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ORIGINAL ARTICLE

Traumatic diaphragmatic injury: a review of CT signs and the difference between blunt and penetrating injury

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PURPOSE
We aimed to present the frequency of computed tomography (CT) signs of diaphragmatic rupture and the differences between blunt and penetrating trauma.

MATERIALS AND METHODS
The CT scans of 23 patients with surgically proven diaphragmatic tears (both blunt and penetrating) were retrospectively reviewed for previously described CT signs of diaphragmatic injuries. The overall frequency of CT signs was reported; frequency of signs in right- and left-sided injuries and blunt and penetrating trauma were separately tabulated and statistically compared.

RESULTS
The discontinuous diaphragm sign was the most common sign, observed in 95.7% of patients, followed by diaphragmatic thickening (69.6%). While the dependent viscera sign and collar sign were exclusively observed in blunt-trauma patients, organ herniation ($P = 0.05$) and dangling diaphragm ($P = 0.0086$) signs were observed significantly more often in blunt trauma than in penetrating trauma. Contiguous injury on either side of the diaphragm was observed more often in penetrating trauma (83.3%) than in blunt trauma (17.7%).

CONCLUSION
Knowledge of the mechanism of injury and familiarity with all CT signs of diaphragmatic injury are necessary to avoid a missed diagnosis because there is variability in the overall occurrence of these signs, with significant differences between blunt and penetrating trauma.

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Traumatic diaphragmatic injury has been found in 3%–8% of patients undergoing surgical exploration after blunt trauma and in 10% of patients with penetrating trauma (1, 2). The rate of initially missed diagnoses on computed tomography (CT) ranges from 12% to 63%. A missed diagnosis can later present as intrathoracic visceral herniation and strangulation with a mortality rate of 30%–60% (2, 3). In this era of increasing nonoperative management for most cases of blunt abdominal trauma, it becomes essential to diagnose diaphragmatic rupture on imaging to ensure early and timely operative repair of the rupture. The reasons for missed early diagnoses include potentially distracting and more severe thoracic and abdominal visceral injuries and lack of familiarity with all the imaging appearances and signs of diaphragmatic rupture (2, 4).

Various imaging modalities including chest radiographs, ultrasonography, CT, and magnetic resonance imaging have been used in the diagnosis of diaphragmatic rupture (1). Currently, multidetector CT (MDCT) is the modality of choice for the detection of diaphragmatic injury. MDCT has increased the accuracy of diagnosis of diaphragmatic rupture. MDCT has inherent technical advantages, such as rapid, volumetric data acquisition for the chest and abdomen within a single breath hold, minimization of motion artifacts, thin-section reconstruction and sagittal and coronal reformat-reducing partial-volume effects that assist in diagnosing subtle defects (1). MDCT also aids in detecting the associated chest, abdomen, ribs, and bony injuries in these polytrauma patients. Various studies have revealed CT to have a variable sensitivity and specificity of 61%–87% and 72%–100%, respectively, for the diagnosis of diaphragmatic rupture (1, 5–7). Killeen et al. (6) demonstrated that the sensitivity for detecting left-sided ruptures (78%) is higher than for right-sided ruptures (50%). This finding has been attributed to the better soft tissue-fat contrast on the left side and the difficulty in diagnosing subtle liver herniation on the right side.

Various signs of diaphragmatic rupture have been described on CT. These signs have been divided into direct and indirect signs and signs of uncertain/controversial origin, according to Desir and Ghaye (8), and have been tabulated in Table 1. It has also been suggested that a possibility of diaphragmatic rupture should be considered when any one of the reported signs are present (2, 3).

Because the biomechanics of blunt and penetrating diaphragmatic ruptures are different, a variation in the frequency of individual signs should also be expected. Although the dependent viscera sign is a good sign of blunt diaphragmatic injury, it is an unreliable indicator for penetrating trauma (9). Penetrating traumatic diaphragm injuries are more easily diagnosed by following the trajectory of the weapon and looking for contiguous injury on either side of diaphragm (1, 7). Thus, it becomes imperative to be familiar with the signs of diaphragmatic rupture to avoid a missed diagnosis. Recently, Desser et al. (10) have reported a new sign, called the dangling diaphragm sign, in patients with blunt diaphragmatic injuries.

