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Early Diagnosis And Management Of Diaphragmatic Injuries

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Abstract. *This prospective study was conducted at the Department of General Surgery in Tikrit Teaching Hospital from December 2008 to December 2012. It included 73 patients who sustained diaphragmatic injuries, primarily from penetrating injuries such as gunshot wounds and shells (65 patients, 89%), with the remaining patients presenting with blunt trauma (8/73, 11%). The study comprised both male and female patients, with a male-to-female ratio of 3.8:1. The majority of patients were in the 20-29 years age group (43/73, 60%). The left hemidiaphragm was the most commonly injured site in both blunt and penetrating traumas, accounting for 89% (7/8) and 66% (43/65) of cases, respectively. Acute presentation with abdominal pain and concurrent intraabdominal and thoracic injuries was the most commonly encountered clinical scenario (58/73, 74.5%). The spleen was the most frequently injured intraabdominal organ in both blunt and penetrating traumas. Diaphragmatic injury should be suspected in all patients with penetrating injury below the nipple in front and inferior scapular angle in the back, confirmed by chest X-ray showing diagnostic findings such as elevation of the injured hemidiaphragm or obliteration of its contour, and/or a pathognomonic "collar sign". Most patients underwent laparotomy for diaphragmatic defect repair and management of intraabdominal visceral injuries, with only two patients requiring thoracotomy in addition to laparotomy. Empyema was the most common postoperative morbidity, and the mortality rate depended on the severity of injury and the time lag between patients' arrival and operation.*

Keyword: *Chest X-ray, Collar sign, Laparotomy, Postoperative morbidity, Mortality rate*

Introduction

A diaphragmatic rupture, also known as a diaphragmatic injury or tear, is a rip in the diaphragm, the muscle that runs across the base of the ribs and is essential to breathing. The most frequent cause of acquired diaphragmatic tears is physical trauma. About 5% of instances of severe physical trauma to the trunk result in diaphragmatic rupture, which can be caused by blunt or penetrating trauma [1]. [2]. Ambroise Pare initially described diaphragmatic rupture in 1579, describing the condition in a French artillery captain who had been shot eight months before to his rupture-related death. With autopsies. Pare also talked about blunt and penetrating trauma victims experiencing diaphragmatic rupture. Records of damage-related diaphragmatic herniation stretch back at least to the 17th century. The distinction between congenital and acquired diaphragmatic hernias—which arise from a congenital abnormality of the diaphragm—was originally made by Petit. A traumatized stomach hernia into the left chest was treated by Naumann in 1888 [3]. Surgical methods like laparotomies and computed

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tomography are examples of diagnostic procedures. Making a diagnosis is frequently challenging since symptoms could not emerge on an X-ray or might seem similarly to other illnesses. Breathing difficulties, diminished lung sound, and chest and abdominal discomfort were among the signs and symptoms. If a rip is found, it must be repaired surgically. Diaphragm injuries typically occur in conjunction with other injuries, suggesting the possibility of more severe damage. The result is frequently influenced more by concomitant injuries than by the actual diaphragmatic damage. [4] Traumatic diaphragmatic hernia, a condition in which abdominal organs protrude into the chest cavity due to elevated abdominal pressure, is nearly invariably linked to diaphragm rupture. Breathing difficulties may result from this herniation, and organs that have herniated through the diaphragm may sustain damage if their blood supply is cut off [5]. Therefore, the purpose of this study is to assess patients who have suffered blunt or penetrating trauma to the upper abdomen and lower chest that is linked to a diaphragmatic injury, and to discuss the optimal management strategy to be used in order to facilitate prompt identification and treatment. assessment of individuals with upper abdominal and lower chest severe or penetrating injuries linked to diaphragmatic damage. When treating individuals who have a penetrating injury below the nipple in the front and an inferior scapular angle in the back, diaphragmatic should be suspected and confirmed by a chest X-ray.

This study aimed to assess the early diagnosis and management of diaphragmatic injuries, focusing on patient demographics, injury characteristics, clinical presentations, diagnostic modalities, surgical approaches, postoperative complications, and mortality rates.

Embryology:

A diaphragm arises from four origins. The majority of the central tendon originates from the septum transversum. The transverse septum is invaded by muscle cells that originate from the third, fourth, and fifth cervical myotomes before it descends. The motor supply from the phrenic nerves originates from the muscle cells, which carry their own nerve supply with them. pleuro-peritoneal membranes and mesodermal folds. cut off the coelom's thoracic and abdominal segments' connection. The diaphragm develops in part due to the esophageal mesentery [6]. The third week of pregnancy is when development starts, and it ends in the eighth week.[7] Failure to form the pleuroperitoneal folds and cause the ensuing muscle migration The most frequent cause of congenital diaphragmatic hernia is failure of pleuro-peritoneal membrane formation. Due to the liver's location on the right side, the posteriorly located defect known as Bochdalek's foramen more frequently appears clinically on the left

side. The intersection of the xiphoid and costal origins (Morgagnis foramen) is another potential, smaller hernia location [6].

