Original Research

STUDY OF DIAPHRAGMATIC INJURY PATIENTS IN A LEVEL 1 TRAUMA CARE CENTRE IN CENTRAL INDIA FROM 2023 TO 2026, WITH EMPHASIS ON TRENDS AND INTRODUCTION OF MINIMAL ACCESS SURGERY

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ABSTRACT

Background: Traumatic diaphragmatic injury is an uncommon but clinically important form of thoracoabdominal trauma. Diagnosis may be difficult, especially in blunt trauma, and delayed presentation can lead to diaphragmatic hernia and associated complications. Open surgery remains the standard treatment, but minimal access surgery is increasingly being introduced in selected stable patients.

Aim: To study the clinical profile, injury pattern, operative management, and outcomes of diaphragmatic injury patients managed at a Level 1 Trauma Care Centre in Central India from 2023 to 2026, with emphasis on trends and the introduction of minimal access surgery.

Materials and Methods: This retrospective observational study was conducted at a Level 1 Trauma Care Centre in Central India. All patients diagnosed with traumatic diaphragmatic injury and managed during the study period from 2023 to 2026 were included. Clinical records were reviewed for demographic details, mechanism of injury, timing of presentation, side of diaphragmatic injury, operative approach, use of minimal access surgery, postoperative complications, mortality, and hospital stay. Data were analysed using descriptive statistics.

Results: A total of 13 patients were included in the study. The mean age was 39.5 ± 11.4 years, with a median age of 41 years and range of 18–55 years. All patients were males. Early presentation was observed in 10 patients (76.9%), while delayed presentation was seen in 3 patients (23.1%). Penetrating trauma was slightly more common than blunt trauma, accounting for 7 cases (53.8%) and 6 cases (46.2%), respectively. Left-sided diaphragmatic injury was predominant, being present in 12 patients (92.3%), while right-sided injury was seen in 1 patient (7.7%). All penetrating injuries presented early, whereas delayed presentation was observed only among blunt trauma patients. Open surgery was performed in 9 patients (69.2%). Minimal access surgery was attempted in 3 patients (23.1%), of whom 2 underwent completed laparoscopic/minimal access repair and 1 required subsequent open re-repair. Postoperative complications were documented in 4 patients (30.8%). Mortality was observed in 1 patient (7.7%). Among valid hospital-stay entries, the mean hospital stay was 13.9 ± 7.9 days, with a median of 14 days and range of 7–34 days.

Conclusion: Traumatic diaphragmatic injury in this series predominantly affected adult males and was most commonly left-sided. Penetrating injuries presented early, while delayed presentation occurred only in blunt trauma, highlighting the need for high clinical suspicion in blunt thoracoabdominal injuries. Open surgery remained the mainstay of management; however, minimal access surgery was feasible in selected stable patients. Larger prospective studies are required to define the role and outcomes of minimal access surgery in diaphragmatic trauma.

Keywords: Diaphragmatic Injury, Traumatic Diaphragmatic Rupture, Thoracoabdominal Trauma, Blunt Trauma, Penetrating Trauma, Minimal Access Surgery, Laparoscopic Repair, Level 1 Trauma Centre.

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INTRODUCTION

Traumatic diaphragmatic injury is an uncommon but clinically significant consequence of thoracoabdominal trauma. It may occur following both blunt and penetrating mechanisms, and its diagnosis is often challenging because the clinical

presentation may be subtle, nonspecific, or masked by associated thoracic, abdominal, or polytrauma-related injuries. The reported incidence of traumatic diaphragmatic injury varies widely in the literature, partly because many injuries are missed during the acute phase and are detected only when complications such as visceral herniation, respiratory compromise, bowel obstruction, strangulation, or chronic diaphragmatic hernia develop later [1,2]. This diagnostic uncertainty makes diaphragmatic injury an important entity for trauma surgeons, emergency physicians, radiologists, and critical care teams working in high-volume trauma centres.

The diaphragm is anatomically positioned between the thoracic and abdominal cavities; hence, injuries to this structure are commonly associated with trauma to the chest, abdomen, or both. Penetrating injuries, especially stab or firearm-related thoracoabdominal wounds, may directly violate the diaphragm, whereas blunt trauma usually produces sudden elevation of intra-abdominal pressure leading to diaphragmatic rupture. Left-sided injuries are reported more commonly than right-sided injuries, probably because the liver provides partial protection to the right hemidiaphragm and because right-sided injuries may be more difficult to diagnose radiologically [1,3]. In clinical practice, however, both sides require careful evaluation, particularly in patients with high-energy road traffic accidents, fall from height, assault, crush injuries, or penetrating trauma involving the lower chest and upper abdomen.

