# A Diagnostic Approach to Penetrating Diaphragmatic Rupture via M-Mode Ultrasonography

Emet M MD[a], Aslan S MD[a], Onbas O MD[c], Cakir Z MD[a], Uzkeser M MD[a], Ozturk G MD[2], Ocak TMD[a]

Departments of Emergency Medicine[a], General Surgery[b], Radiodiagnostics[c], Ataturk University School of Medicine, Erzurum, Turkey

**Abstract**

Penetrating diaphragmatic rupture sometimes poses a diagnostic challenge. We describe two cases due to stab wounds that were identified by M-mode ultrasonography, which showed lesser motion of the left hemidiaphragm compared to the right. We recommend that the addition of M-mode ultrasonography to focused abdominal sonography in trauma (FAST) examination will help clinicians reach the correct diagnosis in cases of suspected penetrating diaphragmatic rupture.

**MeSH Words**: diaphragm; injury, penetrating; trauma, M-mode ultrasonography.

## Introduction

Rupture of the diaphragm is a traumatic medical emergency, associated with mortality rates of 5.5-51% [1]. In 30% of cases, however, diaphragmatic injuries are missed on initial evaluation [2]. This can lead to complications days and even years later, because the diaphragm, owing to its high mobility, does not heal spontaneously. If visceral strangulation occurs, the mortality rate can reach 30-80% [1].

We describe two cases of penetrating diaphragmatic rupture due to stab wounds which were identified by M-mode ultrasonography.

## Case Report

A 28-year-old man with a stab wound complicated by hemopneumothorax was transferred by ambulance from a state hospital to the emergency department of our university tertiary medical center. Initial examination revealed a 2-cm-wide wound between the tenth and eleventh ribs, approximately 11 cm posterior to the left posterior axillary line on the thorax. To manage the pneumothorax, a chest drain had been inserted in the left side of the chest anterior to the axillary line in the fifth intercostal space. The patient was hemodynamically stable. A bedside chest roentgenogram showed left hemidiaphragm elevation, pneumothorax, and the chest tube. A focused abdominal sonography in trauma (FAST) examination was performed by an experienced radiologist using a Siemens Sonoline Antares ultrasound machine (Siemens Medical Solutions USA Inc., Malvern, PA) equipped with a 5-MHz convex transducer. It showed neither free fluid nor organ perforation in the abdomen. In adherence to our current

departmental protocol, the hemidiaphragms were then evaluated with B-mode ultrasound. Scanning was performed first in the oblique transverse subxiphoid plane at the midline to obtain comparative images of both hemidiaphragms. Thereafter, the transducer was positioned in each subcostal area, and each hemidiaphragm was investigated separately in the coronal plane. For M-mode ultrasound assessment of each hemidiaphragm, we used the technique described by Urvoas et al. [3] to identify the motion of the posterior surface of the diaphragm during respiratory maneuvers. The findings showed decreased motion in the left hemidiaphragm relative to the right (Fig. 1).

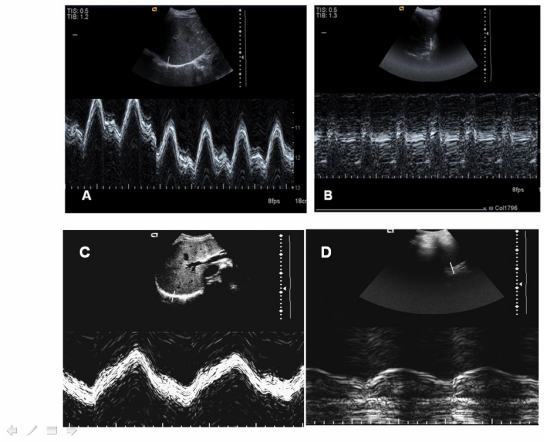


**Figure 1:** Left hemidiaphragmatic injury in a 28-year-old man (A and B) and a 48-year-old man (C and D). Figures show the diaphragmatic motion activities on B- and M-mode sonography during inspiration and expiration. The calipers are in the center of domes. The spectral M-mode ultrasound shows right hemidiaphragmatic motion (A and C). The right hemidiaphragms appear as echogenic continuous lines (A and C). The left hemidiaphragmatic echogenic lines are disrupted (B and D). Additionally, the left hemidiaphragms show compressed curves during both inspiration and expiration. To determine the pathology, the two hemidiaphragms should be analyzed together.

