



TRAUMATIC DIAPHRAGMATIC HERNIA: CASE SERIES AND TOPIC REVIEW

HERNIA DIAFRAGMÁTICA TRAUMÁTICA: SERIE DE CASOS

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SUMMARY

The diaphragmatic hernia is defined as a defect in the continuity of muscular fibers which allow communication among abdominal and thoracic cavities. Diaphragmatic hernias can have a congenital origin as a result of the alteration in the fusion of pleuroperitoneal membranes or in the formation of the transverse septum during development, which origin can be traumatic as a consequence of a muscle tear due to penetrating, iatrogenic injuries or due to blunt abdominal trauma. The traumatic diaphragmatic hernia diagnosis is based on images studies. Conventional chest x-rays remains as the initial evaluation method in patients with a suspicion of a traumatic tear of the diaphragm. Sensitivity between 27 and 73% has been described. Multiple detector computed tomography (MDCT) has become the diagnosis method for patients with traumatic diaphragmatic hernia suspicion. Studies have proven that the sensitivity of this method ranges between 71 - 90% and a specificity between 98 and 100%. We present a series of 10 patients with traumatic diaphragmatic hernia diagnosed through MDCT, with a manifestation checkup carried out by the conventional radiology and the MDCT of this entity.

RESUMEN

La hernia diafragmática se define como un defecto en la continuidad de las fibras musculares, que permite la comunicación entre las cavidades abdominal y torácica. Las hernias diafragmáticas pueden ser de origen congénito, producto de la alteración en la fusión de las membranas pleuroperitoneales o en la conformación del *septum* transverso durante el desarrollo y de origen traumático como consecuencia del desgarro muscular secundario a lesiones penetrantes, iatrogénicas o por trauma cerrado. El diagnóstico de hernia diafragmática traumática se basa en los estudios de imágenes. La radiografía convencional de tórax permanece como el método de valoración inicial en los pacientes con sospecha de ruptura traumática del diafragma. Se ha descrito una sensibilidad entre el 27% y el 73%. La tomografía computarizada de detector múltiple (TCDM) se ha convertido en el método de diagnóstico de elección en pacientes con sospecha de hernia diafragmática traumática; los estudios han demostrado sensibilidad de este método entre el 71% y el 90%, y especificidad entre el 98% y el 100%. Se presenta una serie de diez pacientes con hernia diafragmática traumática diagnosticada por TCDM, con una revisión de las manifestaciones de esta entidad en radiología convencional y en TCDM.

Introduction

The diaphragm comprises a series of muscular and tendinous fibers, forming a sheath that separates the thoracic cavity from the abdominal cavity. Specific sites of the diaphragm are more prone to ruptures as a consequence of normal embryological development. Depending on the mechanism of in-

jury, the diaphragm will tear at specific anatomical locations (1).

Patients with penetrating injuries in the thoracoabdominal region require a surgical approach to confirm the presence of a diaphragmatic rupture. However, in patients with blunt or non-penetrating trauma who do not require immediate surgical treatment, the diagnosis

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of a diaphragmatic hernia remains a challenge for the radiologist (2). Conventional radiography is still the standard imaging technique, although in most cases findings are nonspecific (3). Multi-Detector Computed Tomography (MDCT), a Computerized Axial Tomography (CAT) variant, is the diagnostic imaging modality of choice, given its ability to generate nearly isovolumetric multiplanar reconstructions. Given the above, since tomography does not provide a definitive diagnosis magnetic resonance has become a useful diagnostic tool in cases requiring further confirmation (4).

The aim of this work is to present the most important findings over the past five years in patients with traumatic diaphragmatic hernia diagnosed by tomography, as well as to review signs commonly present in imaging tests of patients afflicted with this condition.

Methodology

Ten patients coming from two fourth-level healthcare institutions were included, all of them with a diagnosis of traumatic diaphragmatic hernia as suggested by a CAT scan and later confirmed during surgery. The tests were performed over the past five years in multi-detector CAT scanners, bearing four or sixteen detectors. Resulting images were retrospectively analyzed to a consensus by two radiologists with extensive experience in thoracic radiology.

The descriptions of radiologic and tomographic findings were recorded in a form which included alterations described in imaging assessments of patients with traumatic diaphragmatic hernia. Demographic data was gathered from the patient's clinical records, including age, sex, and mechanism of injury and location of the diaphragmatic rupture.