Early diagnosis of diaphragmatic injury remains a major challenge. Chest radiography may show indirect signs such as elevated hemidiaphragm, bowel loops in the thorax, mediastinal shift, or associated hemothorax/pneumothorax, but these findings are not always present. Computed tomography has improved diagnostic accuracy, particularly with multidetector CT and coronal/sagittal reconstructions, yet small diaphragmatic defects may still be missed, especially in penetrating trauma or in the presence of associated injuries [4]. Delayed presentation is clinically important because missed injuries may progressively enlarge and allow stomach, colon, spleen, omentum, or liver to herniate into the thoracic cavity. Such delayed traumatic diaphragmatic hernias can present weeks, months, or even years after the initial injury and may be associated with increased morbidity due to obstruction, strangulation, respiratory distress, or emergency operative requirement [2,5].

Surgical repair remains the definitive treatment for traumatic diaphragmatic injury. Traditionally, laparotomy or thoracotomy has been used depending on the timing of presentation, side of injury, presence of associated intra-abdominal pathology, and surgeon preference. In acute trauma, an abdominal approach is often preferred because associated abdominal organ injuries can be assessed and managed simultaneously. In delayed cases, thoracic adhesions and intrathoracic herniation may make a thoracic or combined approach useful [3,6]. However, the optimal operative strategy should be individualized according to hemodynamic stability, chronicity of presentation, associated injuries, availability of expertise, and institutional trauma protocols.

In recent years, minimal access surgery has gained increasing importance in selected trauma patients. Diagnostic laparoscopy is now recognized as a useful modality in hemodynamically stable patients with suspected diaphragmatic injury, particularly in penetrating thoracoabdominal trauma where imaging may fail to detect small defects. The Eastern Association for the Surgery of Trauma guideline conditionally recommends laparoscopy over computed tomography for stable left thoracoabdominal stab-wound patients without peritonitis to reduce missed diaphragmatic injuries [4]. Recent WSES/WSES-AAST guidance has also emphasized the role of diagnostic laparoscopy or thoracoscopy as an accurate, safe, and minimally invasive method for evaluation of the diaphragm in stable patients with penetrating thoracoabdominal trauma or high suspicion of diaphragmatic injury despite equivocal imaging [7,8].

The therapeutic role of minimal access surgery is also expanding. Laparoscopy and thoracoscopy allow direct visualization of the diaphragm and may permit definitive repair in selected cases, with potential advantages such as reduced surgical trauma, lower wound morbidity, shorter recovery time, and better postoperative comfort. Nevertheless, conversion or open surgery may be required in unstable patients, large defects, dense adhesions, contamination, or associated visceral injuries. Therefore, minimal access surgery in diaphragmatic trauma should not be viewed as a replacement for open trauma surgery, but rather as an additional approach in carefully selected patients managed by an experienced trauma team [6,9].

In the Indian setting, diaphragmatic injuries are particularly relevant because trauma burden remains high, with road traffic accidents, occupational trauma, interpersonal violence, and delayed referral contributing to complex presentations at tertiary care and Level 1 trauma centres. Many patients initially receive care at peripheral hospitals and are later referred to higher centres, which may increase the likelihood of delayed diagnosis or late presentation. Despite this, Indian data on trends in diaphragmatic injury and the practical introduction of minimal access surgery in trauma care remain limited. Local

institutional studies are therefore important to understand mechanism-specific patterns, timing of presentation, side of injury, operative approach, postoperative outcomes, and feasibility of laparoscopy in real-world trauma settings [10].

The present study was undertaken at a Level 1 Trauma Care Centre in Central India to analyse patients with diaphragmatic injury managed between 2023 and 2026. The study aimed to assess the clinical and operative trends of diaphragmatic injury patients and to document the introduction and early experience of minimal access surgery for the same. By evaluating mechanism of injury, timing of presentation, laterality, operative management, complications, mortality, and hospital stay, this manuscript seeks to contribute region-specific evidence and highlight the evolving role of minimally invasive approaches in selected diaphragmatic trauma patients.

MATERIALS AND METHODS

The present study was conducted as a retrospective observational study among patients diagnosed with traumatic diaphragmatic injury and managed at a Level 1 Trauma Care Centre in Central India. The study was designed to analyse the clinical and operative trends of diaphragmatic injury cases over the study period and to evaluate the introduction and use of minimal access surgery in selected patients.

The study was carried out at the Trauma Care Centre, Government Medical College and Hospital, Nagpur, Maharashtra, India. The centre functions as a Level 1 trauma care referral centre and caters to patients with major blunt and penetrating trauma from Nagpur and adjoining districts of Central India. The study included patients managed during the period from 2023 to 2026.

The study population consisted of patients with traumatic diaphragmatic injury who were admitted, evaluated, and managed at the Level 1 Trauma Care Centre during the study period. Both early and delayed presentations of diaphragmatic injury were included. Patients were included if they were diagnosed with traumatic diaphragmatic injury due to blunt or penetrating trauma, were managed at the study centre, underwent operative management by open or minimal access approach, and had available clinical, operative, and outcome-related records. Patients with non-traumatic diaphragmatic defects or congenital diaphragmatic hernia, patients referred after definitive surgical repair elsewhere, patients with suspected but unconfirmed diaphragmatic injury, and those with records insufficient to confirm the diagnosis were excluded. All eligible patients with traumatic diaphragmatic injury managed during the defined study period were included. As traumatic diaphragmatic injury is a relatively uncommon trauma entity, universal sampling was followed. A total of 13 patients fulfilled the eligibility criteria and were included in the final analysis. No randomisation was performed, as this was an observational study. The operative approach was decided according to the clinical condition of the patient, timing of presentation, mechanism of injury, associated injuries, hemodynamic stability, imaging findings, intraoperative findings, and the treating surgeon's decision.

