

Case Series

CASE SERIES ON TRAUMATIC DIAPHRAGMATIC INJURIES IN A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Traumatic diaphragmatic injuries (TDI) are usually challenging to diagnose and are often missed, unless they are diagnosed by direct surgical examination. The outcome of cases diagnosed early is dependent on the associated injuries. This case series explores the mechanisms of injury and diagnosis in TDI patients in our tertiary care hospital. **Materials and Methods:** A retrospective analysis was conducted over one year in the Department of General Surgery in a tertiary care center in Chennai, India. Five patients who presented to the emergency department with confirmed TDI were identified, and their trauma mechanisms and diagnostic process were analyzed. **Result:** All five patients were managed surgically. Two of the five patients had road traffic accidents, and three had penetrating trauma either by assault or by accident. Three patients were hemodynamically unstable. Three patients had multiple rib fractures. Two of the five cases were diagnosed pre-operatively, using computed tomography, and they also had visceral organ herniation. One patient expired postoperatively. **Conclusion:** All the injuries were due to high-velocity trauma, and rib fractures accompanied the majority. These observations indicate that trauma surgeons should include TDI in the differential diagnosis in patients with thoraco-abdominal injuries, particularly those with rib fractures or high-impact injuries.

INTRODUCTION

The diaphragm is an important skeletal muscle that plays an essential role in respiration and regulating intra-abdominal pressure.^[1] This dome-shaped muscle develops from the septum transversum around the fourth week of development. The diaphragm is located at the inferior aspect of the rib cage and acts as the floor of the thoracic cavity. The diaphragm attachments include the sternum, sixth to twelfth ribs, first three lumbar vertebrae, and the last thoracic vertebra. The diaphragmatic muscle fibres combine to form the central tendon, which in turn fuses with the fibrous pericardium. At rest, the right dome is slightly higher, due to the presence of the liver.^[2]

Traumatic diaphragmatic injury, though a rare entity, is often easily missed at initial diagnosis, leading to high morbidity and mortality, often posthumously detected. Either blunt or penetrating injuries through the thorax or the abdomen can lead to a diaphragmatic injury.^[3] According to the literature, it affects about 5% of patients presenting with thoraco-abdominal trauma, with herniation of abdominal contents into the thoracic cavity being seen in almost

half of the cases.^[4] Early and prompt diagnosis is necessary to avoid grave complications like strangulation or perforation, which could occur due to delayed diagnosis.^[5,6]

Diagnostic workup generally includes imaging modalities like chest X-ray, computed tomography, magnetic resonance imaging, and sometimes laparoscopy. Although CXR is usually the initial imaging modality used in trauma patients, it is only diagnostic in a little more than one-third of the cases. CT is more sensitive and specific, especially when abdominal organ herniation into the thorax occurs, but can also fail to detect smaller or inapparent injuries. Indeed, preoperative rates of identification of left-sided diaphragmatic rupture are between 40% and 50%, and for right-sided rupture, 0 to 10%. Hence, operative exploration might be indicated if clinical suspicion is high despite non-diagnostic imaging. This suggests the need for thorough assessment and early intervention to enhance outcomes and reduce postoperative complications.^[7-9]

This case series is a single-centre, retrospective review conducted at a tertiary care centre in Chennai, India. We have included five patients who presented

with a traumatic diaphragmatic injury, by either blunt or penetrative mechanism, over one year, to the emergency department, and all of whom were operated. Medical records of these patients were reviewed, and all clinical information was extracted. Data were collected using a structured data collection tool (Excel spreadsheet), into which all relevant data were incorporated. These included patient demographics, mechanism of injury, Glasgow coma score, pre-existing medical conditions, vital signs at presentation, procedures performed, imaging findings, length of stay in the hospital, duration of mechanical ventilation, and discharge or mortality status, among other variables. The data thus obtained were used to compile and report this case series.

CASE REPORT 1

A 49-year-old man arrived at our hospital emergency department with an alleged history of accidental penetrating injury by a cutting machine to the left hypochondrium. On arrival, the patient was agitated, dyspneic, had tachycardia, hypotension, and had desaturation. Resuscitation measures were taken. On examination, a left hypochondriac region laceration through which a gush of air and omental contents seemed prolapsed, oozing food contents, with obvious rib fractures. Extended focused assessment with sonography for trauma revealed positive results for the left lung fields and free fluid in the pelvis. Once stabilized, the patient was shifted for radiological investigations. CT-abdomen showed a defect in the antero-lateral portion of the left hemidiaphragm, for a length of 5.7cm, with herniation of the body of the stomach into the thoracic cavity. CT-chest-left moderate hemopneumothorax with 6,7,8th rib fractures. The patient was emergently shifted for exploratory laparotomy. Firstly, a left intercostal drainage tube was placed and revealed 800ml of hemothorax mixed with food contents, and intra-operatively, left-sided diaphragmatic rent of about 6x2 cm, with stomach herniation was noted [Figure 1]. Laceration of about 6x 3cm over the anterior aspect of the body of the stomach over the greater curvature. The stomach was successfully reduced into the abdominal cavity and sutured in two layers, first with absorbable and second with non-absorbable sutures [Figure 3]. The diaphragmatic rent was closed in two layers with non-absorbable sutures [Figure 2].

