Midwest Surgical Association

The use of laparoscopy in the diagnosis and treatment of blunt and penetrating abdominal injuries: 10-year experience at a level 1 trauma center

Jeremy J. Johnson, M.D.a,*, Tabitha Garwe, Ph.D.a,b, Alexander R. Raines, M.D. a, Joseph B. Thurman, M.D.c, Sandra Carter, M.P.H.b, Jeffrey S. Bender, M.D.a, Roxie M. Albrecht, M.D.a

aDepartment of Surgery, University of Oklahoma College of Medicine, 920 Stanton L. Young Blvd, WP 2140, Oklahoma City, OK 73104, USA; bDepartment of Biostatistics and Epidemiology, University of Oklahoma College of Public Health, Oklahoma City, OK, USA; cUniversity of Oklahoma College of Medicine, Oklahoma City, OK, USA

KEYWORDS:
Abdominal trauma; Diagnostic laparoscopy; Nontherapeutic laparotomy

Abstract

BACKGROUND: Diagnostic laparoscopy (DL) has decreased the rate of nontherapeutic laparotomy for patients suffering from penetrating injuries. We evaluated whether DL similarly lowers the rate of nontherapeutic laparotomy for patients with blunt injuries.

METHODS: All patients undergoing DL over a 10-year period (ie, 2001–2010) in a single level 1 trauma center were classified by the mechanism of injury. Demographic and perioperative data were compared using the Student \( t \) and Fisher exact tests.

RESULTS: There were 131 patients included, 22 of whom sustained blunt injuries. Patients suffering from blunt injuries were more severely injured (Injury Severity Score 18.0 vs 7.3, \( P = .0001 \)). The most common indication for DL after blunt injury was a computed tomographic scan concerning for bowel injury (59.1%). The rate of nontherapeutic laparotomy for patients sustaining penetrating vs blunt injury was 1.8% and nil, respectively.

CONCLUSIONS: DL, when coupled with computed tomographic findings, is an effective tool for the initial management of patients with blunt injuries.

Since this time, the role of selective nonoperative management for these patients gained favor. A new era was marked with the advent of laparoscopy, enabling the surgeon to diagnose or rule out intra-abdominal injuries in a minimally invasive way. The use of diagnostic laparoscopy to evaluate traumatic abdominal injuries was slow to be accepted by some because of a high rate of missed injuries ranging from 22% to 45%. However, with improved equipment, video image, and surgeon experience, diagnostic laparoscopy has become a reliable tool to diagnose and treat penetrating abdominal injuries. Diagnostic laparoscopy represents a quick and effective modality to exclude injury,
effectively decreasing rates of nontherapeutic laparotomy for patients suffering from penetrating injuries. The role of diagnostic laparoscopy for patients with blunt injuries is less clear. There are very few prospective studies that evaluate the role of laparoscopy in blunt abdominal trauma, and none of these were randomized. We sought to compare our experience with diagnostic laparoscopy for patients sustaining both blunt and penetrating abdominal and thoracoabdominal injuries.

Methods

We performed a retrospective, observational study at a single level 1 trauma center on all trauma patients undergoing diagnostic laparoscopy evaluated from 2001 to 2010. Patients were identified from the trauma registry based on International Classification of Ninth Diseases, Ninth Revision procedure code 54.21 (laparoscopy). Demographic and clinical data were recorded including the mechanism of injury, admission vital signs, chest x-ray findings, Injury Severity Score, indication for surgery, time to surgery, operative findings, therapeutic procedures performed, rate of conversion to laparotomy, intensive care unit length of stay, hospital length of stay, complications, and mortality. Complications of interest included wound infection, deep vein thrombosis, pneumonia, fascial dehiscence, anastomotic leak, persistent bleeding requiring reoperation, pancreatic fistula, biloma, urinary tract infection, reoperation, missed injury, intra-abdominal or pelvic abscess, and empyema. Laparoscopy was classified as negative if no injury could be identified. If an injury was identified but did not require treatment, the procedure was deemed nontherapeutic and therapeutic for injuries successfully repaired laparoscopically. Likewise, laparotomies were either recorded as therapeutic or nontherapeutic.

