European Journal of Trauma and Emergency Surgery (2019) 45:705–711
https://doi.org/10.1007/s00068-018-0968-x

ORIGINAL ARTICLE

"Second-look" laparotomy: warranted, or contributor to excessive open abdomens?

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Received: 29 December 2017 / Accepted: 31 May 2018 / Published online: 9 June 2018

Abstract

Introduction The overuse of temporary abdominal closure and second look (SL) laparotomy in emergency general surgery (EGS) cases has been questioned in the recent literature. In an effort to hopefully decrease the number of open abdomen (OA) patients, we hypothesize that reviewing our cases, many of these SL patients could be managed with single-stage operative therapy and thus decrease the number of OA patients.

Methods This is a retrospective review of prospectively collected data from Jun 2013–Jun 2014, evaluating EGS patients managed with an OA who required bowel resection in either index or SL laparotomy. Demographics, clinical variables, complications and mortality were collected. Fisher's exact *t* test was used for statistical analysis.

Results During this time frame, 96 patients were managed with OA and 59 patients required a bowel resection. 55 (57%) of those required one bowel resection at the index operation with 4 (4.2%) only requiring one bowel resection at the second operation. In the patients requiring bowel resections, 18 (30%) required a resection at SL. At SL laparotomy, resection was required for questionably viable bowel at the index operation 60% (11), whereas 39% (7) had normal appearing bowel. Indications for resection at SL laparotomy included evolution of existing ischemia, new onset ischemia, staple line revision, and "other". 23 patients (39%) were hemodynamically unstable, contributing to the need for temporary abdominal closure. In the multivariate analysis, preoperative shock was the only predictor of need for further resection. Complications and mortality were similar in both groups.

Conclusion Almost one-fifth of the patients undergoing SL laparotomy for open abdomen required bowel resections, with 6.8% of those having normal appearing bowel at index operation, therefore in select EGS patients, SL laparotomy is a reasonable strategy.

Keywords Second look · Relook laparotomy · Bowel ischemia · Bowel resection · And mesenteric ischemia

Background

The use of open abdomen (OA) techniques has been well described in the literature for damage control in trauma, emergency general and vascular surgery. This technique is used in severely injured, critically ill patients in whom a limited operation is desired while concurrently dealing with massive transfusions, resuscitation, and correction of acidosis and/or hypothermia [1–5]. Damage control (DC) has been used in emergency surgery for patients with conditions including abdominal compartment syndrome (ACS), severe pancreatitis, and intra-abdominal sepsis [5, 6].

Further uses of the OA technique for general surgery (EGS) patients include mesenteric ischemia, pneumoperitoneum/perforated viscus, excess contamination, gastrointestinal bleed and other diagnoses [7, 8]. One of the predominant

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indications for OA and second look (SL) laparotomy in EGS patients is often bowel viability, which can be ambiguous in the first operation secondary to hypotension, severe acidosis, acute blood loss, hypothermia and other conditions. First introduced by Shaw in 1965 for mesenteric ischemia, "second-look" laparotomy utilized the OA concept and illustrated improvements in mortality [9]. Supportive measures and optimization of hemodynamics between operations may lead to the salvage of questionable segments of intestine [10, 11].

While there are many potential advantages of SL laparotomy, resection of bowel in the second case ranges widely from 10 to 100% in the literature, thus in a subset of patients, SL techniques may be over utilized [11–18]. OA management clearly has pitfalls and its use should be restricted to cases where it is absolutely necessary as noted in the American Association for the Surgery of Trauma prospective study, illustrating OA management as one of the two factors associated with anastomotic failure [7]. Additionally, the risk of surgical site infection, fistula, and overall morbidity is higher in the EGS patient managed with an OA [19, 20].

We sought to better examine our EGS patients managed with an OA focusing on the need for additional bowel resections at SL. We hypothesized that SL was being over utilized and many of these patients could be managed with single-stage operation, decreasing the number of OA patients, and associated morbidity.

Methods

After institutional review board approval was obtained, patients managed with an OA from June 1, 2013 to June 1, 2014, at the University of Maryland Medical Center, a large tertiary referral center for the state, were prospectively enrolled in this observational study. For the purposes of this study, we retrospectively reviewed this prospectively collected data. OA patients were defined as those patients undergoing operative therapy for which the surgeon of record proceeded with temporary abdominal closure at the index operation. The type of temporary abdominal closure was at the discretion of the surgeon. At our institution, the two methods include a modified Barker noncommercial vacuum dressing or a commercial wound closure system. Patients were included if they were admitted to the emergency general surgery service and required a temporary abdominal closure after index laparotomy with a bowel resection during either the index operation, SL laparotomy or both operations. Patients transferred to the medical center with an OA were excluded.

