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Retrocrural Space Obliteration as CT Diagnostic Sign of Massive Chylothorax in Thoracic Injuries

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Authors' contributions

Author MM designed the study, wrote the protocol and performed statistical analysis. Authors MV, CDD, IM, GP, GM and LT found patients and performed literature searches. Author LC performed linguistics adaptations. Authors MI, MR and VD supervised the work and gave the final approval of the version to be published. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Purpose: Blunt traumatic chylothorax could be distinguished in CT (Computer Tomography) scan as low attenuated fluid, due to chylomicrons inside, however blood intermixture in chylous effusion could make densitomery higher and hide chylothorax, due to the possible presence of an underlying hemothorax. The objective of the study is to demonstrate the specificity of retrocrural space obliteration, as additional CT sign to quickly identify and treat chylothorax.
Materials and Methods: This retrospective study was undertaken since May 2012 until May 2013 and included patients scheduled for MDCT (Multi Detector CT) scan before a thoracentesis procedure diagnostic for hemothorax and chylothorax. Were used as a controls, MDCT scans performed for thoracic or thoracic-abdominal trauma, or after a

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thoracic surgery procedure.
Results: Comparison of CT findings revealed significant difference in densitometry between the two groups of effusions (P=0,003), a difference in inability of visualization of retrocrural space (P=0,0002) and cisterna chily (P=0,0009). Inability to observe thoracic duct was not different between the two groups (P=0,8805).
Conclusion: Negative density (-16,7+8HU) in effusions, due to the presence of fat inside, was usually observed in almost 6 anterior regions or at least 2 upper anterior regions and it's the best way to distinguish a chylo-thorax to hemo-thorax. Most accurate CT scan differentiation between post traumatic massive bloody and chylous leakage can be done after assessment of a lower densitometry of effusion and inability in observing chylous structures and fat in retrocrural space due to chylous leakage inside.

Keywords: Chylothorax; chyloperitoneum; CT scan; thoracic duct; cisternaa Chyli; retro-crural space.

ABBREVIATIONS

MDCT: Multi detector computed tomography; XR: X Ray; MIP: Maximum intensity projections; MPR: Multi planar reformations; VR: Volume rendering; ED: Emergency department.

1. BACKGROUND

Bilateral lumbar-lymphatic trunks flow into a lymphatic structure located in the retrocrural space [1], named Cisterna Chyli, to the right side and behind the abdominal aorta at the lower border of the T12 or L1-L2 vertebral body [2]. Retrocrural space is defined as a triangular region in the most inferior portion of the posterior mediastinum, delimited anteriorly and laterally by the diaphragmatic crura, posteriorly by the distal thoracic and proximal lumbar vertebral bodies [3] in addition to cisterna chyli and thoracic duct, normal structures within the retrocrural region comprehend aorta, nerves, the azygos and hemiazygos veins, fat, and lymph nodes. Chylous reflux in thorax, named Chylo-thorax (Fig.1) may develops secondary to damage or obstruction of the thoracic lymphatic vessels or cisterna Chyli [4]. The causes of this condition can be divided into two main groups: traumatic (including iatrogenic) and nontraumatic. Thoracic duct (Fig.2) traumatisms constitute the majority, mainly iatrogenic thoracic procedure, such as central vein catheterization, major lobectomies, or oesophageal resections [5,6]. Only 2.6% of chylothorax has a traumatic non-iatrogenic aetiology, particularly, blunt chest trauma with vertebral fracture [7]. Unremitting chylothorax, it's a condition that has more than a 50% mortality rate if it is not promptly corrected [8]. Conservative management is recommended at first and include chest drain insertion, a medium chain triglyceride diet and sometimes total parenteral nutrition. Aggressive surgical or interventional radiology therapy with ligation or embolization of thoracic duct is recommended for post-traumatic or post-surgical chylothorax if conservative management fails [9]. Blunt traumatic chylothorax is a rare condition however, the diagnosis could be sometimes difficult in the trauma setting due to the possible presence of an underlying hemothorax or empyema [10].

Usually chylothorax could be distinguished in CT (Computed Tomography) scan as low attenuated fluid, due to chylomicrons [11] rising from lymphatic system draining the gut [12], however blood intermixture in chylous effusion could make densitomery higher and hide chylothorax [13]. The objective of the study is to demonstrate the specificity of retrocrural space obliteration due to chylous leakage, as additional CT sign to quickly identify and treat massive chylothorax, and discriminate it from other similar effusion condition.

