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Research Article

Ultrasound Guidance in Detection of Pneumothorax and Thoracentesis Performance

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Abstract

Management of pneumothorax and its early diagnosis are important clinical skills for physicians in emergency departments and respiratory medicine. The recent investigations provided some evidence about the use of ultrasonography in diagnosis of pneumothorax in critical care units. Currently ultrasonography is on hand in most therapeutic and diagnostic departments for both detection and disease management. Advantages of ultrasonography are that it's portable and can be applied in patient's bedside. In this article we reviewed the efficacy of ultrasonography ii diagnosis of pneumothorax and well performance in Thoracentesis. We concluded that diagnostic accuracy of ultrasonography was equal and some times more than chest radiography in detection of pneumothorax. Ultrasonography will increase patient safety and the amount of fluid removed during thoracentesis and can reduce the risk of pneumothorax, hospitalization costs and length of stay.

Keywords: Pneumothorax; Ultrasonography; Chest radiography; Thoracentesis

Introduction

There are two forms of pneumothorax including spontaneous and traumatic. There is no history of trauma for Spontaneous pneumothorax and has two subgroup consisting of primary or secondary [1]. Primary spontaneous pneumothorax is seen in young and normal individuals whereas secondary spontaneous pneumothorax is resulting of lung other pathologies like chronic obstructive pulmonary disease, cystic fibrosis and etc. [1]. The frequency of pneumothorax has higher rate in patients with underlying lung disease [2]. A study indicated that age-adjusted incidence of primary spontaneous pneumothorax of 7.4 per 100,000 per year in men and 1.2 per 100,000 per year in women. For secondary spontaneous pneumothorax, the incidence was 6.3 and 2.0 per 100,000 per year in men and women. They reported that ratio of male-to-female incidence was 6.2:1 for primary and 3.2:1 for secondary spontaneous pneumothorax [3]. There has been reported that Combined hospital admission rates for primary and secondary spontaneous pneumothorax in the United Kingdom was 16.7 per 100,000 for male and 5.8 per 100,000 for female, with corresponding annual mortality rates of 1.26 per million and 0.62 per million between 1991 and 1995 [4].

Different aspect of US has been developed in the recent years for diagnosis, staging, restaging follow-up [5-11]. Chest trauma and allied problems consisted of 25% of mortalities in this series and commonly is responsible for 40% mortality rate [12,13]. Although CXR has insufficient efficacy but it is the first step in managing chest trauma [14-19]. Pneumothorax is one of the leading complications of trauma in multiple trauma patients and is diagnosis is very important. Therefore some studies evaluated US for this matter [20–24]. Considering US in diagnosis and management of patients were well described for some conditions but Thoracic sonography is new method and still is under investigations. In this regards the first US to detect pneumothorax was performed by Wernecke et al. [25]. Therefore in the current article we reviewed the efficacy of Thoracic sonography in diagnosis of Pneumothorax in traumatic patients and its efficacy in thoracentesis.

Thoracentesis

US has the ability to show 20 mL of pleural fluid, but upright posteroanterior CXR can reveal at least 100 mL of fluid [26,27]. Visceral pleural puncture, one of the reasons for pneumothorax is the most considerable complication of thoracentesis [28]. Rate of pneumothorax after Thoracentesis is about as 20% to 39% [29]. Using US provide evidences about the correct place of needle insertion depth into the intercostal space [29-31]. We should consider that many articles which discussed about US-guided thoracentesis revealed needle insertion time was no real-time guidance and insert the needle right after US probe detection [32]. On the other hand, articles proved that after inadequate clinical thoracentesis use of US can develop the procedure up to 88% and has high success rate. Sometimes we see reports about dry taps' patients but in 58% of these cases needle is below the diaphragm and US is the solution [33-37]. In a systematic review and meta-analysis by Gordon et al. [28] revealed best way to lessen the pneumothorax rates after thoracentesis is considering US.

