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Laparoscopy decreases the laparotomy rate for hemodynamically stable patients with blunt hollow viscus and mesenteric injuries

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Abstract

BACKGROUND: The aim of this study was to evaluate the effect of laparoscopy on patients with blunt hollow viscus and mesenteric injuries (BHVMIs).

METHODS: Hemodynamically stable patients with BHVMIs were diagnosed using computed tomography and serial examinations. Patients admitted from July 1, 1999 to June 30, 2006 underwent exploratory laparotomy (group A), and those admitted from January 1, 2007 to December 31, 2013 received laparoscopy (group B).

RESULTS: There were 62 patients in group A, and 59 patients in group B. There were no significant differences in demographic characteristics, injury severity score, and injuries requiring surgical intervention between the groups (all, $P > .05$). Patients in group B had a shorter hospital stay (mean 11.0 vs 17.6 days, $P < .001$) and lower wound infection rate (mean 5.1% vs 16.1%, $P = .049$). The conversion rate of laparoscopy to laparotomy in group B was 8.5%, compared with a 100% laparotomy rate in group A ($P < .001$). There was no difference in the complication rate between groups.

CONCLUSION: Laparoscopy is feasible and safe for hemodynamically stable patients with BHVMIs.

Blunt hollow viscus and mesenteric injuries (BHVMIs) are not common, with a reported incidence ranging from .8% to 1.2% in patients who sustain blunt trauma.[1,2] With advances in treatments such as angioembolization, most patients with solid organ injuries who are hemodynamically stable are treated by nonoperative management.[3,4] The major indication of an emergent laparotomy in patients with blunt abdominal trauma (BAT) is persistent hypotension in the presence of a positive ultrasound of the abdomen. Clinically significant BHVMI, which includes free bowel perforation and bowel wall necrosis after mesenteric ischemia, is the other important indication of surgical intervention in hemodynamically stable patients with BAT.[5] The consequences of delayed recognition of clinically significant BHVMIs include intra-abdominal abscess and sepsis. Delayed diagnosis and treatment significantly

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increases the mortality and morbidity of patients with BHVMIs.[6] After initial resuscitation, a patient with BAT may be suspected to have BHVMI based on physical and radiological examinations.

Early diagnosis provides better outcomes for patients with BHVMIs, but this remains a challenge to trauma surgeons. The typical findings of peritonitis might not be present initially, and the confounding factors such as associated injuries or drug or alcohol intoxication can reduce the reliability of physical examinations. The most popular radiological examination for a hemodynamically stable patient with BAT is computed tomography (CT). However, even with advanced imaging techniques such as multidetector CT (MDCT), BHVMI may still be overlooked.[2] CT scan alone cannot be used to predict the need of a surgical intervention for patients with BHVMIs.[7]

On the other hand, once a diagnosis of BHVMI has been made, the standard treatment is laparotomy. Although laparotomy is effective, the procedure is not without risks and is associated with a 5% mortality rate, 20% morbidity rate, and a 3% long-term risk of bowel obstruction.[8] As experience in laparoscopy for trauma has accumulated, therapeutic interventions have been advocated for patients with penetrating abdominal trauma[9–11] and BAT,[11–13] including those with bowel perforations. However, although some successful results have been reported, the actual role of laparoscopy for the diagnosis and treatment of patients with BHVMIs has remained undefined because heterogeneity of patient populations and lack in a control group in these reports.[11,12]

The purpose of this study was to evaluate the diagnostic and therapeutic value of laparoscopy for hemodynamically stable patients with BHVMIs. We hypothesized that laparoscopy can be effectively used to reduce the laparotomy rate and provide the advantages of minimally invasive surgery for hemodynamically stable patients with BHVMIs.

