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Surgery for Small Bowel Perforation in an Asian Population: Predictors of Morbidity and Mortality

Ker-Kan Tan · Shieh-Ling Bang · Richard Sim

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Abstract
Introduction Peritonitis from small bowel perforation is associated with prohibitive morbidity and mortality rates. The aims of our study were to review our institution's experience in the surgical management of small bowel perforation and to identify factors that could predict morbidity and mortality.
Methods A retrospective review of all patients who underwent operative intervention for peritonitis from small bowel perforation from January 2003 to May 2008 was performed. Patients were identified from the hospital's diagnostic index and operating records. The severity of abdominal sepsis for all patients was graded using the Mannheim peritonitis index (MPI). All the complications were graded according to the classification proposed by Clavien and group.
Results Forty-seven patients, of median age 68 years (18–95 years), formed the study group. Pneumoperitoneum on chest radiographs was seen in only 11 (23.4%) patients. Foreign body ingestion (17.0%), adhesions (14.9%), and malignancy (12.8%) accounted for majority of the pathologies. There was one patient who had several small bowel perforations from Degos disease. Small bowel resection was performed in the majority of the patients (74.5%). The mortality rate in our series was 19.1%, while another 57.4% patients had perioperative complications. On univariate analysis, American Society of Anesthesiologists score≥3, MPI>26, hypotension, stoma creation, abnormal electrolyte level, and renal impairment were related to worse outcome, while the three independent variables that were related to worse outcome after multivariate analysis were MPI>26, hypotension, and abnormal serum potassium level.
Conclusion Surgery for small bowel perforation is associated with significant morbidity and mortality rates. Patients with more severe peritonitis and physiological derangement were more likely to fare worse.

Keywords Intestinal perforation · Treatment outcome · Surgery

Introduction

Peritonitis from small bowel perforation is associated with prohibitive morbidity and mortality rates.[1,2] Despite advances in surgical technique, antimicrobial therapy, and perioperative intensive care support, the mortality rate has been quoted to be as high as 40%.[1,2] Prompt diagnosis is vital in ensuring the best possible outcome in these patients. Unfortunately, nonspecific clinical picture and the diverse etiologies with their own unique characteristics often delayed the diagnosis.[1–4]

Some of the common pathologies responsible for these perforations would include foreign body ingestion, infective causes, and Crohn's disease.[1–4] With the incidence of HIV infection rising worldwide, causations, such as tuberculosis, cytomegalovirus, and other rarer infective etiologies, are likely to become more prevalent.[5–7]

Primary small bowel anastomosis has always been considered safe,[8] with the necessity of stoma rarely discussed. Some of the risk factors associated with anastomotic dehiscence after primary anastomosis include hypoalbuminaemia, peritonitis, bowel obstruction, and hypotension.[9,10]

K.-K. Tan (✉) · S.-L. Bang · R. Sim
Department of General Surgery, Tan Tock Seng Hospital,
11 Jalan Tan Tock Seng,
Singapore 308433, Singapore
e-mail: kerkan@gmail.com

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In view of the numerous issues mentioned above, and the rarity of this topic being discussed in the literature, we undertook the study with the primary aim to review our institution's surgical experience in managing small bowel perforation. Our secondary aim was to identify factors that could predict perioperative complications.

Methods

Study Population

Tan Tock Seng Hospital is a 1,300-bed hospital, the second largest in Singapore, and provides secondary and tertiary medical care for about 1.5 million people. A retrospective review of all patients who underwent operative intervention for peritonitis from small bowel perforation from January 2003 to May 2008 was performed. Patients were identified from the hospital's diagnostic index and operating records. Patients who had small bowel perforation from peptic ulcer, postoperative anastomosis leakage, or abdominal trauma were excluded.

