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## Diaphragmatic injuries

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### Summary

This study seeks to define the clinical presentation, the usefulness of diagnostic tests, surgical management approach and outcome of treatment among patients with diaphragmatic injuries. One hundred and sixteen patients with diaphragmatic injuries were treated. This was 6.5% of 1,778 chest trauma patients. Eighty-four of these patients (6.8%) were among 1230 patients who had blunt chest injury and the remaining 32 patients (5.8%) were among 548 patients who had penetrating chest injury. The commonest mechanisms of injury were motor vehicle accidents (48.8%) for blunt and gunshot wounds (56.3%) for penetrating diaphragmatic injuries. The left diaphragm was most commonly involved (86.9% for blunt, 59.4% for penetration), 12.5% of the patients with penetrating chest injury had bilateral diaphragmatic injuries. There were no bilateral diaphragmatic injuries amongst the patients with blunt chest injury. Chest radiographs gave a highly positive yield in the diagnosis of blunt diaphragmatic hernias (67.9%) while nonspecific chest radiological findings (59.4%) were more common among those with penetrating injuries. In 57 patients (49.1%) out of 116, preoperative diagnosis of diaphragmatic hernia was certain. In the remaining 59 patients (50.9%), diagnosis was intraoperative (40 patients), or at postmortem (19 patients). Surgery was emergent in 69 patients (71.1%), semi emergent in 21 patients (21.6%) and elective in 7 patients (7.2%). Surgical approaches were mainly thoracotomy (57 patients), laparotomy (17 patients), laparotomy and thoracotomy (20 patients). In seventy seven patients (79.4%) the diaphragmatic injuries were left sided and in 20 patients (20.6%), the diaphragmatic injuries were right sided. There were 19 preoperative and 21 postoperative deaths. The overall mortality was 34.5%. Associated abdominal and thoracic injuries were the commonest causes of mortality among the patients with diaphragmatic injuries in this study. We conclude that diaphragmatic injury should be suspected in all thoracoabdominal trauma. Lack of specific signs and symptoms is common and a high index of suspicion is required. Routine chest radiograph remains the best screening test for diaphragmatic rupture. Diaphragmatic injury may be a predictor of severity of injury in blunt trauma patient. Surgical approach should be individualized.

**Keywords:** *Diaphragmatic injuries, herniation, blunt trauma, penetrating trauma.*

### Résumé

L'étude cherche à définir la présentation clinique, l'utilité des analyses diagnostique, l'approche de gestion chirurgicale et le résultat de traitement parmi les malades de blessures diaphragmatiques. Cent seize patients ayant des blessures diaphragmatiques sont traités. Cela était 6,5% de 1,778 patients de trauma poitrine. Quarante-quatre de ces malades (6,8%) faisaient parti des 1230 patients qui avaient de

la blessure émoissée poitrine et le reste de 32 malades (5,8%) faisaient partie des 548 malades qui avaient une blessure poitrine. Les mécanismes de blessure les plus communes étaient les accidents d'auto (48,8%) pour les blessures de balle et d'émoissée, (56,3%) pour les blessures diaphragmatique pénétrant le diaphragme du gauche était plus souvent impliqué (86,9% pour l'émoissée, 59,4% de pénétrant), 12,5% des malades avec une blessure de poitrine avaient des blessures diaphragmatique bilatérales parmi les malades poitrinaires de blessures émoissées. La radiographie poitrine a donné un résultat très positif à propos du diagnostic de hernie émoissée diaphragmatique (67,9%), tandis que les résultats radiologiques du poitrine qui ne sont pas spécifiés (59,4%) étaient plus commun parmi ceux qui ont des blessures pénétrant. Parmi les 116, le diagnostic préopératif du hernie diaphragmatique était certain dans 57. Dans les 59 de malades qui restent (50,9%) le diagnostic était intraopératif (40 malades), ou lors de 'post-mortem' (19 malades). La chirurgie était émergent en 69 malades (71,1%), demi-émergent en 21 malades (21,6%) et électif chez 7 malades (7,2%). Les approches chirurgicales étaient uniquement la thoracotomie (57 malades), laparotomie (17 malades), laparotomie et la thoracotomie (20 malades). Dans soixante dix sept malades (79,4%) les blessures diaphragmatique étaient à gauche et dans le cas de 20 malades (20,6%) c'était à droite. Il y avait 19 morts pré-opératifs et 21 morts post-opératifs. Le total des morts était 34,5%. Les blessures abdominales et thoraciques étaient les causes de mortalité parmi les malades diaphragmatique dans cette étude. Nous arrivons à une conclusion qu'une blessure diaphragmatique doit être soupçonnée dans tous cas de blessure thoraco-abdominale. Une manque des signes et symptômes spécifiques est commun et un indice important de soupçon est requise. La radiographie de poitrine routinière est le meilleur examen pour une rupture diaphragmatique. La blessure diaphragmatique peut être un indice de la sévérité de blessure dans le cas d'un malade de blessure émoissée. L'approche chirurgicale devrait être individualisé.

