Blunt diaphragmatic injuries: imaging findings and possible pitfalls.

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Authors: M. Bonatti¹, F. Lombardo², N. Vezzali¹, G. Bonatti¹; ¹Bolzano/IT, ²Verona/IT
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Learning objectives

1. To review epidemiology and trauma dynamics of blunt diaphragmatic lesions (BDL).

2. To review sonographic signs of BDL.

3. To review chest X-ray signs of BDL.

4. To review MDCT signs of BDL.

5. To explain the possible role of MRI in the suspicion of BDL.

6. To show false negative cases of BDL.

7. To show false positive cases of BDL.
Background

Blunt diaphragmatic injuries (BDI) represent a relatively uncommon event in patients admitted to an Emergency Department (ED) because of blunt trauma, with an estimated prevalence of 0.2-7%.

Although BDI themselves are rarely life threatening in their acute phase, patients suffering from them show high mortality rates, ranging from 5 to 50%, mainly because of associated injuries.

Every diaphragmatic lesion should undergo surgically reparation as soon as possible in order to prevent further complications and to improve patient’s outcome; therefore, early diagnosis is fundamental.
Findings and procedure details

Traumatic mechanisms

The diaphragm is constituted by three main muscular groups, originating from the lumbar vertebrae, from the inferior border of the ribs and from the sternum, that converge into a thin strong central tendinous sheet. The sites where the muscular groups converge (i.e. the left and right lumbocostal triangles and the left and right sternocostal triangles) constitute phisiological weakness points (Fig. 1).

BDI are usually the consequence of high-energy frontal impacts, e.g. motor-vehicle accidents or falls from a height, that determine a sudden increase in abdominal pressure, which is transmitted to the diaphragm that may crack in its weakness points. Less common traumatic mechanisms are represented by high-energy lateral impacts that cause chest wall distortion and subsequent diaphragm shearing and by direct lacerations from fractured ribs.

In the majority of the cases, blunt diaphragmatic lesions show a radial course, starting from the postero-lateral area of the diaphragm and extending towards the central one, and extend for at least 10 cm. Usually, the breakage flaps remain close to each other during the early post-traumatic stages, but afterwards they tend to move away because of the difference between the positive intra-abdominal pressure and the negative pleural space one; this may result in intra-thoracic visceral herniation.

Left BDI are significantly more common than right ones (2:1-7:1 ratios), probably because of the protective effect of the liver and of a relative weakness of the left hemidiaphragm itself.

Clinical presentation and diagnosis

Blunt diaphragmatic injuries are asymptomatic in their acute phase, in the majority if the cases. Anyway, BDI almost never occur as isolated injuries; indeed, they are associated with life threatening abdominal injuries, in particular splenic, hepatic and renal ones, in 50-100% of the cases. Moreover, thoracic lesions, like hemothorax, pneumothorax and rib fractures, coexist in most of the cases.

The main complication of BDI is represented by thoracic herniation of abdominal viscera, which may manifest with a various delay after trauma and may be further complicated by incarceration, strangulation and occlusion, but also by respiratory insufficiency.
Being clinical diagnosis of BDI impossible, imaging plays a central role for this aim. Nowadays, multidetector CT represents the imaging modality of choice for diagnosing BDI.

Anyway, it is well-known that BDI may still remain unrecognized at initial imaging, mainly because of the presence of distracting injuries, and may become manifest only later because of complications. Delayed presentation is associated with increased morbidity and mortality.

**Imaging findings**

>>>Ultrasound

Ultrasound, mainly in the form of FAST scan, is usually the first line imaging modality performed in blunt trauma patients admitted to the ED, in association with chest x-ray.

- Non-visualization of the spleen or of other hypochondriac organs after a severe blunt abdominal trauma should raise the suspicion of BDI, as well as the immobility of one hemidiaphragm.
- If a good thoracic window is present (Fig. 2) (e.g in case of large pleural effusions (star)), ultrasound may directly depict the ruptured diaphragm (arrows); thickened diaphragm edges (arrowheads) can be usually observed.

>>>Chest X-ray

Chest radiograph (CXR) is normal or shows only nonspecific changes in 20-50% of the patients affected by diaphragmatic rupture; repeated scans or comparison with previous ones may increase sensitivity.