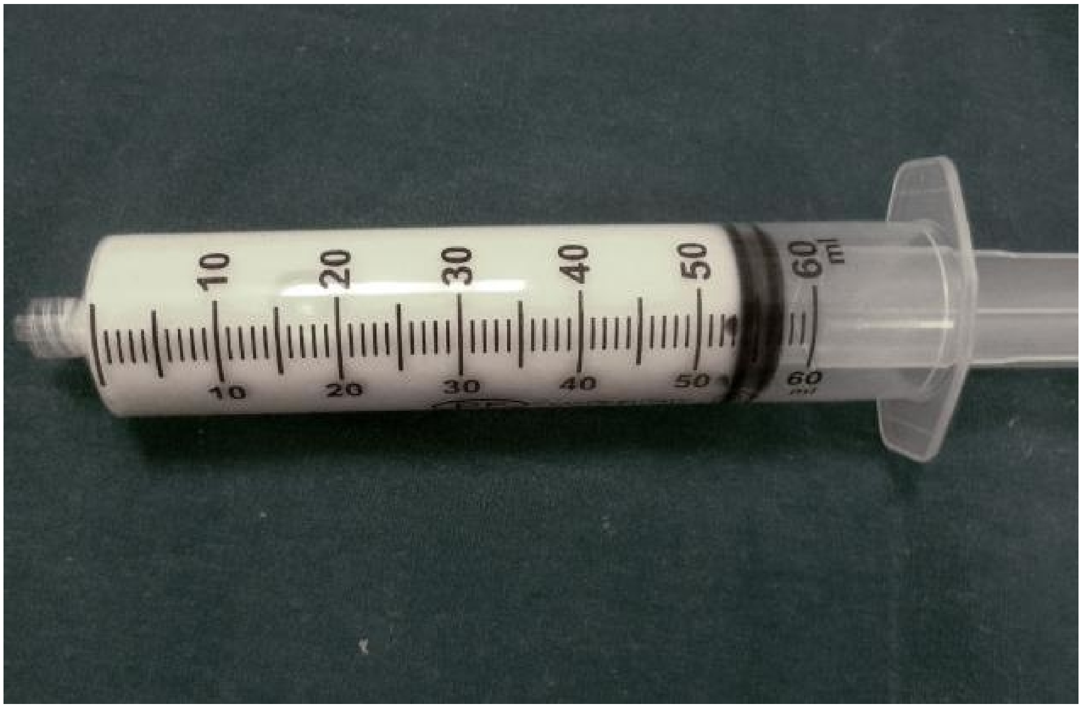

Fig. 1. A chylous effusion. The drainage was performed, after skin anesthetization using 1% lidocaine. An 18-gauge over-the-needle sheath was then advanced into the pleural fluid under continuous ultrasound guidance

2. MATERIALS AND METHODS

2.1 Patients

This retrospective study was undertaken since May 2012 and included patients scheduled for MDCT (Multi Detector CT) scan for thoracic or thoracic-abdominal trauma, or after a thoracic surgery procedure observed in Emergency Radiology department until May 2013. This study was performed according to the declaration of Helsinki, Good Clinical Practice guidelines and in accordance with local ethical and legal. All information regarding clinical data has been treated so to respect the privacy of the involved patients. Data of thoracic CT scan examination were retrospectively collected from PACS (Picture archiving and communication system*)* of Sant'Andrea Hospital, Rome, Italy.

2.1.1 The inclusion criteria were as follows

(A) all records of thoracentesis (Fig. 1) procedure aged >18 years, performed in interventional radiology unit, Sant'Andrea Hospital, Rome, Italy with a final diagnosis of post-traumatic or post-surgical chylothorax and patients with final diagnosis of hemothorax. Chylous leak diagnosis was performed after macroscopic (milky white appearance) and microscopic analysis (triglyceride levels greater than 110 mg/dl) of the effusion [14], while macroscopic examination of frankly hematic fluid was sufficient for diagnosis of hemothorax. (B) patients scheduled for MDCT scan before thoracentesis procedure.

