



Original article

Is non-operative approach applicable for penetrating injuries of the left thoraco-abdominal region?

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ABSTRACT

Objectives: Currently, diagnostic laparoscopy (DL) is recommended for the left thoraco-abdominal region penetrating injuries (LTARP). However, organ and diaphragmatic injury may not be detected in all of these patients. Our aim is to focus on this LTARP patient group without any operative findings and to highlight the evaluation of diagnostic tools in the high-tech era for a possible selected conservative treatment.

Material and methods: The patients who were admitted to ED due to LTARP, and who underwent routine DL were evaluated retrospectively in terms of demographic, clinical, radiological, and operative findings of the patients.

Results: The current study included 79 patients with LTARP. In 44 of 79 patients, abdominal injury was not detected. In 30 patients an isolated diaphragmatic injury was revealed and in 4 patients a visceral injury was accompanying to diaphragmatic injury. Surgical findings revealed that the diaphragm was the organ most likely to sustain injury. In patients with more than one positive diagnostic findings need for surgery rate was 61.5%, however; in patients with one positive diagnostic finding (n = 53), positive surgical finding rate was only 35.8%, (p = 0.03). Regarding the combined use of all diagnostic tools in these patients; such as physical examination, plain chest X-ray, and computed tomography, when this method was used for pre-operative diagnosis, sensitivity was measured as 82.7%, specificity 84.1%, PPV 77.4% and NPV 88.1%.

Conclusion: Although DL is reliable for diagnosis of diaphragmatic and visceral injury in patients with LTARP. However, individual decision making for laparoscopic intervention is needed to prevent morbidity of an unnecessary operation under emergent setting due to high rates of negative intraabdominal findings.

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1. Introduction

Left thoraco-abdominal region penetrating injuries (LTARP) may lead to diaphragmatic damage as well as damage to intra-abdominal and thoracic organs, and therefore they are different from other penetrating abdominal and thoracic injuries. The results of the LTARP may vary from a life-threatening cardiac injury which

requires an emergency department thoracotomy to negative or delayed surgical findings.^{1–3} While abdominal and thoracic injuries are often treated conservatively with the aid of physical examination, laboratory tests, and radiological examination, diagnostic laparoscopy is usually recommended for LTARP. Studies have suggested that delayed diagnosis increases the risk of visceral herniation and strangulation, leading to a mortality rate up to 60% which can be easily missed in acute period due to the lack of specific clinical findings.^{2,3} It is crucial to diagnose diaphragm injury using radiological techniques together with clinical evaluation to avoid unnecessary surgical interventions. Diagnostic laparoscopy (DL), thoracoscopy, or laparotomy may then be necessary to reach a diagnosis in these patients.

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Implementation of routine laparotomy for every abdominal stab wound increases the rate of negative laparotomies (5%–40%), leading to longer hospital stays, more complications and increased costs.⁴ Therefore, the conservative approach has gained favor for penetrating injuries. However, many physicians still prefer to perform diagnostic laparoscopy rather than using the conservative approach for LTARP. Today, laparoscopic surgery is increasingly used for diagnosis and treatment of penetrating abdominal injuries.⁵

Although DL diminishes the negative laparotomy rate, there are still some complications such as vascular or organ injuries, hemorrhage, embolus, adhesions, infection or those related to anesthesia.^{6–8}

Clinical studies have shown that approximately 50% of stab wounds penetrating into the anterior wall of the abdomen, and approximately 85% of stab wounds penetrating into the posterior wall can be treated non-operatively. Therefore, non-operative approach is increasingly being used in these patients.^{9–12}

In our department, all patients with left thoraco-abdominal injuries undergo routine diagnostic laparoscopy without wound exploration. We aimed to analyze the pre-operative diagnostic tools of LTARP patients who underwent diagnostic laparoscopy, and compare them with operative findings in order to prevent unnecessary DL's.

2. Material and methods

The patients with LTARP who were consecutively admitted to the emergency department of Bakirkoy Dr. Sadi Konuk Training and Research Hospital between 2009 and 2013 were included in this study. Physical examination findings, plain chest X-rays, thoracic and abdominal computed tomography (CT) (Siemens Sensation 64 system, 6 mm sections) of the patients were evaluated retrospectively by radiologists. Furthermore, demographic data of the patients such as age, gender, and clinical variables such as type of injury, diagnostic method, injured organs (isolated diaphragm, hollow viscus, solid organ or combination of them), operation durations, type of surgery, conversion rate to open surgery and length of hospital stay were also evaluated.

