Published in final edited form as:

J Pediatr Surg. 2008 January ; 43(1): 20–24. doi:10.1016/j.jpedsurg.2007.09.014.

Improved survival in a multidisciplinary short bowel syndrome program

Biren P. Modi^{a,b}, Monica Langer^{a,b}, Y. Avery Ching^{a,b}, Clarissa Valim^{b,c,d}, Stephen D. Waterford^{a,b}, Julie Iglesias^{a,b}, Debora Duro^{a,c}, Clifford Lo^{a,c}, Tom Jaksic^{a,b}, and Christopher Duggan^{a,c,*}

^aCenter for Advanced Intestinal Rehabilitation (CAIR), Children's Hospital Boston and Harvard Medical School, Boston, MA 02115, USA

^bDepartment of Surgery, Children's Hospital Boston and Harvard Medical School, Boston, MA 02115, USA

^cDivision of Gastroenterology and Nutrition, Children's Hospital Boston and Harvard Medical School, Boston, MA 02115, USA

^dClinical Research Program, Children's Hospital Boston and Harvard Medical School, Boston, MA 02115, USA

Abstract

Purpose—Pediatric short bowel syndrome (SBS) remains a management challenge with significant mortality. In 1999, we initiated a multidisciplinary pediatric intestinal rehabilitation program. The purpose of this study was to determine if the multidisciplinary approach was associated with improved survival in this patient population.

Methods—The Center for Advanced Intestinal Rehabilitation includes dedicated staff in surgery, gastroenterology, nutrition, pharmacy, nursing, and social work. We reviewed the medical records of all inpatients and outpatients with severe SBS treated from 1999 to 2006. These patients were compared to a historical control group of 30 consecutive patients with severe SBS who were treated between 1986 and 1998.

Results—Fifty-four patients with severe SBS managed by the multidisciplinary program were identified. Median follow-up was 403 days. The mean residual small intestinal length was 70 ± 36 vs 83 ± 67 cm in the historical controls ($P = \text{NS}$). Mean peak direct bilirubin was 8.1 ± 7.9 vs 9.0 ± 7.4 mg/dL in controls ($P = \text{NS}$). Full enteral nutrition was achieved in 36 (67%) of 54 patients with severe SBS vs 20 (67%) of 30 patients in the control group ($P = \text{NS}$). The overall survival rate, however, was 89% (48/54), which is significantly higher than in the historical controls (70%, 21/30; $P < .05$).

Conclusions—A multidisciplinary approach to intestinal rehabilitation allows for fully integrated care of inpatients and outpatients with SBS by fostering coordination of surgical, medical, and nutritional management. Our experience with 2 comparable cohorts demonstrates that this multidisciplinary approach is associated with improved survival.

Index words

Short bowel syndrome; Intestinal failure; Multidisciplinary care; Survival; Outcomes

Intestinal failure is the result of nutrient absorption that is insufficient for the growth and maintenance of an individual. Etiologies include both functional and anatomical intestinal dysfunction, with most pediatric patients having true “short” bowel syndrome (SBS) as a result of extensive bowel loss or resection because of congenital or acquired disorders [1,2].

In 2001, we reported our experience in treating 30 patients with severe SBS from 1986 to 1998 [3]. Overall survival in that cohort was 70%. In 1999, we created a multidisciplinary program now known as the Center for Advanced Intestinal Rehabilitation (CAIR), with the goal of providing fully coordinated management by facilitating discussion and planning among the multiple health care practitioners caring for these patients. Recently, other groups have reported their experiences with multidisciplinary management of SBS, with survival rates of 86% and 67% [4,5]. None of these reports, however, has shown an improvement in survival following transition to the multidisciplinary programs. We sought to determine if the transition to a multidisciplinary program was associated with a change in the outcomes of patients with intestinal failure.

1. Methods

The CAIR program consists of dedicated pediatric staff in general surgery, gastroenterology, transplant surgery, nutrition, pharmacy, nursing, and social work. This CAIR team assists in the management of all patients at risk for intestinal failure by providing coordinated input on inpatient management at least on a weekly basis. After discharge from hospital, nutritional, gastrointestinal, and surgical management occurs through the weekly outpatient CAIR clinic.

