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ORIGINAL

Diagnostic utility of transthoracic ultrasound in chest trauma versus chest radiography

Utilidad diagnóstica de la ecografía transtorácica en el traumatismo torácico versus la radiografía de tórax

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ABSTRACT

Objective: to determine the diagnostic utility of transthoracic ultrasound in comparison with chest x-ray in patients with thoracic trauma in the surgical emergency of the Central Hospital of Maracay during the period 2023-2024.
Method: a quantitative research was carried out under the clinical-epidemiological modality of descriptive, non-experimental, observational, prospective and longitudinal type. The study population consisted of 32 patients over 10 years of age, of both sexes, with chest pain and diagnosed with thoracic trauma.
Results: the average age of the patients was 38,15 years (±15,27), with a male predominance (84,38 %). Most of the patients came from the state of Aragua (71,88 %). The most common clinical manifestations were chest pain (100 %) and dyspnea (43,75 %). The leading causes of trauma included motorcycle-vehicle collisions (25 %) and vehicle-to-vehicle collisions (9,38 %). Transthoracic ultrasound detected pneumothorax in 28,13 % of cases and pleural effusion in 18,75 %, with sensitivities and specificities higher than those of chest x-ray. In addition, a high concordance was found in the detection of rib fractures and interstitial patterns.
Conclusion: the study demonstrates that transthoracic ultrasound is an effective and superior diagnostic tool compared to chest x-ray for the detection of pulmonary pathologies in patients with thoracic trauma. Its routine implementation in surgical emergencies can significantly improve the diagnosis and management of these injuries, reducing morbidity and mortality. It is recommended that medical personnel be trained in the use of transthoracic ultrasound and consider its integration into trauma management protocols in emergencies.

Keywords: Chest Trauma; Transthoracic Ultrasound; Chest X-Ray; Pneumothorax; Hemothorax.

RESUMEN

Objetivo: determinar la utilidad diagnóstica de la ecografía transtorácica en comparación con la radiografía de tórax en pacientes con traumatismo torácico en la emergencia quirúrgica del Hospital Central de Maracay durante el periodo 2023-2024.
Método: se realizó una investigación cuantitativa bajo la modalidad clínico-epidemiológica de tipo descriptiva, no experimental, observacional, prospectivo y longitudinal. La población del estudio estuvo conformada por 32 pacientes mayores de 10 años, de ambos sexos, con dolor torácico y diagnosticados con traumatismo torácico.
Resultados: la edad promedio de los pacientes fue de 38,15 años (±15,27), con un predominio masculino (84,38 %). La mayoría de los pacientes provenían del estado Aragua (71,88 %). Las manifestaciones clínicas más

comunes fueron dolor torácico (100 %) y disnea (43,75 %). Las causas principales de traumatismo incluyeron colisiones moto-vehículo (25 %) y colisiones vehículo-vehículo (9,38 %). La ecografía transtorácica detectó neumotórax en el 28,13 % de los casos y derrame pleural en el 18,75 %, con sensibilidades y especificidades superiores a las de la radiografía de tórax. Además, se encontró una alta concordancia en la detección de fracturas costales y patrones intersticiales.
Conclusión: el estudio demostró que la ecografía transtorácica es una herramienta diagnóstica efectiva y superior en comparación con la radiografía de tórax para la detección de patologías pulmonares en pacientes con traumatismo torácico. Su implementación rutinaria en las emergencias quirúrgicas puede mejorar significativamente el diagnóstico y manejo de estas lesiones, reduciendo la morbilidad y mortalidad. Se recomienda capacitar al personal médico en el uso de la ecografía transtorácica y considerar su integración en los protocolos de manejo de trauma en emergencias.

Palabras Clave: Traumatismo Torácico; Ecografía Transtorácica; Radiografía de Tórax; Neumotórax; Hemotórax.

INTRODUCTION

Advances in technology and new high-resolution multifrequency transducers have redefined the value of ultrasound despite its limited use in the chest, giving it a new perspective and validity. It should be noted that chest X-rays are the test of choice for the diagnosis of many respiratory conditions, including chest trauma. However, lung ultrasound may represent a safer and less expensive alternative.