- Diagnosis of BDI (Fig. 3) is possible only if herniated viscera (circle) are recognizable within the thoracic cavity.
- Hemidiaphragm elevation is significantly associated with BDI, showing 61% accuracy in BDI identification, but shows low specificity.
- Other signs associated with BDI are costophrenic sulcus obliteration, distorted diaphragmatic profile and air-fluid levels in the chest.

>>>CT

Nowadays, thanks to the technological developments that lead to the introduction of multidetector scanners in the routine practice, sensitivity has increased up to 61-100%. Many direct and indirect signs of diaphragmatic rupture have been described.
• **Segmental diaphragmatic defects** (**Fig. 4**) (*arrows*) are usually surrounded by diaphragmatic **thickening** as a consequence of muscle retraction (*arrowheads*).

• Partial or complete **diaphragm non-visualization** (**Fig. 5**) (*arrows*), without demonstration of a tear, is usually associated with intrathoracic viscera herniation (*star*).

• **Dangling diaphragm sign** (**Fig. 6**) is appreciable when the free edges of a torn diaphragm become "comma-shaped" (*arrows*) and curl inward, toward the center of the abdomen. Dangling diaphragm sign is usually associated with a segmental diaphragmatic defect and diaphragm thickening.

• **Diaphragm thickening** (**Fig. 7**) (*arrows*) should be evaluated in comparison with the contralateral side and represents the consequence of muscular hematoma. It may represent the only injury sign.

• **Intrathoracic herniation** of abdominal organs (**Fig. 8**) (*star*) represents the typical complication of BDI.

• **Dependent viscera sign** (**Fig. 9**) refers to a direct contact between the abdominal organs and the posterior chest wall (*arrows*), without lung parenchyma interposition.

• **Collar sign** (**Fig. 10**) is the consequence of the waist-like constriction of the herniated structures at the point of diaphragmatic discontinuity (*arrowheads*).

• **Hump and band sign** (**Fig. 11**) refers to the shape of the herniated liver above a diaphragmatic defect (*arrowheads*) and to the hypoattenuation band (*arrows*) that transects the herniated liver at the level of diaphragm torn edges, probably due to local hypoperfusion.

>>>MRI

MRI shows **higher tissue contrast resolution** than CT, but its usage in an emergency setting is limited because of long acquisition times and need for patients’ collaboration.

• MRI is able to depict **diaphragmatic discontinuity** (**Fig. 12**), which is pathognomonic for BDI, as well as the other signs previously described for CT.

>>>False negative cases

• **Mechanical ventilation** (**Fig. 13**), particularly if positive ventilation pressures are used, may reduce viscera herniation (*arrow*); anyway, usually herniation manifests again after extubation (*circle*).

• Slight alterations (**Fig. 14**), like minimal diaphragm thickenings (*arrows*), may remain undiagnosed at initial CT and may manifest only later because of complications (*circle*).

>>>False positive cases
Eventration (Fig. 15) may involve an entire hemidiaphragm (arrows) or only a portion of it (arrowheads). In both cases muscle continuity must be clearly identified and no abnormal diaphragm thickening can be accepted. In case of right-sided eventration, no band sign should be observed.
Fig. 1: BDI distribution

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Fig. 2: BDI at ultrasound

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Fig. 3: BDI at chest x-ray

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Fig. 4: BDI at CT: segmental diaphragmatic defect

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Fig. 5: BDI at CT: diaphragm non-visualization

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Fig. 6: BDI at CT: dangling diaphragm sign

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Fig. 7: BDI at CT: diaphragm thickening

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**Fig. 8:** BDI at CT: intrathoracic viscera herniation

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**Fig. 9:** BDI at CT: dependent viscera sign

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Fig. 10: BDI at CT: collar sign

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Fig. 11: BDI at CT: hump and band sign

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Fig. 12: BDI at MRI

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**Fig. 13:** False negative case: mechanical ventilation

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**Fig. 14:** False negative case: slight alterations

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Fig. 15: False positive case: eventration

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Conclusion

In the era of multidetector CT and of high-quality multiplanar reconstructions, the diagnosis of blunt diaphragmatic injury should be no more overlooked by a radiologists working in an emergency setting. Diaphragm has to be accurately evaluated in every trauma patient, looking for both direct and indirect signs of rupture...and remember, you see only what you know!
References


