure. Given its ease of use, our team has been applying this test both within inpatient and ambulatory settings to optimise care of children with chronic heart failure symptoms. Herein, we present two cases of children with clinical heart failure who benefited from indirect calorimetry.

Case presentations

Case 1

A 4-month-old male presented to hospital with failure to thrive, irritability and diaphoresis. He was found to have severe left ventricular systolic dysfunction and moderate mitral regurgitation secondary to an anomalous origin of the left coronary artery from the pulmonary artery. Surgical repair was undertaken and a left ventricular assist device was required for 7 days post-operatively. Following left ventricular assist device removal, the patient continued to exhibit heart failure symptoms including poor weight gain.

Anthropometric measurements were plotted on WHO growth charts. Shortly after admission to hospital, his dry weight was estimated at the 0.16th percentile (z-score −2.96). Length was 13.7th percentile (z-score −1.09). Thus, weight-for-length was <0.01st percentile (z-score −4.12), indicating severe malnutrition[5]. Enteral feeds were initiated and the concentration was incrementally increased to 30 kcal/oz. Fluids were liberalised as clinically able, though the patient remained fluid restricted and oil was ultimately added to feeds to further increase energy intake. Growth remained a concern despite an intake of 130 kcal/kg/d. Indirect calorimetry was then performed and demonstrated a resting energy expenditure 167% of estimated. With the addition of physical activity, the patient was estimated to require 200% the dietary reference intake for age, double what the predictive equation estimated. Results of the metabolic cart were used to direct changes to nutritional support and energy intake continued to increase until adequate growth was achieved with an intake of 160 kcal/kg, corresponding with 198% dietary reference intake (Fig 1). The patient has since had recovery in ventricular function and has tolerated weaning of heart failure therapy.

Case 2

A 12-month-old female was admitted to hospital for worsening left ventricular function and growth failure in the context of ischaemic cardiomyopathy due to left coronary artery ostial obstruction that was thought to be congenital in nature. She had undergone a corrective repair involving a left coronary osteotomy, but returned to hospital following discharge for poor weight gain. At readmission, she was receiving 24 kcal/oz formula feeds as well as high calorie solids.

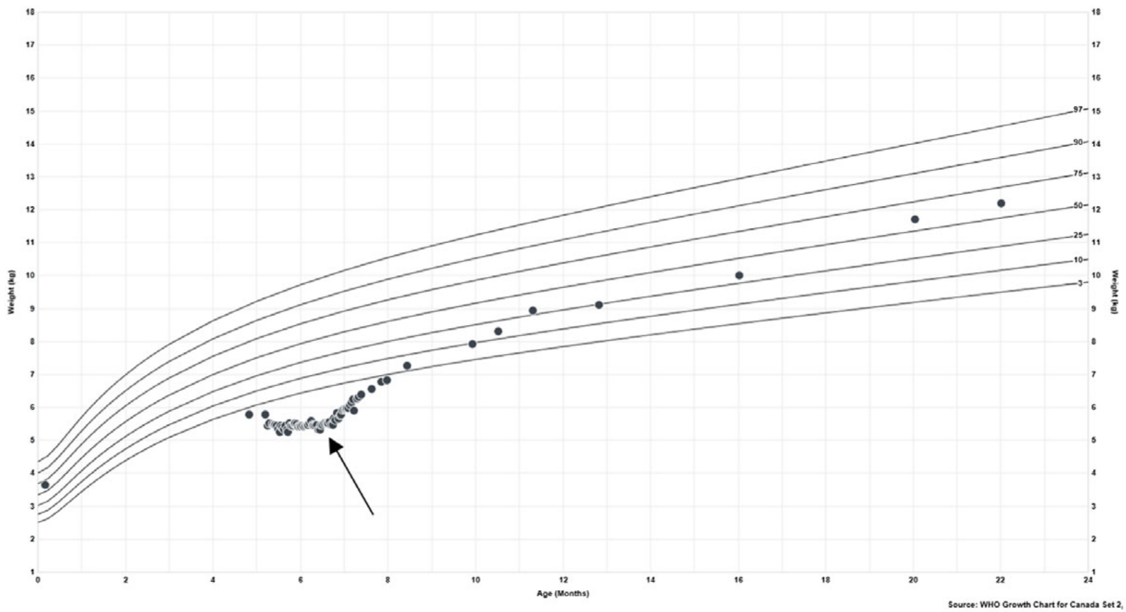

Figure 1. WHO growth chart—weight-for-age: boys birth to 2 years. The arrow indicates the time point when the metabolic cart was completed.

