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Reconstructive operations for enteric and colonic fistulas: Low mortality and recurrence in a single-surgeon series with long follow-up

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ABSTRACT

Background: The aim of the study was to evaluate the outcomes of 100 consecutive patients undergoing reconstructive operation for enteric and colonic fistulas. These fistulas cause dramatic morbidity and profoundly diminish quality of life. Fistula takedown has been associated with high rates of recurrence.
Methods: Consecutive patients undergoing definitive fistula reconstruction by a single surgeon were reviewed retrospectively. Major adverse outcomes included bowel leak, fistula recurrence, death, total parenteral nutrition dependence, and incidence of new stomas.
Results: Among the 100 patients, median follow-up was 2.7 years. A total of 11 patients had postoperative leaks that evolved to 5 fistula recurrences. Of these patients 3 underwent successful secondary or tertiary takedown. The 30-day mortality rate was 1%, and the combined postoperative and fistula-related mortality rate at follow-up was 3%. New postoperative total parenteral nutrition dependence occurred in 2 patients (2%), and 9 (9%) had placement of a new stoma. Leaks were more frequent for patients who had a history of open abdomen than for patients who did not.
Conclusions: With minimal patient selection and a methodic approach to evaluation and management, we achieved a 96% fistula-free survival rate. Few patients acquired new total parenteral nutrition dependence or a new stoma. These results compare favorably with outcomes published elsewhere.

Introduction

Enteric and colonic fistulas lead to dramatic morbidity and markedly diminished quality of life. Some fistulas heal spontaneously but only after control of associated sepsis followed by intense nonoperative surgical management. From the literature, Mawdsley et al[1] gleaned 11 factors believed to influence fistula healing or associated death, or both. However, multivariate analyses have confirmed fewer associations with failure of spontaneous healing: high fistula output,[1–3] referral from another institution,[1,2] nonsurgical cause,[2] occurrence of complications,[2] comorbidity,[1] and jejunal site.[3] Historically, only one-fifth to one-third of fistulas healed spontaneously,[1–6] although a spontaneous healing rate of greater than 46% was reported recently.[7]

Healing for most patients requires a definitive reconstructive operation. Such an operation and the fistula patient's abdomen are not to be entered into casually. Dense adhesions create cicatricial masses of intestine adherent to abdominal walls. This obliterative peritonitis is always intense and renders adhesiolysis dangerous. It usually pervades the entire peritoneal cavity for fistulas arising from postoperative leaks or within multiply reoperated abdomens, or both. Hence, the peritoneal quality associated with a fistula is ripe for the operative creation of another fistula. Indeed, a recent series of ventral hernia repairs showed that a preoperative fistula was associated with an 8.5 times increased risk of a postoperative fistula.[8]

Postoperative mortality rate, which generally ranges from 3% to 20%, is primarily related to the dreaded complication of fistula recurrence. Such recurrence is usually reported after 10% to 30% of definitive reconstructions for fistula,[3,5–7,9–22] has been found to be the sole predictor of death on multivariate analysis,[14] and increases the odds of death by nearly 3[18] to nearly 7[14] times. Of note, 1 large and 2 small series have now reported no death.[7,21,22]

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The present study showed that favorable outcomes can be achieved with the application of well-established principles. The most important principle is to defer the definitive reconstructive operation until the acute phase of obliterative peritonitis has maximally resolved. During this prolonged period, the surgical team must help the patient achieve a reasonable quality of life and manage all complications that accrue. The outcomes are positively affected by consistency, attention to detail, and patient care continuity afforded when a single surgeon takes personal responsibility for the treatment of the patient and supervision of the surgical team.

The primary goal of this study was to quantify the major outcomes of leak, recurrence, death, fistula-free survival, total parenteral nutrition (TPN) dependence, and the incidence of new stomas in a single-surgeon series of reconstructive operations for enteric and colonic fistulas. The secondary goal was to compare outcomes after reconstruction for open abdominal (often called *enteroatmospheric*) versus closed abdominal fistulas in this controlled setting.

Methods

Patient selection and health care record review

Health records of patients undergoing definitive reconstruction of enteric or colonic fistulas by a single surgeon (M.P.B.) were retrospectively reviewed. Exclusion criteria were fistulas located only proximal to the ligament of Treitz, solely internal intestinal fistulas, intestinal fistulas to the genitourinary tract without a cutaneous component, and early postoperative leaks without severe peritoneal agglutination.

Fistulas arising from Roux-en-Y limbs were included, but gastrojejunostomy fistulas in absence of small-bowel or colon fistulas were excluded. Only definitive reconstructive operations were included.

The series began with the first reconstructive operation performed by the surgeon in his career. A total of 5 patients who did not authorize review of their medical records were excluded. The study end date was chosen to provide 100 consecutive eligible patients for review. Of the patients offered operation during the study period, 5 deferred. Only 1 patient with a nonhealing, easily pouched, distal fistula and severe comorbidities was not offered operation.

Data collected from health records were abstracted into a Research Electronic Data Capture database.[23] The Mayo Clinic Institutional Review Board (Rochester, MN) approved the study as minimal risk and waived study-specific consent. All patients consented to medical record review for research.

Definitions

Laparostomy wound

Laparostomy wounds result from abdominal incisions left open and never closed after damage-control operations[12,24] or from complete dehiscence of abdominal incisions with subsequent retraction of bilateral abdominal wall components. The laparostomy wound is the wound of the open abdomen.

Pseudostoma, nonpseudostoma, and drain-controlled fistulas

Pseudostomas are fistulas for which bowel mucosa was exposed, everted, and self-matured. The importance of pseudostomas, in distinction from nonpseudostoma and drain-controlled fistulas, is that they can never heal spontaneously and require a definitive reconstructive operation. All exposed enterotomies and colotomies will evolve into pseudostomas. Nonpseudostoma fistulas have bowel surfaces that communicate with cutaneous surfaces through spontaneous tracts or extubated drain tracts. These are called *enterocutaneous fistulas*. Another type communicates with laparostomy wounds or narrow open-incisional wounds without exposed mucosa. These are called *enteric-open abdominal* or *enteric-wound fistulas*, respectively, and evolve into nonhealing pseudostomas. They are important because they can be converted into drain-controlled fistulas if local tissue coverage is provided before a pseudostoma develops. Drain-controlled fistulas result from percutaneous or operative drainage of fluid collections communicating with the bowel lumen.