In the study, the left thoraco-abdominal region was described as the area within the middle axillary line laterally, the 4th intercostal space superiorly, and the costal edge inferiorly. All patients underwent routine diagnostic laparoscopy without exploration of the wound. Hemodynamically unstable patients and patients with stab wounds of other abdominal regions or dorsal side were excluded from the study. The rate of accurate preoperative diagnosis of diaphragmatic injury was calculated.

2.1. Operative technique

Pneumoperitoneum was created using Veress needle open technique. The optical port in umbilicus and one 5 mm working port was inserted to right or left iliac fossa under laparoscopic vision. A 30° telescope was used to facilitate the inspection of peritoneal cavity and abdominal organs. Non-traumatic hand devices were used for the inspection. Also an additional trocar was inserted if the manipulation was difficult. In all cases, isolated diaphragmatic injuries were repaired with conventional laparoscopic suturing and knotting device.

2.2. Statistical analysis

Statistical analysis was carried out using JMP[®] software version 10.0.0 (SAS[®], Cary, NC). Patient characteristics were analyzed via descriptive statistics. For continuous variables, the median and

range was calculated. For categorical variables, the numbers and percentages in each category were recorded. Differences between normally distributed parameters were compared with Student's *t*-test. Frequency distributions were compared with the chi-square test. Physical examination, plain chest X-ray, thoracic CT, and abdominal CT results were separately analyzed and compared to the surgical findings. Isolated diaphragm, any hollow or solid organ injury and combined injuries were accepted as positive surgical finding for statistical analysis. Also the combination of pre-operative diagnostic tools was analyzed and compared to these surgical findings. Univariate odds ratios (OR) with 95% confidence intervals (CI) were calculated to assess the relationships between diagnostic tools and surgical outcomes.

The numbers of true-positives (TP), true-negatives (TN), false-positives (FP), and false-negatives (FN) for these clinical and radiological modalities were determined using 2×2 tables. Likelihood ratio, odds ratio with 95% confidence interval was calculated for combined use of diagnostic findings. The diagnostic value of these modalities was also assessed in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy using relevant formulas. All *p* values less than 0.05 were considered statistically significant, and all of the performed tests were two-sided.

3. Results

The current study included 79 patients with LTARP. All of the patients were male. The median age was 28 (17–63) years. Thoraco abdominal CT was taken after physical examination and chest X-ray in seventy seven of 79 patients.

The median length of hospital stay was 1 (1–8) days and the median operation time was 58 (30–87) minutes. Diaphragmatic and organ injury were not detected in 44 (56%) patients (Table 1), which constituted a negative laparoscopy result. Isolated or combined diaphragmatic injury was detected in 34 (43%) patients. Thirty patients (38%) had isolated diaphragmatic injury. Among the patients with isolated diaphragmatic injury, 28 patients underwent laparoscopic repair, and 2 patients underwent open surgery and primary diaphragm repair was performed using non-absorbable sutures. Moreover, four patients (5%) had combined injuries: two patients had diaphragmatic and colonic injuries, one patient had diaphragmatic and gastric injuries, and one patient had diaphragmatic, small intestinal and colonic injuries. Patients with colonic or gastric injuries in addition to diaphragmatic injury underwent laparoscopic repair, whereas the patient with diaphragmatic, small intestinal and colonic injuries and the patient with isolated colonic injury were converted to open surgical repair. Therapeutic intervention was applied to total number of 35 patients (44%) who were applied laparoscopy.

The rate of conversion to open surgery procedure in these patients with positive surgical findings ($n = 35$) was 11.4% ($n = 4$). Seven patients (9%) received a chest tube and underwent closed underwater drainage preoperatively due to concomitant pneumothorax.

Table 1
Distribution of injured intraabdominal organs.

