Hostile Abdomen Index Risk Stratification and Laparoscopic Complications

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ABSTRACT

Background: Common life-threatening complications associated with laparoscopy, including bleeding and inadvertent enterotomy, are described in the literature. We investigated the application of the Hostile Abdomen Index related to these complications. We hypothesize that the preoperative score may guide a surgeon in risk stratification.

Methods: We used data from Monmouth Medical Center morbidity and mortality conferences and reviewed bleeding and enterotomy complications in laparoscopic abdominal surgery. Complications were tracked using the Hostile Abdomen Index compared between 2 periods: published early experience with laparoscopic surgery (1998–2003) and unpublished late experience (2004–2010). The index ascribes a number (1–4) before a laparoscope is inserted and another number (1–4) after the laparoscope is inserted into the abdomen.

Results: From 1998 to 2010, 43 patients had bleeding complications (0.45%) and 28 had inadvertent enterotomies (0.29%). There was no difference in bleeding between the early and late experiences. Enterotomy complications decreased in the late experience ($P < .001$). Our rescue success was 97.2% over 13 years. Those laparoscopic cases with high preoperative scores (3–4) had a higher rate of conversion to open procedures.

Conclusions: The Hostile Abdomen Index can be used to track 2 potentially life-threatening laparoscopic complications. The index score has been explained to our surgeons on numerous occasions. A higher chance of bleeding and enterotomy or risk stratification correlates with a preoperative 3 or 4 score and may lead to a more cautious approach toward initial laparotomy or earlier conversion.

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INTRODUCTION

Minimally invasive techniques have become widely used in abdominal surgery. Laparoscopy offers many advantages compared with traditional open procedures.[1–3] Trastulli et al[4] most recently published a meta-analysis that included 9 randomized clinical trials incorporating 1544 patients, comparing laparoscopic and open rectal resection for cancer. Laparoscopy benefits patients with shorter hospital stays, earlier return of bowel function, reduced blood loss, reduced number of blood transfusions, lower rates of wound infection, less intra-abdominal postoperative bleeding, and fewer intestinal obstructions.[4] With cholecystectomy, the benefits of the laparoscopic approach were so readily apparent that laparoscopic surgery became the standard of care without any randomized prospective trial comparing it with the prior gold standard, open cholecystectomy.[5]

Laparoscopy, however, is not without its limitations. The loss of 3-dimensional depth perception, the limited view offered by the camera, the loss of full tactile perception, and the difficulty in controlling major bleeding render laparoscopic surgery more technically demanding than comparable open procedures.[6,7] These factors contribute to serious complications, namely, bleeding and inadvertent enterotomy (IE).[8,9] They can be especially devastating if not promptly recognized and treated, resulting in significant morbidity and mortality. There has been no prior objective index to correlate these injuries with a hostile abdomen.

Our article proposes using the Hostile Abdomen Index (HAI) to track 2 serious complications, bleeding and IE, associated with laparoscopic surgery and to help determine risk stratification.[10] Previously introduced by Goldfarb and Baker,[10] HAI offers an objective preoperative scoring system (1–4) to assess patients' medical history, physical examination, and hostile abdomen conditions (**Figure 1**) before a laparoscope is inserted.[10] Once a laparoscope is inserted, an intraoperative score (1–4) is

The Hostile Abdomen Index for Laparoscopic Surgery

Preoperative Score Criteria	Intraoperative Score Criteria
1. No prior surgery, no abdominal hernia, and no skin disease/infection	1. Normal anatomy other than surgical disorder
2. One prior laparotomy or hernia in region of intended surgery	2. Omental adhesions
3. Two prior laparotomies, extremely large or small patient, acute abdominal wall infection, coagulation defect, portal hypertension, history of abdominal radiation, or history of intestinal Crohn's disease	3. Localized visceral adhesions in area of surgery or iatrogenic injury – no laparotomy required
4. More than two laparotomies, history of abdominal abscess or diffuse peritonitis, large abdominal solid mass, large mesh in area of intended surgery, bowel obstruction and extreme distension, failed prior laparoscopy from adhesions, ascites, previous radiation in intended surgical region, severe, active Crohn's disease, hemodynamic instability, severe COPD, late pregnancy, or acute abdominal wall infection in port region	4. Massive diffuse adhesions or conversion to laparotomy

Figure 1. The Hostile Abdomen Index for laparoscopic surgery. COPD, chronic obstructive pulmonary disease.

assigned. Whether the abdomen was hostile before any manipulation or after laparoscope insertion is identified by the index.