Open abdominal fistula

This fistula type arises within a laparostomy wound.[12] Because the lack of abdominal-wall integrity leads to the distinctive clinical challenges of this fistula and differentiates it from fistulas that communicate with small wounds, we prefer the term *open abdominal fistula* rather than the nondescriptive term *enteroatmospheric fistula* even though the latter seems to be ensconced in surgical lexicon.[25]

Closed abdominal fistula

The closed abdominal fistula arises in an abdomen without a laparostomy wound. It communicates with an intact cutaneous surface (via pseudostoma, spontaneous tract, or drain) or a narrow open abdominal wound (via pseudostoma or nonpseudostoma).

Patient care and conduct of operation

Patient care proceeded in stages consistent with approaches described elsewhere.[11,26–29] Most often, an initial hospital admission was used for resuscitation when necessary and to devise a sustainable outpatient plan for control of fistula effluent and skin care, maintenance of electrolytes and nutrition, and management of comorbidities.

Evaluation began with computed tomography (CT), and abscesses were drained percutaneously. Parenteral nutrition was initiated on presentation for intestinal failure. Therapy was transitioned to oral or enteral alimentation if functional small-bowel length and fistula effluent volume allowed. Physical control of fistula output was achieved with various techniques that evolved during the series.

A closed-suction gauze dressing, modified from Chariker,[30] became our standard means to control effluent that emanated into complex wounds. Dressing changes, as frequently as every 3 hours to prevent succus from bathing the wound, were performed to improve wound quality and encourage wound granulation, contraction, and, in some cases, epithelialization. Vacuum-assisted closures were not placed over wounds with fascial dehiscence or over open abdomens to avoid secondary erosion fistulas. Stoma appliances were used when the fistula emanated through intact skin or after skin grafts were applied. Adjuncts of nothing by mouth status and antimotility agents were used to improve hygienic control when large effluent volume thwarted these measures. Octreotide treatment was initiated for the most difficult cases, but it was continued only when the measured fistula output objectively decreased.

To define the multiple fistulas, obstruction sites, and prior operative alteration of anatomy, the entire gastrointestinal tract was scrupulously examined radiographically. These studies were CT, fistulograms, and fluoroscopic large-bowel and small-bowel contrast medium imaging.

Definitive fistula closure was not attempted during operations for acute abdominal sepsis. However, preliminary nondefinitive operations were used as necessary to manage infection, wounds, and fistula effluent. These operations were termed *hygienic*

operations to distinguish them from definitive *reconstructive operations*, during which fistulas were taken down or intestinal function was restored, or both. In the present series, 33 patients underwent a median of 2 hygienic operations per patient.

Cessation of tobacco use was required before reconstructive operation. Later in the series, nicotine and cotinine assays confirmed cessation. Diabetes mellitus was controlled with glucose monitoring and later with hemoglobin A_{1c} monitoring. Serious heart and lung disease was evaluated with stress echocardiography and pulmonary function testing. Specialty consultation was used liberally to ensure optimization of these and other chronic diseases that potentially caused perioperative morbidity.

Patients who required preoperative home TPN were monitored by a dedicated nutrition service. Enteral protein supplements or TPN with high amino acid levels ($\geq$1.5 g protein/kg per day) was provided with a goal of normal ($\geq$3.5 g/dL) serum albumin levels. Obese patients receiving nutrition orally were counseled to lose weight, but a weight criterion was not set for an operation. Many obese patients lost weight as a consequence of their illness. Patients who were morbidly obese and receiving TPN were provided hypocaloric formulas. All patients were admitted to the operative surgeon's service, where medical care and nonoperative surgical care were respectively coordinated and provided by the operative surgeon, with frequent preoperative outpatient follow-up after initial discharge.

The time of definitive reconstructive operation was chosen to allow maximal resolution of intraperitoneal inflammation. General goals were 1 year from operative closure of the open abdomen, 6 to 9 months after the most recent intraperitoneal operation if fascia was closed, 6 to 9 months after delayed primary closure or spontaneous closure of cutaneous wounds over fascial dehiscence, and 3 months from drainage of the most recent intraperitoneal abscess or communicating fluid collection. However, a definitive reconstructive operation was undertaken earlier than initially planned if a patient had multiple episodes of complications, such as central venous catheter sepsis, volume depletion, or intractable skin breakdown, that threatened the ultimate outcomes.

The operative conduct was similar to that of Hill,[31] with some modifications. To minimize enterotomy on abdominal entry, the surgical team reviewed the CT images to target a segment of midline abdominal wall free of underlying bowel for the initial incision. After a short segment of fascia had been opened safely, rakes were used to facilitate adhesiolysis along the midline under direct vision, with progressive lengthening of the incision. Dense adhesions were divided sharply with fine scissors. Scalpel dissection was not used. Soft adhesions were divided with coagulation cautery set at 20 watts. After the midline incision was opened, leaving the fistula to one side, the adhesions to the abdominal wall were divided to the level of the gutters bilaterally, with the use of rakes to set appropriate tension. Enterolysis was performed from the ligament of Treitz distally and from the ileocolonic junction proximally to the fistulous mass. The fistulous bowel was resected en bloc with the involved midline abdominal wall.

The approach to preservation of the small-bowel length evolved during the series. With an assumption that multiple anastomoses increased the risk of leak, an initial preference for multiple short resections changed to a preference for a single, longer resection for multiple fistulas or injured bowel, or both. Resection of nonfistulous bowel was used selectively (versus repair) for bowel that was injured in serotomy or enterotomy. In all circumstances, the resection of poor-quality bowel to minimize leak and recurrence was prioritized over the preservation of small-bowel length. However, when a single resection threatened to create short bowel syndrome, multiple resections were performed to maintain at least 150 cm of small bowel whenever possible.

All anastomoses were two-layered and sewn by hand. Side-to-side and end-to-side anastomoses were used frequently to account for size discrepancy when one or both limbs were of diminutive caliber. All residual abdominal wall mesh was explanted. Primary closure of associated ventral hernias was performed when possible, and wide hernia defects were bridged with intraperitoneal Vicryl mesh (Ethicon US, LLC, Bridgewater, NJ). Definitive hernia repairs were rarely used, and permanent mesh was never placed.

The focus of postoperative care was the monitoring for leak. Abdominal CT was used to evaluate fever, leukocytosis, or prolonged ileus. Broad-spectrum antibiotics were given for 5 days. Patients were discharged from the hospital only after they were clearly tolerating a general diet or a decision had been made to slowly wean TPN at home or in a facility with step-down care.

Standardization of approach was achieved by the operative surgeon's continual and sole direction of rotating trainees and midlevel providers on the surgeon's personal surgical service. Select practice management guidelines were written near the end of the study period.

Statistical analysis

All results are stated as medians unless otherwise noted. The small number of major complications precluded multivariate analysis of potential risk factors.