Most of the studies about the individual CT signs of diaphragmatic injury have focused only on blunt trauma (2–6, 11–13). Moreover, to our knowledge, no analysis of the dangling diaphragm sign has been conducted in both blunt and penetrating trauma patients (5). Therefore, the purpose of our study was to present the frequency of CT signs in patients with diaphragmatic injury and to describe the differences between blunt and penetrating trauma.

Materials and methods

Study design and population

This study was conducted in our level one apex trauma center. We searched our hospital registry for cases of surgically proven diaphragmatic rupture over a period from 2008 to 2011. The mechanism of injury included both blunt and penetrating trauma. Among these, the patients who had undergone a preoperative CT were included in our study group. For 23 patients, the CT images (including sagittal and coronal reformats) and surgical data were available for retrospective review. The CT scans of these 23 patients were analyzed by three radiologists (A.K. and S.G. with 12-year experience and A.R.P. with five-year experience in the concerned field). The interpretation was performed by a consensus opinion. Forty-six hemidiaphragms were evaluated for CT signs of injury. Patient consent was not required for this retrospective study.

The CT examination was conducted in hemodynamically stable patients with a positive FAST (focused assessment with sonography for trauma). As per the hospital protocol, contrast-enhanced CT of the chest and abdomen was performed approximately 60–70 s after the hand injection of 100 mL of the intravenous contrast agent and scanning on a MDCT scanner (Somatom 40, Siemens Healthcare, Erlangen, Germany). No oral contrast was given to these patients because they all underwent emergency CT. All patients underwent surgery within one week of the emergency CT scan.

Image analysis

All the CT scans were analyzed for the following signs of diaphragmatic injury:

1) Discontinuous diaphragm sign. This sign was considered present if there was visualization of direct discontinuity of the diaphragm along with segmental nonvisualization of the diaphragm (Figs. 1, 2).

2) Thickening of the diaphragm. This sign was considered present if there was thickening of the diaphragm at the site of injury, with or without retraction of the edges (Figs. 2, 3).

3) Organ herniation. This sign was considered present if there was an appearance of an intra-abdominal organ within the thoracic cavity through a defect in the diaphragm (Fig. 4).

4) Dependent viscera sign. As described by Cantwell (9), this sign was considered present if the upper one-third of the liver abutted the posterior ribs on the right side and if the stomach or bowel abutted the posterior ribs or lay posterior to the spleen on the left side (Fig. 4).

5) Dangling diaphragm sign. This sign, as observed by Desser et al. (10), was considered present if the free edge of the torn diaphragm was visible as it curled inwards towards the center of the abdomen, away from or at near right angles to the chest wall. Similar to the authors (10), we considered this sign present when a comma-shaped fragment of the diaphragm was visualized along its course (Fig. 5).

6) Collar sign. This sign referred to the visualization of a focal, waist-like constriction of the herniating abdominal viscus at the level of the torn diaphragm, better identified with sagittal and coronal reformats (Fig. 6) (6). Rees et al. (12) have described two variants of the collar sign, for right-sided liver herniation through diaphragmatic tears. These variants include the “hump” sign (i.e., a rounded portion of the liver herniating through the diaphragm, forming a hump-shaped mass) and the second, “band” sign (i.e., a linear lucency across the liver, along the torn edges of the hemidiaphragm). However, these two described variants of the sign were not marked separately during our image analysis.

7) Contiguous injury on either side of the diaphragm. This sign was defined as contiguous injuries on both