Patients and Methods

This study protocol was approved by the institutional review board of Far Eastern Memorial Hospital in Taiwan. We retrospectively reviewed the medical records from the trauma registry database for hemodynamically stable adult patients who were suspected to have BHVMIs from July 1, 1999 to December 31, 2013. Patients younger than 16 years of age, who were pregnant, or not hemodynamically stable were excluded. After arriving at the emergency department, all patients with BAT were treated and resuscitated according to Advanced Trauma Life Support principles. Patients who were hemodynamically unstable (systolic blood pressure <90 mm Hg) after fluid resuscitation were taken to the operating room for exploratory laparotomy. A CT scan was arranged for every hemodynamically stable patient after fluid resuscitation to detect the presence of intra-abdominal injuries. CT scans were performed at 5-mm intervals without or with intravenous contrast (Iopamidol, Bracco, Milano, Italy) by a 4-slice, 16-slice, or a 64-slice CT scanner. Findings suggestive of BHVMIs included intraperitoneal free air, contrast medium extravasations in the mesenteric vessels, or free fluid without solid organ injury. Patients were managed nonoperatively and followed up with physical examinations every 2 hours if no indications for emergency surgery were present. Surgical intervention was performed if clinically significant BHVMI was suspected. Patients with free intraperitoneal fluid on CT who did not exhibit peritoneal signs on serial examinations were managed nonoperatively. Surgical findings of BHVMIs included bowel perforation, laceration, hematoma, or devascularization of the mesentery, stomach, duodenum, small intestine, large intestine, or rectum.

At our institution, on July 1, 2006, laparoscopy was adopted as a diagnostic and therapeutic method for treating hemodynamically stable patients with BAT, including those with BHVMIs. Patients admitted from July 1, 1999 to June 30, 2006 (before the adoption of laparoscopy) underwent exploratory laparotomy for suspected BHVMIs and were categorized as group A. Patients admitted from January 1, 2007 to December 31, 2013 received laparoscopy for suspected BHVMIs and were categorized as group B. An interval of 6 months between the 2 study periods was chosen to decrease the occurrence of protocol violations. The diagnostic criteria of BHVMIs and the principles of postoperative care were all the same in both time periods, and patients might or might not have associated injuries.

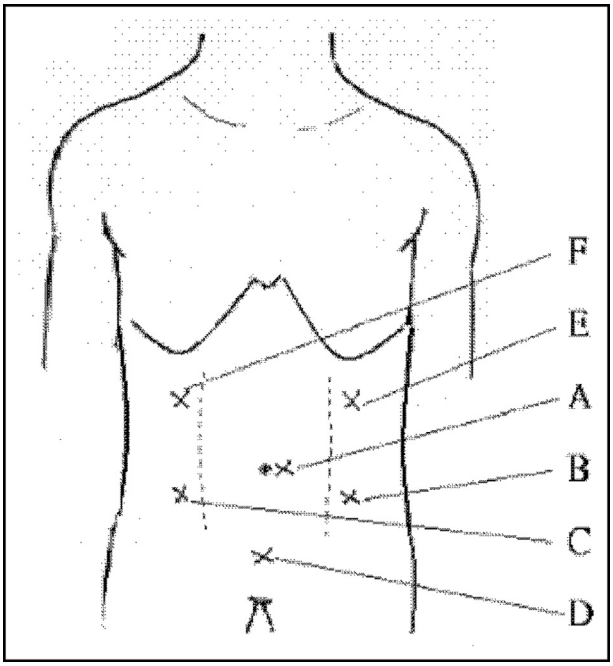

Figure 1 Trocar sites for laparoscopy for patients with blunt hollow viscus and mesenteric injuries. (A) Umbilical port for laparoscope. (B) Working port at left paramedian site. (C) Working port at right paramedian site. (D) Suprapubic port for alternative use of the laparoscope. (E) Optional working port at the left upper abdominal wall. (F) Optional working port at the right upper abdominal wall.

All procedures were performed by surgeons responsible for trauma care and acute care surgery. All surgeons had proficiency in laparotomy and laparoscopy, and had at least performed 10 laparoscopic operations for acute care surgery monthly, and 5 laparoscopic operations for patients with abdominal stab wounds. The same prophylactic antibiotics policy was used in both time periods, and intravenous antibiotics were given to patients before the skin incisions.