Univariate associations between closed and open abdominal fistulas were assessed with the χ^2 test for discrete variables and a two-sample t test for continuous variables. The relationships of multiple anastomoses and intestinal leak and of leak and recurrence with experience early in the series were examined with the Fisher exact test. The Kaplan-Meier method was used to estimate the occurrence of intestinal leak and, separately, recurrence of a fistula after reconstructive operation. The α level for statistical significance was set at .05. Statistical analyses were performed with SAS v 9.4 software package (SAS Institute Inc, Cary, NC).

Results

Patients

In total, 100 patients underwent reconstructive operation for fistula between March 19, 1992, and November 11, 2012, with 43 in the final 5 years. Median age was 62 years, with 49% of patients being female. A total of 71 cases originated in referring institutions.

Comorbidities included heart disease (n = 37), pulmonary disease (n = 27), diabetes mellitus (n = 21), anticoagulation or bleeding diathesis (n = 13), corticosteroid use or other immunosuppression (n = 10), and 74 instances of 42 other, individually less-frequent conditions.

Before reconstruction, 46 patients had an episode of critical illness, 50 required prolonged TPN, and 3 presented with a small-bowel length of less than 150 cm. A total of 13 patients had malignancy, but only 3 of them had active abdominal disease. Of the patients, 10 had a history of inflammatory bowel disease (IBD), and all had postoperative fistulas. Eight patients had prior abdominal irradiation. Median (range) preoperative albumin concentration (n = 88) was 3.3 (1.6–4.4) g/dL; median (range) of preoperative prealbumin level (n = 63) was 20 (3–35) mg/dL. The most frequent preoperative complication was line sepsis—34 patients had a total of 65 episodes.

Table I
Fistula classification

Type of communication	Surface of communication				Total number of fistulas
	Open abdomen, number of fistulas	Closed abdomen, number of fistulas			
	Laparostomy wound	Narrow incisional wound	Skin	Other	
Pseudostoma	51	22	8	1[*]	82
Nonpseudostoma	7	20	35[†]	3[‡]	65
Drain controlled	3[§]	0	21	0	24
Total number of fistulas	61	42	64	4	171

[*] Fistula opened to periprosthetic (mesh) space.
[†] A total of 5 cutaneous fistulas presented at the stage of necessitans with subcutaneous abscesses in the anterior abdominal wall ($n = 2$), superior thigh ($n = 2$), and perineum ($n = 1$).
[‡] Of these nonpseudostomas, 1 each opened to pericardium, bronchus, and pleural space.
[§] Intraperitoneal fistulas controlled by percutaneous drains placed through intact skin lateral to laparostomy.

Index operations

For 94 patients, the fistulas occurred after an abdominal operation. Of these antecedent operations—termed *index operations*—81 were open procedures, 12 were laparoscopic, and 1 was endoscopic. Ventral hernia repairs, colon resections, operations for small-bowel obstruction, and genitourinary tract procedures accounted for 66% of the index operations. A total of 67 index operations were performed at referring institutions, with the other 27 performed at Mayo Clinic (Rochester, MN).

After an index operation and before referral, 69 patients underwent between 1 and 13 additional operations for complications. Among them, 54 patients underwent failed attempts to treat a leak or fistula and presented with a recurrent fistula.

Fistula characteristics

Of the 100 patients, 62 underwent reconstructive operation for small-bowel fistulas, 18 for colonic, 13 for both, and 7 for ileocolonic anastomotic fistulas. Together, they had 171 fistulas. A total of 34 patients had between 2 and 8 multiple fistulas, and 7 had 1 additional fistula each to the upper gastrointestinal tract ($n = 4$), gallbladder ($n = 1$), ileal conduit ($n = 1$), and genitourinary tract ($n = 1$).

First, fistulas were classified by the surface with which they communicated—laparostomy wounds of open abdomens (ie, enteroatmospheric fistulas), other open abdominal wounds, cutaneous surfaces, or other spaces. Second, fistulas were classified by the manner of communication—pseudostoma, nonpseudostoma, or drain. The two classifications were combined to define the fistulas (Table I).

Between presentation and reconstructive operation, four patients had new, additional fistulas in open wounds or open abdomens that we termed *secondary fistulas*. For two patients, primary fistulas healed spontaneously, and secondary fistulas became the indication for definitive reconstructive operation.

Reconstructive operations

Indications

Indications for reconstructive operation were fistula pseudostoma ($n = 45$), nonpseudostoma or drain-controlled fistula that failed to heal with intensive nonoperative management ($n = 49$), symptomatic stricture resulting from healing of fistula ($n = 3$), and re-establishment of intestinal continuity after resection and tube enterostomy decompression of the small bowel (without stomas) at hygienic operation ($n = 2$). In addition, 1 patient had stoma reversal after healing of fistula by intubation, drainage, and proximal diversion at hygienic operation.

Timing of operation

Reconstructive operations were performed at 10.8 months (ie, 324 days) after the last intraperitoneal operation ($n = 94$) and 8.8 months (265 days) after fistula diagnosis ($n = 100$). Operation was performed sooner than initially planned for 31 patients with repeated fistula-related complications (Table II). Median operative duration was 6.5 hours (range, 3–15 hours).

Enterolysis

Adhesions completely obliterated the peritoneal cavity of 88 patients. A total of 74 patients underwent complete enterolysis from ligament of Treitz to ileocolonic junction, and 14 underwent partial enterolysis. Complete enterolysis was performed for the 12 patients with focal adhesions. Thus, complete enterolysis was performed for 86% of patients overall, including 84% of those with a completely obliterated peritoneal cavity.

Bowel resection versus fistula closure

A total of 98 patients underwent bowel resection. Only 2 patients underwent primary fistula closure; 1 patient had cecal fistula at the site of an ancient appendectomy and the other had necrotizing pancreatitis-associated fistula at ligament of Treitz.

Length of resected bowel was a median of 19 cm for small intestine (range, 2–145 cm) and 11 cm for colon (range, 2–88 cm). Postresection length of small bowel was measured in 60 patients (median [range], 212 [40–500] cm). No patient with unmeasured residual small-bowel length became TPN dependent. Near-completion enterectomy was performed once at primary and once at tertiary reconstructive operations.

Anastomoses

A total of 92 patients had 136 anastomoses, with 63 patients having had 1 anastomosis and 29 having had multiple anastomoses

Table II
Indications for early[*] operation

Indication	Number of indications ($n = 31$)
Difficult-to-control fistula effluent	9
Repeated episodes of line sepsis	5
Smoldering abdominal sepsis	4
Repeated episodes of volume depletion	4
Prolonged hospitalization	3
Small-bowel obstruction	2
Wound bleeding	1
Poor nutrition (prior gastric bypass)	1
Severe perineal pain from GU fistula	1
Urgency for other, clean (cardiac) operation	1

GU, genitourinary tract.
[*] Sooner than initially planned.

