Role of Serial Transverse Enteroplasty in the Management of Adult-Type Short Bowel Syndrome: Experience from a Single Tertiary Referral Hospital in Turkey

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ABSTRACT

Background: *There is little knowledge with regard to the management of intestinal failure in countries where home care services and dedicated intestinal rehabilitation centers are limited. This study presents a single-center experience of treating adult-type short bowel syndrome (SBS) with serial transverse enteroplasty (STEP).*

Methods: *Medical records were retrospectively reviewed from November 2009 to April 2018 on patients with adult-type SBS. All patients underwent STEP, and a representative quota sample of control patients treated with conventional measures were included. Clinico-demographic characteristics including baseline and post-treatment information about the orientation of bowel alignment and nutritional status were evaluated.*

Results: *The mean patient age was 51.1 ± 16.2 in the STEP group and 57.6 ± 12.7 in the control group (P = .304). The median small bowel length was 60 cm (interquartile range (IQR): 40-90) in the STEP group (before the lengthening) and 90 cm (IQR: 70-100) in the control (at the initiation of intestinal rehabilitation) (P = .035). Durations of median follow-up were 18 months (IQR: 14-58) and 10 months (IQR: 3-14), respectively (P = .019). In the STEP group, the mean increase in bowel length after STEP was 37.3 ± 11.6 cm, and at their follow-up 7 patients (64%) had successfully progressed to enteral autonomy. In the control group, only 3 patients (27%) were successful. Mean time to wean parenteral nutrition was 45 ± 54 days, and the mean increase in enteral calorie intake was 1.79 ± 1.60-fold after lengthening in the STEP group.*

Conclusions: *STEP is an easy-to-perform procedure in the surgical rehabilitation of adult-type SBS. When performed simultaneously with reconnection surgery, it may offer a cost-effective and comprehensive solution to the treatment strategy in middle income settings.*

Keywords: *Short bowel syndrome, parenteral nutrition, enteral nutrition*

INTRODUCTION

Long-term care of intestinal failure in middle-income countries is challenging due to the limited number of dedicated intestinal rehabilitation centers (IRC).[1] There are multiple IRCs across North America and Europe.[2] An eastern university pediatric IRC is the only dedicated IRC in Turkey. Besides, home care service is a nascent concept in the country, and current home parenteral nutrition (HPN) applications are limited.[3] Regulations by the Ministry of Health for care services providing health services at home came into force on February 27, 2015, after being published in the official journal of the country, *T.C. Resmi Gazete*.[4] Before 2015, HPN application was mostly an informal health service that patients could afford within their personal budgets.

Although there are no pertinent official data in this issue, many of these patients usually follow a self-referral model and present to tertiary hospitals after being exhausted because of unsolved problems at local clinics. Even thereafter, over the course of several hospitalizations, patients lose their motivation due to the socioeconomic difficulties of adhering to the exacting rehabilitation program which typically ends up decimating patients; few of them achieve the desired time of rehabilitation before transplantation, which in itself is a limitation. While the annual number of performed intestinal transplantations fluctuates between 109 and 198 in the United States, the total number of cases in the last 11 years was 6 in Turkey.[5,6] Thus, this article investigates the role of serial transverse enteroplasty (STEP) in the management of adult-type short bowel syndrome (SBS) in middle-income settings.

A consensus definition of SBS proposed by a panel of experts emphasizes the inability to maintain protein-energy, fluid, electrolyte, or micronutrient balances when

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on a conventionally accepted, normal diet.[7] Parenteral nutrition (PN) with close monitoring of liver functions, careful advancement of enteral feeding, and judicious use of medications such as antibiotics for bacterial overgrowth, loperamide, and ursodeoxycholic acid are the cornerstones of the medical management of patients with SBS.[8] If conservative rehabilitation fails then additional surgical measures can be taken to prevent complications such as recurrent line infections, bacterial overgrowth, renal failure, PN cholestasis, or end stage liver disease. Surgical management includes a variety of procedures such as adhesiolysis, closure of an ileostomy to restore intestinal continuity, delaying transit with anti-peristaltic anastomosis of bowel segments, colon interposition, bowel lengthening, tapering of asymmetrical bowel dilatations, and intestinal transplantation (ITx).[9,10]

Serial transverse enteroplasty is an easy-to-perform, anastomose-free, customizable bowel tapering, and lengthening procedure in which the mesentery is never jeopardized and the bowel is never opened.[11] Dilated small bowel segments are tapered with partial transections perpendicular to the long axis of the bowel, using linear incisive staplers in a customized zigzag pattern, switching between parallel tracks at mesenteric and antimesenteric sides on each step (Figure 1). Its role in providing length is 68% in children with SBS.[12] According to the international STEP data registry of the patients who required PN at the time of STEP, 47% achieved full enteral autonomy after the first STEP.[13] Indications of STEP include the presence of dilated remnant small bowel, foreshortened mesentery (duodenum), prior surgeries without preservation of both leaves of the mesentery and/or dilated segments shorter than 20 cm, and circumstances where redilatation occurs.[10]