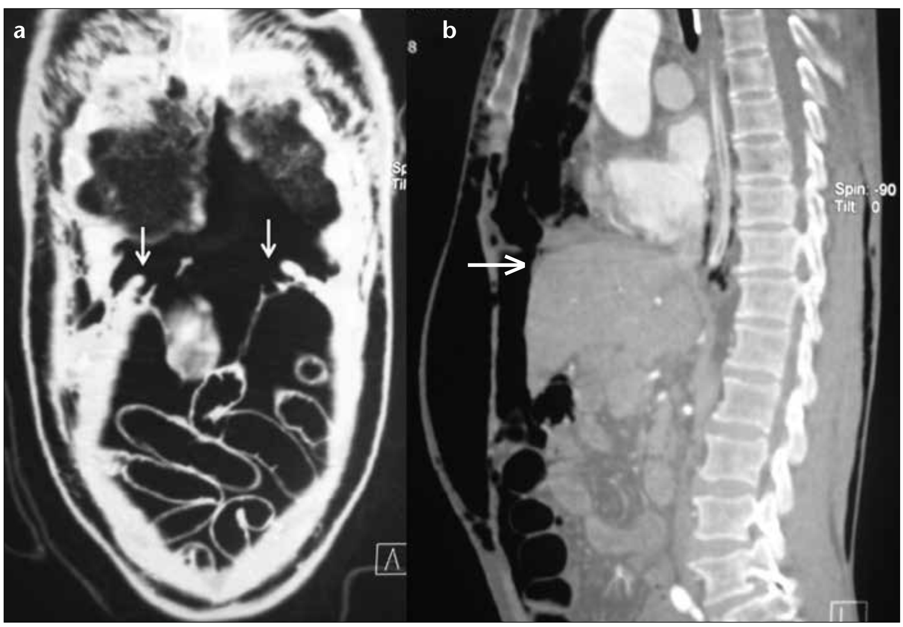

Figure 1. a, b. A case of central tendon rupture. Coronal **(a)** and sagittal **(b)** reformatted CT images demonstrate nonvisualization of the central part of the diaphragm, with thickening and retraction of both cut edges of the diaphragm (**a**, *arrows*). There is pneumoperitoneum (**b**, *arrow*) extending upwards into the chest and in the retrosternal region through the defect in the central part of the diaphragm, along with extensive subcutaneous emphysema.

Table 1. CT signs of diaphragmatic injury[a]

Direct signs
1. Direct discontinuity of the diaphragm
2. Dangling diaphragm sign
Indirect signs
1. Collar sign
2. Intrathoracic herniation of viscera
3. Dependent viscera sign
4. Contiguous injury on either side of the diaphragm
5. Sinus cut-off sign
Signs of uncertain origin
1. Thickening of the diaphragm
2. Hypoattenuated diaphragm
3. Fractured rib
4. Diaphragmatic/peridiaphragmatic contrast extravasation

[a]Modified from Bodanapally et al. (7) and Desir and Ghaye (8).

Figure 2. The axial helical CT scan shows thickening and focal discontinuity of the left hemidiaphragm on the anterior aspect *(arrow)*. In addition, clear-cut discontinuity can be noted in the skin and subcutaneous tissue, indicating the weapon's trajectory.

sides of the diaphragm, implying transdiaphragmatic penetration and injury by the weapon (Fig. 7). Thus, even if the diaphragmatic rent was not directly visualized, tracing the wound track outline across the diaphragm with contiguous injury on either sides of the diaphragm was considered an indirect sign of diaphragmatic injury (7).

Statistical analysis

The frequency of incidence of each sign was tabulated for the overall study population and separately for right- and left-sided injuries, and blunt and penetrating injuries and was expressed as percentages. The comparison was performed by the Fischer's exact test, and $P < 0.05$ was considered statistically significant.

Results

Of the 23 patients analyzed, 21 were males, and two were females. The mean age was 29.04±13.8 years (range, 2–65 years). Seventeen patients (69.6%) had blunt injuries, and six (30.4%) had penetrating injuries. Fifteen patients (65.3%) had left-sided injuries, and seven (30.4%) had right-sided injuries. One patient had involvement of the central dome of the diaphragm. This patient was excluded from the right vs. left analysis and was evaluated separately for CT signs.

Of the CT signs evaluated (Table 2), the discontinuous diaphragm sign was the most common sign and was observed in 22 patients (95.7%), followed by thickening of the diaphragm (69.6%), intrathoracic herniation of organs (65.2%) and dependent-viscera (56.5%), and dangling-diaphragm (56.5%) signs. One blunt-trauma patient with a right-sided diaphragmatic injury did not present diaphragmatic discontinuity but had diaphragmatic thickening and contiguous injury on either side of the diaphragm. The one patient with central tendon involvement had discontinuity of the diaphragm along with thickening of diaphragm, the dangling viscera sign and evidence of soft tissue injury extending on either side of the diaphragm (Fig. 1). There was associated pneumoperitoneum due to a tear in the descending colon along with laceration of the liver and spleen. However, organ herniation or the collar sign were not observed.