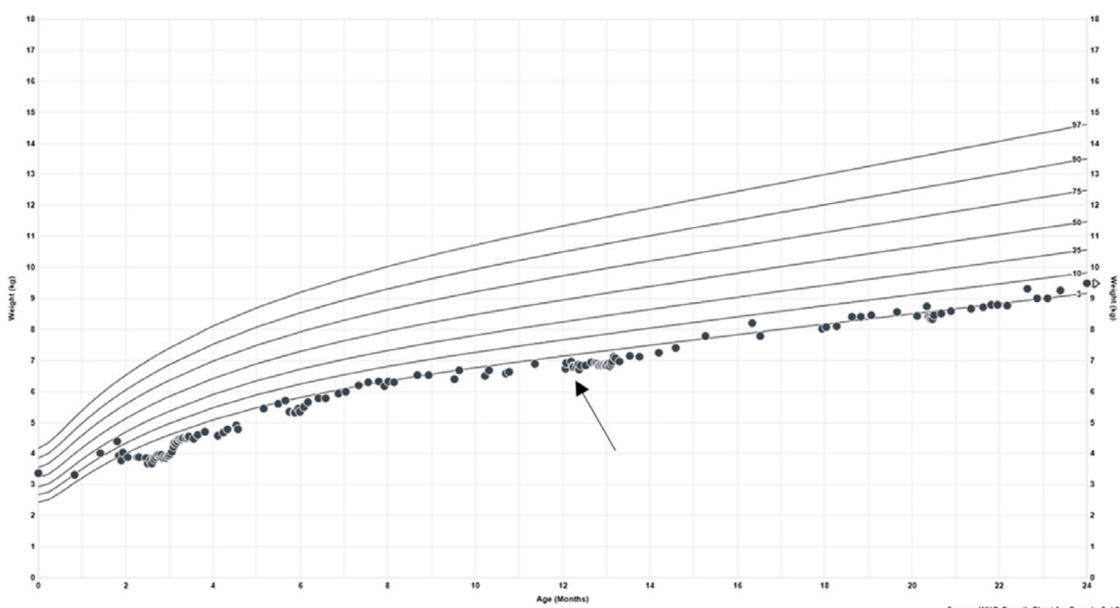

Figure 2. WHO growth chart—weight-for-age: girls birth to 2 years. The arrow indicates the time point when the metabolic cart was completed.

Her weight was at the 0.9th percentile (z-score −2.38), length was at the 22nd percentile (z-score −0.77), and weight for length was at the 0.2nd percentile (z-score of −2.88), indicating moderate malnutrition.[5] A metabolic cart was completed and the patient was found to be hypermetabolic with a resting energy expenditure 139% expected. With the addition of physical activity, the patient was estimated to require 170% the dietary reference intake for age.[6] The patient's formula concentration was incrementally increased from 24 kcal/oz to 28 kcal/oz and parents received additional high calorie high protein teaching in order to optimise energy intake obtained from solids. Despite this, adequate energy intake was not consistently achieved for a variety of reasons, and her growth velocity did not improve (Fig 2). The patient has since been listed for heart transplantation. While growth velocity did not improve, indirect calorimetry provided valuable information as it provided a more precise caloric target and helped direct nutritional recommendations.

Discussion

These cases demonstrate the impact of heart failure on metabolic rate and growth. Energy requirements were up to two times higher than estimations from predictive equations. It can be noted that although both Case 1 and Case 2 were hypermetabolic, their requirements varied, further supporting the use of indirect calorimetry to individualise nutrition care plans.

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The inaccuracy of predictive equations has also been studied in a secondary analysis of a prospective cohort of patients with CHD by Roebuck and colleagues.[7] They evaluated the accuracy of predictive equations in children with CHD following cardiopulmonary bypass. In this analysis, they found that all equations reviewed incorrectly estimated resting energy expenditure and concluded indirect calorimetry remains the gold standard for determining energy requirements.

Nydegger and colleagues used indirect calorimetry to compare resting energy expenditure before and after cardiac surgery to that of healthy controls.[8] They found that resting energy expenditure was significantly higher than healthy controls prior to surgery, and decreased to normal levels 1-week following cardiac surgery. Nutrition status improved, and growth and weight were similar in both groups 6-months after surgery. This is promising for children who are able to undergo surgical repair at an early age, but remains a concern for those without surgical options or those waiting to undergo a heart transplant, such as children with cardiomyopathy, as outlined in the two presented cases.

Growth impairment is one of the markers that is monitored to determine if patients in heart failure should be assessed for heart transplant. Understanding their energy requirements may help determine whether suboptimal growth is a result of inadequate intake or a result of worsening heart failure. Additionally, when used in an outpatient setting, it may decrease the need for heart failure admissions secondary to poor growth.

Conclusion

Indirect calorimetry is an objective and useful tool to measure resting energy expenditure. It has proven invaluable for the paediatric heart failure population, as predictive equations are likely to underestimate true needs. As demonstrated in our two case reports, indirect calorimetry can be used in the non-intensive care units setting as a tool for optimising growth in children with chronic heart failure. Optimal nutrition is essential, both in promoting recovery and in optimising the health of these vulnerable populations in advance of heart transplantation.

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Conflicts of interest. None.

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