Hypothesis: Nontransplantation surgical approaches to improve intestinal function in patients with the short-bowel syndrome have a satisfactory outcome in selected patients.

Patients: Ninety adult (aged >18 years) patients with intestinal remnants shorter than 180 cm were evaluated between 1980 and 1998.

Main Outcome Measures: Clinical improvement (reduction in parenteral nutrition, resolution of anatomical problems, decreased symptoms, or improved oral intake) and postoperative morbidity and mortality rates.

Results: There were 17 deaths within 30 days after resection. Thirty-seven (51%) of the surviving 73 patients underwent 43 procedures to improve intestinal function. Fourteen procedures (33%) were intended to expand intestinal surface area by restoring intestinal continuity (n = 10), recruiting additional length (n = 3), or longitudinal lengthening (n = 1). Twenty-six procedures (60%) aimed to alter intestinal function, either by relieving obstruction (n = 10), repairing fistulas (n = 8), slowing transit (n = 4), eliminating diseased bowel (n = 3), or improving motility (n = 1). Three patients had stomas created to improve oral intake and relieve perianal symptoms. Postoperatively, 2 anastomoses leaked, 2 fistulas recurred, and there was 1 death (mortality, 2%). Thirty-seven procedures (86%) resulted in clinical improvement. Eleven (46%) of the 24 patients receiving parenteral nutrition were able to discontinue it and 5 patients were able to reduce the amount of parenteral nutrition received. Twelve procedures that increased surface area (86%) and 22 procedures that addressed functional problems (85%) resulted in clinical improvement. Success was lowest (50%) in patients having procedures to prolong transit time.

Conclusions: Various nontransplantation surgical procedures have a role in improving intestinal function in short-bowel syndrome. These procedures usually result in clinical improvement in properly selected patients. Success is lowest for procedures designed to prolong intestinal transit time; thus, these procedures should be used only in carefully selected patients.

Arch Surg. 1999;134:706-711

EXTENSIVE intestinal resection can result in the short-bowel syndrome (SBS). There have been many recent advances in the medical management of this condition, including provision of parenteral nutrition (PN), selection of the optimal diet for a given patient, pharmacologic treatment of fluid and electrolyte secretion, and the use of specific nutrients and growth factors to stimulate intestinal absorption and adaptation.1,2 However, while the appropriate diet, nutritional support, and various pharmacologic manipulations can maximize function of the intestinal remnant, there is often a role for surgical intervention in those patients who have continued malabsorption, a need for specialized nutritional support, or intestinal complications.1,2

The goals of surgical treatment include expanding intestinal surface area or improving function of the intestinal remnant. The surgical approach depends on the remnant length and caliber, intestinal function, presence of intestinal complications, and the status of nutritional support. While intestinal transplantation might eventually become the optimal surgical treatment for patients with SBS, current results restrict its use to carefully selected patients who are permanently dependent on PN and develop life-threatening complications.2-4 The aim of

See Invited Critique at end of article

This article is also available on our Web site: www.ama-assn.org/surgery.
PATIENTS AND METHODS

This was a retrospective review of 90 consecutive adult (aged > 18 years) patients undergoing treatment for SBS between 1980 and 1998 at the University of Nebraska Medical Center (University Hospital and Omaha Veterans Affairs Hospital). Short-bowel syndrome was defined as an intestinal remnant shorter than 180 cm with associated malabsorption (diarrhea, steatorrhea, or metabolic abnormalities). Intestinal length was determined from operative notes, intraoperative measurements, and radiographic determinations as available. There were 42 men and 48 women, with an age range of 18 to 84 years. Mesenteric vascular disease and cancer and its treatment with radiation were the most common causes of resection (Table 1). Patient characteristics are presented in Table 2. Twenty patients (22%) were older than 70 years. Three fourths of patients were receiving PN. Thirty-one patients (34%) had an intestinal remnant shorter than 60 cm. Only 23 patients (26%) had an intact ileocecal junction and 53 (61%) had a stoma. Seventeen patients died within 30 days of the resection leading to the SBS.