2.1.2 The inclusion criteria in control group were as follows

(A) patients who undergone MDCT (Multi Detector CT) scan for thoracic or thoracic-abdominal trauma (B) patients evaluated with MDCT scan after a thoracic surgery procedure for multiple reasons. (C) No CT evidence of pleural effusion, pneumothorax or pneumomediastinum.

2.1.3 The exclusion criteria were

(A) patients scheduled with a plain film before thoracentesis procedure (B) head traumas (C) limbs traumas (D) isolated abdominal traumas (E)patients with thoracic or abdominal neoplasms (F) lung inflammatory or vascular diseases (G) patients affected by lymphangioleiomyomatosis (H) patients undergone thoracoabdominal surgery. 1531patients were evaluated since May 2012 to May 2013. Eight patients fulfilled the majority of the inclusion criteria to be listed in chylothorax group, 12 patients in hemothorax group and 80 patients in control group.

2.2 Diagnostic Procedures and Work Up

2.2.1 MDCT scan protocol

Every traumatic and surgical patient performed a 16-row MDCT scans (GE lightspeed 16 plus) of wounded areas, was performed, using the standard protocols for trauma [15]; intravenous administration of 120-130 mL of contrast medium (Iomeprol, 350 mg/mL), was achieved by means of power injection at 3,5-4 mL/sec, followed by 60-mL normal saline flushes at the rate of 3,5-4 mL/sec, with fixed standard delays. Arterial phase imaging of chest, abdomen and pelvis was performed as part of the whole- body multidetector CT examination, performed from the top of the chest to the symphysis pubis after a 35-40 seconds delay after starting the injection of the intravenous contrast material (parameters: 120 kV; 250 mA/sec; collimation, 0.625 mm; reconstruction, 3 mm thick at 3-mm intervals), followed by portal venous phase imaging of the abdomen, performed from the diaphragm to the iliac crest after a 75-80 seconds delay after starting intravenous contrast injection. Images were then post-processed through a dedicated software (Volume Viewer 2, GE), which generated algorithms to obtain reconstructions through maximum intensity projection (MIP), oblique coronal and sagittal multi-planar reformation (MPR). Seven radiologists independently interpreted the images during separate reporting sessions. All observers had an at least 15-year experience at emergency radiology.

2.2.2 Work up in thoracentesis procedures groups

In each group were evaluated mean age, sex, site of trauma or surgical procedure, site of effusion (right, bilateral, left if thoracic, or abdominal if it’s present), cisterna chyli, thoracic duct (Fig. 2) and retrocrural space fat assessment (evaluable, or not evaluable in cisterna chyli and retrocrural space, well, partially or not evaluable in thoracic duct), average densitometry of effusion and quantity of effusion. Every level (upper, medium and lower) of effusion has been sampled using a 5mm circular region of densitometry evaluation in four region of the same scan plan (two on the most anterior region and two in the most posterior region, twelve sampling of fluid densitometry for each patient). This densitometric evaluation (UH) of effusion has been systematically performed for every patients (Fig. 3 and Fig. 4). The valuation of effusion's volume was calculated using a Volume Rendering post-processing software after a manual extrapolation of fluid and automatic volume calculation (cc).