### Introduction

Injury to the diaphragm was first reported in 1541 by Sennertus [1]. Diaphragmatic hernia as a consequence of diaphragmatic injury was reported in 1579 by Ambroise Pare a French surgeon, when he discussed a French artillery captain who initially survived a gunshot wound to the abdomen but died eight months later [2]. The postmortem examination revealed strangulated and gangrenous colon in the chest. A correct antemortem diagnosis of traumatic diaphragmatic hernia was made by Bowditch in 1953 and towards the end of the nineteenth century, surgical procedures for this traumatic condition were being performed [3].

Traumatic injury of the diaphragm may result from penetrating and blunt trauma usually of the lower chest and upper abdomen [4]. Blunt diaphragmatic injuries are more common with excessive automobile speeds and increased use of seat belt restraints [1,5,6], high-velocity missile injuries are the major cause of penetrating diaphragmatic injuries [2]. Small, asymptomatic diaphragmatic injuries, if not detected and repaired, may enlarge over the ensuing months or years and ultimately lead to intestinal herniation, incarceration, obstruction, or strangulation [7]. In the latter instance, mortalities of 80% have been reported [8,9].

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The absence of distinct symptoms of uncomplicated diaphragmatic injury and the frequent co-existence of injuries to other organs make the condition difficult to diagnose. This retrospective study reviews our 20-year experience with penetrating and blunt diaphragmatic injuries and it seeks to define the clinical presentation, the usefulness of diagnostic tests, surgical management approach, and outcome of treatment.

### Material and methods

The unit's record, patients case files, operation records, and post mortem records of all trauma patients referred to and managed by the Cardiothoracic Unit of the University College Hospital, Ibadan between October 1978 and September 1998 were reviewed.

The patients in whom the diagnosis of diaphragmatic injury was made during hospital admission were included in this study. This included those with chronic traumatic diaphragmatic hernias, the acutely injured who were treated and those who died during investigation with confirmed diagnoses at autopsy. It excluded patients who were brought in dead with history of trauma.

Information extracted included age and sex of patients; mechanism of injury; interval between injury and intervention; methods of diagnosis; surgical intervention, approach and findings; associated injuries and outcome of care.

### Results

During the period of 20 years 1,778 patients with chest trauma were treated by the Cardiothoracic Unit of the University College Hospital, Ibadan. One thousand two hundred and thirty patients had blunt and 548 had penetrating thoracic injuries. One hundred and sixteen patients with diaphragmatic injuries were treated.

Eighty-four of the diaphragmatic injuries were the result of blunt thoracic injuries and 32 were caused by penetrating trauma. Ten of the blunt diaphragmatic injuries and nine of the penetrating diaphragmatic injuries died before surgery from associated injuries. Thus 6.8% of blunt chest injuries, 5.8% of penetrating chest injuries or 6.5% of all chest injuries in our institution are associated with diaphragmatic injuries.

