



## Conservative approach in drilling–cutting tool injuries

Osman Köneş<sup>1</sup>, Murat Akarsu<sup>2</sup>, Cevher Akarsu<sup>1</sup>, Mehmet Emin Güneş<sup>1</sup>, Halil Doğan<sup>3</sup>✉

<sup>1</sup>Department of General Surgery, Bakirkoy Dr Sadi Konuk Training and Research Hospital, Istanbul, Turkey

<sup>2</sup>Department of Internal Medicine, Bakirkoy Dr Sadi Konuk Training and Research Hospital, Istanbul, Turkey

<sup>3</sup>Department of Emergency Medicine, University of Health Sciences Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey

### ARTICLE INFO

#### Article history:

Received 2 July 2018

Revision 16 July 2018

Accepted 19 August 2018

Available online 31 August 2018

#### Keywords:

Conservative approach

Drilling

Cutting

Injuries

Trauma

### ABSTRACT

**Objective:** To prevent unnecessary laparotomies by evaluating the effectiveness of conservative approach in abdominal trauma cases due to drilling-cutting instruments. **Methods:** Demographic data, effected region of the body, additional findings of trauma, hemodynamic parameters, duration of admission, diagnostic methods and treatment modalities were retrospectively evaluated in 217 cases with abdominal injury (lower thoracic region, abdominal wall and back) among 1 128 victims with drilling-cutting instrument injuries between January 1, 2012 and December 31, 2017. The conservative approach was based on physical examination, hemogram follow-up and hemodynamic evaluation. **Results:** Totally 177 (81.6%) cases of 217 patients were followed conservatively while 25 cases were operated at early (1-8 hours) and 15 were operated at late (9-48 hours) periods. Two patients who underwent surgery in the early period and two patients who underwent surgery in the late period were accepted as negative laparotomy while 1 patient in the late operated group was regarded as non-therapeutic laparotomy. Diagnostic laparoscopy was performed in 81 cases. Complications developed in 7 patients who were operated in the early period and 10 patients who were operated in the late period. The mean hospital stay period was 5.3 days (1-33) in all cases, 4.5 days (2-20) in conservative treatment group and 8.4 days (3-33) in the operated patients; and the difference was statistically significant. **Conclusions:** Detailed physical examination, accurate assessment and effective use of different diagnostic methods reduce the frequency of negative and non-therapeutic laparotomies in abdominal stab wound injuries.

## 1. Introduction

Peritoneal penetration is not absolute after abdominal (DCII) [1]. Emergency laparotomy is a common practice in patients with penetrating abdominal trauma who are hemodynamically unstable or showing signs of peritoneal irritation[2,3]. Conservative approach is preferred in the last decades in abdominal stabbing cases without the signs of peritoneal irritation and who are hemodynamically stable[4-11]. The conservative approach can reduce unnecessary laparotomies

(38%-40%) and the associated postoperative morbidities by 16% to 3%[12-15].

There is still a debate about when the surgery should be done in abdominal stab wound injuries. Conservative approach rates can be increased by adding ultrasonography, tomography, ultrasound-guided sampling, angiography, echocardiography, endoscopic

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**For reprints contact:** reprints@medknow.com

©2018 Journal of Acute Disease Produced by Wolters Kluwer- Medknow

**How to cite this article:** Köneş O, Akarsu M, Akarsu C, Emin Güneş M, Doğan H. Conservative approach in drilling-cutting tool injuries. J Acute Dis 2018; 7(4): 167-174.

✉ Halil Doğan, Associate Professor, MD, Department of Emergency Medicine, University of Health Sciences Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey.  
Fax: +902125424491  
Telephone: +90 5057067282  
E-mail: drhalildogan@gmail.com

procedures and diagnostic laparoscopy to the physical examination. The aim of this study is to evaluate the effects of conservative approach and timing of the operation on the morbidity of patients with abdominal stab wound injuries.

## 2. Materials and methods

Initially, cases were evaluated according to advanced trauma life support protocols[16]. Foley catheter and tetanus prophylaxis were applied in all cases. Patients were divided into 3 main groups according to the injured areas:

- 1) The anterior wall of the abdomen: The arc of costa on the upper side, the symphysis pubis at the bottom, and the mid-axillary line at both sides.
- 2) Lower thoracic region: Forth intercostal space on the upper side, the arc of costa at the bottom, and the mid-axillary line at both sides.
- 3) Back region: The lower line of scapula at the top, gluteal folds at the bottom, and the mid-axillary line at both sides.

Local exploration was performed after local anesthesia in the injuries of the anterior abdominal wall. All injuries were sutured as primarily after initial evaluation. Asymptomatic, hemodynamically stable cases were hospitalized and those who had no problems with oral intake after 48 hours of investigation were discharged.

Omentum or bowel herniation was not regarded as immediate surgical indication. Laparotomy was applied to cases that could not be pushed in. Physical examination was used as a primary indicator in the conservative approach. In addition, other radiological methods were used.

### 2.1. Assessment methods and special diagnostic techniques

- Serial physical examination-leukocyte count: All patients were followed up with close follow-up and serial physical examination. After admission to the hospital, leukocyte count and physical examination were performed every four hours.

- Diagnostic laparoscopy: In lower thoracic region injuries, it was applied in patients who did not provide definitive laparotomy findings to exclude diaphragmatic injury.