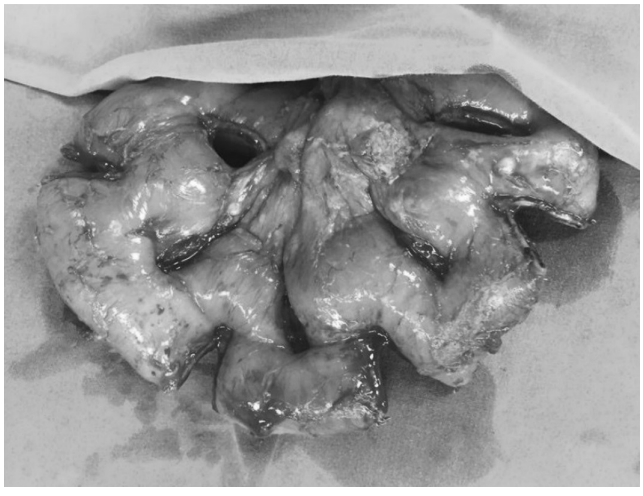

Figure 1. Serial transverse enteroplasty.

Adult-type SBS necessitates multidisciplinary management of more complex clinical problems such as underlying thromboembolic disorders or other patient-specific factors due to Crohn disease, volvulus, malignancy, trauma, etc.[14] Since surgical resection of small bowel often presents with a foreshortened mesentery, STEP is most likely a better bowel lengthening procedure for adults.

METHODS

Medical records were retrospectively reviewed from November 2009 to April 2018 in patients with adult-type SBS. All patients underwent STEP and a representative quota sample of control patients treated with conventional measures were included. Institutional research ethical board approval was obtained for the study (Ethics committee approval number: 27.06.2018/431), and patients' informed consent was obtained. Clinical data included age, gender, primary diagnosis, co-existing medical conditions, and presence of the ileocecal valve. Baseline and post-operative (4 weeks) clinical and laboratory data were recorded to calculate worst organ dysfunction scores.

Extracted data included pre- and post-operative small bowel length (for the STEP group), small bowel length at the initiation of intestinal rehabilitation (for the control group), status of remnant colon, estimated enteral-to-parenteral distribution of daily calorie intake (for the STEP patients only), presence of an additional stoma closure surgery, and the number of staple firings (for the STEP group). All bowel length measurements were made using a soaked 1/0 silk suture thread aligned along the long axis of the bowel lumen.

Serial transverse enteroplasty patients were divided into 2 groups according to the status of parenteral dependency. Very-short small bowel length refers to small bowel remnant of 60 cm and shorter. The primary endpoint of the analysis was to identify prognostic factors for enteral autonomy. Gained colon capacity is scaled in line with the number of anatomical colon segments: ascending, transverse, descending, and rectosigmoid.

Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) for Windows 20.0 program (IBM Corp.; Armonk, NY, USA). Data normality was verified using the Shapiro–Wilk test. Normally distributed data

were presented as mean and standard deviation, and non-normally distributed continuous data were presented as median and interquartile range (IQR). Categorical variables were compared using the Fisher exact test and presented as frequencies and percentage. We used parametric paired samples *t*-test or non-parametric Wilcoxon signed rank sum test for paired data according to their distribution. For non-parametric unpaired data, we used the Mann–Whitney test. Kaplan–Meier estimates were used to construct survival curves and calculate median overall survival. The log-rank test was used to compare survival times across groups. In all analyses, a *P*-value of 5% or lower was considered to be statistically significant.

RESULTS

There were 11 patients who underwent STEP and 11 control patients. The mean patient age was 51.1 ± 16.2 in the STEP group and 57.6 ± 12.7 in the control ($P = .304$). The median small bowel length was 60 cm (IQR: 40-90) in the STEP group (before the lengthening) and 90 cm (IQR: 70-100) in the control (at the initiation of intestinal rehabilitation) ($P = .035$). Durations of median follow-up were 18 months (IQR: 14-58) and 10 months (IQR: 3-14), respectively ($P = .019$). The mean increase in bowel length was 37.3 ± 11.6 cm after STEP.

Mesenteric vascular disease ($n = 9$) and internal hernia ($n = 2$) were the causes of SBS in the STEP group. Four patients had ileocecal valve remaining. Nine patients had pre-STEP end jejunostomy. Before STEP, all of the patients had admissions for fluid and electrolyte disturbances secondary to bowel resection and two patients had additional recurrent line infections. Bacterial overgrowth was excluded clinically and biochemically in all patients; the records of the patients were examined for clinical findings of metabolic acidosis and for chromatographic lactate levels to rule out D-lactic acidosis. Mean duration between bowel resection and STEP was 6.3 ± 2.6 months. Average number of staplers used for the procedure was 14.7 ± 2.4. Although it was not measured consistently, presence of a dilated segment of small bowel (≥4 cm in diameter in radiologic imaging studies) was identified in all patients and bowel was tapered to reach a steady diameter of 1.5-2 cm. All of the 11 patients underwent adhesiolysis to relieve fixed or angulated small intestinal loops and facilitate STEP and the subsequent motility and adaptation. Jejunostomy was closed in seven of nine patients with stoma. One patient underwent a Roux en Y to Bilroth II transition to recruit additional absorptive intestinal segments. Seven patients were assigned to very-short small bowel group. Summary of patient characteristics of STEP group are shown in Table 1.

