CHEST ULTRASONOGRAPHY VERSUS CHEST CT FOR DIAGNOSIS OF POSTTRAUMATIC RESIDUAL HEMOTHORAX

ECOGRÁFÍA TORÁCICA VS. TOMOGRAFÍA MULTICORTES EN EL DIAGNÓSTICO DEL HEMOTÓRX RETENIDO POSTTRAUMÁTICO

SUMMARY

Introduction: Between 5% and 30% of patients who with a hemothorax develop a clotted hemothorax. An intervention is required to evacuate the clotted hemothorax and prevent the development of an empyema, a fibrothorax and/or pulmonary entrapment. Contrast tomography is recommended as the best diagnostic method. An ultrasonography has been widely used to evaluate the pleural cavity. The purpose of this study was to assess the diagnostic performance of chest ultrasonography in comparison with CT in patients suspected of having posttraumatic clotted hemothorax. Materials and Methods: A prospective study to assess two diagnostic tests in San Vicente de Paúl University Hospital (Medellín, Colombia). A total of 68 patients who were suspected to have posttraumatic clotted hemothorax were assessed with a chest ultrasonography and a multi slice CT. The findings of the ultrasonography and the multi slice CT were compared with the surgical findings of the patients or with clinical monitoring. Results: We recruited a total of 68 patients. Of these patients, 47 patients (69.1%) had clotted hemothorax. The chest ultrasonography had a sensitivity of 72.3% and a specificity of 95.2%, a VPP of 77.14%, a VPN of 60.61%, a positive probability ratio of 15.19 and a negative probability ratio of 0.29. The chest CT had a sensitivity of 70.21%, a specificity of 52.38%, a VPP of 76.74%, VPN of 44%, a positive probability ratio of 1.47 and a negative probability ratio of 0.57 in the diagnosis of clotted hemothorax. Conclusion: Chest ultrasonography had a better diagnostic performance than CT in patients suspected of having posttraumatic clotted hemothorax.

RESUMEN

Introducción: Entre el 5% y 30% de los pacientes con trauma de tórax desarrollan hemotórax retenido, que requiere una intervención para evacuarlo y prevenir el desarrollo de empiema, fibrothorax y/o atrapamiento pulmonar. El método diagnóstico recomendado es la tomografía con medio de contraste. El ultrasonido ha sido utilizado ampliamente para evaluar la cavidad pleural. El propósito de este estudio fue evaluar el desempeño diagnóstico de la ecografía en pacientes con sospecha de hemotórax retenido traumático, en comparación con la tomografía con medio de contraste. Materiales y métodos: Estudio prospectivo de evaluación de dos pruebas diagnósticas en el Hospital Universitario San Vicente de Paúl.
Un total de 68 pacientes con sospecha de hemotórax retenido posttraumático se evaluaron con ultrasonido de tórax y tomografía multicorte torácica. El resultado de las ecografías y tomografías multicortes de tórax se comparó con los hallazgos quirúrgicos de los pacientes intervenidos o con el seguimiento clínico. **Resultados:** Se incluyeron en el estudio 68 pacientes. Se confirmó hemotórax retenido en 47 pacientes (69,1%) y se descartó en 21 (30,9%). La ecografía pleural tuvo una sensibilidad de 72,3%, especificidad de 95,24%, VPP de 97,14%, VPN de 60,61%, cociente de probabilidades positivo 15,19 y cociente de probabilidades negativo 0,29. La tomografía de tórax tuvo una sensibilidad de 70,21%, especificidad de 52,38%, VPP 76,74%, VPN de 44%, cociente de probabilidades positivo 1,47 y cociente de probabilidades negativo 0,57 en el diagnóstico de hemotórax retenido. **Conclusión:** La ecografía torácica tuvo un mejor desempeño diagnóstico que la tomografía con medio de contraste en pacientes con sospecha de hemotórax retenido.

**Introduction**

Traumatic injuries are a public health problem of epidemic proportions around the world. They are the main cause of death in the first three decades of a person’s life. Up to 25% of trauma-induced deaths are a consequence of chest injuries. (1,2)

Hemothorax and pneumothorax represent 85% of possible cases of chest trauma (3). Besides its high frequency, chest trauma determines significant morbidity when the thorax is unstable, as well as bronchopleural fistulas, clotted hemothorax or empyema. This condition extends the duration of hospital stay, increases the costs of health services and reduces productivity in young populations.

