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Management of Thoracoabdominal Wound with Damage to the Spleen and Diaphragm: A Case Report

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Abstract

Despite the extensive literature devoted to thoracoabdominal injuries of various origins, severity and nature, the management of patients with such injuries remains a challenge for surgeons of various specialties. **Case Report:** The patient was hospitalized at the First University Clinic of TSMU. He complained of multiple bleeding wounds on the chest and face. Stab wounds located in the following areas: 1) on the left mid-axillary line, in the IX-X intercostal space (2.5 cm × 1.5 cm); 2) on the left scapular line, at the level of the VII intercostal space (1.0 cm × 0.5 cm); 3) on the right paravertebral line, at the level of the VIII intercostal space (3.0 cm × 2.0 cm); 4) on the right scapular line, at the level of the IV intercostal space (2.0 cm × 1.0 cm). There is also a small stab wound on the mental area, on the left. All wounds were sutured with interrupted sutures. FAST was done immediately. Approximately 100 mL of fluid was detected in the left pleural cavity. Free fluid was detected as a narrow band in the left subdiaphragmatic region. A CT scan was performed. The mediastinum was not deviated. The heart was not enlarged. There was no free fluid or air in the mediastinum. On the left was a linear fracture of the VIII rib. A small effusion was visible in the left pleural cavity, with a separation of 0.9 cm. An inhomogeneous, increased-density area (hematoma) was seen at the anterior edge of the spleen. Against this, minor extravasation was observed. Free fluid was visible in the abdominal cavity, only adjacent to the spleen. There was no air. After 2.5 hours from the patient's admission, during a control FAST study, the amount of fluid in the abdomen was increased and the patient was immediately taken to the operating room. Laparotomy, diaphragmorraphy, splenor-

rhaphy, small bowel repair (deserosation), washing and drainage of peritoneal cavity were performed. The patient was discharged from the clinic in an improved condition. The patient's condition is good and he has no complaints. Thus, despite our efforts, we were unable to avoid open surgery, but even with such a complex injury as a penetrating thoracoabdominal wound, under certain circumstances, it is possible to use a watchful waiting approach, in some cases to use a minimally invasive intervention instead of a wide and traumatic laparotomy, and even to get by with active dynamic monitoring of the patient instead of routine drainage of the affected pleural cavity.

Keywords

Thoracoabdominal Wound, Diaphragm, Spleen

1. Introduction

Despite the extensive literature devoted to thoracoabdominal injuries of various origins, severity and nature, the management of patients with such injuries remains a challenge for surgeons of various specialties and therefore does not lose its interest to this day. In light of our everyday example, we propose a discussion of the management of a thoracoabdominal wound with damage to the diaphragm and spleen separately and in general.

2. Case Report

The patient, a 32-year-old man, was hospitalized at ER department of the First University Clinic of Tbilisi State Medical University on 16/03/2025 at 16:25. He complained of multiple bleeding wounds on the chest and face. Neurologically, the patient was conscious, adequate, and no sensorimotor disturbances in the limbs were observed. Breathing was spontaneous, RR—24-26', SpO_2—95% - 96% without oxygenation. T/A—96/60 mmHg, HR—105', t—36.8˚C. Auscultation revealed vesicular breathing on both sides and clear, rhythmic heart sounds. Skin was warm, pale. Subcutaneous fat was moderately developed. Tongue is moist. Abdomen is symmetrical, participating in breathing, soft on palpation, painless, signs of peritoneal irritation are negative. Peristalsis is active. Foley catheter is inserted into the bladder, and the urine is straw-colored. Per rectum, without pathology. Status Localis: bleeding stab wounds located in the following areas: 1) on the left mid-axillary line, in the IX-X intercostal space (2.5 cm × 1.5 cm); 2) on the left scapular line, at the level of the VII intercostal space (1.0 cm × 0.5 cm); 3) on the right paravertebral line, at the level of the VIII intercostal space (3.0 cm × 2.0 cm); 4) on the right scapular line, at the level of the IV intercostal space (2.0 cm × 1.0 cm). There is also a stab wound on the mental area, on the left. All wounds were sutured with interrupted sutures. In parallel with this, crystalloid infusion was started, and blood was taken for laboratory testing. Electrocardiography was unremarkable.

Focused Assessment with Sonography in Trauma (FAST) was done immediately. No fluid was detected in the right pleural cavity, and approximately 100 mL in the left. Free fluid was not detected in the subhepatic or subsplenic spaces, in the lateral grooves on both sides, or in the pelvic cavity. Free fluid was detected as a narrow band in the left subdiaphragmatic region at the inferior margin. The echotexture of the liver and spleen was uniform. The size, shape, and contours of both kidneys were within normal limits, and layer differentiation was preserved. The urinary bladder was moderately full, and the bladder cavity was free. Chest X-ray showed both lungs were expanded.

