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Energy Requirements of a Pediatric Lung Transplant Population

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Abstract

Background: Comparison of estimated energy requirements using predictive equations (PBMR) to measured resting energy requirements (MREE) using indirect calorimetry is not widely investigated in the pediatric lung transplant (LTx) population. In this population, optimal nutrition delivery may promote appropriate weight gain post-transplantation. The purpose of this case series was to evaluate the difference between predicted and measured energy requirements pre- and post- transplant by comparing PBMR calculated by the World Health Organization (WHO) equation and MREE by indirect calorimetry. The secondary aim was to determine if the diagnosis of Cystic Fibrosis (CF) influenced energy expenditure. It was predicted that the majority of LTx children would have higher MREE than PBMR (denoted as % PBMR). The % PBMR value is relative to MREE.

Methods and findings: After exclusion, there were 7 LTx patients (n=5 male, n=4 CF, median age 11.55, age range: 4-16 y) and 14 measurements (7 repeated measures). Measurements were conducted pre- or post- transplant. Pre-LTx patients (n=4 patients, n=2 CF) exhibited a median 106% PBMR (interquartile range: 24%). Post-LTx patients (n=3 patients, n=2 CF) exhibited a median 105% PBMR (24%). The median % PBMR did not differ significantly between CF and non-CF LTx children irrespective of transplant status (113% (22%), 103% (19%), respectively, P=0.12).

Conclusion: These results suggest that MREE was higher than PBMR; the WHO equation may underestimate energy requirements for pre- and post-LTx children. There was a trend towards decreasing energy requirements post-LTx. In children post-LTx, the diagnosis of CF may not affect energy requirements.

Keywords: Transplant; Diagnosis; Cystic fibrosis

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Abbreviations

CF: Cystic Fibrosis; ICU: Intensive Care Unit; LOS: Length of Stay; LTx: Lung Transplant; MREE: Measured Resting Energy Requirements; PBMR: Predictive Basal Metabolic Rate

Introduction

Literature in the area of nutrition repletion for the critically ill child demonstrates that optimal nutrition prescription can be aided through the use of indirect calorimetry [1]. In the pediatric lung transplant population, optimal nutritional delivery may promote weight gain post-transplantation [2]. Increased weight gain has been shown to be associated with higher rates of survival post-transplantation [3]. Better nutritional status pre-transplantation has been shown to decrease intensive care unit (ICU) length of stay (LOS) in adults [4]. The purpose of this exploratory, case series study was to determine if the increased work of breathing associated with the lung transplant population led to a higher resting energy expenditure, pre- and post-transplantation. The secondary aim was to determine if the diagnosis of Cystic Fibrosis (CF) influenced energy expenditure. It was predicted that for the majority of LTx children, MREE would be higher than PBMR (denoted as % PBMR) in a 24 h window.

Methods

A retrospective chart review was conducted on 8 patients in the Lung Transplant Program from September 29, 2009 to September 21, 2012. The LTx patients had indirect calorimetry measurements conducted either on the ward or in an ambulatory outpatient care. The nutrition prescription determined by measured resting energy expenditure (MREE) from indirect calorimetry was compared to the predicted basal metabolic rate (PBMR) calculated based on body weight using the World Health Organisation (WHO) equation appropriate for age and gender [5,6]. The study was approved by the University of Alberta Health Research Ethics Board. Eligible patients for the study were those who were patients at the Stollery Children's Hospital, met the criteria for energy measurement using indirect calorimetry, and had one or more metabolic cart measurements either pre or post-transplant without technical failure. One patient was excluded based on these criteria.

Indirect calorimetry

The V_{max} Encore indirect calorimeter (SM-2900, model 2900, Sensormedics Metabolic cart, Yorba Linda, CA, USA) measured continuous oxygen (VO_2) input and carbon dioxide (VCO_2) output using a canopy. Patients received either maintenance dextrose fluids continually using intravenous (IV) fluids, oral diet or enteral tube feeds. Most patients were in a modified fasted state between 2 to 6 hours before indirect calorimeter measurement, though some remained on tube feeds during the test. All patients were supine during the measurement period. Before measurement, calibration occurred using a gas mixture, according to the manufacturer's instructions. A canopy was placed over the patient's head for at least 30 minutes, or until steady state was achieved. Steady state indicated the test was valid [7,8]. The indirect calorimeter calculated VO_2 and VCO_2, which was then used to calculate the respiratory quotient and measured resting energy expenditure (MREE) using the modified Weir equation. The predicted basal metabolic rate (PBMR) was calculated by using the World Health Organisation (WHO) predictive equation.