After institutional review board approval, we performed a retrospective analysis of all patients seen in the CAIR program between October 1999 and October 2006. This group consisted of all patients considered to be at risk for intestinal failure at our institution, as well as those referred to CAIR after initial management at outside institutions. Patients with severe SBS (defined as dependence on parenteral nutrition [PN] for at least 90 days) were identified. This cohort was then analyzed for patient demographics, primary diagnoses, anatomy, operative interventions, duration of PN dependence, enteral nutritional intake, laboratory parameters, and transplantation status (if any). Outcomes of interest were overall mortality and independence from PN (enteral autonomy).

During the study period, medical, nutritional, and surgical management of all patients was generally unchanged. After confirmation of bowel function, continuous enteral feedings were initiated via an enterostomy at 10 mL/kg per day and advanced 10 mL/kg per day until expected goals were achieved. Feedings were limited by increased emesis, increased gastrostomy output, or increased stool output (>2 mL/kg per hour over 24 hours via ostomy, dehydration, electrolyte abnormalities, or ongoing skin breakdown) [6].

Parenteral nutrition was administered via tunneled central venous catheter or peripherally inserted central catheter using anhydrous dextrose, Trophamine (McGaw Laboratories, Chicago, Ill) and a soy-based lipid source at 2 to 3 g/kg per day (Intralipid 20%, Baxter Healthcare/Fresenius Kabi, Clayton, NC). Multivitamins and trace elements were also routinely provided. Under a compassionate use protocol, 14 patients were converted from Intralipid to an omega-3 fatty acid based lipid source at 1 g/kg (Omegaven, Fresenius Kabi AG, Bad Homburg, Germany) after their direct bilirubin exceeded 2.0 mg/dL. Parenteral

nutrition was weaned when patients were able to maintain adequate hydration and growth with enteral feeding alone. Appropriate laboratory measures were obtained at regular intervals and as clinically warranted.

Patients were included in this analysis only if their surgical, medical, and nutritional care was directed by the CAIR team, so that patients referred for a second opinion but not transferring to CAIR were excluded. Residual bowel length was defined as the most recent measured length along the antimesenteric border from the ligament of Treitz to the end ostomy or the enterocolic junction before admission to CAIR. Only operative measurements were used for this analysis.

Demographic and outcome data were compared to a historical cohort of 30 neonates meeting the same criteria for severe SBS managed at our institution from 1986 to 1998 before the inception of the multidisciplinary program [3]. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS for Windows, version 14.0, SPSS, Chicago, Ill) and SAS software (SAS version 9.2, SAS Institute, Cary, NC). Associations of mortality and enteral autonomy with selected clinical and demographic variables were assessed via comparisons of medians and proportions, unless otherwise specified. Statistical significance of associations was verified via the Fisher exact test, Mann-Whitney *U* test, and Wilcoxon signed rank test, as appropriate. Adjusted associations with both mortality and enteral autonomy were tested using multiple logistic regression models to estimate odds ratios (ORs) with profile likelihood based 95% confidence intervals (CIs). The following candidate variables were included based on univariate analysis results and literature review: peak direct bilirubin, age at admission, percent enteral nutrition at admission, and diagnosis of necrotizing enterocolitis (NEC). Criteria for retention in the models were $P < .05$ or appreciable effect on covariates. Data are presented as median (interquartile range [IQR]) or number (percentage) unless otherwise specified. Two-sided *P* values less than .05 were considered statistically significant.

2. Results

2.1. Demographics

From October 1999 to October 2006, 135 patients were managed through the CAIR program. Of these, 54 patients had severe SBS, with median follow-up of 403 (256–1333) days. Demographic and clinical data for these patients are provided in Table 1. Diagnoses included NEC ($n = 16$), intestinal atresia ($n = 12$), gastroschisis with or without volvulus ($n = 10$), malrotation with volvulus ($n = 5$), segmental volvulus ($n = 4$), Hirschsprung disease ($n = 2$), pseudo-obstruction with generalized dysmotility ($n = 2$), and other ($n = 3$).