A computed tomography CT scan of the head, neck, chest and abdomen was performed 40 minutes after admission. The chest was without deformation. The mediastinum was not deviated. The heart was not enlarged. The amount of fluid in the pericardium was within the normal range. There was no free fluid or air in the mediastinum. On the right dorsally, at the level of the III-IV ribs and the TH8 vertebral body, the subcutaneous soft tissues were easily imbibed. On the left dorsally, at the level of the VII rib, the skin cover was deformed, and a linear fracture was visible in the area of the VIII rib. A small effusion was seen in the left pleural cavity, with a separation of 0.9 cm. No fluid was visible on the right. Initially, before the operation, no damage to the diaphragm was found. On imaging study, the diaphragmatic damage was only detected later, and even then it was questionable. Abdominal CT scan revealed the liver extended beyond the costal arch, the contours were straight, clear, without deformation. The parenchyma was homogeneous, pathological foci were not visualized. The intrahepatic and extrahepatic bile ducts were not dilated. On the left axial line, in the IX-X intercostal space, a skin defect was visible (is the presence of diaphragm damage possible?), and subcutaneous emphysema was visualized adjacently. An inhomogeneous, increased-density area (hematoma) was visible at the anterior edge of the spleen. Against this, minor extravasation was observed. The pancreas was visualized along its entire length, and the structure was uniform. The duct of Wirsung was not dilated. The parapancreatic fatty tissue was not infiltrated. The bilateral kidneys were of normal size and location, no pathological areas were visualized, there were no dilatations, and the paranephral fatty tissue was not infiltrated. Excretion was not impaired. There were no pathological focal changes in the bilateral adrenal glands. Homogeneous contents were seen in the bladder cavity. The walls of the bladder were not thickened. Free fluid was visible in the abdominal cavity, only adjacent to the spleen. There was no air. Angiographic examination showed that the thoracic and abdominal aorta and its main abdominal branches were patent, no extravasation was seen.

According to current selective non-operative management criteria for spleen and diaphragm injuries (see literature below), our initial choice was active watchful-waiting tacktic of management of the patient.

The next FAST study was performed at 18:05. Excerpt: "No fluid is detected in the right pleural cavity, approximately 100 mL of fluid is visible in the left pleural

cavity. No free fluid is detected subhepatically, in the lateral groove on both sides, in the pelvic cavity. A small amount of free fluid is visible under the spleen and in Morrison's area. The echostructure of the liver is uniform. The size, shape, and contours of both kidneys are within the normal range, and differentiation of the layers is preserved. The bladder is moderately filled".

Throughout this time, the patient's hemodynamic and respiratory parameters were stable. Metabolic acidosis and hyperlactatemia present on admission were controlled. Blood loss, which was due to bleeding (including prior to admission) from the wounds described above, was also controlled at this stage. A transfusion of one portion of red blood cell mass was performed.

Table 1. Parameters and results of examination on an hourly basis.

Parameters	Upon admission of the patient	18:05	18:55 - 19:05
T/A	96/60mmHg	115/67 mmHg	115/62 mmHg
HR	105'	108'	92'
SpO_2	96	95% - 96%	96%
RR	24' - 26'	22'	16'
T	36.8˚C	36.8˚C	36.9˚C
WBC	9.10×10^9/L	8.25×10^9/L	
NEU	7.65×10^9/L	7.8×10^9/L	
RBC	5.15×10^{12}/L	4.35×10^{12}/L	
HGB	12.1 g/dl	10.5 g/dl	
HCT	32.7 L/L	29.6 L/L	
FAST	No fluid was detected in the right pleural cavity, and approximately 100 mL in the left. Free fluid was not detected in the subhepatic or subsplenic spaces, in the lateral grooves on both sides, or in the pelvic cavity. Free fluid was detected as a narrow band in the left subdiaphragmatic region at the inferior margin. The echotexture of the liver and spleen was uniform. The size, shape, and contours of both kidneys were within normal limits, layer differentiation was preserved. The urinary bladder was moderately full, the bladder cavity was free	No fluid is detected in the right pleural cavity, approximately 100 mL of fluid is visible in the left pleural cavity. No free fluid is detected subhepatically, in the lateral groove on both sides, in the pelvic cavity. A small amount of free fluid is visible under the spleen and in Morrison's area	No fluid is detected in the right pleural cavity, approximately 100 mL of fluid is detected in the left pleural cavity. A moderate amount of free fluid is detected subhepatically, subdiaphragmatically on the left, in the lateral groove on both sides, in the pelvic area
X-ray	both lungs were expanded		is identical to the previous examination

At 18:56, a repeat chest X-ray examination was performed. "The control X-ray

is identical to the previous examination. The lungs are expanded. The mediastinum is within normal limits. The pleuro-diaphragmatic sinuses are free. Cor: within the norm".