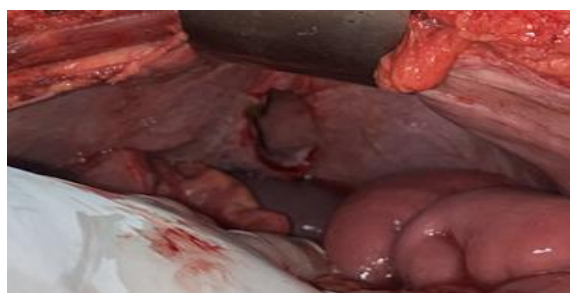


Figure 1: Diaphragmatic rent

A feeding jejunostomy was placed. The external wound was closed in layers. The patient was extubated on day 2, developed pyothorax on post-operative day six. In spite of functioning ICD and higher antibiotic and physiotherapy care, succumbed to death on day twelve.



Figure 2: Diaphragmatic rent repair



Figure 3: Primary repair of the gastric laceration

CASE REPORT 2

A 34-year-old man was brought to the emergency department with an alleged history of assault using a sharp weapon, causing penetrating injury to the left hypochondriac region. On arrival, the patient's vitals were unremarkable. General resuscitation measures were taken. On examination, a left hypochondriac region laceration of size 4x2x2 cm [Figure 4]. Extended focused assessment with sonography for trauma revealed positive results in the left lung fields, splenorenal recess, and in the pelvis. Once the patient was stabilized, was shifted for radiological investigations, CT-abdomen and chest, which showed a linear minimally displaced fracture in the posterolateral aspect of 8 & 9th ribs. Left minimal hemothorax. Mild hemoperitoneum noted. No obvious pneumoperitoneum/ solid organ injury. Soft tissue injury with deeper extension was noted in the left hypochondrium. The patient suddenly deteriorated hemodynamically, requiring intubation and inotropic support. Hence, the patient was shifted for emergency laparotomy. Left intercostal drainage

revealed 200 mL of hemothorax. Hemoperitoneum of 500 mL was noted with a left-sided diaphragmatic rent of about 5x1 cm, with no organ herniation [Figure 5]. A laceration of about 3x3 cm was noted over the superior aspect of the spleen with an active spurt of hemorrhage. Laceration of 3x2 cm noted over segments 2 & 3 of the liver with no active bleeding. Proceeded with splenectomy after ligation of the vasculature, and two-layered closure of the diaphragmatic rent with non-absorbable sutures [Figure 6]. The patient was extubated on the day of surgery and kept on monitoring. Gradually started oral diet on days 4-5. Vaccinations were administered. The patient was discharged on day 14 and is doing well on follow-up.



