

Gastrostomy Placement Improves Height and Weight Gain in Girls With Rett Syndrome

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ABSTRACT

Background: Growth failure and undernutrition complicate the clinical course of girls with Rett syndrome (RTT). These abnormalities are, in part, the consequence of oral motor dysfunction and inadequate dietary intake.

Objective: To determine whether gastrostomy placement for nutritional therapy alters the natural history of growth failure and undernutrition in RTT.

Hypothesis: We hypothesized that gastrostomy placement for nutritional therapy reverses the decline in height, weight, and body mass index (BMI) *z* scores in RTT.

Methods: Standard stadiometric and anthropometric measures were obtained to derive height, weight, and BMI *z* scores and estimates of fat-free mass (FFM) and body fat in a cohort of girls (*n* = 92) with RTT before and after gastrostomy placement. Methyl-CpG-binding protein 2 (*MECP2*) mutations and the presence or absence of a fundoplication were recorded.

Results: The differences in height (*n* = 73), weight (*n* = 81), and BMI (*n* = 81) *z* score slopes before and after gastrostomy placement were 1.31 ± 2.06 ($P < 0.001$), 2.38 ± 3.18 ($P < 0.001$), and 3.25 ± 3.32 ($P < 0.001$), respectively. FFM

and body fat (*n* = 43) increased after gastrostomy by 41 ± 27 g/cm height ($P < 0.001$) and $7.5\% \pm 5.7\%$ body weight ($P < 0.001$), respectively. The differences in height, weight, and BMI *z* score slopes were similar regardless of the age at which the gastrostomy was placed. The differences in height, weight, and BMI *z* score slopes, as well as the change in FFM and body fat deposition after gastrostomy placement, did not differ between those who did or did not have a fundoplication and among the classes of *MECP2* mutations.

Conclusion: Gastrostomy placement for aggressive nutritional therapy favorably altered the natural history of growth failure and undernutrition in RTT, but did not restore height and weight *z* scores to birth values, regardless of the age at which surgery occurred and in the presence or absence of a fundoplication. *JPGN* 49:237–242, 2009. **Key Words:** Body composition—Fundoplication—Gastrostomy—Growth—Neurologically impaired—Rett syndrome. © 2009 by European Society for Pediatric Gastroenterology, Hepatology, and Nutrition and North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition

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The authors report no conflicts of interest.

Growth failure and undernutrition complicate the clinical course of girls with Rett syndrome (RTT), a neurodevelopmental disorder caused by a mutation in the methyl-CpG-binding protein 2 (*MECP2*) gene (1,2). The growth trajectory of RTT deviates from the typical pattern of growth failure in children who have chronic illnesses or other central nervous system or chromosomal disorders (3,4). Early deceleration of head growth, followed by deceleration of height and weight gain, may provide the earliest clinical indication for the diagnosis of RTT (1).

Multiple factors are responsible for the growth abnormalities in RTT. Although a brain-based trophic influence may be associated with early deceleration of head growth, undernutrition due to inadequate dietary intake adds to the cellular abnormalities already present. Feeding difficulties associated with oral motor dysfunction and gastroesophageal dysmotility contribute to inadequate dietary intake (5). Repetitive motor movements do not lead to increased energy expenditure, and

hence, increased dietary energy needs (6). Endocrine abnormalities have not been described consistently in RTT (7–10). The patterns of reduced weight-for-height and height-for-age are consistent with acute and chronic undernutrition, respectively (11), and support the role of nutrition as a causative factor.

The purpose of this study was to examine the role of gastrostomy placement for nutritional therapy on the natural history of growth failure and undernutrition in RTT. We hypothesized that gastrostomy placement for feeding therapy reverses the progressive decline in height, weight, and body mass index (BMI) *z* scores and increases fat-free mass (FFM) and body fat deposition in girls affected with RTT; gastrostomy placement at an earlier, rather than later, age leads to greater improvement in height, weight, and BMI *z* scores; and fundoplication contributes to the reversal of undernutrition in girls with RTT.

SUBJECTS AND METHODS

Subjects

Girls and young women who met the clinical diagnostic criteria for classic or atypical RTT (12) and had an endoscopic, laparoscopic, or surgically placed gastrostomy were selected for enrollment. Girls who had gastrostomy placement with subsequent removal were excluded from the study. All of the subjects were females because males with *MECP2* mutations have a different phenotype and rarely meet the clinical diagnostic criteria of RTT (13).