Data were collected using a structured data collection proforma. The medical records of eligible patients were reviewed in detail, including admission records, trauma evaluation notes, radiological findings, operative notes, postoperative records, discharge summaries, and available follow-up documentation. The variables recorded included age, sex, year of presentation, mechanism of injury, timing of presentation, side of diaphragmatic injury, operative approach used for repair, use of open or minimal access surgery, conversion or need for re-repair wherever applicable, postoperative complications, mortality outcome, and duration of hospital stay.

The diagnosis of diaphragmatic injury was based on clinical suspicion, radiological findings, and/or intraoperative confirmation. Patients were categorised according to mechanism of injury as blunt trauma or penetrating trauma. Timing of presentation was classified as early or delayed based on the clinical presentation and interval between trauma and diagnosis or admission. The side of diaphragmatic injury was recorded as left-sided or right-sided. Operative management was classified according to the surgical approach used. Patients managed by laparotomy or thoracotomy were grouped under open surgery, while patients in whom laparoscopy or other minimal access approach was attempted were grouped separately. Cases in which laparoscopic repair was completed and cases requiring subsequent open re-repair were noted independently.

For the purpose of this study, traumatic diaphragmatic injury was defined as traumatic disruption or tear of the diaphragm resulting from blunt or penetrating trauma, diagnosed by radiological assessment and/or confirmed intraoperatively. Blunt trauma referred to diaphragmatic injury occurring due to non-penetrating mechanisms such as road traffic accident, fall, crush injury, or other blunt force injury. Penetrating trauma referred to diaphragmatic injury caused by penetrating thoracoabdominal trauma such as stab injury or other sharp/penetrating mechanism. Early presentation referred to patients diagnosed and managed during the acute phase following trauma, whereas delayed presentation referred to patients presenting after a delay following the initial trauma,

often with missed diaphragmatic injury, diaphragmatic hernia, respiratory symptoms, abdominal symptoms, or complications. Minimal access surgery was defined as the use of laparoscopic or thoracoscopic approach for diagnosis and/or repair of diaphragmatic injury. Completed minimal access repair referred to cases in which the diaphragmatic injury was repaired successfully using minimal access technique without requiring open conversion or subsequent open re-repair.

Postoperative outcomes were assessed in terms of documented complications, survival status, mortality, and hospital stay. Postoperative complication was defined as any documented adverse postoperative event occurring after surgical management, including respiratory, wound-related, infective, or procedure-related complications. Mortality was defined as death occurring during hospital admission following traumatic diaphragmatic injury and its management. Hospital stay was calculated in days from admission to discharge or death. Erroneous or incomplete hospital-stay entries were excluded from hospital-stay analysis.

Data were entered in Microsoft Excel and analysed using descriptive statistics. Categorical variables were expressed as frequency and percentage. Continuous variables such as age and hospital stay were expressed as mean, standard deviation, median, and range wherever applicable. Mechanism of injury, timing of presentation, side of injury, operative approach, postoperative complications, mortality, and hospital stay were analysed. Since the sample size was small, the analysis was mainly descriptive. Available valid data were used for each variable, and incomplete or erroneous entries were excluded only from the specific analysis affected by that variable.

The study was conducted after obtaining necessary institutional permission. As the study was based on retrospective review of hospital records, patient confidentiality was maintained throughout the analysis. No personal identifiers were disclosed. Data were used only for academic and research purposes. The study followed the ethical principles applicable to observational clinical research.

RESULTS

A total of 13 patients with traumatic diaphragmatic injury were included in the present study. The mean age of the study participants was 39.5 ± 11.4 years, with a median age of 41 years and an age range of 18 to 55 years. All patients included in the study were males, accounting for 13 cases (100%). With respect to timing of presentation, 10 patients (76.9%) presented early, whereas 3 patients (23.1%) had delayed presentation. Thus, the study population predominantly consisted of adult male trauma patients, with most cases being diagnosed and managed during the early phase following injury (Table 1).

Regarding the mechanism of injury, penetrating trauma was slightly more common than blunt trauma. Penetrating trauma was observed in 7 patients (53.8%), while blunt trauma was recorded in 6 patients (46.2%). Analysis of the side of diaphragmatic involvement showed a marked predominance of left-sided injury. Left-sided diaphragmatic injury was present in 12 patients (92.3%), whereas right-sided diaphragmatic injury was observed in only 1 patient (7.7%). This indicates that traumatic diaphragmatic injury in the present series was mainly left-sided, with a near-equal contribution from penetrating and blunt mechanisms (Table 2).