Results

Ten patients were included in the study: five with a previous penetrating trauma (wound by sharp weapon) and five with a history of non-penetrating trauma. Eight of the patients were male and two were female, and ages ranged from 1 to 66 years old (table 1). The form assessed the following findings:

- Alterations in conventional radiography tests.
- Intestinal loops or air-fluid levels in the thoracic cavity.
- Abnormal route of the nasogastric tube.
- Elevated hemidiaphragm.
- Collar sign (or hour glass sign)
- Diaphragm contour abnormalities.
- Deviation of the cardiomedastinum towards the non-affected side.
- Other traumatic thoracic injuries: Pulmonary contusion, pneumothorax and rib fractures.
- Pleural effusion.

Alterations in the MDCT: Abrupt loss of diaphragmatic continuity.

- Thickening of the free edge.
- Dangling diaphragm sign.
- Diaphragm not visualized.
- Protrusion of abdominal organs or peritoneal fat into the pleural space.
- Collar sign.
- Dependent viscera sign.
- Hump sign. Indirect signs associated with the communication between the thoracic and abdominal cavities, such as simultaneous pneumothorax and pneumoperitoneum or hemothorax and hemoperitoneum.
- Hypoattenuation of the diaphragm.

- Irregular or scalloped thickening of the muscular fibers of the diaphragm.
- Rib fracture displaced towards, or in direct contact with, the diaphragm.

Each of the ten patients presented an abnormal thoracic radiography. The most common alterations were: Air-fluid levels in the thoracic cavity, loss of contours and elevation of the hemidiaphragm (table 2). Radiographic findings suggested a diaphragmatic hernia in four patients, two of which presented a right-sided tear and collar sign. An evident diagnosis was made in one case by means of a barium contrast, showing herniation of the splenic flexure of the colon to the thoracic cavity (figure 1). None of the patients had the tip of the nasogastric tube above the hemidiaphragm.

For MDCT tests, the most common signs were: Loss of diaphragm continuity and protrusion of abdominal organs into the pleural space (present in eight of the patients). All of the patients presented at least two signs of diaphragmatic rupture (table 3). Out of the nine cases where a tomography was performed, eight had the presumptive diagnosis confirmed later on. None of the patients presented pneumothorax and pneumoperitoneum simultaneously, and only one out of nine presented the dangling diaphragm sign.

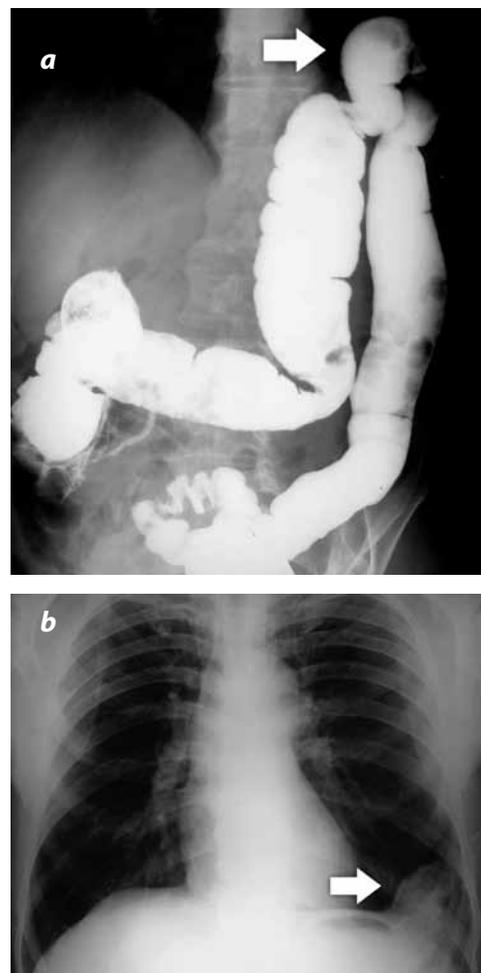


Figure 1. (a). Abdominal radiography with alteration of the left diaphragmatic contour and presence of air-fluid levels. (b) Barium enema evidencing protrusion of the splenic flexure into the thoracic cavity.

