



Research Article

Laparoscopy for Penetrating Trauma, Protocol to Avoid Missing Injuries during the Learning Curve

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Citation: Ramos JP, Arenas CE, Zinco A, Lugo JA, Ottolino PR (2022) Laparoscopy for Penetrating Trauma, Protocol to Avoid Missing Injuries during the Learning Curve. J Surg 7: 1621. DOI: 10.29011/2575-9760.001621

Received Date: 01 November, 2022; **Accepted Date:** 10 November, 2022; **Published Date:** 14 November, 2022

Abstract

Purpose: With recent advances in laparoscopic training, more evidence is being published that supports the safety of a laparoscopic approach in patients with penetrating trauma. However, the learning curve may still be long and associated with significant morbidity. This study aims to present the results obtained during the learning curve in patients with penetrating abdominal trauma undergoing laparoscopy after the implementation of a protocol in a level I trauma center.

Methods We retrospectively reviewed the trauma registry of the southeast metropolitan health service from August 2017 – March 2020 and analyzed the patients that fulfilled the criteria for the laparoscopy for penetrating trauma protocol.

Results: A total of 68 patients with penetrating trauma were initially treated with laparoscopy, 91% male. The most common mechanism of injury was stab wounds (n=56) and GSW (n=12), with a median ISS on admission of 9 (8-13). Within the laparoscopies performed, 86% (n=59) were positive diagnostic laparoscopies and 48 of them were therapeutic. Ten patients (14%) required conversion to laparotomy, the most frequent cause being uncontrolled hemoperitoneum (n = 4). It is observed in the learning curve less conversion to open surgery with the implementation step. This series did not have any missed injuries, operative morbidity, or mortality.

Conclusions: Laparoscopic is a plausible approach for the diagnosis and treatment of penetrating abdominal injuries in hemodynamically stable patients during the learning curve. Proper selection of patients and the use of a standardized protocol are the main factors for the application of this technique

Keywords: Laparoscopy, Minimally invasive surgery; Penetrating trauma; Trauma

Introduction

The management of abdominal trauma is continuously evolving. The better diagnostic techniques and understanding of trauma physiology has helped decrease the burden of morbidity in these patients. Laparotomy for trauma is the current gold standard for the management of penetrating abdominal injuries. The steep learning curve and the risk of inadvertent injuries has slowed down

the implementation of laparoscopy in these patients [1-3]. Trauma midline laparotomy has up to 40% associated morbidity, unrelated to the intrabdominal findings [4,5]. Complications can occur as early as in the immediate post operative period, such as surgical site infection, but can also appear many years after the procedure, with incisional hernias and small bowel obstructions (6% of all patients) [6]. To reduce unnecessary laparotomies, non-operative management has emerged as a successful strategy in up to 70% of the patients [7]. Laparoscopic surgery has many advantages such as shorter hospital stay, lower inflammation, reduced risk of hernias and less adhesions [8-10]. In trauma, laparoscopy has

reduced unnecessary laparotomies in up to 60% of patients [11,12]. Nevertheless, some concern exists about the risk of missed injuries as initial studies reported high incidence of missed small bowel injuries [13,14]. With recent advances in laparoscopic training, more evidence is being published that supports the safety of a laparoscopic approach in patients with penetrating trauma. Careful selection of hemodynamically stable cases and an experienced laparoscopy team are critical for positive outcomes. However, the learning curve may still be long and associated with significant morbidity. The aim of this study is to present our experience and laparoscopy protocol to minimize morbidity and missing injuries during the learning curve upon implementing diagnostic and therapeutic laparoscopy in patients with Penetrating Abdominal Trauma (PAT).