Patients in group A underwent exploratory laparotomy using standard techniques. After a thorough examination of the peritoneal cavity, any significant injuries were identified and treated as required. Following repair of all injuries, peritoneal lavage with copious amounts of warm normal saline was done before closure of the abdominal wounds. Laparoscopic evaluation and management was performed for patients in group B as reported in our prior studies.[10,13] Tube thoracostomy was performed before laparoscopy when chest radiography showed hemothorax/pneumothorax. The placement of trocars for the camera and working ports is shown in Fig. 1. A 30° forward viewing laparoscope was used for visualizing intra-abdominal injuries. A hand-to-hand technique was used to examine the small bowel for mesenteric tears or perforations using atraumatic grasping forceps (Karl Storz, Tuttlingen, Germany). Once a significant BHVMI was identified, therapeutic laparoscopy using techniques including resection, resection and anastomosis, or ostomy was performed as shown in Fig. 2. Conversion to laparotomy was considered for complex injuries or for patients who became hemodynamically unstable. Peritoneal lavage with a suction irrigation instrument (Olympus, Hamburg, Germany) under laparoscopic vision was also performed. All patients were followed and evaluated for postoperative outcomes both in the hospital and after discharge. Assurance of repair and absence of missed injuries were confirmed by a normal postoperative recovery. Surgical wound infections were categorized based on the Centers for Disease Control definitions.[14] Intra-abdominal abscesses were diagnosed by CT if patients had associated symptoms and signs.

The outcomes of the 2 groups were compared. Data extracted from the medical records included demographic characteristics, hemodynamic status in the emergency department hemoglobin level, injury severity score (ISS), rate of detection of intraperitoneal free air by CT for hollow viscus perforation, percentage of significant injuries, operative findings, operative procedures, operation time, blood loss, length of hospital stay, length of intensive care unit stay, hospital mortality, and postoperative complications. The nontherapeutic laparotomy rate in group A and conversion rate to laparotomy in group B were calculated. A significant intra-abdominal injury was defined as an injury requiring a repair or resection, which has an impact on the outcome of the patient. Laparotomy was considered nontherapeutic if no injury required surgical intervention. A laparoscopic procedure was considered therapeutic when surgical repair/resection of a significant injury was performed, and nontherapeutic if hematoma evacuation was the only necessary procedure.

Data were presented as mean ± standard deviation, and comparisons between groups were performed using the independent 2-sample *t* test for continuous variables.