The adequate and early treatment of a hemothorax determines the patient’s full recovery and a short hospital stay. However, inadequate treatment or a late diagnosis poses a risk of super-infection, the development of an empyema, or it could evolve into an organizational stage, pulmonary entrapment and fibrothorax, with the following restrictive disorders and alterations in pulmonary functioning (4-7).

A closed thoracotomy is carried out (tube inside the chest) during the initial treatment of patients with an intra-chestal injury. This procedure is sufficient in 85% of cases in order to completely evacuate the hemothorax or pneumothorax; However, the development of a clotted hemothorax has been documented in between 5% and 30% of cases (1-3,5).

Once intrapleural clots have formed, a thoracentesis and a thoracotomy are not enough to treat the condition. A late diagnosis implies the need to carry out invasive procedures; therefore, the decision to perform surgery must be made at an early stage. Thoracotomy is currently recognized as the surgical procedure of choice in order to evacuate clotted hemothorax as an alternative to thoracotomy. Surgery also allows to explore the thoracic cavity and heal pulmonary and diaphragmatic injuries of the thoracic wall and mediastinales. (4,8-11).

Several radiological studies are used to recognize the presence of non-drained blood in the chest in a timely fashion. The most recent studies have shown how chest x-rays cannot be used as a reliable method to choose the patients that must be treated, given the fact that x-rays can lack precision when detecting different injuries. It has been suggested that this decision should be based on a Computerized Axial Tomography (CAT) scan. The CAT scan has better performance when assessing the pleural space and the pulmonary parenchyma. (12-14).

Emergency ultrasounds have gained ground during the last few years. Its technique has been perfected and documented to the point which it serves as the initial tool to diagnose intra-abdominal and cardiac injuries in the emergency room. The effectiveness of the detection of intra-thoracic injuries is less clear; however, comparative studies with chest x-rays show that it is a sensitive and specific test when diagnosing hemothorax. This test requires less time to be carried out and it detects less pleural fluid compared with simple chest x-rays (15,16).

Despite these advantages, the ultrasound has not been adequately evaluated in the detection of traumatic clotted hemothorax. Therefore, an analysis of the diagnostic performance of this method and of the multi-slice tomography was suggested for the diagnosis of clotted hemothorax.

**Materials and Methods**

**Type of Study**

Prospective study of the evaluation of diagnostic tests.

**Population of the study**

Patients over 15 years of age, with a suspected diagnosis of clotted hemothorax after the treatment of a posttraumatic hemothorax with a thoracotomy tube or through thoracotomy. The patients who died before a period of 48 hours after entering the institution were excluded, as well as patients in which the application of the contrast material or the realization of exams with ionizing radiation was counter indicated, and patients that had received their initial treatment in a different institution.

Every patient that entered the institution with a clinical diagnosis of traumatic hemothorax underwent specific management according to the protocols of the institution (expectant management, closed thoracotomy or thoracotomy) related to a respiratory incentive or assistive respiratory therapy.

A clotted hemothorax was suspected when the clinical signs suggested pleural effusion and the chest x-rays showed one of the following findings: hydro-aerial concentrations, pleural opacity in non-dependent places and an incomplete expansion of the lung. Once the clotted hemothorax was suspected, the patient was requested a chest ultrasound and multi-slice tomography with contrast material in the chest.

The diagnostic findings were interpreted and registered in an independent manner and blindly by a general radiologist. The radiologist carried out the ultrasound, and a different radiologist obtained the tomography with the purpose of defining the presence or lack of presence of clotted hemothorax. The patients who entered this study underwent these radiological studies with a difference no greater than twelve hours.

The following was the tomographic criteria to establish the clotted hemothorax: Pleural liquid with heterogeneous attenuation and images with greater inner density or pleural liquid with partitioning, proven by the distribution in non-dependent places or in the pleural mediastinal space (figure 1).
The ultrasound criteria to define the diagnosis of clotted hemothorax was the presence of pleural liquid with septum in the inner section, or loculations. In addition, the movement of the septum was evaluated along with breathing and the movement of the diaphragm (figure 2). According to the criteria of the surgeons, the patients were treated with a new closed thoracotomy tube, a thoracoscopic evacuation, thoracotomy or a non-operative expectant management.

