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Traumatic diaphragmatic injuries (TDI)

Two-Year' Experience with diaphragmatic injuries at Aboslim Trauma Hospital, Tripoli-Libya (2021-2023)

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Abstract

Background

Traumatic diaphragmatic injuries (TDI) are uncommon but potentially life-threatening, typically resulting from high-energy blunt or penetrating trauma. Due to their often subtle presentation and association with other injuries, TDIs are frequently missed during initial evaluation. Delayed diagnosis can result in herniation of abdominal organs into the thoracic cavity, respiratory compromise, and increased morbidity. This study reviews our institutional experience in diagnosing and managing TDIs over a two-year period at Abo-Slim Trauma Hospital, Tripoli, Libya.

Methods: We conducted a retrospective review of all patients diagnosed with diaphragmatic injuries between June 2021 and June 2023. Data included demographics, mechanism and side of injury, timing and modality of diagnosis, surgical approach, and outcomes. Surgical techniques included laparotomy, laparoscopy, and thoracotomy. Patients were coded DI-2021-7-01 to DI-2021-7-08.

Results: Eight patients were identified, aged (35.9±13.6, Mean±STDVV). Injuries involved the left diaphragm in 7 cases (87.5%) and the right in 1 case (12.5%). Mechanisms included road traffic accidents(n=5),stab wounds(n=2),,and one fall. Diagnosis was immediate in 5 cases (62.5%) and delayed in 3 (37.5%).Surgical repair was performed via laparotomy in 5 cases (indicated by peritonitis or positive FAST), laparoscopy in 2 stable patients, and thoracotomy in one delayed diagnosis.

Conclusion: TDIs remain challenging to diagnose, especially when associated with multiple injuries. The left side is more frequently affected, likely due to the protective role of the liver on the right. Missed injuries contribute to increased complications and length of stay. Early surgical exploration, particularly using laparoscopy in stable patients, improves detection and outcomes. High clinical suspicion and vigilant trauma assessment are critical in ensuring timely intervention.

Introduction

Traumatic diaphragmatic injuries (TDIs) represent a relatively uncommon but clinically significant subset of thoraco-abdominal trauma (1-3). The diaphragm, a thin, dome-shaped musculotendinous structure, plays a crucial role in ventilation and separates the thoracic and abdominal cavities (4, 5).Its anatomical position makes it vulnerable to both blunt and penetrating trauma-particularly in high-energy injuries such as motor vehicle collisions, falls from height, and stab or gunshot wounds to the thoraco-abdominal region (6,7).

The incidence of TDI varies significantly, with reported rates of 0.8-5% in blunt trauma and up to 15% in penetrating injuries (8, 9). However, the true incidence may be underreported due to the diagnostic challenges posed by this condition (8, 10, 11). In the acute setting, symptoms may be subtle or masked by concomitant injuries, while standard imaging studies often fail to reveal small or right-sided diaphragmatic defects (12-14). As a result, diaphragmatic injuries are frequently missed on initial assessment, leading to delayed diagnosis and increased risk of complications such as visceral herniation,strangulation, respiratory distress, and bowel ischemia (2, 10,12,15).

Right-sided injuries are less commonly reported than left-sided ones, likely due to the protective effect of the liver, which may tamponed the defect or obscure it radiologically. Conversely, the left diaphragm is more vulnerable and often lacks a barrier to herniation of the stomach, colon, or spleen into the thoracic cavity (16-19).The mechanism of injury,size and location of the diaphragmatic defect, and associated organ damage all influence the clinical course and management strategy (20,21).

Surgical repair remains the mainstay of treatment and can be performed via laparotomy, thoracotomy,or minimally invasive approaches such as laparoscopy or thoracoscopy (22, 23). The choice of approach depends on patient stability, associated injuries, and available resources (24, 25).Laparotomy is often preferred in unstable patients or when intra-abdominal injuries are suspected,while laparoscopy offers diagnostic and therapeutic advantages in selected cases with isolated diaphragmatic trauma (26).

