Journal of Population Therapeutics & Clinical Pharmacology

A cross-sectional diagnostic study comparing the sensitivity and specificity of ultrasonography and chest radiography in detecting pneumothorax and hemothorax in patients with chest trauma.

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1. Radiological technology
2. Technician-radiological technology

Abstract

Background

After head trauma and abdominal injuries, thoracic trauma makes up 20–25% of all traumas and is the third most common cause of death. Moving an unstable patient to the X-ray room in the Emergency Department (ED) is always dangerous to detect pneumothorax and hemothorax. Bedside X-rays expose nearby patients to radiation as well as the patient in question. When chest trauma patients are first imaged, bedside ultrasonography (USG) can help prevent this.

Objective

To assess the efficacy and precision of chest radiography and ultrasonography in identifying hemothorax and pneumothorax in patients with chest trauma.

Methods

At Kingdom of Saudi Arabia Ministry of Health Riyadh health cluster one Imam Abdulrahman AL Faisal hospital a cross-sectional diagnostic study was carried out over the course of a year. The study included all consecutive patients (n = 255) who had a possible history of chest trauma. A point-of-care ultrasonography-trained emergency medicine physician examined the patients at the bedside using USG, and they then had chest radiography to document hemothorax and pneumothorax.

For chest X-rays (CXRs) and ultrasonography, sensitivity and specificity were calculated and compared with the composite gold standard, which consists of computed tomography thorax and chest radiography.

Results

89 percent of the 255 patients were men. The patients' average age was 43.46 years old (standard deviation: 16.3). The most frequent way of injury (81%), was from a road traffic accident (RTA).

Four hours (2.5-7) was the median (interquartile range) amount of time that passed between the injury and hospital arrival. In subcutaneous emphysema, 16.1% of the patients were affected. Hemodynamic stability was present in about 88.2% of the patients, and 78% of them also had additional system injuries. When it came to identifying pneumothorax, USG's sensitivity and specificity were 85.7% and 95.3%, respectively, whereas CXR's were 71.4% and 100%. According to our research, CXR had a 62.9% and 100% sensitivity and specificity in diagnosing hemothorax, while USG had a 79% and 97.9% sensitivity and specificity. The sensitivity of USG in diagnosing pneumothorax and hemothorax was higher than that of CXR, even in the subset of patients in whom a computed tomography scan was performed. Within that patient subset, USG had a better specificity for hemothorax detection than CXR, and it had the same specificity for pneumothorax detection as CXR.

Conclusion

When it came to identifying pneumothorax and hemothorax, USG's sensitivity was higher than CXR's. When it came to identifying pneumothorax and hemothorax, USG's specificities were similar to those of CXR. For this reason, bedside ultrasound done by an emergency physician during resuscitation aids in the quick diagnosis and prompt treatment of patients with chest damage.

Introduction

Trauma remains a major threat to global public health despite increased urbanization, industrialization, and a sharp rise in the number of vehicles on the road. It is associated with high rates of morbidity and mortality in both developed and developing countries, accounting for an estimated six million deaths globally (Beshay et al., 2020). Thoracic trauma makes up 20–25% of all injuries in patients with polytrauma, and it is the third most common cause of death, behind head trauma and abdominal damage (Demirhan et al., 2009). Blunt chest injuries are more frequent than penetrating injuries and may be dangerous for the traumatized patient's respiration, circulation, and airway, which could have an immediate impact on the course and result of the clinical procedure (Lecky et al., 2010).

When diagnosing a patient with thoracic trauma, imaging studies are crucial. Since chest radiographs are quick, simple to get, affordable, and expose patients to less radiation, they are typically performed as the first imaging exam at the majority of trauma hospitals in India. However, the majority of injuries may go unnoticed on a bedside chest X-ray (CXR) due to its extremely low sensitivity. For this reason, chest trauma examination requires the use of computed tomography (CT). Ultrasonography (USG) performed in the emergency department has been found in recent studies to be helpful in the early commencement of resuscitation and management. (Vafaei et al., 2016)

