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ORIGINAL ARTICLE

Predictors of Outcome Following Surgery in Colonic Perforation: An Institution's Experience Over 6 Years

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Abstract
Background Colonic perforation is associated with abysmal outcome. The aims of our study were to review the surgical outcome of patients with perforated colon and to identify factors predicting peri-operative complications.
Methods A retrospective review of all patients who underwent surgery for colonic perforation from January 2003 to August 2008 was performed. Patients with iatrogenic or traumatic perforation were excluded. The severity of abdominal sepsis was graded using the Mannheim peritonitis index (MPI).
Results A total of 129 patients, with median age of 65 years (22–97 years), formed the study group. While 29.5% had severe peritoneal contamination, 56.6% had an American Society of Anesthesiologists (ASA) score ≥3. Sigmoid colon (47.3%) and caecum (24.8%) were the most common sites of perforation. Diverticulitis and malignancy were the diagnoses in 51.9% and 34.9%, respectively. Hartmann's procedure and right hemicolectomy were performed in 43.4% and 34.1% of the patients, respectively. Stoma was created in 59.7%. The in-hospital mortality rate in our series was 15.5%. After multivariate analysis, the independent variables associated with worse peri-operative complications were ASA score ≥3, MPI >26 and creation of stoma. Malignant perforation was associated with higher ASA score and lower haematocrit level compared to diverticular perforation. Stoma was created more frequently in patients with MPI >26 and left-sided perforation, and was associated with worse complications.
Conclusions Surgery for colonic perforation is associated with high morbidity and mortality rates. Short-term outcome is determined by ASA score and severity of peritonitis. A lower haematocrit level must alert the possibility of malignancy.

Keywords Perforation · Colon · Treatment outcome · Surgery

Introduction

Large-bowel perforation is a surgical emergency fraught with numerous complications.[1–4] Despite advances in surgical techniques and peri-operative care, their outcome remained abysmal.[1–4] Advanced age, worse degree of peritonitis and malignant perforation were some of the associated factors.[1–4]

With majority of current literature based on the Western population, a true reflection of the numerous issues surrounding large-bowel perforation in Asians is lacking. Firstly, Asians have a higher incidence of right-sided diverticulosis comparatively, and the sites and incidences of colorectal malignancy have also been reported to differ significantly between these two populations.[5–8]

Differentiation between malignant from diverticular perforation is also crucial as it determines the extent of surgery, but data are limited in the current literature.[9] Furthermore, the ideal surgical procedure in tackling colonic perforation is still controversial with a wide spectrum of recommendations.[10–15]

All these issues prompted us to undertake this study with the primary aim to review the outcome of patients who underwent surgery for colonic perforation. Our secondary aims were to evaluate the various factors predicting peri-operative complications, differences between diverticular and malignant perforations and also to compare right and left-sided perforations.

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Methods

Study Population

Tan Tock Seng Hospital is a 1,400-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 surgery for colonic perforation from January 2003 to August 2008 was performed. Patients were identified from the hospital's diagnostic index and operating records.

Right-sided pathologies were regarded if it was sited from the caecum until the transverse colon while left-sided pathologies commenced from the splenic flexure. Patients with colonic perforation from abdominal trauma or iatrogenic causes were excluded. Prior to the surgery, fluid resuscitation, parenteral antibiotics, optimisation of their medical conditions and nasogastric decompression would be administered to every patient. All gastrointestinal anastomoses were either hand-sewn or stapled while stoma created could be either a defunctioning or an end stoma.

The data collected included age, gender, American Society of Anesthesiologists (ASA) score, co-morbid conditions, presenting signs and symptoms, and clinical parameters. Laboratory values, including full blood count and renal panel, were also recorded. In addition, duration from symptoms to surgery, duration from admission to surgery, operative findings and interventions, length of surgery, peri-operative 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) (Table 1) with a score of >26 being defined as severe.[16] All colorectal cancers were staged according to the guidelines of the American Joint Committee of Cancer (AJCC).[17] The grades of complications (GOC) were in concordance to the classification proposed by Clavien and group (Table 2).[18–20]

Statistical analysis was performed using both univariate and multivariate analyses. The variables were analysed 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 17.0 statistical package (Chicago, Illinois); all p values reported are two-sided, and p values of <0.05 were considered statistically significant

Table 1 MPI[16]

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

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

Results

During the study period, 129 patients, median age of 65 years (range, 22–97 years), underwent surgery for colonic perforation. More than half (56.6%) of the patients had an ASA score of ≥3 (n=73). Hypertension, hyperlipidaemia and diabetes mellitus were the most common premorbid conditions in 57 (44.2%), 27 (20.9%) and 25 (19.4%) patients, respectively. Pre-operative computed tomography (CT) scan was performed in 77 (59.7%) patients. Table 3 illustrates the characteristics of the study group.