- Diagnostic thoracoscopy: It was performed in order to control the diaphragmatic injury in patients with lower thoracic region and splenic injuries but without subtle laparotomy findings.

- Imaging methods and other investigations: Ultrasound was applied to all patients. Computerized tomography was performed routinely in cases of back injury. In other cases, ultrasound was withdrawn when intraabdominal free fluid was detected. Computerized tomography was performed by oral, rectal and intravenous contrast applications.

Recently, sampling under ultrasound guidance is preferred instead of diagnostic peritoneal lavage. Sampling was performed under local anesthesia to determine the character of the fluid seen on emergency ultrasound performed on bedside of the patients. This liquid was

tested for transudate-exudates differentiation and for gram staining and culture. Bilirubine and amylase were also studied from this fluid in suspected cases.

Rectosigmoidoscopy was performed on those with back injuries having suspected colonic damages. Echocardiography was performed to evaluate pericardial fluid in left lower thoracic region injuries. PA chest X-ray was obtained to evaluate hemothorax and pneumothorax.

### 2.2. Classification according to operation schedule

Patients were categorized according to the time they were taken to the operating room from the time of the application.

- a) Emergency laparotomy: Patients who were immediately operated since the patients were in a state of shock or if the organs cannot be thrown into the womb. This group of patients was excluded from the study.

- b) Early laparotomy: Patients who were operated in first 8 hours after admission.

- c) Late laparotomy: Patients who were operated later than the 8th hour after admission.

### 2.3. Laparotomy classification

- a) Therapeutic laparotomy: The abdominal injury requires repair;
- b) Non-therapeutic laparotomy: An abdominal injury is present but an intervention is not required (non-bleeding liver-spleen injury, serosal bowel injury and non-growing retroperitoneal hematoma);
- c) Negative laparotomy: Laparotomies without any injuries determined.

### 2.4. Data collection and statistical analysis

All clinical data were collected and recorded in a database. The degree of the injury was analyzed according to the Penetration Abdominal Trauma Index (PATI)[17]. Practically, the PATI score examines fourteen organs and assigns a risk factor from 1-5 (eg, pancreas=5, spleen=3, bladder=1) to each organ. Injuries to any organ are graded by severity from 1 for minimal injury (eg, tangential wound to the pancreas) to 5 for maximal injury (eg, pancreatic proximal duct disruption). The severity grade is multiplied by the risk factor. The final penetrating score is obtained by summing the individual organ score. Patient demographics, injury localization, laboratory data, physical examination findings, results of diagnostic methods, follow-up period, treatment plan, unnecessary laparotomies and complications were included in the evaluated data. For statistical analyses, Windows for SPSS (version 15.0; SPSS Inc, Chicago, IL, USA) was performed.

### 3. Results

Totally 418 cases with abdominal injuries (lower thoracic region, abdominal wall and back) among 1 128 cases with DCI who were admitted to the Health Sciences University, Bakırköy Dr. Sadi Konuk Training and Research Hospital, General Surgery Emergency Surgery Unit, between January 2012 and December 2017, were investigated retrospectively. One hundred and seventy three patients without penetration during local wound exploration were excluded. Ten patients who did not accept the treatment and 18 patients who were operated very urgently were also excluded from the evaluation.

Detailed information of these cases is summarized in Table 1. Of the remaining 217 cases, 209 were male and 8 were female and the mean age was 28.6 (range 13-75) years. In 87 (40%) cases, lower thoracic, in 61 (28%) cases anterior abdominal wall, in 39 (37) (18%) patients the back region, in 13 (6%) cases the back and lower thoracic region and in 17 (8%) patients lower thoracic and anterior abdominal wall injuries were determined. Totally 177 cases (81.5%) were followed with conservative approach while 25 cases were operated at early (1-8 hours) and 15 were operated at late (9-48 hours) periods. Negative laparotomy was determined in 4 cases, 2 in early and 2 in the late operated groups. One patient in the late operated group was regarded as non-therapeutic laparotomy (Table 1).

Diagnostic laparoscopy was performed in 81 patients. Diaphragmatic injuries were detected and repaired in 37 of the cases with diagnostic laparoscopy. Repair was performed thoroscopically in 4 of the cases with diaphragmatic injuries. There were complications determined in 7 cases operated in the early period and 9 cases operated in the late period. The mean hospital stay was 5.1 days (1-33) in all cases, 4.3 days (2-20) in conservative approach group, and 8.2 days (3-33) in patients underwent surgery. This was statistically significant difference ( $P=0.009$ ).

Unnecessary laparotomy was determined in 8% of patients who had early surgery and 20% of patients who had late surgery (Table 1).

After DCI, 15 cases (7%) were admitted to the Emergency Department with evisceration. Of these, 11 had omentum, 3 had small bowel, and 1 had sigmoid colon evisceration. Five of the eviscerated cases that developed acute abdomen in their follow-ups were operated.

In 163 cases that were evaluated with ultrasound, the findings were normal. Of 54 patients with abnormal ultrasonographic findings, 31 were found to have organ injury, while 12 of them were solid. In 23 patients, intraabdominal free fluid was detected. These 23 patients had three contrast-enhanced CT. Of 23 patients who had CT, any pathology was not determined in 6 patients, 4 patient had grade I liver injury, 3 patients had grade-III splenic injury, 1 patient had liver laceration, 3 patients had grade-IV liver injury, 1 patient had grade-II splenic injury, 1 patient had retroperitoneal hemorrhage, while grade-III liver + grade-II right kidney injury was present in 1

patient, grade II hepatic and grade-II splenic injury in one patient, and transverse muscle injury in two patients was detected. Pericardial ultrasonography was applied to 23 patients with left lower thoracic region injuries. Pleural effusion was found in one of these patients. Echocardiography was performed in 7 patients. No pathology was detected.