The RTT cohort (*n* = 92) was a sample of convenience on the basis of the number of individuals followed clinically by the principal investigator. Complete data sets were available for a variable number of subjects because of accessibility to individual medical records. Parents gave permission for the participation of their daughters in the research study. Assent was waived for the participants because of their cognitive impairment. The study protocol was approved by the Institutional Review Board for Human Subject Research at Baylor College of Medicine.

Methods

Study Design

The study design was observational, based on the retrospective review of the subjects' medical records. The following information was obtained from the chart: birth measurements, growth, and anthropometric measurements before and after gastrostomy placement, *MECP2* status, the presence of a fundoplication, and the use of the proton pump inhibitor and prokinetic medications after gastrostomy placement.

Procedures

Individual heights and weights were obtained by direct measurement at the time of physical examination and indirectly from medical records provided by parents if gastrostomy placement occurred before evaluation. Standing heights were measured using a wall-mounted stadiometer with a moveable headpiece (Harpenden, Crymych, U.K.). The length of girls unable to stand was measured using a horizontal measuring board with a fixed head piece and a moveable, perpendicular foot piece (Harpenden). Height (length) measurements were obtained without shoes and orthotics and recorded to the nearest 0.1 cm. Weight was measured using an electronic balance and recorded to the nearest 0.1 kg (Scale-Tronix, Inc, Wheaton, IL). Heavy clothes, shoes, and orthotics were removed before weighing. Body mass index (BMI, kg/m²) was calculated as the ratio of weight divided by height squared for girls age 2 years or older. Height (length), weight, and BMI measurements were converted to age-appropriate *z* scores using the normative data from the National Center for Health Statistics reference population (14). For individuals older than 20 years, height, weight, and BMI *z* scores were assumed to be equivalent to those measured at age 20 years. The method of measurement of height and weight values obtained from the private physician's medical records was unknown. Triceps, biceps, subscapular, and suprailiac skinfold thicknesses were measured to the nearest 1 mm using standard anthropometric techniques (15). Body fat, calculated as a proportion of body weight, was estimated from these 4 skinfold thicknesses (16). FFM was calculated as the difference between body weight and body fat and standardized for height or length.

MECP2 mutations, characterized by sequence and deletion analysis (13), were recorded from the medical records provided by the parents. Individual *MECP2* mutations were grouped into 4 classes: missense, early truncation, late truncation, and large deletion mutations (17).

Birth length and weight, as well as the presence of a fundoplication, the use of proton pump inhibitor and prokinetic medications after gastrostomy placement, were recorded using parental recall or the medical record.

Statistical Analysis

Descriptive statistics were calculated using Minitab software (version 11.0, Minitab Statistical Software, Inc, State College, PA). One sample *t* test was applied to detect differences in height, weight, and BMI *z* scores between the RTT cohort before and after gastrostomy placement and the reference population (14). Height, weight, and BMI *z* score slopes were calculated as differences in these measures before (from birth to pregastrostomy) and after (from pre- to postgastrostomy)

TABLE 1. Measures of growth and body composition in girls with Rett syndrome before and after gastrostomy placement

Measure	Birth		Pregastrostomy		Post gastrostomy	
	n	Value	n	Value	n	Value
Height/length (z score)	82	0.2 ± 1.2	81	-1.8 ± 1.3	92	-2.6 ± 1.5
Weight (z score)	91	-0.4 ± 0.8	82	-2.7 ± 2.2	92	-2.6 ± 2.3
BMI (z score)	—	—	81	-1.9 ± 1.8	92	-0.7 ± 1.2
Lean body mass (g/cm height)	—	—	46	116 ± 18	86	151 ± 28
Body fat (% body weight)	—	—	46	20 ± 5	86	27 ± 6

gastrostomy placement. The BMI z score at birth was assumed to equal 0. Paired *t* tests were applied to detect differences in height, weight, and BMI z score slopes before and after gastrostomy placement, as well as changes in FFM, when standardized for height, and body fat, expressed as a proportion of body weight, after gastrostomy placement. Linear regression was used to detect differences in height, weight, and BMI z score slopes before and after gastrostomy placement as a function of the age at which surgery was performed. General linear modeling was applied to detect differences in height, weight, and BMI z score slopes, as well as changes in FFM and body fat deposition, after gastrostomy placement between individuals who did or did not have a fundoplication, adjusting for the age at which surgery was performed. Analysis of variance was used to detect differences in height, weight, BMI z scores, as well as changes in FFM and body fat deposition, before and after gastrostomy placement among the classes of gene mutations. χ^2 analysis was used to detect differences in medication use between those with or without a fundoplication.