Injured intraabdominal organ	n	%
None any intraabdominal injury	44	55.70
Isolated diaphragmatic injury	30	38
Colonic injury	1	1.25
Diaphragmatic and colonic injury	2	2.55
Diaphragmatic and gastric injury	1	1.25
Diaphragmatic, colonic and intestinal injury	1	1.25

On the first postoperative day, 44 cases with negative laparoscopies and 30 cases with isolated diaphragmatic injury were discharged. Among the patients included in the study, diaphragmatic and colonic injuries were detected in two patients, and diaphragmatic and gastric injuries were detected in one patient, all of which were repaired laparoscopically. In the patient with diaphragmatic, small intestinal and colonic injury and the patient with isolated colonic injury, conversion to open surgery was preferred for technical reasons and patient safety. An intra-abdominal abscess occurred during the follow-up period in a case with isolated colonic injury and it was treated using percutaneous drainage. There was no other morbidity requiring re-admission to hospital and there was no mortality in whole series.

Pre-operative diagnostic tests were negative in 34 of 44 patients (77.2%) who didn't have diaphragmatic injuries.

Conversely, in 24 of 35 (68.5%) patients with positive operative findings, there was at least one positive pre-operative radiologic finding. Also in 16 of these patients (45.7%), there was evidence of injury in more than one diagnostic tool. Furthermore, in 16 of 26 patients (61.5%) with more than one positive diagnostic findings therapeutic surgical procedure was required. However, in patients with only one positive diagnostic (radiologic or physical) finding (n = 53), positive visceral organ injury rate was only 35.8% (n = 19, p = 0.03, CI 95%: 0.13–0.92) (Table 2).

The values for diagnostic specificity, sensitivity, positive estimation, negative estimation and accuracy rates of physical examination, plain chest X-ray, thorax CT, and abdominal CT used as preoperative evaluation methods are shown in Table 3.

4. Discussion

Laparotomy is the most commonly used surgical approach in the acute period for abdominal stab wounds, and is the most sensitive method for detection and treatment of concomitant injuries. However, complication rates up to 40% have been noted.¹³ Thus, the conservative approach has gained favor as the reliability of radiologic diagnostic methods has increased.

For LTARP, DL is increasingly being used to differentiate acute diaphragmatic injuries from penetrating abdominal injuries. As the use of DL has increased, the rates of early diagnosis and treatment of diaphragmatic injuries have also increased. Diagnostic laparoscopy is a minimally invasive method. Its most important advantage is the ability to diagnose and treat cases with diaphragmatic and concomitant intra-abdominal injury without requiring open surgery.^{14,15} Furthermore, many publications show that the incidence of negative laparotomies can be decreased with diagnostic laparoscopy.^{5,10,16–18}

The modern approach in patients with penetrating abdominal injuries should aim for prompt treatment of the patient, and a quick and accurate diagnosis using sensible diagnostic tools together with a good clinical evaluation.¹⁹ In a study that included 117 patients, Ertekin et al. stated that the most valuable method for evaluating patients with penetrating abdominal trauma is still a complete physical examination, and this non-operative approach

was used successfully in 79% of patients.²⁰ The results of our study are in accordance with the literature. Making a precise diagnosis may not be possible in some patients by physical examination alone, in which case, radiologic methods are often necessary. Computed tomography is particularly useful in evaluating the retroperitoneum as well as visceral organ injuries.²¹ In their study, Magu et al. noted that the sensitivity, specificity, and accuracy rates of multi-detector CT were 100%, 93%, and 95%, respectively, in the diagnosis of traumatic diaphragmatic hernias.²² Some studies have shown that diagnostic laparoscopy has an accuracy rate of 98–100% in detecting diaphragm injuries with peritoneal penetration.²³ The diagnostic rates of CT for diaphragmatic injuries in the study conducted by Magu et al.²² are close to those for diagnostic laparoscopy,²² demonstrating that the selective non-operative approach is feasible. In our study, the sensitivity, specificity, and accuracy rates of CT were solely 65%, 79.4%, and 73.2%, respectively (OR: 1.92; CI 95%: 0.74–4.94), which are lower than those in the literature. Although, the combination of CT with physical examination and plain chest X-ray; the sensitivity, specificity and accuracy rates were achieved 77.2%, 82.7% 84.1% respectively (OR: 0.34; CI 95%: 0.13–0.92).