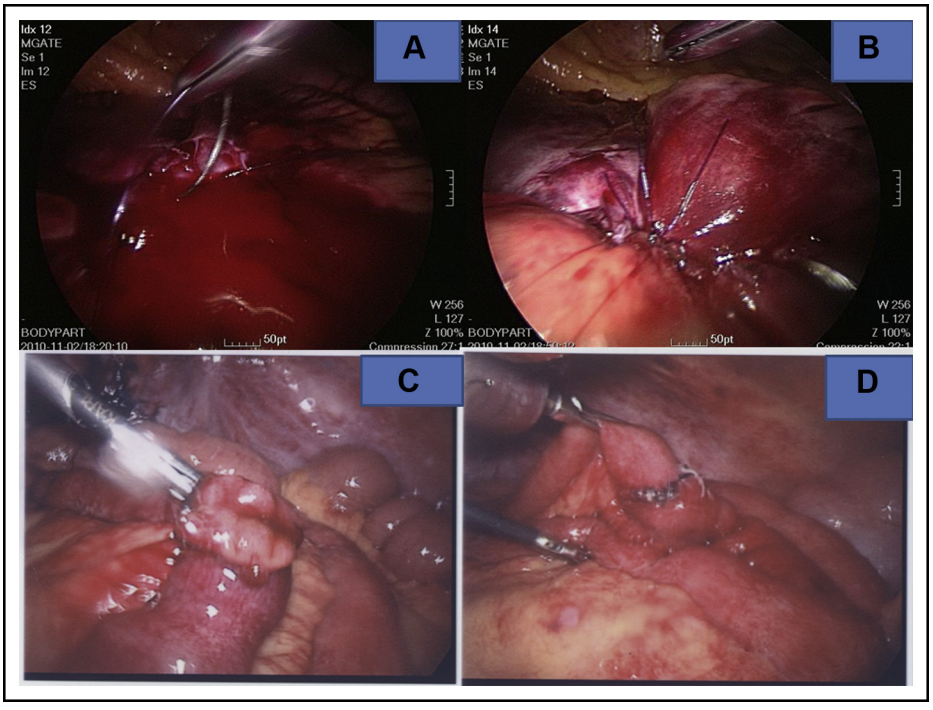

Figure 2 Laparoscopy for blunt hollow viscus and mesenteric injuries. (A) Intracorporeal sutures were placed on the torn mesentery for hemostasis. (B) Hemostasis achieved after completion of repairs by intracorporeal sutures. (C) Small bowel perforation. (D) Completion of small bowel resection and anastomosis.

Table 1 Indications for surgery

	Group A (n = 62)	Group B (n = 59)
Intraperitoneal free air on CT	14	10
Contrast medium extravasation of mesenteric vessels on CT	4	3
Free fluid without solid organ injury on CT and signs of peritonitis	44	46

CT = computed tomography.

Chi-square/Fisher's exact test was used for categorical variables, and the data were presented as count (percentage). The outcomes of patients whose procedures converted to laparotomy in group B were analyzed on an intention to treat basis. All statistical assessments were 2 sided and evaluated at the .05 level of significant difference. Statistical analyses were performed using SPSS 15.0 statistics software (SPSS, Inc, Chicago, IL).

Results

A total of 1,360 patients with BAT (696 in group A and 664 in group B), 135 of whom had BHVMIs, were seen at our hospital during the study period. Fourteen patients were excluded from the analysis. These 14 patients underwent exploratory laparotomy directly because they were hemodynamically unstable (6 in group A and 8 in group B). There were 121 hemodynamically stable patients after fluid resuscitation who underwent a surgical intervention for suspected BHVMI (62 in group A and 59 in group B), and the indications for surgery are shown in Table 1. The most frequent indication for surgery in both groups was free fluid without solid organ injury on CT and signs of peritonitis on serial examinations (71.0% [44/62] in group A, 78.0% [46/59] in group B). Thirteen patients in group A and 10 patients in group B with free fluid and no evidence of solid organ injury on CT and no signs of peritonitis on serial examinations were managed nonoperatively without complications.

The demographic data, ISS, associated injuries, perioperative parameters, and the postoperative outcomes of both groups are shown in Table 2. There were no significant differences in demographic characteristics, hemoglobin level, ISS, rate of associated injuries, intraperitoneal free air detection rate, rate of significant injuries, operation time, blood loss, mortality, rate of total complications, and rate of intra-abdominal abscesses between the 2 groups (all, $P > .05$). The mean age of patients in group A was 38.0 years and in group B was 43.6 years, and the percentage of men was greater in both groups. The mean ISS was 16.3 in group A and 14.3 in group B. The diagnostic rate of hollow viscus perforation by observation of pneumoperitoneum on CT was 53.8% (14/26) in group A and 45.5% (10/22) in group B. Alternately, the false negative rate of diagnosing hollow viscus perforations by abdominal CT was 46.2% in group A and 54.5% in group B.