Chest X-rays are currently the imaging study used in large health centers for monitoring chest trauma and other chest diseases. Considering that, just ten years ago, ultrasonography was a tool used to assess pleural effusions, today it is used in the study of pneumothorax, pneumonia, thromboembolism, injuries to the chest wall, heart, and great vessels, mediastinum, as well as various protocols such as those for the management of patients with respiratory failure or patients with thoracoabdominal trauma.[1]

It should be noted that trauma remains a major public health problem worldwide, as it is associated with high morbidity and mortality, with approximately 5,8 million deaths worldwide. Trauma has also been reported to be the leading cause of death, hospitalization, and long-term disability in the first four decades of life. Chest trauma accounts for 20-25 % of all trauma worldwide and is the third most common cause of death after abdominal injury and traumatic brain injury in polytrauma patients. It directly accounts for approximately 25 % of trauma-related mortality and is a contributing factor in another 25 % of these cases. Blunt chest injuries are more common than penetrating injuries, with the most frequent causes being car accidents, falls, and crush injuries.[2]

A study conducted in Venezuela between 2012 and 2016 confirmed that chest trauma is a common condition in our setting, with an incidence of 14,4 %, which can be life-threatening due to its potential to affect the airway, respiratory function, and hemodynamics through hypovolemia caused by vascular involvement and direct cardiac trauma. This study concluded that the therapeutic strategy of choice is non-surgical, remaining conservative with chest drainage, analgesia, and observation aimed at reducing complications and morbidity and mortality due to chest trauma.[3]

Another study determined the usefulness of chest ultrasound in pneumonia in relation to chest X-rays in patients admitted to hospital. The correlation between ultrasound findings and chest X-rays was assessed in 45 patients diagnosed with pneumonia, using Cohen's Kappa agreement test. There was agreement in 14 cases diagnosed with hepatization by ultrasound and consolidation pattern on X-ray, with a Kappa value of 0,13 and a p-value of 0,077. Similarly, in five cases diagnosed with paraneumonic effusion plus abscess by ultrasound and pleural collection plus abscess on X-ray, the Kappa value was 0,43. And a p-value of 0,0, similarly in 3/ r cases diagnosed with bronchogram by ultrasound and air bronchogram on radiography, demonstrating a Kappa value of 0,022. And a p-value of 0,482. It was therefore concluded that ultrasound showed good agreement when compared with X-ray as a diagnostic method for pneumonia, confirming the hypothesis.[4]

The literature on the subject has repeatedly determined the usefulness of lung ultrasound in the diagnosis of post-surgical pneumothorax. One study showed that thoracic ultrasound performed at the patient's bedside by a thoracic surgeon for the diagnosis of postoperative pneumothorax is a useful and easy-to-perform technique that can be used in daily practice in postoperative follow-up, replacing chest X-rays.[5] Another study compared transthoracic ultrasound with chest X-rays in the postoperative period of thoracic surgery, where 120 hemithoraxes (60 patients) were evaluated with the two diagnostic tests, first ultrasound and then chest X-ray. It was concluded that transthoracic ultrasound can be used as a complementary method and in combination with chest X-rays in the postoperative period of thoracic surgery. It is also suggested that routine use of transthoracic ultrasound during the postoperative period could reduce the use of chest X-rays in selected cases.[6]

Furthermore, various studies have determined the diagnostic validity of chest ultrasound as a single test for the diagnosis of post-traumatic pneumothorax compared to computed tomography.[7] Similarly, a 2022 study compared chest ultrasonography versus supine chest radiography for the diagnosis of pneumothorax in trauma patients in the emergency room. In conclusion, the accuracy of USG performed by non-radiologist frontline physicians for the diagnosis of traumatic pneumothorax was found to be superior to that of supine chest radiography, regardless of the type of trauma, the type of USG operator, or the type of probe. These results suggest that USG could be incorporated into trauma protocols and algorithms in future medical training programs for the diagnosis of traumatic pneumothorax. In addition, USG may improve the routine treatment of trauma patients.[8]