Median length of hospital stay after STEP was 17 days (IQR: 13-25). No patients underwent a repeated procedure. At follow-up, seven patients (64%) successfully progressed to enteral autonomy. Mean time to wean PN was 45 ± 54 days. Average shift in the distribution of total calorie intake toward enteral nutrition was 48 ± 28%, and the mean increase in enteral calorie intake was 1.8 ± 1.6-fold after STEP. Paired analysis comparing the pre- and post-operative frequency distribution of the enteral portion in total calorie intake revealed a significant rise after STEP ($Z = -2.805$, $P = .005$). A total of 7 patients died; however, 4 of these had been weaned off parenteral support prior to death. These 4 patients died due to other comorbidities; 2 had myocardial infarction, 1 had congestive heart failure, and 1 had stroke. Weaning attempts were unsuccessful in the remaining 3 patients. Nevertheless, they had increased enteral tolerance without full autonomy. Yet, they died due to catheter sepsis (1 patient) and complications secondary to end-stage renal disease (2 patients); their survivals were 18, 60, and 16 months, respectively.

No patient underwent a supplementary lengthening procedure. Proximal bowel dilatation was not forced with any surgical procedure. Two patients required additional operative procedures (1 had hematoma and 1 had early adhesions) within the next 1 month, but none were transplanted. However, 1 patient had another episode of mesenteric vascular occlusion after 44 months of post-STEP enteral autonomy. She went back on PN and was taken into the wait-list for intestinal transplantation. Another patient sustained enteral autonomy until 12 months when dehydration-related renal failure was reported. Clinical outcomes of STEP on a case-by-case basis are presented in Table 2, and clinical outcomes of the control group are given in Table 3.

The median overall survival time was estimated to be 18 months (95% CI: 0-73) for the STEP group and 10 months (95% CI: 5-15) for the control group ($P = .029$). The Kaplan–Meier curve of overall survival of both groups are shown in Figure 2. Paired analysis comparing the pre- and postoperative organ dysfunction scores of STEP patients did not reveal any statistically significant difference. Preoperative MELD and MELD-Na scores were 7.5 ± 6.8 and 9.7 ± 9.3; postoperative scores were 6.0 ± 6.7 and 9.1 ± 7.8; $t = 0.785$, $P = .451$; and $t = 0.313$, $P = .761$, respectively.

Table 1. Summary of Patient Characteristics for the STEP Group

	Enteral Autonomy	Parenteral Dependency	*P*	Total
Age, mean ± SD	50 ± 16	54 ± 18	.730	51.1 ± 16.2
Gender, n (%)			.242	
Male	5 (71)	1 (25)		6 (54.5)
Female	2 (29)	3 (75)		5 (45.5)
Follow-up, median months (IQR)	15 (8-56)	38 (17-60)	.257	18 (14-58)
Overall survival, median months (95% CI)	15 (0-55)	18 (0-47)	.752	18 (0-73)
Underlying malignancy, n (%)	3 (33)	0 (0)	1.000	3 (27)
Preoperative small bowel remnant, median cm (IQR)	60 (56-110)	43 (40-68)	.125	60 (40-90)
Increase in small bowel length, mean cm ± SD	38 ± 10	35 ± 15	.685	37.3 ± 11.6
Very-short small bowel, n (%)	4 (57)	3 (75)	1.000	7 (64)
Duration between bowel resection and STEP, mean months ± SD	5 ± 2	9 ± 3	.025*	6 ± 3
Enteral part of total calories before STEP, median % (IQR)	49 (29-51)	23 (17-32)	.088	30 (23-50)
Added colon capacity, median number of segments	2 (1-4)	3 (1-4)	.769	2 (1-4)
Bowel continuity, n (%)			I/C	
GI tract already continuous	0 (0)	2 (50)		2 (18)
GI tract restored with stoma closure	6 (86)	1 (25)		7 (64)
Stoma remained	1 (14)	1 (25)		2 (18)
Added ileocecal valve, n (%)	2 (29)	2 (50)	.576	4 (36)

*$P < .05$.
I/C, incalculable; STEP, serial transverse enteroplasty; PN, parenteral nutrition; iv, intravenous; SD, standard deviation; IQR, interquartile range.

DISCUSSION

Adult-type SBS is a potentially devastating malabsorptive condition associated with total parenteral nutrition (TPN) dependence in prolonged (>6 weeks) or permanent periods of time after significant small bowel resection.[15] Amiot et al. reported the rates of HPN dependence in adults with non-malignant SBS as 74, 64, and 48% at 1, 2, and 5 years, respectively.[16] Massive intestinal resection has a much worse prognosis with a high incidence of early mortality (24 and 39% for 1 month and 1 year, respectively) and very low rates of enteral autonomy (30% among the survivors).[17] On the other hand, Lauro et al. reported that 69.2% of SBS patients with a diverting stoma achieved autonomy just by reconnection surgery and a minimum period of 1 year of intestinal rehabilitation (the mean residual small bowel length of patients was 75.7 cm).[18] In the present study, the rehabilitation program of only 1 of 4 patients, with a bowel of 75 cm or more (the last patient in Table 2), corresponded to the era of the 2015 national regulation for at-home care services. Since there was no colon left in that patient, reconnection surgery was not considered to be indicated. For the other 3 patients, inadequate insurance coverage and lack of foresight for a strong adherence to their intestinal rehabilitation clearly had a negative impact on the decision to try reconnection surgery. Therefore, simultaneous reconnection surgery played a significant role in our study. In any case, without high standard full-term rehabilitation, PN weaning success after STEP was 64% in the STEP group in which the average residual small bowel length is less than what is reported in an article by Laura et al. Besides, success of PN weaning was only 27% in our control group (Table 3).