Table 1. Traumatic Diaphragmatic Hernia: Patient Description

	Age	Gender	Mechanism of injury	Side of Rupture	Radiological Findings	Tomographic Findings
1	25 years	M	ISBW**	Right	Collar sign	Loss of diaphragm continuity; curving of the free edge; colon and fat protrusion into the pleural space
2	47 years	M	ISBW	Left	Elevated hemidiaphragm; loss of hemidiaphragm contour; air-fluid levels in the thoracic cavity	Loss of diaphragm continuity; curving of the free edge; colon and fat protrusion into the pleural space
3	48 years	M	ISBW	Right	Elevated hemidiaphragm; air-fluid levels in the thoracic cavity.	Protrusion of intra-abdominal organs, kidney, hepatic flexure of the colon into the thorax; dependent viscera sign
4	39 years	M	ISBW	Left	Alteration of the diaphragm contour; air-fluid levels	Not performed. Barium enema shows splenic flexure protruding into the thoracic cavity
5	51 years	M	Non-perforating	Right	Elevated hemidiaphragm; Collar sign	Collar sign; dependent viscera sign; hypodense band at the hernia location
6	66 years	F	Non-perforating	Left	Air-fluid levels in the left hemithorax Disappearance of the costophrenic angle due to pleural effusion	Defect in diaphragm continuity; thickening and scalloping of the free edge
7	37 years	M	ISBW	Right	Air-fluid levels in the thorax; loss of hemidiaphragm contour; elevated hemidiaphragm	Dependent viscera sign; loss of diaphragm continuity; thickening of the free edge Protrusion of the liver into the thoracic cavity
8	9 years	F	Non-perforating	Right	Elevated hemidiaphragm; loss of contours	Protrusion of the liver into the pleural space; dependent viscera sign; thickening of the free edge at the rupture site
9	49 years	M	ISBW	Left	Air-fluid levels in the left hemithorax	Loss of continuity in the left hemidiaphragm; thickening of the free edge; protrusion of the intestinal loops into the thoracic cavity
10	29 years	M	ISBW	Left	Disappearance of the costophrenic angle due to pleural effusion	Defect in the continuity of the left hemidiaphragm; fat and colonic loops protruding into the pleural space

*ISBW: Injury by sharp/bladed weapon.

Table 2. Radiological findings

Patient	Intestinal loops or air-fluid levels in the thoracic cavity	Abnormal route of the nasogastric tube	Elevated hemidiaphragm	Collar sign	Abnormal contours of the diaphragm	Deviation of the cardio-mediastinum	Other associated injuries	Pleural effusion	Total
1	-	-	-	+	+	-	-	-	2
2	+	-	+	+	+	-	-	-	4
3	+	-	+	-	+	-	-	-	3
4	+	-	-	+	+	-	-	-	3
5	-	-	+	-	+	-	-	-	2
6	+	-	+	-	+	-	-	+	2
7	+	-	+	-	-	-	-	-	2
8	-	-	+	-	+	+	-	-	3
9	+	-	+	-	-	-	-	-	2
10	-	-	-	-	-	-	-	+	1
Total	6	0	6	3	5	1	0	1	

Table 3. Tomographic findings

Patient	Loss of continuity	Thickening of the free border	Diaphragm dangling	Absence of the diaphragm	Protrusion of organs into the pleural space	Collar sign	Dependent viscera sign	Hump and hypodense band	Other	Total
1	+	+	-	-	+	+	+	-	-	5
2	+	-	+	+	+	-	-	-	-	4
3	-	-	-	+	+	-	+	-	-	3
4	-	-	-	-	-	-	-	-	-	NA
5	+	-	-	-	+	+	+	+	-	5
6	+	+	-	-	-	-	-	-	-	2
7	+	+	-	-	+	+	+	+	-	6
8	+	+	-	-	-	-	+	-	-	4
9	+	+	-	-	+	-	-	-	-	3
10	+	-	-	-	+	-	-	-	-	2
Total	8	5	1	2	8	3	5	2	0	

Discussion

77 to 95% of all traumatic diaphragmatic hernias occur along a non-perforating trauma due to car accidents or falls, with an incidence of 0.16 to 5% in non-perforating trauma cases. This incidence rate is higher in patients with penetrating trauma in the thoracoabdominal region, ranging from 12.3 to 20%. 7 to 66% of traumatic diaphragmatic hernias associated with a non-perforating trauma are not diagnosed in the acute event, mainly because of symptoms related to lesions in other organs or nonspecific findings in chest x-rays (5). Mortality rates due to traumatic diaphragmatic hernia range from 5.5 to 51%, a situation more closely associated with injuries in different organs.