Patient selection

At our institution, diagnostic laparoscopy is used when the patient is hemodynamically stable. Patients with penetrating trauma may include patients sustaining tangential abdominal or flank gunshot wounds, patients with anterior abdominal stab wounds with fascial penetration noted on local exploration, patients sustaining penetrating thoracoabdominal injuries to rule out diaphragmatic injury, patients with positive focused assessment with sonography, patients with peritonitis, and patients with equivocal abdominal/pelvis computed tomographic (CT) scans. For blunt injury patients, diagnostic laparoscopy may be used when CT findings are worrisome for hollow viscous injury, when physical examination findings suggest peritonitis, or when physical examination findings are unreliable secondary to a decreased mental status with a strong suspicion for abdominal injury to rule out an abdominal injury. Ultimately, the decision to perform diagnostic laparoscopy rests with the individual attending trauma surgeon.

We perform diagnostic laparoscopy in the operating room under general anesthesia. Once the abdominal cavity is entered and pneumoperitoneum achieved, a 30° 5- or 10-mm laparoscope is inserted, and the presence of hemothorax, bile, or intestinal contents is assessed. The standard examination of visceral organs includes inspection of the spleen and liver for bleeding and the diaphragm for lacerations. The gastrointestinal tract from the stomach to the rectum is inspected for hollow viscous injury, contusions, bleeding, and mesenteric injury. The lesser sac is opened through the gastrocolic ligament, allowing visualization of the posterior wall of the stomach as well as the body and tail of the pancreas.

Statistical analysis

Univariate analysis was performed using the Student t test and Fisher exact test with a value of \( P < .05 \) considered significant. All analyses were performed using SAS 9.3 (SAS Institute, Cary, NC). This study was approved by the University of Oklahoma Health Sciences Center Institutional Review Board.

Results

Over the 10-year study period at our American College of Surgeons’ verified level 1 trauma center, 131 patients underwent diagnostic laparoscopy. One hundred nine of these patients suffered penetrating injuries, whereas 22 presented after blunt trauma. Table 1 depicts demographic and patient outcome data categorized by the mechanism of injury. Patient age was similar between the 2 groups. Patients sustaining blunt injuries were more likely to be female, have higher injury severity scores (18.0 vs 7.3, \( P = .0001 \)), and have a longer mean hospital length of stay (11 vs 5.3 days, \( P = .03 \)).

Penetrating trauma

Of the 109 patients undergoing diagnostic laparoscopy for penetrating trauma, 26 suffered gunshot wounds and 83 stab wounds. The most common indication for diagnostic laparoscopy was a penetrating thoracoabdominal injury to evaluate for diaphragm and intra-abdominal injury in 49 (45%) patients. Laparoscopy for a penetrating abdominal injury secondary to a stab wound was performed in 42 (38.5%) patients. The remaining 18 patients underwent laparoscopy for tangential gunshot wounds to rule out violation of the peritoneal cavity.

Laparoscopy was negative in 74 (67.9%) patients and nontherapeutic in 13 (11.9%) patients. Eleven (10.1%) patients underwent a total of 13 therapeutic laparoscopic procedures including repair of a diaphragmatic injury, hollow viscous injury, hepatorrhaphy, cholecystectomy, and repair of a fascial injury. Eleven (10.1%) patients in this group required conversion to laparotomy, with 2 (1.8%)
patients undergoing a nontherapeutic laparotomy. Procedures completed after conversion to an open procedure included hepatorrhaphy, repair of enterotomy, partial gastric resection, and pancreatic drainage.