Medical management included PN as necessary, optimizing enteral intake, and treatment of gastric hypersecretion, diarrhea, steatorrhea, and bacterial overgrowth as appropriate with histamine-receptor antagonists, proton-pump inhibitors, antidiarrheal agents, cholestyramine, and antibiotics. Patients were considered for surgical therapy if they required PN or had continued significant malabsorptive symptoms. Thirty-one (51%) of the 63 surviving patients underwent operative procedures to improve intestinal function. Follow-up of patients undergoing operative procedures ranged from 7 to 192 months, with 20 patients (54%) followed up for more than 3 years.

Operations included all nontransplantation procedures performed to improve intestinal function, expand intestinal surface area, and treat intestinal complications. Our overall surgical strategy in these patients has been described previously. Strictureplasty was performed by means of a Heineke-Mikulicz-type enteroplasty at the stenotic region of the intestine. Serosal patch was performed by suturing adjacent serosal surfaces over intestinal defects. Artificial valves were created by distal intussusception of a segment of small intestine. Ten-centimeter reversed segments were employed. Intestinal lengthening involved longitudinal transection of the intestine between the mesenteric and antimesenteric edges and anastomosis of these parallel intestinal segments. Clinical improvement was defined as reducing (>25%) or discontinuing PN requirements while maintaining body weight, resolving a specific anatomical problem (eg, obstruction or fistula, as demonstrated clinically and radiographically), alleviating symptoms of malabsorption (eg, diarrhea or metabolic abnormalities such as hypocalcemia), or significantly improving (>25%) oral intake. Statistical comparisons were made using χ2 analysis, with P < .05 signifying statistical significance.

Table 1. Conditions Necessitating Resection

<table>
<thead>
<tr>
<th>No. of Patients by Outcome Group</th>
<th>Died Within 30 d</th>
<th>Operation</th>
<th>No Operation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesenteric vascular disease</td>
<td>13</td>
<td>5</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>Cancer/irradiation</td>
<td>3</td>
<td>12</td>
<td>13</td>
<td>28</td>
</tr>
<tr>
<td>Crohn disease</td>
<td>0</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Other benign disease</td>
<td>1</td>
<td>14</td>
<td>9</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>37</td>
<td>36</td>
<td>90</td>
</tr>
</tbody>
</table>

The present study was to evaluate the role and outcome of various nontransplantation surgical approaches to improving intestinal function in adults with SBS.

RESULTS

Thirty-seven (51%) of the 73 patients surviving more than 30 days underwent operative procedures. Patients with remnants shorter than 60 cm were less likely to undergo operation (P < .05). Thirty-seven (51%) of the 73 patients undergoing operation were more likely to have a stoma (P < .05).

The 37 patients underwent 43 operative procedures to improve intestinal absorption (Table 3). These procedures were performed within 12 months of resection in 20 patients (47%). Fourteen (33%) of these procedures were undertaken to expand intestinal surface area. Twenty-six procedures (60%) aimed to improve intestinal remnant function. Three patients (7%) had stomas created to improve oral intake and relieve perianal symptoms. Postoperatively, 2 anastomoses leaked, 2 fistulas recurred, and there was 1 death (mortality, 2%).

Procedures to expand intestinal surface area included restoring intestinal continuity, recruiting additional intestine, and the intestinal lengthening procedure. Ostomy closure was performed in 10 patients with stomas and remnants ranging from 30 to 180 cm. Eight of these patients had anastomosis to a remnant of left colon. In 3 patients additional intestine was recruited proximal to a stoma including right colon, left colon, and 60 cm of small intestine with right colon, respectively. One adult patient with segmental dilatation of a 120-cm remnant underwent intestinal lengthening of a 25-cm segment.