The incidence of significant injuries was 95.2% (59/62) in group A and 88.1% (52/59) in group B. In group A, 3 patients had injuries that did not require an intervention: 1 mesorectal hematoma and 2 retroperitoneal hematomas. These 3 patients underwent a nontherapeutic laparotomy based on the indication of free fluid without solid organ injury on CT and physical findings. The nontherapeutic

Table 2 Patients' demographic and clinical characteristics

	Group A (n = 62)	Group B (n = 59)	*P* value
Sex (male:female)	50:12	44:15	.423†
Age (years)	38.0 ± 16.9	43.6 ± 20.6	.104‡
Initial SBP (mm Hg)	124.3 ± 30.3	126.2 ± 27.2	.716‡
Hb (mg/dL)	13.2 ± 2.2	13.7 ± 1.9	.130‡
ISS	16.3 ± 7.2	14.3 ± 6.8	.123‡
Associated injuries	31/62 (50.0)	36/59 (61.0)	.223†
Free air on CT for hollow viscus perforation	14/26 (53.8)	10/22 (45.5)	.562†
Injuries requiring intervention	59/62 (95.2)	52/59 (88.1)	.198§
Laparotomy	62/62 (100.0)	5/59 (8.5)	<.001†
Operation time (minutes)	138.7 ± 48.4	129.9 ± 47.1	.312‡
Blood loss (mL)	785.5 ± 977.5	500.2 ± 725.5	.068‡
Length of hospital stay (days)	17.6 ± 11.0	11.0 ± 6.1	<.001‡
Length of ICU stay (days)	3.3 ± 6.1	1.8 ± 4.2	.122‡
Mortality	1/62 (1.6)	0/59 (.0)	1.000§
Complications	17/62 (27.4)	9/59 (15.3)	.103†
Wound infection	10/62 (16.1)	3/59 (5.1)	.049†
Intra-abdominal abscess	5/62 (8.1)	2/59 (3.4)	.440§
Other complications	3/62 (4.8)	4/59 (6.8)	.713§

Data are presented as mean ± standard deviation or count (percentage).
CT = computed tomography; Hb = hemoglobin; ICU = intensive care unit; ISS = injury severity score; SBP = systolic blood pressure.
P values are derived from ‡Student *t* tests, †chi-square test, §Fisher's exact test.

Table 3 Injuries and operative procedures

Injured organs/procedures	Group A (n = 62)	Group B (n = 59)
Hollow viscus perforation		
Stomach	2	1
Repair	2	1[L]
Duodenum	2	0
Repair	2	0
Small bowel	16	14
Repair	13	10[L]
		1[C]
Bowel resection and anastomosis	3	3[L]
Colon and rectum	3	6
Repair	1	0
Bowel resection and anastomosis	0	0
Repair or resection and ostomy	2	6[L]
Mesenteric injury		
Gastroepiploic vessels tear	1	1
Ligation	1	1[L]
Small bowel mesentery	6	14
Repair for hemostasis	4	7[L]
Resection and anastomosis	2	6[L]
Drainage of hematoma	0	1[L]
Mesocolon or mesorectum	2	3
Repair for hemostasis	1	1[L]
Drainage of hematoma	1	2[L]
Mesenteric injury with hollow viscus injury		
Small bowel	29	10
Repair of mesentery and bowel	11	8[L]
		2[C]
Resection and anastomosis	18	10
		8[L]
		2[C]
Colon or rectum	3	5
Ostomy and/or repair	3	5[L]
Miscellaneous	3	8
Urinary bladder	3	6
Repair	3	6[L]
Gall bladder	0	1
Cholecystectomy	0	1[L]
Ovary	0	1
Oophorectomy	0	1[L]
Retroperitoneal hematoma	2	4
Drainage of hematoma	2	4[L]

C = converted to laparotomy; L = laparoscopic procedures.

laparotomy rate in group A was thus 4.8% (3/62). In contrast, 11.9% (7/59) of patients in group B underwent a diagnostic laparoscopy only according to the same indication. The insignificant injuries in group B included 1 small bowel mesenteric hematoma, 2 mesocolon hematomas, and 4 retroperitoneal hematomas. None of them required conversion to laparotomy.