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Variable	Number	Percentage
Total patients	13	100
Age, years		
Mean ± SD	39.5 ± 11.4	—
Median	41	—
Range	18–55	—
Sex		
Male	13	100
Female	0	0
Type of presentation		
Early presentation	10	76.9
Delayed presentation	3	23.1

Table 2. Distribution According To Mechanism of Injury and Side of Diaphragmatic Injury

Variable	Number	Percentage
Mechanism of injury		
Penetrating trauma	7	53.8
Blunt trauma	6	46.2

Side of diaphragmatic injury		
Left-sided injury	12	92.3
Right-sided injury	1	7.7

The association between mechanism of injury and timing of presentation showed that all patients with penetrating trauma presented early. Among the 7 patients with penetrating diaphragmatic injury, all 7 cases (100%) were early presentations, and no delayed presentation was seen in this group. In contrast, among the 6 patients with blunt trauma, 3 patients (50.0%) presented early and 3 patients (50.0%) presented late. Overall, all delayed presentations in the present study were associated with blunt trauma. This finding suggests that blunt diaphragmatic injuries were more likely to be missed initially and diagnosed later, whereas penetrating injuries were identified and managed in the acute setting (Table 3).

Table 3. Association between Mechanism of Injury and Timing of Presentation

Mechanism of injury	**Early presentation**	**Delayed presentation**	**Total**
Penetrating trauma	7	0	7
Blunt trauma	3	3	6
Total	**10**	**3**	**13**

With respect to operative management, open surgery only was performed in 9 patients (69.2%), making it the predominant operative approach in this series. Minimal access surgery was attempted in 3 patients (23.1%), reflecting the introduction of laparoscopic/minimal access techniques in selected cases of diaphragmatic injury. Among these, completed laparoscopic or minimal access repair was achieved in 2 patients (15.4%), while 1 patient (7.7%) underwent laparoscopy followed by open re-repair. One case (7.7%) had incomplete procedure details available in the dataset. These findings show that although open surgery remained the mainstay of management, minimal access surgery was feasible in selected patients and was successfully completed in two cases (Table 4).

Table 4. Operative Approach and Minimal Access Surgery Profile

Operative approach / procedure profile	**Number**	**Percentage**
Open surgery only	9	69.2
Minimal access surgery attempted	3	23.1
Incomplete procedure detail available	1	7.7
Completed laparoscopic/minimal access repair	2	15.4
Laparoscopy followed by open re-repair	1	7.7

Postoperative complications were documented in 4 patients (30.8%), while 9 patients (69.2%) had no documented postoperative complication. Mortality was recorded in 1 patient (7.7%), whereas 12 patients (92.3%) survived and were discharged. Hospital stay was analysed after excluding one erroneous negative hospital-stay value and one incomplete record. Among the 11 valid hospital-stay entries, the mean hospital stay was 13.9 ± 7.9 days, with a median of 14 days and a range of 7 to 34 days. These outcome findings suggest that most patients survived following operative management, although postoperative morbidity was observed in nearly one-third of cases (Table 5).

Table 5. Postoperative Outcome and Hospital Stay

Outcome variable	**Number / Value**	**Percentage**
Postoperative complications documented	4	30.8
No postoperative complication documented	9	69.2
Mortality	1	7.7
Survived / discharged	12	92.3
Hospital stay, days*		
Mean ± SD	13.9 ± 7.9	—
Median	14	—
Range	7–34	—