2.2. Outcomes

Enteral tolerance increased significantly from 0% (0%–63%) of total calories at admission to 100% (69%–100%) of total calories at follow-up ($P < .001$). Overall, 36 of the 54 patients were free of PN at follow-up. In the patients still receiving PN at last follow-up, their median enteral tolerance had increased from 8% (0%–43%) at admission to 31% (2%–67%) at follow-up ($P = \text{NS}$).

Six patients died during the study period for an overall survival rate of 89%. Of the fatalities, 5 occurred while the patients were being evaluated for or were listed for transplantation, and all 5 deaths were because of liver failure and sepsis. One patient died of progressive congenital cardiac disease. Significant factors associated with mortality in univariate analysis are listed in Table 2. As expected, variables significantly related to mortality included enteral tolerance at follow-up and peak direct bilirubin. No patient who achieved enteral autonomy went on to die, whereas 6 of 18 patients who were unable to

weaned from PN died ($P < .001$). All 6 fatalities and 29 of the 48 survivors had a peak direct bilirubin greater than 2.5 mg/dL, nearly achieving significant association with mortality ($P = .08$). The presence of the ileocecal valve did not correlate with mortality in the 47 patients for whom these data were available. Residual bowel length, duration of PN, diagnosis of NEC, referral status, and provision of parenteral fish oil were also not significantly related to mortality in this cohort.

As mentioned above, 36 of the 54 patients were independent of PN at last follow-up. Only 8 of the 54 patients had achieved enteral autonomy before transfer of care to our program ($P < .0001$). In univariate analysis (Table 3), duration of PN, as expected, correlated with attainment of enteral autonomy ($P < .005$). Residual bowel length tended to be higher in patients able to achieve enteral autonomy than those still dependent on PN ($P = .09$). A diagnosis of NEC tended to be associated with achieving enteral autonomy ($P = .06$). Peak direct bilirubin, direct bilirubin greater than 2.5 mg/dL, preservation of the ileocecal valve, referral status, and provision of parenteral fish oil did not correlate with ability to achieve enteral autonomy in this cohort.

In multiple logistic regression models, only peak direct bilirubin was a significant predictor of mortality (OR = 1.17; CI, 1.06–1.34; $P = .02$). Peak direct bilirubin negatively predicted enteral autonomy (OR = 0.91; CI, 0.83–0.98; $P = .01$), whereas a diagnosis of NEC predicted enteral autonomy (OR = 6.52; CI, 1.43–48.38; $P = .01$).

2.3. Comparison to control group

We then compared the CAIR cohort to the group of patients with severe SBS managed before the initiation of the multidisciplinary program. Thirty infants (14 male) with severe SBS were included in this historical cohort. Diagnoses included NEC ($n = 13$), intestinal atresias ($n = 9$), gastroschisis with or without volvulus ($n = 5$), and malrotation with volvulus ($n = 3$). Of these 30 patients, 20 (67%) were weaned from PN completely. Of the 10 patients not weaned from PN, 9 died of progressive liver failure ($n = 6$), sepsis ($n = 2$), or cardiac arrest ($n = 1$) [3].

The 2 groups did not differ among parameters that have been associated in the literature with SBS outcomes (Table 4). Despite the apparent equivalent prognostic status of both groups, survival in the present cohort was 89%, significantly higher than the 70% survival in the historical group ($P < .05$). In the historical group, 90% of patients not able to wean from PN died, compared with only 33% in the current CAIR cohort ($P < .01$). Conversely, none of the 36 patients who achieved enteral autonomy died in the current group.

Three patients in the historical group received a Bianchi bowel lengthening and tapering procedure, whereas 5 patients in the current cohort received 1 Bianchi procedure and 5 serial transverse enteroplasty procedures, for a total of 6 bowel lengthening procedures ($P = \text{NS}$). Finally, only 1 patient received an intestinal transplant in the historical group compared with 5 patients in the current cohort ($P = \text{NS}$).

3. Discussion

Available data from published single-center reports reveal survival rates for pediatric SBS between 53% and 91% [4,5,7–12]. Our overall survival rate of 89% ranks among the better outcomes, and this is the only report that has been able to demonstrate significantly higher survival in comparison to a historical control group despite equivalent prognostic markers. As expected, peak direct bilirubin was significantly associated with mortality and enteral autonomy in our cohort. Interestingly, a diagnosis of NEC was predictive of enteral

autonomy in this cohort, perhaps reflective of problems with gastrointestinal motility in the non-NEC group.