Clotted hemothorax was confirmed in patients that underwent surgery with the finding of intrapleural clots with or without aggregate infection. Patients whose surgery did not show clots or septum were considered negative, as well as those patients whose clinical monitoring evolved in the resolution of symptoms. Clinical monitoring was performed during their hospital stay, as well as fifteen days after the patients were released from the hospital, during the external consultation services.

**Chest Tomography**

CAT scans were performed with the CAT machine GE Prospeed 64 channel multi-detector. In each study, 50cm³ of intravenous iodinated contrast material were administered (Iopamidol 300 mg of iodine/ml) at an injection speed of 3 ml/s. 200 milliamps and a kilovoltage of 120 were used. The radiological acquisition was done 20 seconds after applying the contrast material. The slices were performed with a collimation of 5 mm, an interval of 5 mm and reconstructions of up to 1.25 mm from the supraclavicular regions to the upper abdomen. The images were transferred to the AW 3.1 GE work station in order to carry out multi planar reconstructions and to undergo interpretation by the radiologist who was on duty at the time.

**Chest Ultrasounds**

Chest ultrasounds were carried out with Ultrasound machine Toshiba Just Vision 200. 3.75 MHZ sectorial transducers and 7.5 lineal transducers were used. All of the studies were performed with the patients sitting down and with their hands on their knees, in order to evaluate the front and rear regions of the affected hemithorax. If the patient’s clinical conditions prevented the seating position for the ultrasound, the ultrasound was performed with the patient in a supine position, with the arms abducted, analyzing the front and lateral regions of the affected hemithorax.

**Therapeutic Procedures**

The therapeutic procedures were made through a new thoracotomy tube, video thoracoscopy or thoracotomy, in accordance with the criteria of the surgeon who was performing the procedure.

**Interpretation of images and reference standard (surgery or clinical monitoring)**

According to the radiological report, the treating physician defined the conduct of each patient. Thus, the patients were divided into two groups: Patients who received expectant management and patients who received surgical treatment. For the expectant management group, the reference test was the clinical monitoring for up to fifteen days after the release from the hospital. During the evaluation the patient was asked whether they had symptoms of breathing problems, fever, chest pain, the presence of tachypnea was evaluated, as well as a reduction in the vesicular murmur or the dullness in the beat of the affected hemithorax.

If the patient was asymptomatic and the clinical evaluation did not show unusual findings, he/she was released by the surgery service; If a chest complication was suspected, the relevant radiological studies were performed. The surgical findings were the reference test for the surgical treatment group. The presence or absence of clotted hemothorax was compared according to the pleural ultrasound and the CAT scan of the chest with the surgical findings and the clinical monitoring.
**Statistical analysis**

The sensitivity, the specificity, the predictive positive and negative values and the ultrasound and CAT scan of the chest were determined. A *true positive* was defined as the case where the presence of a clotted hemothorax was detected in the radiological studies, which was confirmed during surgery; a *false positive* was defined as a case where the presence of a clotted hemothorax in the radiological studies was detected but not during surgery; a *true negative* was defined as a case where the clotted hemothorax was not found in the radiological studies or in the clinical monitoring, and *false negative* was determined in the case where the clotted hemothorax was not found in the reference tests. The acquired information was processed using statistical programs SPSS 15.0 and Epidat 3.0.

The study was approved by the Postgraduate committees of the Radiology and Surgery departments of the Universidad de Antioquia and by the Ethics Committee of the San Vicente de Paúl University Hospital. The informed consent of the patients or a close relative was acquired when the clinical conditions of the patient did not allow consent.

**Results**

In principle, 77 patients complied with the inclusion criteria, in data collected from April of 2004 until April of 2008. From this group, 9 patients were excluded. A total of 68 patients were included in the study, out of which 62 were men (89.7%) and 6 were women (8.8%), with an average age of 34.8 years (16-70).