In a study by Patel et al. [38] indicated that considering US for thoracentesis would decrease total hospital stay, lower costs, and lower incidence of pneumothorax and hemorrhage. The Patient Protection and Affordable Care Act of 2010 and the Centers for Medicare and Medicaid Services Reporting Hospital Quality Data for Annual Payment Update Program Quality Measures FY 2012–2014 describe as important aim for high efficacy in healthcare delivery, safer and considerable medical care, and avoidance of preventable complications, including iatrogenic pneumothorax [39-41]. In this regards David Kopman Feller [42] reported that US is an easily learned technique which is portable and effective in reliable physical exam and could provide real-time guidance for thoracentesis and other procedures. Luigi Cavanna et al. [43] reported that using US during thoracentesis drastically would decrease the rate of pneumothorax and tube thoracostomy in cancerous objects.

Pneumothorax

A pneumothorax has two main etiology including: Traumatic and atraumatic. Atraumatic pneumothorax has been divided to primary spontaneous or secondary spontaneous. For detecting pneumothorax currently we use clinical signs and symptoms, as well as subtle and plain chest radiography. Any wasting time for diagnosing a pneumothorax could result in progression of a pneumothorax and resultant hemodynamic instability [44].

Man articles discussed and compared the usefulness of US versus CXR in establishing pneumothorax in emergency rooms [45]. Although the gold standard diagnosis for pneumothorax is CT scan but here has been reported that the sensitivity of US is the same [45-47]. Moreover emergency departments, Lichtenstein and Menu revealed that sensitivity and a specificity of US in ICU patients is 95.3% and 91.1% respectively [48]. A study by Chin EJ, et al. [49] indicated that pre-hospital medical personnel could be trained to diagnose pneumothorax b US and the outcomes have been proved. In an article which was meta-analysis showed sensitivity of 78.6–90.9 % and specificity of 98.2–98.4 % for US which chest radiographs had showed sensitivity of 39.8–50.2 % and specificity of 99.3–99.4 % [50,51].

Here are some features that can help pneumothorax to be detected or omitted by US: lung sliding, B-lines, lung pulse and lung point [52,53]. Lung sliding or B-lines can exclude pneumothorax when we report them on anterior surface of a supine patient's chest [54-62]. A meta-analysis by Ebrahimi et al. [63] indicated that the diagnostic accuracy of US was higher than supine CXR for diagnosis of pneumothorax. They indicated sensitivity and specificity of US were 0.87 and 0.99. The pooled sensitivity and specificity of CXR were 0.46 and 1.0, respectively. In study by Michael S. Kristensen et al. [64] showed that Ultrasonography is a reliable device for intraoperative and emergency diagnosis of pneumothorax. US provide us diagnosis and management of interstitial syndrome, lung consolidation, atelectasis, pleural effusion and differentiate etiologies of acute breathlessness during pregnancy.

Limitations

US can be considered as alternative for CXR but its accuracy is close to operator technique and knowledge. But progressions in structural changes of US improved the quality and spatial resolution which could be resulted in better outcomes in emergency departments [65-73].

Probe selection and equipment

Diagnosis of pneumothorax can be applied in the bedside of the patients by many of the current devices. Maybe a straight linear array high frequency probe (5-13 MHz) can be adequate in detecting superficial structures including the pleural line and providing better resolution [74]. Most micro convex transducers can provide reliable image for both superficial (pleura) and deeper structures (e.g. lung consolidation, atelectasis). Due to their small size they can indicate posterior thoracic wall in the supine position [75]. In this regards, curved low-frequency transducer (4.0 MHz), can show superficial and deeper structures in high quality images [76,77].

Conclusion

Many current investigations revealed the safety and efficacy of US-guided thoracentesis which can reduce the risk of hospitalization costs, pneumothorax and length of stay. Based on published articles and met-analysis ultrasonography has reliable accuracy and even is more accurate than chest radiography for diagnosis of pneumothorax. Therefore considering ultrasonography in emergency departments for both traumatic and non-traumatic patients for detection of pneumothorax is being advised.

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