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Role of Laparoscopy in Penetrating Anterior Abdominal Wall Injuries

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ABSTRACT

Background: Penetrating abdominal trauma in patients is associated with severe morbidity and sometimes death. The incidence of penetrating trauma varies widely over the world. Similarly, the global experience with laparoscopy in trauma patients varied. Many recent investigations have indicated that laparoscopy plays a useful function in such cases. **Objective:** This study aimed to assess the diagnostic and therapeutic utility of laparoscopy in penetrating abdominal trauma (PAT) patients with respect to the precision and effectiveness of care and the avoidance of needless laparotomy. **Patients and methods:** This prospective study was conducted at Sohag University Hospitals, Sohag, Egypt. We included all patients with penetrating anterior abdominal wall injuries who were vitally stable.

Results: We involved 60 patients who were admitted to the Emergency Room after suffering from penetrating abdominal injuries. The patients' mean age was 37.4 years and the percentage of male patients was higher (81.67%). Stab wounds accounted for 60% of injuries while gunshot wounds accounted for 40%. Hospital stay in laparoscopy was longer due to gastric, small intestinal, and colonic injuries. The average operation time in laparoscopy was 2.5 hours and about 2.25 hours in laparotomy. There were no post-operative complications in the form of postoperative leakage or wound infection found in the studied patients. **Conclusion:** Stab wounds were more common than gunshot wounds and the laparoscopic approach proved to be accurate and effective in the management of PAT and led to successful avoidance of unnecessary laparotomy. The patients experienced an uncomplicated course, with no postoperative complications and relatively short hospitalization. Further research and studies should be conducted to evaluate the long-term outcomes and potential benefits of laparoscopy in PAT cases, including larger sample sizes and comparative analyses.

Keywords: Laparoscopy, Laparotomy, Penetrating abdominal injuries, Diagnostic accuracy, Therapeutic role.

INTRODUCTION

The conventional gold standard for treating patients with PAT is exploratory laparotomy. It has been shown that negative or non-therapeutic laparotomies can result in up to 5% death and 20% morbidity [1]. Following PAT, peritoneal penetration (PP) is not always achieved [2]. Not all PAT patients require a laparotomy because only around half of them have small bowel injuries [3]. On the other hand, intestinal damage identification is more difficult and has been found to have accuracy rates as low as 18%, despite more recent studies reported accuracy rates of 100%. Solid visceral injury can be accurately identified by diagnostic laparoscopy (DL) [4]. In PAT, laparoscopy can be utilized for screening, diagnosis, or treatment purposes. A screening laparoscopy has to do for looking for visceral harm that call for a laparotomy. All injuries must be identified by DL with the same accuracy as other diagnostic methods like computed tomography [5].

For therapeutic laparoscopy to be deemed successfully, all damage must be able to be detected and repaired completely. The range of injuries that can be addressed laparoscopically in a trauma environment is enormous [5]. On the other hand, patients who suffer from PAT who wait for surgical procedures are more likely to experience problems and a delayed diagnosis [6]. The list of conditions for which laparoscopic procedures are indicated has been growing over the past few years. Nonetheless, there is ongoing debate regarding the diagnostic and therapeutic utility of laparoscopy in the management of penetrating and blunt abdominal injuries [7]. Diagnostic laparoscopy has a 100% negative predictive value and 100% sensitivity, making it a dependable method for evaluating peritoneal penetration [8]. In patients with peritoneal penetration, a laparotomy may be performed after a diagnostic laparoscopy to assess for potential additional intra-abdominal injuries such as small intestine perforations, vascular injuries, or growing retroperitoneal hematomas [9]. The current study aimed to assess the diagnostic and therapeutic utility of laparoscopy in PAT patients with respect to the precision and effectiveness of care and the avoidance of needless laparotomy.

PATIENTS AND METHODS

This prospective study was conducted at Sohag University Hospitals, Sohag, Egypt. We included 60 (49 males and 11 females) patients who were exposed to penetrating abdominal injuries and admitted to the Emergency Department. All patients underwent blood examinations, abdominopelvic ultrasonography, and abdominal and pelvic Computed tomography when needed.