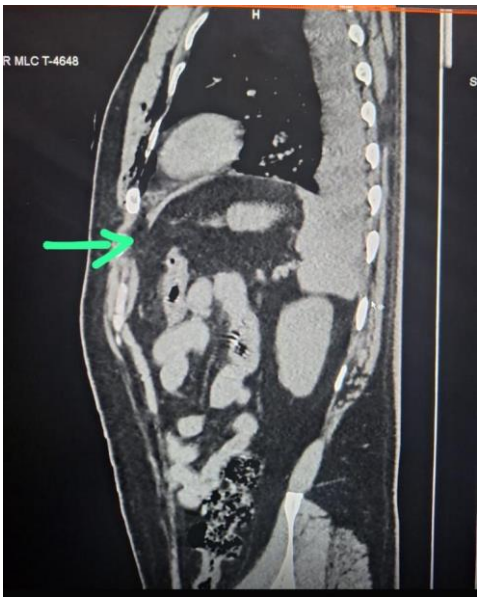

Figure 1: CT Image Showing Diaphragmatic Rent In Stab Patient

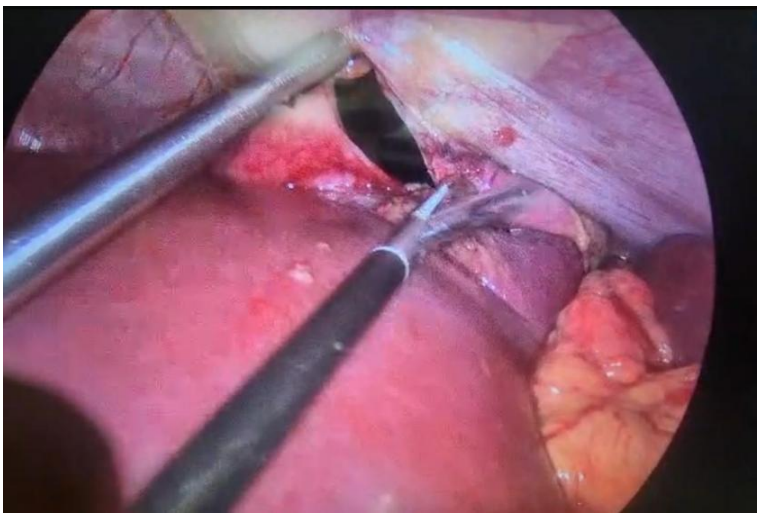

Figure 2: Diaphragmatic rent Laproscopic view

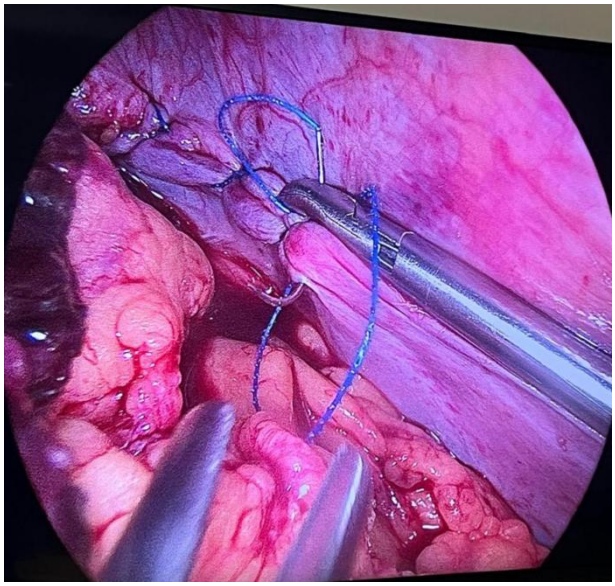

Figure 3: Defect suturing laparoscopically

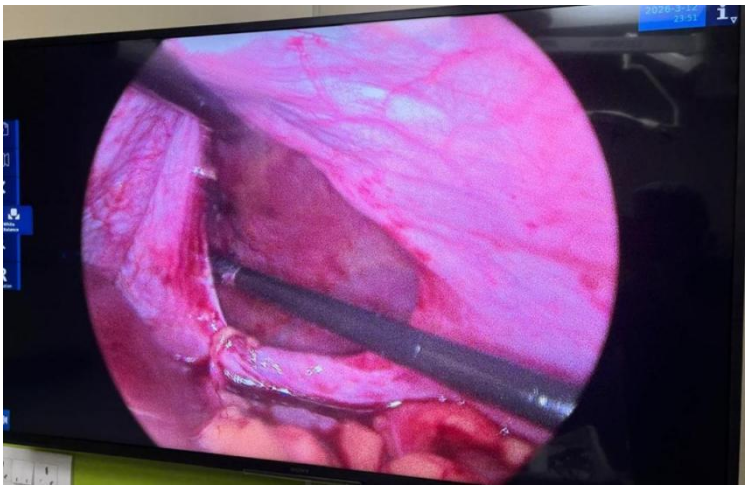

Figure 4: Diaphragmatic rent after contents reduced in abdomen

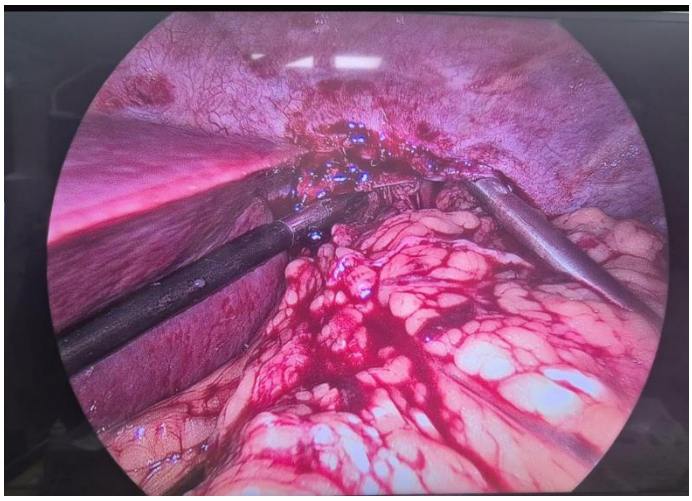

Figure 5: Laproscopic view of diaphragmatic hernia with stomach as content

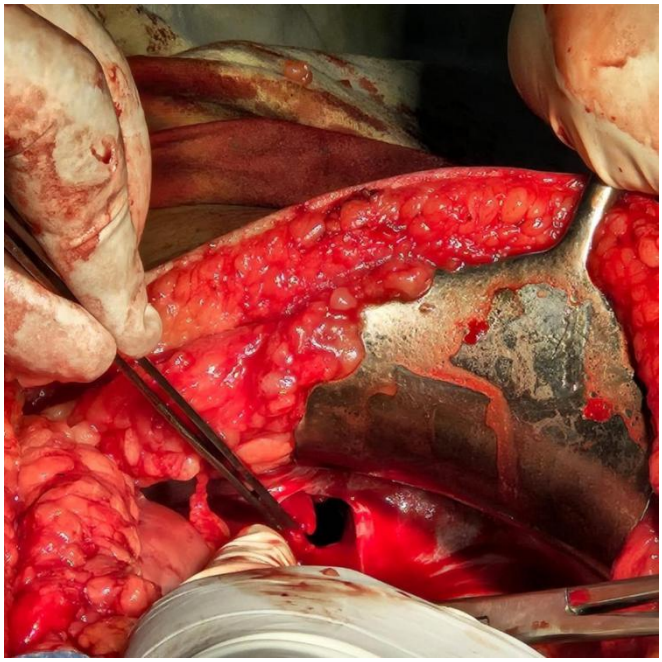

Figure 6: Diaphragmatic rent on exploratory laparotomy

DISCUSSION

Traumatic diaphragmatic injury remains an uncommon but important form of thoracoabdominal trauma because it is frequently associated with diagnostic delay, associated visceral injury, and potential late complications. In the present study, 13 patients with traumatic diaphragmatic injury managed at a Level 1 Trauma Care Centre in Central India were analysed. Although the sample size was small, the study provides useful institutional experience regarding the pattern of diaphragmatic trauma, timing of presentation, operative approach, postoperative outcome, and early introduction of minimal access surgery in selected cases.

In the present study, all patients were males, and the mean age was 39.5 ± 11.4 years, with an age range of 18 to 55 years. This reflects the typical demographic profile of trauma patients, where young and middle-aged adult males are more commonly affected due to greater exposure to road traffic accidents, outdoor occupational activities, interpersonal violence, and high-risk mobility patterns. Similar male predominance has been reported in published series of traumatic diaphragmatic injury, where the condition is more frequently observed among active adult males exposed to blunt or penetrating thoracoabdominal trauma [11,12]. This demographic pattern has practical implications for trauma prevention strategies, particularly in India, where road traffic injuries and interpersonal assault remain important contributors to major trauma burden.

The mechanism of injury in the present study showed a near-equal distribution between penetrating and blunt trauma, with penetrating trauma accounting for 53.8% and blunt trauma for 46.2% of cases. This finding indicates that both mechanisms contributed substantially to diaphragmatic injury in our trauma centre. Penetrating trauma usually produces direct diaphragmatic violation, particularly in lower chest or upper abdominal wounds, whereas blunt trauma causes sudden elevation of intra-abdominal pressure and shearing forces across the diaphragm. Panda et al., in their review of CT signs of diaphragmatic injury, highlighted that diaphragmatic injury may occur after both blunt and penetrating trauma, with imaging characteristics varying according to the mechanism of injury [11]. The relatively high proportion of penetrating trauma in our study may reflect referral patterns to a Level 1 trauma centre, where cases of stab injuries and thoracoabdominal penetrating wounds are more likely to undergo emergency operative evaluation.