Patients and Methods

Patient Selection

During this retrospective study, data was collected from the trauma registry of the southeast metropolitan health service in Santiago, Chile, from August 2017 to March 2020. The metropolitan health service covers a population of 1.7 million inhabitants and within the service is Dr Sotero del Rio Hospital, a level I trauma center. A strict inclusion protocol was established to determine eligible patients for laparoscopic surgery (Figure 1). Demographic data, trauma mechanism, site of injury, intraoperative findings, hospital stay, complications, and mortality were recorded. Patients undergoing laparoscopic surgery were selected using the following criteria: penetrating stab or GSW in hemodynamically stable (SBP>90 mmHg) patients with a triphasic tomography without retroperitoneal injuries,with either pneumoperitoneum, suspicious trajectory or free fluid. Patients that failed initial non-operative management were also included (developed abdominal pain during observation period). The exclusion criteria were hemodynamic instability (SBP < 90), retroperitoneal hematoma in tomography, or previous abdominal surgeries.

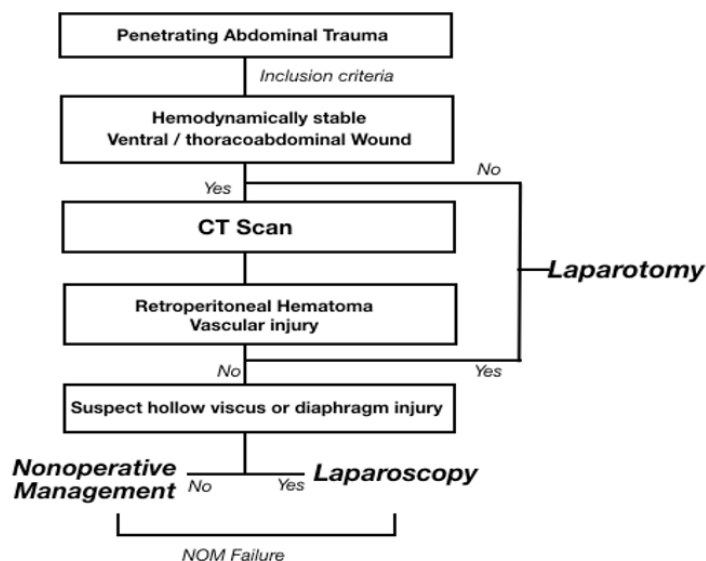


Figure 1: Algorithm used for the selection of patients with penetrating abdominal trauma undergoing laparoscopic surgery. NOM: Non-operative management. CT: computed to-mography.

Definitions

Diagnostic Laparoscopy: Procedure performed with no clear pre-operative diagnosis. Among these, negative or positive outcomes were defined according to the intraoperative findings.

Therapeutic Laparoscopy: positive diagnostic laparoscopy, where the lesion found requires surgical resolution. (Suture, Anastomosis)

Laparoscopic Technique

All patients underwent general anesthesia. Patients were placed in supine position with both arms opened and were prepped and draped in the usual sterile manner. CO2

pneumoperitoneum was established with a pressure of 10-15 mmHg. A 30° laparoscopic camera was used for the abdominal examination. The camera port was located in the peri umbilical position and two 5mm trocars were placed at the mid-axillary line on both sides of the patient. (Figure 2). According to the findings, the necessary trocars were added following the principle of triangulation. The surgical procedure was standardized for all cases. The first step was quick assessment of the abdomen and injury penetration to the peritoneum. Liquid blood, clots, and gastrointestinal contents were suctioned and any active bleeding was controlled. The next step was the systematic inspection of the entire abdominal cavity. The extent of mobilization was guided by clinical findings and preoperative imaging. Gravity retraction was achieved by changing the operating table position. Inspection started at the supramesocolic level; we began with diaphragmatic inspection, then liver and gallbladder, following by the spleen and then the anterior and posterior gastric wall, through the lesser sac. Intraperitoneal pancreas and duodenum were examined but mobilized only if needed. We then ran the small bowel twice from the ligament of Treitz to the ileocecal junction, and then back to the ligament of Treitz. Careful inspection of the small bowel was mandatory as described by Koto et al [15]. Meticulous revision of ascending, transverse, descending, and sigmoid colon, as well as the retroperitoneum and pelvic structures, was performed. When cases were performed by residents, a second running of the small bowel was performed by the attending surgeon. Decision to convert to open procedure was decided by the leading attending. When injured bowel was eviscerated for repair we considered the procedure as a conversion to open. After surgery, patients were admitted to the ward for hemodynamic monitoring and discharged once they tolerated oral feed and medications as per local trauma protocols.