Herniation of the stomach, small intestine and mesentery were observed significantly more often in left-sided injuries than in right-sided injuries, while splenic and pancreatic herniations were observed exclusively in left-sided diaphragmatic injuries (Table 3). Overall, the most common organs to herniate were the stomach and mesentery (52.3%).

We found a significant difference in the incidence of certain signs with respect to blunt and penetrating trauma (Table 4). In our study, the dependent viscera and collar signs were observed exclusively in blunt-trauma patients. Furthermore, organ herniation was observed significantly more often in blunt trauma than in penetrating trauma, whereas 82.4% (14/17) of patients with blunt trauma presented organ herniation compared with only 16.7% (1/6) with penetrating trauma (P = 0.009). The dangling diaphragm sign was observed in 70.6% (12/17) of patients with blunt trauma compared with 16.7% (1/6) of patients with penetrating trauma; however, this difference was not significant (P = 0.052).

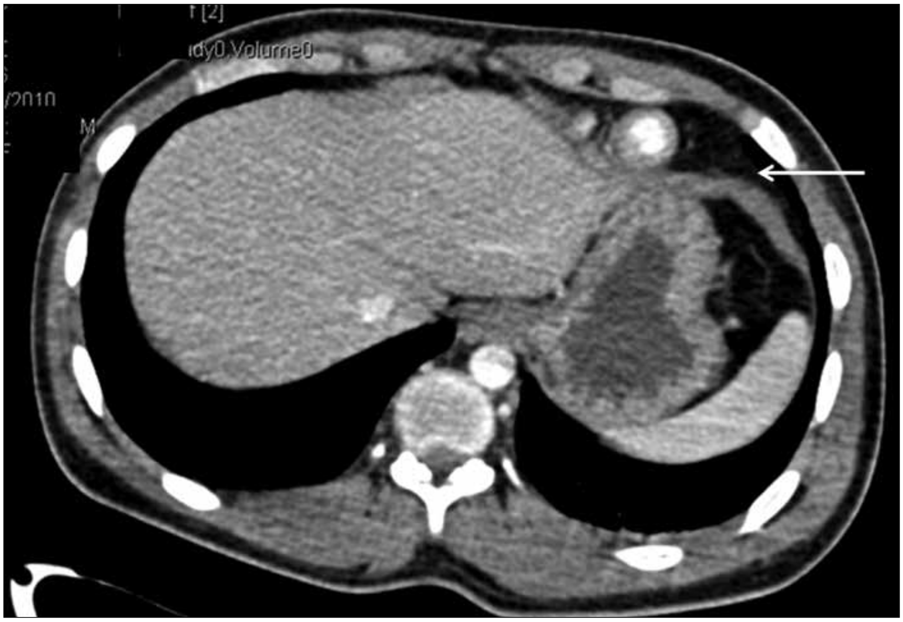

Figure 3. The axial helical CT scan shows thickening of the left hemidiaphragm *(arrow)*.