Left-sided diaphragmatic injury was observed in 92.3% of patients in the present series, while right-sided injury was present in only 7.7%. This marked left-sided predominance is consistent with most published literature. Left-sided injuries are more commonly diagnosed because the left hemidiaphragm is relatively unprotected, whereas the liver cushions and protects the right hemidiaphragm to some extent. In addition, right-sided injuries may be radiologically subtle and may remain undetected in the acute setting. Radjou et al., in an Indian study on diaphragmatic injury, also reported predominance of left-sided involvement and emphasized that traumatic diaphragmatic injury should be suspected in patients with thoracoabdominal trauma, especially when associated radiological or intraoperative findings suggest diaphragmatic violation [10]. Similarly, several international studies have observed that left-sided traumatic diaphragmatic rupture is more frequent than right-sided rupture [12,13].

Timing of presentation was an important observation in the present study. Early presentation was seen in 76.9% of cases, while delayed presentation occurred in 23.1%. More importantly, all penetrating injuries presented early, whereas all delayed presentations were seen among patients with blunt trauma. Among blunt trauma patients, 50% presented early and 50% presented late. This supports the well-recognised fact that blunt diaphragmatic injuries are more likely to be missed initially because symptoms may be nonspecific and may be overshadowed by other thoracic, abdominal, skeletal, or head injuries. Delayed diagnosis may occur when the initial tear is small or when herniation of abdominal viscera develops gradually. Rashid et al. reviewed delayed presentations of diaphragmatic rupture and noted that missed traumatic diaphragmatic rupture may present later with respiratory compromise, gastrointestinal obstruction, strangulation, or chronic diaphragmatic hernia [2]. Zhao et al. also described delayed traumatic diaphragmatic rupture as a clinically important entity in which abdominal organs may migrate into the thoracic cavity, causing respiratory and ischemic complications [14]. These observations are in agreement with our finding that delayed presentation was particularly associated with blunt trauma.