RESULTS

Growth and anthropometric measurements were obtained before and after gastrostomy at mean ages 5.9 ± 3.8 years and 11.8 ± 6.0 years, respectively. The racial and ethnic distribution of the cohort was 75% white, 7% African American, 14% Hispanic, 13% Asian, and 1% Native American. *MECP2* mutations were identified in 88% of those individuals tested. The 8 common mutations, including R168X, T158M, R255X, R270X, R294X, R106W, R306C, and R133C, were found in 54% of individuals with mutations. Mutations were classified as 19% missense, 31% early truncation, 16% late truncation, 13% large deletion, and 13% unknown. Gastrostomy placement occurred at age 7.5 ± 4.8 years. The duration of follow-up after gastrostomy placement was 4.5 ± 3.9 years. A fundoplication was performed in 66% of the RTT cohort. Proton pump inhibitor and prokinetic medications were used by 37% and 20% of the RTT cohort ($n = 88$), respectively, after gastrostomy placement.

The measures of growth and body composition obtained at birth and before and after gastrostomy placement for the RTT cohort are shown in Table 1. Height (length), weight, and BMI z scores before and after gastrostomy were significantly lower in the RTT cohort than in the reference population (14). Height ($n = 73$), weight ($n = 81$), and BMI ($n = 81$) z score slopes before and after gastrostomy placement in the RTT cohort are shown in Figures 1 to 3, respectively. The differences in height, weight, and BMI z score slopes before and after gastrostomy placement were 1.25 ± 2.10 ($n = 73$, $P < 0.001$), 2.52 ± 3.38 ($n = 81$, $P < 0.001$), and 3.25 ± 3.32 ($n = 81$, $P < 0.001$), respectively. Height (length) and weight z scores after gastrostomy were significantly lower than birth length and weight z scores, respectively. Measures of FFM, standardized for height ($n = 43$), and body fat, standardized for body weight ($n = 43$), before and after gastrostomy are shown in Figures 4 and 5, respectively. The changes in FFM and body fat after gastrostomy placement increased significantly by 41 ± 27 g/cm height and $7.5\% \pm 5.7\%$ body weight, respectively.

The differences in height, weight, and BMI z score slopes before and after gastrostomy placement were not significant across the ages at which gastrostomy placement was performed (data not shown). When adjusted for

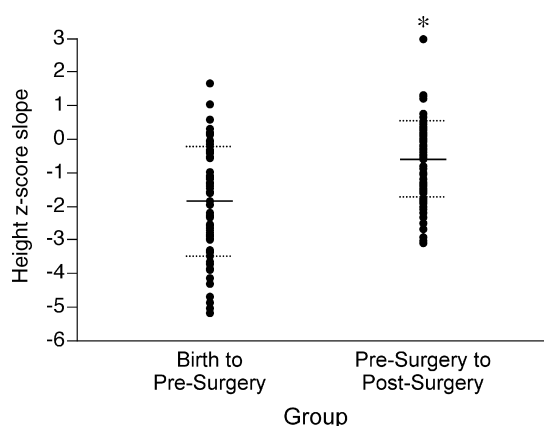


FIG. 1. Height z score slopes before and after gastrostomy placement in girls with Rett syndrome ($n = 73$, $P < 0.001$) (—, mean; ···, \pm SD).

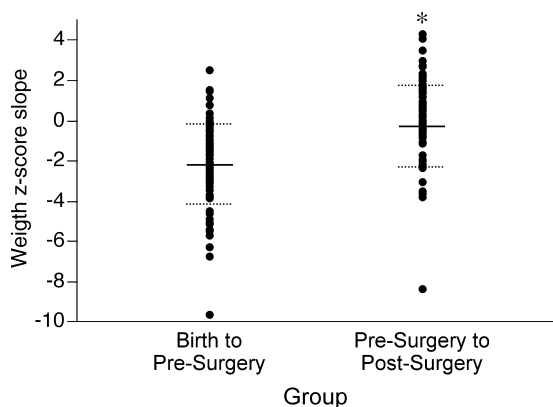


FIG. 2. Weight z score slopes before and after gastrostomy placement in girls with Rett syndrome ($n=81$, $P<0.001$) (—, mean; ···, \pm SD).