A decision-tree was developed by Layec et al. to support decision making on the management of adult patients with SBS type II (some colon in continuity).[19] According to this algorithm, three different procedures are suggested for patients with a postduodenal small bowel length ≤60 cm. Those with a dilated remnant small bowel could have a Bianchi procedure or step procedure in association with jejuno-colonic anastomosis and those without

Table 2. Clinical Outcomes of STEP on a Case-by-Case Basis

Age	Gender	Pre-STEP Bowel (cm)	Post-STEP Bowel (cm)	Remnant Colon	Comorbidities	Intestinal Surgical History	Indication for STEP	Adaptive Time Before STEP	GI tract Continuity	Postoperative Weaning Status	Mortality by Cause
53	M	60	100	Ascending and distal	DM	Massive intestinal resection and closure of colonic end with end jejunostomy after AMI due to acute SMA occlusion.	Non-adherence to rehabilitation and multiple recurrent ARF episodes	4 months	Jejunostomy closed	Successfully weaned at day 90	SVO
70	F	40	88	Rectum	HT, MY, DM	Massive intestinal resection and closure of colonic end with end jejunostomy after AMI due to acute SMA occlusion.	Inability to wean PN/iv fluids after rehabilitation	12 months	Jejunostomy remained	Unsuccessful	Catheter-related sepsis
63	F	110	160	Intact colon and ileocecal valve	HT, AF, Breast Cancer, ICH, CVA, Hypothyroidism, Retinal Detachment, RBBB	Intestinal resection, closure of colonic end with end jejunostomy and percutaneous transluminal angioplasty with celiac arterial stenting after MVO.	Non-adherence to rehabilitation	3 months	Jejunostomy closed	Successfully weaned at day 10	MI
15	M	56	90	Intact colon and ileocecal valve	None	Massive intestinal resection with end jejunostomy and colonic mucus fistula after internal hernia	Recurrent line infections	8 months	Stomas closed	Successfully weaned at day 23	Patient alive
60	F	110	150	Rectum	HT, Colon Cancer	Several intestinal resections, closure of colonic end with end jejunostomy after MVO due to surgical complications including anastomotic leak, enterocutaneous fistula and MIO.	Non-adherence to rehabilitation and multiple recurrent ARF episodes	4 months	Jejunostomy closed	Successfully weaned at day 21	MI
46	M	60	80	Sigmoid and distal	DM, PAD, DVT, Hyperhomocysteinemia	Massive intestinal resection, closure of colonic end, end jejunostomy and supraceliac aortomesenteric bypass after AMI due to acute SMA occlusion.	Recurrent line infections	5months	Jejunostomy closed	Successfully weaned at day 18	Patient alive

51	M	45	60	Intact colon and ileocecal valve	Antithrombin Deficiency	Massive intestinal resection with jejunoileal anostomosis due to MVO. Previous proximal gastrectomy with Bilroth I reconstruction and subsequent anti-reflux Roux en Y surgery.	Non-adherence to rehabilitation	8 months	GI Tract already continuous	Unsuccessful	ESRD
29*	F	75	120	Descending and distal	DVT, Restless Legs Syndrome, JAK2 mutation-related thrombosis	Massive intestinal resection with jejunocolic anostomosis and arterial embolectomy after AMI due to acute SMA occlusion.	Non-adherence to rehabilitation	8 months	GI Tract already continuous	Unsuccessful	Patient alive
64**	F	40	73	Intact colon and ileocecal valve	DM,HT, Unipolar Depression, Restless Legs Syndrome, Hyperlipidemia,	Massive intestinal resection and closure of ileal end with end jejunostomy after MVO.	Non-adherence to rehabilitation	6 months	Jejunostomy closed	Unsuccessful	ESRD
59	M	40	75	Descending and distal	CAD with a history of Cardiac Arrest and CABG, Chronic Sacral Decubitus Ulcer	Several intestinal resections, end jejunostomy and colonic mucus fistula after MVO and subsequent surgical complications secondary to anastomotic leak.	Non-adherence to rehabilitation	7 months	Jejunostomy closed	Successfully weaned at day 150	CHF
52	M	90	140	None	Familial Adenomatous Polyposis Syndrome, Colon Cancer	Massive intestinal resection with end jejunostomy and closure of anal canal after MVO. Previous total proctocolectomy and ileal-anal pouch surgery.	Non-adherence to rehabilitation	4 months	Jejunostomy remained	Successfully weaned at day 5	Patient alive

*This patient had another episode of MVO after 44 months of post-STEP enteral autonomy; she is back on parenteral nutrition and is currently on the wait-list for intestinal transplantation. **This patient sustained enteral autonomy until 12 months when dehydration-related renal failure has been reported.