In Venezuela, the use of transthoracic ultrasound as a diagnostic method in patients with respiratory pathologies or for monitoring complications has not yet been standardized. The usefulness of ultrasound in multiple conditions and locations of the body has already been demonstrated, as it offers a number of advantages over other radiological techniques. These include the absence of ionizing radiation, the possibility of performing the examination at the patient's bedside, real-time assessment, and the accessibility of the equipment. These characteristics are particularly useful in people who are more susceptible to the adverse effects of radiation or in patients who are difficult to move, such as those admitted to intensive care units.

All of the above highlights the importance of this research, given the need to implement transthoracic ultrasound as a diagnostic method for chest trauma in the surgical emergency room of the Central Hospital of Maracay (HCM).

METHOD

A quantitative, descriptive, non-experimental, observational, prospective, and longitudinal clinical-epidemiological study was conducted to determine the diagnostic utility of transthoracic ultrasound in chest trauma versus chest X-rays in patients treated in the emergency room of the Central Hospital of Maracay between July 2023 and September 2024. The study was based on the research line of the postgraduate curriculum in General Surgery and complied with the standards of good clinical practice established by the World Health Organization for research involving human subjects.

The sample was non-probabilistic, intentional, and consisted of 32 patients who met the inclusion criteria: older than 10 years of age, of any sex, with chest pain, and admitted to the emergency room of the General Surgery Department of the Central Hospital of Maracay with a diagnosis of chest trauma. Those who did not meet the criteria, were under 10 years of age, did not have chest pain, or did not authorize their participation in the study were excluded.

With regard to data collection techniques, direct observation was used and a data collection form developed by the researcher was used as a data collection tool, containing the variables according to the proposed objectives, including the patient's clinical and epidemiological data, as well as the results obtained through ultrasound and chest X-rays. Information collection and processing procedure. Therefore, each patient underwent a transthoracic ultrasound using Sonosite M – Turbo ultrasonography equipment with a 7-11MHz linear transducer and Convex 3-5 MHz (available in the surgical emergency department of the Central Hospital of Maracay) at the time of admission, as well as a chest X-ray for later comparison.

Quantitative variables were analyzed using mean, median, and mode, standard deviation. Qualitative variables were analyzed using absolute and relative frequencies. Confidence intervals were constructed at 95 %, and associations were made using Chi-square. Sensitivity, specificity, and Area Under the Curve (AUC) were calculated, and $p< 0,05$ was established as statistically significant.

RESULTS

A total of 32 patients who attended the General Surgery Emergency Department of the Central Hospital of Maracay with a diagnosis of chest trauma were studied, of which, as shown in table 1, the majority of them were over 35 years of age, representing 56,25 %, with an average age of 38,15 years and a standard deviation of 15,27. With regard to sex, the majority of patients were male, representing 84,38 % of the total, corresponding to 27 patients. Most of them came from the state of Aragua, with 71,88 % (table 1).

Table 1. Distribution by age, gender, and origin of patients with chest trauma who attended the surgical emergency department of the Central Hospital of Maracay

		n	%[M]	95 % CI[I]
EPIDEMIOLOGICAL DATA				
Age (X ± SD) 38,15 ± 15,27				
Age (Groups)	Less than 35	14	4	26,36- 62,34
	Over 35	18	56,25	37,66- 73,64

Gender	Female	5	15,63	5,28-32,79
	Male	27	84,38	67,21- 94,72
Origin	Aragua	23	71,88	53,25- 86,25
	Miranda	4	12,50	3,51- 28,99
	La Guaira	4	12,50	3,51- 28,99
	Capital District	1	3,13	0,08-16,22

Of the total number of patients evaluated, 32 (100 %) presented chest pain, 14 (43 %) presented dyspnea, 10 (31,25 %) presented abolished lung sounds on auscultation in one of the hemithoraces evaluated, 8 (25 %) presented cough, 5 (15,63 %) presented a key sign in one or more rib arches, and only 3 (9,38 %) presented subcutaneous emphysema. Similarly, it was evident that the majority of patients evaluated did not present comorbidities upon questioning (29, 90,63 %), as can be seen in table 2.