Operative Findings

The median MPI score was 20 (range 0–43) with 38 (29.5%) patients having severe peritonitis (MPI >26). Left-sided perforation occurred more frequently (n=77, 59.7%), with sigmoid colon involved in 61 (47.3%) patients. Diverticulitis and malignancy were the most common aetiologies in 67 (51.9%) and 45 (34.9%) patients, respectively. Table 4 highlights the surgical observations and procedures performed.

Hartmann's procedure was performed most frequently in 56 (43.4%) patients, followed by right hemicolectomy (n=44, 34.1%) and anterior resection (n=13, 10.1%). In total, 77 (59.7%) patients had stoma created. As shown in Table 5, the in-hospital mortality rate in our series was 15.5% (n=20), with only 31 (24.0%) patients discharged well without any complications. The median length of stay was 10 days (2–141 days).

Analysis of the Complications

Worse complications (GOC III to V) occurred more frequently in patients of advanced age, higher ASA score (3–4), MPI >26, pre-operative renal impairment and in patients who had stoma created (Table 6). After multivariate

Table 2 Classification of surgical complications[18–20]

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

analysis, the independent factors were high ASA score, MPI >26 and stoma creation. Factors such as malignancy and site of perforation were not related.

Analysis for the Comparison Between Diverticular and Malignant Perforations

Patients with malignant perforation had a higher ASA score and lower haematocrit level compared to those with perforated diverticulitis (Table 7). The other factors such as MPI, age, site of perforation and grading of complications were not significant.

Table 3 Characteristics of the study group

	Number (%)
Median age, range (yrs)	65 (22–97)
≤60	52 (40.3)
>60	77 (59.7)
Gender	
Male	68 (52.7)
Female	61 (47.3)
ASA score	
1	12 (9.3)
2	44 (34.1)
3	58 (45.0)
4	15 (11.6)
Premorbid condition	
Hypertension	57 (44.2)
Diabetes mellitus	25 (19.4)
Hyperlipidaemia	27 (20.9)
Ischaemic heart disease	14 (10.9)
History of cerebrovascular accident	8 (6.2)
Number of premorbid condition	
0–1	91 (70.5)
>1	38 (29.5)
Pre-operative CT scan	
Performed	77 (59.7)
Not performed	52 (40.3)

Analysis for the Comparison Between Right- and Left-Sided Perforations

Surgery in left-sided perforations usually took longer and often resulted in the creation of stoma (Table 8). Other factors such as age, ASA score, MPI and haematological results were not related.

Comparison of Stoma vs. No Stoma

The independent variables associated with stoma creation included MPI >26, left-sided perforation and malignant perforation (Table 9). Patients with stoma also fared worse than those without. ASA score was not an independent factor after multivariate analysis.

Discussion

To our knowledge, our series is one of the largest focusing on the numerous issues surrounding colonic perforation in an Asian population. Similar to the Western population, diverticulosis and colorectal cancers accounted for majority (86.8%) of the pathologies;[2–4] however, the differences in the distribution of diverticulosis and colorectal malignancy in Asians from their Western counterparts resulted in the paucity of related information in the literature.[5–8] Colorectal malignancies in Asians have been shown to occur more frequently at a younger age and were less advanced comparatively. This phenomenon has been attributed to genetic risk factors, cancer biology or other uncharacterized carcinogens.[5,6]

In addition, the incidence of right colonic diverticulosis is much higher in Asians, and its complications present in younger adults more frequently.[7,8] This has resulted in a significant proportion of patients undergoing unnecessary surgery on the misdiagnosis of acute appendicitis.[9] To complicate matters, left-sided diverticuli in the elderly Asian population still result in similar complications observed in the Western population.[21–23] This is also seen