(range, 2–6). All anastomoses were hand sewn. The incidence of postoperative leak did not differ between those patients undergoing single versus multiple anastomoses (9.5% vs 17.2%, $P = .30$ with the Fisher exact test). A total of 43 anastomoses were end to end, 49 were end to side, and 44 were side to side. A total of 22 patients underwent colocolostomies or colorectostomies with or without additional small-bowel anastomoses. The 8 nonanastomotic procedures were 2 fistula closures and 6 resections with stoma.

Stomas

A total of 27 patients had stomas immediately after their reconstructive operations. Among them, 11 had pre-existing permanent stomas. For 5 patients, new permanent stomas were created during reconstructive operations. Temporary stomas were created to protect distal anastomoses in 11 patients. Three of these temporary stomas were not reversed because of patient comorbidities, and a fourth one was not reversed because of unanticipated distal stricture for which the patient deferred reoperation. A total of 7 temporary stomas were successfully reversed without leak or recurrent fistula. In summary, after reconstructive operation and 7 stoma reversals, the incidence of new stoma was 9 in 100 patients (9%).

Concurrent procedures

A total of 12 patients underwent 13 concurrent procedures. These included a reversal of gastric bypass to create adequate functional enteric length, a revision of gastrojejunostomy for fistula, a cholecystectomy for fistula, 7 cholecystectomies for incidental calculi, a bilateral nephrectomy for polycystic disease, a unilateral nephrectomy for ureteral obstruction with pyelonephritis, and a salpingo-oophorectomy for benign cyst.

Repair of associated ventral hernias

Abdominal wall hernias were present in 61 patients. In the majority ($n = 41$), planned postoperative ventral hernias were created. Primary repair was performed for 16 patients. Only 4 patients, all with open abdominal hernias, underwent concurrent complex ventral hernia repairs (Table III). In 13 cases, permanent prosthetic material was explanted from the abdominal wall. In no case was permanent prosthetic material placed.

Management of cutaneous wounds

At the completion of reconstructive operations, cutaneous wounds were closed primarily for 78 patients, of which 35 patients required local subcutaneous-cutaneous advancement flaps. Delayed primary suture closure was performed for 9 patients. Delayed split-thickness skin grafts were placed for 5 patients and no graft failed. Wounds were left open to heal by secondary intention for 8 patients. A total of 26 sutured wounds were opened because of infection ($n = 9$), hematoma ($n = 5$), superficial dehiscence ($n = 8$), or other indication ($n = 4$). Among a total of 87 sutured wounds, 26 (29.9%) failed. Ten patients had open lateral wounds at prior stoma or fistula sites. In total, only 56 patients were discharged from the hospital without some type of open cutaneous wound.

Major outcomes

Follow-up

One patient discharged on postoperative day (POD) 6 without complications was lost to follow-up. Median follow-up for the other 99 patients was 2.7 years.

Table III
Management of abdominal wall of 61 patients with preoperative VH

Management technique	Type of VH	
	Open abdomen	Other
Primary fascial closure	9	7
Vicryl* mesh bridge	23	6
Bioprosthetic bridge	4	2
Skin or SQ closure only	2	4
Component separation with bioprosthetic onlay or underlay, primary fascial closure	2	0
Muscle flap	2	0

SQ, subcutaneous; *VH*, ventral hernia.
* Ethicon US, LLC, Bridgewater, NJ.

Postoperative leaks

Postoperative leaks were defined as (1) extrusion of succus or stool through a cutaneous surface or wound or into the peritoneal cavity, (2) audible air extrusion from an exposed bowel surface, (3) extravasation of luminal contrast medium on imaging with or without clinical evidence of leak, and (4) contrast medium filling of bowel at fluoroscopy after drain injection with or without clinical evidence of leak.

A total of 11 patients had postoperative leaks. Six leaks healed—2 after reoperation on POD 2 (intubation and drainage of missed enterotomy) and POD 36 (skin graft over exposed bowel with pinpoint erosion enterotomy leaking air only) and 4 after nonoperative management. No endoscopic therapy was used. Healing was defined as tolerance of general diet without clinical or radiographic evidence of leak developing at any time during the follow-up period. The 6 leaks healed between 31 and 58 days after reconstructive operation. For 5 patients, leaks did not heal and thus were further classified as *recurrent fistulas*.

Fistula recurrence

All 5 recurrent fistulas began as leaks, by our definition. All nonhealing leaks were classified as recurrent fistulas. For 3 patients, recurrent fistulas were successfully taken down at secondary ($n = 2$) or tertiary ($n = 1$) procedures without postoperative or fistula-related death. However, the other 2 patients died with unoperated recurrent fistulas. One died of intracranial hemorrhage related to Ehlers-Danlos syndrome on POD 303 before a planned secondary reconstructive operation. The death was considered a fistula-unrelated death. The second patient chose to withdraw dialysis for chronic renal failure rather than undergo reoperation. This was considered a fistula-related death and occurred on POD 122, 10 days after hospital discharge.

Mortality rate

No intraoperative deaths occurred. One patient had an in-hospital postoperative death within 30 days of operation. This patient with cirrhosis (preoperative Model for End-stage Liver Disease score of 15) underwent fistula takedown and died in the hospital from hepatic decompensation and intractable coagulopathy on POD 26 without leak. Two deaths occurred later than 30 days and after hospital discharge. One was the late fistula-related death from renal failure described earlier. The second death was of a patient who had postoperative hemorrhage from a previously undetected renal pseudoaneurysm caused by preoperative percutaneous ureteral stent placement for stricture. This patient had multiorgan failure, was withdrawn from dialysis, and died without leak and in hospice on POD 55, 2 days after discharge. The death was considered a postoperative death.

The combined postoperative and fistula-related mortality rate was 3.0%. No deaths were attributed to leak-related sepsis. The 30-day and inhospital mortality rates were both 1% and represent the patient with cirrhosis, which has been described earlier. One-year all-cause mortality rate was 9%.

TPN dependence

Three patients were TPN dependent preoperatively. In addition, 2 patients became TPN dependent as a result of reconstructive operation. An additional patient became TPN dependent after creation of a proximal stoma for bowel obstruction in a hostile abdomen at 6.5 years after reconstructive operation.

Stomas at follow-up

Two patients acquired stomas at operations long after reconstruction, 1 for intractable short gut diarrhea and 1 for bowel obstruction. The stomas occurred at 4.5 and 6.5 years after reconstruction.

Major outcome summary

A total of 96 patients survived fistula free after a primary or secondary/tertiary reconstructive operation. Two patients died of postoperative complications without leak or recurrence. Another patient had a late recurrent fistula–related death from renal failure, and a fourth patient with Ehlers-Danlos syndrome died before reoperation for recurrent fistula. No survivor had recurrent fistula at follow-up, and no other deaths were fistula related. Reconstructive operation resulted in new TPN dependence in 2% of cases and in new stomas in 9% of cases.