Decision for surgery was based on clinical assessment with the aid of plain radiographs or CT scans, which would be performed based on the surgeons' preference. Prior to the surgery, fluid resuscitation, and parenteral antibiotics would be administered to every patient. Nasogastric decompression would commence either pre- or intraoperatively depending on when the perforation was diagnosed. During the exploratory laparotomy, once the site of perforation was identified and the contamination controlled, the surgical procedure and the necessity of stoma were dependent on the surgeons' operative assessment. All gastrointestinal anastomoses were either hand-sewn or stapled. Prior to closure, copious lavage of the peritoneum would be performed. All patients would be transferred to the high dependency or surgical intensive care units postoperatively.

The data collected included age, gender, American Society of Anesthesiologists (ASA) score, comorbid conditions, presenting signs and symptoms, and clinical parameters. Laboratory values, including full blood count and renal panel, were also recorded. In addition, cause of perforation, operative findings and interventions, length of surgery, perioperative complications, mortality, and length of hospital stay were also documented.

The severity of abdominal sepsis for all patients was graded using the Mannheim peritonitis index (MPI)[11] (Table 1) with a score of >26 being defined as severe. The grades of complications (GOC) were in concordance to the classification proposed by Clavien and group[12,13] (Table 2).

Statistical analysis was performed using both univariate and multivariate analyses. The variables were analyzed to the various outcomes using the Fisher's exact test, and their odds ratio and 95% confidence interval were also reported. For the multivariate analysis, the logistic regression model was applied. All analyses were performed using the SPSS 16.0 statistical package (Chicago, IL), and all p values reported are two-sided, and p values of <0.05 were considered statistically significant.

Table 1 Mannheim Peritonitis Index[11]

Risk factor score		Score
Age>50 years old		5
Female sex		5
Organ failure[a]		7
Malignancy		4
Preoperative duration of peritonitis >24 h		4
Origin of sepsis not colonic		4
Diffuse generalized peritonitis		6
Exudate	Clear	0
	Cloudy, purulent	6
	Fecal	12

[a] Kidney failure = creatinine level>177 μmol/L, urea level> 167 mmol/L, or oliguria<20 ml/h; pulmonary insufficiency = PO_2< 50 mmHg or PCO_2>50 mmHg; intestinal obstruction/paralysis >24 h or complete mechanical ileus, shock hypodynamic, or hyperdynamic

Results

Study Group

Forty-seven patients formed the study group, with 55.3% of them older than 60 years old. Nearly half of study group had an ASA score of 3 (n=22, 46.8%). One third of the patients had at least two comorbid conditions, while nine (19.1%) were immunosuppressed. Though all patients had erect chest radiographs, pneumoperitoneum was seen in only 11 (23.4%) patients. Preoperative CT scan was performed in 32 (68.1%) patients, and some of the findings seen included pneumoperitoneum (n=21, 65.6%), abscess or inflammatory mass without extra-luminal gas (n=8, 25.0%), extravasation of oral contrast (n=1, 6.3%), and intestinal obstruction (n=2, 9.4%). Foreign bodies were also detected in several patients. Table 3 illustrates the various characteristics of this study group.

Clinical Parameters and Investigations

Eleven (23.4%) patients were hypotensive (systolic blood pressure <90 mmHg) on admission, with four of them requiring inotropic support in the emergency department. The majority of patients (n=36, 76.6%) had abnormal total white count, while anemia was present in about one third of

Table 2 Classification of Surgical Complications[12–13]

Grade of Complications (GOC)
Grade I: Any deviation from the normal postoperative course without the need for pharmacological treatment or surgical, endoscopic, and radiological interventions
Grade II: Requiring pharmacological treatment with drugs other than such allowed for grade I complications. Blood transfusions and total parenteral nutrition are also included
Grade III: Requiring surgical, endoscopic or radiological intervention
Grade IV: Life-threatening complication(s) requiring ICU management (including organ dysfunction)
Grade V: Death of a patient

the study group. Preoperative electrolyte imbalances were also documented in about one third of the study group. Though serum albumin was only performed in 33 (70.2%) patients, it was abnormal in 28 (84.8%) of them (Table 4).