Inclusion criteria: Age between 5 - 65 years old. All patients with penetrating anterior abdominal wall injuries and vitally stable. Physical status American Society of Anesthesiologists (ASA) I, II, and III.

Exclusion criteria: Patients who only require conservative care and no intervention. Vitally unstable patients. Patients with comorbidities that need rapid interventions. American Society of Anesthesiologists classification IV, V, and VI. Individuals who had a confirmed serious abdominal injury (such as pancreatico-duodenal damage) that cannot be treated laparoscopically. Patients who had a history of major

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abdominal surgery and who were expected to have significant intra-abdominal adhesions, as well as those with general or local contraindications for laparoscopy, such as decompensated cardiac patients. Polytraumatized patients (more than two organs damaged) and those with elevated intracranial tension.

Preoperative assessment: All patients were subjected to the following: Gathering demographic information (age, sex, weight; height; body mass index (BMI)). Through history taking that included complete clinical history as the mechanism of trauma (Gun shoot, stab wound and explosion, heart rate and hemoglobin).
Laboratory investigation included complete blood count (CBC), liver function tests, kidney function tests, serum electrolyte, and international randomized ratio (INR).
Radiological investigations included abdominal U/S, lower chest, abdomen and pelvis x-ray in the erect position, and when necessary, an IV and oral contrast were used for a CT scan of the abdomen and pelvis.

Operative assessment:

In the event of left-sided trauma, two more 5-mm laparoscopic ports were placed under direct vision at the right iliac fossa and right upper quadrant (paramedian area). In the event of right-sided damage, the reverse procedure was carried out.

Laparoscopy results were categorized as negative in the event that no injury was found, non-therapeutic in the event that an injury was found but did not necessitate surgical intervention, therapeutic in the event that an injury was found and fixed, and positive in the event that an injury needed to be converted to open exploration in order to provide better management. Surgical intervention was carried out in accordance with the affected organs.

Cases, where a minor intestinal perforation was found were treated with 3-0 Vicryl sutures following intraperitoneal collection irrigation and drainage. Moreover, cauterization and suture ligation were used to limit bleeding in situations with ruptured mesentery. Reduction of the omentum and wound healing were performed in cases of prolapsed omentum through the wound entrance site. Management of splenic and hepatic damage patients is contingent upon the extent of the injury, determining whether to do a segmental hepatectomy or repair the spleen. When diaphragmatic damage occurred, prolene 2-0 repair was carried out.

Postoperative assessment: Patients received analgesics, antibiotics, IV fluids, and hemostatic agents as needed while in the hospital. They were also monitored with regard to vital signs (heart rate, systolic and diastolic blood pressure), urine bag of the drain, and other factors. Early mobilization and liquid intake (2 h after surgery) were encouraged.

Postoperatively, the patients were observed for vital data, Hb level, and return of bowel functions and wound complications. The patients who underwent splenectomy and were younger than 25 years old were given vaccination against meningococcal, pneumococcal, and H. influenza type B infections. The patients were discharged after the return of normal bowel functions, drain removal, and any complication was ruled out. Following surgery, the patient's hemodynamic status was monitored and any consequences were evaluated. The type of procedure, length of the operation, amount of blood lost, length of hospital stay, and any potential problems were evaluated.

Ethical approval: The Ethics Committee at Faculty of Medicine, Sohag University approved the study. Each participant was given a full summary of the study's aims before filling out an informed consent form. The Helsinki Declaration was upheld throughout the investigation.

Statistical analysis

IBM Inc., Chicago, IL, USA SPSS version 26 for statistical analysis was used. To assess if the data distribution was normally distributed, the Shapiro-Wilks test and histograms were employed. Standard deviation (SD) and mean were used to depict quantitative parametric data. The interquartile range (IQR) and median were used to display quantitative non-parametric data. Qualitative factors were displayed as percentages (%) and frequencies.