Outcomes over time

Both leaks and recurrences were clustered in the first 22 patients, although no change in practice or patient characteristics occurred at that point in the series. Four leaks (18.1%) occurred in the first 22 cases vs 7 (8.9%) in the last 78; however, this difference was not statistically significant ($P = .25$, Fisher exact test). Similarly, the difference in recurrence—3 (13.6%) vs 2 (2.6%)—was not statistically significant ($P = .17$).

Abdominal wall outcomes at follow-up

A total of 55 patients underwent primary fascial closure (16 with and 39 without preoperative ventral hernia), and 5 (9%) had a ventral hernia at follow-up. The 4 patients who underwent concurrent complex ventral hernia repair did not have hernia recurrence. Of the other 41 with a planned ventral hernia, only 1 patient underwent subsequent ventral hernia repair. No patient with a planned or recurrent ventral hernia had incarceration. One patient with primary closure and 1 patient with planned ventral hernia died postoperatively. In summary, 61 patients had preoperative hernias and 45 had postoperative hernias.

Comparison of open and closed abdominal fistulas

A total of 42 patients had pre-reconstruction open abdomen resulting from earlier laparostomy. These abdomens were closed with split-thickness skin grafts for 24 patients. Closure was completed with delayed primary closure that used cutaneous-subcutaneous advancement flaps over drains and Malecot catheter–intubated fistulas for 2 patients. The other 16 open abdomens closed around the pseudostomas by second intention. Reconstructive operation was performed at 166 days (5.5 months) after spontaneous closure ($n = 16$) and 339 days (11.3 months) after operative closure ($n = 26$).

Table IV compares the variables of patients with open versus closed abdominal fistulas. Of major outcomes, leaks were more frequent among patients with open abdomen (19.0% vs 5.2%). This outcome corresponded to a statistically significant difference in Kaplan-Meyer leak-free survival at 1 and 6 months. Patients with open abdomen had more preoperative complications (2 vs 1), longer initial (preoperative) hospitalization (86 vs 26 days), longer operative duration (7 vs 6 hours), and longer postoperative hospital length of stay (36 vs 22 days). The interim between diagnosis and reconstructive operation was dramatically longer (383 vs 146.5 days) for patients with open abdominal fistulas.

Discussion

Review of outcomes

We believe the following are the major outcomes pertinent for reconstructive fistula operations, with our results in parentheses. First is fistula-free survival (96%) that included combined postoperative or fistula-related death (3%) and recurrence (5%). Second is leak (11%); third, new permanent TPN dependence (2%); fourth, fascial closure (55%); fifth, intact cutaneous closure at hospital discharge (56%); and sixth, new permanent stoma (9%).

We suggest that these parameters should be points of disclosure for informed consent conversations and should be quality metrics for these operations. Fistula-free survival must be the primary priority for all decision making. This goal means that all intestine at risk for fistula recurrence—because of intrinsic disease, the fistulous process, or intraoperative injury—must be resected even if the procedure leads to short-bowel syndrome. Possibly, bowel length can be maximized in this circumstance through multiple resections and anastomoses. However, multiple anastomoses may increase the risk of leak. The present study, with its limited sample size, had insufficient power to assess this question. A future study that anticipated the 17.2% leak rate for multiple anastomoses, seen in the present study, would require a total of 365 patients for a 2-sided study with an α level of .05 to have 80% power to detect a leak rate reduction of at least 10% in single anastomosis. That patient number is derived with the assumption of the same ratio of multiple resection to single resection as we saw in our series (ie, 115 patients with multiple to 250 with single resection).

Recurrence is a grave consequence of leak and presents patients with greater consequences and more difficult choices. Minimization of new TPN dependence and new stomas reflects the degree to which fistula-free survival can be achieved and simultaneously maintaining full intestinal function. These two outcomes can be expected to affect the surviving patients' quality of life. The importance of fascial and cutaneous closures is not to avoid hernias and open wounds per se but to provide protection of the peritoneal contents and thereby minimize recurrence through erosion. Therefore, these closures are given higher priority than avoidance of stomas.

Equitable comparisons between case series are impossible because of differences in the reported case mix and data points. Nonetheless, given the measures cited above, our results compare favorably with those recently reported—both overall (Tables V and VI) and for our subset of patients with open abdominal fistulas (Table VII). In general, only much smaller series report better leak, recurrence, and mortality rates, and these series all reported substantially shorter or no follow-up.[16,21,22] The notable exception is the latest study from the UK national fistula unit at Saint Mark's Hospital in London, which reported no deaths in a large series with good follow-up. The higher recurrence rate in the Saint Mark's study corresponds to the hospital's higher incidence of IBD.[7] To our knowledge, our fistula-free survival rate of 96% is the best reported among all studies with reported follow-up.

Table IV
Comparison of characteristics and outcomes for open versus closed abdominal fistulas

Characteristic/outcome	Closed abdominal fistulas ($n = 58$)	Open abdominal fistulas ($n = 42$)	P Value*
Leak, number (%)	3 (5.2)	8 (19.0)	
Recurrence, number (%)	2 (3.4)	3 (7.1)	
Fistula-related or postoperative death, number (%)	0 (0)	3 (7.1)	
Intestinal leak-free survival, %			**.04**
At 1 mo	94.8	85.7	
At 6 mo	94.8	80.8	
Fistula recurrence-free survival, %			.41
At 1 mo	96.5	92.9	
At 6 mo	96.5	92.9	
Comorbidity, median, number	2.0	2.0	.86
Interim from diagnosis to reconstructive operation, median, days	146.5	383.0	**< .001**
Hygienic operation, median, number	2.0	3.0	.09
Duration of first hospitalization, median, days	26.0	86.0	**.002**
Postreferral hospitalization, median, number	1.0	1.0	.06
Episode of line sepsis, median, number	1.0	2.0	.59
Preoperative complication, median, number	1.0	2.0	**.003**
Operative time, median, hours	6.0	7.0	**.02**
Duration of postoperative hospitalization, median, days	22.0	36.0	**.02**
Postoperative† complications, median, number	2.0	2.0	.13
Unplanned reoperation, number (%)	13 (22.4)	11 (26.2)	.66
Early‡ postdischarge complication, number (%)	15 (25.9)	14 (36.8)	.25

* Bold indicates statistical significance.
† Before hospital discharge.
‡ Within 90 days of discharge.

Incidence of new TPN dependence was reported infrequently in other studies. However, our 2% incidence of new TPN dependence appears favorable to those reported. We suspect that it reflects our willingness to use multiple short resections and multiple anastomoses when necessary to preserve bowel length.