Operative Findings

There was a wide spectrum of pathologies responsible for the small bowel perforation in our study group. The three most common etiologies were foreign body ingestion (n=8, 17.0%), adhesions (n=7, 14.9%), and malignancy (n=6, 12.8%). Tuberculosis (n=5, 10.6%) and cytomegalovirus infection (n=1, 2.1%) accounted for the infective causes. Interestingly, one of our patients had numerous small bowel perforations from Degos disease. Nearly half of the study group (48.9%) had a MPI score of >26 (Table 5).

Small bowel resection was performed in the majority of the patients (n=35, 74.5%), while right hemicolectomy was performed in another six (12.8%). Three (6.4%) patients

Table 3 Characteristics of the 47 Patients who Underwent Surgery for Small Bowel Perforation

	Parameter (%)
Median age, range (years)	68 (18–95)
≤60	21 (44.7)
>60	26 (55.3)
Gender	
Male	30 (63.8)
Female	17 (36.2)
ASA status	
1	4 (8.5)
2	9 (19.1)
3	22 (46.8)
4	12 (25.5)
Premorbid condition	
Hypertension	20 (42.6)
Diabetes mellitus	8 (17.0)
Hyperlipidemia	11 (23.4)
Ischemic heart disease	9 (19.1)
History of cerebrovascular accident	6 (12.8)
Number of premorbid condition	
0–1	31 (66.0)
2–5	16 (34.0)
Immunosuppression	
No	38 (80.9)
Yes	9 (19.1)
3 patients has HIV infection	
2 patients on chemotherapy	
1 patient has SLE on corticosteroids	
3 patients has end-stage renal failure	

Table 4 Clinical Parameters and Laboratory Investigations of the Study Group

	Parameter (%)
Median systolic blood pressure (mmHg)	115 (64–172)
Hypotensive (<90 mmHg)	11 (23.4)
Not hypotensive	36 (76.6)
Median white blood cell count ($\times 10^9$/L)	12.0 (1.3–31.7)
<4.0 or >10.0	36 (76.6)
4.0 to 10.0	11 (23.4)
Median hematocrit (%)	39.1 (20.0–57.4)
<33.0	15 (31.9)
≥33.0	32 (68.1)
Median serum sodium level (mmol/L)	134 (110–146)
<135 or >144	21 (44.7)
135–144	26 (55.3)
Median serum potassium level (mmol/L)	4.0 (3.1–8.5)
<3.5 or >5.0	13 (27.7)
3.5–5.0	34 (72.3)
Median serum urea level (mmol/L)	6.2 (1.9–58.5)
≤9.3	30 (63.8)
>9.3	17 (36.2)
Median serum creatinine level (umol/L)	94 (25–1,020)
≤110	29 (61.7)
>110	18 (38.3)
Median serum albumin level (g/L)	22 (12–43)
<35	28 (59.6)
≥35	5 (10.6)
Not performed	14 (29.8)

Table 5 Surgical Observations and Perioperative Outcome of the Study Group

	Parameter (%)
Causes of perforation	
Foreign bodies	8 (17.0)
Adhesions	7 (14.9)
Idiopathic	7 (14.9)
Malignancy	6 (12.8)
Lymphoma	4
Leiomyosarcoma	1
Metastatic lung squamous cell carcinoma	1
Tuberculosis	5 (10.6)
Ischemic bowel	3 (6.4)
Meckel's diverticulum	3 (6.4)
Small bowel diverticuli	2 (4.3)
NSAID-induced ulcerations	2 (4.3)
CMV Gut	1 (2.1)
Crohn's disease	1 (2.1)
Degos disease	1 (2.1)
Incisional Hernia	1 (2.1)
Median Mannheim peritonitis index (MPI)	26 (6–43)
≤26	24 (51.1)
>26	23 (48.9)
Nature of anastomosis	
Handsewn	20 (42.6)
Stapled	13 (27.7)
No anastomosis as no bowel resection	4 (8.5)
Stoma	10 (21.3)
Grade of complications	
No complications	11 (23.4)
Grade I	3 (6.4)
Grade II	9 (19.1)
Grade III	2 (4.3)
Grade IV	13 (27.7)
Death or Grade V	9 (19.1)
Causes of death	
Septicemia	7 (14.9)
Bronchopneumonia	1 (2.1)
Cardiogenic shock	1 (2.1)

had wedge resection of the perforated Meckel's diverticulum, while one (2.1%) underwent en bloc small bowel resection and sigmoid colectomy for a small bowel malignancy that had invaded into the sigmoid colon. Primary closure of the perforation was performed in one (2.1%) patient. In another patient (2.1%), only drainage of the abscess during laparotomy was performed as the site of perforation was not uncovered. The foreign body, which was a fish bone, was identified in the abscess cavity.