Despite advances in imaging and minimally invasive techniques, the diagnosis and management of TDI remain challenging, especially in resource-limited environments. This is particularly relevant in developing countries, where access to high-resolution imaging, surgical expertise, and trauma systems may be limited. Understanding regional patterns, diagnostic pitfalls, and treatment outcomes is crucial for improving care and guiding clinical decision-making(8).

This study presents a retrospective review of our experience at Abo-Slim Trauma Hospital in Tripoli,Libya,evaluating the clinical characteristics, mechanisms of

injury, dliagnostic timelines, and surgical approaches used in the management of diaphragmatic injuries over a two-year period. By sharing our institutional experience, we aim to raise awareness of the diagnostic challenges and emphasize importance of early recognition and appropriate surgical intervention to reduce morbidity and mortality in patients with TDI.

Anatomical considerations and side predilection

Several anatomical and physiological factors influence the incidence and presentation of diaphragmatic injuries. The left hemidiaphragm is more frequently injured, accounting for approximately 70-90% of all reported cases (15). This asymmetry is largely attributed to the protective effect of the liver on the right side and potential difficulties in radiological detection due to the organ's presence. In addition, the posterolateral region of the diaphragm is particularly susceptible to rupture due to its relatively weak structure and embryological fusion planes (27).

Diagnostic Challenges:

Standard chest radiography is often the first imaging modality used in trauma settings; however, its sensitivity in detecting diaphragmatic rupture is low, particularly for small or right-sided defects (28).Computed tomography (CT), especially with multi-detector technology and coronal or sagittal reconstructions, has significantly improved diagnostic accuracy, wvith reported sensitivities exceeding 80% in expert hands (29). Magnetic resonance imaging (MRI) may offer even greater sensitivity but is seldom practical in the acute trauma setting (30). Diagnostic laparoscopy and thoracoscopy have emerged as valuable tools for direct visualization and repair, particularly in hemodynamically stable patients with equivocal imaging findings (31).

Surgical Management

There is consensus that all full-thickness diaphragmatic injuries should be repaired surgically to prevent herniation and potential strangulation of abdominal contents (32, 33). Laparotomy is often performed in poly traumatic patients or when there is suspicion of intra-abdominal haemorrhage or visceral injury (34, 35). Thoracotomy may be used for chronic or delayed presentations with dense adhesions in the thoracic cavity (36). Minimally invasive techniques, including laparoscopy and thoracoscopy, are increasingly used in stable patients, allowing both diagnosis and repair with reduced morbidity (37). Delayed repairs are associated with increased complexity and complication rates,emphasizing the importance of early recognition (38,39).

Missed Injuries and Delayed Complications

A significant proportion of diaphragmatic injuries are not diagnosed during the initial trauma workup and only become apparent when patients present later with herniation-related symptoms. Herniated bowel, stomach, or solid organs can lead to volvulus, strangulation, or respiratory distress. In some series, up to 20% of TDIs are diagnosed weeks to months after the initial trauma event, often requiring more complex surgical correction (15,40-42).

Relevance to Low-Resource Settings

In resource-limited healthcare environments, the reliance on clinical judgment and basic imaging remain high. Access to advanced imaging or minimally invasive surgery is often restricted. As such, delays in diagnosis and inappropriate surgical approaches may lead to increased complications.

Sharing institutional experiences in such contexts is essential to inform clinical practice and highlight the importance of high clinical suspicion in trauma patients (43,44).

Materials and Methods

This retrospective study was conducted at Abo-Slim Trauma Hospital, a major trauma referral center in Tripoli, Libya. The objective was to review all cases of traumatic diaphragmatic injury (TDI)managed surgically between June 2021 and June 2023. Ethical approval for the study was obtained from the hospital's surgical review board, and all data were anonymized to maintain patient confidentiality. Each case was assigned a unique identifier for reference purposes, coded as DI-2021-7-01 through DI-2021-7-08,reflecting the year and sequence of inclusion in the study.