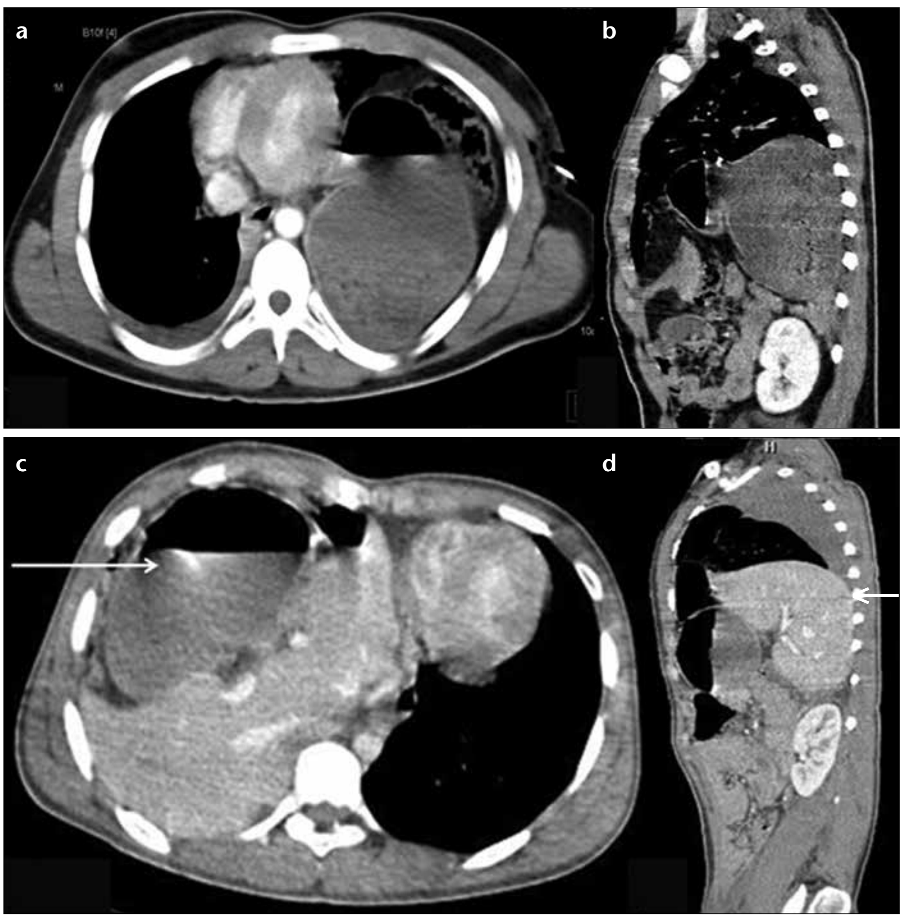

Figure 4. a–d. Axial (a) and sagittal (b) reformatted CT images show the stomach, omentum, and bowel loops lying in the intrathoracic region, causing a mild mediastinal shift to the right. The stomach is directly in contact with the posterior chest wall without the intervening diaphragmatic crus, suggestive of the dependent viscera sign on the left side. Axial (c) and sagittal (d) reformatted CT images of another patient display herniation of the liver and stomach *(long arrow)* into the right side of the thorax, with a mediastinal shift to the left. The posterior aspect of the liver is in direct contact with the posterior right chest wall, suggestive of the dependent viscera sign on the right *(short arrow)*.

More patients with penetrating trauma, compared with blunt trauma, presented contiguous injuries on either side of the diaphragm. This sign was observed in 83.3% (5/6) of penetrating-trauma patients versus 17.7% (3/17) of blunt-trauma patients, indicating that this sign is a significant sign for penetrating trauma.

Discussion

Our results demonstrate that the majority of patients in our study (65.3%) had left-sided injuries. Left-sided injuries have previously been described to be more common than right-sided injuries. This phenomenon has been attributed to the protective effect of the liver on the right and to weakness of the left hemidiaphragm at points of embryonic fusion (7). Moreover, in penetrating trauma, left-sided injuries have been more commonly described due to the higher number of right-handed assailants who preferentially face their victims (8).

We also found certain differences in the frequencies of these signs with respect to the mechanism of injury. In our study, the dependent viscera and collar signs were exclusively observed in blunt-trauma patients, whereas contiguous injury across the diaphragm was an important sign in penetrating trauma. Additionally, organ herniation was observed significantly more often in blunt trauma than in penetrating trauma. Despite traumatic diaphragmatic rupture being more commonly associated with penetrating trauma than with blunt trauma, most of the articles in literature have focused on analysis of the CT signs in blunt trauma (2, 3, 5, 6, 12, 13). The results from such studies cannot be extrapolated to patients with penetrating diaphragmatic trauma because the pathophysiology of blunt and penetrating injuries is different. Blunt traumatic diaphragm injuries are often large (10 cm) due to the impact of the trauma and the sudden rise in the intra-abdominal pressure, and these injuries are observed in the posterolateral aspect, which is the weakest part of the diaphragm (7). By contrast, penetrating trauma due to stab or gunshot wounds cause injury along the trajectory of the weapon, are more variable

Table 2. Comparison of the overall frequency of CT signs in traumatic diaphragmatic rupture

CT signs	Overall (n=23)	Right (n=7)	Left (n=15)	*P*
Discontinuous diaphragm sign[a]	22 (95.7)	6 (85.7)	15 (100)	0.318
Thickening of the diaphragm[a]	16 (69.6)	6 (85.7)	9 (60)	0.350
Organ herniation	15 (65.2)	3 (42.9)	12 (80)	0.145
Dependent viscera sign	13 (56.5)	2 (28.6)	11 (73.3)	0.074
Dangling diaphragm sign	13 (56.5)	3 (42.9)	10 (66.7)	0.376
Collar sign	10 (43.5)	3 (42.9)	7 (46.7)	1.000
Contiguous injury on either side of the diaphragm[a]	8 (34.8)	5 (71.4)	2 (13.3)	0.014

[a]One patient with blunt abdominal trauma had a tear involving the central tendon and hence was not included in the right vs. left analyses.
Data are given as n (%).