The right crus arise from the sides of the bodies of the first three lumber vertebrae; the left crus arise from the sides of the body of the first tow lumber vertebrae.[8]

From the rear of the second lumbar vertebra's body to the first lumbar vertebra's transverse process tip, the medial arcuate ligament is located. From the lower border of the twelfth rib to the tip of the transverse process of the first lumbar vertebra, the lateral arcuate ligament is located. The median arcuate ligament, which spans the anterior surface of the aorta, connects the fibrous medial margins of the two crura.[8]

Pathophysiology:

The diaphragm is the most significant respiratory muscle. It moves air into and out of the pulmonary gas-exchange units by acting as a critical pump. The upper respiratory centers located in the brain, spinal cord, peripheral nerves, neuromuscular junctions, and respiratory muscles are the anatomical and functional components of respiration. The respiratory muscle that is most important is the diaphragm. It functions as a vital pump, transferring air into and out of the pulmonary gas-exchange units. The anatomical and functional elements of respiration are the higher respiratory centers, which are found in the brain, spinal cord, peripheral nerves, neuromuscular junctions, and breathing muscles. During inspiration, diaphragmatic contraction expands the rib cage and decreases intrapleural pressure, facilitating the entry of gases into the lungs. [9] The respiratory accessory muscles that contract in tandem with the diaphragm are the parasternal portion of the internal and external intercostal muscles, the sternocleidomastoid, the trapezius, and the scalene. [10] The diaphragm is also necessary for speaking, peeing, and giving birth [11]. Depending on the location of the damage, a diaphragmatic rupture can be categorized as right, left, or bilateral; moreover, it can be classified as blunt or penetrating based on the mechanism of injury. [12] A potential diaphragmatic damage should be considered in cases of penetrating injuries to the upper abdomen and lower thorax, such as gunshot and explosive wounds [13].

Clinical presentation:

The method of injury (blank vs. penetrating) and the existence of concomitant injuries determine the clinical appearance. Diaphragmatic injury symptoms are sometimes confused with other ailments.[14] Normal ventilation depends on the diaphragm, and injuries can seriously impair breathing. A diaphragmatic disturbance may be indicated by a history of

respiratory distress and associated pulmonary symptoms.[14] Seldom do diaphragmatic tears happen on their own. These patients frequently have simultaneous head or extremities trauma, as well as thoracic and/or stomach injuries [15].

Physical signs:

The physical examination, which should first focus on airway, ventilation, and circulation, should be followed by the treatment of any airway, ventilatory, or circulatory impairment. The examination of the neck and chest should pay particular attention to findings of tracheal deviation (also known as mediastinal shift), symmetry of chest expansion, and lack of breath sounds (also known as lung displacement). Due to their great frequency, linked injuries typically influence physical results.[16] Since linked intra-abdominal organ injury (e.g., hemoperitonium from splenic and liver injuries or acute abdomen from the existence of holoviscus injuries) may be the cause of the acute abdomen, abdominal examination should be given special attention [16].

Investigations:

Chest radiography:

The frequency and seriousness of related injuries make diaphragmatic rupture a critical diagnosis. In individuals who are at risk, the challenges in diagnosing the condition necessitate an aggressive search.[17].

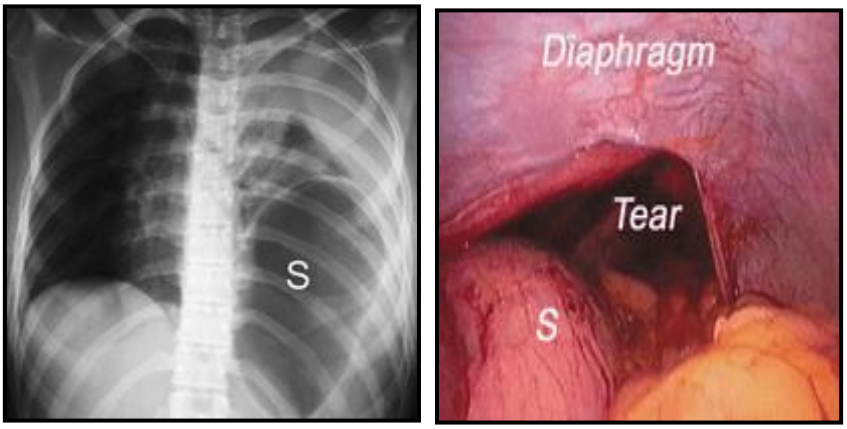


Figure 2:

The most crucial diagnostic test is chest radiography, which might reveal characteristics that point to a diaphragmatic injury (such as a pattern of bowel in the chest).Furthermore, although not exclusive to diaphragmatic injuries, a hemothorax or pneumothorax could be the only radiographic finding in the chest [17].