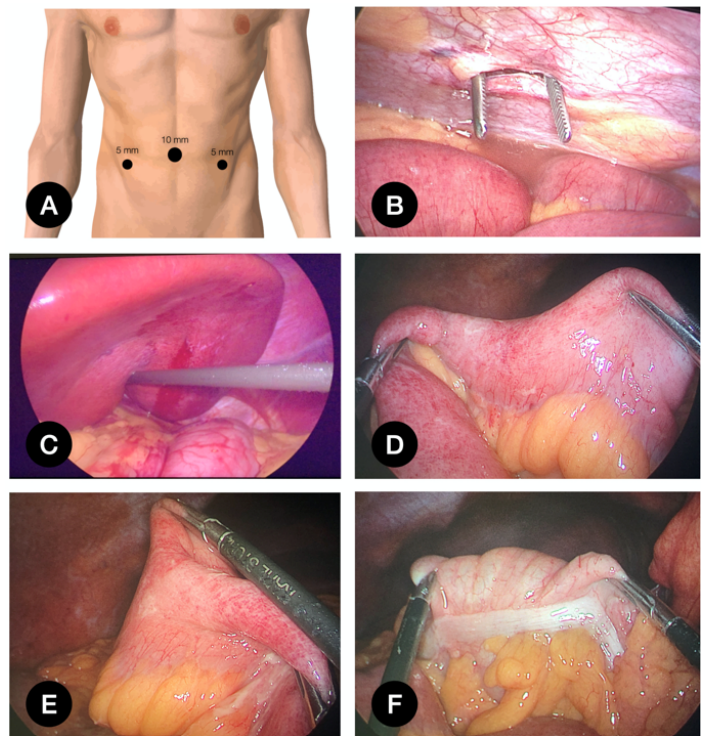


Figure 2: Key surgical steps established for performing laparoscopy in trauma. **A:** Insertion of 3 trocars for cavity exploration. **B:** Establish penetration of the peritoneum. **C:** Gastroesophageal junction review. **D-E:** Review of the entire small intestine. **F:** Review of the entire colon.

Statistical Analysis

Demographic details of the patients were summarized descriptively by mean, median, minimum, and maximum values for continuous variables and frequency count and by percentage calculations for categorical variables. All statistical procedures were performed with Minitab 19 software.

Results

A total of 68 patients with PAT were managed laparoscopically (Table 1). The median age was 31 years, and 91,2% of patients were male. The majority of the patients (82,3%) sustained stab wounds. All were hemodynamically stable on admission, with median mean arterial pressure of 89 mmHg (76-102), and heart rate 83 bpm (68-99). The median ISS was 9 (8-13). Thirty-eight percent of patients (n = 26) had a previous history of substance abuse. The most common location of injury was the thoracoabdominal area, comprised of the left upper quadrant (LUQ) (18 patients), followed by the right upper quadrant (RUQ) (9 patients) and the epigastrium (8 patients). 36,7% of the patients had extra-abdominal injuries, where pneumothorax stands out as the most frequent secondary injury with 16,1%. Organ evisceration was present in 4 (5,8%) patients (Table 1). We found intraabdominal injuries in 88,2% of patients (n=60) and had to perform a therapeutic laparoscopy in 45 of them (66,1%). Nine patients (13,2%) required conversion to laparotomy (Figure 3).