Rectosigmoidoscopy was performed on 7 patients with back injuries. No pathology was detected.

One of 10 cases, who had cranial tomography, had left temporal fracture and pneumocephaly and one of them only had pneumocephaly. These additional trauma findings did not prolong the patient's hospital stay.

Urine tests were performed in a total of 44 patients with back injuries and hematuria were detected in 6 patients. In 1 of these 6 patients, hematuria was macroscopic and grade-II right kidney injury was detected. Control urine test was delivered twelve hours later and it was normal in remaining 5 patients.

### 4. Discussion

Patients with minimal or asymptomatic abdominal stab wound injuries still remains challenging in terms of approach to trauma surgeons in the emergency department. Although there is no doubt that any complication in terms of hemodynamic instability or peritoneal irritation deserves the urgent laparotomy, it is now possible to make the right decision about the most challenging diagnostic problems. Surgeons need to decide which abdominal stab wound injury patient needs laparotomy, when patients should be treated, and which diagnostic procedure should be used. Some current guidelines recommend the follow-up of hemodynamically stable patients with DCII without peritonitis[18,19]. The aim of diagnosis and approach is to be able to identify what is necessary while reducing the ratio of unnecessary laparotomies.

Nonselective laparotomy in the trunk DCII causes negative laparotomy in 38% of patients and morbidity in approximately 40% of patients[13,20-22]. Complication rates in non-therapeutic laparotomies can also be up to 41%[19,23,24]. Complications of negative laparotomy can be severe. In post-traumatic laparotomies, the mortality rate is between 0% and 6% and negative laparotomy has a complication rate of 5%-22%[4,13,14,22,25]. According to a previous study, when exploration is a routine procedure, the rates of negative and non-therapeutic laparotomy are 12% and 23% respectively[26]. When the selective approach is the routine procedure in the next period of study, these rates fall to 7% and 4%, respectively[26]. Conservative approach was reportedly not to increase mortality and morbidity[22,27,28]. In another study, a strong correlation was found between the increase in the rates of conservative management and the decrease in non-therapeutic laparotomy rates in recent years, but failure in the conservative approach has been found to increase mortality[29]. Failure rate in conservative approach is found between

Table 1

Patients operated at early period.