Figure 5. a, b. Sagittal **(a)** and coronal **(b)** reformatted CT images show retraction of the cut edges of the left hemidiaphragm, with thickening and inward curling at the site of rupture *(arrows)*, suggestive of the dangling diaphragm sign.

in location and are usually smaller in size (less than 4 cm), unless associated with blast injuries (1, 7). These small defects may be easily missed on the initial CT (and even intraoperatively) unless deliberately sought for, especially when accompanied by other more threatening injuries (14, 15).

Overall, in our study, the discontinuous diaphragm sign was the most frequent sign observed, noted in 22 out of 23 patients (95.7%). The one patient in whom this sign was absent had a right-sided blunt injury and thickening of the diaphragm, although contiguous injury on either side of the diaphragm was also present. This sign has been reported to be quite sensitive (73%–82%) and specific (88%–90%) in blunt trauma (9), with the overall incidence of this sign on conventional CT being 82% (10). Although studies focusing on penetrating trauma have found this sign to have low sensitivity (36%–40%) and high specificity (90%–95%) (1, 7), we observed this sign in all six patients with penetrating trauma, indicating a frequency of 100%.

Because detection of the discontinuous diaphragm sign relies on the contrast provided by fat and because the liver is isoattenuating to the diaphragm on the right side, detection of this sign is reportedly more difficult on the right side unless there is a fatty liver (3, 12). However, we found no significant difference in this sign on both sides. Potential pitfalls of this sign include obscuration of the diaphragm by adjacent atelectasis or hematoma (11) and a false positive diagnosis due to the incidence of diaphragmatic defects in the normal population—an incidence that increases with aging (16), especially in the seventh and eighth decades. However, this factor was not a problem in our study because the mean age of our study population was 29 years. Rarely, congenital hernia may also present with a focal discontinuity of diaphragm in younger patients, but its specific location in the posterolateral aspect (and more on the left side) of the diaphragm, along with the absence of a history of trauma, help in ruling out this entity.

Thickening of the diaphragm, although considered relatively nonspecific in various studies (1, 2, 7), was the second most commonly observed sign in our study, noted in 69.6% (16/23) of patients. The importance of this sign also lies in its presence in our one patient with blunt right-sided injury who was negative for all other signs. Thus, this sign should suggest a possibility of diaphragmatic injury even if it is the only sign present. Confirmation can either be performed by careful follow-up in cases of blunt trauma or intraoperatively for penetrating trauma. There was no significant difference in this sign with respect to the mechanism of injury, whereas Bodanapally et al. (7) found this sign to have a low sensitivity in penetrating trauma.

Organ herniation was the third most common sign in our study, observed in 65.2% (15/23) of patients. This sign has been reported to have a higher sensitivity (55%–81%) and specificity (94%–100%) in blunt trauma (2, 5) compared with the lower sensitivity (48%) and specificity (70%) in penetrating trauma (7). We too observed this sign to be present significantly more in blunt injuries than in penetrating injuries (82.4% vs. 16.7%, $P = 0.009$). Stomach, small intestine and mesenteric herniation were significantly observed on the left side (Table 3), which is likely due to the preponderance of patients with left-sided