At 19:00, another FAST study was performed. "No fluid is detected in the right pleural cavity, approximately 100 mL of fluid is detected in the left pleural cavity. A moderate amount of free fluid is detected subhepatically, subdiaphragmatically on the left, in the lateral groove on both sides, in the pelvic area".

The patient was transferred to the operating room. It is noteworthy that upon admission to the operating room, hemodynamics are stable—T/A: 115/62 mmHg, P: 92', RR: 16', Cor: tones rhythmic, Pulmo: breathing bilaterally vesicular (**Table 1**).

The operation was performed (16/03/2025 19:20-16/03/2025 23:10)—laparotomy, diaphragmorraphy, splenorrhaphy, small bowel repair, washing and drainage of peritoneal cavity. Approximately 500 mL of blood was observed in the peritoneal cavity. A wound (3.0 cm × 1.0 cm) was observed on the left lateral (adjacent to the ribs) part of the diaphragm. A wound (2.0 cm × 1.0 cm) was also observed on the anterior edge of the spleen, from which oozing was observed (**Figures 1-3**). A wound (up to 2 cm) was observed on the small intestine, 1.5 m from the ligament of Treitz. Only serous layer was damaged, therefore no leakage of the contents was observed.

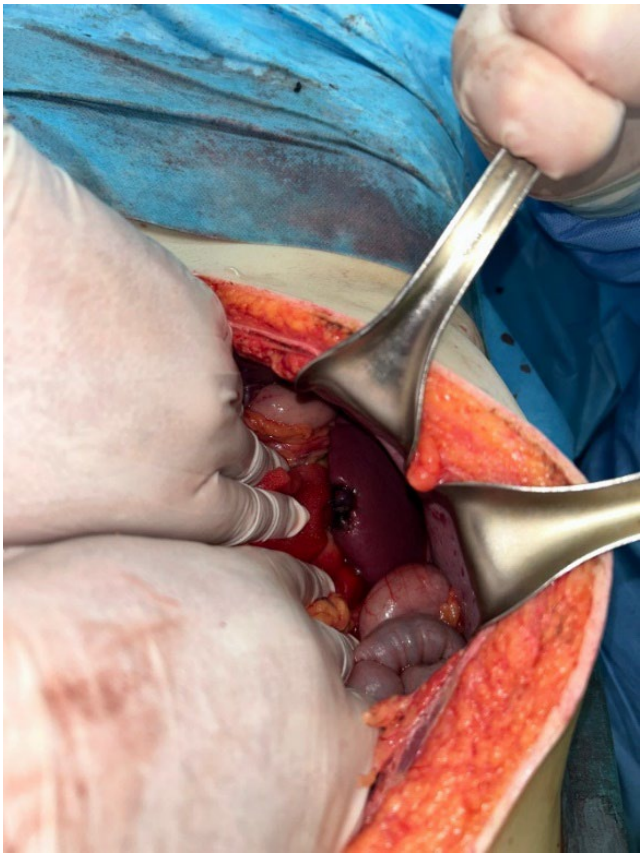

Figure 1. Spleen injury (sutured).

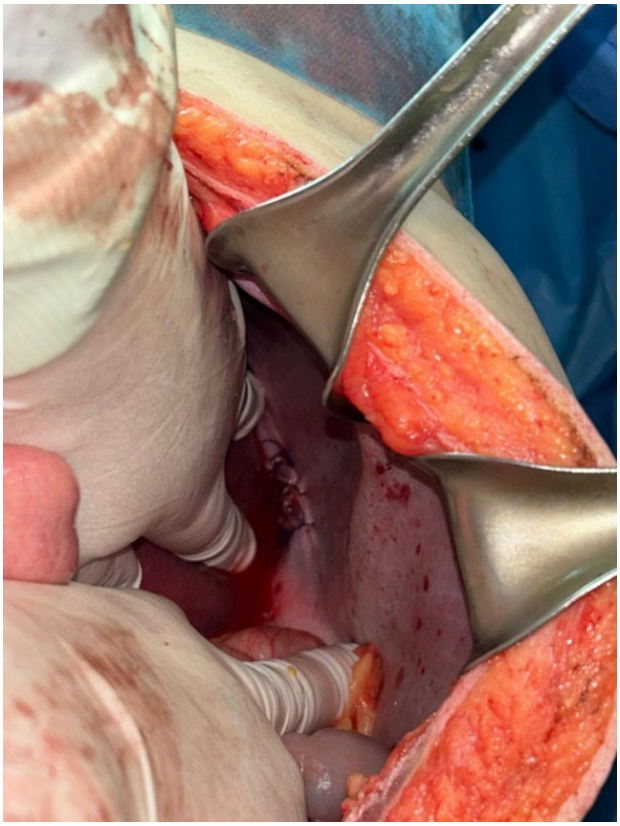

Figure 2. Diaphragm damage 1 (sutured).