Figure 4: external penetrating wound

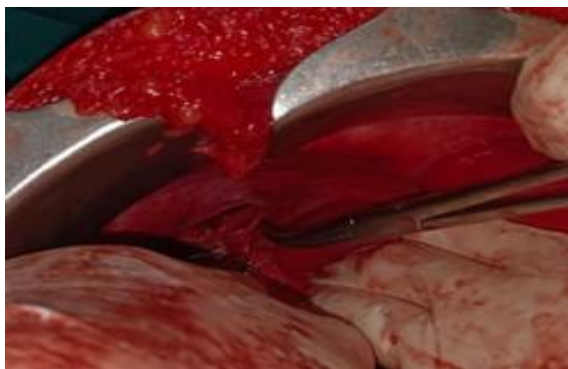


Figure 5: Diaphragmatic rent

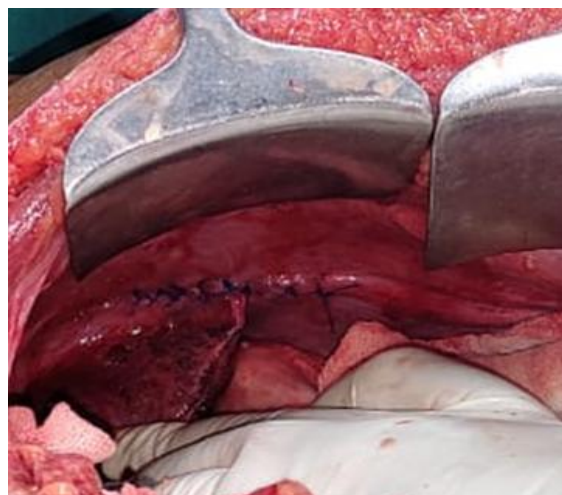


Figure 6: Diaphragmatic rent repair

CASE REPORT 3

An 18-year-old male was brought to the emergency department following a high-velocity head-on collision between his two-wheeler and a lorry. There was no history of loss of consciousness, seizure activity, or vomiting at the scene. He was semi-conscious and hemodynamically unstable with tachycardia, blood pressure of 80/60 mmHg, and room air saturation of 86%. He had shallow, labored breathing with bilateral decreased air entry on auscultation. On abdominal examination, it was distended, with diffuse tenderness and guarding. Extended focused assessment with sonography for trauma revealed positive results in bilateral lung fields and free fluid in the pelvis. Appropriate resuscitation measures were taken, and once stabilized, the patient was shifted for radiological investigations. CT thorax reported bilateral moderate hemothorax. Contrast CT of the abdomen reported a grade IV liver laceration involving segments V, VI and VII, grade IV splenic laceration with active bleeding, right diaphragmatic rupture with herniation of liver segments into the right thoracic cavity, retroperitoneal hematoma, comminuted pelvic fracture involving left superior and inferior pubic rami, comminuted displaced fracture of the right iliac bone and minimal left renal contusion noted. Bilateral intercostal drainage was done, and 800 ml of blood was drained from the right hemothorax and 300 ml from the left hemothorax. An exploratory laparotomy was done, and 1.5 litres of hemoperitoneum were evacuated. Right-sided diaphragmatic rent of about 10 x 5 cm [Figure 7] with liver segments herniated into the thorax, with multiple lacerations over the liver, with active bleed, and a grossly lacerated spleen without an active bleed. The diaphragmatic rent was repaired after successfully reducing the liver into the abdominal cavity and by using two-layered non-absorbable sutures in a continuous interlocking manner. Liver lacerations were managed with packing using Surgicel and Gelfoam, hemostasis was successfully achieved.

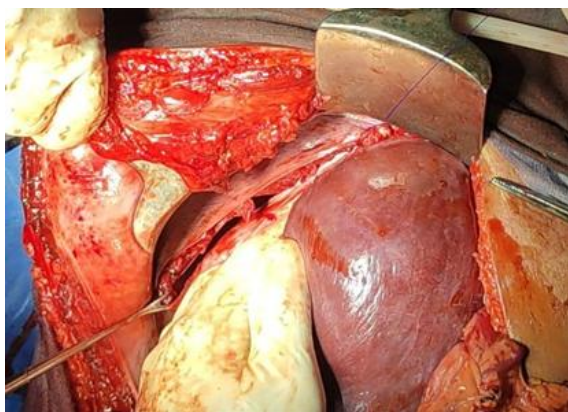


Figure 7: A large diaphragmatic rent

The spleen was not removed but monitored for hemostasis due to borderline perfusion. The pelvic fracture was managed with immobilisation and a pelvic binder. Postoperatively, the right intercostal drainage tube was retained for 10 days due to the presence of thoraco-abdominal communication. The patient was extubated on day 2, oral intake started on day 4. The patient was discharged after two weeks and is doing well on follow-up.

CASE REPORT 4

A 36-year-old man was brought to the emergency department with an alleged history of assault using a sharp weapon, causing stab injury to the left hypochondriac region. On arrival, the patient vitals were unremarkable. General resuscitation measures were taken. On examination, a deep puncture wound of size left hypochondriac region laceration of size 2 x 1 x 4 cm. Extended focused assessment with sonography for trauma revealed positive results in the left lung fields and in the splenorenal recess. Once the patient was stabilized, was shifted for radiological investigations, CT- abdomen and chest showed moderate hemoperitoneum with an ill- defined hematoma collection measuring 2.2 x 9.2 x 8.2 cm in the left lower anterior chest wall. The patient was shifted for emergency laparotomy. Intra operatively, 200 ml clots evacuated with a diaphragmatic rent of size 2 x 2 cm noted with no other solid or hollow viscus injury [Figure 8]. Proceeded with two- layered closure of the diaphragmatic rent with non-absorbable sutures [Figure 9]. The patient was extubated on the day of surgery and kept on monitoring. Gradually started oral diet on day 2. The patient was discharged on day 10 and is healthy on follow-up.