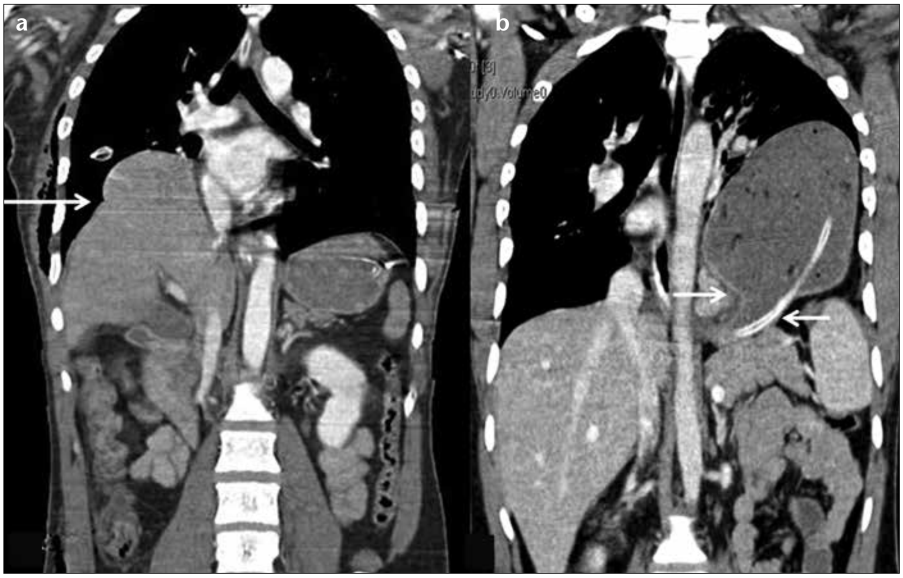

Figure 6. a, b. Coronal reformatted CT image **(a)** shows a rounded portion of the liver herniating through the diaphragm, forming a hump-shaped mass *(arrow)*, which is suggestive of the collar sign on the right. The coronal reformatted CT image of another patient **(b)** displays intrathoracic herniation of the stomach through a defect in the left hemidiaphragm, with a focal constriction of the stomach at the site of herniation *(arrows)*, which depicts the collar sign on the left.

Figure 7. a, b. Coronal **(a)** and sagittal **(b)** reformatted CT images demonstrate liver laceration (with a speck of air within) and transdiaphragmatic injury to the overlying lung, causing hemothorax and lung contusion (**a**, *arrow*). This is suggestive of contiguous injury across the diaphragm. In addition, the diaphragm also exhibits focal thickening and discontinuity (**b**, *arrow*). The outline of the diaphragm is well visualized due to hemothorax and hemoperitoneum on either side.

injuries in the study population. We also had cases with associated splenic and pancreatic herniations, which were exclusively noted in left-sided injuries. Pancreatic herniation associated with diaphragmatic trauma has not been previously described.

Both the dependent-viscera sign and the dangling-diaphragm sign were noted in 56.5% (13/23) of patients in our study. Although there was no significant difference in these signs according to the side of injury, both these signs were observed significantly more often in blunt than in penetrating trauma in our study. The dependent-viscera sign was observed in 76.5% (13/17) of patients with blunt trauma, whereas none of the patients with penetrating trauma manifested this sign. Similarly, Bodanapally et al. (7) found this sign to be 0% sensitive and 100% specific for penetrating trauma. The unreliability of the dependent viscera sign in penetrating trauma has been attributed to the small size of the defect and its variable location (1).

The dangling diaphragm sign was observed more often in blunt trauma than in penetrating trauma, though the difference was not significant (70.6% vs. 16.7%, $P = 0.05$). Although Desser et al. (10) first described this sign in blunt diaphragmatic trauma with a sensitivity of 54% and a specificity of 98% (similar to other signs of blunt diaphragmatic injury), the incidence of this sign in penetrating trauma has not yet been described.

The collar sign was observed in only 10 of our 23 patients; thus, the detection rate of this sign was 43.5%, which is lower than the other signs. This sign was also absent in penetrating trauma because intrathoracic herniation is a prerequisite for identification of the collar sign. Only one patient in our study with penetrating trauma had intrathoracic herniation, but without a waist-like constriction or the collar sign. Because the overall incidence of visceral herniation is lower in penetrating trauma due to the smaller size of the tears, the collar sign may not be very useful in these patients. However, if the collar sign is present, then the diagnosis of diaphragmatic injury should be unequivocally made. The presence of constriction at the site of herniation can differentiate a diaphragmatic tear from other causes of a raised diaphragm, such as focal eventration and diaphragmatic palsy. However, it is important to note that a similar constriction is also occasionally observed in congenital hernias.