While some research has indicated that ultrasonography (USG) is more sensitive and specific in identifying pneumothorax and hemothorax in patients with chest trauma, a 2016 study found that USG is highly operator-dependent and unreliable in identifying injuries without bleeding or free fluid. While the radiologist performed USG in the majority of previous trials, the resuscitating emergency physician conducted the evaluation in the current study. Comparing the sensitivity and specificity of USG and CXR in patients with chest injuries is another extremely rare study conducted in India. Thus, the goal of this research is to evaluate the sensitivity and specificity of chest radiography and ultrasonography in identifying hemothorax and pneumothorax in patients with chest injuries. (Dangi et al., 2018)

Materials And Methods

This cross-sectional diagnostic study was carried out for a year at Kingdom of Saudi Arabia Ministry of Health Riyadh health cluster one Imam Abdulrahman AL Faisal hospital The study comprised all consecutive patients who visited the Department of Emergency Medicine and Trauma with suspected chest trauma. Pregnant women and patients with a history of penetrating chest trauma were not allowed to participate in the trial. Using OpenEpi v 3 (Open-Source Epidemiologic Statistics for Public Health Version 3, Atlanta, GA) with a 5% level of significance, 80% power, and the sensitivity (83.6%) of ultrasonography in detecting pneumothorax as reported by Vafaei et al., the estimated sample size (n= 255) was determined (Vafaei et al., 2016).

An emergency medicine physician skilled in Point of Care Ultrasonography (POCUS) assessed the study population at the patient's bedside using ultrasonography. Using a high-frequency linear probe, the diagnosis of pneumothorax was made by bilaterally scanning the intercostal space (second-sixth) while the patient remained supine. In order to rule out pneumothorax, the pleural line was located and checked for lung sliding for four to five breathing cycles. If lung sliding was absent. A probe was used bilaterally to investigate the lateral chest area above the diaphragm in coronal view in order to look for hemothorax. Hemothorax was diagnosed based on the visualization of anechoic regions in the pleural space. (Lichtenstein, 2015)

The patient then had a chest scan to record the hemothorax and pneumothorax. CT scanning was performed on patients who had a significant clinical suspicion of pneumothorax or hemothorax but whose chest radiography did not show evidence of pneumothorax or hemothorax. A radiologist who was unaware of the results of the ultrasonography interpreted the chest radiography and CT scan. The treating physician/surgeon decided what additional procedures/treatments the patient needed.

Calculations were made to determine the sensitivity and specificity of chest radiography and ultrasonography in comparison to the composite gold standard, which is either CT thorax or chest radiography. At the time of the patient's admission, during chest radiography, CT scan, and ultrasonography, data were gathered utilizing a structured proforma. Microsoft Excel (Microsoft Corporation, Redmond, USA) was used to enter and analyze the data. Categorical data were expressed as percentages and proportions, and continuous variables were expressed as mean and standard deviation (SD) or median and interquartile range (IQR).

Results

During the trial period, 255 patients with chest injuries were included in the study. In the study population, there was a statistically significant male preponderance (n=226) ($p<0.005$). The patients' average age was 43.46 years, with a standard deviation of 16.3. Seventy-one percent of the patients were wage workers, and eighty-one percent of the injuries were caused by road traffic accidents (RTAs). Four hours (IQR) was the median (IQR) amount of time that passed between

the injury and hospital arrival (2.5-7). 81.2% of the patients reported chest wall soreness, 36.9% had bony crepitus, 20.4% had a chest wall contusion, and 16.1% had subcutaneous emphysema. Among the 255 patients, 198 had at least one non-chest injury, such as a head, abdominal, pelvic, or long bone injury, and 88.2% of them were hemodynamically stable. Twenty.4% had a Glasgow Coma Scale (GCS) of less than nine, while roughly 73.7% had a GCS between 13 and 15.
Out of the 255 patients, 63 (24.7%) and 53 (20.8%) were found to have hemothorax and pneumothorax, respectively, using ultrasonography. 61 patients with unilateral pneumothorax and two with bilateral pneumothorax were diagnosed with pneumothorax, whereas 51 patients with unilateral hemothorax and two with bilateral hemothorax were identified with hemothorax.
Of the 255 patients, 45 (17.6%) and 39 (15.3%) were found to have hemothorax and pneumothorax, respectively, using CXR. 45 patients were diagnosed with pneumothorax; 44 of these patients had unilateral pneumothorax, 1 had bilateral pneumothorax, and 39 of the patients had unilateral hemothorax. The sensitivity and specificity of using a CT scan and a composite gold standard to diagnose pneumothorax and hemothorax, respectively, are displayed in Tables 1-2.