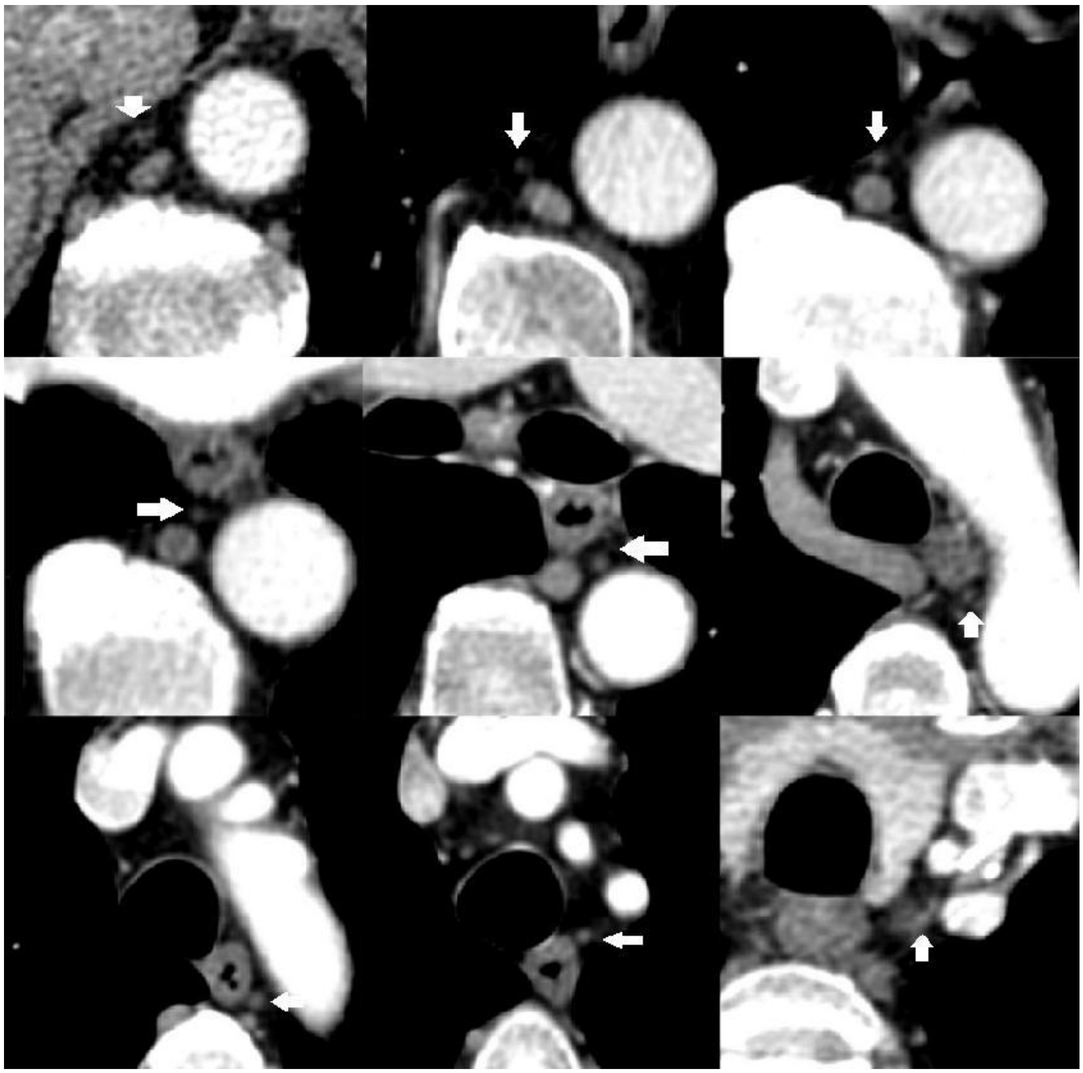

Fig. 2. Thoracic duct evaluation along his mediastinal route

2.2.3 Work up in effusion-less group

In each patients age, sex, site of trauma, cisterna chyli, thoracic duct and retrocrural space assessment were evaluated. Were recorded assessment of cisterna chyli, (Evaluable or not evaluable) and position in relation of the adjacent vertebral body (T12, L1, L2). Thoracic duct were recorded as well, partial if it was observable only in the upper or in the lower part or not evaluable [16].

2.2.4 Retrocrural space examination

Retrocrural space was recorded as evaluable if the radiologist who performed the measures was able to observe fat tissue, and distinguish vessels or lymph nodes inside it.

Fig. 3. Hematic effusions densitometry: High value due to blood and clotting, usually 136 at the same side of trauma

2.3 Statistical Analysis

Each patient was numerated and the values were plotted on a table created and analyzed with Excel 5.0 (Microsoft, Redmond, Walsh), Word 6.0.1 (Microsoft) and MED Calc for Windows (Release 10.4.8). Descriptive statistics as means (M) and standard deviations (SD) were calculated. Sensitivity and specificity of each variable were determined. The positive (PPV) and negative predictive values (NPV) of each variable were also determined. All values were reported with their 95% confidence intervals. Data analysis to assess differences between two means was performed with Student T-test or an analogous non-parametric test (Wilcoxon test) where appropriate. Person's Chi-square test was used to compare categorical data. Ordinal variables (i.e. time and volume) were correlated using spearman ranks. The level of statistical significance was set at 0,05.