Ten (21.3%) patients had stoma created. Hand-sewn and stapled anastomoses after bowel resection were performed in 20 (42.6%) and 13 (27.7%) patients, respectively. The majority of the patients (n=30, 63.8%) had surgery within 24 h of admission, and the median duration of the surgery was 135 min (50–315 min). *Escherichia coli* and *Klebsiella pneumoniae* were the two most common microorganisms cultured from the peritoneal fluid.

Outcome

The mortality rate in our series was 19.1% (n=9) with septicemia being the cause of death in the majority of them, while another 27 (57.4%) patients had associated perioperative morbidity. The median length of stay was 15 days (range, 4–150 days; Table 5).

There were five (11.8%) patients who developed wound dehiscence, while another patient (2.1%) had postoperative anastomotic leak that necessitated relook laparotomy. Two patients underwent tracheostomy for prolonged ventilation. One patient developed intra-abdominal abscess that failed percutaneous drainage and required laparotomy and drainage.

Analysis—Complications

Worse complications (GOC III to V) occurred more frequently in patients who had higher ASA scores (3–4), MPI>26, or were hypotensive on admission. Preoperative renal impairment, electrolyte imbalances, and creation of stoma were also associated with poorer outcome. Factors such as age, gender, type of anastomosis, and duration of surgery were not related. The three independent variables that were related to significant complications (GOC III to V) after multivariate analysis were MPI>26, hypotension on presentation, and an abnormal serum potassium level (Table 6).

Analysis—Stoma Creation

In our series, stoma was created in patients with higher ASA score (3–4) and MPI>26. Other risk factors included abnormal serum sodium and urea levels and hypotension on admission. After multivariate analysis, the independent variables were MPI>26, hypotension on presentation, and abnormal serum urea level (Table 7).

Discussion

Though our mortality rate was comparable to other series at 19.1%, it was still considerable. Apart from mortality, most of our patients had perioperative morbidity as only 11

Table 6 Analysis of the 47 Patients who had Worse Perioperative Outcome

Characteristics	GOC 0–II (n=23)	GOC III–V (n=24)	OR (95% CI)	P value
>60 years old	10 (43.5%)	16 (66.7%)	2.60 (0.80–8.49)	>0.05
Female gender	8 (34.8%)	9 (37.5%)	1.13 (0.34–3.70)	>0.05
ASA score 3–4	11 (47.8%)	23 (95.8%)	25.09 (2.89–218.28)	<0.001
≥2 premorbid conditions	6 (26.1%)	10 (41.7%)	2.02 (0.59–6.96)	>0.05
MPI>26	4 (17.4%)	19 (79.2%)	18.05 (4.19–77.76)	<0.001[a]
Hypotensive	1 (4.3%)	10 (41.7%)	16.15 (1.85–141.32)	0.004[a]
Abnormal WBC	18 (78.3%)	18 (75.0%)	0.83 (0.22–3.23)	>0.05
Hct (<33.0) (%)	6 (26.1%)	9 (37.5%)	1.60 (0.46–5.59)	>0.05
Abnormal serum sodium level	5 (21.7%)	16 (66.7%)	7.20 (1.95–26.54)	0.003
Abnormal serum potassium level	2 (8.7%)	11 (45.8%)	8.89 (1.69–46.63)	0.008[a]
Serum urea >9.3 (mmol/L)	3 (13.0%)	14 (58.3%)	9.33 (2.17–40.18)	0.002
Serum creatinine >110 (umol/L)	4 (17.4%)	14 (58.3%)	6.65 (1.73–25.64)	0.006
Serum albumin <35 (g/L)	10/13 (76.9%)	18/20 (90.0%)	2.70 (0.39–18.96)	>0.05
Operation after 24 h from admission	5 (21.7%)	9 (37.5%)	1.37 (0.38–4.89)	>0.05
Creation of stoma	1 (4.3%)	9 (37.5%)	13.20 (1.51–115.35)	0.010
Stapled anastomosis	8/19 (42.1%)	5/14 (35.7%)	0.76 (0.18–3.17)	>0.05
Duration of operation >2 h	10 (43.5%)	16 (66.7%)	2.60 (0.80–8.49)	>0.05