**Table 1:** Mechanism of injury 116 patients with diaphragmatic injury.

|                                      | Side of injury |      |           | No of patients |
|--------------------------------------|----------------|------|-----------|----------------|
|                                      | Right          | Left | Bilateral |                |
| <b>Blunt injury</b>                  |                |      |           |                |
| Moto vehicle accident                | 2              | 39   | -         | 41             |
| Pedestrian vs automobile             | 5              | 18   | -         | 23             |
| Motor bicycle                        | 1              | 10   | -         | 11             |
| Fall from height                     | 3              | 6    | -         | 9              |
| Total                                | 11             | 73   | -         | 84             |
| <b>Penetrating injury</b>            |                |      |           |                |
| Gun shot                             | 5              | 10   | 3         | 18             |
| Stab wound                           | 3              | 7    | 1         | 11             |
| Fall from height (impalement injury) | 1              | 1    | -         | 2              |
| <b>Others</b>                        |                |      |           |                |
| Decortication                        | -              | 1    | -         | 1              |
| Total                                | 9              | 19   | 4         | 32             |

The commonest cause of blunt injury was motor vehicle accident while gunshot wound was responsible for the majority of penetrating injuries (Table 1). The left diaphragm was the commonest location. The impalement injuries occurred in palmwine tappers who fell on their axes. A case of iatrogenic diaphragmatic hernia complicated decortication/empyemectomy for chronic empyema thoracis.

The majority of the patients were haemodynamically stable at presentation (Table 2), but had abnormal chest signs. However, they had various combinations of abdominal and chest signs depending on the severity of injury. Chest radiograph gave a highly positive yield in the diagnosis of blunt diaphragmatic rupture while nonspecific chest radiological findings were more common among those with penetrating injuries (Table 3). Figure 1 shows preoperative plain chest x-rays of a complicated blunt diaphragmatic injury.

**Table 2:** Clinical findings at presentation

|                     | Blunt injury<br>n = 84 (%) | Penetrating injury<br>n = 32 (%) |
|---------------------|----------------------------|----------------------------------|
| Stable              | 62 (73.8)                  | 23 (71.9)                        |
| Hypotensive         | 22 (26.2)                  | 9 (28.1)                         |
| Acute abdomen       | 37 (44.0)                  | 15 (46.9)                        |
| Chest               |                            |                                  |
| Abnormal percussion | 69 (82.1)                  | 27 (84.4)                        |
| Mediastinal shift   | 34 (40.5)                  | 6 (18.8)                         |

**Table 3:** Radiographic findings on initial chest x-rays in 116 patients with diaphragmatic injury.

| Finding                    | Blunt<br>n = 84 (%) | Penetrating<br>n = 32 (%) |
|----------------------------|---------------------|---------------------------|
| Normal                     | 3 (3.6)             | 6 (18.8)                  |
| Diagnostic                 | 57 (67.9)           | 0 (0)                     |
| Non-specific abnormalities | 24 (28.5)           | 19 (59.4)                 |
| Mediastinal shift          | 23                  | 2                         |
| Fractured ribs             | 18                  | 1                         |
| Obscured diaphragm         | 17                  | 15                        |
| Haemothorax                | 16                  | 9                         |
| Mediastinal widening       | 10                  | 2                         |
| Atelectasis                | 6                   | 5                         |



**Fig. 1a:** Preoperative posteroanterior (PA) view of chest showing herniated stomach in the left hemithorax.





Fig. 1b: Preoperative left lateral view of chest showing dilated, herniated stomach.