AF, Atrial Fibrillation; AMI, Acute Mesenteric Ischemia; ARF, Acute Renal Failure; CABG, Coronary Artery Bypass Grafting; CAD, Coronary Artery Disease; CHF, Congestive Heart Failure; CVA, Cerebrovascular Accident; DM, Diabetes Mellitus; DVT, Deep Vein Thrombosis; ESRD, End Stage Renal Disease; HT, Hypertension; ICH. Intracerebral hemorrhage; PAD. peripheral arterial disease; RBBB, right bundle branch block; SMA, Superior Mesenteric Artery; STEP, Serial Transverse Enteroplasty; MI, Myocardial Infarction; MIO, Mechanical Intestinal Obstruction; MVO, Mesenteric Vascular Occlusion.

Table 3. Clinical Outcomes of Control Group on a Case-by-Case Basis

Age	Gender	Absorptive Small Bowel (cm)	Remnant Colon	Status of GI tract Continuity	Comorbidities at the Intestinal Resection	Intestinal Surgical History	Postoperative Follow-up	Parenteral Support for Intestinal Rehabilitation (months)	Adherence to Intestinal Rehabilitation and Outpatient Follow-up Plan	Postoperative Weaning Status	Mortality by Cause
60	M	70	Transverse and distal	End Jejunostomy. Unsuccessful closure attempts	COPD	Massive intestinal resection and closure of colonic end with end jejunostomy after AMI due to acute SMA occlusion	3 months	3 months (interrupted)	Weak (Inadequate insurance coverage)	Unsuccessful	ARDS, following aspiration of gastric contents
58	F	93	All segments but sigmoid. Intact valve	Double barrel Jejunoileostomy. Unsuccessful closure attempts	DM	Several intestinal resections with surgical complications including anastomotic leak and ente rocutaneous fistula after incisional hernia operation	11 months	11 months	Strong	Unsuccessful	Catheter-related sepsis
45	F	90	Inact colon and ileocecal valve	Continuous GI Tract	HT, Unilateral renal atrophy	Intestinal resection due to inflammatory bowel disease.	39 months	<1 month	Strong	Successfully weaned at day 7	Patient alive
69	F	50	Inact colon and ileocecal valve	Double barrel Jejunoileostomy. Unsuccessful closure attempts	HT, DM	Massive intestinal resection after AMI. Stoma is in between segments of 50-cm jejunum and 80-cm ileum.	6 months	6 months	Strong	Unsuccessful	Primary: CVA, Secondary: ESRD
75	F	90	Inact colon and ileocecal valve	Double barrel Jejunoileostomy, successfully closed after 2 months	AF	Several intestinal resections with surgical complications (including anastomotic leak and hemorrhage) after AMI. Stoma was in between segments of 60-cm jejunum and 30-cm	10 months	3 months	Strong	Successfully weaned at day 21 after stoma closure	CVA
54	F	120	Rectum	End Jejunostomy. Stoma closure was not planned	Crohn's, CKD	Several intestinal resections with surgical complications including anastomotic leak and enterocutaneous fistula due to Crohn's Disease	10 months	10 months	Strong	Unsuccessful	ESRD

51	F	120	Transverse and distal	Double barrel Jejunocolostomy, successfully closed after 1 month	COPD, HT, Goiter	Massive intestinal resection after MVO.	6 months	6 months (interrupted)	Weak (Delayed diagnosis of SBS)	Unsuccessful	E SRD
48	M	100	Inact colon and ileocecal valve	Double barrel Jejunoileostomy, successfully closed after 2 months	HT	Massive intestinal resection due to adenocarcinoma of the small bowel	58 months	2.5 months	Strong	Successfully weaned at day 9 after stoma closure	Patient alive
41	M	100	Transverse and distal	Double barrel Jejunocolostomy. Unsuccessful closure attempts	None	Several intestinal resections with surgical complications including anastomotic leak and enterocutaneous fistula after mechanical intestinal obstruction	14 months	14 months	Strong	Unsuccessful	Primary: SAH, Secondary: Epileptic seizure
81	M	70	Transverse and distal	Double barrel Jejunocolostomy. Unsuccessful closure attempts	AF, hyperthyroidism, DVT	Massive intestinal resection and closure of colonic end with end jejunostomy after AMI due to acute SMA occlusion	2 months	2 months	Weak (Inadequate insurance coverage)	Unsuccessful	Catheter-related sepsis
52	M	~90*	Inact colon and ileocecal valve	Double barrel Jejunoileostomy. Successfully closed after 3 months	Diffuse large B cell lymphoma	Massive intestinal resection due to Petersen's space hernia after subtotal gastrectomy with Billroth II anastomosis	3 months	3 months	Weak (Delayed diagnosis of SBS)	Unsuccessful	ARF

*This patient had a remaining small bowel length of 150 cm. However, the level of Billroth II anastomosis was not provided in the operation note. In a rough estimate, real absorptive length should be around 90 cm when duodenum and the afferent loop of gastrojejunostomy are taken into account.
AF, Atrial Fibrillation; AMI, Acute Mesenteric Ischemia; ARF, Acute Renal Failure; CKD, Chronic Kidney Disease; CVA, Cerebrovascular Accident; DM, Diabetes Mellitus; DVT, Deep Vein Thrombosis; ESRD, End Stage Renal Disease; HT, Hypertension; SAH, Subarachnoid hemorrhage; SMA, Superior Mesenteric Artery; MVO, Mesenteric Vascular Occlusion.