Penetrating trauma was the most common cause of hemothorax (56 cases, 82.3%); out of these, 46 (66.6%) were victims of sharp weapons and 10 (14.7%) were victims of a firearm. Closed chest trauma occurred in 12 patients (17.6%).

Initial treatment was closed thoracotomy in 53 patients (77.9%), thoracotomy or sternotomy in 11 patients (5.9%). The imaging studies that determined the final behavior were carried out, on average, on the seventh day of hospital stay (range 1-25). Ultrasound scans and tomography were considered as inclusion criteria, with a time difference no greater than 12 hours. The attending surgeon took the therapeutic decision based on the results of the images.

The management of the clotted hemothorax was distributed in video thoracoscopy to 29 patients (42.02%), thoracotomy to 15 (22.1%), and re-accommodation of the chest probe to 5 patients (7.4%). 21 patients (30.9%) did not have a diagnosis of clotted hemothorax. Some patients underwent two procedures.

The time period between the trauma until the surgery of the patients who underwent treatment by clotted hemothorax was 9.2 days (2-25). Average hospital stay was 17.8 days (range 4-55). An ultrasound scan of the clotted hemothorax was performed in 35 (51.5%) patients (table 1). A tomographic diagnosis of the clotted hemothorax was made in 43 (63.2%) patients (table 2). A Clotted hemothorax was confirmed in 47 patients (69.1%) and was disregarded in 21 patients (30.9%).

| Table 1. Performance of the ultrasound in the diagnosis of clotted hemothorax |
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| **Ultrasound** | **Clotted Hemothorax** | **Without clotted hemothorax** | **Total** |
| Positive | 34 | 1 | 35 (51.5%) |
| Negative | 13 | 20 | 33 |
| **Total** | 47 (69.1%) | 21 (30.9%) | 68 |

Out of the 35 patients who had a positive CAT scan for clotted hemothorax by ultrasound, 34 were true positives with only one false positive, according to the reference tests, and 33 were interpreted as negative. 13 corresponded to false negatives. Out of 43 patients with a tomographic diagnosis of clotted hemothorax, 33 corresponded to true positives, with 10 false positives, and out of the 25 interpreted as negative, 14 corresponded to false negatives according to the reference tests.

The pleural CAT scan had a sensitivity of 72.3% (Ic 95%: 58, 49-86, 19), a specificity of 95.24% (IC 95%: 83, 75-100); a positive predictive value (PPV) of 97.14% (IC 95%: 90, 19-100); a negative predictive value (NPV) of 60.61% (IC 95%: 42, 42-78, 79); a positive probability quotient of 15.19 (IC 95%: 2.23-103,71) and a negative probabilities quotient of 0.29 (IC 95%: 0.18-0.47). The chest tomography had a sensitivity of 70.21% (Ic 95%: 56.07-84.35); a specificity of 52.38% (IC95%: 28, 64-76.12); a VPN of 44% (IC 95%: 22.54-65.46); a positive probabilities quotient of 1.47 (IC 95% -0.02-0-48), and a negative probabilities quotient of 0.57 (IC 95%: 0.31-1.04) in the diagnosis of clotted hemothorax.

**Discussion**

The diagnosis of a clotted hemothorax has usually been based on a combination of clinical findings, such as the reduction of vesicular murmur and the respiratory excursion of the affected hemithorax, the lack of activity of the thoracotomy probe, respiratory problems and radiological findings of the simple chest plate such as the clouding of the costophrenic or cardiophrenic angle indicating persistence of effusion.

Chest x-rays have been evaluated in the context of the patient with chest trauma. X-rays has been a particularly ineffective method for examining therapeutic behaviors for clotted hemothorax, as it frequently underestimates the seriousness and the extension of the trauma, and in some cases fails to detect the presence of post traumatic chest complications. Chest x-rays is a technique which has a better performance for the diagnosis and classification of post traumatic chest injuries and was established as the standard tool to diagnose clotted hemothorax, guide interventional procedures and to take therapeutic decisions (12-14).

Velmahos (13) compared the chest x-rays with the tomography to detect post traumatic residual hemothorax and concluded that x-rays are insufficient to choose the patients that must be taken to surgery. In one third of the cases, the findings were overestimated. The concordance of the tomographic and thoracoscopic findings was acceptable.