The pattern of rupture depends on the force vectors that develop during impact. Lateral impacts cause an anteroposterior elongation of the thoracic wall with subsequent rupture of the diaphragm or detachment of its insertions. Frontal impacts increase intra-abdominal pressure abruptly, transmitting the impact to the pillars of the diaphragm and conditioning its rupture. A rib fracture or injury may cause the rupture of the diaphragmatic insertion, with transverse rupture of the diaphragmatic dome in extreme cases (6,7).

The rupture of the diaphragm is more frequent in lateral impacts and usually tears towards the side where the impact was received. Frontal impacts pose a greater risk of compromising the left side, but frequency for both sides is the same in posterior impacts (8).

In non-penetrating traumas, the greater resistance of the right hemidiaphragm and the protection the liver provides reflects in less frequent ruptures on this side (12-40%), whereas tears on the left side occur in 50 to 88% of cases (6, 9).

Traumatic diaphragmatic hernia is associated with the injury of intrathoracic and intra-abdominal organs in 44 to 100% of all cases (8, 10). Spleen and liver trauma are the most common, with renal, aortic, cardiac and bone (spine and pelvis) traumas being less frequent (8).

Clinical manifestations vary, depending on which viscera are displaced through the rupture in the diaphragm to the pleural space: dyspnea,

thoracic pain, shoulder pain, (9, 10) or digestive symptoms, among others (11-14). When the defect in the continuity of the muscular fibers is small, organs protruding to the thoracic cavity may experience ischemia and necrosis, negatively affecting the prognosis (15).

Herniation of the viscera to the thorax may or may not occur after a rupture of the diaphragm. Nevertheless, within three years 80% of patients experience some degree of protrusion of the abdominal organs to the pleural space (16), a condition favored by Valsalva maneuvers, pregnancy and other additional traumas.

Diverse associated injuries may occur when the diaphragm tears, such as pleural effusion, empyema, intrathoracic splenosis due to rupture of the spleen, and venous obstruction due to the deviation of the cardiomeastinum. (12).

Thoracic radiography continues to be the initial diagnostic imaging procedure when facing either a penetrating or non-penetrating trauma. It can yield normal or nonspecific results in 20 to 50% of cases (1) and the presence of atelectasis, subphrenic accumulations, pleural effusions, pulmonary contusions and other conditions limit the diagnosis (1,16). In 1991, Gelman and collaborators carried out a retrospective study of fifty patients with non-penetrating traumas and confirmed diaphragmatic hernia diagnoses. They found ruptures in the left side of the diaphragm of 44 patients (88%), out of which 36 had other associated injuries such as splenic trauma, pelvic fracture and rupture of the bladder wall. Twenty patients (46%) had diagnostic or highly suggestive radiographies. Five of them had virtually normal X-rays at the time of admission, but after five hours the radiological findings were definitive. In this study, the most important symptoms were: the presence of air-fluid levels, the tip of the nasogastric tube above the diaphragm and an elevated hemidiaphragm (5). Our case series includes ten patients with abnormal radiographies, six of which also had an elevated diaphragm (figure 2) and presence of air-fluid levels (figure 3) in the thoracic cavity, both strongly suggestive of a diaphragmatic hernia.

Echographic examination of patients with non-penetrating trauma (echo-fast) allows for lung bases analysis and the suggestion of a diaphragmatic rupture, observing the absence of diaphragmatic excursion (in patients without assisted respiration), loss of continuity or protrusion of the viscera to the pleural space. Studies conducted to this moment had not included a large patient sample, which limits the sensitivity and specificity of this diagnostic method. Bialvas and collaborators described, in 2004, some echographic signs found in these patients including the impossibility to visualize of the diaphragm, the loss of its continuity, herniation of viscera to the thorax and the absence of diaphragmatic excursion (17).

Hence, CAT constitutes the diagnostic method of choice for diaphragmatic hernias. Several tomographic signs have been described and classified into three categories, as follows: direct, indirect and associated with traumatic diaphragmatic hernia.