RESULTS

This prospective study involved 60 patients who were admitted to the Emergency Room after suffering penetrating abdominal injuries. The age range was 5–65 years old, with a mean value of 37.4 ± 17.33 years. There were 49 (81.67%) males and 11 (18.33%) females. The weight ranged from 56 to 90 kg with a mean value of 72.8 ± 11.02 kg. The height ranged from 156 to 182 m with a mean value of 169.8 ± 8.28 m. BMI ranged from 17.9 to 35.34 kg/m^2 with a mean value of 25.5 ± 4.87 kg/m^2 (Table 1).

Table (1): Patient demographics for the research

Parameters		n = 60
Age (years)	**Mean ± SD**	37.4 ± 17.33
	Range	5 – 65
Sex	**Male**	49 (81.67%)
	Female	11 (18.33%)
Weight (kg)	**Mean ± SD**	72.8 ± 11.02
	Range	56 – 90
Height (m)	**Mean ± SD**	169.8 ± 8.28
	Range	156 – 182
Body mass index (kg/m^2)	**Mean ± SD**	25.5 ± 4.87
	Range	17.9 - 35.34

The mechanism of injury was stabbing wounds in 36 (60%) patients and gun shoot wounds in 24 (40%) patients. Seven (20.59%) patients had epigastrium-related stabbing wounds, 13 (38.24%) had right upper quadrant wounds, 22 (64.71%) had left upper quadrant wounds, four (11.76%) had right lower quadrant wounds, and four (11.76%) had left lower quadrant wounds (Table 2).

Table (2): Clinical characteristics

	(n=60)
Mechanism of injuries	
Stab wounds	36 (60%)
Gun shoot wounds	24 (40%)
Site of stab wounds	
Epigastrium	7 (20.59%)
Right upper quadrant	13 (38.24%)
Left upper quadrant	22 (64.71%)
Right lower quadrant	4 (11.76%)
Left lower quadrant	4 (11.76%)

16 patients (47.06%) had gunshot wounds in the right upper quadrant, 8 patients (23.53%) in the left upper quadrant, 7 patients (20.59%) in the right lower quadrant, and 9 patients (26.47%) in the left lower quadrant (Figure 1).

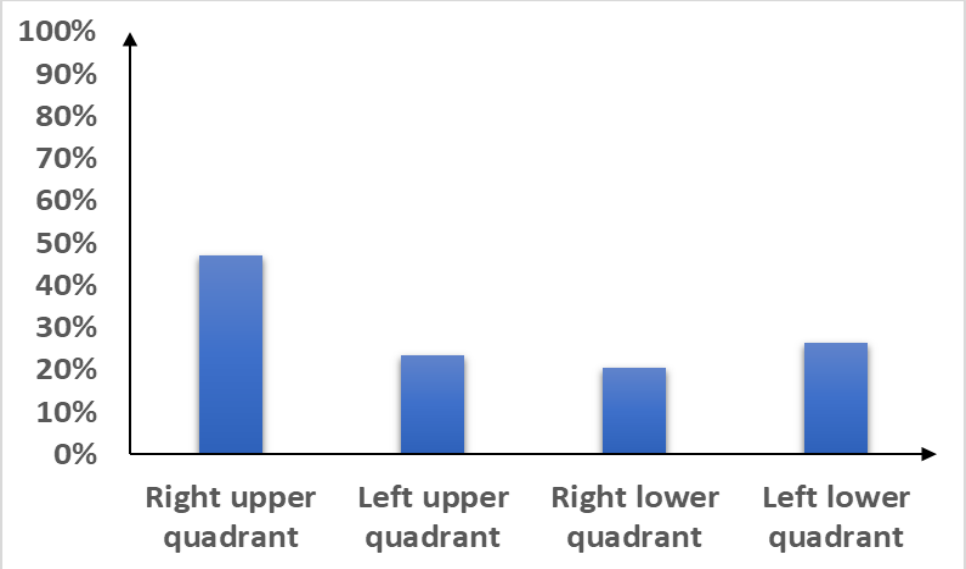

Figure (1): Site of Gun shoot wounds of the studied patients.