[a] Statistically significant on multivariate analysis

(23.4%) were discharged well without any perioperative complications. Some of the factors associated with poorer outcome in our series included worse peritoneal contamination and significant physiological derangement.

MPI has been recently adopted in our institution due to its ease of application and its ability to predict the outcome of patients according to the severity of the peritonitis.[14] This was affirmed in our series as patients with higher MPI scores were associated with worse perioperative outcome. Despite the advent of other scoring systems such as physiologic and operative severity score for the enumeration of mortality and morbidity and acute physiology and chronic health evaluation, the authors felt that MPI still has its roles in predicting surgical outcome in patients with peritonitis.

Besides MPI, those patients who were hypotensive or had deranged electrolyte levels were also more likely to

Table 7 Risk Factors Associated with Stoma Creation

Characteristics	No stoma (n=37)	Stoma created (n=10)	OR (95% CI)	P value
>60 years old	19 (51.4%)	7 (70.0%)	2.21 (0.49–9.89)	>0.05
Female gender	14 (37.8%)	3 (30.0%)	0.70 (0.16–3.18)	>0.05
ASA score 3–4	24 (64.9%)	10 (100.0%)	NA	0.043
≥2 premorbid conditions	13 (35.1%)	3 (30.0%)	0.79 (0.18–3.59)	>0.05
MPI>26	15 (40.5%)	8 (80.0%)	5.87 (1.09–31.56)	0.036[a]
Hypotensive	5 (13.5%)	6 (60.0%)	9.60 (1.98–46.50)	0.006[a]
Abnormal WBC	29 (78.4%)	7 (70.0%)	0.64 (0.16–3.07)	>0.05
Hct (<33.0) (%)	10 (27.0%)	5 (50.0%)	2.70 (0.64–11.36)	>0.05
Abnormal serum sodium level	16 (43.2%)	5 (50.0%)	1.31 (0.32–5.32)	0.003
Abnormal serum potassium level	9 (24.3%)	4 (40.0%)	2.07 (0.48–9.03)	>0.05
Serum urea >9.3 (mmol/L)	9 (24.3%)	8 (80.0%)	12.44 (2.22–69.63)	0.002[a]
Serum creatinine >110 (umol/L)	12 (32.4%)	6 (60.0%)	3.13 (0.74–13.19)	>0.05
Serum albumin <35 (g/L)	20/25 (80.0%)	8/8 (100.0%)	NA	>0.05
Operation after 24 h from admission	11 (29.7%)	6 (60.0%)	3.55 (0.83–15.09)	>0.05
GOC III to V	15 (40.5%)	9 (90.0%)	13.20 (1.51–115.35)	0.010
Duration of operation >2 h	18 (48.6%)	8 (80.0%)	4.22 (0.79–22.62)	>0.05

[a] Statistically significant on multivariate analysis

fare worse. The authors postulated that these factors would imply the depletion of any remaining physiological reserves, and these physiological derangements are often direct consequences of severe peritonitis.[15,16]

Also seen in our series and several others in the literature, the numerous pathologies responsible for the small bowel perforation made early preoperative diagnosis difficult. No specific clinical or laboratory finding has been shown to be specific enough.[2,3] Pneumoperitoneum on chest radiographs is often absent[2] and was seen in only 23.4% of our patients. These issues have resulted in the increased adoption of CT scans in the evaluation of patients presenting with acute abdomen in our institution and was performed in 68.1% of our patients. Some of the CT features suggestive of bowel perforation would include extraluminal air and oral contrast extravasation.[17] CT scan is also useful to differentiate bowel perforation from other acute abdominal conditions such as acute pancreatitis that could be managed non-operatively.