The patient underwent urgent laparotomy. Two lacerations on the left of the left hemidiaphragm were observed: the first was 5 cm wide, situated medially, and the other was 3 cm wide, situated laterally. A great part of the stomach was herniated through the narrower hole. The malposition was ameliorated and the diaphragm was sutured primarily. The postoperative course was unremarkable and the patient was discharged home after 10 days.

**Case 2**

A 48-year-old man presented to the emergency room with a stab wound under the left twelfth rib, approximately 11 cm anterior to the left anterior axillary line. Physical examination revealed abdominal tenderness and defense, with no rebound. There was no respiratory compromise and the patient was hemodynamically stable. A chest x-ray performed in the upright position revealed free air under the right hemidiaphragm, but there was no difference in level between the hemidiaphragms (Fig. 2). M-mode ultrasound showed decreased motion of the left hemidiaphragm relative to the right (Fig. 1).

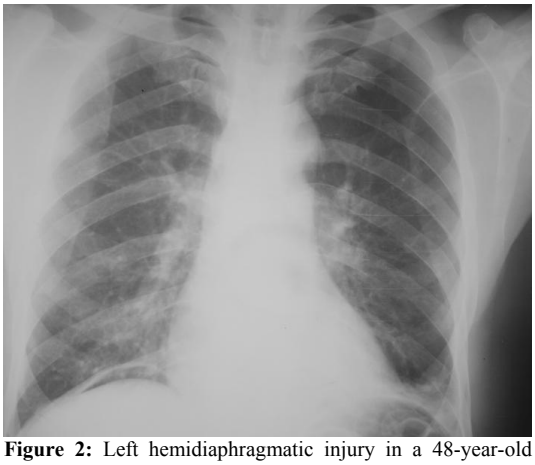

**Figure 2:** Left hemidiaphragmatic injury in a 48-year-old man. The figure shows the anteroposterior chest x-ray findings. Note the free air under the right hemidiaphragm. There is no sign of right hemidiaphragmatic injury.

At laparotomy, a 1-cm-wide laceration was noted on the left hemidiaphragm, and a necrosed part of the omentum was herniated through the rupture. A nearly-4-cm-long laceration was noted in the middle part of the transverse colon. The tears were repaired as necessary. The postoperative course was unremarkable and the patient was discharged home after 9 days.

**Discussion**

Diaphragmatic injuries are often missed because of technical difficulties in visualization studies. In up to one-half of all patients, findings on the first anteroposterior chest x-ray film are normal or nonspecific. If the left hemidiaphragm is ruptured, admission radiographs are diagnostic in only 27–62% of patients [4]. In our second case,

chest x-ray yielded no evidence of a diaphragmatic injury (Fig. 2).

Indications of diaphragmatic rupture on ultrasound include a disrupted or non-visualized diaphragm and herniation of abdominal organs through the defect [5]. However, unlike blunt ruptures, which are generally 10 cm or more in length, penetrating ruptures measure less than 2 cm in 84% of cases, making them difficult to visualize directly [1]. In our cases, visualization on ultrasound was inhibited by the air in the lungs and the relatively narrow width of the lacerations.

Several studies have applied M-mode ultrasound to evaluate diaphragmatic movement abnormalities in both adults and children [6,7]. Urvoas et al. [3] defined the classification of the diaphragmatic motion parameters on M-mode ultrasound as normal, decreased, absent, or paradoxical. Blaivas et al. [8] was the first to add M-mode ultrasound to the standard evaluation in 3 patients with blunt diaphragm injury. They found an absence of the expected respiratory excursion in the ruptured diaphragm. Our search of the literature failed to yield any reports on the use of M-mode ultrasound in penetrating diaphragmatic rupture. In both our cases with penetrating injuries, M-mode ultrasound showed decreased motion in the injured hemidiaphragm compared to the noninjured one (Fig. 1).