Table 2. Clinical manifestations and comorbidities present in patients with chest trauma who attended the surgical emergency department of the Central Hospital of Maracay

			n	%M	95 % CII
CLINICAL DATA					
Clinical Manifestations	Dyspnea	Yes	14	43,7	26,36
		No	18	56,25	37,66- 73,64
	Chest pain	Yes	32	100,00	89,11- 100,00
		No	0	0	
	Noise Abolished	Yes	10	31,25	16,12- 50,01
		No	22	68,75	49,99- 83,88
	Subcutaneous emphysema	Yes	3	9,38	1,98-25,02
		No	29	90,63	74,98- 98,02
	Cough	Yes	8	25	11,46- 43,40
		No	24	75	56,60- 88,54
	Key sign	Yes	5	15,63	5,28- 32,79
		No	27	84,38	67,21- 94,72
COMORBIDITIES					
Comorbidities	Arterial hypertension	Yes	3	9,38	1,98- 25,02
	Obesity				
	Systemic vasculitis				
		No	29	90,63	74,98

The majority of patients treated in the emergency department had a trauma mechanism (cause) of vehicle rollover, accounting for 13 patients, equivalent to 40,63 %. This was followed by motorcycle-vehicle collisions with 25 %, vehicle-vehicle collisions and motorcycle-fixed object collisions with 9,38 % each, while falls from height and wounds caused by firearms accounted for only 6,25 % each (table 3).

Table 3. Causes of Thoracic Trauma in patients who attended the surgical emergency room at the Central Hospital of Maracay

Causes	n	%M	95 % CI[1]
Vehicle-vehicle collision	3	9,3	1,98
Motorcycle-Vehicle Collision	8	25	11,46- 43,40
Motorcycle-Motorcycle Collision	1	3,1	0,08-16,22
Motorcycle-fixed object collision	3	9,3	1,98- 25,02
Fall from height	2	6,25	0,77-20,81
Firearm injury	2	6,25	0,77- 20,81
Rollover	1	40,63	23,70- 59,36

The most relevant ultrasound signs were: the barcode sign, the absence of pleural sliding, and the interstitial

pattern, each representing 25 % (8 patients), followed by the anechoic pattern with 18,75 % (6), rib cage disruptions represented as fractures were only evident in 9,38 % (3) of patients, and finally, in only one patient (3,13 %), the lung point sign was evident (table 4).

Table 4. Pulmonary ultrasound signs present in patients with chest trauma who attended the surgical emergency department of the Central Hospital of Maracay

Ultrasound		n	%[M]	95 % CI[I]
Bar code sign	Yes	8	25,0	11,46- 43,40
	No	24	75	56,60- 88,54
Absence of pleural sliding	Yes	8	25	11,46-43,40
	No	24	75	56,60- 88,54
Pulmonary point sign	Yes	1	3,13	0,08-16,22
	No	31	96,88	83,78- 99,92
Anechoic pattern	Yes	6	18,75	7,21- 36,44
	No	26	81,25	63,56- 92,79
Interstitial pattern (B lines)	Yes	8	25	11,46-43,40
	No	24	75	56,60- 88,54
Fractures	Yes	3	9,38	1,98- 25,02
	No	29	90,63	74,98- 98,02

Regarding radiological signs in the patients studied, it was observed that 7 of them, representing 21,88 %, presented increased radiolucency and rib fractures, while 15,63 % presented increased homogeneous density and only 12,50 % (4) showed an interstitial patternt (table 5).