Figure 3. Diaphragm damage 2 (sutured).

After the operation, the patient's treatment continued in the postoperative ward, from where he was transferred to the surgical department on 17/03/2025 at 02:00. Ultrasound study of the pleural cavities was performed postoperativly: "approximately 150 mL of fluid is detected on the left". Laboratory tests were performed on the same day (WBC—7.48 × 10^9/L; NEU—6.42 × 10^9/L; RBC—3.07 × 10^{12}/L; HGB—9.1 g/dl; HCT—26.5 L/L; PLT—115 × 10^3 μl; CRP—98 mg/L). At the end of the same day, a control laboratory study of the pleural cavities was carried out. On the left, the amount of fluid was the same.

According to the tests performed on 18/03/2025-HGB—9.3 g/dL, HCT—27.2 L/L. Hemodynamics stable: P—95', rhythmic, T/A—135/85 mmHg, RR—18', T—36.6˚C, SpO_2—97%, Cor—tones rhythmic. Pulmo-breathing vesicular, slightly attenuated in the left lower field. On the same day, an ultrasound examination of the pleural cavities was performed again. On the left, up to 300 mL of fluid. Tube Thoracostomy (TT) of the left pleural cavity was performed. Approximately 300 mL of dark blood was obtained.

On 20/03/2025, there was no longer any discharge from the pleural cavity drainage. A follow-up chest X-ray was performed (normal) and the drainage was removed.

Laboratory tests conducted on 22/03/2025-HGB—10.1 g/dL, HCT—29.7 L/L. Ultrasound examination of pleural cavities: "The pleural cavity on the right is free, up to 100 mL of fluid is detected on the left".

On March 24, 2025, the patient was discharged from the clinic in an improved condition. Contact with the patient was established periodically over the next six months. The patient's condition is good and he has no complaints.

3. Discussion

Although the seemingly typical case we present may have limitations in generalization and may be subject to selection bias, we intend to use it as an example to consider the various options and possibilities for management of thoracoabdominal wounds. In any case, further research directions are needed to better understand the details of treatment for such a complex type of injury.

First of all, it should be noted that currently only certain degrees of spleen damage can be treated surgically, and in the case of isolated spleen damage, Selective Non-operative Management (SNOM) should be attempted initially. **Patients with hemodynamic stability and absence of other abdominal organ injuries requiring surgery should undergo an initial attempt of SNOM irrespective of injury grade.** SNOM of moderate or severe spleen injuries should be considered only in an environment that provides capability for patient intensive monitoring, AG/AE, an immediately available OR and immediate access to blood and blood product or alternatively in the presence of a rapid centralization system and only in patients with stable or stabilized hemodynamic and absence of other internal injuries requiring surgery. … In patients being considered for SNOM, CT scan with intravenous contrast should be performed to define the anatomic spleen injury and

identify associated injuries. … Strong evidence exists that age above 55 years old, high ISS, and moderate to severe splenic injuries are prognostic factors for SNOM failure. These patients require more intensive monitoring and higher index of suspicion. Age above 55 years old alone, large hemoperitoneum alone, hypotension before resuscitation, GCS < 12 and low-hematocrit level at the admission, associated abdominal injuries, blush at CT scan, anticoagulation drugs, HIV disease, drug addiction, cirrhosis, and need for blood transfusions should be taken into account, **but they are not absolute contraindications for SNOM** [1]. It should be noted that in our case, the damage to the diaphragm was not initially identified by documents and was only assumed.

Imaging studies performed upon admission and in the subsequent period showed that there was practically no fluid in the peritoneal cavity. It was visible near of the spleen, in the form of a narrow strip. Ultrasound examination revealed only 100 mL of fluid in the left pleural cavity. Immediately after assessing vital signs and receiving the results of the first FAST examination, the surgeons first performed surgical management of the bleeding wounds, which was a completely correct decision and thus prevented further blood loss (all the described wounds were actively bleeding and, as it turned out during the interview with the patient and the 112 brigade members, there was a significant amount of blood loss even before arriving at the clinic). It is understandable that management of the multiple wounds described above took some time. Then, performance of a CT scan of the abdominal cavity was also correct dicision. It is worth noting that the patient's vital parameters were stable throughout the entire period of these studies and active monitoring.