Of the 98 procedures completed laparoscopically for patients suffering penetrating injuries, 1 patient had a missed injury requiring reintervention. This patient suffered a gunshot wound and on initial laparoscopy was found to have a bilious hemoperitoneum believed to be secondary to a liver injury. A drain was placed in the right upper quadrant that continued to put out a significant amount of bile postoperatively. The patient underwent endoscopic retrograde cholangiopancreatography and was found to have a common bile duct injury, which was successfully treated with biliary stent placement.

The mean length of hospital stay for patients with penetrating injuries was 4 (6 6) days for the laparoscopy group compared with 16 (6 25) days for those requiring conversion to laparotomy. There were 9 complications in 98 patients managed solely with laparoscopy. Complications included superficial wound infection (3), pneumonia (3), reoperation (1), and empyema (1). There were 3 complications in 2 of the 11 patients converted to laparotomy; 1 patient developed pneumonia and the other had empyema. Of the 3 patients converted to laparotomy, 1 developed pneumonia.

There were 2 deaths during the study period in this patient cohort. The first patient was an 83-year-old man who underwent a negative diagnostic laparoscopy for a suspected diaphragm injury identified on a CT scan and died on hospital day 7 secondary to multisystem organ failure. The second death was in a 77-year-old man who underwent a diagnostic laparoscopy converted to a laparotomy for a diaphragm repair and died on hospital day 24 from a pulmonary embolism.

**Blunt trauma**

Over the 10-year study period, 22 patients sustaining blunt trauma underwent diagnostic laparoscopy. The most common indication for laparoscopy in this cohort was a CT scan equivocal for hollow viscous injury in 17 (77.3%) patients and peritonitis in the remaining 5 (22.7%) patients. Laparoscopy was negative in 4 (18.2%) patients and nontherapeutic in 15 (68.2%) patients. Three patients (13.6%) required conversion to an open procedure, 2 for repair of an enterotomy and the 3rd for an open diaphragm repair. Therefore, the nontherapeutic laparotomy rate in this cohort was nil. No patients sustaining blunt trauma underwent a therapeutic laparoscopic procedure. There were no missed injuries in the 19 patients who avoided laparotomy.

The mean length of hospital stay for patients with blunt injuries was 9 (6 11) days for the laparoscopy-only group compared with 20 (6 13) days for those requiring laparotomy. There were 2 complications in 19 patients managed solely with laparoscopy: 1 had pneumonia and the other had empyema. Of the 3 patients converted to laparotomy, 1 developed pneumonia.

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**Comments**

For hemodynamically stable patients who have sustained blunt abdominal injury and who are suspected to have intra-abdominal pathology, diagnostic laparoscopy is a reasonable option in the further evaluation and possible treatment of these patients. This modality allows for direct

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patient demographic and clinical characteristics by injury type</th>
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<tbody>
<tr>
<td>Patient characteristics</td>
<td>Penetrating injury (n = 109)</td>
</tr>
<tr>
<td>Mean age ± SD</td>
<td>32 (11)</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>91 (83)</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td></td>
</tr>
<tr>
<td>Initial HR</td>
<td>99 ± 21</td>
</tr>
<tr>
<td>Initial SBP</td>
<td>135 ± 20</td>
</tr>
<tr>
<td>ISS</td>
<td>18 (10)</td>
</tr>
<tr>
<td>Laparoscopy findings, n (%)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>74 (68)</td>
</tr>
<tr>
<td>Positive, nontherapeutic</td>
<td>13 (12)</td>
</tr>
<tr>
<td>Positive, therapeutic</td>
<td>11 (10)</td>
</tr>
<tr>
<td>Conversion to laparotomy</td>
<td>11 (10)</td>
</tr>
<tr>
<td>Mean ICU LOS ± SD*</td>
<td>17 (18)</td>
</tr>
<tr>
<td>Mean hospital LOS ± SD</td>
<td>5.3 (10)</td>
</tr>
<tr>
<td>Complications, n (%)</td>
<td>12</td>
</tr>
<tr>
<td>Mortality, n (%)</td>
<td>1 (1)</td>
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</tbody>
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HR = heart rate; ICU = intensive care unit; ISS = Injury Severity Score; LOS = length of stay; NT = no significance test conducted; SBP = systolic blood pressure; SD = standard deviation.