The predominance of early presentation among penetrating injuries in our study is clinically understandable. Penetrating thoracoabdominal wounds often prompt early surgical exploration or diagnostic evaluation because of visible external injury, suspicion of hollow viscus injury, hemothorax, pneumothorax, or hemodynamic instability. In contrast, blunt diaphragmatic rupture may lack external signs and may be missed on initial chest radiograph or even CT scan, particularly if imaging quality is suboptimal or if the defect is small. The EAST practice management guideline has emphasized the

diagnostic difficulty of traumatic diaphragmatic injury and has conditionally supported the use of laparoscopy over computed tomography in stable patients with left thoracoabdominal stab wounds to reduce missed injuries [4]. This is relevant to our study because it supports the need for a high index of suspicion and selective use of diagnostic laparoscopy in suitable patients.

Open surgery remained the predominant operative approach in the present study, being performed in 69.2% of patients. This reflects standard trauma surgery practice, especially in emergency settings where patients may have associated intra-abdominal injuries, hemodynamic instability, contamination, or need for rapid exploration. Open laparotomy or thoracotomy continues to be the mainstay of management in unstable patients and in those with complex associated injuries. The choice of operative approach in diaphragmatic injury depends on several factors, including timing of diagnosis, mechanism of trauma, associated abdominal or thoracic injuries, side of injury, chronicity, and surgeon expertise. In acute trauma, an abdominal approach is often preferred because associated abdominal injuries can be identified and managed simultaneously. In delayed cases, thoracic adhesions or chronic herniation may require thoracic or combined access [3,6].

A notable finding of the present study was the introduction of minimal access surgery in selected patients. Minimal access surgery was attempted in 3 patients, representing 23.1% of the total series. Among these, completed laparoscopic or minimal access repair was achieved in 2 patients, while 1 patient required subsequent open re-repair. This finding is important because it reflects a gradual transition from exclusively open repair toward selective laparoscopic management in stable and suitable patients. The role of laparoscopy in traumatic diaphragmatic injury has expanded from a purely diagnostic tool to a therapeutic modality in carefully selected cases. Laparoscopy allows direct visualization of the diaphragm, identification of small injuries, reduction of herniated abdominal contents, and repair of diaphragmatic defects with reduced access trauma. Charara et al. reported successful laparoscopic repair of acute traumatic diaphragmatic hernia and highlighted that minimally invasive repair may be feasible in selected stable patients [15]. Similarly, other reports have described laparoscopic repair as an effective approach when adequate expertise and facilities are available [16].

The need for open re-repair in one patient in our series highlights an important practical point: minimal access surgery in traumatic diaphragmatic injury should be used selectively and should not be considered a replacement for open surgery in all cases. Conversion or subsequent open surgery may be required when there are large defects, poor tissue quality, associated visceral injuries, dense adhesions, contamination, inadequate visualization, or clinical deterioration. Therefore, laparoscopy should be considered an additional tool in the trauma surgeon's armamentarium rather than a universal approach. This interpretation is consistent with current trauma literature, which supports minimally invasive surgery in hemodynamically stable patients but emphasizes the need for careful selection, institutional capability, and readiness for conversion when required [7,8,17].

Postoperative complications were documented in 30.8% of patients in the present study. This morbidity rate is clinically relevant, although interpretation is limited by the small sample size and retrospective nature of documentation. Postoperative complications after diaphragmatic injury repair may be related not only to the diaphragmatic tear itself but also to associated thoracic injury, abdominal visceral injury, contamination, shock, delayed presentation, respiratory compromise, and need for major operative intervention. Published studies have shown that morbidity in traumatic diaphragmatic injury is commonly influenced by associated injuries rather than isolated diaphragmatic rupture alone [12,13]. In our study, the presence of postoperative complications in nearly one-third of cases indicates that diaphragmatic trauma should be viewed as a marker of significant thoracoabdominal injury requiring multidisciplinary trauma care.

Mortality in the present study was 7.7%, with 1 death among 13 patients. Most patients survived and were discharged. Mortality in traumatic diaphragmatic injury varies across studies depending on mechanism of trauma, associated injuries, shock at admission, delayed diagnosis, respiratory compromise, and institutional trauma care capacity. In many series, mortality is more strongly associated with associated injuries than with diaphragmatic rupture alone. Topaloglu et al. observed that prognosis in traumatic diaphragmatic rupture depends on early diagnosis, associated organ injury, and timely surgical management [12]. The relatively low mortality in our small series may reflect early identification in most cases and availability of definitive operative management at a Level 1 trauma centre, although firm conclusions cannot be drawn due to the limited number of patients.