Injured organ	Operation indication	PATI	Positive CT findings	Morbidity	Laparotomy classification
Small bowel	Acute abdomen	2	Contrast leakage	Absent	Therapeutic
Spleen-diaphragm	Shock	6	Grade 4 spleen damage	Absent	Therapeutic
Stomach, kidney, ureter, small bowel	Acute abdomen	20	Kidney damage	Atelectasis	Therapeutic
Stomach	Acute abdomen	2	PX, Contrast leakage	PX after tube withdrawal	Therapeutic
Small bowel	Acute abdomen	12	No finding	Absent	Therapeutic
Small bowel	Acute abdomen	6	Intra-abdominal fluid	Absent	Therapeutic
Kidney diaphragm	Acute abdomen	3	Kidney damage	Absent	Therapeutic
Stomach transverse colon, pancreas	Shock	29	Stomach and pancreas damage	Intraabdominal sepsis + parotid fistula +pancreas fistula+ nasocomial pneumonia +depression	Therapeutic
Stomach intercostal artery	Shock	8	Absent	Absent	Therapeutic
Small bowel	Acute abdomen	7	Absent	Sub-ileus	Therapeutic
Absent	Acute abdomen	0	Absent	Absent	Negative
Lung	Shock	0	Contusion in lung	Absent	Therapeutic
Colon	Acute abdomen	12	Absent	Wound infection - nasocomial Pneumonia	Therapeutic
Absent	Acute abdomen	0	Absent	Absent	Negative
Liver- small bowel	Acute abdomen	23	Liver Grade 4 laceration	Absent	Therapeutic
Transverse muscle	Decrease in hematocrit	0	Absent	Absent	Therapeutic
Lung	Decrease in hematocrit	0	Contusion in lung	Absent	Therapeutic
Small bowel	Acute abdomen	4	Intra-abdominal fluid	Absent	Therapeutic
Liver-lung	Shock	8	Liver and Lung damage	Absent	Therapeutic
Small bowel	Acute abdomen	4	Intra-abdominal fluid	Absent	Therapeutic
Small bowel-colon	Acute abdomen	12	Intra-abdominal fluid	Absent	Therapeutic
Absent	Inability to duck	0	Absent	Absent	Therapeutic
Liver	Decrease in hematocrit	0	Liver Grade 2 laceration	Absent	Therapeutic
Small bowel -colon	Acute abdomen	14	Intra-abdominal fluid	Absent	Therapeutic
Small bowel	Acute abdomen	4	Intra-abdominal fluid	Wound infection - nasocomial pneumonia	Therapeutic
Absent	Acute abdomen	0	Absent	Absent	Negative
Absent	Fever	0	Absent	Empyema	Non therapeutic
Small bowel and meso	Acute abdomen	6	Intra-abdominal fluid	Wound infection	Therapeutic
Liver	Acute abdomen	8	Liver Grade 3 laceration	Atelectasis	Therapeutic
Absent	Acute abdomen	0	Intra-abdominal fluid	Absent	Negative
Stomach-liver	Acute abdomen	6	Intra-abdominal fluid, Liver Grade 3 laceration	Absent	Therapeutic
Small bowel -colon	Acute abdomen	18	Intra-abdominal fluid	Absent	Therapeutic
Lung	Decrease in hematocrit	0	Phemothorax	Absent	Therapeutic
Colon	Acute abdomen	0	Intra-abdominal fluid	Wound infection	Therapeutic
Diaphragm	Decrease in hematocrit	0	Absent	Absent	Therapeutic
Stomach pancreas	Acute abdomen	23	Intra-abdominal fluid	Atelectasis	Therapeutic
Liver small bowel	Acute abdomen	23	Intra-abdominal fluid	Evisceration	Therapeutic
Stomach	Acute abdomen	4	Intra-abdominal fluid	Absent	Therapeutic
Liver-gall bladder	Acute abdomen	10	Intra-abdominal fluid, Liver grade 3 laceration	Wound infection	Therapeutic
Stomach diaphragm	Decrease in hematocrit	2	Intra-abdominal fluid	ARF-pneumonia	Therapeutic
Absent	Acute abdomen	0	Absent	Absent	Negative
Absent	Fever	0	Absent	Empyema	Non therapeutic
Small bowel and meso	Acute abdomen	6	Intra-abdominal fluid	Wound infection	Therapeutic
Liver	Acute abdomen	8	Liver Grade 3 laceration	Atelectasis	Therapeutic
Absent	Acute abdomen	0	Intra-abdominal fluid	Absent	Negative
Stomach - liver	Acute abdomen	6	Intra-abdominal fluid, Liver Grade 3 laceration	Absent	Therapeutic
Small bowel -Colon	Acute abdomen	18	Intra-abdominal fluid	Absent	Therapeutic
Lung	Decrease in hematocrit	0	Phemothorax	Absent	Therapeutic
Colon	Acute abdomen	0	Intra-abdominal fluid	Wound infection	Therapeutic
Diaphragm	Decrease in hematocrit	0	Absent	Absent	Therapeutic
Stomach pancreas	Acute abdomen	23	Intra-abdominal fluid	Atelectasis	Therapeutic
Liver Small bowel	Acute abdomen	23	Intra-abdominal fluid	Evisceration	Therapeutic
Stomach	Acute abdomen	4	Intra-abdominal fluid	Absent	Therapeutic
Liver – Gall bladder	Acute abdomen	10	Intra-abdominal fluid, Liver Grade 3 laceration	Wound infection	Therapeutic
Stomach diaphragm	Decrease in hematocrit	2	Intra-abdominal fluid	ARF-pneumonia	Therapeutic

10%-20%[19,24,30]. Again, it has been suggested that failure rates in the conservative management of abdominal DCII are higher in severe injuries requiring blood transfusion and splenic injuries[29]. Totally 177 (81.5%) patients were followed up conservatively. Twenty-five patients (11.5%) were operated at early period (1-8 hours) and 15 patients (7%) in the late period (9-48 hours). The rate of unnecessary laparotomies including very urgent laparotomies was 2%. The rate of unnecessary laparotomies was 8% in patients operated at early periods and this ratio was 20% in late operated group.

One of the suggestions of Shaftan's study in 1960 was that with physical examination, laparotomy requirement could be predicted safely and securely in abdominal trauma patients[4]. Many different studies have published similar results with Shaftan's work[19,31-34]. Following the implementation of the standard resuscitative protocol as an initial approach in all patients, our algorithm is based on leukocyte count, serial physical examinations and other diagnostic tests. In the course of this algorithm, the occurrence of widespread peritonitis findings, as in previous studies, was accepted as a fine indicator for laparotomy decision[30,35]. In a recent study, Clarke and colleagues found that conservative management was a safe method for patients with DCII[3]. There are also studies showing that the conservative approach reduces negative laparotomy[24,36-38]. In our study, 2 of the early laparotomy group and 4 of the late laparotomy group; to perform laparotomy was decided with only results of physical examination. Therapeutic and non-therapeutic laparotomy rates were equal in both groups and negative laparotomy was present in only 1 patient. Nevertheless, we emphasize that the physical examination should be combined with other diagnostic procedures.

The traditional recommendation is to operate all patients with DCII having evisceration[8,39,40]. In a prospective study, Kimberly and colleagues found that laparotomy was necessary in 77% of patients with omental evisceration and 80% of patients with visceral evisceration. In a similar study, it was emphasized that conservative treatment may be appropriate for selected patients with omental evisceration[20,41]. Neither omental nor intestinal evisceration in our study was an absolute indication for laparotomy. Fifteen cases (7%) were admitted to the emergency department with evisceration after DCII. Of these, 11 had omentum, 3 had small bowel, and 1 had sigmoid colon evisceration. Five of the eviscerated cases that developed acute abdomen in their follow ups were operated.