the age at which surgery occurred, the differences in height, weight, or BMI z score slopes, as well as the change in FFM and body fat deposition, after gastrostomy placement were not significantly different between those individuals who did or did not have a fundoplication (data not shown). A greater proportion of the RTT cohort without a fundoplication received proton pump inhibitor (60% vs 26%, $P<0.01$) and prokinetic (37% vs 12%, $P<0.01$) medications than those with a fundoplication. Height (length), weight, or BMI z score slopes before and after gastrostomy placement, as well as changes in FFM and body fat deposition after gastrostomy placement, did not differ among the classes of gene mutations (data not shown).

DISCUSSION

Early deceleration of height, weight, and BMI z scores characterizes the natural history of growth failure and undernutrition in girls with RTT. Our study is the first to

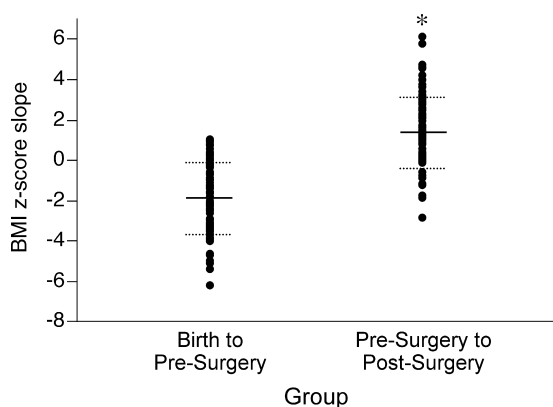


FIG. 3. Body mass index (BMI) z score slopes before and after gastrostomy placement in girls with Rett syndrome ($n=81$, $P<0.001$) (—, mean; ···, \pm SD).

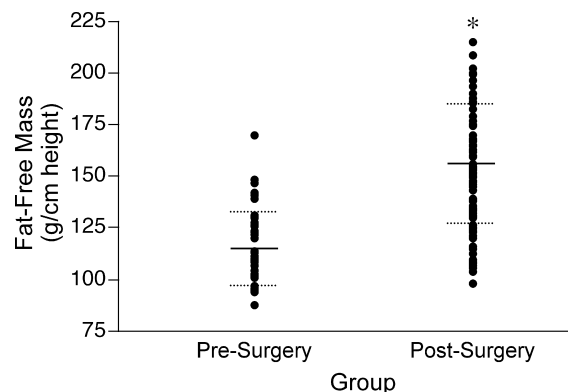


FIG. 4. Fat-free mass, standardized for height, before and after gastrostomy placement in girls with Rett syndrome ($n=43$, $P<0.001$) (—, mean; ···, \pm SD).

demonstrate that gastrostomy placement for nutritional therapy reverses the progressive decline in height, weight, and BMI z scores and enhances FFM and body fat deposition in girls with RTT, regardless of the age at which surgical intervention occurred. The reversal of undernutrition was accomplished equally in the presence or absence of a fundoplication. The type of gene mutation did not influence the magnitude of growth failure and undernutrition before, or the rate of recovery after, gastrostomy placement. Although gastrostomy placement reversed the pattern of growth failure and undernutrition, gastrostomy feeding did not restore the height and weight z scores of the RTT cohort to birth values.

Gastrostomy placement provides a therapeutic option for neurologically impaired children with feeding difficulties who have poor weight gain, although evidence-based practice guidelines and the risks and benefits of this procedure are lacking (18–20). Gastrostomy placement may promote weight gain, reverse linear stunting, improve health, decrease the frequency of chest infections, and

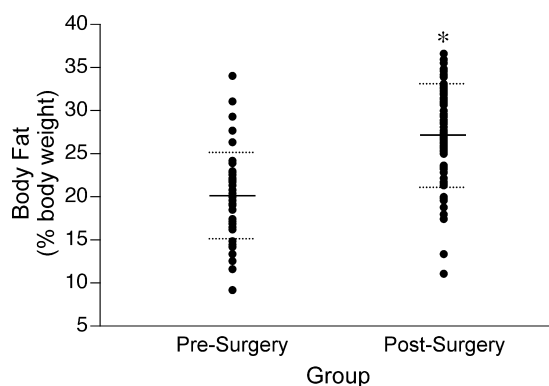


FIG. 5. Body fat, standardized for body weight, before and after gastrostomy placement in girls with Rett syndrome ($n=43$, $P<0.001$) (—, mean; ···, \pm SD).