Patient demographics and clinical variables were prospectively collected. The Charlson Comorbidity Index (CCI) was calculated in the standard fashion [21]. The operative diagnosis was recorded from surgeon documentation and included small bowel obstruction, mesenteric ischemia, incarcerated hernia, sepsis, perforated viscus, gastrointestinal bleed, or "other". SL was defined when the surgeon elected to leave the abdomen open at the index operation. Preoperative variables collected for the index operation included symptoms upon presentation, shock index SI (heart rate/systolic blood pressure), shock (defined as vasopressor support required to maintain Mean Arterial Pressure > 65), the presence or absence of peritonitis on initial physical exam and imaging studies performed.

Intraoperative variables recorded from the index operation were retrospectively collected from the anesthesia record. Intraoperative use of vasopressor medications, crystalloid infusion amounts, and transfusion requirements were collected. Indications for resection performed, type of anastomosis and criteria for open abdomen at SL laparotomy were extracted from operative notes comparatively between those requiring second resection (SLR) versus no resection (SLNR). Interim resuscitation and time between operations were documented. Sub-group analysis of patients with embolic versus non-occlusive mesenteric ischemia NOMI were compared.

Discharge disposition and in-hospital mortality were recorded. The Social Security Death Index was used to assess morality within the initial 6-month and 1-year periods after discharge. Surgical site infections (SSIs) were recorded and were classified according to the Centers for Disease Control and Prevention classification: superficial incisional, deep incisional, and organ space infections. In determining the presence of wound-related SSI (non-organ space SSIs), the deepest level of infection was counted, in an effort to not overestimate the number of SSIs. Other complications that were compared included anastomotic failure, enteric fistula and fascial dehiscence.

Continuous variables are presented as mean with standard deviation. Categorical variables are presented as mean and percentage or median and interquartile range. Nonparametric test for trend (Cochran–Armitage trend test) was used for the ordered group of age to test for trend in proportions for in-hospital and 6-month mortality. Fisher's exact test was used for categorical variables. Unpaired *t* test was used to compare means between two groups. In an effort to adjust for individual patient risk factors, a multivariate logistic regression model was created to assess the difference between those requiring resection at SL (SLR) versus no resection (SLNR). Odds ratios (ORs) and confidence intervals (CIs) were reported for the logistic model. Statistical significance was assumed at $p < 0.05$. SAS 9.4 software (SAS Institute, Cary, NC) was used to complete the statistical analysis.