The reason for improved survival in the more recent cohort is not clear. The significantly reduced mortality in those patients still requiring PN (33% vs 90% historically, $P < .001$) is important. Although enteral autonomy continues to offer the best chance of survival, our ability to keep patients alive despite ongoing PN dependence has improved in association with the multidisciplinary approach.

Many changes in management through such a program could result in improved outcomes. With frequent discussions between surgeons and gastroenterologists, surgical interventions such as bowel lengthening with the serial transverse enteroplasty procedure and intestinal transplantation have become more frequently performed. Advances in nutrition, with the use of more elemental formulas, may play a role in the improved outcomes [3]. In addition, there are clear intangible advantages to having all health care providers together while discussing a patient's care. These include improved monitoring of medications, coherent and integrated plans that are better conveyed to the patients' caretakers, and open discussions not possible via telephone or electronic mail. Finally, the multidisciplinary platform provides a research tool for analysis of a defined cohort of patients for the purposes of improving patient care [13–15].

The present paper report the outcomes of a multi-disciplinary SBS program and compare these outcomes to those of a historical cohort. One weakness of this comparison is that both cohorts were studied retrospectively and over different periods, necessarily creating the possibility that the groups are not directly comparable. We attempted to correct for this possibility by demonstrating equivalence between the cohorts based on traditional prognostic markers. Differences in management and outcomes over time cannot be overcome, however, and such differences may confound the comparison.

Nonetheless, survival has improved significantly in the current cohort. The development and institution of a multidisciplinary program for the care of patients with SBS is associated with improved outcomes, including improved survival, at our center. We recommend that patients with intestinal failure be managed through similar multidisciplinary programs.

Acknowledgments

We thank the members of the CAIR team for their assistance. This research was funded by the Children's Hospital Surgical Foundation and the Rappaport Surgical Fellowship (BPM).

References

1. Buchman AL. Etiology and initial management of short bowel syndrome. *Gastroenterology*. 2006; 130:S5–S15. [PubMed: 16473072]
2. Goulet O, Ruemmele F. Causes and management of intestinal failure in children. *Gastroenterology*. 2006; 130:S16–S28. [PubMed: 16473066]
3. Andorsky DJ, Lund DP, Lillehei CW, et al. Nutritional and other postoperative management of neonates with short bowel syndrome correlates with clinical outcomes. *J Pediatr*. 2001; 139:27–33. [PubMed: 11445790]
4. Sudan D, DiBaise J, Torres C, et al. A multidisciplinary approach to the treatment of intestinal failure. *J Gastrointest Surg*. 2005; 9:165–76. [PubMed: 15694812]
5. Diamond IR, de Silva N, Pencharz PB, et al. Neonatal short bowel syndrome outcomes after establishment of the first Canadian multi-disciplinary intestinal rehabilitation program: preliminary experience. *J Pediatr Surg*. 2007; 42:806–11. [PubMed: 17502188]