Direct signs

- Abrupt loss of diaphragm continuity (12, 18-20) associated with a thickening of the free edge due to retraction or hemorrhage (figures 4 and 10). More easily spotted when the defect is small or in contact with the abdominal fat or the aerated lung. This sign has a sensitivity ranging from 17 to 80%, with a specificity of 90 to 100% (2, 4, 10, 21-23).
- No visualization of the hemidiaphragm. A sign commonly related to large hernial defects (figure 5). This sign has a specificity of 91% and a sensitivity ranging from 18 to 43% (19, 21, 23).
- Dangling diaphragm sign. A comma-shaped curving of the free edge at the rupture site (figure 6). Associated with the focal thickening of the torn diaphragmatic edge. This sign has a specificity of 98% and a sensitivity of 54% (22).

Indirect signs

- Protrusion of abdominal organs or peritoneal fat into the pleural space (figure 7). This sign has a specificity of 98% and a sensitivity ranging from 50 to 95% (2, 10, 19, 23).
- Collar sign. A sign secondary to the compression of a herniated structure at the site of rupture (20) (figures 8a and 8b). The radiologist should take into account that this image can also be a product of a diaphragmatic displacement, hepatic lacerations or artifacts caused by breathing (2, 12).
- Dependent viscera sign. A reference to the herniated abdominal organ in direct contact with the posterior thoracic wall (figure 4). This sign has no interposition of the lung parenchyma. Axial sections usually show the spleen, liver, stomach and intestinal loops suspended above the diaphragm and separated from the posterior thoracic wall by the lung parenchyma. The loss of diaphragmatic support causes abdominal viscera to slightly drop, due to gravity, into contact with the posterior thoracic wall. This sign has a specificity ranging from 54 to 90% and a sensitivity ranging from 98 to 100% (7, 12, 24).
- Hump sign. A consequence of hepatic herniation (Figure 9). Most of the times it is related to a hypodense band in the hepatic parenchyma between the torn diaphragm edges, a consequence of a compression-driven hypoperfusion condition.
- Elevated abdominal organs. The cephalic displacement of abdominal organs causes the contralateral hemidiaphragm to be at a lower level. A coronal reconstruction could suggest a rupture if a displacement of more than 5 cm in the right side and 4 cm in the



Figure 2. Girl, 9 months old. Fell from a certain height. Presented pneumothorax. Thoracic radiography showed elevated right hemidiaphragm and loss of contours. Thoracotomy tube inserted for pneumothorax management.

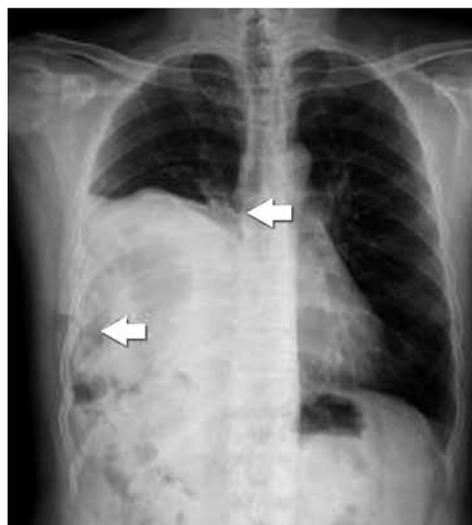


Figure 3. Male, 48 years old. History of sharp weapon injury eight months earlier. Thoracic X-rays revealed elevation of the diaphragm and air-fluid levels in the thoracic cavity.



Figure 4. Male, 25 years old. History of sharp weapon injury in the thoracoabdominal region two years earlier. Admitted for pain and dyspnea. Thoracic axial section tomography: abrupt loss of diaphragm continuity with protrusion of the abdominal organs to the pleural space. Specifically liver, colon and gallbladder. Dependent viscera sign.



Figure 5. Male, 47 years old. History of sharp weapon injury 14 months earlier. Admitted for a two-hour picture of retrosternal chest pain. Patient underwent thoroscopic surgery. Hernial contents found during the intervention: omentum, transverse and descending colon. Axial section chest CAT scan did not show the diaphragm but a rupture is inferred from the noticeable displacement of loops into the pleural space.