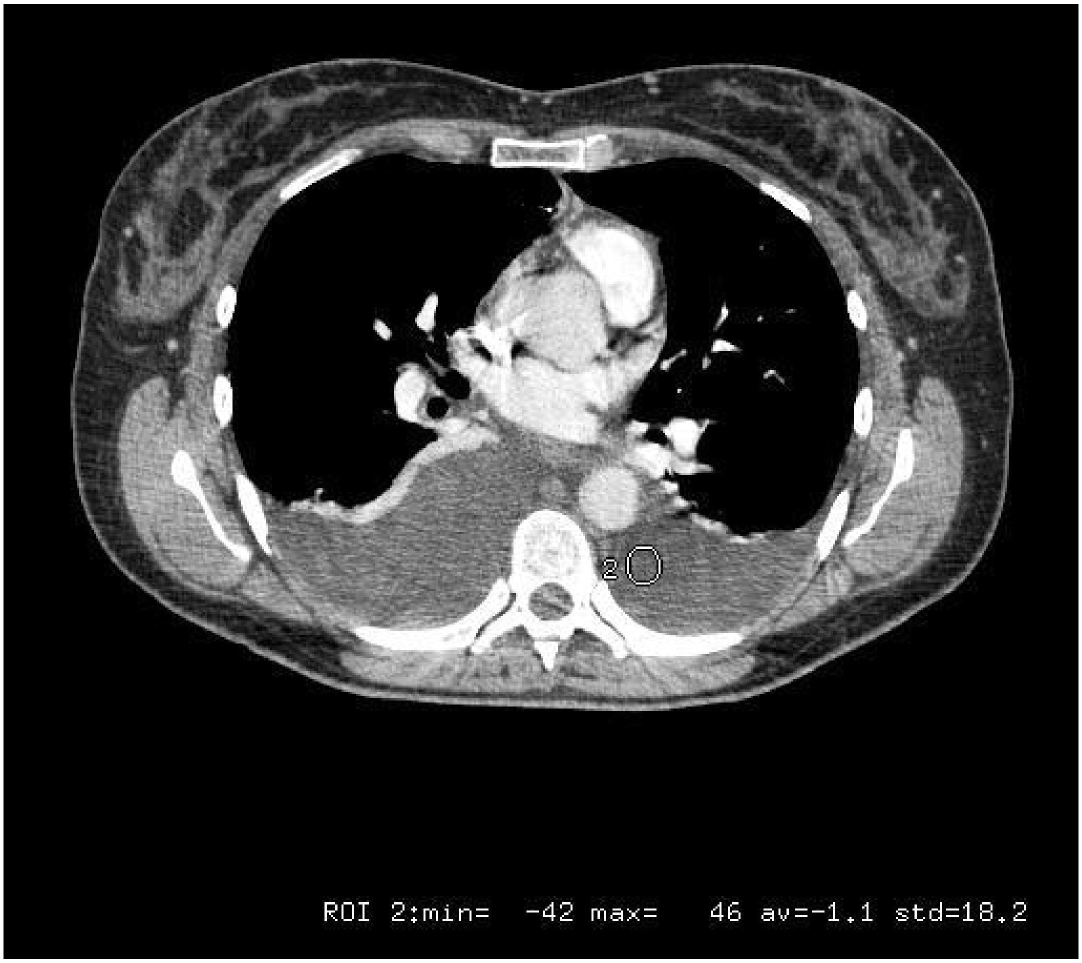

Fig. 4. Chylous effusions densitometry: negative value due to fatty composition of the fluid in chylous leakage, mainly in anterior side

3. RESULTS

3.1 Group Analysis

3.1.1 Effusion-less

consisted of 80 patients (Table 1), with a mean age of 52±20 years old, 53 male and 27female, 70 patients went to emergency department for chest (23 patients, 33%) or multiple trauma (47 patients, 67%), without any radiological evidence of pleural effusion or pneumo-thorax and 10 patients who performed MDCT scan due to dyspnea after thoracic invasive procedure: as major lobectomy (1 patient), sleeve lobectomy (2 patients), atypical lung resection (3 patients), surgical placement of thoracic aorta endoprotesis (4 patients). Among this sample, cisterna chyli was evaluable in 78 patients, (93,7%) (Table 2), whereas 95% of the patients had an evaluable thoracic duct, 55% completely evaluable. Cisterna chyli was in most cases located at T12 (55%) and L1 (30%) level. Vascular, fatty, and lymphatic structures in retrocrural space were evaluable in 97,5% of the patients.