One of our most interesting cases must be the patient who had small bowel perforations from Degos disease. Degos disease causing bowel perforation is extremely rare with very few cases reported in the literature.[18] Degos disease is an occlusive arteriopathy involving small caliber vessels and is often progressive. It often leads to tissue infarction and its systemic variant involving the gastrointestinal tract is perhaps the most aggressive.[18] Intestinal perforation, like in our patient, is one of its most severe complications and accounts for majority of the mortalities in patients with systemic Degos disease. Our patient was discharged well but passed away few months later from other related complications.

Tuberculosis is the main infective etiology in our series. It typically affects the ileocecal area, and its management is often challenging.[19,20] Some of the complications that mandate surgical intervention would include perforation, bowel obstruction, and hemorrhage. The nutritional state of the patient, condition of the bowel, and length of diseased segments are just some of the factors to consider during surgery in these patients.[19,20]

Though seen in one patient, Crohn's disease is one of the more common pathologies responsible for small bowel perforation in the West.[1–4] The perforation may arise from active disease process, secondary to distal obstruction, or a consequence of steroid therapy.[3,4,21,22] While some authors advocated aggressive early surgical resection,[21] others have suggested nonsurgical treatment unless clinically indicated.[22] But when surgery is indicated, resection of the involved segment is the treatment of choice. Differentiation between Crohn's disease and tuberculosis is difficult as their clinical presentations, radiological features, operative findings, and even histological evaluation can be very similar.[21,22]

In our series, there were six (12.8%) patients who had perforation from small bowel malignancy. Perforation in malignant small bowel tumors could arise from tumor necrosis, bowel ischemia, or increased intraluminal pressure secondary to distal bowel obstruction.[23,24] The most common histological subtypes of primary small bowel cancers resulting in small bowel perforation include lymphoma, adenocarcinoma, and sarcoma, while metastatic lesions from various organs could also be responsible.[23,24]

Though the etiologies of small bowel perforation vary greatly, the surgical principles are perhaps less controversial. Early containment of the contamination, copious lavage, and resection of the diseased segment should be adopted. Even though suture plication of the perforation site was performed in one of our patients, this is no longer practiced in our institution. If possible, bowel resection and primary anastomosis is the treatment of choice. Apart from removing the diseased segments, resection also allows sufficient histological and/or microbiological evaluation of the specimen.[2–4] In cases of perforated Meckel's diverticulum, wedge resection of the diverticulum is acceptable.[25]

Primary small bowel anastomosis has generally been considered safe.[8] Some of the risk factors associated with anastomotic dehiscence would include hypoalbuminemia, hypotension, and peritonitis.[9,10] Fortunately, there was only one patient in our series with this adverse outcome. The authors postulated that our low rate of anastomotic dehiscence could be because stoma was created in a sizeable proportion of our patients (n=10, 21.3%). Even though those patients who had stoma created fared worse, the authors attributed this to the underlying factors that necessitated its creation rather than the procedure itself. Hence, the decision to exteriorize or primary anastomose after small bowel resection is perhaps dependent on the degree of physiological derangement, severity of peritoneal contamination, and the condition of the bowel.

Comparing our series to those in the literature,[1–4] the prevalence of the various etiologies appears to be geographically and economically related. While typhoid fever is the most common causation in developing countries, this is not the case in developed countries. And while Crohn's disease is a rare entity in Asians, tuberculosis is rarely seen in the West. The proportion of foreign body ingestion causing perforation is also likely to remain constant or rise in any graying population. The rise of HIV infection worldwide will likely bring about a new wave of infective causation, already evident by the number of tuberculosis and cytomegalovirus related perforations in our series.

Conclusion

Surgery for small bowel perforation is associated with significant morbidity and mortality rates. Patients with more severe peritonitis and physiological derangement were more likely to fare worse.

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