The study population included all patients who sustained diaphragmatic injuries secondary to trauma and underwent surgical repair during the defined period. Inclusion criteria were: confirmed diagnosis of diaphragmatic rupture (either by imaging or intraoperative), surgical intervention performed at our institution, and availability of complete medical records. Patients with congenital diaphragmatic hernias, non-traumatic diaphragmatic defects, or incomplete documentation were excluded from the analysis.

Patient data were retrieved from surgical theatre logbooks, case files, operative notes, and discharge summaries. The collected variables included age, sex, mechanism of injury (classified as road traffic accident, stab wound, or fall from height), side of diaphragmatic involvement (right or left), and the timing of diagnosis (immediate versus delayed). Diagnostic methods were also recorded, including findings from chest radiographs, computed tomography (CT), and intraoperative observations. For delayed diagnoses, the mode and circumstances of eventual discovery were noted, particularly in cases where the injury was initially missed during laparotomy, laparoscopy, or thoracotomy.

Operative details such as surgical approach-laparotomy, laparoscopy, or thoracotomy-were analyzed in relation to the patient's hemodynamic stability and the presence of associated injuries. The choice of surgical technique was further examined in the context of diagnostic indications such as positive diagnostic peritoneal lavage (DPL), abdominal rigidity, or imaging suggestive of intra-abdominal pathology. In each case, the nature of the diaphragmatic defect, repair method (e.g.Primary suture repair), and intraoperative findings were documented.

Clinical outcomes were also reviewed, including the duration of hospital stay, any immediate postoperative complications, and mortality. Data were summarized descriptively. Continuous variables such as age and length of hospital stay were expressed as mean values, while categorical data were reported as frequencies and percentages. Each case was assessed individually to explore diagnostic and therapeutic decision-making and to identify any common patterns in missed injuries or delayed diagnosis.

This method allowed us to evaluate the diagnostic challenges and surgical strategies associated with TDI in a real-world, resource-limited setting, and to highlight potential areas for improved trauma care delivery.

Results

Over the two-year study period from June 2021 to June 2023, a total of eight patients were identified with traumatic diaphragmatic injuries requiring surgical repair at Abo-Slim Trauma Hospital. These cases were assigned unique identifiers ranging from DI-2021-7-01 to DI-2021-7-08 for consistency and anonymization purposes. The patients ranged in age from 22 to 53 years, with a mean age of 37.5years. gender one female and seven male patients.

Left-sided diaphragmatic injury was far more common, occurring in seven patients (87%), while right-sided injury was observed in only one patient (13%).The mechanism of injury varied, with road traffic accidents (RTA) being the most frequent cause, accounting for five cases (62.5%). Penetrating trauma due to stab wounds was observed in two patients (25%), and one patient (12.5%) sustained injury following a fall from height.

Diagnosis was made immediately in five cases (62.5%), either through imaging or during surgical exploration. However, three patients (37.5%) experienced delayed diagnosis. The delays ranged from days to weeks and were recognized when patients re-presented with non-specific symptoms or complications suggestive of intra-thoracic herniation.

Regarding surgical management, laparotomy was the most common approach, performed in five patients (62.5%). Of these, four uderwent laparotomy based on clinical indications such as abdominal rigidity or positive Focused Assessment

Sonography in Trauma (FAST), while the fifth case involved a delayed presentation that necessitated open exploration and repair. Laparoscopic repair was successfully performed in two patients (25%) who were hemodynamically stable and had no other significant intra-abdominal injuries. The remaining one patient, with a missed right-sided injury, underwent thoracotomy during a subsequent admission after symptoms of bowel herniation and respiratory compromise developed.

No intraoperative mortalities were recorded. Postoperatively, all patients recovered with standard care and were eventually discharged. However, patients with delayed diagnosis experienced longer hospital stays and had an increased risk of postoperative complications, including pleural effusion and prolonged ileus.

