Journal of Pediatric Surgery 50 (2015) 734–738

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Long-term nutritional morbidity for congenital diaphragmatic hernia survivors: Failure to thrive extends well into childhood and adolescence

Beth Haliburton [a], Marialena Mouzaki [b], Monping Chiang [a], Vikki Scaini [b], Margaret Marcon [b], Theo J. Moraes [c], Priscilla P. Chiu [a,*]

[a] Department of Surgery, Division of Pediatric General and Thoracic Surgery, The Hospital for Sick Children, Toronto, ON, Canada
[b] Department of Pediatrics, Division of Gastroenterology, Hepatology and Nutrition, The Hospital for Sick Children, Toronto, ON, Canada
[c] Department of Pediatrics, Division of Respiratory Medicine, The Hospital for Sick Children, Toronto, ON, Canada

ARTICLE INFO

Article history:
Received 20 January 2015
Accepted 13 February 2015

Key words:
Congenital diaphragmatic hernia
Nutritional morbidity
Failure to thrive
Enteral feeding tubes
Calorimetry

ABSTRACT

Background: Failure to thrive (FTT) is well documented among congenital diaphragmatic hernia (CDH) survivors ≤3 years of age, but its etiology, severity, and persistence beyond this age require further elucidation.
Methods: We conducted a single-center, retrospective study assessing anthropometrics, measured energy expenditure, and feeding tube (FT) use of 5–17 year olds in our multidisciplinary CDH clinic since January 2001. We stratified clinic visits based on age A: 5.0–6.9, B: 7.0–9.9, C: 10.0–14.9, and D: 15–17.9 years.
Results: One hundred sixteen patients with 376 outpatient visits were reviewed. Anthropometric z-scores were below zero and did not vary across age cohorts. FTT and growth stunting each occurred in 14% of clinic visits. FTs inserted during infancy occurred in 25% of patients, and 60% remained by age 7 years. In cohort A, those with FTs were lighter and shorter than those without ($p < 0.05$) but had similar BMIs. FTT incidence was higher in the FT group ($p = 0.020$), but FTs were present in only 30% of those with FTT. Indirect calorimetry revealed increased energy expenditure in 58% of patients.
Conclusions: Failure to thrive continues in long-term CDH survivors, FTs may not improve incidence of FTT. Increased energy expenditure may play a role.

Failure to thrive (FTT) is a well-recognized morbidity among congenital diaphragmatic hernia (CDH) survivors [1–9]. The incidence of growth retardation in the first 3 years of life has been reported to be up to 56%, with up to one third of survivors requiring a feeding tube (FT) for nutritional rehabilitation during infancy [2,7,8]. The pathogenesis of FTT is likely multifactorial; previously published reports suggest that neonatal metabolic stress response and suboptimal nutritional intake secondary to oral aversion and gastroesophageal reflux disease (GERD) are key contributors [7]. In addition, the type of surgical repair and the degree of respiratory compromise at hospital discharge have been associated with persistent FTT at 1 year of age [8].

While nutritional morbidity of CDH patients early in life is well-documented, FTT beyond infancy and particularly among children and adolescent survivors has not been clearly delineated [2]. To our knowledge, there is only one report comparing the body mass index (BMI) of young adults with CDH to age matched adults treated for other forms of respiratory failure in infancy [10]. The aim of that study was primarily on exercise capacity with details on fatigue during daily activity. However, they also commented briefly on growth and nutritional status, reporting no difference in BMI despite lower height z-scores in the CDH group. All patients in this study were of adult age in their mid-20s, who underwent CDH repair prior to the early 1990s when aggressive mechanical ventilation may have been widely practiced. Since then, medical and surgical practices have improved significantly making these results difficult to apply to survivors of current treatment techniques.

The objective of our study was to determine the long-term nutritional morbidity of patients who had CDH corrected in infancy. Specifically, our aims were to review the nutritional status of patients followed in the multidisciplinary CDH clinic at The Hospital for Sick Children in Toronto and to also assess their energy expenditure as a potential contributor to FTT. We hypothesized that FTT is a persistent morbidity of children and adolescents with CDH and that their resting energy expenditure (REE) is increased.