Regarding the penetrated injured organ, in the E area, one wound was found in the liver. 16 wounds were found in the RUQ area (4 wounds in the diaphragm, 7 in the liver, 3 in the small bowl, and 2 in the colon). In the LUQ area, 28 wounds were found (7 wounds in the diaphragm, 5 in the liver, 4 in the spleen, 4 in the stomach, 3 in the small bowl, 3 in the colon, 1 in the pancreas and 1 in the kidney). 6 wounds were found in RLQ area (1 wound was in the diaphragm, 1 in the liver and 4 in small bowl). 3 wounds were found in LLQ area (2 wounds were in small bowl and 1 in colon). There were four negative explorations (negative injury to any organ) (Table 3 and figures 2-6).

Table (3): Injured organs in relation to the site of injury of the studied patients

	E	RUQ	LUQ	RLQ	LLQ	Total
Diaphragm	0	4	7	1	0	12
Liver	1	7	5	1	0	14
Spleen	0	0	4	0	0	4
Stomach	0	0	4	0	0	4
Small bowl	0	3	3	4	2	12
Colon	0	2	3	0	1	6
Pancreas	0	0	1	0	0	1
Kidney	0	0	1	0	0	1
Total	1	16	28	6	3	**54**
Negative exploration (negative injury to any organ)						**4**

E: Epigastrium, RUQ: Right upper quadrant, LUQ: Left upper quadrant, RLQ: Right lower quadrant, LLQ: Left lower quadrant.

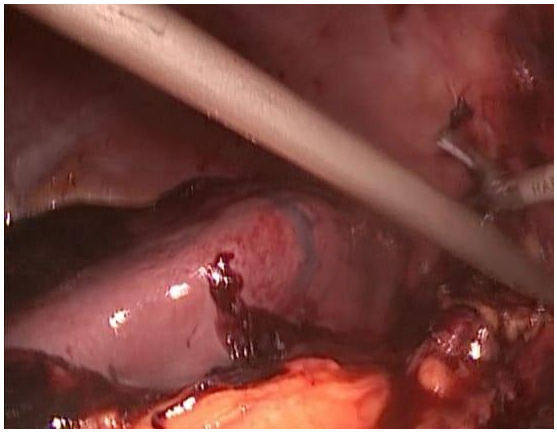

Figure (2): Splenic injury.

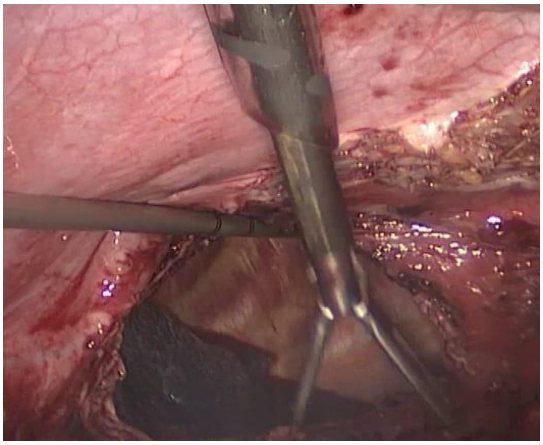

Figure (3): Diaphragmatic injury.

Figure (4): Hemoperitoneum.

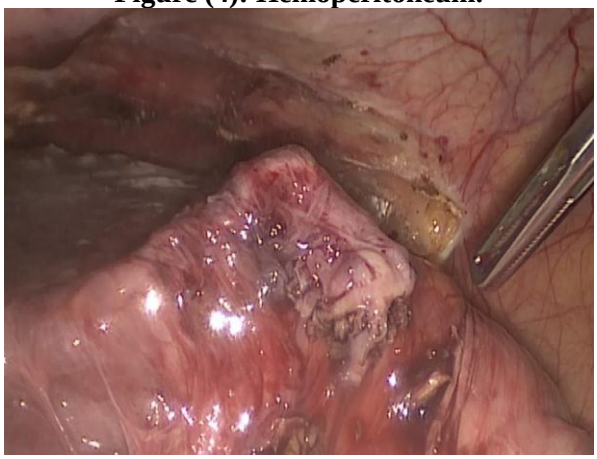

Figure (5): Stomach wall perforation.