Other methods of investigation might be employed as well. For example, ultrasonography could be used to see major herniations or disruptions, but it might not pick up on little rips from piercing injuries.[18]

Next-generation helical Because CT scanning does a poor job of seeing the diaphragm, it is useful but not completely sensitive. If an abdominal herniation is seen, a diagnosis can be determined [19]. Due to its ability to precisely view the architecture of the diaphragm, MRI may help in the diagnosing process. When a patient is in stable condition and has a diagnosis that is not clear-cut (due to some penetrating injuries), or when a diagnosis is made later, MRI may be utilized[20]. In cases where laparotomy is not necessary and the diagnosis is uncertain, thoracoscopy has been utilized to improve visualization of the diaphragm[19] . Chest radiography and contrast investigations (via NG or enema) are frequently utilized when a delayed diagnosis is being considered. In this case, an MRI is usually the best diagnostic test.[20]

Treatment:

In the Emergency Department, the initial focus in caring for patients with diaphragmatic injuries should be on resuscitation. Following the standard trauma protocol, attention should be given to the ABCs (Airway, Breathing, Circulation). It is crucial to establish a patent airway, assist ventilation if necessary, and initiate fluid resuscitation as needed. Additionally, inserting a nasogastric (NG) tube can aid in diagnosis, especially if the tube appears in the chest on radiograph. This procedure not only helps in confirming the diagnosis but also decompresses any abdominal herniation, reducing the abdominoperitoneal gradient that promotes herniation into the chest. Furthermore, consider the placement of a chest tube to drain any associated hemothorax or pneumothorax. However, this procedure should be performed cautiously to avoid injuring herniated abdominal contents within the pleural cavity.

Surgery:

Surgical repair of diaphragmatic injuries is typically performed using a trans-abdominal approach. This approach allows for the management of associated intra-abdominal organ injuries along with the repair of the injured diaphragm. In cases where thoracic injuries are present, thoracotomy may be necessary. Indications for thoracotomy include initial blood loss exceeding 1.5 liters, ongoing loss of more than 200 ml per hour, cardiac tamponade, other mediastinal injuries, persistent air leak, and retained foreign bodies larger than 1.5 cm in diameter. Complications of diaphragmatic injuries often result from associated organ injuries,

with death typically occurring due to these injuries. Expansion pulmonary edema is a common serious morbidity. Delayed complications can arise from undiagnosed diaphragmatic injuries, leading to bowel herniation, incarceration, and strangulation [22,23,24].

Patients & Methods

A prospective study involving 73 patients (58 male, 15 female) admitted to the surgical department of Tikrit Teaching Hospital between December 2008 and December 2012 with diaphragmatic injuries, resulting from both penetrating and blunt trauma, was conducted. Upon admission, patients underwent resuscitation in the emergency ward, followed by an assessment to determine the type of injury. Chest X-rays and plain abdomen imaging were performed on all patients, and the data was categorized based on the findings of the chest X-rays. The study evaluated and recorded the mechanism of injuries, associated injuries, surgical approaches, as well as the morbidity and mortality rates.

Results

Among (73) patients presented with diaphragmatic injuries (43/73, 60%) of them were in the (21-30) years age group with a mean age of 24 (± 5.3) years as shown in table (1).

Table 1: The distribution of cases in respect to age

Age	Penetrating		Blunt		Total	%
	No.	%	No.	%		
(< 21)	12	16	1	20	13	14
(21 30)	42	61	4	45	45	60
(31 40)	4	6	2	17	10	10
(41 50)	3	5	-	-	7	10
(≥ 51)	6	10	-	-	2	5
Total	67	98%	7	14%	77	100%