*Calculated for only those patients admitted to the ICU.
visualized the peritoneal cavity and its contents, possible intervention, and conversion to an open approach should it be necessary. Furthermore, this treatment approach minimizes the invasiveness and inherent risks that exist when a patient is immediately subjected to laparotomy. Overall, diagnostic laparoscopy allowed for the avoidance of laparotomy in >80% (117/131) of patients in our series. For patients sustaining blunt trauma, diagnostic laparoscopy resulted in 0 nontherapeutic laparotomies. Although rarely performed, it is a safe and effective diagnostic tool in this population. Importantly, there were no missed injuries using diagnostic laparoscopy as a screening tool for patients sustaining blunt trauma.

A multitude of literature has been published regarding the use of laparoscopy in patients with abdominal trauma. The majority of this literature has pertained to penetrating trauma. It is well established that laparoscopy is an acceptable diagnostic and/or treatment modality for penetrating abdominal injuries in hemodynamically stable patients. Specifically, it has been shown that up to 70% of patients can avoid traditional laparotomy when exploration is indicated. The relative morbidity and mortality, complication rates, and missed injury rates are low and comparable with open approaches. Additionally, a wide variety of intra-abdominal pathology can be addressed laparoscopically including injuries to the bowel, diaphragm, liver, spleen, and pancreas.

The potential for a missed hollow viscous injury after diagnostic laparoscopy exists and may have devastating consequences. In the current study, 1 (.8%) patient had a missed common bile duct injury that required reintervention. These results are comparable with Kaban et al, who showed that laparoscopy yielded a sensitivity of 92% and a specificity of 100% in detecting injuries in patients who suffered from blunt abdominal injury while also avoiding 50% of laparotomies in that same population. Earlier reports commonly cited a high missed injury rate as a result of using diagnostic laparoscopy to screen patients with potential abdominal injuries. Kawahara et al used a systematic approach to laparoscopic abdominal exploration, which resulted in no missed injuries.

Although the primary goal of laparoscopy in trauma is to make a diagnosis and/or exclude injury, it may also serve as a therapeutic tool in patients requiring intervention. We found that almost half (11/24) of the patients requiring surgical therapy were successfully treated laparoscopically. These results are similar to previously reported rates of therapeutic laparoscopy, ranging from 8% to 50%. With increasing surgeon expertise, improved equipment, and enhanced technology, these rates are likely to continue to climb.

When unexplained free intraperitoneal fluid is identified on a CT scan in a hemodynamically stable patient after blunt trauma, management options include observation, diagnostic peritoneal lavage, diagnostic laparoscopy, and exploratory laparotomy. Benefits of diagnostic laparoscopy compared with peritoneal lavage include accurate visualization of the source and extent of bleeding as well as the potential for therapeutic repair of an enteroctomy. Omori et al reported that laparoscopic approaches to isolated bowel rupture in blunt trauma actually offered better results than laparotomy with no difference in postoperative complications and decreased operative blood loss, with minimally increased mean operative times. Furthermore, peritoneal lavage may be too sensitive a test; Wood et al reported it led to a nontherapeutic laparotomy in 15% to 20% of patients.

There are limitations of our study that warrant discussion. The data were collected retrospectively and entered into the trauma registry by multiple hospital employees. Thus, there may be an underascertainment of cases. Over the 10-year study period, we performed only 22 diagnostic laparoscopies for blunt trauma, which represented less than 17% of the total patients studied. Furthermore, we lacked a control group to compare diagnostic laparoscopy with initial nonoperative management.