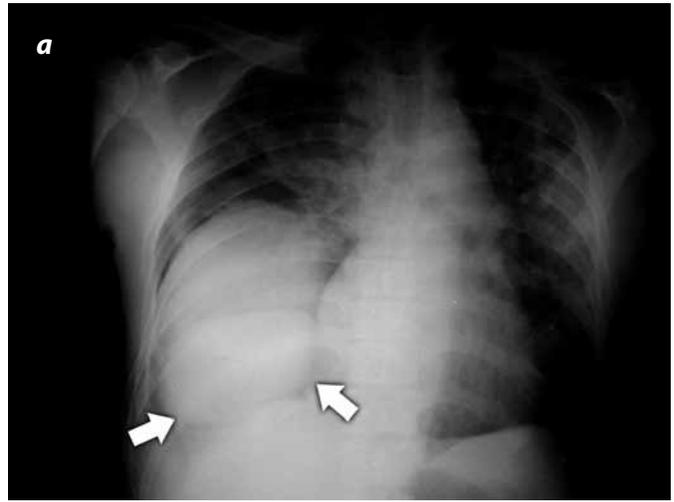


Figure 8. Male, 25 years old. History of sharp weapon injury 3 years earlier. (a) Thorax radiography. (b) Thoracic tomography for coronal reconstruction. Collar sign due to compression of the herniated liver into the thoracic cavity.



Figure 6. Female, 66 years old. Car accident. Multiple trauma. A coronal reconstruction with a chest CAT scan reveals a defect in the left hemidiaphragm continuity with a curving of the free edge. Intestinal loops protruding into the thoracic cavity.



Figure 7. Male, 29 years old. Sagittal section tomography. History of sharp weapon injury 6 months earlier. Patient has a diaphragmatic incarcerated hernia with intestinal loops edema.



Figure 9. Male, 51 years old. Non-penetrating trauma due to a fall. CAT scan for coronal reconstruction reveals protrusion of the liver into the thorax. Hump sign.

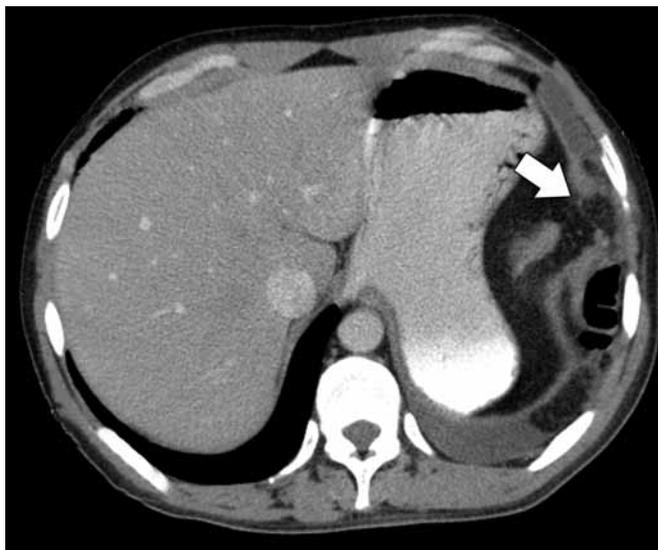


Figure 10. Male, 49 years old. History of sharp weapon injury two months earlier. Initial radiography reveals a pleural effusion. Chest CAT scan points out a loss in the continuity of the left hemidiaphragm, along with thickening of the free edge and protrusion of intestinal loops into the thoracic cavity.

right side is found. We highlight that an elevated hemidiaphragm could be a simple anatomical variation or may indicate eventration, paralysis of the diaphragm or presence of subpulmonary fluid. Therefore, this sign should not be considered a diagnostic tool of diaphragmatic hernia by itself (5, 21).

Some signs are closely related to the communication between the abdominal and thoracic cavities, such as the presence of simultaneous pneumothorax and pneumoperitoneum or hemothorax and hemo-peritoneum, or the visualization of abdominal viscera in contact with thoracic fluid (2, 21).

Several findings that may indicate a rupture have been described, such as extravasation of diaphragmatic or peridiaphragmatic contrast dye in penetrating injuries (22, 25), hypoattenuation of the diaphragm due to hypoperfusion (21), the thickening of the diaphragm in an irregular or scalloped pattern (21) and the presence of a rib fracture displaced in direction of, or in close contact with, the diaphragm.

The sensitivity and specificity of the tomographic signs varies depending on the characteristics of the tomography equipment used. In 2002, Larici and collaborators carried out a retrospective study with helical tomography equipment, using multiplanar reconstructions of 47 patients, 25 of them with confirmed diagnoses of traumatic diaphragmatic hernia. Their study yielded a sensitivity estimate of 84%, a specificity of 77%, a Positive Predictive Value (PPV) of 81% and a Negative Predictive Value (NPV) of 81% (25).