Procedures to improve intestinal function included either relieving obstruction, repairing fistulas, slowing intestinal transit, eliminating diseased bowel, or improving motility. Six of the 10 patients with obstruction had a stricturoplasty performed. Lysis of adhesions, limited resection, colostomy formation, and stoma revision were performed in the other 4 patients. Three of 8 fistulas were repaired by a serosal patch and the others were resected. Two reversed segments and 2 intestinal valves were created to slow intestinal transit time in patients with remnants of 100, 120, 150, and 180 cm, respectively. Three patients with intractable Crohn disease underwent limited resection. One patient underwent tapering of a dilated segment of intestine to improve motility.

Overall, 37 (86%) of the procedures resulted in clinical improvement (Table 4). Eleven (46%) of the 24 pa-
tients receiving PN were able to discontinue it and 5 reduced the amount of PN. Twenty-eight procedures (65%) resulted in improved oral intake. Thirty-six procedures (84%) resulted in improvement of malabsorptive and obstructive symptoms. Twelve procedures that increased surface area (86%) resulted in clinical improvement. Two patients undergoing stoma closure had unsatisfactory results; one had an anastomotic leak and the other elected to have a stoma reinstated because of severe diarrhea and perianal complications. Twenty-two procedures (85%) that addressed functional problems resulted in clinical improvement. Two fistulas recurred and 1 persisted after further operative attempts at repair. Success was lowest (50%) in patients having procedures to prolong transit time. One of the reversed segments was taken down for persistent nausea and pain. One patient with a valve had no improvement in diarrhea. Stoma formation resulted in improved oral intake and improvement in perianal complications in all 3 patients undergoing the procedure. Of those patients undergoing operation, 2 have subsequently undergone intestinal transplantation and 3 are awaiting transplantation.

**COMMENT**

In the present study, one half of adult patients undergoing intestinal resection that resulted in SBS underwent surgical procedures to improve intestinal absorption. These patients were more likely to have a longer intestinal remnant and an ostomy than those not undergoing operation. The most common operations were restoration of intestinal continuity and procedures to relieve obstruction and repair enterocutaneous fistulas. However, a smaller group of patients were candidates for more specialized procedures designed to improve the function of the intestinal remnant.

Ostomy closure should be considered in patients with significant small intestinal remnants and intact colon dis-
tal to a stoma. Restoring intestinal continuity will increase absorption and prolong transit time in many patients.7 We performed ostomy closure in only one fourth of patients with stoma. Most of our patients had only a remnant of left colon distally. However, jejunoileal anastomosis is functionally equivalent to adding 25 to 30 cm of small intestine length.8 Short-chain fatty acids reaching the colon are a potential source of additional calories.9 Four of our 6 patients receiving PN were able to eliminate or reduce PN after ostomy closure. However, patients with a short remnant (<60 cm) may have severe diarrhea with resultant perianal complications and reduced oral intake if continuity is maintained. In 3 of our patients colostomy formation was undertaken to relieve perianal symptoms and permit greater oral intake, including 1 patient who had previously had an ostomy closed. Reconnecting the colon introduces the risk of nephrolithiasis as well.10 Unfortunately, we found that only one fourth of our patients with stomas were candidates for ostomy closure.

Other procedures to expand intestinal surface area are applicable to a small group of patients. Occasionally a significant segment of small intestine will have been bypassed in previous procedures and can be restored to continuity. The intestinal lengthening procedure has been performed in many children, but adults seem to be less likely to develop dilated intestinal segments.3 Our 1 adult patient who underwent intestinal lengthening was able to reduce PN requirements after the procedure.