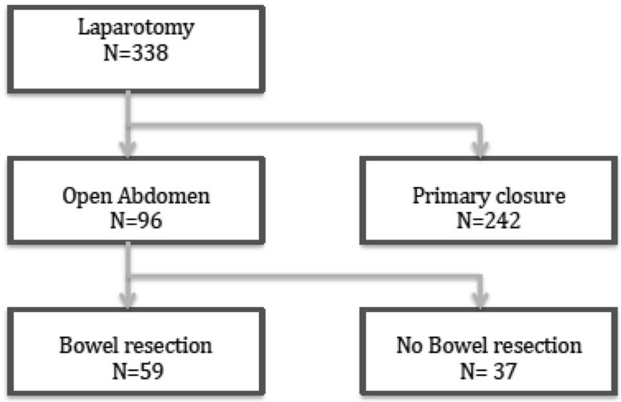

Fig. 1 Flow diagram on inclusion criteria

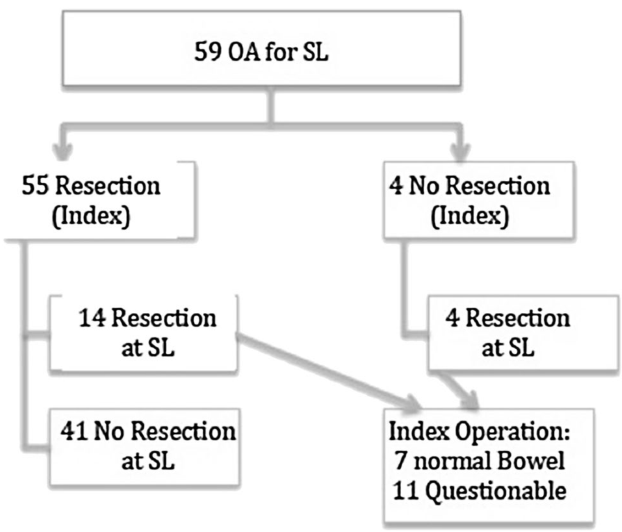

Fig. 2 Flow diagram on bowel resection

Results

A total of 338 primary laparotomies (excluding re-exploration of initial laparotomy) were performed during the 1-year study period, of which 96 patients (28%) were managed with an OA. Of this cohort, the 59 patients that underwent a bowel resection at the index and/or second operation and were left open for SL indications were included in the analysis (Fig. 1). Eighteen patients (31%) underwent resection at the SL laparotomy (SLR) versus 41 patients (69%) that did not require resection at the SL laparotomy (SLNR) (Fig. 2). Median age was similar between the two groups with 44% male in the SLR group and 56% male in the SLNR group. BMI and comorbidities were equivalent between groups. Abdominal pain was the presenting symptom in 66% of the SLR versus 68% of the SLNR. Median shock index was higher in SLR, with shock index of 1 in SLR versus 0.8 in SLNR ($p = 0.022$).

Preoperative characteristics were the same between SLR and SLNR group. Mesenteric ischemia was the most common indication for the operating room (OR) in the SLR group and perforated viscus in the SLNR group. The vast majority of patients in both groups had preoperative CT imaging; however, only four patients total had angiogram and all were in the SLNR group (Table 1).

Index operation estimated blood loss (EBL) and crystalloid infusion were higher in the SLR group of patients as compared to SLNR. There was no difference in intraoperative vasopressor or packed red blood cell (PRBC) transfusion between the two groups. Complications, length of stay (LOS), ventilator days, and mortality were equivalent between the two groups (Table 2).

Hemodynamic instability was the most common indication for OA in both groups (39%) (Table 3). Fluid resuscitation and inotropic support were comparative in both groups. Median time between index operation to SL was 36 h in SLR versus 26 h in SLNR (Table 2). Planned relook laparotomy remained the most common indication for return to the operating room followed by worsening hemodynamics (Table 4). In the subset of patients with mesenteric ischemia, NOMI was associated with higher hemodynamic instability and perioperative vasopressor requirements then thromboembolic etiology.

Of the 59 patients with OA and bowel resection, 18 required resection at SL. Of these 18 patients, 11 (60%) had areas of questionable bowel viability at the index operation, whereas 7 (38.9%) had normal appearing bowel. Indications for resection at SL laparotomy were as follows: 33% had progression of bowel ischemia to necrosis, 28% had new onset bowel ischemia/necrosis not noted at index operation, 22% underwent revision of previous staple lines for questionable viability, and 17% had "other" indications (Table 5).

Multivariate analysis was performed. Only preoperative peritonitis, before the index operation, was associated with need for resection at SL (OR 4.28, CI 1.05–17.45) (Tables 6, 7).

Discussion

The current study supports the use of SL laparotomy and OA management for EGS patients in the subset of patients with initial bowel resection or questionable bowel viability at the index operation. Almost a third of these patients required bowel resection during the SL procedure. The significant predictors for SL were preoperative peritonitis, with an increased association of bowel resection.

The data supporting SL laparotomy have been highly variable, mainly from series on mesenteric ischemia,

Table 1 Preoperative characteristics. All data presented as n (%) unless otherwise noted

Variable	SL resection ($n = 18$)	SL no resection ($n = 41$)	*P* values
Age (years) median (IQR)	65 (56–68)	63 (53–70)	0.79
Sex (M)	8 (44.4)	23 (56)	0.572
BMI (Kg/m^2) median (IQR)	27.2 (18–52.9)	31.9 (25.9–38)	0.35
Comorbidities			
PVD	9 (50)	17 (41.5)	0.58
DM	7 (38.9)	15 (36.6)	1
CHF	3 (16.7)	11 (26.8)	0.516
COPD	3 (16.7)	8 (19.5)	1
CKD	2 (11.1%)	10 (24.4%)	0.311
ESLD	1 (5.6%)	5 (12.2%)	0.656
CCI	2.5 (0–5)	3 (1–4)	0.80
Preoperative characteristics			
Abdominal pain	12 (66.7)	28 (68.3)	1
Nausea	6 (33.3)	15 (36.6)	1
Shock	12 (66.7)	15 (36.6)	0.048
Peritonitis	11 (61.1)	14 (34.1)	0.085
Shock index	1 (0.8–1.1)	0.8 (0.6–0.9)	0.022
Mesenteric ischemia	6 (33.3)	9 (21.9)	0.517
Incarcerated hernia	4 (22.2)	2 (4.9)	0.064
Perforated viscus	3 (16.7)	10 (24.4)	0.735
Sepsis	2 (11.1)	7 (17)	0.708
GIB	1(5.6)	3 (7.3)	1
SBO	1 (5.6)	6 (14.6)	0.422
"Other"	1 (5.6)	4 (9.8)	1
CT (CTA or CT)	13 (72.2)	25 (60.9)	0.557
Spy	3 (16.7)	3 (7.3)	0.357
Anglogram	0 (0)	4 (9.8)	0.303