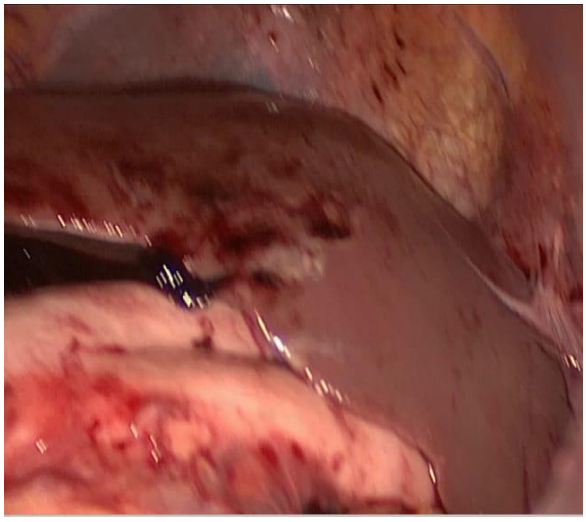

Figure (6): Liver injury.

Ultrasound could not detect diaphragmatic injuries, which were found laparoscopically in 12 (20%). Concerning liver, 14 (23.33%) patients were seen laparoscopically. Single pancreatic injury couldn't be seen by Ultrasonography (1.66%). Regarding gastric injury, 4 (6.66%) patients couldn't be identified by US. As regards small bowl, 3 (5%) out of 12 (20%) patients and in colon, 1 (1.66%) out of 6 (10%) patients could not be identified by US. Ultrasound showed no collection in 19 (31.66%) and only 4 (6.66%) cases were found negative in laparoscopic exploration (Table 4).

Table (4): Comparison between Ultrasound and laparoscopy as regards injured organs of the studied patients

Finding as regards Free collection or organ injury	U/S N=60	Laparoscopy N=60
Diaphragm	0 (0.00%)	12 (20%)
Liver	12 (20%)	14 (23.33%)
Spleen	4 (6.66%)	4 (6.66%)
Stomach	0 (0.00%)	4 (6.66%)
Small Bowel	3 (5%)	12 (20%)
Colon	1 (1.66%)	6 (10%)
Pancreas	0 (0.00%)	1 (1.66%)
Kidney	1 (1.66%)	1 (1.66%)
No Collection or Organ Injury	19 (31.66%)	4 (6.66%)

US could not diagnose penetrating anterior abdominal wall injuries (P value =0.011, kappa value = 0.203, sensitivity 64.8%, specificity 100%, PPV 100%, NPV 17.4%, and accuracy 67.2%) as indicated in table (5).

Table (5): Diagnostic accuracy of the US

P-value	0.011*
Kappa value	0.203
Sensitivity	64.8%
Specificity	100.0%
PPV	100.0%
NPV	17.4%
Accuracy	67.2%

About 56 cases (93.33%) were completed by laparoscopy. Conversion to open (laparotomy) occurred in 4 (6.67%) patients. Of these 4 patients, 2 cases suffered from splenic injury and underwent splenectomy, 1 case suffered from liver injury and was treated by hemostasis by suturing and gel foam, and 1 case suffered from pancreatic injury and was treated by repairing pancreatic injury as shown in table (6).

Table (6): Rate of Success of the procedure of the studied patients

procedure	(n=60)
Conversion to open (laparotomy)	4 (6.67%)
Laparoscopy	56 (93.33%)

12 (23.1%) patients suffered from diaphragmatic injury were repaired. 13 (25%) patients suffered from liver injury underwent hemostasis by diathermy and 1 (1.9%) patient underwent laparotomy and hemostasis. 2 (3.8%) patients suffered from splenic injury had to conserve no intervention and 2 (3.8%) patients converted to laparotomy and splenectomy. 4 (7.7%) patients who suffered from stomach injury were repaired. 12 (23.1%) patients who suffered from small bowl injuries were repaired. 6 (11.5%) patients who suffered from colonic injury were repaired (Table 7).