METHODS

We retrospectively analyzed intraoperative laparoscopic bleeding and IE complications at Monmouth Medical Center, from 1998 to 2010. Monmouth Medical Center is a 527-bed university-affiliated teaching hospital. Data from morbidity and mortality conferences were used. This study is exempt from institutional review board approval because it used data only from our morbidity and mortality database, without patient identifiers. Simple descriptive statistics were used. General surgeons performed cholecystectomies, appendectomies, and hernia repairs. The colon resections were performed by colorectal surgeons, and surgeons fellowship-trained in advanced laparoscopy performed the gastric surgeries, splenectomies, liver wedge resections, and retroperitoneal biopsies.

Complications of all surgeries performed at Monmouth Medical Center were collected in a database described by Goldfarb et al.[10] The surgical residents and quality control nursing staff independently collected complications. All reported cases were presented at the weekly morbidity and mortality conference in the presence of the attending surgical staff, surgical residents, and quality control nurses.[10]

Diagnosis of bleeding or IE was made during the primary surgical procedure, postoperatively in the same hospital-ization, or during a separate admission in the postoperative period. Bleeding complications were defined as conversion to an open procedure to control bleeding or operative/postoperative evacuation of a radiographically evident hematoma with concurrent decrease in measured hemoglobin. Inadvertent enterotomy was defined as transmural penetration of the small or large intestine. Conversion to an open procedure or reoperation was not required for inclusion.

The data were extracted from the morbidity and mortality records, and HAI was calculated based on age, sex, number of previous abdominal surgeries, type of prior abdominal procedures, preoperative surgical diagnosis, and comorbidities as listed in HAI (**Figure 1**).

We chose to divide the cases into 2 periods with laparoscopic surgery, 1998 to 2003 and 2004 to 2010, to explore any differences between early *published* data and later *unpublished* experience. These 2 periods have been separated specifically to compare the time before and after the concept of HAI was published.[10] Our patient data are retrospective. We, therefore, did not obtain HAI data on patients without complications, as in a case-control study.

RESULTS

A total of 9485 laparoscopic abdominal surgery cases were performed from 1998 to 2010. There were 43 cases of bleeding (0.45%) and 28 cases of IE (0.29%) (**Tables 1** and **3**). The mean age was 57 years (range 15–89) and there were 40 women (56.3%) and 31 men (43.7%).

Table 1.
Bleeding and Inadvertent Enterotomy (IE) Complications Based on Year and Laparoscopic Procedure[a]

Year	Cholecystectomy Bleeding/IE	Colon Bleeding/IE	Hernia Bleeding/IE	Gastric Bleeding/IE	Appendectomy Bleeding/IE	Other Bleeding/IE	Total
1998	1/3	—	—	1/0	—	1/0	3/3
1999	0/2	0/1	—	—	—	—	0/3
2000	2/0	1/0	—	—	1/0	—	4/0
2001	0/1	—	0/2	1/0	—	1/0	2/3
2002	2/1	1/2	1/1	—	1/0	—	5/4
2003	1/0	0/4	1/1	1/0	—	1/0	4/5
2004	0/1	1/0	0/2	1/0	1/0	—	3/3
2005	1/1	—	—	—	1/0	—	2/1
2006	2/1	—	0/1	—	—	—	2/2
2007	2/1	2/0	1/0	1/1	2/0	0/1	8/3
2008	—	1/0	—	—	—	2/0	3/0
2009	2/0	2/0	1/0	—	—	—	5/0
2010	—	—	2/0	0/1	—	—	2/1
Total	13/11	8/7	6/7	5/2	6/0	5/1	43/28

[a] A yearly summary of bleeding and inadvertent enterotomy complications based on laparoscopic procedure. There were 43 bleeding complications and 28 inadvertent laparotomies over 13 years. Cholecystectomy was associated with the most bleeding (n = 13, 30.2%) and inadvertent enterotomy (n = 11, 39.2%) complications over the same period.