In the last few decades, DPL was accepted as the gold standard in the evaluation of blunt abdominal trauma[42] and in the 1980s it was adopted in the assessment of penetrated injuries[43,44]. That published the first report on selective approach using peritoneal lavage in abdominal DCII[5]. As other diagnostic modalities evolved, DPL was almost abandoned as the first approach. In a recent study, Gonzales and colleagues found that patients with less than 1 000 erythrocytes in the cell counts after DPL had negative local wound exploration or were having minor abdominal knife injuries, so they could safely be sent home immediately from the emergency department[45]. In a recent study, Hashemzadeh and colleagues have

proposed that DPL can be used diagnostically for thoracoabdominal stabs with new threshold values[46]. However, new and increasingly divergent diagnostic methods have led to the gradual elimination of DPL from routine practice[19,29]. Although DPL has been a routine procedure for all patients with peritoneal penetration in our institution in the past, it has been abandoned since 1998[26]. DPL has been applied until recently, to the hemodynamically stable patients with symptoms of suspected peritonitis, loss of consciousness due to head trauma, and / or progressive peritonitis. But in our study, DPL was not performed.

Diagnostic laparoscopy is currently being used not only for diagnostic purposes but also for therapeutic purposes, and many interventions can be done in this way[47-51]. Diagnostic laparoscopy (DL) in penetrating trauma was first reported in 1977 by Carnevale *et al*[52]. Although DL has a limited role in anterior abdominal injuries, the thoracoabdominal region is suitable for laparoscopic evaluation and for intervention when needed[47,54-56]. However, in detecting diaphragm injuries, the increasing sensitivity of CT which is in use more commonly in thoraco-abdominal stabs helps to make the operation decision[57]. We recommend the use of DL in the management of anterior abdominal anomalies in the evaluation of peritonitis without an indication of laparotomy or in cases of selected omental or luminal organ herniations. At the same time, we prefer DL to catch all suspected diaphragm injuries to all patients with left thoraco- abdominal injuries. In our study, no negative or non-therapeutic laparotomy was performed after DL. Diagnostic laparoscopy was performed in 81 patients. Diaphragmatic injuries were detected and repaired in 37 of the cases with diagnostic laparoscopy[58].

The use of USG in blunt trauma has been routine since the 1980s[59] and it was reported to have 81%-88% sensitivity and 97%-100% specificity[60-63]. In some recent studies, authors have pointed out the benefits of FAST in penetrating abdominal trauma[64-66]. In fifty % of the FAST images, we have performed, there were free fluid in the abdomen; and spleen, liver or kidney injuries were detected, and at the same time we were able to take samples for macroscopic and microscopic analysis from the fluid under USG guidance.

Although FAST alone did not mandate laparotomy, it was used as an indicator of the injuries that required surgery. Udabi *et al* suggested that FAST should be used earlier in the algorithm, but emphasize that it is not as reliable as in blunt trauma and has a 15% negative laparotomy rate. Therefore, when selecting patients with penetrating abdominal trauma for laparotomy, FAST should be combined with other diagnostic modalities[64,67].

Combined with emerging imaging technologies and whole-body scanning techniques, CT has become more widely used in trauma patients[68-70]. Although the diagnostic value of CT in different traumas has not been discussed, in some studies, it was reported as not highly required in DCII[29,70]. Nevertheless, a recent meta-analysis showed that CT could detect 94.7% of laparotomy requirements in hemodynamically stable penetrating abdominal

trauma patients[71]. Current studies on the efficacy of tomography emphasize that CT should be in the first diagnostic steps[19,72-74]. Back injuries should not be assessed with local wound exploration due to thick paraspinal muscles in this region. Three contrasted CT and / or colonoscopy will give enough information about the damage[18,66,75-78]. We enrolled CT in 60 patients with back injury and having intraabdominal free fluid detected in ultrasound. We found solid organ injuries in 13 patients. Although it is difficult to perform endoscopy in an unplanned colon, we do at least Rectosigmoidoscopy after an enema in left-sided injuries. In this study, rectosigmoidoscopy was performed on 7 patients.

In conclusion, the use of physical examination and / or different diagnostic methods allows for a reduction in the number of non-therapeutic laparotomies and non-appearance of negative laparotomy. The surgeon must make vital decisions to perform appropriate choice among various diagnostic techniques in the nonoperative approach of abdominal stab wound injuries.

### Conflict of interest statement

We declare that we have no conflict of interest.