In a series in which 32% of patients had IBD, Runstrom et al[19] showed that the creation of stomas to avoid anastomoses lowers the recurrence rate from 34% to 14% ($P = .02$). As the rate of anastomosis-deferring stoma increased from 17% to 57% ($P = .002$), the postoperative healing rate increased from 73% to 94% ($P = .02$). We have achieved similar healing with many fewer stomas—but in a cohort with much fewer IBD cases.

Notable features of our clinical approach include consistency achieved through comprehensive care coordinated by one operative surgeon through the entirety of each patient's course from initial evaluation through reconstructive operation to follow-up. Among the features were the long planned interval from the most recent prior intraperitoneal operation to reconstructive operation, the complete enterolysis, and the anastomoses sewn by hand. A default reliance on fistula resection with rare and selected use of fistula closure was also a feature, as were the use of end-to-side and side-to-side anastomoses for bowel with diminutive luminal caliber and the rare concurrent definitive abdominal wall reconstruction. We believe that our good results are related to these

Table V
Major outcomes*

First author	Year	Number of patients	Interim, months	Leak, %†	Recurrence, %	Death, %	Follow-up, months
Bannon	2019	100	11‡	11	5	3	32
Leang[22]	2018	13	8§	8	8	0	–
Owen[18]	2013	153	9§	30	24	9	–
Rahbour[7]	2013	149	12‡	14	11	0	23
Ravindran[21]	2014	41	8§,‖	5	2	0	–
Murphy[20]	2013	19	22¶	–	21	11	44
Runstrom[19]	2013	101	–	–	22	9	11
Martinez[17]	2012	71	2‡	31	21	20	–
Visschers[6]	2012	49	3#	22	16	4	24
Datta[16]	2010	35	9¶	11	3	3	–
Gyorki[15]	2010	21	6**	33	29	5	37
Brenner[14]	2009	135	6§	–	17	8	–
Dionigi[13]	2008	19	6§	32	16	21	22
Connolly[12]	2008	61	11††	–	12	5	29
Draus[10]	2006	77	3§	–	10	–	–
Lynch[9]	2004	203	6§	–	21	3	10
Hollington[5]	2004	167	8¶	33	28	3	18

* Dash indicates data not provided in paper.
† Leak rate was abstracted from a study when sufficient data were present and recurrence was adjusted accordingly.
‡ Interim between last major operation and reconstructive operation.
§ Interim between diagnosis and reconstructive operation.
‖ Interim for postoperative fistulas; 1-mo interim for other fistulas.
¶ Interim from last operation or from diagnosis if spontaneous fistula.
# Interim not defined.
** Interim between presentation and reconstructive operation.
†† Interim from laparostomy.

Table VI
Quality metrics*

First Author	Year	Number of patients	Fistula-free survival %	Leak† %	New TPN dependence %	New permanent stoma, %
Bannon‡	2019	100	96	11	2	9
Leang[22]	2018	13	100	8	–	0
Owen[18]	2013	153	84§	30	3	–
Rahbour[7]	2013	149	82	14	12‖	–
Ravindran[21]	2014	41	98	5	5	–
Murphy[20]	2013	19	79	–	0	–
Runstrom[19]	2013	101	86	–	–	33
Martinez[17]	2012	71	80§	31	–	–
Visschers[6]	2012	49	93	22	–	–
Datta[16]	2010	35	–	11	0	0
Gyorki[15]	2010	21	76	33	5	–
Brenner[14]	2009	135	84	–	–	–
Dionigi[13]	2008	19	–	32	–	–
Connolly[12]	2008	61	–	–	–	–
Draus[10]	2006	77	–	–	–	–
Lynch[9]	2004	203	85	–	6	29
Hollington[5]	2004	167	82§	33	–	–

TPN, total parenteral nutrition.
* Dash indicates data not provided in paper.
† Leak rate was abstracted from a study when sufficient data were present and recurrence was adjusted accordingly.
‡ Intact cutaneous wound closure at hospital discharge, 56%.
§ Overall fistula closure rate; may include some patients who died.
‖ Includes patients treated nonoperatively.

features. However, the expertise of experienced interventional radiology and home parenteral nutrition practices surely contributed.

A further contributor to our good results was our 10% incidence of IBD, which ranged from 0% to 55% in other studies.[3,5–7,9–22] This low rate certainly contributed to our low incidence of recurrence. The presence of IBD has been found to carry odds ratios for recurrence of 2.6 on univariate[18] and 4.9 on multivariate[14] analyses.

A series by Martinez et al[17] had a similarly low incidence of IBD and was composed primarily of postoperative fistulas. However, for 24% ($n = 17$) of their patients, sepsis was the indication for reconstructive operation. In several other studies, reconstruction was performed concurrently with primary sepsis control in 5%,[15] 6%,[6] and 10%[14] of operations. In contrast, we performed reconstructive operation months after control of sepsis, and this may explain our relatively better results.

In other respects, however, our patients presented with difficult-to-manage fistulas. Among our patients, 71% were referred from other institutions compared with 50% to 80% among other series that had at least 40 patients.[5–7,9,10,14,17–19,21] Whether fistulas are recurrent or primary is rarely reported in the literature. Our 54% incidence of recurrent fistulas is substantially greater than the 9% reported by Runstrom et al[19] and the 20% reported by Lynch et al[9], but it is less than the 71% reported by Owen et al.[18] Connolly et al[12] and Dionigi et al[13] reported only patients with open abdominal fistulas ($n = 61$ and $n = 19$, respectively). Other series have included 3% to 47% open abdominal fistulas[5,12,16,17,19,21] compared with our 42%. Of our patients, 69% had undergone additional operations after their index operation and before referral. In addition, 46% had an episode of critical illness (at our institution or at the referring institution) before reconstruction, 50% required prolonged preoperative TPN, and the median serum albumin concentration before reconstruction was below normal. Multiple enteric or colonic, or both, fistulas were present in 34% of patients, and in 3%, 1 of these fistulas had intrathoracic communication. Of patients in the series, 7% had additional fistulas to other abdominal structures.

Postoperative intestinal leaks versus recurrent fistulas

We differentiate postoperative intestinal leaks from recurrent fistulas. Leaks heal with immediate reoperation or nonoperative management and without repeat reconstructive operation. By comparison, recurrent fistulas represent nonhealing leaks and present patients with the choice of living with the fistula permanently or undergoing a repeat reconstructive operation after another prolonged interval to allow resolution of obliterative peritonitis. Although important, the effect of leaks on patients' quality of life is much less than the effect of recurrence. This distinction facilitates appropriate informed consent before reconstructive operation. A reasonable expectation is for patients to be more willing to accept risks of leak than of recurrence.