Table 4 Surgical observations and procedures of the study group

	Number (%)
Mannheim peritonitis index (MPI)	20 (0–43)
≤26	91 (70.5)
>26	38 (29.5)
Site of perforation	
Right-sided	52 (40.3)
Caecum	32 (24.8)
Ascending Colon	10 (7.8)
Hepatic flexure	2 (1.6)
Transverse colon	8 (6.2)
Left-sided	77 (59.7)
Splenic Flexure	1 (0.8)
Descending Colon	4 (3.1)
Sigmoid Colon	61 (47.3)
Rectosigmoid	5 (3.9)
Upper rectum	6 (4.7)
Cause of perforation	
Diverticulitis	67 (51.9)
Hinchey II	29
Hinchey III	27
Hinchey IV	11
Malignancy	45 (34.9)
Stage I	0 (0.0)
Stage II	9 (20.0)
Stage III	20 (44.4)
Stage IV	16 (35.6)
Ischaemic colitis	6 (4.7)
Severe appendicitis causing caecal perforation	4 (3.1)
Stercoral ulcer	4 (3.1)
Tuberculosis	1 (0.8)
Volvulus	1 (0.8)
Idiopathic	1 (0.8)
Surgery performed	
Hartmann's procedure	56 (43.4)
Right hemicolectomy with/without stoma	44 (34.1)
Anterior resection with/without stoma	13 (10.1)
Subtotal or total colectomy	7 (5.4)
Defunctioning stoma	4 (3.1)
Sigmoid colectomy	3 (2.3)
Left hemicolectomy	1 (0.8)
Primary closure of perforation	1 (0.8)
Creation of stoma	
Yes	77 (59.7)
No	52 (40.3)
Duration of surgery	
≤120 min	45 (34.9)
>120 min	84 (65.1)

Table 5 Peri-operative outcome of the study group

	Number (%)
Grade of complications	
No complications	31 (24.0)
Grade I	16 (12.4)
Grade II	21 (16.3)
Grade III	9 (7.0)
Grade IV	32 (24.8)
Death or grade V	20 (15.5)
Median length of stay (days)	10 (2–141)

in our series with the majority (64%) of the perforated diverticulitis sited in the left colon.

Differentiation between malignant and diverticular perforation still confounds surgeons worldwide. This is especially so since their radiological findings could be indistinct;[24–27] however, this difference is crucial as it determines the extent of surgical resection. Through our series, it would be prudent to be suspicious of any underlying malignancy in patients with colonic perforation also having low haematocrit levels. Interestingly, despite reported worse outcome in malignant perforation,[28,29] this was not seen in our series. Though this association had been attributed to the higher likelihood of diffuse peritonitis in malignant perforation compared to a contained abscess in diverticulitis,[28,29] the majority of our patients with diverticular perforations actually had Hinchey III or IV diseases, and there was no notable difference in the severity of peritonitis from their MPI scores.

Our series also affirmed the high morbidity and mortality rates associated with colonic perforation.[1–4] Our mortality rate of 15.5% is similar to those quoted in other series while another 31.8% of our patients also had significant complications (GOC III–IV). Some of the independent factors in our series that are accountable for these abysmal results included worse peritonitis (MPI >26) and higher ASA score.

Suffice to say, it is the severity of peritonitis and not the surgical procedure or the underlying diagnoses that is responsible for the outcome. MPI has been adopted in our institution in recent years and has been shown to correspond to the patients' outcome.[9,30–32]

Compared to right-sided perforation, over 80% of our patients with left-sided perforation had stoma created with Hartmann's procedure accounting for 90% of them. Even though there was no difference seen in the degree of peritonitis or ASA score, the likely explanation for this difference is due to the higher quoted incidence of an anastomotic dehiscence in a colocolic or colorectal anastomosis compared to an ileo-colic anastomosis, especially in an unprepared colon.[33,34]