Data analysis

Data were analyzed using the statistical data analysis package, SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows Version 21.0. Armonk, NY: IBM Corp.). Age, gender, MREE, PBMR, %PBMR, and test location (pediatric intensive care unit (PICU), ward or ambulatory) were compared between pre-transplant and post-transplant participants. On normally distributed data, the authors conducted the independent T-test. On skewed data, the authors conducted the Mann Whitney test.

Results

Demographics

After exclusion, there were 7 participants (n=5 male) with the median age at which an indirect calorimetry measurement was performed being 11.55 years (range: 4–16 y). There were a total of 14 measurements. 4 patients had at least 1 repeat measurement. The median age of pre-transplant (14 years) and post-transplant (9.2 years) participants differed significantly (p=0.004). There were no differences in gender or pediatric ICU:ward:ambulatory distribution pre (0:3:2) or post-transplant (2:3:4) **(Table 1)**. There were 4 patients (n=2 CF) pre-transplant and 3 patients (n=2 CF) post-transplant patients **(Table 1)**.

Pre and post-transplant

Both pre and post-transplantation, the WHO predictive equation underestimated energy requirements in comparison to indirect calorimetry **(Table 1)**. In some cases, the patient's clinical course may have influenced MREE findings. Patient 3 recovered without transplant. During an inpatient treatment for CF exacerbation with evidence of weight loss and a fall in BMI, patient 5 demonstrated increased % PBMR. This patient also refused transplant. In patient 6, her clinical status had been excellent and her MREE/kg and % PBMR both improved over time. Post-LTx, patient 7 had episodic acute rejection and viral infective episodes at 8 and 12 months. MREE/kg was measured within 2 months post-treatment. The convalescent course showed favourable MREE/kg and % PBMR. The patient further succumbed to acute airway rejection with a drop in BMI at 23 months. Following this, the patient developed bronchiolitis obliterans syndrome. In the early post-LTx period both patients 7 and 8 showed marginally elevated % PBMR. Overall, the 24 h window of energy requirements demonstrates a trend towards higher energy requirements pre-transplant compared to post-transplant **(Table 1)**.

Cystic fibrosis

The absolute values of energy measurements trended higher for CF vs non-CF patients. There were two patients each in pre- and post-transplant groups that had CF.

Discussion

The results from this case series study showed that pediatric lung transplant recipients have a wide range of resting caloric requirements that cannot be accurately predicted using the WHO equation. There seemed to be a trend of decreasing energy requirements post-transplant, similar to the findings by Kalnins et al., where their cohort of 12 pediatric lung transplant patients had a statistically significant decline in energy needs post-transplant [2]. Increased work of breathing associated with the lung transplant population seems to lead to higher resting energy expenditure, which is improved post-transplant. Optimising nutritional delivery to this population may help to decrease PICU LOS [4]. In adults, it has been shown that mortality in those with an ICU LOS >5 d is associated with BMI, where higher BMIs have lower rate of mortality [4]. In the pediatric lung transplant population, Fulton et al demonstrated that children who lived >1 y had significant weight gain sooner after LTx compared to those who lived <1 y post-transplant [3]. Chronic malnutrition has been documented at 30% in the pre and post lung transplant pediatric population [9]. One strategy to address malnutrition in this population may be implementing an oral and/or enteral feeding algorithm. It has been shown that these algorithms reduce the number of hours NPO by decreasing the time to first feeds by 10.5 h, and increasing the number of patients receiving 70% estimated average requirement by 15% [10]. Future directions could determine other strategies to combat malnutrition in this population.

The study sample was dependent on previously collected data and may not be representative of the general pediatric lung transplant population. There were few patients enrolled and almost half of the measurements were repeated measures, which may have

Table 1 Demographics and nutritional status for pre and post-transplant children.

Patient	Age (y) at test	Gender	Transplant Status	Cystic Fibrosis (Y/N)	Unit	Time Since Transplant (m)	Time Since Listed (m)	CDC BMI Z-score	MREE/kg	PBMR/kg	%PBMR	VO2	VCO_2	VO_2/kg
1	16.3	M	Pre-	N	Ambulatory	-	19.6	-0.9	29	28	105	0.257	0.236	4.1
3	13.9	M	Pre-	Y	Ward	-	Not listed	-1.68	37	34	106	0.196	0.182	5.1
4	15.8	M	Pre-	N	Ward	-	22.3	-4.53	32	32	100	0.199	0.197	4.4
5	12.7	F	Pre-	Y	Ward	-	23.3	-0.05	31	29	110	0.178	0.202	4.4
	14		Pre-		Ambulatory		39.7	-0.79	41	29	142	0.264	0.206	5.9
6	4.3	F	Post-	N	Ambulatory	0.9	-	-2.1	50	61	82	0.092	0.08	7.1
	4.7		Post-		Ward	10.7		-1.92	66	63	105	0.113	0.113	9.1
7	8.3	M	Post-	Y	Ward	1.4	-	-2.96	53	44	120	0.170	0.167	7.3
	8.8		Post-		Ward	7.8		-1.02	39	43	91	0.126	0.118	5.7
	9.2		Post-		PICU	12.1		-0.87	46	45	102	0.143	0.121	6.6
	10.2		Post-		Ambulatory	23.5		-1.9	43	44	97	0.138	0.127	6.0
8	11.2	M	Post-	Y	PICU	9.9	-	-1.02	46	40	115	0.182	0.191	6.2
	11.9		Post-		Ambulatory	18.6		-1.26	53	41	129	0.221	0.181	7.0
	13.3		Post-		Ambulatory	35.7		-0.45	40	35	116	0.218	0.179	5.8