As early as 1960, Shaftan advocated the application of trained surgical judgment rather than mandatory laparotomy in the management of penetrating abdominal injury. This new approach to civilian penetrating trauma was prompted at that time by the high rate of nontherapeutic laparotomies and associated morbidity. Since then, selective management for patients with abdominal wounds has evolved to incorporate ancillary studies that supplement the findings of serial physical examination and provide objective data for decision-making [2].

Regardless of whether a diaphragmatic injury was identified preoperatively, patient management should have been and was conducted according to Advanced Trauma Life Support (ATLS) principles, which require first monitoring vital signs (ABCDE), followed by a complete examination of the patient and, first of all, identifying and correcting the most life-threatening injury.

ATLS protocol is a standardized method for the initial assessment and management of trauma patients. **It emphasizes a systematic approach to identify and treat life-threatening injuries first, prioritizing those that pose the greatest risk to survival.** The protocol is divided into a primary survey, resuscitation, a secondary survey, and definitive care. The primary survey, guided by the mnemonic ABCDE, focuses on immediate threats to life. In essence, ATLS provides a framework for healthcare professionals to: **1) Treat the greatest threat to life first. 2)**

Initiate treatment even without a complete diagnosis. 3) Prioritize life-saving interventions over obtaining a detailed history initially.

About 10% of blunt and 15% to 30% of penetrating chest injuries require operative intervention. Due to the fact that associated injuries determine the choice of treatment, management of these patients is performed according to the rules of ATLS: **managements in the primary survey (life-threatening injuries) and the secondary survey (potentially life-threatening injuries)**. During the primary survey A (airway), B (breathing), C (circulation) D (disability) and E (environment and exposure) are managed [3].

First of all, attention was rightly paid to the presence of blood in the peritoneum and pleural cavity and as soon as it increased, the patient was taken to the operating room. Diaphragmatic injury itself, regardless of whether it was identified before the operation, is not an indication for immediate emergency intervention. As noted, first of all, it is of utmost importance to identify and monitor damage to vital organ(s). It is precisely such tactics that were chosen in this case, especially since diaphragmatic injury was not documented and could only be assumed.

A Traumatic Diaphragmatic Rupture (TDR) can develop in cases of thoracoabdominal injuries and **in a very high percent of cases it is associated with other organs injuries**. In some cases, TDR itself can cause life-threatening complications, **but generally the outcome of the injury with TDR depends on the severity of the lesions and complications of the associated organs injury**. Hospital mortality is 15% after blunt injuries and 4% after penetrating lesions. **In case of a significant TDR, diagnosis is simple, although in most cases, correct diagnosis is often delayed. When TDR is a part of a polytrauma, the management of the patient must be done according to ATLS protocol and treatment can be done in the primary survey, however most typically carried out during the secondary survey** [3]-[5].

Traditional trauma practice was for open surgical exploration of all penetrating upper abdominal or low thoracic wounds in order to identify and treat Traumatic Diaphragmatic Injury (TDI) as well as injury to other thoracic or abdominal structures. **This nonselective approach has given way to a more selective policy that includes imaging and clinical observation for patients who do not meet criteria for urgent surgery. While this has resulted in reduced morbidity and mortality from unnecessary surgery, it has had the unanticipated effect of increasing the chances for missed or delayed diagnoses of TDI. … Initial management focuses on basic ATLS priorities and is not changed by the presence of a TDI. Since most TDI do not occur in isolation, life-threatening injuries should be addressed first.** If the injuries dictate an exploratory laparotomy for other reasons, then this should include a full inspection and palpation of both hemidiaphragms. This is particularly true in the presence of any injury to closely associated organs or structures. **The diaphragm injury itself is rarely an urgent concern, and the workup and management of more critical issues should take precedent.** The presence of a TDI will rarely affect oxygenation or ventilation, but associated pul-

monary or chest wall injuries may dictate intubation [6].

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. Therefore, the conservative approach has gained favor for penetrating injuries. … 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. … 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. **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.** The results of our study are in accordance with the literature. … **Many studies have reported that the non-operative method is reliable, applicable, and cost-effective for abdominal stabs in a large proportion of patients** [7]-[12].