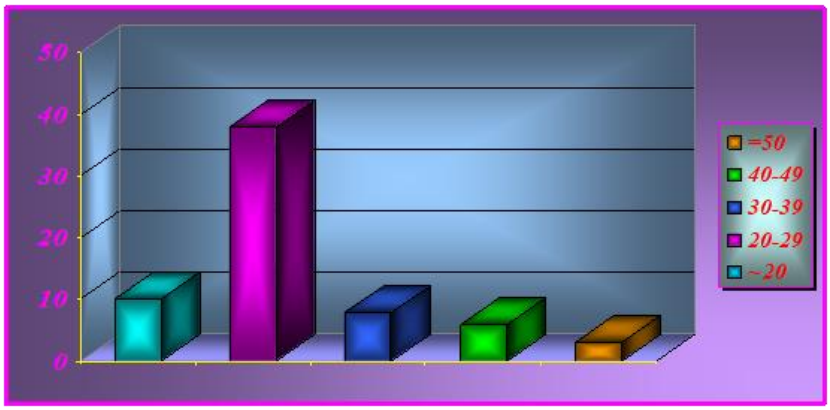


Figure 3: Distribution of cases according to age in penetrating injury

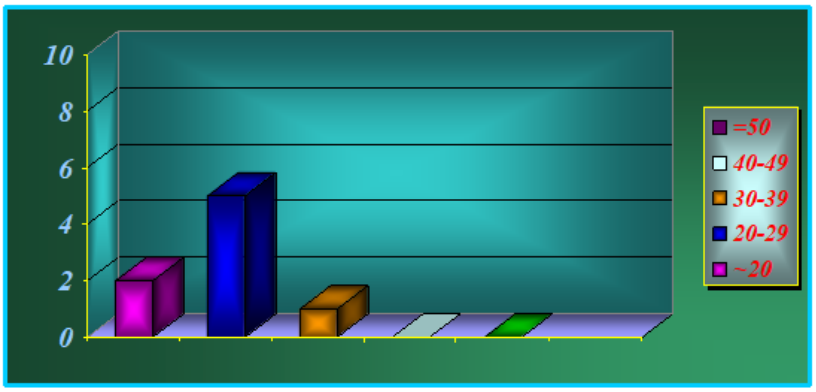


Figure 4: Case distribution for blunt trauma based on age

Concerning the gender distribution in our study, (58/73, 79%) were male, the remaining (15/73, 21%) were female with a (♂ : ♀) ratio of [3.8 : 1]. as shown in table (2).

Table 2 shows the breakdown of cases by gender.

Gender	No. of patients	Percentage %
Male	58	79 %
Female	15	21 %
Total	73	100 %

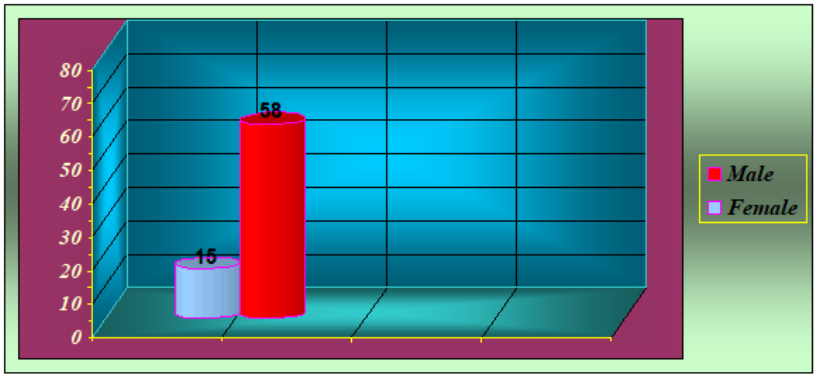


Figure 5:

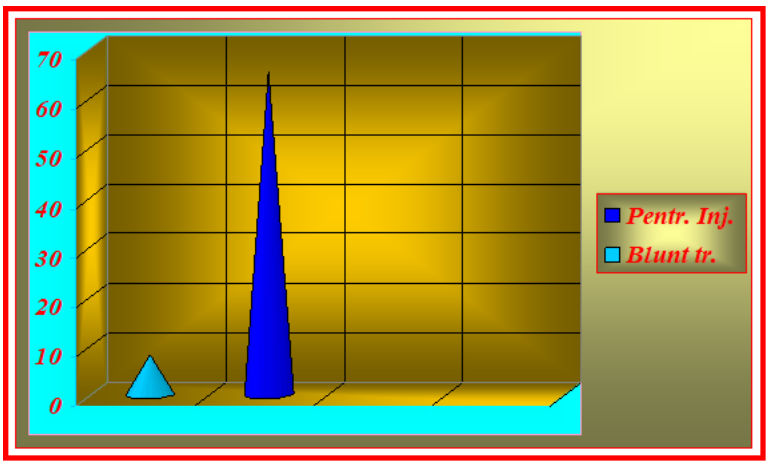
M : F Ratio: 3.8 : 1

Concerning the types of diaphragmatic injury being penetrating or blunt, (65/73, 89%) were penetrating injury, the remaining (8/73, 11%) resulted from blunt trauma, as shown in table (3).

Table 3:

Type of injury	*No. of patients*	*Percentage %*
Penetrating injury	**65**	**89 %**
Blunt trauma	**8**	**11 %**
Total	**73**	**100%**

Figure 6:

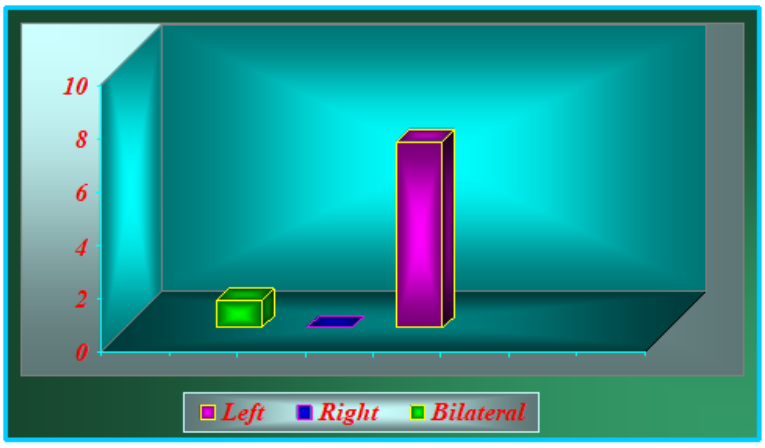


Regarding the site of diaphragmatic injuries in blunt trauma,(7/8, 87%) had left diaphragmatic injury. The remaining one patient (1/8, 12%) had bilateral diaphragmatic injury. No right hemidiaphragm injury was encountered as in table (4).