Parameters	N	Percentage/Ran ge
Total	68	100%
Age (mean/median)	32/31	(24-38)
Gender		
Male	62	91.2%
Female	6	8.8%
Penetrating trauma	68	100 %
Mechanism of injury		
Stab wound	56	82.35 %
Gunshot wound	12	17.66%
Associated injuries	25	36.7 %
Pneumothorax	11	16.1%
Limb injuries	5	7.3%
Soft tissue injuries	3	4.4%
Others	6	8.8%
MAP (mmHg) (mean/median)	88.5 /89	(76-102)
HR (lpm) (mean/median)	85.4 /83	(68-99)
Trauma scoring ISS Median	9	(8-13)

Table 1: Demographics and characteristics upon presentation. MAP, mean arterial pressure, HR heart rate, ISS injury severity score

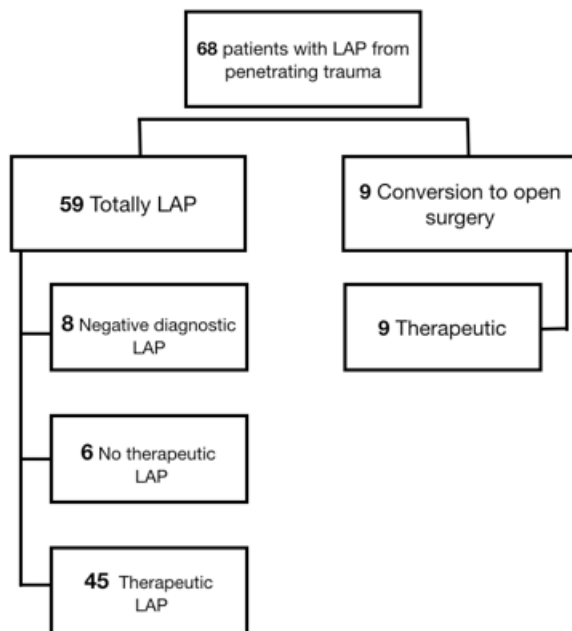


Figure 3: Flow chart summary of patients admitted to the protocol. LAP; laparoscopy

In 9 patients, a conversion to open surgery was performed. The most common was extensive bleeding that could not be controlled laparoscopically (5 patients) followed by poor visibility of the injury (3 patients) and complex visceral injury (2 patients) (Figure 3). The most frequently injured structures were liver (13 patients) and diaphragm (12 patients), followed by small bowel (9 patients) and colon (8 patients). When analyzing the type of procedure during the 30-month period of implementation of the protocol, we observed a greater number of conversion and diagnostic laparoscopies at the beginning of the stud period. Over time, the number of therapeutics laparoscopies increased (Figure 4).

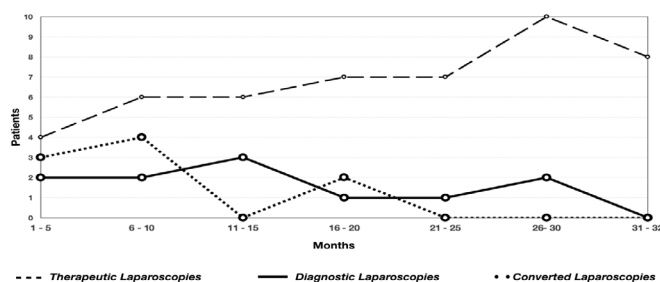


Figure 4: Numbers of patients with therapeutic, diagnostic, and converted laparoscopies during the implementation of the protocol.

The mean and length of hospital stay were significantly shorter in the groups managed without laparotomy. The mean length of stay for diagnostic and therapeutic laparoscopy patients

was 3,9 days, while it was 6,6 days for those converted to laparotomy. There were no mortalities and no missed injuries

Discussion

A laparoscopic approach to the abdominal cavity in penetrating trauma is safe when implemented with a strict protocol for patient selection and when done in a methodical way to reduce unnoticed injuries. The learning curve for laparoscopy in trauma can be overcome with these systems in place to produce equivalent or improved patient outcomes. Laparoscopy is currently the gold standard for many abdominal procedures, however, in the management of trauma patients the development of laparoscopic surgery has been much slower, mainly because of the risk of missing injuries. Initial experience reported high accuracy of laparoscopy for the diagnosis of hemoperitoneum and solid organ injuries but the sensitivity for the diagnosis of GI injuries was as low as 18% [16]. Subsequent experiences reported better outcomes due to advancement in technology, surgeon experience, and standardized abdominal exploration [17,18]. The use of laparoscopy decreases the rate of nontherapeutic laparotomies and allows for minimally invasive management of selected intra-abdominal injuries, reducing hospital length of stay and wound complications [3,19-21]. Even though the laparoscopic approach in trauma patients is amassing increasing evidence for safe outcomes, many trauma centers have decided against its development because benefits did not outweigh the risk of missing GI injuries. To date, laparoscopy has been reserved for assess peritoneal violation in PAT only in many cities [1,2,22-24].