TABLE 1: Sensitivity and specificity of detecting pneumothorax and hemothorax when the composite gold standard was considered as the gold standard (n=255)

	Pneumothorax		**Hemothorax**	
	Ultrasonography (%)	Chest X-ray (%)	Ultrasonography (%)	**Chest X-ray (%)**
Sensitivity	85.7	71.4	79	**62.9**
Specificity	**95.3**	**100**	**97.9**	**100**

TABLE 2: Sensitivity and specificity of detecting pneumothorax and hemothorax when CT scan was considered as the gold standard (n=60)

	Pneumothorax		**Hemothorax**	
	Ultrasonography (%)	Chest X-ray (%)	Ultrasonography (%)	**Chest X-ray (%)**
Sensitivity	81.8	45.5	65.7	**34.3**
Specificity	**92.6**	**92.6**	**96**	**92**

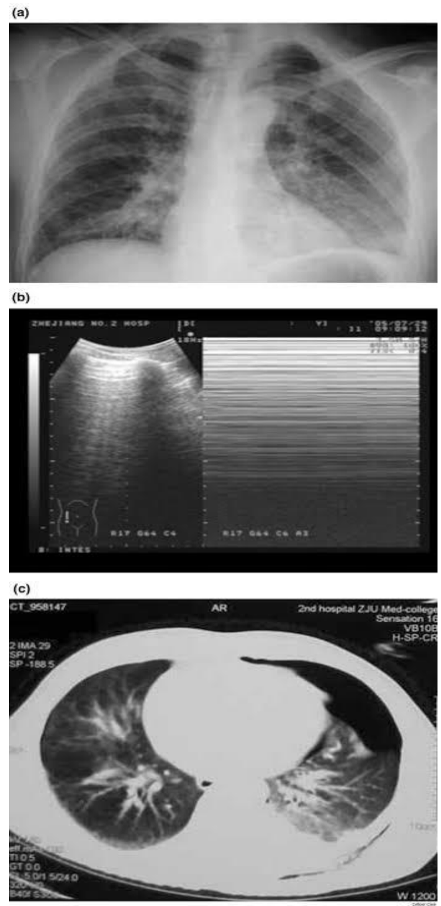

figure 1: Pneumothorax Ultrasonography

Figure 2: Traumatic Hemothorax

Discussion

Moving an unstable patient to the X-ray room in the Emergency Department (ED) is always dangerous, and bedside X-rays expose nearby patients to radiation as well as the patient in question in a crowded, busy ED. When bedside USG is the first imaging modality used in patients with chest injuries, this can be prevented. Males made up 89% of the subjects in our study, while females made up 11%. This study bears similarities to prior research conducted in India and other nations (Choudhary et al., 2015).

The fact that most men engage in outdoor activities helps to explain this pattern of masculine preponderance. In our study, 41.6% of the patients were between the ages of 21 and 40. Because the family's primary provider will be in this age range and likely engage in more travel, this study is comparable to others in that regard. (Kasabe et al., 2016).

Similar to previous research, we discovered that the most frequent clinical presentation in the current investigation was chest tenderness, which was present in 81.2% of our patients. In our study, we found that 78% of our patients also had related injuries in addition to a chest injury. Iyer et al. discovered a same percentage in another study conducted in India (Iyer et al., 2018).

In our analysis, head injuries accounted for almost one-third of all related injuries. Another study conducted in India by Choudhary et al. discovered a similarly high frequency of head injuries (Choudhary et al., 2015).

On the other hand, a head injury was reported to be the most common related injury in a different study conducted outside of India by Horst et al., accounting for one-fourth of the patients' injuries. This is due to the fact that helmets and seat belts are not frequently worn when riding two-wheelers in our area, which raises the risk of head injuries (Horst et al., 2017).

The study found that USG had a sensitivity of 85.7% and a specificity of 95.3% in identifying pneumothorax. This is in line with research conducted by Vafaei et al., which discovered that USG had an 83.6% sensitivity and a 97.9% specificity in identifying pneumothorax (Vafaei et al., 2016). Ebrahimi et al. conducted a meta-analysis in 2014, which revealed that the combined sensitivity and specificity were 87% and 99%, respectively (Ebrahimi et al., 2014).