Figure 8: Diaphragmatic rent

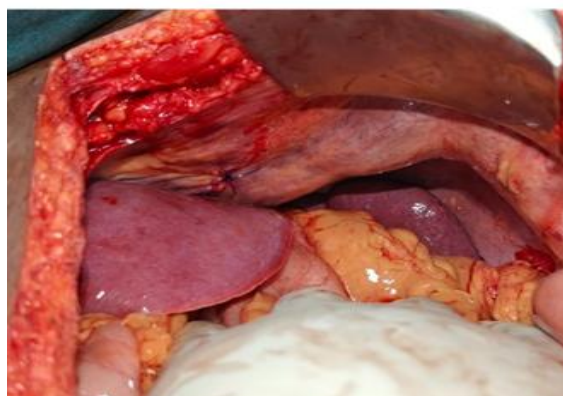


Figure 9: Diaphragmatic rent repair

CASE REPORT 5

A 55-year-old man was brought to the emergency department following a road traffic accident between his two-wheeler and a four-wheeler. The patient fell to his left side. There was no history of loss of consciousness, seizure activity or vomiting at the scene. He was conscious and hemodynamically stable on arrival. The patient had complaints of severe abdominal pain and dyspnea. On abdominal examination, it was distended, with diffuse tenderness and guarding. Extended focused assessment with sonography for trauma revealed positive results in the left lung fields and free fluid in the pelvis. Appropriate resuscitation measures were taken, and once stabilized, the patient was shifted for radiological investigations. CT thorax reported minimally displaced fracture of the left 9th, 10th and 11th ribs on the anterolateral aspect with moderate hemothorax. CT abdomen reported moderate hemoperitoneum, suggested contrast CT of the abdomen. Left intercostal drainage was done, and 500 ml of blood was drained. An exploratory laparotomy was done, and 500ml of hemoperitoneum was evacuated. Left-sided diaphragmatic rent of about 4 x 3 cm noted with no organ herniation. A splenic laceration of about 4 x 1 cm noted over the anterior pole, with no active bleeding [Figure 10]. The diaphragmatic rent was repaired using two-layered non-absorbable sutures in a continuous interlocking manner [Figure 11]. The splenic laceration was managed conservatively. Postoperatively, the patient was extubated on day 1, oral intake started on day 3. The patient was discharged after two weeks and is healthy on follow-up.

DISCUSSION

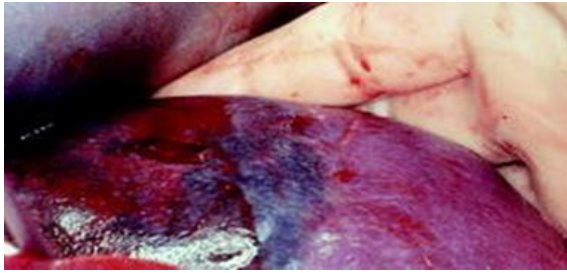


Figure 10: Grade II splenic injury



Figure 11: Diaphragmatic rent repair

This case series brings to light the significant correlation between lower rib fractures (ribs 6–12) and high-energy trauma, as significant markers for traumatic diaphragmatic injury (TDI). In our study, three of five patients presented with penetrating trauma as a mechanism of injury, and two of five with high velocity road traffic accident. Three of the five patients had rib fractures with hemothorax, and intercostal drainage was performed. One patient had hemothorax, inspite of no rib fractures, probably due to seepage of blood from the abdominal cavity via the large diaphragmatic rent. Three of the five patients presented with hemodynamically unstable status, requiring aggressive resuscitation measures. Detection of the diaphragmatic injury on CT was in two patients; interestingly, the same had herniation of abdominal organs into the thoracic cavity too. The patient mentioned in case 4 had an isolated diaphragmatic rent with no other injuries. Lastly, one patient succumbed to death, while all the others survived. The summary of all the case details with clinical, radiological, and intraoperative findings are given in [Table 1].

Table 1: Summary of all cases with Traumatic Diaphragmatic Injury (TDI) discussed in this case series.