Table 4: Associated injuries in 109 patients with diaphragmatic injury.

| Site                | Blunt<br>n = 79 (%) | Penetrating<br>n = 30 (%) |
|---------------------|---------------------|---------------------------|
| <i>Abdominal</i>    |                     |                           |
| Spleen              | 20 (26.0)           | 11 (34.4)                 |
| Liver               | 11 (14.2)           | 13 (40.6)                 |
| Kidney              | 4 (5.2)             | 5 (15.6)                  |
| Small bowel         | 3 (3.9)             | 7 (21.9)                  |
| Colon               | 3 (3.9)             | 4 (12.5)                  |
| Pancreas            | 1 (1.3)             | 1 (3.1)                   |
| Oesophagus          | 1 (0)               | 1 (3.1)                   |
| <i>Thoracic</i>     |                     |                           |
| Lung                | 32 (41.6)           | 13 (40.6)                 |
| Intercostal         | 18 (23.4)           | 12 (37.5)                 |
| Heart               | 6 (7.8)             | 1 (3.1)                   |
| Aorta               | 5 (6.5)             | 3 (9.4)                   |
| Internal mammary    | 0 (0)               | 4 (12.5)                  |
| <i>Orthopaedics</i> |                     |                           |
| Extremities         | 25 (32.5)           | 2 (6.3)                   |
| Pelvic              | 17 (22.1)           | 2 (6.3)                   |
| <i>Neurologic</i>   |                     |                           |
| Cranio-cervical     | 14 (18.2)           | 1 (3.1)                   |
| Lumbar              | 12 (15.6)           | 3 (9.4)                   |

Majority of the patients (94%) had associated injuries. The liver and spleen were the two intraabdominal organs most frequently injured in both types of diaphragmatic injuries (Table 4); orthopaedic injuries occurred commonly with blunt trauma. On the whole 97 patients were operated. Seventy-nine of the operated patients (81.4%) had concomitant injuries. Thirty-four patients (46%) operated upon following blunt diaphragmatic injury and 19 patients (82.6%) operated upon following penetrating diaphragmatic injury had associated abdominal injury. All the 19 unoperated patients had severe concomitant injuries. The severity of the associated injuries were the determining factors for mortality both among the operated and the unoperated.

The indication for surgery included penetrating wound to lower chest and/or upper abdomen; positive diagnostic abdominal tap; radiological evidence of herniated abdominal

viscera and significant intrathoracic haemorrhage. In 57 patients (49.1%) out of 116 patients, the preoperative diagnosis of TDH was certain based on clinical and radiological findings. In the remaining 59 patients (50.9%) diagnosis was intraoperative (40 patients) or at postmortem (19 patients). In 69 out of the 97 operated patients (71.1%), surgery was emergent, semiemergent in 21 patients (21.6%) and elective in 7 patients (7.2%). Emergency cases were operated on within 24 hours of arrival at the hospital based on progressive respiratory distress and shock. Semi-emergency cases were operated on after 24 hours but within 72 hours. These were relatively clinically stable and diagnoses of diaphragmatic tear was relatively delayed. Elective cases presented after 2 weeks of injury.

Table 5: Operative approach in the management of diaphragmatic injuries in 97 patients

| Approach                   | Blunt<br>n = 74 | Penetrating<br>n = 23 | Total |
|----------------------------|-----------------|-----------------------|-------|
| Thoracotomy                | 57              | -                     | 57    |
| Laparotomy                 | 1               | 16                    | 17    |
| Laparotomy and Thoracotomy | 13              | 7                     | 20    |
| Thoracotomy and Laparotomy | 1               | -                     | 1     |
| Laparotomy and Stenotomy   | 2               | -                     | 2     |
| Total                      | 74              | 23                    | 97    |

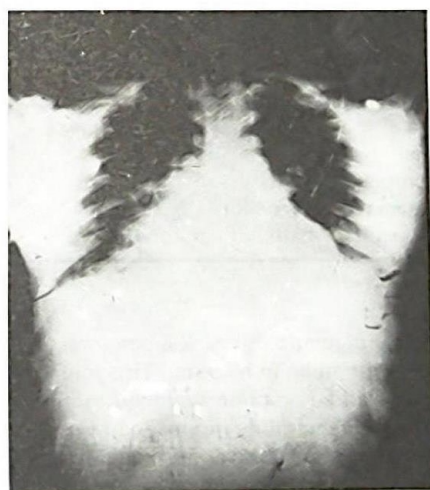


Fig. 2 Postoperative PA view of chest.