Table (7): Procedures of the studied patients

Procedure	Treatment	(n=52)
Diaphragm	Repair	12 (23.1%)
Liver	Hemostasis by diathermy	13 (25%)
	Laparotomy and hemostasis	1 (1.9%)
Spleen	Conserve no intervention	2 (3.8%)
	Converted to laparotomy and splenectomy	2 (3.8%)
Stomach	Repair	4 (7.7%)
Small bowl	Repair	12 (23.1%)
Colon	Repair	6 (11.5%)

The average length of stay in the hospital was 4.6 ± 2.33 days post-laparoscopy and 4.3 ± 2.15 post-laparotomy. Hospital stay in laparoscopy was longer due to gastric, small intestinal, and colonic injuries which underwent 3 days NPO, 3 days oral fluids, and 3 days semisolid oral feeding. All of them were done laparoscopically without laparotomy. The average operation time in laparoscopy was 2.5 hours and about 2.25 hours in laparotomy. They were almost equal as time in laparoscopy was consumed in the insertion of the instrument, handling with it and insufflation of the abdomen, and in laparotomy was consumed in the opening of the large incision and closing it. There were no missed injuries after the follow-up of the patients following laparoscopy. There were 8 cases exposed to non-therapeutic laparoscopy. There were no post-operative complications in the form of postoperative leakage or wound infection found in the studied patients (Table 8).

Table (8): Operative time, hospital stay, and complications

Procedure/ variables	Laparoscopy	Open Laparotomy
Operation time In hour (Mean ± SD)	2.5±1.28	2.25±1.125
Hospital Stay in days (Mean ± SD)	4.6±2.33	4.3±2.15
Complications	0 (0.00%)	0 (0.00%)

CT abdomen and pelvis with IV contrast was done on 28 cases only from 60 when ultrasonography was insufficient. CT accuracy for diaphragmatic injury was 25%, while in liver, spleen, and stomach was 100%, and for small bowel and mesentery was 50%. CT had 97 % sensitivity and 98 % specificity for peritoneal violation. CT had an overall sensitivity of 96 % in detecting mesenteric injury (Table 9).

Table (9): Comparison between CT abdomen with IV contrast finding and laparoscopic finding

Organ injured	CT finding	Laparoscopic Finding	Accuracy
Diaphragm (hernia)	2	8	25%
Liver	11	11	100%
Spleen	4	4	100%
Stomach	2	2	100%
Small Bowel	1	2	50%
Mesentery	1	2	50%

DISCUSSION

In our study, the proportion of male patients was higher (81.67%). This likely reflects higher rates of violence and assault injuries among young men. They adhere to the results of **Riad *et al.*** [10] who reported that the mean age of the laparoscopic group was 28 ±

2.3 years and that all of the patients were male. **Miles *et al.*** [11] who aimed to assess the function of laparoscopy in trauma patients' treatment for piercing abdominal injuries, revealed that males were 171 (82%), and females were 38 (18%). **Awad *et al.*** [12] reported that forty patients were enrolled, with a male-to-female ratio of 5.6:1.

We found that stab wounds accounted for 60% of injuries, while gunshot wounds accounted for 40%. Similarly, stab wounds predominated over gun injuries in the study by **Abdallah and Gharib** [13] and **Miles *et al.*** [11]. Regional differences in crime rates and firearm regulations may explain these variations.

In our study, in terms of anatomical location, the left upper quadrant was the most common region for stab wounds (64.71%) followed by the right upper quadrant (38.24%). A similar pattern was seen with gunshot wounds affecting the right (47.06%) and left (23.53%) upper quadrants predominately. Serious vascular injuries were not seen in our study. We found that negative exploration was reported in 4 patients with penetrating injuries (6%). **Abdallah and Gharib** [13]**,** reported that of the latter, five patients (or 26%) experienced a negative laparoscopic exploration. Retroperitoneal hematomas with free hemoperitoneum were present in six individuals (37%) and two of them also had tiny and easily accessible liver rips. **Johnson *et al.*** [14] reported that four patients (18.2%) out of the twenty-two who had a diagnostic laparoscopy due to penetrating trauma had a negative result.