Patients with bleeding and IE were categorized into 6 groups: 24 cholecystectomies (33.8%), 15 colon procedures (21.1%), 13 hernia repairs (18.3%), 7 gastric procedures (9.9%), 6 appendectomies (8.5%), and 6 "other" procedures (8.5%) (**Table 1**). Other operations with complications included splenectomy, retroperitoneal lymph node biopsy, liver wedge resection, nephrectomy, and retroperitoneal mass biopsy.

Forty cases were converted to open procedures, and of those 40, 11 (27.5%) had a preoperative score of 1 or 2 and 29 (72.5%) had a preoperative score of 3 or 4.

Bleeding and IE were compared regarding early experience (1998–2003) and late experience (2004–2010) (**Table 2**). There was no statistically significant difference in bleeding between the early (0.62%) and late (0.38%) experiences ($P = .073$). IE complications decreased in the late experience (0.15%) compared with the early experience (0.62%) ($P < .001$).

We specifically analyzed laparoscopic ventral hernia repair for incidence of bleeding and IE. There were no bleeding complications reported during this type of surgery. There were, however, 6 events of IE during laparoscopic ventral hernia repair. These events took place from

2001 to 2006 (4 "early" and 2 "late" events). There was no further IE reported after 2006. Two of the ventral hernia repair patients with IE events had a preoperative score of 3 and the other 4 patients had a preoperative score of 4.

Of 71 patients with bleeding or IE complications, there were 2 mortalities over 13 years (**Table 3**). The first mortality case was a 67-year-old man with a preoperative score of 3 and intraoperative score of 2, who underwent extended right hemicolectomy and resection of retroperitoneal lymph node for colon carcinoma. Postoperatively, the patient had intra-abdominal bleeding, causing an ileus, aspiration, and respiratory failure. He was found to have 800 mL of intraperitoneal blood on autopsy. The second mortality case was a 52-year-old man with both preoperative and intraoperative scores of 4, who underwent a laparoscopic retroperitoneal lymph node and liver wedge resection for metastatic colon carcinoma. The patient had bleeding from the liver intraoperatively and a probable carbon dioxide embolism.

More bleeding (n = 22, 51.2%) and IE (n = 25, 89.2%) complications were found in patients with preoperative scores of 3 and 4 in both periods over a combined 13 years (**Table 2**). Of those with a high preoperative score

Table 2.
Hostile Abdomen Index Preoperative and Intraoperative Scores and Complications, 1998 to 2003 and 2004 to 2010[a]

1998–2003	Preoperative Score 1		Preoperative Score 2		Preoperative Score 3		Preoperative Score 4	
Intraoperative score 4	Bleeding	3	Bleeding	3	Bleeding	4	Bleeding	1
	Enterotomy		Enterotomy	2	Enterotomy	5	Enterotomy	9
Intraoperative score 3	Bleeding		Bleeding		Bleeding	1	Bleeding	1
	Enterotomy		Enterotomy		Enterotomy	1	Enterotomy	
Intraoperative score 2	Bleeding	1	Bleeding		Bleeding		Bleeding	
	Enterotomy		Enterotomy		Enterotomy		Enterotomy	
Intraoperative score 1	Bleeding	2	Bleeding	1	Bleeding	1	Bleeding	
	Enterotomy		Enterotomy		Enterotomy	1	Enterotomy	
2004–2010	**Preoperative Score 1**		**Preoperative Score 2**		**Preoperative Score 3**		**Preoperative Score 4**	
Intraoperative score 4	Bleeding	1	Bleeding	1	Bleeding	3	Bleeding	1
	Enterotomy	1	Enterotomy		Enterotomy	3	Enterotomy	3
Intraoperative score 3	Bleeding	1	Bleeding	1	Bleeding	4	Bleeding	3
	Enterotomy		Enterotomy		Enterotomy	1	Enterotomy	2
Intraoperative score 2	Bleeding		Bleeding		Bleeding	1	Bleeding	
	Enterotomy		Enterotomy		Enterotomy		Enterotomy	
Intraoperative score 1	Bleeding	3	Bleeding	4	Bleeding	2	Bleeding	
	Enterotomy		Enterotomy		Enterotomy		Enterotomy	