Table 1. Epidemiological features of effusion-less sample (80 patients)

Parameter	Value
Age [Y.O]	52+20
Sex [%]	Male: 53 (66%)
	Female: 27 (44%)
Site of trauma (70 patients) [70%]	Thorax: 23 (33%)
	Thorax- Abdomen: 47 (67%)
Surgical Procedure (10 patients) [70%]	Lobectomy: 1 (10%)
	Sleeve Lobectomy: 2 (20%)
	Atypical lung resection: 3 (30%)
	Thoracic aorta endoprotesis: 4 (40%)

Table 2. Evaluability, and localization of cisternaa chyli, thoracic duct and retrocrural 171 **space in effusion-less sample (80 patients) *N.E.= Not evaluated**

		Cisternaa chyli	Thoracic duct	Retrocrural space
Evaluability (%)	Well evaluable	75 (93,7%)	44 (55%)	78 (97,5%)
	Patially evaluable	N.E.*	32 (40%)	N.E.
	Not evaluable	5 (6,3%)	4 (5%)	2 (2,5%)
Localization (%)	T12	41 (55%)	N.E.	N.E.
	L1	22 (30%)	N.E.	N.E.
	L2	11 (15%)	N.E.	N.E.

3.1.2 Hemo-thorax

Consisted of 19 patients (Table 3), with a mean age of 63+16 years old, 14 male (74%) and 5 female (26%), 11 patients went to emergency department for trauma (58%): 9 patients for chest (81%) 2 for multiple trauma (19%), with costal fractures (11 patients, 100%), scapular fractures (2 patients; 18%), and splanchnic lesions (2 patients, 18%). Eight patients (42%) undergone thoracic surgical procedures as lobectomy (5 patients 62%), atypical lung resection (2 patients 25%) or surgical placement of thoracic aorta endoprotesis (1 patient, 13%). Average time after injuries was 3,5+4,7 days, with a median of 1 day. Blood effusion, in exception for bilateral (1 patient, 5%), was observed in correspondence of the side of trauma or surgery. Traumatism were associated with costal fractures (19 patients, 100%). The average volume of the total effusions was estimate to be 172+1510 cc.

Table 3. Evaluation of the patients with hemothorax

N.	Age	Sex	Side of leak	Modality of trauma or surgery	Volume(cc)	Density(HU)	Days after injury	Retrocrural space	Cysterna chyli	Thoracic duct
1	69	M	Left	Left thoracic trauma, costal fractures	2500	13±4	1	Evaluable	Evaluable	Complete
2	65	M	Left	Left superior lobectomy	200	10±7	3	Evaluable	Evaluable	Complete
3	72	M	Right	Middle lobe lobectomy	2700	15±6	2	Evaluable	Evaluable	Partial
4	50	F	Left	Left thoracic trauma, costal, splenic, left kidney fractures with hemoperitoneum	459	25±7	1	Evaluable	Evaluable	Complete
5	63	F	Right	Right thoracic trauma, costal fractures	560	20±8	1	Evaluable	Evaluable	Complete
6	64	M	Left	Left thoracic trauma, costal and left kidney fracture	450	18±7	1	Evaluable	Evaluable	Complete
7	72	M	Left	Left thoracic trauma, costal and scapular fractures	480	30±6	1	Evaluable	Not evaluable	Not evaluable
8	28	M	Bilateral	Thoraci aorta protesis	4500	20±7	20	Evaluable	Evaluable	Complete
9	67	M	Left	Atypical superior left lobe resection	750	35±9	4	Evaluable	Evaluable	Partial
10	70	M	Left	Left superior lobectomy	350	27±10	6	Evaluable	Evaluable	Complete
11	59	M	Right	Superior and middle lobectomy	1400	17±4	12	Evaluable	Evaluable	Partial
12	74	M	Right	Right superior lobectomy	220	40±13	7	Evaluable	Evaluable	Complete
13	62	M	Right	Atipical right lobe resection	1400	15±6	2	Evaluable	Evaluable	Partial
14	68	F	Right	Right thoracic trauma, costal fractures	600	20±7	1	Evaluable	Evaluable	Complete
15	72	M	Left	Left thoracic trauma, costal and scapular fractures	1700	34±15	1	Evaluable	Evaluable	Complete
16	74	M	Left	Left thoracic trauma, costal fractures	2500	30±7	1	Evaluable	Evaluable	Complete
17	38	M	Left	Left thoracic trauma, costal fractures, neumothorax	800	26±7	1	Evaluable	Evaluable	Partial
18	85	F	Left	Left thoracic trauma, costal fractures	2600	15±9	1	Evaluable	Evaluable	Complete
19	91	F	Right	Right thoracic trauma, costal fractures	3500	14±9	1	Evaluable	Evaluable	Partial