Patients with SBS frequently require surgery for intestinal complications.11 Obstruction and fistula formation were common problems in our study. Both conditions reduce oral intake, cause significant symptoms, and may increase the risk of sepsis. Chronic intestinal obstruction increases the mortality rate in patients receiving long-term PN.10 Operative resolution of these problems resulted in improved intestinal function for most patients in our study. In patients with short intestinal remnants, procedures such as stricturoplasty and serosal patching need to be considered to avoid further resection.5

While the goal in patients with SBS is generally to minimize further resection, in some circumstances resecting diseased bowel will improve intestinal function.12 Radiation-induced enteritis, intestinal pseudo-obstruction, and Crohn disease may contribute to impaired motility and absorption. In our study, limited resection of segments with Crohn disease that had been intractable to medical treatment had a beneficial effect in 3 patients.

Surgeons have been interested in operations to prolong intestinal transit for more than 100 years.13,14 However, there have been few well-performed studies of these procedures. We created reversed segments and intestinal valves in only 4 adult patients. Unfortunately, these procedures had the lowest success rate, with only 2 patients benefiting with either a decrease in PN requirements or resolution of diarrhea. In other reports these procedures have been performed at the same time that intestinal continuity was reestablished.13 We have preferred to determine the beneficial effect of restoring continuity prior to considering procedures to prolong transit time, since restoring continuity will often result in functional improvement.

Our experience suggests that various nontransplantation surgical procedures have a role in improving intestinal absorption in SBS. These procedures usually result in clinical improvement for most properly selected patients. Success is lowest for procedures designed to prolong intestinal transit time. Patients with very short remnants (<60 cm) are less likely to tolerate ostomy closure or to benefit from procedures that result in modest improvements in transit time and surface area. Thus, these procedures should be given careful consideration and performed only in highly selected patients. Patients who continue to receive PN after operative treatment may become candidates for intestinal transplantation.


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REFERENCES


DISCUSSION

Merrill T. Dayton, MD, Salt Lake City, Utah: Dr Thompson and his colleagues at the University of Nebraska have previously published a large series on SBS that included a combination of pediatric and adult patients. However, that initial publication in 1995 included predominantly pediatric patients. The present series is an update of the adult portion of their series, in which they have doubled the number of adults reported. This is a retrospective chart review of 90 patients who were left with...
less than 180 cm of small intestine after their initial devastat-
ing operation. There was a 19% mortality in this series, most
within the mesenteric ischemia group. This paper focuses on
the remaining 73 patients, 50% of whom underwent some kind
of operative procedure within 12 months of the initial one. In
the manuscript the procedures were divided into 2 general cat-
ergories, those that expand intestinal surface and those that at-
ter or improve intestinal function. Under the first category, those
that expand intestinal surface, the procedures really involved
recruiting bowel that had been bypassed and was merely be-
ing included back into the alimentary canal again. Under those
that improved intestinal function, most of the procedures were
those done to relieve obstruction, treat fistulae, or to resect se-
verely diseased bowel (in the case of Crohn disease).

Their results demonstrate that, in 86% of procedures, they
had a successful outcome as measured by the ability to wean
patients off of total parenteral nutrition (TPN) (which oc-
curred in 46% of the patients who had been on TPN), improv-
ing oral intake, or ameliorating their bowel symptoms. The au-
thors correctly point out that the least successful group was those
who had had procedures done to decrease transit time.

I think that Dr Thompson and his colleagues at the Univer-
sity of Nebraska are to be commended for taking on a very
difficult clinical problem, carefully studying it, and trying to
make some suggestions that can improve our management of
it. Indeed, Dr Thompson is considered one of the worldwide
experts on this topic.

This retrospective study, however, confirms what I think
Dr Thompson and his colleagues would agree with: we really
haven’t made much progress in managing the truly refractory,
TPN-dependent patient with hopelessly inadequate amounts
of small bowel for alimentation. Specifically, procedures to grow
neomucosa, lengthening existing small-bowel remnants, and di-
minus intestinal transit time have been very disappointing and
discouraging. Indeed, to this reviewer it appears that for this
group of patients transplantation represents our best hope at
present.

Most of the procedures performed in this series were done
to eliminate the anatomical problems that most GI surgeons
would intuitively perform, such as relieving obstruction, deal-
ing with fistulae, and so forth.

