Ultrasound Guidance in Detection of Pneumothorax and Thoracentesis Performance: a Review

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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 provide some evidence about the use of ultrasonography in the diagnosis of pneumothorax in critical care units. Currently, ultrasonography is used in most therapeutic and diagnostic departments for both detection and disease management. Advantages of ultrasonography are that it’s portable and can be applied on patient’s bedside. In this article, we reviewed the efficacy of ultrasonography in the diagnosis of pneumothorax and its performance in Thoracentesis. We concluded that diagnostic accuracy of ultrasonography was equal and sometimes more than chest radiography in the detection of pneumothorax. Ultrasonography will increase patient safety, the amount of fluid removed during thoracentesis and can reduce the risk of pneumothorax, hospitalization costs and length of stay.

Introduction:
There are two forms of pneumothorax; spontaneous and traumatic. There is no history of trauma in Spontaneous pneumothorax which has two subgroups consisting of primary or secondary (Papagiannis et al., 2015). Primary spontaneous pneumothorax is common in young and normal individuals whereas secondary spontaneous pneumothorax is caused due to lung and other pathologies like the chronic obstructive pulmonary disease, cystic fibrosis. The frequency of pneumothorax is higher in patients with underlying lung disease (MacDuff et al., 2010). A study indicated that age-adjusted incidence of primary spontaneous pneumothorax is 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 (Melton et al., 1979).

Reports also suggest cases of hospital admitted rates for both primary and secondary spontaneous pneumothorax in the United Kingdom were 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 (Gupta et al., 2000).

Different aspect of ultrasound (US) has been developed in past few decades for diagnosis, staging and restaging follow-up (Sholli et al., 1990; Cavanna et al., 1992; Civardi et al., 2002). Chest trauma and allied problems consisted of 25% of mortalities in this series and are commonly responsible for 40% mortality rate (Hill, 2011; Heron, 2012). Although CXR has insufficient efficacy but it is the first step in managing chest trauma (Wilkerson & Stone, 2010; Xiouchaki et al., 2011; Rodriguez et al., 2013; Forouzanfar et al., 2014).

Pneumothorax is one of the major complications of trauma in multiple trauma patients and its proper diagnosis is very important to save a life. However, very few studies have been conducted in this regard (Tang et al., 2012; Kline et al., 2013; Fankhauser et al., 2013; Barbara, 2014; Aspler et al., 2014). Utilizing the US in diagnosis and management of patients is well described for some conditions but Thoracic sonography is a new method and the process is still under investigation. In this regard the first US to detect pneumothorax was performed by
Pneumothorax:
A pneumothorax has two main etiology; 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. Wastage of time in diagnosing a pneumothorax could result in progression of a pneumothorax and resultant hemodynamic instability (Bridges et al., 1993).

Although the gold standard diagnosis of pneumothorax is CT scan but it has been seen that the sensitivity of US is the same. (Soldati et al., 2008). Moreover emergency departments, Meta-analysis Reports also revealed the sensitivity of 78.6–90.9 % and specificity of 98.2–98.4 % for US which chests radiographs had showed sensitivity of 39.8–50.2 % and specificity of 99.3–99.4 % (Alrajih et al., 2012; Alrajab et al., 2013).

Lung sliding, B-lines, lung pulse, and lung point are some features which can help pneumothorax to be detected or omitted by the US (Volpicelli et al., 2012). Lung sliding or B-lines can exclude pneumothorax when we report them on the anterior surface of a supine patient’s chest (Lichtenstein et al., 2005; Soldati et al., 2008; Ebrahimi et al., 2014; Kristensen et al., 2014; Obrador et al., 2014). A meta-analysis by Ebrahimi et al. (2014) 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. A study by Kristensen et al. (2014) showed that Ultrasonography is a reliable device for intraoperative and emergency diagnosis of pneumothorax. The US provide us diagnosis and management of interstitial syndrome, lung consolidation, atelectasis, pleural effusion and differentiate etiologies of acute breathlessness during pregnancy.

Limitations:
The ultrasound (US) can be considered as an alternative for CXR but its accuracy depends on operator’s skill and knowledge. However, progressions in structural changes of US improved the quality and spatial resolution which resulted in better outcomes in emergency departments. (Obrador et al., 2014; Haghighi et al., 2014; Heydari et al., 2014; Xirouchaki et al., 2014; Williams et al., 2014; Mundada et al., 2014; See et al., 2014; Wagner et al., 2014).

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 (Mundada et al., 2014). Most micro convex transducers can provide a 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. In this regards, curved low-frequency transducer (~4.0 MHz), can show superficial and deeper structures in high-quality images. (Laursen et al., 2011; Volpicelli et al., 2012).
Conclusion:
Many current investigations reveal the safety and efficacy of US-guided thoracentesis which can reduce the risk of hospitalization costs, pneumothorax and duration of recovery. Based on available reports and meta-analysis ultrasonography could be considered as having reliable accuracy and is more accurate than chest radiography for diagnosis of pneumothorax. Conclusively, ultrasonography in emergency departments for both traumatic and non-traumatic patients for detection of pneumothorax is being advised.

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References:
DHHS (Department of Health and Human Services) (2012): Hospital inpatient prospective payment systems for acute care hospital and longterm care hospital prospective payment system and FY 2012 rates; Hospital's FTE resident caps for graduate medical education payment.US Government Printing Office website.

MacDuff, A., Arnold, A. & Harvey, J. (2010): Management of