Our distinction of leak from recurrence begs the question of when to classify a prolonged leak as a recurrence. We had no a priori criterion but can suggest one empirically on the basis of our

Table VII
Open abdomen series*

First author	Year	Number of patients	Interim, months	Leak %	Recurrence %	Death %	Fistula-free survival, %	IBD, %
Bannon (subset)	2019	42	13	19	7	7	90	12
Martinez[32]	2018	62	3	37	27	13	69	–
Dionigi[13]	2008	19	6	32	16	21	–	37
Connolly[12]	2008	61	11	–	12	5	–	27
Visschers (subset)[11]	2008	49	–	–	16	16	82	9
Hollington (subset)[5]	2004	32	–	–	34	19	47	–

IBD, inflammatory bowel disease.
* Dash indicates data not provided in paper.

data. One patient underwent early reoperation for leak. Leaks healed between 1 and 2 months postoperatively for the other 5 patients.

Our data thus support 2 months as the criterion for when to differentiate leak from recurrence. However, because the number of leaks was small, a longer duration may appear reasonable when a larger data set is examined. The 2-month mark is compatible with the data of Martinez et al[3] for spontaneous closure of primary fistulas. Median time to healing was 1 month for both small-bowel and colon fistulas, and longest time to healing was 2 months for small-bowel fistulas.[3] However, longest time to healing was 6 months for colon fistulas.[3]

Timing of the operation

Obliterative peritonitis accompanies fistulas and increases the risk of enterotomy with consequent increased risk of leak or recurrence, or both.[8,19,33,34] Therefore, safety of operation is improved when conducted after adhesions become as soft and nonvascular as possible.

However, Owen et al[18] and Brenner et al[14] showed that longer intervals (≥36 weeks and >1 year) from diagnosis to operation correlated with a greater incidence of recurrent fistulas. The association was found to be important in the study by Brenner et al[14] on multivariate analysis that did not examine open abdominal fistulas as a potential risk factor. Owen et al[18] did not examine the influence of the open abdomen per se. They found that Category IV fistulas correlated with recurrence, but they did not perform multivariate analysis. (Category IV fistulas are those "presenting through a large dehiscence and at the bottom of gaping wounds"[35] and would be expected to include open abdomen fistulas.) The lack of explicit assessment of open abdomen as a potential risk factor for recurrence in these studies may confound the conclusion that longer preoperative duration correlates with recurrence. Because open abdomen was associated with longer interims to operation and higher incidence of leak in our study, possibly the patients with longer duration to operation in the studies by Brenner et al[14] and Owen et al[18] were those with open abdominal fistulas, and the more frequent recurrences were related to the inherent difficulty of reconstructing these fistulas rather than long preoperative duration per se. Indeed, Brenner et al[14] found that the reason for delay in 9 of 31 patients in their long interval group was "…to achieve more favorable wound characteristics in large slow-healing wounds.…"

Without fistula-related morbidities that are life threatening or complicate reconstructive operation, long interims between last celiotomy and reconstructive operation are preferable because they improve the technical conduct of operation and hence minimize intraoperative bowel injury. Consequently, we believe that our long interims make a critical contribution to our good outcomes. Our interim of 13 months between diagnosis and reconstructive operation for open abdominal fistulas is the longest reported (Table VII), and our overall interim of 11 months from last intraperitoneal operation is substantially longer than most (Table V). Only 2 studies report longer overall interims: one is a small study of only 19 patients,[20] and the other is from Saint Mark's Hospital, a UK national fistula unit. The interim from Saint Mark's lengthened from a median of 8 months[5] to 12 months[7] between 2 series, and these authors similarly cite the longer interim as a factor driving improved outcomes in their later series.[7]

We agree with Owen et al[18] that preoperative line sepsis is an especially serious threat. Repeated episodes led us to shorten the planned interim to definitive operation in five cases. The impacts of such preoperative threats are mitigated by the active management of the entire preoperative phase by the operative surgeon.

Prediction of healing

Much of the literature regarding fistulas has focused on the definition of factors predictive of spontaneous healing,[1–4] with the expectation that knowledge of such factors will inform a decision to choose between operative management and a nonoperative trial. This is true for spontaneous fistulas.

However, we believe there is little utility in such an approach for postoperative fistulas. Our median interval from last operation to reconstructive operation was 10.8 months. Consequently, when these long intervals are used, one learns empirically and with certainty whether a given patient's fistula will heal—there is no need for prediction. This approach sets a future operative date as described earlier in this report. The interim is spent attempting to heal the fistula. If the fistula persists on the date of planned operation 9 to 12 months later, the fistula is definitively nonhealing and operation is indicated.

A high volume (>500 mL/day) of fistula effluent clearly affects preoperative management. However, classification of fistulas into high and low output for the purpose of prediction of closure is markedly diminished in importance for postoperative fistulas with the described rationale. Future studies of predictive factors for spontaneous healing could exclude postoperative fistulas and focus on spontaneous fistulas, specifically fistulas related to Crohn disease. Thereby, the studies likely would have improved utility for this latter population of patients.

Anastomosis type

Brenner et al[14] report a reduction in recurrence from 35% with resection and stapled anastomosis to 12% with hand-sewn anastomosis. Although limited by the study's retrospective nature, these data support our belief that anastomoses sewn by hand allow better accommodation of serosal imperfections and narrow bowel. We performed simple closure in only 2 instances, thereby acknowledging that simple fistula closure has been associated with higher recurrence rates than resection.[9,17]

Effect of open abdomen

Open abdominal fistulas are especially challenging.[36–39] In the present series, leaks were substantially more likely with open abdomens than with closed abdomens. Frank recurrences and death were too infrequent to power a significant difference. However, all fistula-related and postoperative deaths occurred in cases with open abdomen.

Of our 5 recurrences, 3 followed a reconstructive operation for open abdominal fistulas. Only 2 recurrences occurred in the last 78 cases. Both occurred in patients who presented with an open abdomen and were due to small-bowel erosion after nondefinitive fascial closure.

Visschers et al[11] have defined *abdominal wall defect* as "any defect of all layers of the abdominal wall leaving the abdominal contents exposed" and then seemed to equate this with the open abdomen. However, this definition could include small wounds associated with dehiscence. An initial study by Visschers et al[11] found that fistulas associated with these abdominal wall defects successfully closed less frequently, both spontaneously and after reconstructive operation, than those associated with a closed abdominal wall. A later study by Visschers et al[6] that added patients to the first cohort found no difference in recurrence with and without an abdominal wall defect (14% vs 19%, $P = .42$). Similarly, Martinez et al[17] found that history of open abdomen management was no more frequent among patients with and without recurrence (54% vs 29%, $P = .06$).