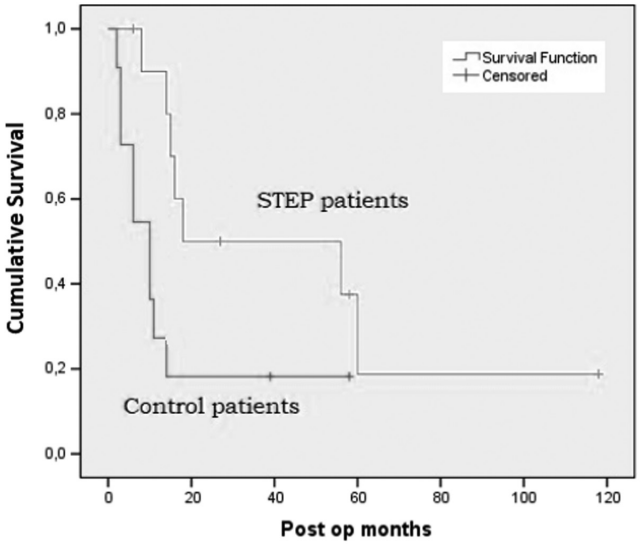

Figure 2. Kaplan–Meier curves of overall survival.

a dilated remnant small bowel could have a segmental reversal of the small bowel during the jejuno-colonic anastomosis. In the present study, the presence of a dilated segment of small bowel (≥4 cm) was identified in all patients with radiologic imaging studies before the STEP procedure.

Chances of success and how long it takes to wean off PN, in adults who underwent STEP after SBS, differs from patient to patient depending on the specifics of each case; there are studies reporting that abrupt weaning took place within several weeks as well as more gradual weaning lasted for almost a year.[20-28] In general, children have a longer PN weaning time when compared with adults. The median time to reach enteral autonomy was 21 months in the International STEP Data Registry where the median age of patients with follow up after first STEP was 6.6 months (IQR: 2.4-37.8).[13] One of the factors (other than reconnection surgery) explaining this difference is the declining trend of the total caloric requirements with age. During infancy, the requirements can be 120-140 kcal/kg/day whereas a healthy teenager or young adult may only require 35 kcal/kg/day or less.[13]

Trend toward faster weaning of TPN in our study with respect to other adult cases was suggestive of an over-treatment effect owing to simultaneous reconnection surgery in the majority of patients. Our intestinal rehabilitation program to maintain protein-energy, fluid, electrolyte, or micronutrient balances was in line with the adult solutions suggested by Tannuri et al.[29] Yet, the timing of the STEP surgery in our unit was a consequence of the cost-effectiveness strategy in our limited resource settings; nevertheless, achieving autonomy before the minimum 1-year period of intestinal rehabilitation is a promising result for us given the difficulties of HPN treatment in our country. Quite complex and intricate work had to be done so that these matters could be put down in a right sense in limited resource settings, where non-adherence to the rehabilitation program is the biggest obstacle against stoma closure before STEP. Thus, the closure is to be decided on a case-by-case basis. Nevertheless, different from children, adults may not tolerate excessively frequent bowel movements as good as children, given that a significant population of early childhood patients use diapers.

Our postoperative parenteral weaning strategy was to start enteral nutrition support with a target of 5-10 kcal/kg/day for the first 2 days and gradually increase to meet full needs by 4-7 days. In the meantime, while monitoring closely for volume and fluid balance, parenteral calorie intake was gradually tapered by 10-30% on a daily basis until the enteral portion was dominant with 60% of the total sum. Then, the patient was discharged if oral daily fluid intake was 500 cm^3 more than the stool output, and the daily urinary output was more than 1000 cm^3. Although fluid and electrolyte balance were stable during the post-operative sick leave period (approximately post-operative 1 month), all the patients lost significant weight (6.3 ± 1.5 kg). Yet, this weight loss was well tolerated and body weight was stable or improved after this period due to the adaptation of new bowel segments.

In previous publications, age-adjusted small bowel length and intact ileocecal valve are proven to be the major predictors of weaning from PN in pediatric SBS while cholestasis and age-adjusted small bowel length are the major predictors of mortality.[30] The most influential prognostic factor related to enteral autonomy in our study was stoma closure. Other factors were very short bowel status, preoperative enteral part of total calories, gained colon capacity, and preoperative small bowel length. None of the patients had cholestasis. Nevertheless, paired analysis comparing the pre- and post-operative enteral portion of total calorie intake revealed a significant treatment effect ($P = .005$, $Z = -2.803$). The mean increase in enteral calorie intake was 1.98 ± 1.64-fold after STEP. Similarly, Fernandes et al. in their meta-analysis of pediatric STEP

patients reported that mean percent of total nutrition provided enterally was 35.1 before STEP and 69.5 after STEP.[31]

A simulation study of intestinal failure treatment in adults reported that HPN costs were €13 276 for treatment introduction, followed by €77 652 annually and the costs of ITx were ~ €73 000 during the first year and then €13 000 annually.[32] On the other hand, the costs of average 14.7 ± 2.4 cartridges (60-2.5 mm) for STEP used in this study were €774 ± 126.