I do have a few questions for the authors. Dr Thompson,
you mentioned that you had selected 180 cm as the cut-off value
for SBS. That seems a little generous to me. Would you com-
ment on that, and what, in your mind, is really the critical length
at which one is likely to see SBS? In that same vein, the manu-
script is a little bit confusing because in Table 2 it talks about
3 different categories, those less than 60 cm, those 60 to 120
cm, and those greater than 120 cm. Would you talk about those
values vs 180 cm and how they were used to compile this pa-
tient population?

The manuscript also mentions that 27% of the patients with
SBS were not even on TPN. Do you continue to track these pa-
tients once they are nutritionally independent? Are they con-
sidered SBS if in fact they don’t even require TPN?

One of your findings was that those who had less than 60
cm of remaining small intestine were least likely to undergo
an operative procedure. Why is that? It seems like that group
might stand to benefit the very most from procedures that would
improve absorption.

And, finally, you made reference to this but as you know
Wilmore and colleagues suggested that a combination of growth
hormone, glutamine, and a high-carbohydrate diet would help
wean patients off of TPN quicker. Do you use this in your pa-
tient population and have you found it to be successful?

Frank G. Moody, MD, Houston, Tex: I would like to have
Dr Thompson focus on a couple of unique things that they have
done here. Specifically, to tell us about the bowel that is di-

lated, which they divided and then put in the series, or they im-
bricated it in order to improve its motility. Did these man-
uevers in fact change motility or absorption? Can you give
us a little bit more detail on that small group of patients?

Fabrizio Michelassi, MD, Chicago, Ill: It is not easy to
find appropriate outcome parameters to measure success or fail-
ure. In this vein, what parameters, Dr Thompson, can we choose
to quantitate functional results? It’s obvious that, if a patient
does not need TPN after surgery, this is a successful outcome.
But to quantitate amelioration of diarrhea, I think it is quite
difficult. How did you do that? Did you measure how much
antidiarrheal medications these patients were using postop-
eratively? The other issue to remember is that amelioration
comes over time. Did you measure amelioration at specific time
intervals from the surgery, and have you actually studied the
correlation between time and amelioration?

Would you comment on the role of glutamine enterally
administered, either preoperatively or postoperatively?

Dr Thompson: Let me start with Dr Dayton’s questions.
I have used 180 cm for these studies, but it does give a skewed
view compared with what we consider the real severe SBS pa-
tients. I have been impressed over the years that there is no magic
cut-off number, and I am sure you have all had similar expe-
riences where you will see patients who have 2 ft of small bowel
that seem to defy our knowledge and do very well and like-
wise patients with longer remnants who don’t do as well. So
this is an attempt to capture all of those patients. The patients
that we include here who have 180 cm are likely for example
to have had irradiated bowel and the underlying disease af-
facts bowel function. That’s why I have included this group of
patients, and I try to stratify the patients in the tables. The group
with less than 60 cm is clearly the most challenging group, the
group that is going to be the most likely to need intestinal trans-
plantation or long-term TPN. Admittedly, the classic defini-
tion is less than 120 cm.

The reason that we don’t operate on more of the patients
with less than 60 cm probably reflects a bias that we have. I
used to recommend that if someone has a remnant less than
90 cm that we shouldn’t put their intestine back in continuity.
They are going to have diarrhea; they are going to be miser-
able. What I have learned is there are a lot of advantages to hav-
ing the intestinal remnant in continuity and I think now would
say even people down to the 60-cm range probably almost au-
tomatically should be considered to be put back into continu-
ity to see if that will improve their absorptive capacity. As you
get much shorter than that, the success will be lower. Clearly
these patients with short remnants are at risk for the same com-
plications but perhaps get intestinal complications less fre-
frentially as well.