No missed injuries requiring reintervention occurred in group B, so the accuracy rate of diagnostic laparoscopy was 100%. The laparotomy rate in group B was 8.5% (5/59) because of converting procedures, as compared with 100% (62/62) in group A ($P < .001$). Group B had a significantly shorter length of hospital stay (11.0 vs 17.6 days, $P < .001$) and fewer wound infections (5.1% [3/59] vs 16.1% [10/62], $P = .049$) than group A.

The operative findings and the procedures of both groups are shown in Table 3. As indicated in Tables 2 and 3, 52 patients with 69 significant injuries in group B were treated by laparoscopic-based procedures. Five patients in group B required conversion to laparotomy for therapy. Three conversions were for complex injuries (2 small bowel mesenteric devascularizations and 1 multiple small bowel perforations) and 2 patients with mesenteric and small bowel injuries required conversion because they became hemodynamically unstable during the laparoscopic procedures. Six patients in group B were found to have an intraperitoneal urinary bladder perforation, and all of them underwent a repair laparoscopically. Concomitant hollow viscus injuries were found by laparoscopy in 2 of the 6 patients (1 small bowel perforation and 1 colon perforation). Two patients in group B underwent a diagnostic laparoscopy for suspected BHVMIs, but underwent procedures for lesions mimicking BHVMI; 1 laparoscopic cholecystectomy for a ruptured gall bladder and 1 laparoscopic oophorectomy for a ruptured ovary, all of them caused by blunt trauma.

No clinically significant intraoperative complications such as tension pneumothorax were noted. There was 1 death in group A because of associated chest injuries, and no deaths in group B. In group A, 17 patients had postoperative complications. There were 10 wound infections (16.1%), 5 intra-abdominal abscesses (8.1%), 2 postoperative ileus (3.2%) requiring readmission, and 1 ventral hernia (1.6%) that occurred 3 months postoperatively after a wound infection. In group B, 9 patients who underwent a therapeutic laparoscopy developed postoperative complications. There were 3 wound infections (5.1%), 2 intra-abdominal abscesses (3.4%), 2 postoperative ileus (3.4%) requiring readmission, and 2 ventral hernias (3.4%) that developed at about 2 months postoperatively from the laparotomy wound required for conversion.

Comments

This study compared 2 approaches for the management of hemodynamically stable patients suspected of having clinically significant BHVMI by CT and serial physical examinations before and after the adoption of laparoscopy. The results based on 121 patients demonstrated that the laparoscopic-based approach is effective for managing patients with BHVMIs when used by trauma surgeons who have experience in laparoscopic surgery. In this report, laparoscopy prevented 91.5% of laparotomies, provided patients with the advantages of minimally invasive surgery in terms of shorter length of hospital stay and a lower rate of wound infections without an increased rate of

postoperative complications. Our previous studies have shown the value of laparoscopy for BAT[13] and this study further emphasizes the importance of laparoscopy in the treatment for patients with BHVMIs.

In our previous comparative study, we found that a laparoscopic-based approach can significantly decrease the laparotomy rate for hemodynamically stable patients with BAT, including patients with BHVMIs.[13] However, the role of laparoscopy for hemodynamically stable patients with BHVMIs remained undefined because the number of patients in this subset was not large enough to form a definite conclusion. In this study, we have focused on patients with BHVMIs and increased number of patients by extending the study periods to 14 years. The value of laparoscopy for hemodynamically stable patients with BHVMIs was thus proven.