There are 3 steps in the laparoscopic approach of trauma patients [25]. The first one is screening laparoscopy that involves only the assessment of peritoneal violation; the risk of missing injuries is low and requires basic laparoscopic skills. The second step is diagnostic laparoscopy, where a systematic inspection of the peritoneal cavity is performed. This step requires intermediate laparoscopic skills for a complete inspection that has a low likelihood of missing injuries. The final step is therapeutic laparoscopy, where injuries are treated through a minimally invasive approach. Skills required depend on the complexity of the injuries; intermediate laparoscopic skills are required for minor bleeding control but advanced skills may be necessary for bowel repair or resection. As surgeon's increase in their experience, the first cases were screening laparoscopies, and then advancing to diagnostic laparoscopies and finally to therapeutic procedures.

Three tenets were key to our approach: correct patient selection, a standardized surgery protocol, and advanced laparoscopic skills. For patient selection, we recommend a step-up approach beginning with more simple cases. LUQ injuries in a stable patient after 24hrs of successful non-operative management is a good case to start, as this minimizes the risk of missing gastrointestinal injuries and allows laparoscopic assessment and

repair of diaphragm injuries. In our study we reported a total of 35 LUQ lesions in which 12 diaphragmatic repairs were performed. Once proficiency is achieved, one can advance to more complex cases such as flank stab wounds and gunshot wounds.

The difference found between therapeutic and converted laparoscopies during the implementation period (Figure 4) can be explained by the improvement of the laparoscopic skills of the treating teams as experience with the procedure increased. Learning curves usually have 2 phases of higher complication rates [26]. The first phase is at the beginning of the curve where inexperience with the new procedure may increase complications [27]. This peak can be diminished by using surgery protocols and mentoring by experts, or working in teams. The second phase occurs as more complex patients are included in the procedure and surgeons may be overconfident. We had higher conversion rate at the beginning of our learning curve, mainly because of advanced bowel repair, but this did not occur in the last 30 patients. The main cause of conversion was the poor visibility of an injury due to intestinal or mesentery hematomas, or for more complex repairs such as intestinal anastomoses. Unlike elective procedures, in trauma cases the learning curve involves a team of surgeons and not only one attending. All teams must follow standardized protocols and video-record all procedures for team analysis and learning. When we started our trauma laparoscopy protocol, there was always a trauma surgeon and an MIS surgeon in the room (3 different teams). After the first 30 cases most teams had the skills necessary for laparoscopic exploration so only the trauma surgeon or the MIS surgeon were present in the OR and general surgery residents were involved in patient care.

There are several limitations to implementation of a laparoscopy protocol in trauma patients. First, the institution must have the technical resources available at all times. Second, there has to be a multidisciplinary trauma team that is willing to go through a progressive training in surgical skills based on simulation programs. This is particularly important for centers that have low volume in elective MIS. Other limitations include that the same surgical teams have been present throughout the entire study duration, and that has allowed us to consolidate these skills. However, this might not be the situation in centers with high staff turnover. Even though this allowed for a consistent evaluation of our protocol, we recognize that is also a weakness, when none of them is on call, patients that could have been approached laparoscopically are done open, and this could be a reason why in a high volume center we have just 68 patients in 4 years. Overall, this data shows that a laparoscopic approach is possible in highly selected patients by following a strict protocol.

Conclusion

The implementation of a strict laparoscopy protocol in penetrating abdominal trauma, both in the selection of patients and in the surgical technique, reduces complications during the learning curve of its implementation.

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