S.no	Age/sex	Mechanism of injury	Hemodynamic condition	CT findings	Other injuries	Procedure	Outcome
1	49/M	Accidental injury by wood cutting machine	Unstable	Defect in the anterolateral portion of left hemi diaphragm with herniation of body of stomach into thoracic cavity, left 6th, 7th, 8th rib fractures with moderate hemopneumothorax.	Rib fractures	Exploratory laparotomy with diaphragmatic repair with primary closure of gastric rent with feeding jejunostomy with left ICD insertion and layered closure of wound	Expired
2	38/M	Assault by sharp weapon	Unstable	Left 8th & 9th rib fractures, with mild hemothorax and hemoperitoneum.	Rib fractures, Grade IV splenic injury	Emergency laparotomy with diaphragmatic rent repair and splenectomy and left ICD insertion layered closure of penetrating wound.	Survived
3	18/M	High- velocity road traffic accident	Unstable	Bilateral moderate hemothorax with grade IV liver injury and grade IV splenic injury, right diaphragmatic rupture with herniation of liver, with hemoperitoneum and multiple pelvic bone fractures.	Grade IV liver and grade IV splenic injury, multiple pelvic bone fractures.	Emergency laparotomy with diaphragmatic repair and bilateral ICD insertion.	Survived
4	36/M	Assault by sharp weapon	Stable	Moderate hemoperitoneum	Exploratory laparotomy with diaphragmatic repair	Nil	Survived
5	55/M	High- velocity road traffic accident	Stable	Left 9th, 10th and 11th rib fracture, with moderate hemothorax,	Exploratory laparotomy with	Rib fractures, Grade II splenic injury	Survived

				and moderate hemoperitoneum	diaphragmatic repair.		
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According to literature review, penetrative TDIs occur more common as compared to blunt TDIs by about two- thirds ^[3,10] Left sided injuries are more common, compared to right, probably due to protective effect of liver, or left side embryologic weakness; hence, right sided injuries often go unnoticed and present late. ^[10-12] TDIs may occur even in posterior injuries. ^[11]

Traumatic diaphragmatic injuries have been said to occur in three phases. Firstly, the acute phase where

the patient's diagnosis is established immediately till up to 14 days after injury. The latent or second phase where patients are diagnosed in the period after acute injury, but maybe delayed for decades. Third or obstructive phase, with complications such as obstruction/ strangulation of the herniated organ. ^[11,13]

AAST grading has been described for diaphragmatic injuries,^[14] as given in [Table 2].

Table 2: Diaphragm injury scale (from MooreEE et al Organ injury scaling IV: Thoracic, vascular, lung, cardiac, and diaphragm. J Trauma, 1994 Mar; 36(3):299-300) (14).

Grade	Injury description
I	Contusion
II	Laceration $\leq$ 2 cm
III	Laceration 2 – 10 cm
IV	Laceration > 10 cm with tissue loss $\leq$ 25cm ²
V	Laceration with tissue loss > 25cm ²

As per literature, two – layered non absorbable suture material is used in interrupted mattress fashion to close the diaphragmatic rent. In case of a large defect, placement of biological or prosthetic meshes have been described. ^[11,12] Delayed presenting cases have been operated by the use of laparoscopy or robotic. ^[3,10]

Radiographic studies, such as chest X-ray (CXR) and computed tomography (CT), were frequently used but usually inadequate for clear diagnosis, particularly in the absence of herniation of abdominal contents into the thoracic cavity. Studies from other centres also cite delayed diagnosis with inconclusive imaging, where many cases are ultimately diagnosed intraoperatively. Delayed diagnosis after one week can lead to considerably higher mortality, particularly in patients without apparent herniated gastrointestinal contents on early imaging. ^[7,9,15]

Overall, our results are consistent with including clinical judgment in addition to imaging in trauma protocols and quick judgment in exploring the abdomen surgically in patients with suspicious findings, even in the absence of radiographic findings. This is a step that can enhance early detection and outcomes in TDI, especially in cases that have high-energy trauma or when standard imaging is not successful in detecting injury.

Our study only comprises a small sample size and includes patients over one year and those who presented to our emergency department, and does not include dead on arrival or autopsy review; thus, there is a limitation in the ability to draw absolute conclusions, and further studies involving large patient groups are warranted.

CONCLUSION

This case series emphasizes the importance of clinical suspicion in diagnosing diaphragmatic injuries, particularly in high-velocity trauma and rib

fractures, specifically the 6th to 12th ribs. While in some instances, CT scans served as a useful tool for diagnosing diaphragmatic injuries, the drawbacks of CT were prominent in undiagnosed cases, highlighting the value of clinical judgment and early surgical intervention.

Because TDI and herniation are so far and infrequent, and because of the small population in this observational study, additional research and studies involving larger multicentre groups are needed. Future studies need to address refining the accuracy of the CT, and in identifying TDI even when herniation is not obvious, and also formulating clear follow-up protocols to identify delayed presenting cases earlier to decrease morbidity and mortality.

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