Table 6 Analysis of variables associated with worse peri-operative outcome

Characteristics	GOC 0–II (n=68; %)	GOC III–V (n=61; %)	OR (95% CI)	P value
>60 years old	33 (48.5)	44 (72.1)	**2.75 (1.32–5.72)**	**0.007**
Female gender	33 (48.5)	28 (45.9)	0.90 (0.45–1.80)	>0.05
ASA score 3–4	20 (29.4)	53 (86.9)	**15.90 (6.41–39.43)**	**<0.001**[a]
≥2 premorbid conditions	15 (22.1)	23 (37.7)	2.14 (0.99–4.63)	0.056
MPI >26	2 (2.9)	36 (59.0)	**47.52 (10.64–212.21)**	**<0.001**[a]
WBC >10.0	44 (64.7)	39 (63.9)	0.97 (0.47–1.99)	>0.05
HCT (<33.0) (%)	17 (25.0)	25 (41.0)	2.08 (0.99–4.41)	>0.05
Abnormal serum sodium level	13 (19.1)	23 (37.7)	**2.56 (1.16–5.68)**	**0.030**
Abnormal serum potassium level	17 (25.0)	22 (36.1)	1.69 (0.79–3.61)	>0.05
Serum Urea >9.3 (mmol/L)	5 (7.4)	26 (42.6)	**9.36 (3.30–26.55)**	**<0.001**
Serum creatinine >110 (μmol/L)	10 (14.7)	29 (47.5)	**5.26 (2.27–12.16)**	**<0.001**
Left-sided perforation	36 (52.9)	41 (67.2)	1.82 (0.89–3.73)	>0.05
Creation of stoma	25 (36.7)	52 (85.2)	**9.94 (4.20–23.54)**	**<0.001**[a]
Duration of operation >2 h	48 (70.6)	36 (59.0)	0.60 (0.29–1.25)	>0.05
Malignant perforation	24 (35.3)	21 (34.4)	0.96 (0.47–1.99)	>0.05

[a] Statistically significant on multivariate analysis

Bold figures are statistically significant

Apart from the site of perforation, stoma was also created more frequently in patients with underlying malignancy, worse peritonitis and higher ASA score. This is not surprising as stoma has always been advocated in patients with anticipated worse outcome.[11,35,36] The higher rate of complications seen in patients who had stoma created merely reflected the worse cohort of patients that necessitated its formation.

As seen in our series, Hartmann's procedure is the most frequently performed surgery as it has been shown to be a safe surgical option in our patients, who are mostly of advanced age with poor ASA score. Furthermore, the shorter operative time compared to an anterior resection also reduces the risks of a lengthier surgery and negates the complications of a primary anastomosis; however, the morbidity from a stoma is not negligible and numerous patients often ended up with a

Table 7 Comparison of patients with diverticulitis against malignancy

Characteristics	Diverticulitis (n=67; %)	Malignancy (n=45; %)	OR (95% CI)	P value
>60 years old	39 (58.2)	28 (62.2)	1.18 (0.55–2.56)	>0.05
Female gender	30 (44.8)	23 (51.1)	1.29 (0.61–2.75)	>0.05
ASA score 3–4	32 (47.8)	30 (66.7)	**2.19 (1.00–4.80)**	**0.055**
≥2 premorbid conditions	21 (31.3)	13 (28.9)	0.89 (0.39–2.03)	>0.05
MPI >26	15 (22.4)	14 (31.1)	1.57 (0.67–3.68)	>0.05
WBC >10.0	45 (67.2)	25 (55.6)	0.61 (0.28–1.33)	>0.05
HCT (<33.0) (%)	8 (11.9)	25 (55.6)	**9.22 (3.59–23.69)**	**<0.001**
Abnormal serum sodium level	15 (22.4)	16 (35.6)	1.91 (0.83–4.42)	>0.05
Abnormal serum potassium level	18 (26.9)	14 (31.1)	1.23 (0.54–2.82)	>0.05
Serum Urea >9.3 (mmol/L)	18 (26.9)	10 (22.2)	0.78 (0.32–1.89)	>0.05
Serum Creatinine >110 (μmol/L)	20 (29.9)	14 (31.1)	1.06 (0.47–2.41)	>0.05
Left-sided perforation	43 (64.2)	25 (55.6)	0.70 (0.32–1.51)	>0.05
Duration of surgery >120 min	45 (67.2)	29 (64.4)	0.89 (0.40–1.96)	>0.05
GOC III to V	28 (41.8)	21 (46.7)	1.22 (0.57–2.61)	>0.05