[a] Bleeding and inadvertent enterotomy complications from 2 periods, 1998 to 2003 and 2004 to 2010, compared using the Hostile Abdomen Index preoperative and intraoperative scoring system. A preoperative score of 3 or 4, indicating multiple prior laparotomies or severe comorbidities, was associated with a higher intraoperative score in both periods.

(3 and 4), 9 patients with bleeding (20.9%) and 20 patients with IE (71.4%) had an intraoperative score of 4 (**Table 2**). Cholecystectomy was associated with the most complications of bleeding (n = 13) and inadvertent enterotomy (n = 11) (**Table 1**).

DISCUSSION

Despite an initial learning curve in minimally invasive surgery, bleeding remains a substantial complication in laparoscopic surgery.[11] Opitz et al[11] analyzed 43 028 laparoscopic procedures in a nationwide prospective multicenter study in Switzerland from 1995 to 2001. The most frequent surgery was cholecystectomy (52%), followed by groin hernia repair (18%), appendectomy (12%), colorectal resection (4%), and 4% others (fundoplication or bariatric surgery).[11] The overall bleeding rate was 3.3% (1.7% intraoperative bleeding, 1.5% postoperative bleeding, and major vascular injuries of 0.09%).[11] Bleeding caused by major vascular injuries had the highest mortality rate (2.4%), followed by intraoperative bleeding (1.5%), and postoperative bleeding (0.6%).[11] Morbidity due to cardiac/

pulmonary complications, wound infection, and conversion to open procedure was also increased in patients with bleeding complications.[11] One-third of major vascular injuries occurred during the setup phase of the procedure (23% during the insertion of the first trocar and 10% during establishment of pneumoperitoneum by a Veress needle).[11]

We report 43 patients with bleeding complications over 13 years (0.45%). This falls within the 0.05% to 4% range of bleeding complications reported in the literature.[11] No statistically significant difference in bleeding was found between early (1998–2003) and late (2004–2010) surgical experience (**Table 3**).

Inadvertent enterotomy is another laparoscopic complication with potentially catastrophic consequences, as evidenced by LeBlanc et al.[12] A literature review of 3925 laparoscopic incisional and ventral hernia repairs by LeBlanc et al[12] in 2007 found a 0.05% mortality rate. The occurrence of intestinal injury during these procedures was 1.78%.[12] If an IE occurred, the mortality rate increased

Table 3.
A Comparison of Early and Late Experience Complications

Complications	1998–2003	2004–2010	Total
Total laparoscopic cases	2891	6594	9485
Bleeding (%)	18 (0.62)	25 (0.38)	43 (0.45)
Inadvertent enterotomy (%)	18 (0.62)	10 (0.15)	28 (0.29)
Deaths (%)	0 (0.00)	2 (0.03)	2 (0.02)

dramatically to 2.8%.[12] A recognized enterotomy was associated with a mortality rate of 1.7%, which increased >4-fold to 7.7% if unrecognized.[12] Failure to address these complications at the time of surgery arises from the inherent disadvantages of laparoscopic surgery, including lack of depth perception, decreased tactile feedback, and a narrow visual field or surgeon's skill set.[6,7]

The incidence of IE in our study was 0.29% (n = 28) over the course of 13 years. A comparison between early and late experiences in laparoscopic abdominal surgery showed a statistically significant decrease in the number of IE from 0.62% to 0.15%, respectively ($P < .001$) (**Table 3**). The volume of laparoscopic surgery increased over the years, as did the complexity of the cases, but IEs have decreased. An improved surgeons' skill set could be a contributing factor. It should be stressed that the skill set of the laparoscopic surgeon must be integrated with the risk stratification of preoperative HAI.