A detailed summary of patient characteristics, mechanisms of injury, diagnostic timing,surgical approach,and outcomes is presented in Table 1.

Table 1:Summary of Clinical Characteristics,Diagnosis,and Management of Diaphragmatic Injury

Cases (D-2021-7-01 to DI-2021-7-08)

Case ID	Age/Sex	Mechanism of Injury	Side of Injury	Teming of Diagnosis	Diagnostic Modality	Surgical Approach	Intraoperative Findings	Outcome
DI-2021-7-01	22/F	Road Traftfic Accident	Left	Delayed	Chest X-ray+CT Chest	Laparotomy	Large tear;stomach,small bowel,transverse colon,spleen,and omentum herniated into thoracic cavity	ICU 3 days;discharged in good condition;well on 2-year follow-up
DI-2021-7-02	53/M	Road Traffic Accident	Right	Early (Day 2)	Chest X-ray+CT Chest/Abdomen	Thoracotomy	Right diaphragmatic tear confirmed on imaging	Discharged in good condition
DI-2021-7-03	50/M	Road Traffic Accident	Left	Delayed (Day 3)	Chest X-ray+CT Chest	Laparoscopy	Stomach gas seen in chest; diaphragmatic defect confirmed and repaired	Recovered well

DI-2021-7-04	50/M	Stab wound	Left	Immediate	Cinical+ Operative	Laparotomy	Pancreatic injury and ruptured left diaphragm;repair using interrupted Prolene 1 sutures	Discharged in stable condition
DI-2021-7-05	20/M	Fall from height	Left	Immediate	FAST	Laparotomy	Splenic injuries,retroperitoneal hematoma,left diaphragmatic tear	Recovered postoperatively
DI-2021-7-06	20/M	Road Traffic Accident	Left	Immediate	FAST	Laparotomy	Multiple lacerations;diaphragmatic rupture	Discharged after stabilization
DI-2021-7-07	28/M	Road Traffic Accident	Left	Immediate	Peritonitis	Laparotomy	Left lobe liver tear,small splenic tear,retroperitoneal hematoma,left diaphragm tear	Discharged in stable condition
DI-2021-7-08	30/M	Stab wound	Left	Delayed (Day 2)	Chest X-ray (initially NAD). CT Chest	Laparoscopy	Stomach herniation into thoracic cavity;confirmed diaphragmatic defect	Uneventful recovery

Discussion

This retrospective review of eight cases of traumatic diaphragmatic injury (TDI) managed at Abo-Slim Trauma Hospital, Tripoli-Libya, highlights the diagnostic and therapeutic challenges associated with this uncommon but potentially life-threatening condition. The findings of this case series are consistent with the broader literature, particularly in terms of the predominance of left-sided injuries,the high association with blunt trauma, and the critical role of timely surgical intervention (45, 46).

Mechanism and Laterality of Injury

In our series, seven of the eight patients (87.5%) had left-sided diaphragmatic injuries, with only one case involving the right hemidiaphragm. This aligns with the established observation that the left side is more vulnerable to rupture due to the absence of the liver's protective buffering effect (45).The right hemidiaphragm, although not immune to injury, is less frequently ruptured and more likely to be missed radiologically, as illustrated by DI-2021-7-02, where a right-sided rupture was only recognized after CT imaging and was managed via thoracotomy (45, 47,48).

Blunt trauma-predominantly road traffic accidents (RTA)-was the most common cause,accounting for five of the eight cases (62.5%). This reflects global patterns where high-velocity deceleration injuries dominate TDI etiologies. Penetrating trauma, such as stab wounds,accounted for two cases (25%), and one patient sustained the injury due to a fall from height. These findings support the need for a high index of suspicion in poly traumatic patients, particularly those with thoraco-abdominal involvement (6-8,49-52).