In this study, no organ injury was detected in 56% of the 79 patients (n = 44) who presented due to LTARP and who underwent DL. There will be no need for surgery to those patients with a good physical examination and radiological assessment. The incidence of body injury makes routine diagnostic laparoscopy which is used to reveal possible diaphragmatic injuries controversial. This is because diaphragmatic injury is not commonly seen in penetrating abdominal injuries, and the rate was between 4% and 12%.²⁴

Moreover, Mihos et al. noted the incidence of diaphragmatic rupture in penetrating stab wounds as 10–15%.²⁵ Our study found a higher rate of diaphragmatic injury than the noted studies, with an incidence of 38%. However, these studies included stab wounds into all four quadrants. Thus, the high rate of diaphragmatic rupture in our study can be explained by the limitation of our study in the LTARP patients.

Many studies have reported that the non-operative method is reliable, applicable, and cost-effective for abdominal stabs in a large proportion of patients.^{26–28} In patients with abdominal stab wounds, the rate of negative laparotomy and laparoscopy should be decreased, but this should not cause delay in the diagnosis and treatment of possible injuries. Especially in penetrating stab wounds, the early diagnosis of possible diaphragmatic injuries is very important in patients who will not undergo surgery due to other reasons.

In our study, the rate of unnecessary diagnostic laparoscopies was relatively high at about 56%. Furthermore, in patients with less than two diagnostic findings, the rate of unnecessary surgery was 64.2%. The rate of unnecessary surgery decrease to 38.5% (p = 0.003, OR: 0.34, CI 95% 0.13–0.92). In this study our aim was to emphasize that there is no need of surgery for the diagnosis of diaphragmatic rupture which can be diagnosed by physical examination and radiologic evaluation.

Table 2

Comparison of patients with less than two or more than two positive diagnostic findings and rates of positive surgical findings.

Surgical findings on LTARP ^a	<2 positive diagnostic findings	≥2 positive diagnostic findings	p value	OR ^b	CI ^c [95%]
Visceral organ or diaphragmatic injury (positive/negative) (n)	19/34	16/10	0.003	0.34	0.13–0.92
Rate of required therapeutic surgery (%)	35.8	61.5			
Rate of unnecessary surgery (%)	64.2	38.5			

^a LTARP: left thoraco-abdominal region penetrating injuries.

^b OR: odds ratio.

^c CI: confidence interval.

Table 3
Diagnostic value of clinic and imaging modalities used pre-operative evaluation.

Diagnostic modality	PPV ^a (%)	NPV ^b (%)	Accuracy (%)	Specificity (%)	Sensitivity (%)	LR ^c	OR ^d	CI ^e [95%]
Physical examination	69.2	69.8	69.6	82.2	52.9	0.28	0.54	0.18–1.65
Plain chest X-ray	66.7	62.5	63.2	88.9	29.4	0.05	3.12	0.95–10.2
Thorax CT	51.5	63.0	58.2	64.4	50.0	0.10	2.16	0.85–5.48
Abdominal CT	53.6	62.7	59.5	71.1	44.1	0.17	1.92	0.74–4.94
Combination of diagnostic tools above	77.4	88.1	77.2	84.1	82.7	0.03	0.34	0.13–0.92

^a PPV: positive predictive value.

^b NPV: negative predictive value.

^c LR: likelihood ratio.

^d OR: odds ratio.

^e CI: confidence interval.

Our study results indicate that an accurate preoperative diagnosis may protect many patients from unnecessary surgeries. Regarding the odds ratios of the diagnostic tools; physical examination is still more reliable than imaging modalities.

Nevertheless, careful preoperative evaluation of all diagnostic tests may increase the accuracy of the diagnosis (Table 3). Thereby, we assume that it is beneficial to make a decision whenever possible based on physical examination and radiologic findings, such as tomography, before opting for surgery.

5. Limitations

The retrospective design and the number of subjects included to study were major limitations.

6. Conclusion

Diagnostic laparoscopy is still crucial for the LTAR penetrating injuries. Selected cases can be treated non-operatively. In addition, the increasing diagnostic value of CT in diaphragmatic injuries is not always sufficient for non-operative management, repeated physical examination should be always complementary.

Disclosures

The authors have no conflicts of interest or financial ties to disclose. The manuscript has not been published previously or submitted recently for publication.

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