We believe that the outcome of a complication is better delineated by calculating the rescue success, or the percentage of people who survive the complication. The reciprocal of rescue success is failure to rescue.[13] Khuri et al[14] identified determinants of 30-day mortality and long-term survival after major surgery by analyzing the National Surgical Quality Improvement Program data of 105 951 patients in the Veterans Administration from 1991 to 1999. The most important determinant of decreased postoperative survival was the occurrence, within 30 days postoperatively, of any of 22 types of complications collected in the National Surgical Quality Improvement Program.[14] Some of these included pulmonary embolism, wound infection, myocardial infarction, pneumonia, sepsis, and others.[14] The occurrence of a complication within 30 days of surgery reduced median patient survival by 69%.[14] The study confirms the significance of not only identifying patients with postoperative complications, but also the impact that a failure to rescue imparts on patients' survival. We identified only 2 cases of failure to rescue (2.8%) out of 71 laparoscopic bleeding and IE complications over

13 years. Our rescue success was, therefore, 97.2% with regard to survival from bleeding or IE.

It is difficult to discern, communicate, and catalog the multitude of factors that may lead to laparoscopic complications. To help risk strategize, we used the HAI to compare bleeding and inadvertent enterotomy complications during 2 periods. This is the first retrospective study looking at both these complications in abdominal laparoscopic procedures performed in a single institution over 13 years.

HAI provides a preoperative scoring system, graded 1 through 4, based on increasingly hostile abdominal challenges.[10] The information can be ascertained by analyzing a patient's medical and surgical history. Specific emphasis is placed, for example, on prior laparotomies, hernias, severe comorbidities, and inflammatory bowel disease (**Figure 1**). Intraoperatively, the patient's abdomen is assessed again after insertion of a laparoscope. At this point, the surgeon, for example, can determine whether adhesions may necessitate conversion to a laparotomy. The goal of this index is to prompt the surgeon by risk stratification to consider an open approach preoperatively or to convert more quickly if difficulty is encountered intraoperatively.

Using the HAI, we were able to analyze laparoscopic complications presented at morbidity and mortality conferences from 1998 to 2010 (**Table 2**). These were further broken down by specific year and procedure (**Table 1**). We noted a statistically significant decrease in IE between early and late experiences (**Table 3**). Whether this was improved by the introduction and use of the HAI was not determined. More bleeding (n = 22, 51.2%) and IE (n = 25, 89.2%) complications were found in patients with a preoperative score of 3 and 4 in both periods over a combined 13 years (**Table 2**). Of those with a high preoperative score (3 and 4), 9 patients with bleeding (20.9%) and 20 patients with IE (71.4%) had an intraoperative score of 4 (**Table 2**). Patients with severe comorbidities and previous laparotomies are more likely to have diffuse adhesions and require conversion to laparotomy.

There are limitations to this study. First, our study was a single-institution retrospective analysis with a relatively small number of complications. Our next step in the HAI review will be a prospective study analyzing the use of HAI before and during all operations, including those with complications. Our study is based only on review of surgical morbidity and mortality reports; therefore, only complicated surgeries could be analyzed in our dataset. Second, we have only addressed the most common complications, which are bleeding and inadvertent enterotomy, and have not included other complications of laparoscopic surgery. We do propose, however, the use of HAI when analyzing all types of complications in a future prospective study. Third, the operative time prior to conversion from laparoscopic to open surgery was not assessed, and that delay may correlate with a higher intraoperative HAI score. Finally, we did not ask the surgeons how often they converted based on HAI, although anecdotally they were influenced by it.

CONCLUSIONS

HAI presents a way to stratify risk and help track laparoscopic complications. The score communicates information regarding a patient's hostile abdomen conditions. That information may be used to facilitate data sharing among surgeons. More effectively, the index could be used as a way to stratify risk of complications if a laparoscopic approach is considered. Risk stratification may have a broader implication than predicting laparoscopic complications. Further research, including a prospective study, will have to be conducted to explore whether the HAI helps prevent laparoscopic complications.

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