Early detection of hemodynamically stable patients with BHVMIs can improve outcomes. Common diagnostic methods include serial physical examinations, CT, and diagnostic peritoneal lavage (DPL). Some authors have suggested that the optimal method of diagnosis for significant intra-abdominal injuries is via the serial examinations by an experienced trauma surgeon.[15] Although some have advocated a surgical exploration for patients with free fluid without solid organ injury on CT mandatorily,[16] most studies have suggested a more conservative approach using serial examinations.[17,18] This study also stresses on the importance of serial examinations for the diagnosis of clinically significant BHVMIs. On the other hand, some authors considered CT to be superior to clinical examinations for BHVMIs.[1,19] Joseph et al[1] reported that the sensitivity and specificity of CT were 86% and 88%, respectively, whereas the sensitivity and specificity of clinical examinations were 53% and 69%, respectively. However, although CT is the most commonly used imaging modality by surgeons,[20] the efficacy of CT in the diagnosis of BHVMI has not been well established.[2] Elton et al[21] reported that CT findings significant for BHVMIs included isolated free fluid, pneumoperitoneum, and bowel wall thickening. Brofman et al[22] have reported various MDCT findings consistent with BHVMIs. Other than findings specific for bowel injuries, the authors identified mesenteric extravasations, mesenteric vascular beading, and termination of mesenteric vessels as specific for mesenteric injury. CT alone was not found to be reliable in this study because the false negative rate of pneumoperitoneum detection by CT was high in both groups (46.2% in group A and 54.5% in group B). In contrast to a higher diagnostic rate of CT using modern technology,[1] the high false negative rate of CT for pneumoperitoneum in this study may be attributed to the use of older generations of equipments for most patients. However, although a higher detection rate of intraperitoneal free air, the use of newer generations of MDCT has not improved the sensitivity for diagnosis of BHVMIs, especially for patients with bowel wall ischemia after mesenteric injuries.[2] A combination of suggestive CT findings and physical examination findings consistent with peritonitis seems to be a better strategy. No significant BHVMI has been missed by the diagnostic modalities used in this study, although modern generations of CT were not used routinely.

Although DPL is considered a dying procedure by some authors,[23] Wang et al[5] argued that DPL is useful to exclude hollow viscus perforations undetected by CT. No hollow viscus perforations were missed in their study, and the sensitivity and specificity of DPL by cell count ratio were 100% and 75%, respectively. The value of DPL cannot be evaluated in this study because it was not incorporated into the diagnostic algorithms.

Jones et al[24] reported that all intra-abdominal injuries following BAT become clinically apparent within 9 hours, and all patients requiring an intervention manifest symptoms or signs within 60 minutes of arrival. A prompt decision of the surgical needs for patients without confounding factors could be made by serial examinations and CT. In this study, the purpose of diagnostic laparoscopy was to identify and localize injuries, not to replace CT. Further study is warranted to determine the value of laparoscopy for an early diagnosis in patients with free fluid without solid organ injury on CT, as compared with serial examinations.

Several studies have demonstrated that laparoscopy can play a role in the treatment of patients with BHVMIs.[9,11,12] Mathonnet et al[12] reported 15 patients with blunt small bowel perforations successfully treated by laparoscopy, and the sensitivity and specificity of laparoscopy for small bowel perforations were 100%. Similarly, another case series also showed that some patients with small bowel or mesenteric injuries could be managed by laparoscopic repair. The study by Chol and Lim[9] illustrated that a variety of intra-abdominal lesions, including BHVMIs, can be treated laparoscopically with favorable outcomes. The results of the aforementioned studies are promising, but the studies have certain limitations. First, they enrolled patients with either penetrating or blunt trauma. Second, they were case series reporting new techniques without a control group. Finally, all the studies did not mention the experience level of the surgeons for performing advanced laparoscopic techniques. We believe that this study is the first to compare the outcomes of hemodynamically stable patients with BHVMIs treated by laparotomy or laparoscopy.