Laparatomy is indicated for patients who are hemodynamically unstable or have signs of peritoneal irritation. For hemodynamically stable patients, as in our cases, despite its invasive nature, laparoscopy is still the diagnostic method of choice. Other modalities include helical computerized tomography (CT) and peritoneal lavage. However, when penetrating wounds to the left lower chest or upper abdomen are accompanied by normal findings on abdominal examination but the risk of diaphragm injury cannot be ruled out, the use of laparotomy/laparoscopy versus observation is unclear. Furthermore, CT may not be immediately available at the hospital, and its findings in terms of diaphragm injury are often equivocal. We suggest that in these cases, M-mode ultrasonography may offer the ideal solution. M-mode ultrasonography also has other advantages over standard imaging technologies: it requires only active breathing (i.e., no ventilatation) without the patient needing to take deep breaths; the examination takes only about 5 minutes with an experienced operator; and the examination can be performed at the bedside [9]. In addition, because there is no radiation, M-mode ultrasonography is safe for use in pregnant women and children. In our cases, by rapidly applying M-mode ultrasonography, we were able to reach the diagnosis without delay and provide rapid treatment.

Our report indicates that M-mode ultrasonography is a promising new bedside tool, combined with FAST examination, for the diagnosis of penetrating diaphragmatic injuries. Nevertheless, it should be borne in mind that this is a new technique and warrants further, systematic studies, with determination of its false-negative and false-positive rates, before introduction into routine use.

**References**


1. Sliker CW. Imaging of diaphragm injuries. Radiol Clin N Am. 2006;44:199–211.

2. Abdel Hadi MS, Al-Mulhim AA, Al-Awad NI, Zakaria HM, Al-Awami MS. Diaphragmatic injury. A clinical review. Saudi Med J. 2001;22:890-894.

3. Urvoas E, Pariente D, Fausser C, Lipsich J, Taleb R, Devictor D. Diaphragmatic paralysis in children: diagnosis with TM-mode US. Pediatr Radiol. 1994;24:564–568.

4. Mirvis SE, Shanmuganagthan K. Imaging hemidiaphragmatic injury. Eur Radiol. 2007;17:1411-1421.

5. Kim HH, Shin YR, Kim KJ, Hwang SS, Ha HK, Byun JY, et al. Blunt traumatic rupture of the diaphragm: sonographic diagnosis. J Ultrasound Med. 1997;16:593-608.

6. Epelman M, Navarro OM, Daneman A, Miller SF. M-mode sonography of diaphragmatic motion: description of technique and experience in 278 pediatric patients. Pediatr Radiol. 2005;35:661–667.

7. Gerscovich EO, Cronan M, McGahan JP, Jain K, Jones CD, McDonald C. Ultrasonographic evaluation of

diaphragmatic motion. J Ultrasound Med. 2001;20:597–604.

8. Blaivas M, Brannam L, Hawkins M, Lyon M, Sriram K. Bedside emergency ultrasonographic diagnosis of diaphragmatic rupture in blunt abdominal trauma. Am J Emerg Med. 2004;22:601-604.

9. Lloyd T, Tang YM, Benson MD, King S. Diaphragmatic paralysis: the use of M mode ultrasound for diagnosis in adults. Spinal Cord. 2006;44:505–508.

**Competing Interests:** None declared.

**Funding:** None declared.

This manuscript has been peer reviewed

---

**Correspondence:**

Mucahit Emet, MD
Atatürk University, School of Medicine, Department of Emergency Medicine
25090 Erzurum
TURKEY
Tel : +90-442-3166333/1464
Fax: +90-442-3166340
E-mail: mucahitemet@gmail.com