1. Methods

1.1. General

With research ethics board approval, a retrospective review of patients followed in the multidisciplinary CDH clinic in our institution was performed. Inclusion criteria were ages 5–17 years, CDH clinic

* Corresponding author at: Division of Pediatric General, and Thoracic Surgery, The Hospital for Sick Children, 555 University Avenue, Room 1518, Toronto, ON, Canada M5G 1X8.
E-mail addresses: beth.haliburton@sickkids.ca (B. Haliburton), marialena.mouzaki@sickkids.ca (M. Mouzaki), monping.chaing@sickkids.ca (M. Chiang), Vikki.scaini@sickkids.ca (V. Scaini), peggy.marcon@sickkids.ca (M. Marcon), theo.moreas@sickkids.ca (T.J. Moraes), priscilla.chiu@sickkids.ca (P.P. Chiu).

http://dx.doi.org/10.1016/j.jpedsurg.2015.02.026
0022-3468/

attendance between January 2001 and June 2014 and surgical repair performed at our institution between 1996 and 2009.

1.2. Data collection

Data on birth anthropometrics, gender, side of defect, type of surgical repair, and feeding tube (FT) use were collected. Anthropometrics, including height, weight and body mass index (BMI) data were documented and plotted on Canadian Pediatric Endocrine Group (CPEG) charts (http://cpeg-gcep.net/) (adapted from WHO growth standards) [11] at each clinic visit. Anthropometrics were converted to z-scores using CPEG growth standards (z-score of 0 is equivalent to 50th percentile, −1 to the 16th percentile, and −2.0 is equivalent to 2nd percentile). FTT was defined as BMI z-score ≤ −2.0 and stunting as height z-score ≤ −2.0 [10]. Jancelewicz *et al.* had previously reported on our CDH clinic surveillance protocol and the frequency of clinic visits [12], but since that publication, indirect calorimetry had been included in our protocol for patients over the age of 5 years. Indirect calorimetry was performed by a trained technician using a VMax™. Encore 29 Viasys Health Care (Palm Springs, CA). As per convention, measured REE results were expressed as percentage predicted REE using the FAO/WHO/UNU equations; with normal range defined as 90–110% predicted REE; <90% is considered hypometabolism and >110% hypermetabolism. Not all patients were fasted prior to completing calorimetry owing to timing of clinic visit. Results were considered valid only if steady state was achieved during the test.

1.3. Statistical analyses

Clinic visits were stratified into four age cohorts A: 5.0–6.9, B: 7.0–9.9, C: 10.0–14.9 and D: 15–17.9 years to allow for comparison throughout childhood and adolescence. Student's *t*-test was used to compare the groups. Pearson's correlation coefficient was used to explore associations between variables. Statistical significance level was set at $p = 0.05$.

2. Results

Two hundred and two infants had been referred to our institution for management of CDH during the study period and 116 patients were included in our analysis (Fig. 1A). Population characteristics are described in Table 1. Briefly, the majority of patients were male, born at term with left-sided CDH. Data from 376 unique visits were collected and the frequency of clinic visits varied between 1 and 10 per patient over the study period (Fig. 1B).

Median population anthropometric z-scores were below average (Table 1) with no significant differences across age cohorts (Fig. 2). The lowest BMI z-scores were noted in age cohort B (mean ± SD: −0.62 ± 1.45), but were not significantly different than the other age cohorts (Fig. 2). The proportion of stunting was not different between the groups (cohort A: 14%, B: 13%, C: 13%, D: 19%; $p = 0.889$) (Fig. 3). The incidence of FTT was significantly different between the age groups with the lowest occurring in cohort A (7% vs. B: 17%, C: 19% and D: each 19%; $p = 0.02$) (Fig. 3). Patients who were seen in clinic 3 or more times during our study period had a statistically significant, but clinically insignificant increase in z-scores (weight z-score increased by 0.4 ± 0.1, $p = 0.004$; height z-score increased by 0.3 ± 0.1, $p = 0.008$; BMI z-score increased by 0.2 ± 0.1, $p = 0.040$). A mean period of 6.7 years elapsed between these visits.