Diagnostic Challenges and Delays

Early diagnosis remains a cornerstone in reducing morbidity of TDI (53). Five patients (62.5%) were diagnosed immediately, either through suggestive imaging or intraoperatively, during laparotomy for other indications. However,three patients (37.5%) experienced delayed diagnosis, often several days after initial trauma. For instance, DI-2021-7-01 developed progressive respiratory symptoms only after hospital readmission, and diagnosis was confirmed on CT after being missed in the initial orthopaedic management. This is consistent with studies reporting delayed recognition in up to 30%of TDIs, especially when symptoms are vague or overshadowed by orthopaedic or neurological injuries (54,55).

Similarly,DI-2021-7-08,initially hemodynamically stable with negative chest X-ray findings,developed symptoms suggestive of visceral herniation only the next day,highlighting the limitations of plain radiographs and the value of repeated imaging. Several studies emphasize the role of CT scanning,particularly multi-

detector CT (MDCT), in detecting subtle diaphragmatic defects not visible on chest X-ray. The "collar sign or hourglass sign" and "dependent viscera sign" on CT has been found to be highly suggestive of TDI (56).

Surgical Management and Outcomes

All eight patients in our study underwent surgical repair. Laparotomy was the most commonly employed approach (5 cases), often dictated by clinical signs such as abdominal rigidity or Focused Assessment Sonography in Trauma (FAST). For example, DI-2021-7-05, DI-2021-7-06, and DI-2021-7-07had signs of intra-abdominal bleeding or solid organ injury, necessitating open exploration (34, 57,58). Laparoscopy was successfully employed in DI-2021-7-03 and DI-2021-7-08, both of whom were hemodynamically stable and had minimal associated injuries. This minimally invasive approach enabled both diagnosis and repair and is increasingly favoured in stable patients due to its lower morbidity and shorter recovery time. However, its utility is limited in the presence of extensive intra-abdominal injuries or hemodynamic instability (26, 59).

The lone thoracotomy (DI-2021-7-02) was performed for a delayed-diagnosis right-sided injury with significant thoracic involvement. In such cases,especially when adhesions or herniated contents need to be addressed within the thoracic cavity,thoracotomy remains appropriate.

Associated Injuries

A key observation in our series is the frequent association of TDI with other traumatic injuries.Orthopedic fractures (limbs and pelvis), splenic lacerations, retroperitoneal hematoma,and liver injuries were common. These associated injuries not only influenced the timing and method of diagnosis but also dictated surgical approach and post-operative recovery. This mirrors findings in large trauma series, which consistently demonstrate that TDI is a marker of severe,multisystem trauma.

Outcomes and Prognosis

There were no in-hospital mortalities in our cohort. All patients survived and were discharged in stable condition, with follow-up confirming good long-term outcomes, including DI-2021-7-01, who remained well two years post-operatively. However, patients with delayed diagnoses had longer hospital stays and a more complex recovery, underlining the consequences of missed or late recognition.

Conclusion

Traumatic diaphragmatic injuries remain a diagnostic and surgical challenge, particularly in the context of poly trauma. Our institutional experience underscores the importance of maintaining a high index of suspicion in all patients with thoraco-abdominal trauma, especially following road traffic accidents, stab wounds, or falls from height. Given the nonspecific presentation of TDI and the limitations of initial

imaging, repeated investigations and close clinical monitoring are often necessary, even in patients who appear stable.

Diagnostic laparoscopy has proven to be an invaluable tool for both diagnosis and repair in selected hemodynamically stable patients, offering the benefits of minimally invasive access. However, delays in diagnosis-as observed in several of our cases-are associated with more complex surgical interventions, increased risk of complications, and prolonged hospitalization, which place a significant burden on both patients and healthcare resources.

In resource-limited settings, where access to advanced imaging and surgical technologies may be restricted, clinical acumen and timely surgical exploration become the cornerstones of effective management. This series reinforces the need for multidisciplinary vigilance, robust trauma protocols, and early operative intervention to improve patient outcomes in diaphragmatic trauma.

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