Table 4: The distribution of cases according to the site of injury in blunt trauma

Site	No.	Percentage %
Left	7	87.5 %
Right	-	-
Bilateral	1	12.5 %
Total	8	100 %

Figure 7:

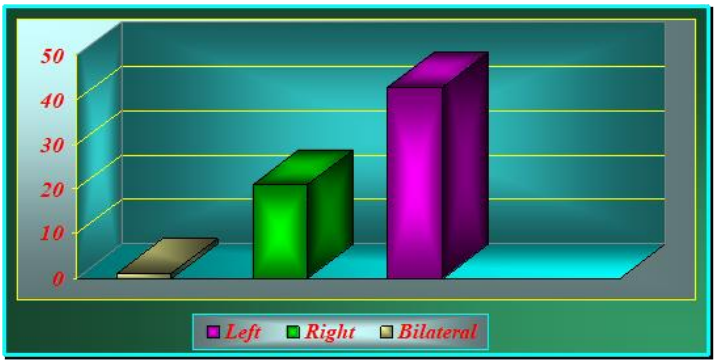


In respect to the site of injury in penetrating trauma, (43/65, 66%) had left diaphragmatic injury, (21/65, 32%) of patients had right diaphragmatic injury, and only one patient had bilateral diaphragmatic injury(1/65, 2%) as in table (5).

Table 5: Distribution of cases according to the site of injury in penetrating trauma

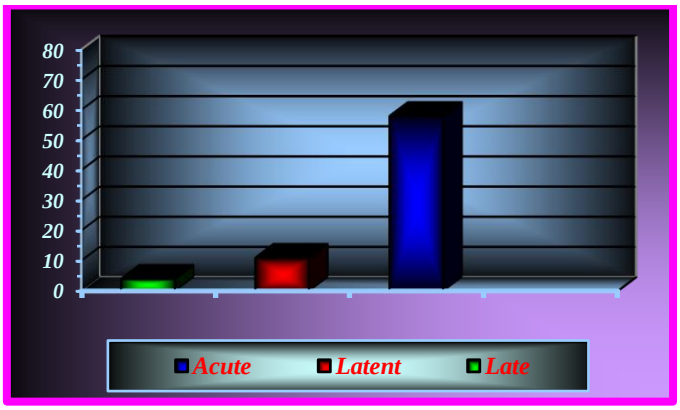
Site	No.	Percentage %
Left	43	66 %
Right	21	32 %
Bilateral	1	2 %
Total	65	100 %

Figure 8:



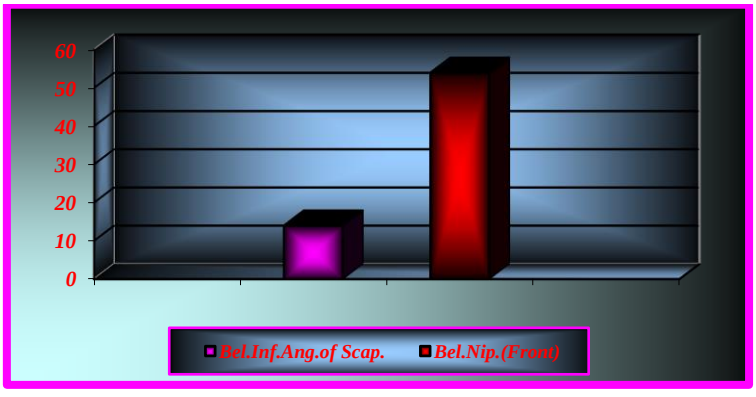
The clinical presentation of our patients with diaphragmatic injuries, were classified into three phases: Acute (up to 12 hr.), Latent (12-24 hr.), and late phase (> 24 hr.).

Figure 9:



Concerning the associated injuries in blunt trauma of diaphragm, (6/8, 75%) had rib fracture, (3/8, 37.5%) had splenic injury, renal injury and pneumothorax each in (2/8, 25%),

Figure 10:



Regarding the radiological chest X-ray findings in our patients, showed that chest X-ray was normal in (2/73, 3%), non specific findings as haemothorx in (21/73, 24%) (figure 11) and rib fractures in (49/73, 67%) (figure 12). Diagnostic features was found in (8/73, 11%) as elevation of the injured hemidiaphragm (figure 13) and in (4/73, 6%) as distortion and

obliteration of the diaphragmatic contour (figure 14). Path gnomonic findings of focal constriction across air containing structure in the thorax (collar sign) was found in (3/73, 5%) (figure 15).

Chest X– ray findings in acute diaphragmatic injury.