Table 4. Evaluation of the patients with chylothorax

N.	Age	Sex	Side of leak	Modality of injury	Modality of Injury	Volume(cc)	Density(HU)	Days after injury	Retrocrural space	Cisterna chyli	Thoracic duct
1	87	F	Bilateral	Left subclavian catheterization	Left subclavian	3200	-2±10	1	Not evaluable	Not evaluable	Not evaluable
2	67	F	Bilateral + abdominal	Spinal trauma with L1 fracture	catheterization	2800	1±5	1	Not evaluable	Not evaluable	Not evaluable
3	78	M	Bilateral	Multiple traumas with T12 fracture		5300	-2±3	1	Not evaluable	Not evaluable	Not evaluable
4	73	M	Right	Lower right lobectomy	Spinal trauma with	350	-1±8	3	Not evaluable	Not evaluable	Not evaluable
5	58	F	Left	Left superior lobectomy	L1 fracture	200	5±8	2	Not evaluable	Not evaluable	Not evaluable
6	32	F	Right	Upper left thoracic stricture		250	-3±7	5	Not evaluable	Not evaluable	Not evaluable
7	27	M	Bilateral	Left subcavian vein catheterization	Multiple traumas	1745	8±6	25	Evaluable	Evaluable	Partial
8	67	M	Left	Left subcavian vein catheterization	with T12 fracture	1450	2±9	6	Evaluable	Evaluable	Partial

3.1.3 Chylothorax

Table 4 described 8 patients, with a mean age of 62±20 years old, 4 male and 4 female, 2 patients carried to emergency department for chest (1 patient) or multiple trauma (1 patient), with spinal fracture (T12 and L1) and 6 patients (75%) undergone invasive thoracic procedure: lung major operation, (2 patients), left subclavian vein catheterization (3 patients), surgical management of left thoracic outlet syndrome (1 patient). Average time after injuries was 5±7 days, with a median of 2,5 days. The average volume of the total effusion was 2043±1571 cc mostly bilateral (4 patients, 50%). The average values of chylothorax densitometry in all patients was 1.6±12 UH, with a most negative areas on the upper and anterior zones (-13±10) despite the lower posteriors (5±8) (P=0,002 CI 95% -28,8 to -8,4).

3.2 Difference and Correlations

Comparison of CT findings revealed significant difference in densitometry between the two groups of effusions (P=0,003 CI 95% -44,5123 to -13,4877), a difference in inability of visualization of retrocrural space (P=0,0002 95% CI 31,2% to 96,8%) and cisterna chily (P= 0,0009 95% CI 24,9% to 92,4%). Inability to observe thoracic duct was not different between the two groups (P=0,8805 95% CI -38,3% to 39,2%) (Table 5). There was no statistical difference in term of time after injuries between chylothorax and hemothorax groups (P=0,45 CI 95% -7.1 to 3,2) and no statistical difference in volume of effusion between two groups (P= 0,63 CI 95% -1011 to 1641). There were no correlations between time after injuries and volume (P=0,9 r=-0,009 in hemothorax and P=0,17 r=-0,5 in chylothorax group) or densitometry of effusion (P=0,4 r=0,2 in hemothorax and P=0,7 r=0,13 in chylothorax group) and no correlation between densitometry and volume of effusion (P=0,07 r=0,42 in hemothorax and P=0,45; r=-0,2 in chylothorax group).