Our study found that postoperative intestinal leak-free survival was less with open abdominal fistulas than with closed abdominal fistulas. We report that leak-free survival declines between 1 and 6 months for open abdominal fistulas and stays stable for closed abdominal fistulas, an outcome that possibly reflects the impact of recurrence through erosion in the former group.

We also found that, compared with closed abdominal fistulas, open abdominal fistulas were associated with more preoperative complications and longer durations of initial hospital stay, of interim between diagnosis and operation, of the operation, and of postoperative length of stay. Particularly striking are the magnitude of the differences in initial and preoperative lengths of stay and the interim between diagnosis and operation. The existences of differences in leak rate and resource utilization are unsurprising. However, we believe ours is the first study to show and quantify poorer outcomes with open abdominal fistulas clearly defined as those associated with laparostomy wounds. With its elimination of intersurgeon heterogeneity, the single-surgeon design may have helped detect these differences.

Abdominal wall outcomes

Management of ventral hernias associated with prior open abdomens is a vexing problem. We took a minimalist approach to the repair of these hernias. More aggressive options exist but present their own concerns. In a series of open abdominal fistulas from the UK Department of Health (Intestinal Failure Unit at Salford Royal NHS Foundation Trust), Connolly et al[12] demonstrated markedly increased recurrence from 0% with primary repair to 24.1% with concurrent placement of synthetic or biologic mesh. These data give pause to consideration of concurrent complex hernia repair with mesh. Although other authors have stated that placement of permanent mesh is safe in contaminated fields, little of these data are specific to fistula reconstruction, and no series has involved unselected patients with fistula.[40–44] Our creation of planned ventral hernias in lieu of complex hernia repairs is feasible and may avoid some complications leading to recurrence.

Nonetheless, we agree with the maxim of Fischer[45] regarding the importance of secure abdominal wall closure. We ascribe 1 leak and 2 recurrences in our series to inadequate abdominal wall coverage, so we do believe that the minimalist approach we have taken to the abdominal wall has limitations. Component separation without underlay may seem an appropriate compromise, but in 1 small study, this was associated with a 27% fistula recurrence.[46] Other options have yet to be adequately evaluated.[47]

Because we recognize a secure closure of either fascia or cutaneous-subcutaneous tissues is necessary to protect the bowel, and because we wish to improve our 30% failure rate for sutured wounds, our approach has evolved to the following management of the superficial abdominal wall. All superficial wounds are left open at completion of the reconstructive operation. Wounds with underlying fascial closures are treated with a wound vacuum-assisted closure, and delayed primary closure is performed selectively. Wounds with underlying Vicryl mesh (Ethicon US, LLC) bridges at the fascial level are treated initially with our gauze closed-suction dressing (to avoid bowel erosion by a wound vacuum-assisted closure) and then with mandatory delayed primary closure before hospital discharge to protect the peritoneal contents.

Learning curve

Our low numbers of leaks and recurrences did not generate sufficient power to show a time association. Consequently, we could not prove a learning curve by evaluation of these parameters, although we are certain the surgeon improved with time. Showing the observed differences in rates of leak and recurrence between the early and late periods of the study with 80% power in a two-sided test of proportions at an α of .05 would require 609 patients for leak and 219 patients for recurrence.

Limitations and strengths

The present study has limitations. The single-surgeon design invokes the potential for selection bias. For example, our small percentage of patients with IBD reflects institutional triage of these patients to colorectal surgeons. Our study must be understood and interpreted as one of postoperative fistulas. Within the surgeon's practice of postoperative fistulas, however, there was little selectivity. Only 1 patient with a nonhealing fistula was not offered operation. The surgeon was generally known among peers to accept the most difficult fistula problems, but without an analysis of all institutional patients with postoperative fistulas, we cannot prove that the patients reported herein were not more favorable candidates for successful operation than those operated on by other surgeons. Single-surgeon design also limits generalizability of results in less easily defined ways through intersurgeon heterogeneity.

The study's retrospective nature may underestimate the number of patients who were not offered operation and those who declined an operation offered. The low incidence of leak and recurrence precluded regression analysis to define risk factors associated with these complications. Consequently, we cannot discern which technical factors and elements of patient care were associated with the good outcomes and cannot define factors associated with failures.

The single-surgeon design improved the comparison of open abdominal fistulas and closed abdominal fistulas. Another strength of the study is the long and comprehensive follow-up, which allowed us to recognize the absence of incarceration associated with the planned ventral hernias and a low incidence of late complications necessitating delayed creation of stomas and delayed gut failure requiring home TPN.

A final strength is the homogeneity of the series. Many other reports are heterogeneous, including cases both operative and nonoperative, and had primary fistula sites proximal and distal to the ligament of Treitz or were performed for sepsis and definitive reconstruction, or both. In contrast, this series focused on patients with postoperative fistulas of the small bowel and colon. Its homogeneity improves interpretation of results. Future understanding of fistula care may be further improved by the study of fistulas that are related to Crohn disease, other spontaneous fistulas, those with mesh erosion, and other postoperative fistulas separately.

In conclusion, a methodical approach to treatment of enterocutaneous fistulas can result in low rates of recurrence and death. Fistulas arising in an open abdomen are associated with more preoperative complications, longer interims from diagnosis to operation, longer operative duration, more postoperative leaks, and longer preoperative and postoperative hospital stays.

We believe the consistency achieved in a single-surgeon practice contributed substantially to the good results presented in this study. The physician authors (acute care surgeons who supervise emergency general surgery and trauma services) believe this degree of consistency is difficult to achieve on services supervised by a number of attending physicians working in rotation. This observation argues first for the development and use of practice management guidelines and second for concentration of such patients in specialty centers. Excellent results have been achieved, even with a high percentage of patients with IBD, in the United Kingdom with this latter approach.[5,7,12]

With the current reimbursement mechanism in the United States, such concentration of patients may be feasible for "simple"

closed abdominal fistulas. However, this approach is not currently feasible for patients with open abdominal fistulas because no single institution can carry the economic burden of their resource-intensive care. However, few other such horrific clinical problems can be so successfully reversed by general surgeons. This situation seems to present a tragic choice between provision of suboptimal care for these patients on the one hand and the undermining of sustainability of the tertiary referral center on the other. To begin to address this problem, surgeons need accurate definitions of open abdominal fistulas and a quantitative understanding of these fistulas' relatively resource-intensive care. Documentation of more resource utilization by patients with open abdominal fistulas has implications for system design. We hope this study provides enough of this information to prompt other investigators to examine the issue more precisely and to develop sustainable economic models for the care of these patients.

Conflict of interest

The authors have indicated that they have no conflicts of interest regarding the content of this article.

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