An intriguing analysis of non-transplant procedures to improve bowel function in SBS (where 34% of the cases had a remnant bowel less than 60 cm) have presented evidence that one-fourth of the patients with stomas were candidates for stoma closure and only 4 of 6 patients had improved enteral tolerance after the closure.[33] Besides, the analysis warned against bowel continuity in patients with a short remnant (<60 cm) due to severe diarrhea resulting in perianal complications and reduced oral intake; and highlighted one patient who needed a colostomy after the stoma closure. In our study, there were 2 patients with a subtotal colectomy (remnant rectum or shorter) and preoperative small bowel less than 100 cm. These patients were not candidates for stoma closure surgery but underwent adhesiolysis to facilitate intestinal motility. One of the patients, who failed to wean TPN, had dense strictures on small bowel segments fixed in Douglas' pouch. Relieving these dense strictures mobilized a significant amount of small bowel segments and enabled a more efficient use of STEP and possibly enhanced the future adaptation because the enteral calorie balance improved from 23% to 50%. The other patient who failed to wean (also in the very short bowel group) had an intact colon but small bowel was 60 cm even after STEP. This patient had a previous antireflux Roux en Y surgery after proximal gastrectomy and Bilroth I. During the STEP operation a recruitment of small bowel segments was undertaken. The Y arm was anastomosed to the previous gastroenterostomy stump, in other words, to the end point of the roux arm. Thus, a Bilroth II formation was established and the enteral calorie balance improved from 35% to 55%. A similar restoration for maximal continuity was reported by Fun et al., where they replaced Billroth II with Billroth I during STEP procedure.[23] Different bowel alignments for a gastrojejunostomy definitely influences the outcome of enteral autonomy. The last control patient in Table 3 stresses the impact of this information. We believe that the lack of focus on the alignment in the operation note contributed to the delayed diagnosis of SBS for this patient.

Last but not least, not assessing intestinal absorptive capacity with quantitative tests like serum citrulline levels was a limitation in this study. Besides, a follow up of 18 months is too short. Longer follow-up periods are needed to assess whether patients remain on track in their rehabilitation program and to observe for complications. Yet, the basic reason for our short follow-up was the rate of mortality. The basic structural difference in middle income settings is the lack of an intestinal program and an SBS registry and this leads in turn to radically higher rates for mortality and weak adherence to rehabilitation in SBS patients. We believe that implementing a standardized intestinal rehabilitation program will be easier if there is a registry available for them. Future studies are likely to cover longer periods of follow-up with lower mortality rates owing to the implementation of national regulations for at-home care services.

It is essential that we understand how adult-type SBS differs from the pediatric form to implement a triage model of care. Remnant colon in adults when reconstructed to the absorptive system triggers a faster compensation for enteral autonomy. STEP procedure simultaneously performed with reconnection surgery is a reasonable solution for SBS in middle income settings. Simultaneous procedure may offer additional benefit; however, it remains to be established how much of this autonomy effect is due to STEP procedure rather than a closed stoma. Hopefully, with awareness the impact of this devastating condition can be reduced.

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Informed Consent: Informed consent was obtained from all individual participants included in the study.

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REFERENCES

1. Gondolesi GE, Pattín F, Nikkoupur H. Management of intestinal failure in middle-income countries, for children and adults. Curr Opin Organ Transplant. 2018;23(2):212-218. [CrossRef]

2. Merritt RJ, Cohran V, Raphael BP, et al. Intestinal rehabilitation programs in the management of pediatric intestinal failure and short bowel syndrome. J Pediatr Gastroenterol Nutr. 2017;65(5):588-596. [CrossRef]

3. Ozcelik H, Gozum S, Ozer Z. Is home parenteral nutrition safe for cancer patients? Positive effects and potential catheter-related complications: a systematic review. Eur J Cancer Care. 2019;28(3):e13003. [CrossRef]

4. Resmi Gazete (27.02.2015, Sayı: 29280) sayılı "Sağlık bakanlığı ve bağlı kuruluşları tarafından evde sağlık hizmetlerinin sunulmasına dair yönetmelik". https://www.resmigazete.gov.tr/eskiler/2015/02/20150227-14.htm.

5. Kesseli S, Sudan D. Small bowel transplantation. Surg Clin North Am. 2019;99(1):103-116. [CrossRef]

6. Organ, Doku Nakli ve Diyaliz Hizmetleri Daire Başkanlığı Kamuya Açık Organ Nakil İstatistikleri Transplantasyon, Diyaliz ve İzlem Sistemleri. Nakil sayıları [Analysis in brief on the Internet]. Krizma Software; c2016. [date unknown]; [cited 2019 Feb 13]. https://organkds.saglik.gov.tr/KamuyaAcikRapor.aspx?q=ORGANNAKLI.

7. O'Keefe SJ, Buchman AL, Fishbein TM, Jeejeebhoy KN, Jeppesen PB, Shaffer J. Short bowel syndrome and intestinal failure: consensus definitions and overview. Clin Gastroenterol Hepatol. 2006;4(1):6-10. [CrossRef]

8. Goulet O, Ruemmele F. Causes and management of intestinal failure in children. Gastroenterology. 2006;130(2)(Suppl 1):S16-S28. [CrossRef]

9. Dore M, Junco PT, Andres AM, et al. Surgical rehabilitation techniques in children with poor prognosis short bowel syndrome. Eur J Pediatr Surg. 2016;26(1):112-116. [CrossRef]

10. Rege A. The surgical approach to short bowel syndrome - autologous reconstruction versus transplantation. Viszeralmedizin. 2014;30(3):179-189. [CrossRef]