BMI Body mass index, *PVD* peripheral vascular disease, *DM* diabetes mellitus, *CHD* congestive heart failure, *COPD* chronic obstructive pulmonary disease, *CKD* chronic kidney disease, *ESLD* end stage liver disease, *CCI* Charlson comorbidity index, *GIB* gastrointestinal bleed, *SBO* small bowel obstruction

with rates of SL ranging from 7 to 63% and re-resection rates ranging from 10 to 100%. The largest study was a retrospective review by Alhan et al. of 107 patients, of which 10% underwent SL and 7 patients, underwent additional bowel resections at SL. Sachs et al. showed an 18–20% benefit from SL [11–18]. Compared to current literature, 30% of the patients in our population required a bowel resection at SL laparotomy, showing that in select instances time is needed to determine the full extent of the disease, in conjunction with adequate resuscitation, management of other conditions and supportive care [14].

In the current series, of the 18 patients requiring bowel resection at SL, 60% [15] had questionable areas of bowel viability, while 39% had normal appearing bowel at the end of the index operation. At SL laparotomy, indication for resection included evolution of existing ischemia in 6, new onset ischemia in 5, staple line revision in 4, and "other" causes in 3.

NOMI represents a distinct pathology as the intestine demonstrates normal appearing serosa as the mucosa becomes progressively more ischemic and eventually necrotic [10]. Case reports have demonstrated that patients with NOMI presenting with areas of ischemic, but viable appearing bowel, can be treated with systemic anticoagulation and bowel can thus maintain viability [22]. Thus, the SL approach perhaps coupled with other modalities for testing bowel viability, including laser fluorescence angiography or Doppler flow, is an ideal situation for this patient population. In these instances, it is reasonable to perform a SL laparotomy to ensure the disease status has not progressed to necrosis requiring resection after being on appropriate medical treatment.

In the current study, the mortality rate in the resection group at SL was 50% (9/18), versus 39% (16/41) in the no resection group. Comparably, an increased risk of mortality was demonstrated by Denecke et al. where they noted a

Table 2 Intraoperative variable and outcomes. All data presented as *n* (%) or median and IQR unless otherwise noted

Variable	Median (IQR) or *n* (%)		*P* values
	SL resection (*n* = 18)	SL no resection (*n* = 41)	
Intraoperative requirements			
EBL (ml)	375 (150–1000)	200 (100–500)	0.08
Crystalloids (ml)	4000 (2600–6600)	3000 (2000–4000)	0.11
Pressors	14 (77.8)	35 (85.4)	0.475
PRBC transfusion (units)	2 (1–6)	2 (0–3)	0.26
Postoperative requirements			
Total volume(ml)	6113 (5186–9000)	5280 (2970–8000)	0.087
Pressors	9/18 (50%)	13/32 (38%)	0.565
Ionotropes	4/18 (22%)	6/34 (17%)	0.723
Time to SL (h)	36 (25.5–48)	26 (24–48)	0.68
Complications			
Leak	2 (11.1)	1 (2.4)	0.218
Fistula	2 (11.1)	2 (4.9)	0.578
Dehiscence	2 (11.1)	4 (9.8)	1
Surgical site infection	7 (38.9)	15 (36.6)	1
LOS SICU (days)	14 (9–19)	16 (6–26)	0.81
Ventilation days (days)	8 (6–16)	14 (5–26)	0.99
LOS total (days)	22 (15–31)	20 (14–48)	0.86
In-hospital mortality	6 (33.3)	13 (31.7)	1
6-month mortality	9 (50)	16 (39)	0.569

Table 3 Reason for OA at index operation

Variable	SL resection (*n* = 18)	SL no resection (*n* = 41)
Questionable bowel	4 (22%)	7 (17%)
Hemodynamic instability	7 (39%)	16 (39%)
Contamination	2 (11%)	5 (12%)
Need for heparin drip or reassess vascular graft	1 (5.5%)	6 (14.6%)
Others	6 (33%)	4 (9.7%)
Not available	0	3 (7.3%)

Table 4 Reason for SL

Variable	SL resection (*n* = 18)	SL no resection (*n* = 41)
Planned	12 (66%)	22 (54%)
Staged hernia repair	1 (5.5%)	5 (12.2%)
Mesenteric ischemia	1 (5.5%)	5 (12.2)
Worsening hemodynamics	4 (22%)	5 (12.2%)
Other	0	4 (unknown)
Not available	0	3