Non- specific findings:

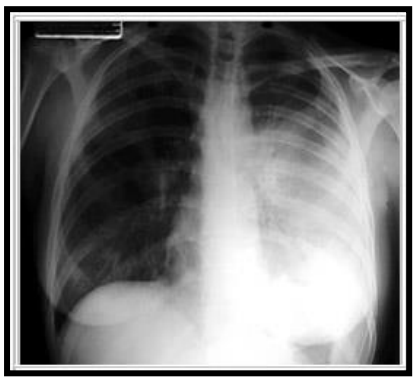


Figure 11: Left haemothorx.

Figure 12: Multiple rib fractures and pleural fluid.

Diagnostic findings:

Figure 13: Elevation of right hemidiaphragm with left,(Bilateral diaphragmatic injury).

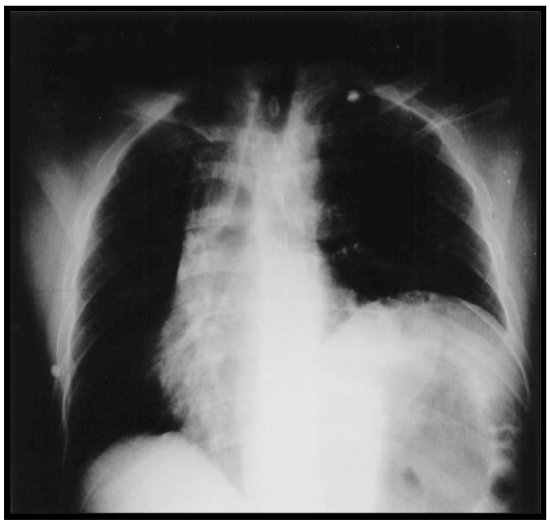


Figure 14: Elevation of left hemidiaphragm haemothorx
Pathognomonic findings:

Figure 15: Herniation of splenic flexure of colon (Collar sign).

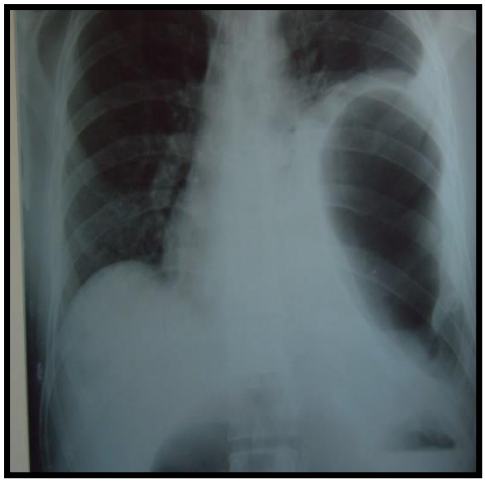


Figure 16: Collar sign.

The figure (17) entrance of the shell below the nipple of left side (in front), patient presented with diaphragmatic and splenic injury. The figure (18) entrance of shell in the right lower chest from the back, patient presented with diaphragmatic and liver injury.

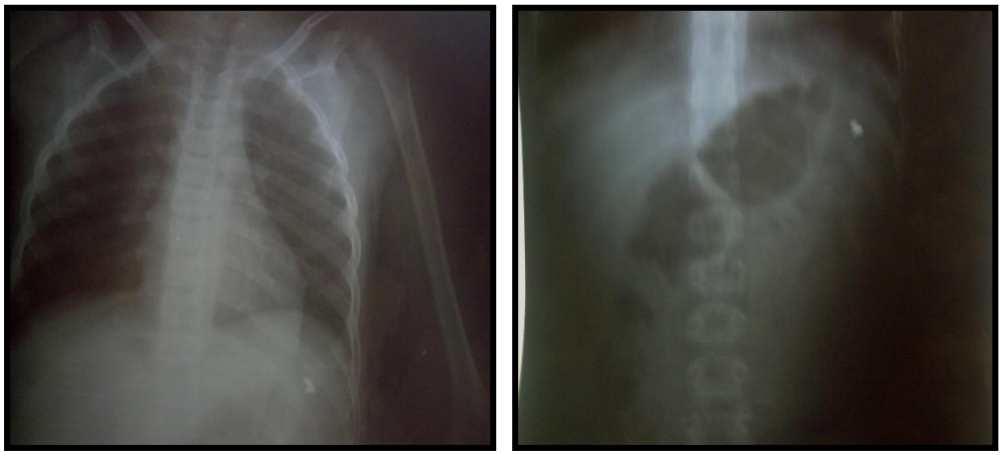


Figure 17: a; Chest X-ray with b; Plain X-ray of abdomen. shell injury of left lower chest. (Splenic injury)