11. Kim HB, Fauza D, Garza J, Oh JT, Nurko S, Jaksic T. Serial transverse enteroplasty (STEP): a novel bowel lengthening procedure. J Pediatr Surg. 2003;38(3):425-429. [CrossRef]

12. Khalil BA, Ba'ath ME, Aziz A, et al. Intestinal rehabilitation and bowel reconstructive surgery: improved outcomes in children with short bowel syndrome. J Pediatr Gastroenterol Nutr. 2012;54(4):505-509. [CrossRef]

13. Jones BA, Hull MA, Potanos KM, et al. Report of 111 consecutive patients enrolled in the International Serial Transverse Enteroplasty (STEP) Data Registry: a retrospective observational study. J Am Coll Surg. 2013;216(3):438-446. [CrossRef]

14. Grant D, Abu-Elmagd K, Mazariegos G, et al. Intestinal transplant registry report: global activity and trends. Am J Transplant. 2015;15(1):210-219. [CrossRef]

15. Sigalet DL. Short bowel syndrome in infants and children: an overview. Seminpediatr Surg. 2001;10(2):49-55. [CrossRef]

16. Amiot A, Messing B, Corcos O, Panis Y, Joly F. Determinants of home parenteral nutrition dependence and survival of 268 patients with non-malignant short bowel syndrome. Clinnutr. 2013;32(3):368-374. [CrossRef]

17. Thompson JS. Comparison of massive vs. repeated resection leading to short bowel syndrome. J Gastrointest Surg. 2000;4(1):101-104. [CrossRef]

18. Lauro A, Cirocchi R, Cautero N, et al. Reconnection surgery in adult post-operative short bowel syndrome <100 cm: is colonic continuity sufficient to achieve enteral autonomy without autologous gastrointestinal reconstruction? Report from a single center and systematic review of literature. G Chir. 2017;38(4):163-175. [CrossRef]

19. Layec S, Beyer L, Corcos O, et al. Increased intestinal absorption by segmental reversal of the small bowel in adult patients with short-bowel syndrome: a case-control study. Am J Clin Nutr. 2013;97(1):100-108. [CrossRef]

20. Yannam GR, Sudan DL, Grant W, Botha J, Langnas A, Thompson JS. Intestinal lengthening in adult patients with short bowel syndrome. J Gastrointest Surg. 2010;14(12):1931-1936. [CrossRef]

21. Sudan D, Thompson J, Botha J, et al. Comparison of intestinal lengthening procedures for patients with short bowel syndrome. Ann Surg. 2007;246(4):593-601; discussion 601-604. [CrossRef]

22. Modi BP, Langer M, Duggan C, Kim HB, Jaksic T. Serial transverse enteroplasty for management of refractory D-lactic acidosis in short-bowel syndrome. J Pediatr Gastroenterol Nutr. 2006;43(3):395-397. [CrossRef]

23. Fan S, Li Y, Zhang S, Wang J, Li J. Success of serial transverse enteroplasty in an adult with extreme short bowel syndrome: a case report. Int Surg. 2015;100(4):626-631. [CrossRef]

24. Andres AM, Thompson J, Grant W, et al. Repeat surgical bowel lengthening with the STEP procedure. Transplantation. 2008;85(9):1294-1299. [CrossRef]

25. Botey M, Alastrué A, Haetta H, Fernández-Llamazares J, Clavell A, Moreno P. Long-term results of serial transverse enteroplasty with neovalve creation for extreme short bowel syndrome: report of two cases. Case Rep Gastroenterol. 2017;11(1):229-240. [CrossRef]

26. Son SY, Cui LH, Shin HJ, Hur H, Han SU. Case report of an adult patient who underwent a serial transverse enteroplasty procedure for short bowel syndrome following an esophagectomy and total gastrectomy. J Clin Nutr. 2017;9(2):68-73.

27. Fujiki M, Pogatschnik C, Moccia L, et al. Serial transverse enteroplasty procedure in the New Era of gut rehabilitation. Transplantation. 2017;101(6)(Suppl 2):S43. [CrossRef]

28. Bueno J, Burgos R, Redecillas S, López M, Balsells J. Duodenal lengthening in an adult with ultra-short bowel syndrome. A case report. Rev EspEnferm Dig. 2018;110(1):59-62. [CrossRef]

29. Tannuri U, Barros F, Tannuri AC. Treatment of short bowel syndrome in children. Value of the intestinal rehabilitation program. Rev Assoc Med Bras. 2016;62(6):575-583. [CrossRef]

30. Spencer AU, Neaga A, West B, et al. Pediatric short bowel syndrome: redefining predictors of success. Ann Surg. 2005;242(3):403-409; discussion 409. [CrossRef]

31. Fernandes MA, Usatin D, Allen IE, Rhee S, Vu L. Improved enteral tolerance following step procedure: systematic literature review and meta-analysis. Pediatr Surg Int. 2016;32(10):921-926. [CrossRef]

32. Roskott AM, Groen H, Rings EH, et al. Cost-effectiveness of intestinal transplantation for adult patients with intestinal failure: a simulation study. Am J Clin Nutr. 2015;101(1):79-86. [CrossRef]

33. Thompson JS, Langnas AN. Surgical approaches to improving intestinal function in the short-bowel syndrome. Arch Surg. 1999;134(7):706-709; discussion 709-711. [CrossRef]