In our population, 25% of the patients received FTs during infancy. By age 7 years (cohort A) 60% of these tubes remained *in situ*. Interestingly, despite the incidence of FTT in cohort A, only 30% of those with a BMI z-score < −2.0 had an FT in place. Similarly, of those with stunting, only 26% had FTs. Remarkably, by 7 years of age, the proportion of FTT was still higher in those who had had an FT compared to those that without tubes (6 vs 10%, $p = 0.03$) (Table 2).

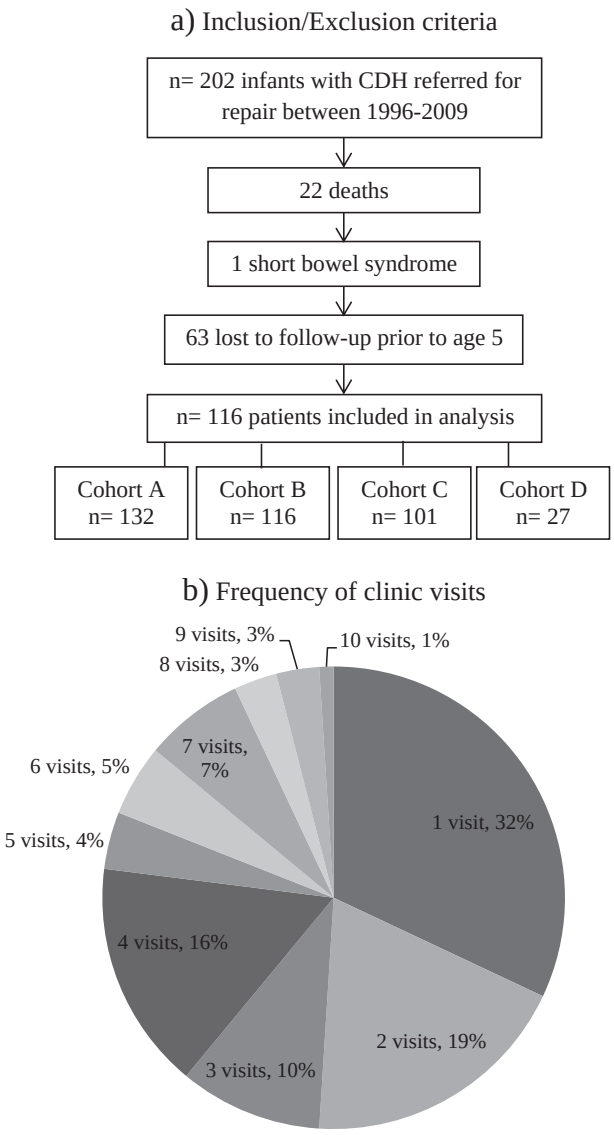

Fig. 1. a: Inclusion/Exclusion criteria. b: Frequency of clinic visits.

Indirect calorimetry data were available for 35 patients; 2 failed to reach steady state so were not included in analysis. Sixty percent of the measurements were completed in a fasted state. In our study, the measured REE of each patient ranged from 83% to 137% of predicted REE (median 114%), with 58% of patients demonstrating elevated REE (Table 3). The measured REE of those with FTT was 105% of predicted

Table 1
CDH patient demographics.

	Population
n	116
Male: female	79:37
Gestational age in weeks: mean ± SD	38 ± 2
Preterm:term	35:78[a]
Patch:primary repair	44:67[a]
R:L:bilateral	16:99:1
Feeding tube inserted during infancy (tube:no tube)	25:91
Number of clinic visits	376
All clinic weight z-scores: median (range)	−0.79 (−4.31 to 2.32)
All clinic height z-scores: median (range)	−0.60 (−4.46 to 2.81)
All clinic BMI z-scores: median (range)	−0.65 (−3.47 to 3.00)

[a] Missing data.