We reported that by using laparoscopy on 35 patients, we were able to 100% minimize the number of non-therapeutic laparotomies conducted for hemoperitoneum. As a screening tool for abdominal trauma, diagnostic laparoscopy resulted in less than 1% of missed injuries (conversion to laparotomy at first positive findings, such as peritoneal puncture in penetrating trauma patients or free bleeding in blunt trauma patients). According to **Riad *et al.*** [10]**,** 96.15% of laparoscopic diagnoses for peritoneal penetration with or without intra-abdominal damage were successful. Missed intestinal damage occurred on one occasion (4%). This study's overlooked case may be related to our initial experiences with the novel methodology. In a study with 38 patients, a missed injury incidence of 0% was reported [15], while **Fabian *et al.*** [16] reported a missed injury rate of 40%. This demonstrates the utility of laparoscopy to stratify patients based on injury and guide appropriate surgical versus conservative management. Additionally, its underutilized role as a minimally invasive intervention to fix certain traumatic intra-abdominal pathologies was highlighted.

There is a complementry functions of laparoscopic abdominal exploration and diagnostic peritoneal lavage (DPL) in knife wounds to the abdomen [17]. In 31 patients, they avoided non-therapeutic investigation in 55 percent of cases, while 11 out of 12 patients had DPL results that were positive for injuries requiring surgery.

The percentage of missed injuries after laparoscopy was 0% in our study. When laparoscopy was utilized as a diagnostic procedure. The findings showed missed injury rates ranging from 41% to 77%, which was less encouraging. Most surgeons who have used the laparoscope less frequently would find this level of diagnostic accuracy inadequate. **Brandt *et al.*** [18] examined 21 trauma patients who had both penetrating and blunt injuries and were evaluated laparoscopically. The results showed that emergency laparoscopy was 100% accurate in identifying individuals who required a laparotomy. They found that thanks to the laparoscopic screening, nine individuals were spared an unnecessary laparotomy. A methodical approach to laparoscopic abdominal examination was taken by **Kawahara *et al.*** [19] and no injuries were missed.

In terms of gunshot wounds specifically, we found that the right upper quadrant (47.06%) and left upper quadrant (23.53%) were again the most commonly affected regions in our patients. This was likely due to the central location of the liver, stomach, and spleen. We found a very high rate of liver injury from gun violence (50%) along with damage to the small bowel (29.2%), stomach (8.3%), colon (16.7%), and pancreas (4.2%). However, our patients had no major vascular compromise from gun wounds. **Miles *et al.*** [10] reported that eight out of ten GSWs and all fourteen stab wounds may have been treated laparoscopically, according to an analysis of the surgical data of patients who had negative laparotomies. **Ahmed *et al.*** [20] showed that in patients with penetrating abdominal trauma who were hemodynamically stable, DL could prevent 77% of needless laparotomies.

Notably, our patients had an uncomplicated course with no postoperative complications and relatively short hospitalizations (average 4.6 days). **Abdallah and Gharib** [13] reported that the group that underwent laparoscopic surgery had an average hospital stay of three days, with a range of two to five days. **Lee *et al.*** [21] discovered in their research that diagnostic laparoscopy, when performed on carefully chosen trauma patients who were hemodynamically stable, was both safe and technically possible.

LIMITATIONS

There were several limitations to be acknowledged in this study. The relatively small sample size of patients, can restrict how broadly the results can be applied. Because only one center was used for the study, bias may have been introduced, limiting the results' external validity. The study focused on short-term outcomes, and long-term follow-up data were not included, thus limiting the assessment of potential complications or late-onset

issues. The study did not include a comparison group undergoing traditional laparotomy, making it difficult to directly compare the efficacy of laparoscopy versus open surgery in PAT cases.

RECOMMENDATIONS

Because laparoscopy provides correct assessment and prevents needless laparotomy, it should be regarded as an important diagnostic and therapeutic tool in the management of patients with penetrating abdominal trauma. Healthcare professionals should be aware of the specific anatomical patterns and injury distribution associated with stab and gunshot wounds to guide clinical decision-making and prioritize interventions. Further research and studies should be conducted to evaluate the long-term outcomes and potential benefits of laparoscopy in PAT cases, including larger sample sizes and comparative analyses.

CONCLUSION

Based on the results of this study, stab wounds were more common than gunshot wounds and the laparoscopic approach proved to be accurate and effective in the management of PAT and led to a successful avoidance of unnecessary laparotomy. The patients in this study experienced an uncomplicated course, with no postoperative complications and relatively short hospitalization.

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