Part of the difficulty in both assessing the outcome, which
is really the essence of several of the questions, and in choos-
ing what procedures to do in these patients, is that it is a very
heterogeneous group. The goals of the surgical therapy are very
different for these different groups of patients. A lot of these
procedures have been performed, but it is not clear in some
cases if the patient was going to benefit from the very begin-
ning. A good example of this is the intestinal lengthening pro-
cedure that Dr Moody brought up. These have been per-
formed, predominately in the pediatric population, and while
you can lengthen the remnant 5 cm or 10 cm, you can predict
from the outset that that’s not going to improve their overall
clinical situation. We should not undertake these procedures
unless there is something to gain. There are some benefits to
reducing TPN. Certainly ameliorating symptoms is also an im-
portant goal but clearly in terms of long-term function and sur-
vival, getting patients off TPN has to be the most important goal.

We have investigated several of these procedures, as you
know, Dr Moody, in the laboratory. It has actually been fairly
difficult to tell in the short-term laboratory studies if any of these procedures are of great benefit. Early on they cause problems with ileus and poor intake. They also tend to alter the hormonal response to resection. There is a great need on the clinical side to study these patients over time and see how beneficial the procedures are.

I am very aware of Dr Wilmore’s work with glutamine and growth hormone. Dr Grosfeld and I just last week spent a week in Japan at a conference discussing a lot of these issues, and I feel I am learning more about this all of the time. My general concept about intestinal adaptation has been that at the time of a massive resection a signal is sent into motion, a genetic signal, almost immediately, which sets into progress a response that leads to a variety of other responses. This leads to increased proliferation, structural adaptation, an altered hormonal response, induction of growth factors, changes in growth factor receptors, and so forth.

My view had generally been that this was a time-limited response, that after a period of several months, this response was over and couldn’t be regained. This was a golden period that you had to stimulate intestinal adaptation. The more we learn about this suggests that this might be a narrow view, although I think for the most part it’s true. As we discussed at this conference, perhaps different growth factors and nutrients are going to behave differently. Epidermal growth factor, for example, a growth factor that leads to a variety of other responses. This leads to increased proliferation, structural adaptation, an altered hormonal response, induction of growth factors, changes in growth factor receptors, and so forth.

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Although much progress has been made in the past 3 decades in the management of SBS following massive intestinal resection, residual multivariate dysfunctions that persist in many of the surviving patients are challenging. These consist primarily of absorption and motility problems, but also include intestinal discontinuity, fistulae, obstruction, intractable gastrointestinal disease, and recalcitrant malnutrition. Thompson and Langnas have presented impressive evidence that significant alleviation of intestinal insufficiency and improvement in intestinal absorption and function can be achieved in most of a selected subset of their patients with SBS who underwent nontransplantation surgical procedures to expand intestinal surface area or to improve function of the intestinal remnant.

Our experience and philosophy are in agreement with theirs in that (1) elective operative procedures should be avoided in patients with less than 60 cm of small bowel; (2) currently available operative techniques to prolong intestinal transit time have an unfavorable risk–benefit ratio and should be avoided; (3) parenteral and enteral nutritional support and pharmacologic and endocrine therapy of SBS should be optimized before undertaking surgical interventions; (4) further resection of diseased bowel may be necessary in some patients to improve function of the residual normal intestinal segments; (5) an abdominal ostomy is better tolerated than chronic severe erosive diarrhea in most patients; (6) intestinal lengthening procedures have reasonable efficacy and safety in infants and children, but cannot be recommended at this time in adults; and (7) intestinal transplantation should still be restricted to carefully selected patients who are permanently dependent on parenteral nutrition and develop life-threatening complications.

The authors are to be commended for their persistent, conscientious, and innovative treatment of these severely intestinally impaired patients. Though they did not describe the preoperative therapy and courses of patients in detail, their cumulative results are very impressive, emphasize the great importance of the individualization of management of the complex accompanying problems of patients with SBS, and underline the need for continued multifaceted clinical and basic investigation in this vital area of endeavor if additional progress is to be made in outcomes and quality of life.

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