6. Utter, S.; Duggan, C. Short bowel syndrome. In: Hendricks, KM.; Duggan, C., editors. *Manual of Pediatric Nutrition*. 4. Hamilton, Ontario: BC Decker; 2005. p. 718-35.
7. Bueno J, Ohwada S, Kocoshis S, et al. Factors impacting the survival of children with intestinal failure referred for intestinal transplantation. *J Pediatr Surg*. 1999; 34:27–32. [PubMed: 10022138]
8. Casaccia G, Trucchi A, Spirydakos I, et al. Congenital intestinal anomalies, neonatal short bowel syndrome, and prenatal/neonatal counseling. *J Pediatr Surg*. 2006; 41:804–7. [PubMed: 16567197]
9. Goulet O, Baglin-Gobet S, Talbotec C, et al. Outcome and long-term growth after extensive small bowel resection in the neonatal period: a survey of 87 children. *Eur J Pediatr Surg*. 2005; 15:95–101. [PubMed: 15877257]
10. Quiros-Tejeira RE, Ament ME, Reyen L, et al. Long-term parenteral nutritional support and intestinal adaptation in children with short bowel syndrome: a 25-year experience. *J Pediatr*. 2004; 145:157–63. [PubMed: 15289760]
11. Sondheimer JM, Cadnapaphornchai M, Sontag M, et al. Predicting the duration of dependence on parenteral nutrition after neonatal intestinal resection. *J Pediatr*. 1998; 132:80–4. [PubMed: 9470005]
12. Spencer AU, Neaga A, West B, et al. Pediatric short bowel syndrome: redefining predictors of success. *Ann Surg*. 2005; 242:403–9. [PubMed: 16135926]
13. Duggan C, Piper H, Javid PJ, et al. Growth and nutritional status in infants with short-bowel syndrome after the serial transverse enteroplasty procedure. *Clin Gastroenterol Hepatol*. 2006; 4:1237–41. [PubMed: 16904948]
14. Gura KM, Duggan CP, Collier SB, et al. Reversal of parenteral nutrition-associated liver disease in two infants with short bowel syndrome using parenteral fish oil: implications for future management. *Pediatrics*. 2006; 118:e197–e201. [PubMed: 16818533]
15. Javid PJ, Collier S, Richardson D, et al. The role of enteral nutrition in the reversal of parenteral nutrition-associated liver dysfunction in infants. *J Pediatr Surg*. 2005; 40:1015–8. [PubMed: 15991188]

Table 1

Characteristics of 54 patients with severe SBS managed through CAIR

Characteristic	Median (IQR) or n (%)
Age at admission, d	64 (1–350)
Male sex	30 (56%)
Diagnosis of NEC	16 (30%)
Gestational age (n = 48), wk	34 (28–37)
Admission weight (n = 53), kg	3.45 (2.2–8.2)
Referral from outside institution	23 (43%)
Residual bowel length (n = 32), cm	60 (36–77)
Ileocecal valve preserved (n = 47)	24 (51%)
Enteral tolerance at admission (n = 52), % total calories	0 (0–63)
Enteral tolerance at follow-up (n = 52), % total calories	100 (69–100)
Enteral autonomy at admission	8 (15%)
Enteral autonomy at follow-up	36 (67%)
Duration of PN, d	229 (129–408)

Table 2

Significant factors associated with mortality among 54 patients with severe SBS managed through CAIR

Variable	Mortality (n = 6)	Survival (n = 48)	P
Enteral tolerance at follow-up (n = 52)	42 (13–77)	100 (87–100)	<.05 ^a
Peak direct bilirubin (mg/dL)	17.4 (13.8–24.5)	5.1 (0.4–11.4)	<.01 ^a
Enteral autonomy at follow-up, n (%)	0 (0)	36 (75)	<.001 ^b
Peak direct bilirubin >2.5 mg/dL, n (%)	6 (100)	29 (60)	.08 ^b

Values are expressed as median (IQR) unless otherwise indicated.

^a Mann-Whitney *U* test.

^b Fisher exact test.

Table 3

Significant factors associated with enteral autonomy among 54 patients with severe SBS managed through CAIR

Variable	Enteral autonomy (n = 36)	PN dependence (n = 18)	P
Admission bowel length (n = 32), cm	64 (51–83)	47 (24–72)	.09 ^a
Duration of PN, d	189 (109–253)	374 (214–638)	<.005 ^a
Diagnosis of NEC, n (%)	14 (39)	2 (11)	.06 ^b

Values are expressed as median (IQR) unless otherwise indicated.

^aMann-Whitney *U* test.

^bFisher exact test.

Table 4

Comparison of the CAIR cohort to a historical cohort reported previously [3]

Variable	Historical Group (n = 30)	CAIR cohort (n = 54)	P
Diagnosis of NEC, n (%)	13 (43)	16 (30)	NS
Residual bowel length (cm)	83 ± 67	70 ± 36	NS
Peak direct bilirubin (mg/dL)	9.0 ± 7.4	8.1 ± 7.9	NS
Enteral autonomy at follow-up, n (%)	20 (67)	36 (67)	NS
Duration of PN (d)	606 ± 719	475 ± 1026	NS
Ileocecal valve preserved, n (%)	17 (54)	23 (49)	NS
Mortality, n (%)	9 (30)	6 (11)	<.05

Values are expressed as n (%) or mean (SD).