Nichim and collaborators also did a retrospective study in 2005, using helical tomography equipment with a sample of 179 non-penetrating trauma patients, 16 of them cases of traumatic diaphragmatic hernia. Their findings revealed that the sign with the highest sensitivity was the presence of abdominal organs in the thoracic cavity (90.9%). The collar and dependent viscera signs had a specificity of 100% (21).

Desser and collaborators, in 2010, used multisection tomography equipment for a retrospective study in 48 patients, 16 of them with confirmed diaphragmatic hernia diagnoses. Their study aimed to describe the dangling diaphragm sign. According to their observations, this sign has a sensitivity of 54% and a specificity of 98% (22).

The presented case series is based on multisection tomography equipment imaging, and multiplanar reconstructions were decisive for the diagnoses of six patients. The loss of diaphragm continuity and the protrusion of organs into the pleural space were the most frequent tomographic findings.

In patients with non-conclusive tomographic tests and a high suspicion of rupture, spin-echo axial, coronal and sagittal T1-weighted magnetic resonance sequences and gadolinium-containing contrast agents allows for substantially improved visualization of the described signs. In these images, the diaphragm will be observed as a low-intensity band (10, 26), and are most useful in patients with a stable hemodynamic status. The use of gadolinium facilitates the valuation of the diaphragm in patients with pulmonary contusions or atelectasia, increasing their contrast (26).

Shanmugatanan carried out a retrospective study in 1996 using 1.5T resonators and T1-weighted sequences in 16 non-penetrating trauma patients, where he calculated the specificity of magnetic resonance at 100%. Gradient echo sequences did not provide a level of detail comparable to images acquired through T1-weighted scans. The diaphragm was observed as a low-intensity structure in both sequences, but abdominal and mediastinal fat favored the delimitation of diaphragmatic muscular fibers in spin-echo sequences (10).

The treatment of a traumatic diaphragmatic hernia is always surgical (27). According to the timing of the diagnosis and the patient's condition, the surgeon will decide on the best approach for the reparation of the hernia, choosing either an abdominal or a thoracic point of entry.

In this case series the main cause of traumatic diaphragmatic hernia was penetrating trauma, a fact most likely due to the hospital's location in economically-depressed areas of Bogotá and the vulnerable population requiring its healthcare services. Every patient received surgical treatment. Diagnosis in patients with penetrating trauma was not made initially, but rather during the following three years when they returned to the emergency room as a consequence of pain or a new associated trauma. The ultrasound scan performed on each patient during admittance did not suggest or reveal the presence of a diaphragmatic rupture. A magnetic resonance was not requested since tomography and radiology confirmed the diagnoses.

Conclusions

Traumatic diaphragmatic hernia is a relatively uncommon injury in penetrating and non-penetrating thoracoabdominal traumas. Patients presenting trauma due to a penetrating injury require surgical examination at the time of diagnosis. The conservative approach to non-penetrating trauma steers the physician into clinical suspicion with the initial thoracic radiography. Multidetector CT equipment tomography and multiplanar examination improve diagnostic accuracy. Diagnosis can be confirmed in presence of two or more tomographic signs. In this case series, five out of ten patients had a rupture of the diaphragm due to penetrating trauma; this is likely related to the location of the hospitals and the particularly vulnerable population being attended there, but it should not be considered a representative statistic of the population of Bogotá.

References

1. Iochum S, Ludig T, Walter F, et al. Imaging of diaphragmatic injury: a diagnostic challenge? *Radiographics*. 2002;22:(Suppl)S103-16.
2. Beigi AA, Masoudpour H, Sehat S, et al. Prognostic factors and outcome of traumatic diaphragmatic rupture. *Ulus Travma Acil Cerrahi Derg*. 2010;16:215-9.
3. Kitada M, Ozawa K, Satoh K, et al. Recurrent diaphragmatic hernia 3 years after initial repair for traumatic diaphragmatic rupture: a case report. *Ann Thorac Cardiovasc Surg*. 2010;16:273-5.