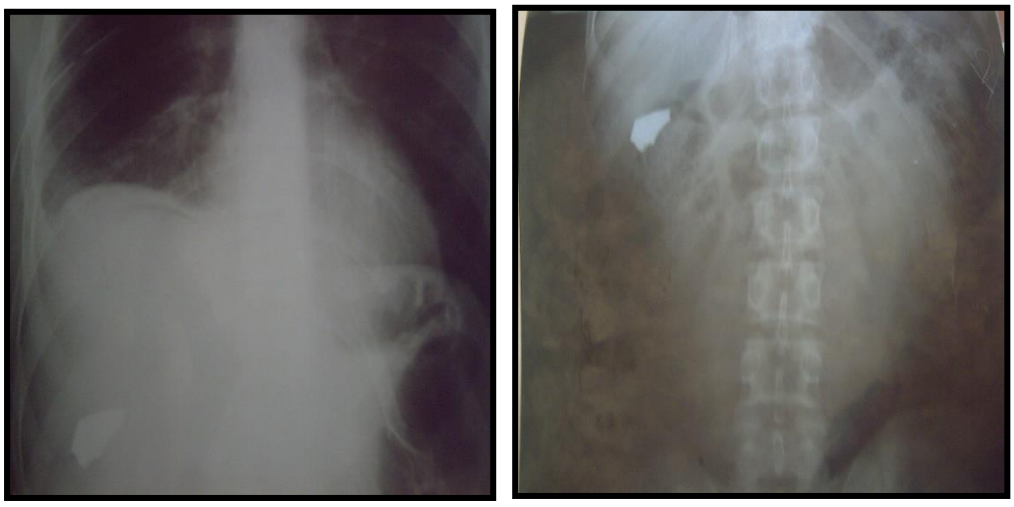


Figure 18: a; Chest X-ray b; Plain X- ray of abdomen show shell injury of right lower chest (liver injury)

Table 6: Chest X- Ray finding in patients with diaphragmatic injury

Chest X− Ray Finding	No.	Percentage
Normal	**2**	**3 %**
Non specific		
• **Haemothorax**	**21**	**29 %**
• **Pneumothorax**	**7**	**10 %**
• **Mediastinal shift**	**2**	**3 %**
• **Rib fracture**	**49**	**67 %**
Diagnostic		
• **Elevation of injured hemidiaphragm.**	**8**	**11 %**
• **Distortion and/or obliteration of diaphragmatic contour**	**4**	**5 %**
Pathognomonic		
• **Focal constriction across air containing structure in the thorax [collar sign].**	**3**	**4 %**

Regard to the types of diaphragmatic injury repair, (22/73, 30%) were approached via laprotomy with a defect of (10) cm or more and repaired with two layers of non absorbable sutures (1st interrupted and 2nd continuous), (49/73, 67%) of patients were also approached via laprotomies, but the defect was less than (10)cm and repaired by two layers of continuous non absorbable sutures. Two patients required in addition to laprotomy for acute abdomen, thoracotomy because initial of blood loss via chest tube more than (1.5) liters in one of them and continuous blood loss of more (200cc)/hour in the other. Table (7).

In these two patients the defect was (≥ 10 cm) and repaired with two layers non absorbable sutures 1st interrupted and 2nd continuous.

Table 7: Types of repair according to the size of defect in diaphragm

Operation	Defect size	Type of repair	No.	Percentage
Laparotomy	**> 10 cm**	**Two layers, non absorbable suture, 1st interrupted second continuous.**	**22**	**30 %**
Laparotomy	**< 10 cm**	**Two layers non absorbable, both continuous.**	**49**	**67 %**

Thoracotomy & Laparotomy	**> 10 cm**	**Two layers non absorbable suture, 1st interrupted second continuous.**	**2**	**3 %**
Total			**73**	**100 %**

Regard to the postoperative morbidity and mortality, thoracic empyema was found in (4/73, 5%), Subphrenic abscess in (3/73, 4%), and atelectasis in (2/73, 8%). Six patients (8%) died, who were multiple injured patients with massive blood loss and two of them with bilateral diaphragmatic injury. Table (8).

Table 8: Postoperative morbidity and mortality

Complications	No.	Percentage
Thoracic Empyema	**4**	**5 %**
Subphrenic Abscess	**3**	**4 %**
Atelectasis	**2**	**3 %**
Mortality	**6**	**8 %**

Concerning the relation between postoperative mortality and time lag between the injury and operation, study showed that after a time lag of (6-12 hr.) one patient died (1/6, 17%), after (13-24 hr.) two patients (2/6, 33%) and after (24 hr.) three patients died (3/6, 50%). Table (13).

Discussion

Sixty percent of the patients in our research who had diaphragmatic injuries were between the ages of 20 and 29. This finding is consistent with that of Shah R et al., who also found that most cases of traumatic diaphragmatic damage occur in the third decade of life.[25] In terms of our patients' gender distribution, we found that the male to female ratio was [3.8: 1]. This outcome is consistent with that of Hasdiraz L. et al., who similarly discovered a 2:1 male preponderance.The somewhat higher ratio in our data may be explained by the greater number of men working in various occupations that are frequently the targets of bombings and terrorist explosions [26].