A non-operative approach can be applicable for some penetrating injuries to the left thoraco-abdominal region, particularly in hemodynamically stable patients without peritonitis or other clear indications for immediate surgery. This approach, often referred to as SNOM, involves careful monitoring and serial examinations to detect any signs of deterioration requiring surgical intervention. Factors Favoring SNOM: Hemodynamic Stability: Patients with stable vital signs and no signs of significant blood loss are more likely to be candidates for SNOM. Absence of Peritonitis: The presence of peritonitis (inflammation of the abdominal lining) generally necessitates immediate surgical exploration. Isolated Organ Injury: SNOM can be considered for patients with isolated injuries to solid organs (like the liver, spleen, or kidney) without other significant injuries. Penetrating Stab Wounds: SNOM is more commonly accepted for stab wounds compared to gunshot wounds. CT Scanning: Advanced imaging like CT scans can help assess the extent of injury and guide decisions about SNOM. Diaphragmatic Injuries: In some cases, diaphragmatic injuries can be managed non-operatively, especially with the use of high-resolution CT scanning. **In summary, while immediate surgery is often necessary for penetrating thoraco-abdominal injuries, a selective non-operative approach can be a safe and effective option for carefully selected patients, particularly those with stab wounds and isolated solid organ injuries, who are hemodynamically stable and without signs of peritonitis** [13].

In general, early diagnosis of diaphragmatic injuries still remains a significant problem. Currently, computed tomography is considered to be the most informative study, however, in acute cases, especially in cases of small penetrating wounds and the absence of hernia, its informativeness decreases. Laparoscopy or Video-

assisted Thoracoscopy (VATS) remains other alternative and informative diagnostic/treatment methods to exclude diaphragmatic injuries. These methods are all the more valuable in cases of isolated diaphragmatic injuries or when concomitant injuries to another organ (e.g., spleen) can be managed nonoperatively. As is known and confirmed by literary sources, this intervention does not require emergency action and can be performed, according to various data, even 6 - 48 hours after the injury.

The diagnosis of traumatic diaphragmatic injury is not always easily made. Special imaging procedures may be used, but they are time-consuming and may provide an additional risk for polytrauma patients by causing a delay in adequate management. In the primary survey, chest radiography is currently the most valuable simple test, although it is diagnostic or suggestive of a diaphragmatic rupture in only 25% - 70% of cases. … CT is the second choice imaging technique, although the axially oriented diaphragm is not always well demonstrated on conventional CT. In a single-layer spiral CT study, the sensitivity for left- and right-sided diaphragmatic injuries was 78% and 50%, but with a Multidetector CT (MDCT), the specificity was 100% and 83% for left and right-sided ruptures, respectively. Currently, in polytrauma and trauma cases, including patients with thoracoabdominal trauma, a whole body MDCT is performed. … When there is a high degree of suspicion, only direct visualisation by laparoscopy or thoracoscopy may exclude/confirm the existence of a diaphragmatic defect. In patients with thoracoabdominal trauma who do not have any abdominal injury and do not require laparotomy, VATS is an excellent tool for the diagnosis and treatment of diaphragmatic injury. VATS can be used to manage TDR, remove clots and properly carry out chest drainage, although it cannot be performed in haemodynamically unstable patients and it also requires general anaesthesia and one-lung ventilation, also. **In case of thoracoabdominal stab wounds or tangential gunshot wounds, when the patient is haemodynamically stable, and there is no sign of peritonitis or diffuse abdominal tenderness, and the patient is in a non-operative method management, a laparoscopy can be indicated to verify a diaphragmatic rupture. Another study suggests that if the hemodynamically stable left thoracoabdominal stab wound patients without signs of peritonitis is managed with a non-operative method, 48 hours after admission, a diagnostic laparoscopy may be performed to check the diaphragm. In 22% of these patients (15/68), a left diaphragmatic injury was found** [3] [8] [14]-[16].

We feel patients selected for laparoscopic repair should be hemodynamically stable, have no other contraindications to laparoscopy, and not have significant associated intraabdominal injuries. In addressing this issue, some studies have incorporated a period of observation to allow for other injuries to manifest if present prior to attempted laparoscopic repair. **These periods of observation have ranged from 6 hours to 24 hours.** In summary, the superior diagnostic capability of laparoscopy to CT along with its relative safety and feasibility make it the preferred choice for most patients needing evaluation for penetrating TDI. Not only that,

laparoscopy may be the preferred surgical approach over open repair in those patients with isolated TDI in stable patients. The surgical repair approach (abdominal vs. thoracic) in acutely injured patients with associated injuries will be determined by the life-threatening nature and surgical amenability of those associated injuries [17]-[19].

In our case, we encountered a similar situation. As noted, regardless of the diaphragmatic injury, patient management should be guided by ATLS principles. As mentioned above, diaphragmatic injury does not require immediate emergency intervention. Therefore, when a small splenic wound was known to be present in a hemodynamically and respiratory stable patient, and minimal fluid had persisted for several hours only in the area adjacent to the spleen, our surgical team opted for watchful waiting tactic. If, during active dynamic monitoring, no increase in the amount of blood in the abdominal cavity had been observed, then laparotomy could have been avoided altogether and, after confirmation of damage to the diaphragm, the diaphragmatic defect could have been sutured using a minimally invasive method. In this case, surgeons would have had sufficient time to analyze and select a definite method of accessing the diaphragm. We believe that if laparotomy had not subsequently become necessary due to splenic injury, a VATS approach would have been more appropriate for repairing the diaphragmatic defect. Unfortunately, two and a half hours after admission, an increase in the amount of fluid in the abdominal cavity was noted and therefore a laparotomy was performed.

