Pleural Ultrasonography versus Chest Radiography for the Diagnosis of Pneumothorax

Thesis

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LIST OF ABBREVIATIONS

ACCP	American College of Chest Physicians
AP	Anteroposterior
ARDS	Acute respiratory distress syndrome
BTS	British Thoracic Society
CK-MB	Creatine kinase-muscle/brain
Cm	Centimeter
Cm H_2O	Centimetre of water
COPD	Chronic obstructive pulmonary disease
CT	Computed tomography
CXR	Chest X Ray
ECG	Electrocardiogram
ED	Emergency department
E-FAST	Extended Focused Assessment with Sonography in Trauma
FAST	Focused Assessment with Sonography in Trauma
FP	False positive

HIV	Human immunodeficiency virus
ICU	Intensive Care Units
MHz	Megahertz
Mm Hg	Millimetre of mercury
NPV	Negative Predictive value
PO_2	Partial pressure of oxygen
PPV	Positive Predictive value
PTX	Pneumothorax
ROC	Receiver operating characteristic
TP	True Positive
US	Ultrasonography
V/Q scan	Ventilation-perfusion scan

ABSTRACT

Background: Pneumothorax (PTX) is an emergency that requires urgent management to avoid catastrophic consequences. PTX is also an important cause of respiratory failure in the emergency department**,** and may occur frequently as a complication of central venous catheter insertion.

Aim: The aim of this study is to compare the diagnostic accuracy of bedside lung US with those for anteroposterior (AP) chest X ray (CXR) for the detection of PTX in critically ill patients.

Methods: This study was conducted on fifty adult patients from both sexes, mechanically ventilated at least 48 hours and planned for central line insertion. We excluded overt pneumothorax, patients requiring immediate invasive intervention, pregnancy and lactation. Lung ultrasound was done to all patients after 30 minutes from central line insertion followed by CXR to confirm the diagnosis of pneumothorax. Pneumothorax was confirmed using CT chest.

Results: Results showed that ultrasound is superior to chest X Ray in detection of PTX.Ultrasound showed sensitivity of 94.87%, specificity of 81.82%, positive predictive value of 94.87%, negative predictive value of 21.82% and accuracy of 92.0% in detection of PTX, while Chest X Ray showed sensitivity of 76.92%, specificity of 63.64%, positive predictive value of 88.24%, negative predictive value of 43.75% and accuracy of 74.0% in detection of PTX.

Conclusions: In conclusion, US represent a good approach for the evaluation of PTX, with advantages of timeliness, high accuracy and high reliability.

***Key words*:** Pneumothorax (PTX), chest X Ray (CXR), ultrasound (US), intensive care unit (ICU), computed tomography (CT)

INTRODUCTION

Pneumothorax (PTX) is a frequently encountered dilemma in Intensive Care Units (ICU) worldwide and is defined as air inside the pleural space. PTXs has various pathognomonic mechanisms including spontaneous PTX, traumatic, or iatrogenic due to invasive procedures including mechanically ventilated patients, central venous catheter (CVC) insertion, obtaining lung biopsies, and thoracocentesis(**Bobbio *et al.*, 2015**).

PTX is a medical emergency which mandates rapid intervention to circumvent its catastrophic consequences. PTX also poses as a main causative of respiratory failure in the emergency department (ER). Positive pressure ventilation is a well-known risk factor for the development of PTX(**Alrajhi *et al.*, 2012**).

PTX is a common complication following ribs fracture with an incidence of up to fifty percent in chest trauma patients. Rapid and precise diagnosis or exclusion of PTX is of great importance in emergency situations and in the ICU(**Carnell *et al.*, 2011**).

The traditional modality for diagnosing or ruling out PTX was mostly plain chest radiographs (CXR). Thus CXR plays an important role in the setting of chest trauma or following invasive procedures(**Walley *et al.*, 2014**).

In certain patient populations such as the critically ill, who mostly assume a supine or semi-recumbent position, anterior-posterior (AP) CXR is obtained which offers less accuracy. If the diagnosis via CXR is questionable and the patient is stable, further investigation using imaging with ultrasonography (US) or chest computed tomography (CT) scan is recommended(**Labovitz *et al.*, 2010**).