4. Killeen KL, Mirvis SE, Shanmuganathan K. Helical CT of diaphragmatic rupture caused by blunt trauma. *AJR Am J Roentgenol.* 1999;173:1611-6.
5. Gelman R, Mirvis SE, Gens D. Diaphragmatic rupture due to blunt trauma: sensitivity of plain chest radiographs. *AJR Am J Roentgenol.* 1991;156:51-7.
6. Panicek DM, Benson CB, Gottlieb RH, et al. The diaphragm: anatomic, pathologic, and radiologic considerations. *Radiographics.* 1988;8:385-425.
7. Sangster GP, González-Beicos A, Carbo AI, et al. Blunt traumatic injuries of the lung parenchyma, pleura, thoracic wall, and intrathoracic airways: multidetector computer tomography imaging findings. *Emerg Radiol.* 2007;14:297-310.
8. Chughtai T, Ali S, Sharkey P, et al. Update on managing diaphragmatic rupture in blunt trauma: a review of 208 consecutive cases. *Can J Surg.* 2009;52:177-81.
9. Scharff JR, Naunheim KS. Traumatic diaphragmatic injuries. *Thorac Surg Clin.* 2007;17:81-5.
10. Shanmuganathan K, Killeen K, Mirvis SE, et al. Imaging of diaphragmatic injuries. *J Thorac Imaging.* 2000;15:104-11.
11. Freixinet Gilart J, Hernández Rodríguez H, Martínez Vallina P, Moreno Balsalobre R, Rodríguez Suárez P; SEPAR. Guidelines for the diagnosis and treatment of thoracic traumatism. *Arch Bronconeumol.* 2011;47:41-9.
12. Morgan BS, Watcyn-Jones T, Garner JP. Traumatic diaphragmatic injury. *J R Army Med Corps.* 2010;156:139-44.
13. Rashid F, Chakrabarty MM, Singh R, et al. A review on delayed presentation of diaphragmatic rupture. *World J Emerg Surg.* 2009;4:32.
14. Al-Refai RE, Awad E, Mokbel EM. Blunt traumatic diaphragmatic rupture: a retrospective observational study of 46 patients. *Interact Cardiovasc Thorac Surg.* 2009;9:45-9.
15. Demirhan R, Onan B, Oz K, et al. Comprehensive analysis of 4205 patients with chest trauma: a 10-year experience. *Interact Cardiovasc Thorac Surg.* 2009;9:450-3.
16. Shackleton KL, Stewart ET, Taylor AJ. Traumatic diaphragmatic injuries: spectrum of radiographic findings. *Radiographics.* 1998;18:49-59.
17. Blaivas M, Brannam L, Hawkins M, et al. Bedside emergency ultrasonographic diagnosis of diaphragmatic rupture in blunt abdominal trauma. *Am J Emerg Med.* 2004;22:601-4.
18. Holland DG, Quint LE. Traumatic rupture of the diaphragm without visceral herniation: CT diagnosis. *AJR Am J Roentgenol.* 1991;157:17-8.
19. Heiberg E, Wolverson MK, Hurd RN, et al. CT recognition of traumatic rupture of the diaphragm. *AJR Am J Roentgenol.* 1980;135:369-72.
20. Van Hise ML, Primack SL, Israel RS, et al. CT in blunt chest trauma: indications and limitations. *Radiographics.* 1998;18:1071-84.
21. Nchimi A, Szapiro D, Ghaye B, et al. Helical CT of blunt diaphragmatic rupture. *AJR Am J Roentgenol.* 2005;184:24-30.
22. Desser TS, Edwards B, Hunt S, et al. The dangling diaphragm sign: sensitivity and comparison with existing CT signs of blunt traumatic diaphragmatic rupture. *Emerg Radiol.* 2010;17:37-44.
23. Worthy SA, Kang EY, Hartman TE, et al. Diaphragmatic rupture: CT findings in 11 patients. *Radiology.* 1995;194:885-8.
24. Cantwell CP. The dependent viscera sign. *Radiology.* 2006;238:752-3.
25. Larici AR, Gotway MB, Litt HI, et al. Helical CT with sagittal and coronal reconstructions: accuracy for detection of diaphragmatic injury. *AJR Am J Roentgenol.* 2002;179:451-7.
26. Mirvis SE, Shanmuganagthan K. Imaging hemidiaphragmatic injury. *Eur Radiol.* 2007;17:1411-21.
27. García-Navarro A, Villar-Del Moral JM, Muffak-Granero K, et al. [Traumatic diaphragmatic rupture]. *Cir Esp.* 2005;77:105-7.

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