Most of the patient in our study had their injury resulted from penetrating trauma (89%).This result is in agreement with that of : Miller L et al; who also found that penetrating trauma caused diaphragmatic injury in (91%) of patients.[27]

According to research on the location of diaphragmatic injuries in cases of severe blunt trauma, the majority of patients (87.5%) had left-sided diaphragmatic injuries, while the remaining patients (12.5%) had bilateral diaphragmatic injuries. There was not a single right diaphragmatic injury. This outcome is consistent with those of Ramos CT [28] and

Shanmuganathan K et al. [29], who discovered that in cases of severe blunt trauma, bilateral diaphragmatic damage occurs least frequently and the left hemidiaphragm most frequently. The right side's liver's protective function and the left hemidiaphragm's inferiority over the right because of a line of embryonic fusion between the costal and lumber parts.[30]

In respect to the site of diaphragmatic injury in penetrating trauma, most of the patients had left sided diaphragmatic injury (43/65, 66%).

This finding is consistent with those of Thillois JM et al. [31], Nursal TZ [32], and Grillo IA [33], who similarly found that left-sided diaphragmatic injuries account for the majority of penetrating trauma cases. In terms of clinical presentation stages, the majority of patients (74.5%) were in the acute phase, while the least amount of patients (5.5%) were in the late phase. This finding is consistent with that of Grimes, who discovered that the acute phase of clinical presentation is the most prevalent and the late phase to be the least common [34]

When the diaphragm is bluntly traumatized, the spleen is the visceral organ most frequently affected (37.5%). This finding was in line with that of Freixinet JL, et al., who discovered that the most often affected organ in blunt diaphragmatic injury was the spleen.[35] This might be explained by the stomach's tugging action in acute trauma or by the tissue's brittle nature and fixation by varying ligaments.

The spleen was shown to be the most frequently affected visceral organ in penetrating diaphragmatic injuries, accounting for 66% of cases, with the stomach following at 31%. This finding is consistent with those of James R. [36], Troop B. [37], and Simpson J. [16], who also found that the stomach was the most frequently affected organ in penetrating diaphragmatic injuries, with the spleen coming in second. This might be explained by the fact that the left side is the more frequently affected by diaphragmatic injuries, and the stomach and spleen are situated near to the penetration site. A splenectomy was used to treat every damaged spleen.

Regarding the association between the site of the chest wall penetration and diaphragm injury, we found that all of the patients with penetrating diaphragm injury had chest wall penetration either below the nipple from front (78%) or below the inferior scapular angle from back (22%). This outcome concurs with that of Shahani R. [38], who said that any penetration of the chest wall below the nipple and inferior scapular angle should raise suspicions of diaphragm damage. This may be explained by the diaphragm's origin from the lowest six ribs on both sides, and by rising to the level of the nipple during expiration, the diaphragm's dome becomes exposed to damage.

In reference to the chest x-ray radiological results, they indicated a diagnostic suspicion of diaphragmatic damage in eight cases (elevating the injured diaphragm), four cases (distortion and/or obliteration of the diaphragm contour), and three cases (collar sign). This conclusion is consistent with that of Sadeghi N et al. [39], who discovered that in more than 20% of patients, a chest x-ray was diagnostically suspicious for diaphragm damage.

Depending on the extent of the damage, several techniques were employed to heal diaphragmatic injuries. Two layers of non-absorbable sutures, the first interrupted and the second continuous, were used to repair defects larger than ten centimeters, whereas two layers of non-absorbable sutures, both continuous, were used to repair defects less than ten centimeters. The majority of patients underwent laprotomies; however, two needed thoracotomies as a result of substantial blood loss from lung injuries sustained through chest tubes.This finding is consistent with that of Athanassiadi K, et al. [9] and Baka B, et al. [40], who similarly repaired diaphragmatic injuries using two approaches (continuous and interrupted), presumably depending on the magnitude of the defect. Eren S. [41] said that mesh should be used to fix any fault that is ten centimeters or larger. Since the majority of the patients in our research were undergoing contaminated emergency surgery, mesh was never utilized.

The most frequent consequence in our research was infection (9%), with four cases worsened by empyema thoraces (5%) and three additional cases by subphrenic abscess.(%4)

This finding concurs with that of Williams M, et al. [42], who discovered that infection was the most frequent consequence following diaphragmatic damage. According to Hosdiraz L. et al. [26], thoracic empyema complicates instances in which there is diaphragmatic damage in 57% of cases.

In terms of the relationship between postoperative mortality and the interval between the injury and the surgery, we discovered that the mortality rose with the interval.This outcome is consistent with that of Snyder HE [43], who similarly discovered that mortality would increase with an increase in the amount of time between an accident and an operation.

Conclusions

1. Diaphragmatic injuries should suspected in cases of penetration injury to the thorax below the nipple in front, inferior scapular angle in back.
2. The mortality and morbidity are directly proportional to the lag interval between time of injury and exploration.
3. Try to don't missed any diaphragmatic injury even small one (less than one cm), by carful inspection of both sides.

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