Furthermore, similar to Bodanapally et al. (7), we found contiguous injury across the diaphragm sign to be significant in penetrating trauma (observed in five out of six patients [83.3%]), in contrast with the paucity of the other, above-mentioned specific signs in this group of patients (Table 4). Whereas contiguous injury was also observed in three out of 17 patients with blunt trauma, this sign in patients does not

Table 3. Incidence of associated organ herniation

Organ	Right (n=7)	Left (n=15)	*P*
Stomach	1 (8.3)	11 (91.7)	0.016
Spleen	0 (0)	2 (100)	0.455
Small intestine	1 (9.1)	10 (90.9)	0.032
Colon	2 (50)	2 (50)	0.378
Pancreas	0 (0)	2 (100)	0.455
Liver	3 (60)	2 (40)	0.160
Kidney	2 (66.6)	1 (33.3)	0.227
Mesentery	1 (8.3)	11 (91.7)	0.016

Data are given as n (%).

Table 4. Comparison of the frequency of CT signs in blunt vs. penetrating trauma

CT signs	Blunt (n=17)	Penetrating (n=6)	*P*
Discontinuous diaphragm sign	16 (94.1)	6 (100)	1.000
Collar sign	11 (64.7)	0 (0)	0.014
Dependent-viscera sign	13 (76.5)	0 (0)	0.002
Dangling diaphragm sign	12 (70.6)	1 (16.7)	0.052
Organ herniation	14 (82.4)	1 (16.7)	0.009
Thickening of the diaphragm	11 (64.7)	5 (83.3)	0.621
Contiguous injury on either side of the diaphragm	3 (17.7)	5 (83.3)	0.009

Data are given as n (%).

necessarily translate into a tear in the intervening diaphragm because contiguous injury on either side of the diaphragm may be secondary to impact/contusion injuries on both sides of the diaphragm, without an underlying diaphragmatic tear or rupture.

Thus, there are multiple CT signs of diaphragmatic injury. Knowing the mechanism of injury and actively searching the CT scans for the presence of any one of these signs can enable clinicians to diagnose an underlying diaphragmatic injury. While previous studies have commented upon the difference in signs between left and right sides, we did not find any significant difference in the incidence of these signs between the two sides. This result can be explained by the fact that all our patients underwent MDCT scanning with high-quality reformatting, which improved our diagnostic ability and obviated earlier problems, such as the inability to visualize the right hemidiaphragm due to lack of inherent tissue contrast.

However, we found a significant difference in the frequency of these signs with respect to the mechanism of trauma. If the mechanism of trauma is known, then it is advisable to look for specific signs while evaluating CT to avoid a missed diagnosis.

There were certain limitations in our study. The first limitation is that because our study was a retrospective investigation, the radiologists were aware that all patients had surgically confirmed diaphragmatic tears. This fact introduced a type of observer bias in the consideration of all signs of diaphragmatic injury. Because we did not evaluate the CT scans of patients with intraoperatively proven normal diaphragms, we also could not comment upon the specificity and sensitivity of the individual signs. Additionally, the small sample size of the study could explain some of the discordant results, such as the lack of a significant difference in signs between the right and left sides. However, it should be noted that a small sample size is a general problem in studies of diaphragmatic injury due to the relative rarity of cases. Another potential limitation is that we have not analyzed all the described CT signs of diaphragmatic injury, such as the sinus cut-off sign, fractured ribs, a hypoattenuated diaphragm and diaphragmatic/peridiaphragmatic contrast extravasation, as enumerated by Desir and Ghaye (8). Nonetheless, because detection of these signs depends on associated injuries (such as the presence of a pleural effusion in the sinus cut-off sign and in rib fracture/laceration), it was not possible to universally analyze these signs in all our patients (8, 17). Moreover, signs such as diaphragmatic and peridiaphragmatic contrast extravasation, pneumothorax, hemothorax, pneumoperitoneum and hemoperitoneum are more likely due to associated chest, liver and spleen injuries rather than diaphragmatic injury (7).

In conclusion, knowledge of the mechanism of injury and familiarity with all CT signs of diaphragmatic injury is ideal to avoid a missed diagnosis because there is variability in the overall occurrence of these signs, with significant differences in the incidence of these signs between blunt and penetrating trauma. Intrathoracic herniation, and the collar and dependent viscera signs were significantly observed in blunt injury, whereas contiguous injury on either side of the diaphragm was the most helpful sign for diagnosing diaphragmatic injury in penetrating trauma. Because this study was a retrospective analysis, a further prospective study can be undertaken to specifically evaluate the difference between the signs in blunt and penetrating diaphragmatic injuries.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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