Hospital stay among valid entries showed a mean duration of 13.9 ± 7.9 days, with a median stay of 14 days and range of 7 to 34 days. This suggests that patients with diaphragmatic injury often require prolonged inpatient care, likely due to associated injuries, postoperative monitoring, respiratory care, chest tube management, infection

prevention, and rehabilitation. One erroneous negative hospital-stay value and one incomplete record were excluded from hospital-stay analysis, which was appropriate to avoid distortion of descriptive statistics. Minimally invasive surgery has been associated in some studies with shorter hospital stay, less postoperative pain, and reduced wound morbidity when compared with open surgery; however, in the present dataset, the number of minimal access cases was too small to draw comparative conclusions [17]. Future larger studies from similar trauma centres may help clarify whether selected laparoscopic repair can reduce hospital stay and postoperative morbidity in Indian trauma settings.

The present study also has relevance in the Indian trauma-care context. Level 1 trauma centres in Central India receive a mixed burden of blunt and penetrating injuries, often referred from peripheral centres. Delayed diagnosis is an important concern, particularly in blunt trauma, where initial symptoms may be mild and imaging findings may be subtle. The finding that all delayed presentations in the present study were associated with blunt trauma supports the need for systematic assessment of the diaphragm in thoracoabdominal injuries, especially in patients with left lower chest trauma, abdominal trauma, unexplained respiratory symptoms, elevated hemidiaphragm, hemothorax, or suspicious CT findings. This is particularly important in resource-variable settings, where initial evaluation may occur at centres without advanced trauma imaging or specialist surgical availability.

The introduction of minimal access surgery in this series represents an important institutional trend. Although the number of cases was small, successful completed laparoscopic repair in two patients suggests that minimal access surgery may be feasible in selected diaphragmatic injury patients at high-volume trauma centres. This is especially relevant for stable patients, isolated diaphragmatic injury, selected penetrating injuries, and delayed diaphragmatic hernia without severe contamination or instability. However, the study also reinforces that open surgery remains indispensable in trauma care, especially for unstable patients and those with complex associated injuries. Therefore, an integrated approach is required, where laparoscopy is used selectively without compromising the principles of timely trauma exploration and definitive repair.

The major limitation of the present study was the small sample size, which is expected given the relative rarity of traumatic diaphragmatic injury. The study was retrospective and dependent on available hospital records; therefore, some variables, such as exact injury-to-presentation interval, associated organ injuries, specific postoperative complications, and long-term follow-up, may not have been uniformly documented. One record had incomplete operative/outcome details, and one hospital-stay entry was erroneous and had to be excluded from stay analysis. Due to the small sample size, inferential statistics and subgroup comparisons between open and minimal access surgery were not appropriate. Nevertheless, the study provides useful preliminary data from a Level 1 Trauma Care Centre in Central India and documents an important transition toward selective use of minimal access surgery.

Overall, the present study showed that traumatic diaphragmatic injury predominantly affected adult males and was most commonly left-sided. Penetrating injuries presented early, whereas delayed presentation was observed only among blunt trauma patients. Open surgery remained the mainstay of treatment, but minimal access surgery was introduced and successfully completed in selected cases. The findings support the importance of early suspicion, accurate diagnosis, timely operative intervention, and careful selection of patients for laparoscopic management. Larger prospective multicentre studies from Indian trauma centres are recommended to better define injury patterns, diagnostic delays, operative strategies, morbidity, mortality, and the evolving role of minimal access surgery in traumatic diaphragmatic injury.

CONCLUSIONS

The present study highlighted the clinical and operative profile of traumatic diaphragmatic injury patients managed at a Level 1 Trauma Care Centre in Central India. Diaphragmatic injury was observed predominantly among adult male trauma patients, with most cases presenting during the early phase following injury.

Penetrating trauma was slightly more common than blunt trauma in this series. However, delayed presentation was observed only among patients with blunt trauma, suggesting that blunt diaphragmatic injuries are more likely to be missed initially and may present later with complications. This finding emphasizes the need for a high index of suspicion in all patients with blunt thoracoabdominal trauma, especially when radiological or clinical findings are equivocal.

Left-sided diaphragmatic injury was the predominant pattern in the present study. This supports the established observation that left hemidiaphragmatic injuries are more frequently detected, while right-sided injuries may be less common or more difficult to diagnose.

Open surgery remained the mainstay of treatment for traumatic diaphragmatic injury in this series. However, minimal access surgery was introduced in selected patients and was successfully completed

in two cases. This suggests that laparoscopic or minimal access repair may be feasible in carefully selected, hemodynamically stable patients when adequate expertise and facilities are available.

Postoperative morbidity was documented in nearly one-third of patients, while mortality was observed in one patient. These outcomes indicate that traumatic diaphragmatic injury should be considered a serious marker of thoracoabdominal trauma, often requiring prompt diagnosis, timely operative intervention, and multidisciplinary postoperative care.

Overall, the study supports early recognition, careful evaluation of thoracoabdominal trauma, and individualized surgical planning in diaphragmatic injury patients. Minimal access surgery appears to be a promising addition to conventional open surgery in selected cases, but larger prospective studies are required to define its role, safety, indications, and outcomes in Indian trauma care settings.

Conflict of Ineterst: None to Declare

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