### References

- [1] Dapri G, Himpens J, Lipski D, Bruyns J, Capelluto E, Stevens E, et al. Role of laparoscopy in the management of visceral injuries following abdominal stab wounds. *J Laparoendosc Adv Surg Tech A* 2007; **17**: 713–718.
- [2] Van Haarst EP, van Bezooijen BP, Coene PP, KLuitse JS. The efficacy of serial physical examination in penetrating abdominal trauma. *Injury* 1999; **30**(9): 599-604.
- [3] Clarke DL, Allorto NL, Thomson SR. An audit of failed non-operative management of abdominal stab wounds. *Injury* 2010; **41**(5): 488-491.
- [4] Shaftan GW. Indications for operation in abdominal trauma. *Am J Surg* 1960; **99**: 657–664.
- [5] Thal ER. Evaluation of peritoneal lavage and local exploration in lower chest and abdominal stab wounds. *J Trauma* 1977; **17**: 642–648.
- [6] McAlvananah MJ, Shaftan GW. Selective conservatism in penetrating abdominal stab wounds: a continuing reappraisal. *J Trauma* 1978; **18**: 206–212.
- [7] Demetriades D, Rabinowitz B. Indications for operation in abdominal stab wounds. A prospective study of 651 patients. *Ann Surg* 1987; **205**: 129–132.
- [8] Leppaniemi AK, Haapiainen RK. Selective nonoperative management of abdominal stab wounds: prospective randomized study. *World J Surg* 1996; **20**: 1101–1106.
- [9] Bostrom L, Heinius G, Nilsson B. Trends in the incidence and severity of stab wounds in Sweden 1987–1994. *Eur J Surg* 2000; **166**: 765–770.
- [10] Casali M, Di Saverio S, Tugnoli G, Biscardi A, Villani S, Cancellieri F et al. Penetrating abdominal trauma: 20 years experience in a Western European Trauma Center. *Ann Ital Chir* 2008; **79**: 399–407.
- [11] Plackett TP, Fleurat J, Putty B, Demetriades D, Plurad D. Selective nonoperative management of anterior abdominal stab wounds: 1992–2008. *J Trauma* 2011; **70**: 408–413.
- [12] Forde KA, Ganepola GAP. Is mandatory exploration for penetrating abdominal trauma extinct? The morbidity and mortality of negative exploration in a large municipal hospital. *J Trauma* 1974; **14**: 764–766.
- [13] Sirinek KR, Page CP, Root HD, Levine BA. Is exploratory celiotomy necessary for all patients with truncal stab wounds? *Arch Surg* 1990; **125**: 844–848.
- [14] Lowe RJ, Boyd DR, Folk FA, Baker RJ. The negative laparotomy for abdominal trauma. *J Trauma* 1972; **12**: 853–861.
- [15] Demetriades D, Vandenbossche P, Ritz M, Goodmann D, Kowalszik J. Nontherapeutic operations for penetrating trauma: Early morbidity and mortality. *Br J Surg* 1993; **80**: 860–861.
- [16] American College of Surgeons. *Advanced trauma life support*. H, Chicago; 1997.
- [17] Moore EE, Dunn EL, Moore JB, Thompson JS. Penetrating abdominal trauma index. *J Trauma* 1981; **21**: 439–445.
- [18] Biffl WL, Moore EE. Management guidelines for penetrating abdominal trauma. *World J Surg* 2015; **39**(6): 1373–1380.
- [19] Como JJ, Bokhari F, Chiu WC, Duane TM, Holevar MR, Tandoh MA, et al. Practice management guidelines for selective nonoperative management of penetrating abdominal trauma. *J Trauma* 2010; **68**: 721–733.
- [20] Arikan S, Kocakusak A, Yucel AF, Gokhan A. A prospective comparison of the selective observation and routine exploration methods for penetrating abdominal stab wounds with organ or omentum evisceration. *J Trauma* 2005; **58**(3): 526-532.
- [21] Schmelzer TM, Mostafa G, Gunter OL, James Norton H, Sing RF. Evaluation of selective treatment of penetrating abdominal trauma. *J Surg Educ* 2008; **65**(5): 340-345.
- [22] Leppaniemi A, Salo J, Haapiainen R. Complications of negative laparotomy for truncal stab wounds. *J Trauma* 1995; **38**: 54–58.
- [23] Renz BM, Feliciano DV. Unnecessary laparotomies for trauma: a prospective study of morbidity. *J Trauma* 1995; **38**: 350–356.
- [24] Velmahos GC, Demetriades D, Toutouzas KG, Sarkisyan G, Chan LS, Ishak R, et al. Selective nonoperative management in 1856 patients with abdominal gunshot wounds: Should routine laparotomy still be the standard of care? *Ann Surg* 2001; **234**: 395–402.
- [25] Thompson JS, Moore EE, van Duzer-Moore S, Galloway AC. The evolution of abdominal stab wound management. *J Trauma* 1980; **20**: 478–484.
- [26] Taviloglu K, Gunay K, Ertekin C, Calis A, Türel O. Abdominal stab wounds: The role of selective management. *Eur J Surgery* 1998; **164**: 17–21.
- [27] Mathonnet M, Peyrou P, Gainant A, Bouvier S, Cubertafond P. Role of laparoscopy in blunt perforations of the small bowel. *Surg Endosc* 2003; **17**: 641–645.
- [28] Ahmed N, Whelan J, Brownlee J, Chari V, Chung R. The contribution of