Operative approaches are summarized in Table 5. Figure 2 shows postoperative chest x-ray of the patient in figure 1, the repair was done through thoracotomy approach. Twenty patients had laparotomy initially but required thoracotomy subsequently. Laparotomy was the approach for the associated abdominal visceral injury. One main indication for thoracotomy was the technical difficulty imposed by the position of the liver in the transabdominal repair of the right dome of the diaphragm. Seventeen patients, who had laparotomy alone had transabdominal repair of diaphragmatic defects and pleural drainage. One patient had an initial thoracotomy for the repair of diaphragmatic hernia and subsequently had laparotomy for surgi-



cal acute abdomen due to undetected colonic injury. Two patients had initial laparotomy for diaphragmatic hernia repair and subsequent sternotomy for cardiac haemorrhage. Seventy-seven (79.4%) of the operated diaphragmatic injuries were left sided and 20 (20.6%) were right sided.

There were 21 postoperative deaths (21.6%). Seven with penetrating injury and 14 with blunt injury. Nineteen other patients died during resuscitation. Nine among the penetrating and 10 among the blunt injured. The overall mortality was 34.5% (40 out of 116 patients). The causes of death are listed in table 6.

**Table 6:** Causes of 40 deaths in patients having diaphragmatic injury.

| Causes of death                      | Number (n) |
|--------------------------------------|------------|
| <b>Operated</b>                      | 21         |
| Abdomen                              |            |
| Liver injury                         | 9          |
| Thorax                               |            |
| Pulmonary insufficiency              | 7          |
| Cardiac injury                       | 2          |
| Craino-cervical                      | 2          |
| Sepsis                               | 1          |
| <b>Unoperated</b>                    | 19         |
| Orthopaedics                         |            |
| Pelvic and limb fractures            | 4          |
| Thorax                               |            |
| Chestwall, lung and tracheobronchial | 3          |
| Cardiac injury                       | 3          |
| Aorta                                | 1          |
| Abdomen                              |            |
| Spleen/pancreatic avulsion injury    | 3          |
| Liver laceration/avulsion            | 2          |
| Renal pedicle/shattered vertebra     | 1          |

## Discussion

Traumatic diaphragmatic injury is a common and noteworthy marker of severe trauma in Nigeria. This injury occurs in 1 to 5% of hospitalized automobile accidents victims and in 0.4 – 15% of victims of penetrating trauma to lower chest [6, 10-12]. Corresponding figures of its relationship with chest trauma from our study are 6.8% and 5.8%, respectively. It is therefore important to be familiar with these injuries, learn to recognize them early, and treat them appropriately.

Recent advances in initial care and rapid transportation have created the opportunity to evaluate increasing numbers of severely traumatized patients with multiple injuries. However, traumatic diaphragmatic injury, with or without herniation remains a difficult lesion to diagnose in the multiply injured. In the acute phase, the patients present either haemodynamically stable or in shock depending on the type and extent of associated injuries. Chest signs due to herniated abdominal viscera and attendant respiratory distress, and intraabdominal signs of associated visceral injuries were found useful signals of diaphragmatic injuries. The classic Bowditch description of mediastinal shift, dullness to percussion in the left lung base, and bowel sounds in the chest diagnostic of left diaphragmatic rupture [13], while helpful, is unfortunately

masked by conditions such as left pneumothorax or hemothorax. Right sided and small diaphragmatic rents are not associated with specific signs [10,11,13,14].