Our results showed that laparoscopy is safe for patients with BHVMIs. The diagnostic accuracy of laparoscopy for patients suspected to have BHVMIs was 100%. Missed injuries were avoided because we used a standard method of laparoscopic examination as previously reported.[10,13] Complications related to CO_2 pneumoperitoneum in trauma patients (tension pneumothorax, air embolism, or intracranial hypertension) were not encountered in this study. Similar to the conclusions of our previous studies, we suggest that such complications can be minimized by appropriate preoperative management.[10,13]

Our previous report illustrated that laparoscopy can decrease the laparotomy rate and shorten the duration of

hospital stay for patients with BAT.[13] Similarly, the advantages of laparoscopy for patients with BHVMIs in terms of a lower laparotomy rate, shorter length of hospital stay, and lower wound infection rate were shown in this study. Keys to the low laparotomy rate in this study included the accuracy of diagnostic laparoscopy for patients with insignificant injuries, and high success rate of therapeutic laparoscopy. Factors associated with the high success rate of laparoscopic treatment included using laparoscopic-assisted procedures if feasible, and surgeon experience with laparoscopy for trauma and acute care surgery. The shorter length of hospital stay and lower wound infection rate compared with laparotomy reflect the minimally invasive nature of laparoscopy. For the success of therapeutic laparoscopy, it is crucial that surgeons have adequate experience in laparoscopy for trauma. Advanced skills in laparoscopy can be obtained by trauma surgeons by participating in acute care surgery. This was proven to be valid in this study because all the surgeons had performed at least 10 laparoscopic operations for acute care surgery monthly. This is one of the reasons that trauma surgeons have to take part in acute care surgery.

Although a shorter length of hospital stay in laparoscopic group, we found that the mean lengths of stay are relatively long in both groups for modestly injured patients (17.6 days, ISS 16.3 in group A; 11.0 days, ISS 14.3 in group B). There were 2 possible contributing factors. First, even with a normal postoperative recovery of abdominal injuries, patients would stay in the hospital undergoing the other procedures for their associated injuries such as bone fractures. Second, it might reflect the cultural differences in patients' attitude and reimbursement system between Taiwan and the United States. A similar trend of longer lengths of hospital stay was observed in our previous study for treating perforated appendicitis, compared with a study from American hospitals, both in laparoscopic or open groups (laparoscopic 6.3 vs 4 days; open 9.3 vs 6 days).[25,26]

Procedures performed for BHVMIs in the study of Chol and Lim[9] included gastric wall repair, small bowel repair, small bowel resection anastomosis, ligation of bleeders in the mesentery, sigmoid colon repair, and Hartmann's procedure, and the procedures were performed completely laparoscopically, or laparoscopically assisted without conversion. As shown in Table 3, similar procedures were performed in this study with a comparable success rate. Joseph et al[1] reported that 27% of patients with bladder injuries had concomitant hollow viscus perforations. Interestingly, a similar percentage of patients with concomitant hollow viscus and bladder perforations was noted in this study (33.3%, 2/6). It deserves further studies to determine if bladder injury is a marker for hollow viscus injuries.

Except for the lower wound infection rate of patients in group B, there were no differences in the other postoperative complications (intra-abdominal abscess, adhesion ileus, or ventral hernia) between the 2 groups. An increased risk of intra-abdominal abscesses in patients undergoing laparoscopy has been debated,[27] but was not observed in the present or our prior studies.[13] This finding supports the value of irrigating the peritoneal cavity under laparoscopic guidance.

As a retrospective study to compare different algorithms for hemodynamically stable patients with clinically significant BHVMIs in 2 time periods, there are some factors that should be considered. First, as the incidence of patients with BHVMI was low, the total number of patients during the 14-year study period was small. Second, the follow-up time was not long enough to asses for complications as adhesions resulting in ileus or ventral hernias. Third, a comparison of our results with the other series examining laparoscopy for hollow viscus and mesenteric injuries could not be performed because we focused on injuries as a result of blunt mechanisms. Finally, the study was performed by surgeons at a single institution and thus the results may not be reproducible at other centers.

Conclusions

For surgeons experienced in laparoscopic surgery, laparoscopy is a feasible and safe method for the management of hemodynamically stable patients with BHVMIs diagnosed by CT and serial physical examinations. It can reduce the laparotomy rate and provide patients with the advantages of minimally invasive surgery in terms of shorter length of hospital stay and lower wound infection rate.

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