The diagnosis of diaphragm injury can be difficult for trauma surgeons. Using many non-invasive methods, including physical examination, chest X-ray, computed tomography, magnetic resonance imaging and diagnostic peritoneal lavage, a preoperative diagnosis can be obtained only about 70% on time. Paci *et al.* reported that a diaphragmatic injury in five (38.5%) of 13 patients who had penetrating thoracic trauma. Furthermore, one patient needed conversion from VATS to open operation due to a broad laceration of the diaphragm and diaphragm laceration missed with radiologic methods in the whole of 13 patients in their study. **Diaphragmatic lacerations without herniation are difficult to diagnose. We think that VATS is a standard indication for the hemodynamically stable patient who presents with acute penetrating thoracic trauma. In addition to possible accompanying traumatic pathologies, VATS in small diaphragmatic lacerations and accompanying traumatic pathologies are extremely useful both diagnostically and therapeutically. Furthermore, other advantages of VATS were fewer postoperative complications, better postoperative pain control, fewer wound and pulmonary complications, shorter chest tube duration, and a faster return to regular activities compared to thoracotomy.** Martinez *et al.* reported missed injury rate in penetrating thoracic trauma is approximately 30%. They pay attention that all radiological images can be non-pathological in more than 70% of these patients. We found s missed injury rate as 18%. **In properly selected patients, localization penetrating trauma may increase this rate. We conclude that the**

diagnosis of diaphragmatic injuries due to penetrating thoracic trauma is difficult to detect radiologically. Hidden injuries may lead to serious complications in the later period. VATS should be performed for both diagnosis and treatment in suspected penetrating thoracic trauma cases in which the diagnosis cannot be reached by imaging methods [20]-[23].

It is known that in traumatic pleural injuries, including thoracoabdominal ones, the cut off for pleural cavity drainage, according to various sources, is the presence of 300 mL - 500 mL of blood or more. According to some literature, pleural cavity drainage is, of course, possible with any penetrating wound, regardless of the amount of blood accumulated within. However, in such cases, firstly, there is a high risk of iatrogenic injury and, secondly, a high probability of developing various complications and negative consequences typical of pleural cavity drainage.

Despite potential benefits of TT drainage, many possible complications exist. Contraindications to thoracostomy placement have to be considered in the context of the overall risk-benefit assessment. For example, there are no contraindications to TT placement for tension pneumothorax (PTX). However, previous history of pleurodesis or lung transplantation may preclude "blind" chest tube placement and trigger the performance of image-guided TT procedure. Patients with extensive pulmonary blebs also have a relative contraindication to TT placement because of the risk of bronchial fistula formation. Elective or semi-elective TT placement should be avoided in patients with clinically significant coagulopathy and consideration should be given to normalization of coagulation parameters prior to commencing with the procedure. **Cumulative rates of early (24hrs post-placement period) chest tube complications are approximately 3 and 8% - 10%, respectively. Thoracostomy procedures carry multiple, often underestimated risks and the list of published complications of TT is extensive. The number of anatomic structures potentially affected during TT placement includes primary and secondary injuries of the lung, intercostal/intrathoracic vasculature, esophagus, stomach, liver, spleen, diaphragm, major blood vessels, and even cardiac structures. While TT complications can be categorized as acute (insertion site infection, including necrotizing fasciitis, empyema) or chronic, procedural and non-procedural, provider and patient-related, we have chosen to categorize them into organ-specific complications and thoracic cage complications/injuries (extrapulmonary anatomic (bronchopleural fistula, Intercostal arterial hemorrhage, arteriovenous fistula, including chest wall, chylothorax, fibrothorax), physiological (reexpansion pulmonary edema, vagus nerve irritation, including hemodynamic collapse), technical (non-functioning tube, contralateral PTX, subcutaneous placement, persistent leakage around chest tube, unintended tube dislodgement), and miscellaneous (tube erosion (non-acute), Horner's syndrome, determination of tube thoracostomy failure))** [24]-[32].

No contemporary literature has found objective evidence of the benefits of early pleural drainage compared with conservative treatment and active monitoring in

traumatic hemothorax (HTX) with a blood volume in the pleural cavity of less than 300 mL. In our case, drainage was performed 2 days after surgery, when the pleural fluid volume reached 300 mL. Two days after the procedure, no further discharge was observed and the drain was removed.