Table 5. Radiological signs of chest injury in patients who attended the surgical emergency department of the Central Hospital of Maracay

X-rays		n	%[M]	95 % CI[I]
Increased radiolucency	Yes	7	2	9,28- 39,97
	No	25	78,13	60,03- 90,72
Increased density	Yes	5	15,63	5,28- 32,79
	No	27	84,38	67,21- 94,72
Interstitial pattern	Yes	4	12,50	3,51- 28,99
	No	28	87,50	71,01- 96,49
Fracture	Yes	7	21,88	9,28- 39,97
	No	25	78,13	60,03- 90,72

When comparing the two diagnostic methods, we can see that 25 % (8) showed signs of pneumothorax on ultrasound, while 21,88 % (7) showed radiological signs of pneumothorax, with a P= 0,0000053. Similarly, in 18,75 % (6) of the patients evaluated by ultrasound, pleural effusion was evident, while 15,63 % (5) presented pleural effusion on X-ray. Regarding the interstitial pattern, 21,88 % of patients were diagnosed by ultrasound, while only 12,50 % (4) showed an interstitial pattern on chest radiography. Finally, pulmonary ultrasound was able to diagnose 9,38 % (3) of patients with rib fractures or rib, while chest X-rays diagnosed 21,88 % (7) with rib fractures (table 6).

Table 6. Transthoracic ultrasound versus chest X-ray in the diagnosis of post-traumatic pathologies in patients who attended the surgical emergency department of the Central Hospital of Maracay

Variables		Ultrasound			X-ray			Diagnostic tests RX			
		n	%[H]	IC95 %[I]	n	%[H]	95 % CI[I]	P	Sensitivity	Specificity	AUC
Pneumothorax	Yes	8	25	11,46- 43,40	7	21,88	9,28- 39,97	0,0000053	7	10	0,960
	No	24	75,00	56,60- 88,54	25	78,13	60,03- 90,72				
Pleural effusion	Yes	6	18,75	7,21- 36,44	5	15,63	5,28- 32,79	0,0000148	83,33	10	0,917
	No	26	81,25	63,56- 92,69	27	84,38	67,21- 94,72				
Interstitial Pattern	Yes	7	21,88	9,28- 39,97	4	12,50	3,51-28,99	0,0004866	57,14	10	0,786
	No	25	78,13	60,03- 90,72	28	87,50	71,01- 96,49				

Rib fracture	Yes	3	9,38	1,98- 25,02	7	21,88	9,28- 39,97	0,0599798	66,67	82,73	0,747
	No	29	90,63	74,98- 98,02	25	78,13	60,03- 90,72				

DISCUSSION

Currently, pulmonary ultrasound is considered a dynamic, diagnostic, and noninvasive tool that allows for real-time study of the functionality of the organ being examined. However, despite its many advantages, it has not replaced chest X-rays, which continue to be a cornerstone in the evaluation of patients with chest trauma. This study compared the diagnostic utility of transthoracic ultrasound with chest X-rays in patients with chest trauma in the surgical emergency department of the Central Hospital of Maracay, and the results reveal significant clinical implications.

Of the total number of patients evaluated with chest trauma, the majority were male (84,38 %), with an average age of 38,15 and a standard deviation of 15,27. This is particularly relevant to the study conducted by Aswin K et al. where 89 % were male.[9] The average age of the patients was 43,46 (standard deviation 16,3). Similarly, the study conducted by Rohit B et al, whose age range was 18 to 68 years, had an average age of 46,8 years.[10]

The most important clinical manifestation was chest pain in 100 % of cases, while the least common clinical sign was subcutaneous emphysema in 9,38 % of cases. while in the study conducted,[14] 16,1 % presented subcutaneous emphysema. Similarly, in the same study, traffic accidents were the most common mode of injury in 81 % of cases,[11] which is consistent with this study, where the sum of causes related to traffic accidents represented 87,5 %.

The findings of this research show a certain relationship with the study conducted by Ariza et al.[5], where there were slightly more ultrasound signs than radiological signs, with the exception of signs of fracture.

Regarding the pathologies diagnosed in the study, pulmonary ultrasound showed that 8 patients (25 %) had signs of pneumothorax, compared to chest X-rays, which only diagnosed 7 patients (21,88 %). Meanwhile, 18,75 % (6) presented pleural effusion on ultrasound, while 15,63 % (5) presented pleural effusion on chest X-ray. The interstitial pattern was evident in 21,88 % of patients assessed by ultrasound, while chest X-rays only revealed an interstitial pattern in 12,50 (4) patients. Finally, pulmonary ultrasound was able to diagnose 9,38 % (3) of patients with rib fractures, while chest X-rays diagnosed 21,88 % (7) with rib fractures.