Recent findings in tomography, along with the development of multi-detecting equipment, allow the acquisition of very thin slices at great speed, which enables the acquisition of axial images and high quality multiplanar reconstructions. However, this is an expensive method with high technology, a trained personnel and the use of intravenous contrast materials, with potential adverse reactions such as anaphylaxis and nephropathy.

Ultrasound is a useful tool when evaluating and managing pleural pathology; it has been used with greater frequency in the past few years for initial evaluation of a traumatized patient. It is a radiological technique which provides high sensitivity, specificity and precision. This technique can detect small pleural effusions associated with chest trauma, before
identification with x-rays, which allows for early interventions. It is a low-cost technique, requires less infrastructure, is versatile and can be moved, allowing the evaluation of critical patients in intensive care units with mechanical ventilation. This technique is useful, moreover, to guide percutaneous procedures.

Although the clotted hemothorax is a widely recognized entity, the factors which determine its presence in patients with chest trauma and secondary hemothorax are not clear. Some hypotheses have been suggested, for example, alterations in breathing mechanics which prevent the fragmentation of intrapleural coagulated blood; the fast depletion of proteolytic intrapleural enzymes with great quantities of stored blood, obstruction by blood detritus of the pleural lymphatic pleuraeals, superinfection derived from concomitant abdominal wounds; etc. To the date, the potential value of each one of these factors in its origin has not been determined. However, it is clear that its inopportune treatment gives way to a series of unfavorable findings.

The ever increasing usage of ultrasound scans in a traumatized patient to define surgical conduct during initial attention, and its well-known high sensitivity and specificity for the study of pleuropulmonary conditions (14,17-21), stimulated us to evaluate its potential use in the diagnosis of post traumatic clotted hemothorax.

In the comparison made by Ma and Mateer (16) of the chest ultrasound with x-rays, it was found that the ultrasound was a method which was widely specific, sensitive and efficient to assess therapeutic conduct in the patient with chest trauma; it also allows an early identification of the hemothorax, requires less time to carry out. In addition, it is possible to differentiate pleural liquid from pleural buildup or pulmonary contusion. These findings can overlap the chest x-rays.

This study proved an excellent performance of pleural ultrasound for the diagnosis of clotted hemothorax. A positive probabilities quotient of 15.19 x-rays causes significant changes in the pre-test probability. In addition, the CAT scan positive probabilities quotient of 1.47 leads to very modest changes in the pre-test probability. Although sensitivity was similar for both tests, the greater specificity of the ultrasound grants an additional value to identify patients who do not require additional procedures.

The improved performance of the ultrasound over the multi-slice tomography in the detection of clotted hemothorax is explained by the fact that the ultrasound offers a better visualization of the pleural liquid characteristics. Furthermore, it evaluates the presence, the width and the movement of the septum in the inner part of the pleural space. One must also consider the fact that the density of the sub-acute or chronic intrapleural clots is lessened when compared with the density of the clot when it is in its acute stage. This means that the increase in pleural space density is not evident when evaluated by tomography.

However, the ultrasound presents some operative limitations: some patients who undergo a chest ultrasound present dressings, gauze and bandages in the chest area, and those elements can occasionally create difficulties for the test. The secondary pain to the trauma or the procedure that the patient undergoes prevents normal breathing mechanics and this reduces the possibility to adequately visualize diaphragmatic excursion and the movement of the septum. These findings are necessary to diagnose. Likewise, the presence of pneumothorax and subcutaneous emphysema, which are common in the traumatized patient, can hinder the chest ultrasound, given that the reverberation device does not allow adequate visualization of the structures behind the area where the aerial accumulation was located.

A limitation of the study was that during the chest tomography evaluations, an objective measure of the dilution of the liquid found in the pleural space with Housefield Units (UH) was not entered. This fact can explain some false negative results of the tomography for the diagnosis of clotted hemothorax.

### Conclusion

The chest ultrasound in a patient who has a clotted hemothorax is a radiological proof with excellent performance, with a sensitivity which is comparable to the CAT scan and with a great capacity to identify patients without a clotted hemothorax. This influences clinical practice, as it prevents procedures in patients who are not singled out.

### References


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