Thoracic trauma accounts for up to 25% of traumatic deaths in the United States, and the incidence of traumatic hemothoraces is estimated to approach 300,000 cases each year. Patients who develop traumatic hemothoraces are at risk for serious complications, including respiratory failure, retained HTX, empyema, fibrothorax, need for thoracoscopic or open surgical intervention, and prolonged hospitalization. … **However, the decision to proceed with TT must be balanced against the risk of complications that may arise from thoracostomy tube placement. Data suggest that TT placement carries up to a 21% risk of complications. Given this risk of complications, some patients with traumatic HTX might be more safely managed with observation rather than TT**. … **In this study of patients presenting with traumatic HTX at a Level I trauma center, we have found that selective observation of traumatic HTX is safe and may result in better outcomes.** The only difference in outcomes between patients who received early TT and those who required delayed TT due to failed observation was an increased likelihood of discharge to a rehabilitation facility rather than to home in patients who failed observation. We have further found that older age, fewer ventilation-free days, HTX size of 300 or greater, and presence of a concurrent pneumothorax independently predict delayed TT placement due to failed observation. … **Our analysis of patients who received TT (early TT or failed observation) versus those who were successfully observed confirms the findings by Wells *et al.*, who demonstrated the association of TT with longer hospital Length of Stay (LOS) and high rates of empyema but no difference in mortality**. Our study additionally suggests that TT is associated with higher rates of discharge to a rehabilitation facility rather than discharge to home. **Taken together, these findings suggest that avoiding unnecessary TT in patients with small hemothoraces without concurrent pneuomothoraces or need for mechanical ventilation may help these stable patients leave the hospital safely and return home sooner. … We have found that a subset of patients with traumatic HTX can be safely observed without TT. Factors that predict failed observation include older age, fewer ventilation-free days, HTX size of 300 or greater, and presence of a concurrent PTX. Avoidance of unnecessary TT may result in better outcomes for patients who are successfully observed, with little additional risk to patients who ultimately fail observation** [33] [34].

While multiple studies have been performed trying to identify the optimal volume cutoff for HTX observation, methodological heterogeneity and a paucity of prospective data have limited conclusive results. Two retrospective studies have shown no increased risk of mortality with HTX observation, and that chest tube placement is more likely with HTX volume greater than 300 mL. A prospective multicenter trial did show that failure after observation was more likely with higher

numbers of rib fractures and pulmonary contusions but could not analyze an association with HTX volume due to missing imaging data. An ongoing prospective randomized study of HTX observation vs drainage may shed more light on the firm indications for drainage in otherwise stable patients. Current guidelines also recognize that it is safe to observe small HTX, but do not provide a cutoff volume and emphasize management decisions based on surgeon judgment and pulmonary function. **We recommend observation for small HTX with a CT volume less than 300 mL calculated using a summation-type measurement. In the recent report by Al Tannir and colleagues, implementation of a protocol with a 300 mL cutoff decreased chest tube placement and hospital length of stay without increasing pulmonary complications**. If HTX observation is being pursued, the patient should be monitored in an inpatient setting with at least 1 additional chest radiograph to ensure that the HTX does not increase in size. … For traumatic PTX and HTX, patient hemodynamic status, clinical setting, and imaging parameters should combine to guide the management strategy. For diagnosis, ultrasound and chest X-ray are 2 readily available tools. However, chest CT remains the most sensitive and specific imaging modality. **While hard cutoffs remain to be defined, a PTX greater than 35 mm or a HTX larger than 300 mL should prompt consideration for drainage** [33]-[39].

It remains plausible that not all severely injured patients with traumatic HTXs require TT drainage. Although HTX size was an independent predictor of TT, this intervention displayed no associated mortality benefit within a large cohort of patients treated over a number of years at a level 1 trauma centre. TT was also clearly associated with a longer hospital LOS, and a greater risk of empyema. Consequently, in the presence of clinical stability with adequate monitoring, and the absence of significant concomitant thoracic injury, small traumatic HTXs that fall at or below the Stein line may be safe to manage expectantly. This does not diminish the utility of TT as a crucial and successful intervention in managing the vast majority of traumatic thoracic injuries. It does reinforce that the indications for this procedure should be considered carefully because the potential morbidity associated with TT must be balanced against the risk of clinical deterioration in the setting of a known HTX [34] [40] [41].

4. Conclusion

Thus, despite our efforts, we were unable to avoid open surgery, but even with such a complex injury as a penetrating thoracoabdominal wound, under certain circumstances, it is possible to use a watchful waiting approach, in some cases to use a minimally invasive intervention instead of a wide and traumatic laparotomy, and even to get by with active dynamic monitoring of the patient instead of routine drainage of the affected pleural cavity.

Informed Consent

The patient has provided informed consent.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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