Bold figures are statistically significant

Table 8 Analysis of variables associated with site of perforation

Characteristics	Right-sided perforation (n=52; %)	Left-sided perforation (n=77; %)	OR (95% CI)	P value
>60 years old	26 (50.0)	51 (66.2%)	1.96 (0.96–4.03)	>0.05
Female gender	28 (53.8)	33 (42.9)	0.64 (0.32–1.31)	>0.05
ASA score 3–4	26 (50.0)	47 (61.0)	1.57 (0.77–3.19)	>0.05
≥2 premorbid conditions	12 (23.1)	26 (33.8)	1.70 (0.76–3.78)	>0.05
MPI >26	12 (23.1)	26 (33.8)	1.70 (0.76–3.78)	>0.05
WBC >10.0	35 (67.3)	48 (62.3)	0.80 (0.38–1.69)	>0.05
HCT (<33.0) (%)	17 (32.7)	25 (32.5)	0.99 (0.47–2.10)	>0.05
Abnormal serum sodium level	14 (26.9)	22 (28.6)	1.09 (0.49–2.39)	>0.05
Abnormal serum potassium level	15 (28.8)	24 (31.2)	1.12 (0.52–2.41)	>0.05
Serum urea >9.3 (mmol/L)	9 (17.3)	22 (28.6)	1.91 (0.80–4.57)	>0.05
Serum creatinine >110 (μmol/L)	9 (17.3)	30 (39.0)	**3.05 (1.30–7.15)**	**0.011**
Creation of stoma	15 (28.8)	62 (80.5)	**10.20 (4.48–23.23)**	**<0.001**[a]
Duration of operation >2 h	28 (53.8)	56 (72.7)	**2.29 (1.09–4.80)**	**0.038**[a]

[a] Statistically significant on multivariate analysis

Bold figures are statistically significant

permanent stoma due to the challenges incurred during reversal of Hartmann's procedures.[15,37–39]

Ultimately, the ideal surgical procedure to perform should be left to the discretion of the primary surgeon at the time of operation. As seen in our series and others in the literature, some of the factors that must be considered would include the site of perforation, state of the bowel, underlying pathology, degree of contamination and haemodynamic stability and physiological status of the patient.

As with most studies, there were several limitations in the present one. This series of patients was enrolled from a single institution, and despite our study being one of the largest in the literature, its retrospective nature and the relatively small number of patients may mask several other important factors that could be accountable for the outcomes measured. In addition, there were no prior standardised guidelines or protocol in the management of patients with colonic perforation, and any decisions were based on the discretion of the primary surgeon.

Although these limitations are significant, the authors felt that this study remains important in highlighting the numerous issues pertinent in colonic perforation that are

Table 9 Characteristics associated with stoma creation

Characteristics	No stoma (n=52; %)	Stoma created (n=77; %)	OR (95% CI)	P value
>60 years old	28 (53.8)	49 (63.6)	1.50 (0.73–3.07)	>0.05
Female gender	29 (55.8)	32 (41.6)	0.56 (0.28–1.15)	>0.05
ASA score 3–4	17 (32.7)	56 (72.7)	**5.49 (2.55–11.81)**	**<0.001**
≥2 premorbid conditions	14 (26.9)	24 (31.2)	1.23 (0.56–2.68)	>0.05
MPI >26	2 (3.9)	36 (46.8)	**21.95 (4.98–96.68)**	**<0.001**[a]
WBC >10.0	37 (71.2)	46 (59.7)	0.60 (0.28–1.28)	>0.05
HCT (<33.0) (%)	8 (15.4)	34 (44.2)	**4.35 (1.81–10.46)**	**0.001**
Abnormal serum sodium level	7 (13.5)	29 (37.7)	**3.88 (1.55–9.75)**	**0.003**
Abnormal serum potassium level	14 (26.9)	25 (32.5)	1.31 (0.60–2.84)	>0.05
Serum urea >9.3 (mmol/L)	4 (7.7)	27 (35.1)	**6.48 (2.11–19.91)**	**<0.001**
Serum creatinine >110 (μmol/L)	5 (9.6)	34 (44.2)	**7.43 (2.67–20.73)**	**<0.001**
GOC III to V	9 (17.3)	52 (67.5)	**9.94 (4.20–23.54)**	**<0.001**[a]
Left-sided perforation	15 (28.8)	62 (80.5)	**10.20 (4.48–23.23)**	**<0.001**[a]
Malignant perforation vs. diverticulitis	14/49 (28.6)	31/63 (49.2)	**2.42 (1.10–5.35)**	**0.033**[a]
Duration of operation >2 h	33 (63.5)	51 (66.2)	1.13 (0.54–2.36)	>0.05

[a] Statistically significant on multivariate analysis

Bold figures are statistically significant

rarely seen in the Western population or reported in the literature. Our study also identified various factors that could perhaps aid all surgeons in the management of patients with colonic perforation.

Conclusions

Surgery for colonic perforation is associated with high morbidity and mortality rates. Short-term outcome is determined by ASA score and severity of peritonitis but not aetiology or site of the perforation. A lower haematocrit level must alert the possibility of malignant perforation.

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