The results associated with the pathologies diagnosed in the present study are closely related to other studies, such as that of Aritza et al.[5], whose results show high concordance for pneumothorax and pleural effusion and moderate concordance for the interstitial pattern. Similarly, Aswin K et al.[9] highlighted that the sensitivity and specificity of pulmonary ultrasound (USG) for detecting pneumothorax were 85,7 % and 95,3 %, respectively, and those of chest X-ray (CXR) were 71,4 % and 100 %, respectively. In both studies, the specificity of USG for detecting pneumothorax was the same as that of CXR, and the specificity of USG for detecting hemothorax was higher than that of CXR in that subset of patients.

Currently, the rise of lung ultrasound is evident. Even in trained hands, it surpasses chest radiography due to its high sensitivity and specificity. In trauma, it is vitally important and allows for bedside evaluation, enabling a timely diagnosis in real time.

It was observed that, although the margin of difference was small, transthoracic ultrasound in this study outperformed chest X-rays in most post-traumatic thoracic pathologies, with a significant difference in rib fractures, where chest X-rays were superior. It is therefore important that both studies complement each other to provide a better diagnosis for patients, but it is vitally important that, over time, training leads to the individualization of both studies, so that neither depends on the other when making decisions in the emergency room.

Most patients who arrive at the surgical emergency department of the Central Hospital of Maracay are hemodynamically stable. However, not all patients are so fortunate, and invasive procedures are often necessary to improve the patient's condition, ranging from pleural drainages to endotracheal intubation, which are managed by the intensive care unit, making patient mobilization difficult. This is where transthoracic ultrasound plays a key role, enabling the diagnosis and monitoring of these patients. On many occasions, the institution's radiography equipment was out of service due to maintenance, and measures were taken to perform lung ultrasound in a timely manner on the patient.

The results of this study have significant clinical importance for the management of patients with chest trauma. Transthoracic ultrasound has proven to be a highly effective diagnostic tool, with superior sensitivity and specificity compared to chest X-rays, particularly in the detection of pneumothorax and pleural effusion. This diagnostic superiority is crucial in the context of emergencies, where rapid and accurate detection can mean the difference between life and death. Ultrasound provides immediate bedside assessment, facilitating rapid clinical decisions and reducing the need to transport the patient for X-ray, which can be vital in critical situations.

This study contributes to the validation of the implementation of transthoracic ultrasound, as the findings

reaffirm its usefulness as a complementary diagnostic tool and, in many cases, superior to chest X-rays. This supports its integration into trauma and surgical emergency management protocols, as seen in previous studies such as that by Pinos et al.[5]

The results provide valuable comparative data that can be used in international studies and in different clinical contexts. Comparison with previous research such as that of Guido et al.[4] and Barrera-Moreno[6] demonstrates consistency in the benefits of ultrasound for various lung pathologies.

The differences according to the Glasgow scale in patients before and after CD were not statistically significant (p>0,05). Similarly, the relationship between the study variables and the impact of CD in patients with TBI was not statistically significant. Although the data generally indicate that CD is a beneficial procedure for a high percentage of patients, as also demonstrated in previous studies [4,8,11,12,13] the lack of statistical significance could be a consequence of the low number of patients included in this study.

CONCLUSION

The study determined the diagnostic utility of transthoracic ultrasound compared to chest X-ray in patients with chest trauma in the surgical emergency department of the Central Hospital of Maracay. The findings demonstrated that ultrasound is highly effective in detecting post-traumatic lung pathologies such as pneumothorax and pleural effusion, with superior sensitivity and specificity, underscoring its value as a diagnostic tool. In addition, the results indicated a significant prevalence of clinical manifestations such as chest pain and dyspnea, and highlighted the high incidence of injuries related to motorcycle accidents.

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