Table 5 Causes of resection at SL

Causes of further resection	*N* (%)
Progression of ischemia	6 (33.3)
New onset ischemia	5 (27.8)
Staple line revision	4 (22.2)
Others	3 (16.7)

Table 6 Multivariate analysis to assess risk factors for bowel resection at SL

Variable	*p* value	OR	CI
Age > 50 y (years)	0.69	0.70	0.12–3.99
CCI > 5	0.66	1.42	0.3–6.70
Preoperative shock	0.16	2.48	0.7–8.77
Preoperative peritonitis	0.04	4.28	1.05–17.45
Time to OR for SL > 24 h (h)	0.13	2.99	0.72–12.63
Index operative transfusion > 4u (units)	0.09	4.25	0.79–22.63

50% mortality in the subset of patients requiring SL laparotomy for mesenteric ischemia in which bowel resection was required and 0% mortality in the group without bowel resection [15]. Kaminsky et al. demonstrated a 80% mortality rate in those requiring SL laparotomy versus 35% mortality in those that did not require a SL laparotomy [11]. Thus, in this population, mortality remains high regardless of technique.

Table 7 Literature review

Studies	Index operation		Second look laparotomy	
	Exploration (*n*)	Bowel resection % (*n*)	Exploration % (*n*)	Bowel resection % (*n*)
Alhan et al. [12]	107	93.4 (101)	10 (11)	63.6 (7)
Kaminsky et al. [11]	41		36.5 (15)	40 (6)
Yanar et al. [13]	14	78.5 (11)	100 (14)	7 (1)
Ward et al. [14]	29	72 (21)	76 (22)	50 (11)
Denecke et al. [15]	115	75.6 (87)	41.4 (36)	27 (10)
Woosup et al.	58	53 (31)	39.6 (23)	39 (9)
Wadman et al. [18]	75	56 (42)	32 (24)	41 (10)

OA management techniques in emergency general surgery allow time for ongoing resuscitation and optimization of patient parameters, allowing the full extent of bowel disease to demarcate. This has been extrapolated from damage control laparotomy in trauma patients with temporary abdominal closures and planned SL laparotomy, allowing time for correction of coagulopathy, acidosis, and hypothermia [5]. Garcia–Garcia et al. studied 182 critically ill with severe non-trauma secondary peritonitis that underwent either damage control laparotomy or definitive surgical management. The bowel reconstruction rate was 80%, thereby creation of less colostomies as compared to the single-stage operation [23].

OAs are fraught with complications; therefore, the technique should be selectively used in specific individuals. OA is associated with higher rates of infections, enterocutaneous fistulas and ventral hernias [6]. Ott et al. showed trauma patients undergoing colectomy had a sixfold increase in anastomotic leak when coupled with an open abdomen [24]. Burlew et al. compiled data from the AAST multicenter study of 204 patients with enteric injuries requiring an open abdomen. This demonstrated higher leak rates in those patients with open abdomens coupled with left-sided anastomosis, delay in anastomosis, delayed fascial closure and persistent shock [25]. A recently published multicenter study sponsored by the American Association for the Surgery of Trauma illustrated OA and contamination at initial operation as being associated with more anastomotic failures [7]. The current literature demonstrates higher rate of ECF and intra-abdominal abscess with large bowel resections and increased abdominal re-exploration [26, 27]. Similar results, although not statistically significant, were seen in our study with higher rates of leaks, dehiscence and surgical site infections (SSIs) in the SL resection group.

The article is not without its limitation. The population examined here are emergency general surgery patients with OAs and management was not standardized. Thus, the individualized patient management strategies are subject to bias. Many findings were not statistically significant, thus was most likely attributed to small sample size and thus inadequately powered to demonstrate risk factors or mortality benefits associated with bowel resection at second look. Finally, peritonitis was a predictor for SL, however, this is subjective to examiner and level of experience therefore adding to the limitations of the study.

Conclusion

One-third of the patients undergoing SL laparotomy following initial operation with bowel resection underwent an additional resection of intestine for ongoing ischemia and/or bowel necrosis. As no currently available method is infallible in identifying all at risk bowel at index operation, the technique of SL laparotomy to reassess bowel viability remains an attractive option for the EGS patient.

Funding None.

Compliance with ethical standards

Conflict of interest Natasha Hansraj, Amelia Pasley, Donald Harris, Jose Diaz, Jason Pasley and Brandon Bruns declare that they have no conflict of interest.

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