%PBMR is the percent ratio of MREE:PBMR. PICU, Pediatric Intensive Care Unit; LTx, Lung transplant; MREE, measured resting energy expenditure; PBMR, predicted basal metabolic rate using World Health Organisation equation; VO2, volume of inspired oxygen; VCO2, volume of expired carbon dioxide

skewed our analysis. Also, indirect calorimetry is intrinsically dependent on ventilation, and CF directly impacts ventilation. In the four CF children, the disease state may have confounded indirect calorimetry results. Confounding factors are not fully elucidated in this population, as the patient clinical picture and medications change between patients, and the evolving phases of illness and recovery. Interpretation of any item of our results should not be done in isolation. A more global overview of the clinical situation and inter-relationship of each component would be helpful. Our results on % PBMR appear to reflect the clinical status of our patients accurately. Overall, as one of the first exploratory studies in the pediatric lung transplant population, this study provides valuable nutritional insight for clinicians.

Conclusion

The pediatric lung transplant population of chronically ill children may benefit from the use of indirect calorimetry to predict their energy requirements. The diagnosis of CF did not appear to influence energy expenditure, though there was a trend of increased energy requirements in these and other patients during pulmonary exacerbation. Studies in pediatric critical care demonstrate a constant evolution in energy requirements throughout the course of stay, which is dependent on the clinical picture, and cannot be reliably predicted by equations [11]. Accurate prediction of energy requirements in this population would help provide the healthcare team with the information necessary to deliver adequate energy. In the case of CF patients, accurate prediction would simply be one factor in adequate energy delivery, as malabsorption is an important factor in obtaining energy needs for these patients. Indirect calorimetry measured higher energy requirements compared to PBMR both pre and post-transplant.

References

1 Leong AY, Field CJ, Larsen BM (2013) Nutrition support of the postoperative cardiac surgery child. Nutr Clin Pr. 58: 572-579.

2 Kalnins D, Pencharz PB, Grasemann H, Solomon M (2013) Energy expenditure and nutritional status in pediatric patients before and after lung transplantation. J Pediatr 163: 2011-2013.

3 Fulton J, Orenstein D, Koehler A, Kurland G (1995) Nutrition in the pediatric double lung transplant patient with cystic fibrosis. Nutr Clin Pract. 10:67-72.

4 Plöchl W, Pezawas L, Artemiou O, Grimm M, Klepetko W, et al. (1996) Nutritional status, ICU duration and ICU mortality in lung transplant recipients. Intensive Care Med 22: 1179-1185.

5 WHO (2015) Energy and protein requirements: Report of a Joint FAO/WHO/UNU Expert Consultation. Geneva, 1985.

6 Kreymann KG, Berger MM, Deutz NEP (2006) ESPEN Guidelines on Enteral Nutrition: Intensive care. ESPEN Guidel Enter Nutr 25: 210-223.

7 Campo K, Castro G, Hamilton V (2016) Energy expenditure in chilean children with maple syrup urine disease (MSUD). JIMD Rep. 26: 69-76.

8 Mehta NM, John M, Bechard LJ, et al. (2013) Resting energy expenditure after fontan surgery in children with single-ventricle heart defects. Journal of Parenteral and Enteral Nutrition.

9 Kyle UG, Spoede ET, Mallory GB (2013) Changes in body composition after lung transplantation in children. J Heart Lung Transplant. 32: 800-806.

10 Meyer R, Harrison S, Sargent S, Ramnarayan P, Habibi P, et al. (2009) The impact of enteral feeding protocols on nutritional support in critically ill children. J Hum Nutr Diet. 22: 428-436.

11 Oshima T, Berger MM, De Waele E (2016) Indirect calorimetry in nutritional therapy. A position paper by the ICALIC study group. Clin Nutr.