Table 5. Summary of evidences

		No effusions (80 patients)	Hemothorax (19 patients)	Chylothorax (8 patients)
Age		52±20	63 + 15	62±20
Sex	Male	53 (66%)	14 (74%)	4 (50%)
	Female	27 (44%)	5 (26%)	4 (50%)
Modality of injuries	Trauma	70 (87%)	11 (58%)	2 (25%)
	Iatrogenic	10 (13%)	8 (42%)	6 (75%)
Average Densitometry of effusion (HU)		N.E	26±19	-1,6±12
Average volume of effusion (cc)		N.E	1721+1510	2036 + 1571
Average time after injury(Days)		N.E	3,5 + 4,7	5,5 + 7,5
Fat assessment in retro-crural space	Possible	78 (97,5%)	19 (100%)	2 (25%)
	Not possible	2 (2,5%)		6 (75%)
Evaluation of thoracic duct	Complete	44 (55%)	12 (63%)	0
	Partial	32 (40%)	6 (31%)	2 (25%)
	Not possible	4 (5%)	1 (6%)	6 (75%)
Evaluation of Cisterna Chyli	Possible	75 (93,7%)	18 (95%)	2 (25%)
	Not possible	5 (5.3%)	1 (5%)	6 (75%)

4. DISCUSSION

Post-operative chylothorax was mainly associated with injuries in lower right lobe or upper left lobe, bilateral leakage was mainly caused to proximal thoracic duct injuries as left subclavian vein catheterization. In our experience, half of iatrogenic chylothorax rose from mistake in left subclavian catheterization (3 patients, 50% of iatrogenic chylothorax, 42% of total).

Traumatic injuries at T12-L1-L2 level, with consequent stress of cisterna chyli may cause its breakage with chylous effusion extending both inferiorly, in retro peritoneal space around the aorta, the abdominal vessels up to the pelvis, than superiorly, defining a chylous leakage through diaphragmatic hiatus with consequent chylo-thorax [17].

Chylo-peritoneum can be observed at abdominal examination, [18] as low density liquid in retro-peritoneum without enhancement after contrast media, and surrounds as a sleeve in cranio-caudal direction the abdominal aorta at level of the kidneys [19]. Literature report the most frequent trauma near to the left subclavian vein tract, as caused to wrong puncture of the subclavian vein during central venous catheterization procedure [20] than thoracic outlet syndrome repair [21]. In both cases, chylous leakage rising from these zones defines a chylo-thorax originating from the superior-anterior mediastinum.

Initial hypothesis of retrocrural space loss of fat as diagnostic signs of chylous effusion were confirmed, comparison of CT findings revealed statistical difference with hemothorax in inability of visualization of fat and vessels in retrocrural space (75% P=0,0002 95% CI 31,2% to 96,8%) and cisterna chyli (75% P=0,0009 95% CI 24,9% to 92,4%) while inability to observe thoracic duct was not different between the two groups (P=0,8805 95% CI -38,3% to 39,2%). A direct correlation was found between time after injuries and assessment of fat in retrocrural space (P=0,02 r=0,8), as a sign of reabsorption of fluid. Despite expectations, a statistical direct correlation was not found between time after surgery and volume of chylous effusion (P=0,73 r=-0,13).

5. CONCLUSION

In our experience, negative density (-16,7+8HU) of effusions, was usually observed in almost 6 anterior regions or at least 2 upper anterior regions and was the best way to distinguish chylo-thorax to hemo-thorax (Specificity 89% Positive Predictive Value 80%).

Bloody effusion in traumas was bilateral, or observed in correspondence of the side of trauma or surgery, while not every chylous leaks was founded at the same side of lesion. Post-traumatic hemothorax was always observed with costal fractures, while chylothorax was observed in patient with vertebral fractures. In surgical patients, chylous effusion was mainly associated with intervention along intra- mediastinal route of thoracic duct (left on the top, right on the low).

In conclusion, CT scan differentiation between post traumatic massive bloody and chylous leakage can be done after assessment of a lower densitometry of effusion and inability in observing chylous structures and fat in retrocrural space (Sensitivity 75% Specificity 100%, Positive Predictive Value 100% Negative Predictive Value 90%).

6. LIMITATION OF THE STUDY

The small sample of patient considered was not sufficient to had significant results and more study must be performed to confirm or deny those results.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images.

ETHICAL ISSUES

This study was performed according to the declaration of Helsinki, Good Clinical Practice guidelines and in accordance with local ethical and legal. All information regarding clinical data has been treated so to respect the privacy of the involved patients.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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