- laparoscopy in evaluation of penetrating abdominal wounds. *J Am Coll Surg* 2005; **201**: 213–216.
- [29]Zafar SN, Rushing A, Haut ER, Kisat MT, Villegas CV, Chi A, et al. Outcome of selective non-operative management of penetrating abdominal injuries from the North American National Trauma Database. *Br J Surg* 2012; **99**(Suppl 1): 155-164.
- [30]Navsaria PH, Berli JU, Edu S, Nicol AJ. Non-operative management of abdominal stab wounds – an analysis of 186 patients. *S Afr J Surg* 2007; **45**: 128–130, 132.
- [31]Clarke DL, Allorto NL, Thomson SR. An audit of failed non-operative management of abdominal stab wounds. *Injury* 2010; **41**: 488–491.
- [32]Demetriades D, Rabinowitz B, Sofianos C. Non-operative management of penetrating liver injuries: A prospective study. *Br J Surg* 1986; **73**: 736–737.
- [33]Kent AL, Jeans P, Edwards JR, Byrne PD. Ten year review of thoracic and abdominal penetrating trauma management. *Aust N Z J Surg* 1993; **63**: 772–779.
- [34]Tsai MJ, Chen JP, Liu TJ, Wu CC, Wu TC, Yang MD. Management of penetrating abdominal injury. *Gaoxiong Yi Xue Ke Xue Za Zhi* 1991; **7**: 32–37.
- [35]Biff WL, Kaups KL, Cothren CC, Brasel KJ, Dicker RA, Bullard MK, et al. Management of patients with anterior abdominal stab wounds: A Western Trauma Association multicenter trial. *J Trauma* 2009; **66**(5): 1294-1301.
- [36]Hashemzadeh S, Pourzand A, Fakhree MB, Golmohammadi H, Daryani A. Nonoperative management of anterior thoracoabdominal stab wounds in selected patients. *Eur J Emerg Med* 2012; **19**(2): 77-82.
- [37]Paydar S, Salahi R, Izadifard F, Jaafari Z, Abbasi HR, Eshraghian A, Hosseini S, et al. Comparison of conservative management and laparotomy in the management of stable patients with abdominal stab wound. *Am J Emerg Med* 2012; **30**(7): 1146-1151.
- [38]Lenzini MM. Nonoperative management of penetrating abdominal trauma. *JAAPA* 2006; **19**(7): 52-54, 56.
- [39]Oreskovich MR, Carrico CJ. Stab wounds of the anterior abdomen: Analysis of a management plan using local wound exploration and quantitative peritoneal lavage. *Ann Surg* 1983; **193**: 411–419.
- [40]Thanvendran A, Vijayaragavan A, Rasaretnam R. Selective surgery for abdominal stab wounds. *Br J Surg* 1975; **62**: 750–752.
- [41]da Silva M, Navsaria PH, Edu S, Nicol AJ. Evisceration following abdominal stab wounds: Analysis of 66 cases. *World J Surg* 2009; **33**(2): 215-219.
- [42]Root HD, Keizer PJ, Perry JF Jr. Peritoneal trauma, experimental and clinical studies. *Surgery* 1967; **62**: 679–686.
- [43]Thompson JS, Moore EE. Peritoneal lavage in the evaluation of penetrating abdominal trauma. *Surg Gynecol Obstet* 1981; **153**: 861–863.
- [44]Goldenberg JH, Bernstein DM, Rodman GH, Suarez CA. Selection of patients with abdominal stab wounds for laparotomy. *J Trauma* 1982; **2**: 476–480.
- [45]Gonzalez RP, Turk B, Falimirski ME, Holevar MR. Abdominal stab wounds: Diagnostic peritoneal lavage criteria for emergency room discharge. *J Trauma* 2001; **51**: 939–943.
- [46]Hashemzadeh S, Mameghani K, Fouladi RF, Ansari E. Diagnostic peritoneal lavage in hemodynamically stable patients with lower chest or anterior abdominal stab wounds. *Ulus Travma Acil Cerrahi Derg* 2012; **18**(1): 37-42.
- [47]O'Malley E, Boyle E, O'Callaghan A, Coffey JC, Walsh SR. Role of laparoscopy in penetrating abdominal trauma: a systematic review. *World J Surg* 2011; **37**(1): 113-122.
- [48]Lin HF, Wu JM, Tu CC, Chen HA, Shih HC. Value of diagnostic and therapeutic laparoscopy for abdominal stab wounds. *World J Surg* 2010; **34**(7): 1653-1662.
- [49]Saribeyoglu K, Pekmezci S, Bilgi B, Kagan Z, Adem K, Ilknur EK, et al. Laparoscopy offers diagnosis and treatment in abdominal stab injuries. *Surg Laparosc Endosc Percutan Tech* 2007; **17**(5): 396-401.
- [50]Sugrue M, Balogh Z, Lynch J, Bardsley J, Sisson G, Weigelt J, et al. Guidelines for the management of haemodynamically stable patients with stab wounds to the anterior abdomen. *ANZ J Surg* 2007; **77**(8): 614-620.
- [51]Choi YB, Lim KS. Therapeutic laparoscopy for abdominal trauma. *Surg Endosc* 2003; **17**: 421–427.
- [52]Carnevale N, Baron N, Delany HM. Peritoneoscopy as an aid in the diagnosis of abdominal trauma: A preliminary report. *J Trauma* 1977; **17**: 634–641.
- [53]Simon RJ, Rabin J, Kuhls D. Impact of increased use of laparoscopy on negative laparotomy rates after penetrating trauma. *J Trauma* 2002; **53**: 297–302.
- [54]Friese RS, Coln CE, Gentilello LM. Laparoscopy is sufficient to exclude occult diaphragm injury after penetrating abdominal trauma. *J Trauma* 2005; **58**: 789–792.
- [55]Ivatury RR, Simon RJ, Weksler B, Bayard V, Stahl WM. Laparoscopy in the evaluation of the intrathoracic abdomen after penetrating injury. *J Trauma* 1992; **33**: 101–109.
- [56]DeMaria EJ, Dalton JM, Gore DC, Kellum JM, Sugerma HJ. Complementary roles of laparoscopic abdominal exploration and diagnostic peritoneal lavage for evaluating abdominal stab wounds: A prospective study. *J Laparoendosc Adv Surg Tech* 2000; **10**: 131–136.
- [57]Kones O, Akarsu C, Dogan H, Okuturlar Y, Dural AC, Karabulut M, et al. Is non-operative approach applicable for penetrating injuries of the left thoraco-abdominal region? *Turkish J Emerg Med* 2016; **16**(1): 22-25.
- [58]Bagheri R. The role of thoracoscopy for the diagnosis of hidden diaphragmatic injuries in penetrating thoracoabdominal trauma. *Interact Cardiovasc Thorac Surg* 2009; **9**(2): 195-197.
- [59]Gruessner R, Mentges B, Duber C, Ruckert K, Rothmund M. Sonography versus peritoneal lavage in blunt abdominal trauma. *J Trauma* 1989; **29**: 242–244.
- [60]Boulanger BR, Brenneman FD, Kirkpatrick AW, McLellan BA, Nathens AB. The indeterminate abdominal sonogram in multisystem blunt abdominal trauma. *J Trauma* 1998; **45**: 52–56.
- [61]Bode PJ, Edwards MJR, Kruit MC, van Vugt AB. Sonography in a clinical algorithm for early evaluation of 1671 patients with blunt abdominal. *AJR Am J Roentgenol* 1999; **172**: 905–911.
- [62]Rozycki GS, Ochsner MG, Schmidt JA, Frankel HL, Davis TP, Wang D,