Our study shows that diagnostic laparoscopy can be safely used for patients sustaining both blunt and penetrating abdominal trauma. Diagnostic laparoscopy eliminated nontherapeutic laparotomies for patients sustaining blunt trauma. This may be an underused modality for the initial evaluation of patients sustaining blunt abdominal trauma.

References

Discussion

Dr Akpofure Peter Ekeh (Dayton, OH): First, in your article, you elaborately describe the conduct of how you conduct your laparoscopies. This includes running the entire small intestine and then opening up the lesser sac and inspecting the posterior surface of the stomach. Was this done consistently in all patients? I mean, we all know that even in the midst of any trauma faculty, you have a wide breath of laparoscopies skills and level of comfort. So this seems to be something pretty elaborate. Second, did you use laparoscopy for all the patients who had free fluid in the abdomen on an CT scan without seeing a solid organ injury (ie, in all the patients that you suspected a hollow viscous injury)?

Jeremy J. Johnson, M.D. (Oklahoma City, OK): The lesser sac was not opened in all patients. It depended on the location of the stab wound and the kind of trajectory of the injury. You know, obviously, if the peritoneal cavity was not violated or the diaphragm was not injured, then we did not feel the need to open the lesser sac. Laparoscopy for the blunt trauma patients with free fluid was mainly for patients who had either an unreliable examination secondary to a decreased mental status or a patient with an equivocal examination; it was determined to take a look and not let that patient be observed.

Peter Hallowell, M.D. (Charlottesville, VA): When I go back to my institution and I am taking call, what criteria would you use? Would you use diagnostic laparoscopy in your blunt trauma patients? I can recall Dr Onders teaching us that laparoscopy is an extension of your physical examination. What would your criteria be?

Dr Johnson: I think that just about all stable trauma patients get a CT scan, and with that in mind, if a patient has an unexplained finding on the CT scan (ie, fluid in the pelvis) and you do not see a solid organ injury or a male with fluid in his belly, in those patients nonoperative management can be used, but if they have got a head injury or their physical exam finding is worrisome, I think sticking a scope in is good to do initially. Just it would decrease the length of stay and probably hospital costs as well in the long run.

James G. Tyburski, M.D. (Detroit, MI): Along those lines, if you had a blunt trauma patient, particularly the blunt trauma, and a little bit of blood when you went in, where do you go? I mean, if the blood is up by the spleen, do you mobilize the splenic flexure in these patients, looking for a colon injury? Give me a feel for what your group does for a degree of exploration you do laparoscopically vs open and the old-fashioned exploratory laparotomy for blunt trauma.

Dr Johnson: I think that on a CT scan we would probably know how much blood we would be expecting to find in the abdomen. Simple hepatorrhaphies can be pretty easily done laparoscopically. I think a spleen bad enough to warrant exploration would probably have a laparotomy done. I do not think we have done a splenectomy laparoscopically in the trauma setting. I think a CT scan is important to guide you and kind of know what to expect.

Samir Gupta, M.D. (Peoria, IL): I am a little concerned about a patient who is unstable or has a head injury that you are doing a carbon dioxide insufflation on. Are you limiting your insufflation pressure? If they have a blunt diaphragmatic injury, do you not worry or in a patient who has a significant liver injury introducing carbon dioxide as an embolic event?

Dr Johnson: Yes. So with a severe blunt head injury, I do not think that patient was in our study. If so, they would probably have an intracranial pressure monitor (ICP) monitor in place before the operation. With intrathoracic pressures, if there is a large injury in the diaphragm, that really excludes a laparoscopic procedure because so much of your pneumoperitoneum enters the thoracic cavity and it is hard to keep a pneumoperitoneum. We have a chest tube in place and just leave it to water seal. If you clamp it, you can get tension physiology. If you have it on suction, then there goes all of your air, so it can be tricky with a larger injury to the diaphragm. That usually requires open procedure.