reduce the time spent feeding children who have a broad spectrum of neurological disorders (20–24). Our study in girls with RTT provides further evidence in support of this approach to feeding children with neurological impairments. Although caution has been advised against the risk of overfeeding and increased body fat deposition in children with cerebral palsy (25), we showed significant gains in FFM, as well as body fat, in the RTT cohort. We were unable to identify risk factors for growth failure and undernutrition, as well as prognostic factors for the reversal of growth arrest, on the basis of the classification of gene mutations in RTT, because the small number of subjects within each group precluded phenotype–genotype correlations.

Feeding problems that arise from chewing and swallowing dysfunction, aspiration and respiratory complications, undernutrition, and growth failure are the major indications for gastrostomy placement in children with neurological disabilities (21). Warning signs in these children include mealtimes requiring more than 30 minutes to complete a feeding, oral and pharyngeal phase abnormalities on a videofluoroscopic swallow function study, and decreased weight-for-height or BMI measures. Supplemental oral feedings alone may not improve weight and height gains in children with neurological disabilities (26). Nevertheless, we encourage a 6-month trial period of aggressive oral formula supplementation before gastrostomy placement, a procedure often unwanted by the families of girls with RTT. Although some children with neuromuscular disorders may eat small amounts of food for pleasure after gastrostomy placement, the majority receive more than 80% of their nutrient intake through gastrostomy feedings (21). We assume that girls with RTT have similar patterns of food consumption as children with other neurological disorders on the basis of our clinical observations.

The timing of gastrostomy placement is controversial. The best clinical response may be associated with the shortest time interval between the neurological insult and the surgical procedure. Children with cerebral palsy who have gastrostomies placed within the first year of life are more likely to exceed the fifth percentile for height and weight (27). Gastrostomy feedings initiated within 1 year of a neurological insult are associated with improved weight-for-age, weight-for-length, and length-for-age, whereas the same intervention initiated 8 years after a neurological insult fails to improve length-for-age, despite improved weight-for-age (28). In the present study, although the average age of gastrostomy placement was 7.5 years, we documented significant gains in height-for-age, weight-for-age, and BMI-for-age *z* scores, regardless of the age at which gastrostomy placement occurred in the girls with RTT. Nevertheless, after an average treatment period of 4.5 years, we were unable to restore height and weight *z* scores to birth channels. Although birth measurements may be inaccurate, we

suspect that RTT may be associated with genetic downsizing, given the magnitude of the persistent height deficit.

Although the role of a fundoplication concurrent with gastrostomy placement is controversial (29), we recommend both procedures because of the frequency with which we encounter symptoms and the adverse consequences of reflux in RTT (5). The risk of having acid reflux or esophagitis after gastrostomy placement alone in neurologically impaired children averages 35% to 60% and 19%, respectively, depending on the methods of diagnosis and feeding (29–32). The likelihood that ongoing medical therapy will be required for acid reflux after gastrostomy placement is 52% (29). A subsequent fundoplication procedure is reported in 13% to 25% of individuals whose symptoms are unresponsive to medical management (24,30,33,34). In the present study, 37% and 20% of the RTT cohort received proton pump inhibitor and prokinetic therapy, respectively, after gastrostomy placement; however, a greater proportion of individuals without a fundoplication required both of these medications. We assumed that a fundoplication would confer an additional benefit in reversing growth failure and undernutrition in RTT by minimizing symptoms associated with gastroesophageal reflux, but our study did not support this expectation.

CONCLUSIONS

Gastrostomy placement for nutritional therapy reversed the progressive decline in height, weight, and BMI *z* scores and enhanced LBM and body fat deposition in the RTT cohort, regardless of the age at which surgery occurred. Halting the progression of undernutrition occurred in the presence or absence of a fundoplication. Although gastrostomy placement favorably altered the natural history of growth failure and undernutrition in RTT, aggressive refeeding did not restore height and weight *z* scores to their birth values. Further improvement of the growth potential of girls with RTT has yet to be determined.

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