- et al. A prospective study of surgeonperformed ultrasound as the primary adjuvant modality for injured patient assessment. *J Trauma* 1995; **39**: 492–500.
- [63]McKenney MG, Martin L, Lentz K, Lopez C, Sleeman D, Aristide G, et al 1,000 consecutive ultrasounds for blunt abdominal trauma. *J Trauma* 1996; **40**: 607–612.
- [64]Udobi KF, Rodriguez A, Chiu WC, Scalea TM. The role of ultrasonography (FAST) in penetrating abdominal trauma. *J Trauma* 2001; **50**: 475–579.
- [65]Bernard RB, Kearney PA, Tsuei B, Ochoa JB. The routine use of sonography in penetrating torso injury is beneficial. *J Trauma* 2001; **51**: 320–325.
- [66]Soto JA, Morales C, Munera F, Sanabria A, Guevara JM, Suárez T. Penetrating stab wounds to abdomen: Use of serial US and contrast-enhanced CT in stable patients. *Radiology* 2001; **220**: 365–371.
- [67]Biffl WL, Kaups KL, Pham TN, Rowell SE, Jurkovich GJ, Burlew CC, et al. Validating the Western Trauma Association algorithm for managing patients with anterior abdominal stab wounds: A Western Trauma Association multicenter trial. *J Trauma* 2011; **71**(6): 1494–1502.
- [68]Shanmuganathan K, Mirvis SE, Chiu WC, Killeen KL, Hogan GJ, Scalea TM. Penetrating torso trauma: triple-contrast helical CT in peritoneal violation and organ injury—a prospective study in 200 patients. *Radiology* 2004; **231**: 775–784.
- [69]Antevil JL, Sise MJ, Sack DI, Kidder B, Hopper A, Brown CV. Spiral computed tomography for the initial evaluation of spine trauma: A new standard of care? *J Trauma* 2006; **61**: 382–387.
- [70]Sliker CW, Shanmuganathan K, Mirvis SE. Diagnosis of blunt cerebrovascular injuries with 16-MDCT: Accuracy of whole-body MDCT compared with neck MDCT angiography. *AJR Am J Roentgenol* 2008; **190**: 790–799.
- [71]Exadaktylos A, Stettbacher A, Edul S, Nichols A, Bautz P. Successful management of abdominal stab wounds with clinical evaluation: experiences of an South-African trauma unit with 496 consecutive patients. *Der Unfallchirurg* 2003; **106**: 215–219.
- [72]Goodman CS, Hur JY, Adajar MA, Coulam CH. How well does CT predict the need for laparotomy in hemodynamically stable patients with penetrating abdominal injury? A review and meta-analysis. *AJR Am J Roentgenol* 2009; **193**: 432–437.
- [73]Berardoni NE, Kopelman TR, O'Neill PJ, August DL, Vail SJ, Pieri PG, et al. Use of computed tomography in the initial evaluation of anterior abdominal stab wounds. *Am J Surg* 2011; **202**(6): 690-695.
- [74]Castrillon GA, Soto JA. Multidetector computed tomography of penetrating abdominal trauma. *Semin Roentgenol* 2012; **47**(4): 371-376.
- [75]Albrecht RM, Vigil A, Schermer CR, Windsor J, Echenique A, Hudson-Civetta J. Stab wounds to the back/flank in hemodynamically stable patients: evaluation using triple-contrast computed tomography. *Am J Surg* 1999; **65**: 683–687.
- [76]Ivatury RR, Ochsner MG, Simon R, Lowery RC. Cavitory endoscopy. In: Ivatury RR, Cayten CG, eds. *The textbook of penetrating trauma*. Baltimore: Williams & Wilkins; 1996, p. 281–99.
- [77]Simon RJ, Ivatury RR. Current concepts in the use of cavitory endoscopy in the evaluation and treatment of blunt and penetrating truncal injuries. *Surg Clin North Am* 1995; **75**: 157–174.
- [78]Taviloglu K. When to operate on abdominal stab wounds. *Scand J Surg* 2002; **91**: 58–61.