According to a 2016–2017 study by Salama et al., the sensitivity and specificity for pneumothorax were shown to be 81% and 100%, respectively. In our investigation, 41 patients with subcutaneous emphysema had an unclear USG window. This might have somewhat decreased our study's sensitivity and specificity (Salama et al., 2017).

In our investigation, CXR's sensitivity and specificity for identifying pneumothorax were 71.4% and 100%, respectively. According to Vafaei et al., they were, respectively, 67.3% and 92.7%. They were shown to be 46% and 100%, respectively, in the meta-analysis conducted by Ebrahimi et al. The investigation by Salama et al. revealed that the sensitivity and specificity were, respectively, 75% and 88.9%. Because CXR was considered the gold standard in our study for patients with a clinical suspicion of a chest injury and positive results from CXR, the higher specificity of CXR was attained. Only in individuals with a strong suspicion of a chest injury but negative CXR results was a CT scan regarded as gold standard.

This resulted from the fact that, due to institutional regulation, we were unable to perform CT scans on every patient. CT scans were only performed on patients with strong clinical suspicion and negative CXR results. However, this limitation is tolerable because the majority of research indicate that CXR has good specificity.

The results of this study showed that USG had a 79% sensitivity and a 97.9% specificity in identifying hemothorax. This result was in line with the majority of the previous research.

According to Vafaei et al., the corresponding sensitivity and specificity were 75.9% and 95.9%. Movaghar et al.'s meta-analysis found that the pooled sensitivity and specificity were 67% and 99%, respectively. Our study's sensitivity for hemothorax detection is lower than that of pneumothorax detection, which is similar to the findings of Vafaei et al.'s study. It was discovered that diagnosing hemothorax was challenging in patients who had concurrent pneumothorax and severe subcutaneous emphysema. A meticulous USG evaluation was required for such patients.

In our investigation, the sensitivity and specificity of CXR in identifying hemothorax were found to be 62.9% and 100%, respectively. The sensitivity and specificity were shown to be 58.6% and 95.1%, respectively, in the investigation conducted by Vafaei et al. Movaghar et al.'s meta-analysis revealed that the combined sensitivity and specificity were 54% and 99%. As previously said, CXR was regarded as the gold standard for a sizable portion of patients, which explains why it has a higher specificity. Compared to CXR, USG has a better sensitivity for pneumothorax and hemothorax detection. When the composite gold standard was taken into account, the specificity of USG in diagnosing pneumothorax and hemothorax was poorer than that of CXR. But USG's specificity was about the same as CXR's.

Strengths and limitations

The use of a composite gold standard in our study has limitations, but these are acceptable because the pooled specificities of CXR were significantly higher in the meta-analyses conducted by Ebrahimi et al. to detect pneumothorax and Movaghar et al. to detect hemothorax. Therefore, in patients with clinical suspicion and positive CXR results, CXR was considered the gold standard. In our investigation, the composite gold standard was the only one employed because subcutaneous emphysema made it challenging to interpret some USG data. Notwithstanding these drawbacks, we found that USG was more sensitive than CXR.

The sensitivity of USG in diagnosing pneumothorax and hemothorax was higher than that of CXR, even in the subset of patients in whom a CT scan was performed. When it came to the subset of patients in question, USG's specificity for identifying pneumothorax was equal to that of CXR, while its specificity for identifying hemothorax was greater. Our study's added benefit is that it was conducted by an emergency physician, who had a thorough understanding of the patients' clinical characteristics and a higher pretest likelihood. Additionally, there was no delay in the patient's transition to the radiologist's room for the USG.

Conclusions

When it comes to identifying pneumothorax and hemothorax in individuals with chest injuries, USG has higher sensitivity than CXR. When comparing USG and CXR with the composite gold standard, the variations in specificities for detecting pneumothorax and hemothorax were slight. When CT scan was regarded as the gold standard, however, USG's specificities in diagnosing pneumothorax and hemothorax were higher and the same, respectively, in comparison to CXR.

In patients with chest injuries, USG had higher sensitivity than CXR in identifying pneumothorax and hemothorax. When the composite gold standard was taken into account, the specificities of USG in detecting pneumothorax and hemothorax were somewhat lower than those of CXR. However, when CT scan was taken into consideration as the gold standard, the specificities of

USG in diagnosing pneumothorax and hemothorax were higher and the same, respectively, as compared to CXR.

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