The diagnosis of acute diaphragmatic injury, with or without hernia may require additional tools. Chest x-ray findings were diagnostic in 67.9% of complicated blunt injury in our series compared to the 25 to 58% rate reported in the literature [6,10-14]. Traumatic diaphragmatic "hernias" were classified as immediate, interval and late events [15]. The higher chest x-ray diagnostic rate in our study may probably be related to long distance referrals, large tears and inappropriate means of transportation. We therefore, along with others [2,11,12,15] found bi-plane chest x-ray, with or without contrast, or radiopaque nasogastric tube the most important, single tool for preoperative diagnosis of blunt diaphragmatic hernia. Admission chest x-ray for penetrating diaphragmatic injury was non-specific in 59.4% of our patients. This discrepancy in diagnostic sensitivity of chest x-ray among the penetrating group when compared with the blunt injured diaphragm is probably related to differences in sizes of the diaphragmatic disruption [12,13] which are usually larger in blunt injuries.

Patients in this study not initially diagnosed by chest x-rays were taken to surgery for signs of intraabdominal injury at which diagnosis was during intraoperative exploration. The specific contributions to diagnosis of peritoneal lavage [6], computerized tomographic (CT) scan [16], renografin [17], peritoneal scintigraphy [18] in the acute setting, are difficult to evaluate [11-13].

It is uniformly agreed that once the diagnosis of diaphragmatic injury is made or suspected, the patient should be operated on as soon as possible to avoid potential complications from the herniation of the abdominal viscera into the thorax [2,4,7-9]. There has been considerable controversy on the merits of repairing diaphragmatic injuries through the chest or through the abdomen. To some extent this controversy has been confused by inclusion in many reviews of patients with both acute and chronic tears. In the present series, the operative approach used was determined by the patients' condition and the suspected injuries. We believe with others that patients should be individualized [14,19]. During the acute postinjury period in patients with intrathoracic or intraabdominal injuries, the diaphragmatic rupture was repaired through the incision required for the emergency repair of other organ injuries. In interval rupture or late diagnosis we exclusively used thoracotomy.

The left sided diaphragmatic injury predominated in this series (79.4%) and falls within the 50 to 88 percent estimates in the literature [1,4,6,13]. However, some authors have suggested that the right to left ratio is now approaching one to one among the blunt injured diaphragms [20]. The patients presented in this series paralleled others reported in the relative frequency of blunt versus penetrating injuries. The literature contains reports that span a wide range from a blunt – to – penetrating ratio of 3:1 in one series [21] to a ratio of 1:8 in another [22]. Clearly, the relative frequency of the two mechanisms of injury is a reflection of the geographic and socioeconomic region served by the hospital. Our report agrees with the position described in the literature where the majority of injuries occur in men and are more to the left than the right hemidiaphragm [11].

The frequency and severity of associated injuries seen in the group of patients presented here are consistent with those in other reports [6,11]. While abdominal injuries are the most commonly found injuries associated with diaphragmatic injury



ries, the presence of diaphragmatic injuries in a multisystem injured patient is a marker of the severity [8]. However, we also found that it is possible to have blunt diaphragmatic rupture without an associated injury. This is usually less frequent [2].

The mortality rate (21.6%) among the patients treated and overall mortality rate of 34.5% which included those who died during resuscitation fall within the range of 4.3% (in a series of predominantly penetrating injuries) to 37% (in a series of blunt injuries) [11]. The predominant causes of death in our series which consist of multisystem organ failure, massive haemorrhage parallel the causes of death in the literature [6,11,14].

In summary we recommend that diaphragmatic injury should be suspected in all thoracoabdominal trauma. Lack of specific signs and symptoms is common and a high index of suspicion is needed for speedy diagnosis. Chest radiograph remains the best screening test for diaphragmatic rupture. It gives a highly positive yield in blunt trauma, and is useful in penetrating wounds. Non-specific radiological features such as obscured or elevated diaphragm, mediastinal shift and haemothorax when taken together, suggest diaphragmatic injury in the traumatized patient with penetrating chest injury. At every exploratory laparotomy or thoracotomy for trauma routine inspection and documentation of integrity of the diaphragm should be done. Diaphragmatic injury may be a predictor of severity of injury in the trauma patient.

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