Though thoracic CT is viewed as the gold standard imaging technique for both diagnosing and quantifying PTX, yet it is costly and can't be routinely performed. Other drawbacks include the hazard of transportation of unstable patients as well the exposure to radiation(**Nazerian *et al.*, 2014**).

To those physicians who are able to perform bedside US, lung US has unfolded as a more applicable modality for the diagnosis/exclusion of PTX. The lack of exposure to radiation, being readily available as well as portable, real time imaging, less laborious, and the reproducibility of the studies, are amongst the many advantages of US vs. CXR and CT scans(**Karakitsos *et al.*, 2006**).

US has been used to exclude PTX following invasive procedures including CVC insertion and transbronchial biopsy sampling. Indeed there is a learning curve to the use of chest

ultrasound, yet luckily it's relatively short(**Karakitsos *et al.*, 2006**).

The use of chest US for the assessment of PTX as well other lung diseases has been gaining popularity. This is especially evident in the literature of both critical care and emergency medicine. Several early trials by Litchenstein et al (1999, 2000, 2005) set the key diagnostic signs of PTX via chest US and showed a higher preference for chest US over CXR. Yet chest US is still not largely utilized despite the previously mentioned evidence and other original research favoring the use of ultrasonography(**Ding *et al.*, 2011**).

As a matter of fact, the British thoracic society guidelines on pleural procedures and thoracic ultrasound state that “The utility of thoracic US for diagnosing PTX is limited in hospital practice due to the ready availability of CXR and conflicting data from published reports"(**Walley *et al.*, 2014**).

Fortunately, a growing number of recent publications in the last few years have been focused on emphasizing the value of chest US in PTX diagnosis and assessment, aiming for US to replace standard CXR in this particular area. (**Donmez *et al.*, 2012**).

AIM OF THE WORK

This study aims to compare between the accuracy of using bedside lung ultrasound & those for antero-posterior chest X ray for the revealing of the incidence of PTX occurrence in critically ill patients especially mechanically ventilated with central venous line.

CHAPTER I

Pneumothorax

PTX is defined as an abnormal collection of air in the pleural space between the lung and the chest wall, which can impair oxygenation and/or ventilation. It comprises a major health problem worldwide, and is associated with considerable healthcare costs as well as morbidity. In certain situations, PTX could turn out to fatal if not managed rapidly. Current research aims at providing ambulatory outpatient management to a larger number of patients (**Bintcliffe and Maskell, 2014**).

A- Epidemiology of Pneumothorax:

One study which analyzed 3 national databases - between 1991 and 1995- showed that the annual consultation rates for PTX in the United Kingdom (UK) were reported to be 24/100 000 for males and 9.8/100 000 for females, and that admission rates were 16.7/100 000 and 5.8/100 000, respectively **(Gupta *et al.*, 2000**).

The overall incidence is estimated at a rate of 1 PTX per year in a general practice population of average size. Across the UK this is equivalent to around 8000 PTX admissions per year, which corresponds to 50,000 bed days taking into consideration that the average length of hospitalization is just under 1 week. On average,

the cost burden of these hospitalizations alone has been estimated at £13.65m for the National Health Service (NHS). In the United States, the annual costs average around $130m (**Bintcliffe and Maskell, 2014**).

Worldwide, the age-adjusted incidence of 1^{ry} spontaneous PTX among males and females was reported to be 7.4–18 and 1.2–6 cases per 100,000 populations, respectively. While the incidence of 2^{ry} spontaneous PTX in men and women was almost similar (approximately 6.3 and 2 cases per 100,000 men and women, respectively)(**Onuki *et al.*, 2017**).

B- Pathophysiology of PTX

In a healthy individual, the pleural pressure is negative if we compared it to the atmospheric pressure all through the entire respiratory cycle. This difference in pressure between the alveoli & pleural cavity is called the trans-pulmonary pressure. This trans-pulmonary pressure is responsible for the elastic recoil of lungs. Conversely in PTX, an abnormal connection is created between the pulmonary alveoli/airways and the pleural cavity, hence air escapes from the alveoli into the pleural space till equalization of the pressure of these two. Likewise, when the the pleural cavity becomes pathologically connected to the chest wall, air moves from the environment into the pleural cavity until there