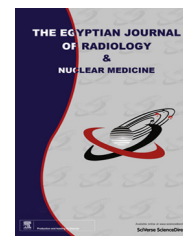




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ORIGINAL ARTICLE

Chest ultrasound in the evaluation of complicated pneumonia in the ICU patients: Can be viable alternative to CT?



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Abstract *Objective:* To compare ultrasound (US) and computed tomography (CT) for evaluating patients with complicated pneumonia admitted to the intensive care unit (ICU) to assess if US can be an alternative to CT.

Subjects and methods: We prospectively compared US and CT findings in 48 patients admitted to the ICU with complicated pneumonia with their final diagnosis at discharge. Images were evaluated for parenchymal findings (consolidation, necrosis, and abscess) and pleural findings (effusion, loculation or fibrin strands in the pleural fluid).

Results: US was similar to CT in the evaluation of parenchymal and pleural abnormalities except for two patients with consolidation and effusion, three patients with loculated effusion, one patient with pulmonary necrosis and another patient with lung abscess. US was superior to CT in detection of fibrin strands within pleural effusion.

Conclusion: Chest US provides an accurate evaluation of the pleural and parenchymal abnormalities associated with complicated pneumonia in the ICU patients. Considering that chest US is a bedside and avoids transportation of the patient outside ICU, free of radiation exposure and easily repeatable, chest US appears to be an attractive alternative to CT.

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1. Introduction

During the last 20 years, several studies have investigated chest US as an accurate diagnostic tool for the diagnosis of pneumonia and results of these studies have shown US to be superior to chest radiography in almost every setting ranging from ICUs to emergency departments and outpatient clinics (1–4). US has grown to such an extent that an evidence-based consensus conference was held in 2010 and 2011 bringing together

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dozens of published experts from multiple countries around the world (5). The consensus conference found chest US to have broad utility in evaluating patients for different pathologic pulmonary conditions including pneumonia and pleural effusion.

Management of the ICU patients with complicated pneumonia requires imaging techniques which are essential for optimizing diagnostic and therapeutic procedures. To date, imaging of these patients has relied on bedside chest radiography and chest CT for characterization of pleural effusion and underlying parenchymal disease before chest tube placement or surgery (6). However, performing a chest CT scan requires transportation of the patient to the radiology department, a risky procedure necessitating the presence of trained physicians and sophisticated cardio-respiratory monitoring (7). In addition, multi-detector row CT exposes the patient to a substantial radiation dose which limits the repeatability of the procedure (8). For these reasons, chest CT remains a radiological test, access to which is limited in many ICUs. It is, therefore, not surprising that alternative imaging strategy such as US has been investigated.

We prospectively compared the information obtained from chest US and chest CT in the ICU patients with complicated pneumonia with their final diagnosis at discharge to determine if US could serve as a useful alternative to CT. In those patients who underwent drainage of pleural effusion, imaging findings were correlated with data obtained from analysis of pleural fluid.

2. Subjects and methods

Among 2234 patients admitted to ICU for different diagnoses between June 2009 and July 2013, 52 patients were suspected to have complicated pneumonia on the basis of clinical examination and chest radiography. These patients underwent both chest US and chest CT and 48 patients had final diagnosis of complicated pneumonia and they were included in this study. Other four patients with uncertain diagnoses were excluded. There were 31 males and 17 females and their ages ranged from 28 to 67 years (mean age, 46 years). US was performed first and the mean time between US and CT was 2.7 days (range, 0–4 days).

Chest US was performed by an experienced radiologist using a scanner (Mindray DC-7) and a scanner (Medison SONOACE SA 9900), both scanners with a 3–7 MHz curved and 5–12 MHz linear-array transducers. The patient position was determined according to the side and site of chest abnormality that was localized on the basis of physical examination and chest radiography findings. US approaches used were direct intercostal and abdominal approaches. In direct intercostal approach, the transducer was directly applied to the chest whereas in abdominal approach, the transducer was directed superiorly from the abdomen to examine the lower reaches of the pleural space and the liver and spleen provided sonographic windows to the thorax. We used abdominal approach in most patients (33 patients) as lung consolidation or pleural effusion was found predominantly in dependant and dorsal lung regions and was easily distinguished from the liver or spleen once the diaphragm had been located. Longitudinal and transverse images were obtained for the region of the chest abnormality (9,10). After US examination, decontamination procedures were applied for probes and the US machine using an US disinfectant detergent (T-Spary, New Jersey, USA) with active ingredients (n-Alkyl, dimethyl Benzyl and ammonium

chlorides) to avoid dissemination of resistant pathogens in the ICU (11,12).

Chest CT was performed using 8-MDCT scanner (Hitachi Healthcare) in a supine position with head first. Patients were instructed to hold breathing for the duration of scan (25 s). The images were acquired from the level of the thoracic inlet to the diaphragm with 5 mm slice thickness obtained at 5 mm intervals, 0.8 s scan time, a collimation of 2.5×8 , 120 kV X-ray tube voltage, 225 MA current, 350 field of view (FOV) and scan type was volume scan. All patients underwent CT following bolus injection of 50 ml of non-ionic, low osmolar contrast medium, Iohexol (Omnipaque 300 mg I/ml-GE healthcare, Ireland) through an 18–24 gauge cannula placed in a superficial arm vein. Images were printed at mediastinal window setting (level, 20 H; width, 350 H) and lung window setting (level, –650 H; width, 1500 H).

US and CT images were examined for the presence of parenchymal consolidation, lung necrosis, abscess, pleural effusion and the presence of loculation or fibrin strands within the pleural fluid. In addition, the volume of pleural effusion was assessed by multiplying the height of the pleural effusion by its transversal area, measured half-way between upper and lower limits (13), this was enough to quantify small (≤ 500 ml) and large (≥ 1000 ml) pleural effusions (14,15).

On chest US, pleural effusion was seen as dark zone free of echo in dependant lung regions delineated by the chest wall and the diaphragm (9). Pleural effusion was defined as loculated if the collection had a lobulated or lenticular shape with a convex border (16,17). Parenchymal consolidation was defined as a wedge-shaped hypoechoic tissue structure containing bright linear and branching echoes representing sonographic air bronchograms (air-filled bronchi) (18). Pulmonary necrosis was defined as a focal rounded area of decreased echogenicity within a portion of consolidated lung (19). Abscess was defined as an intrapulmonary rounded hypoechoic lesion with outer margins containing fluid and/or air (20,21).

On chest CT, pleural effusion was defined as loculated if the collection had a lobulated or lenticular shape with a convex border (16,17). Parenchymal consolidation was defined as air-space density with air bronchograms (22). Pulmonary necrosis was defined as a low-density area within a consolidated lung that had diminished enhancement relative to the adjacent parenchyma (16). Abscess was defined as an intrapulmonary cavity containing fluid and/or air with no central enhancement (23).

According to previous studies (6,24–26), patients in our study were treated with either antibiotics (17 patients) or with antibiotics and drainage of pleural effusion (31 patients) either by US-guided (18 patients) or by chest tube (13 patients). The response to therapeutic management was monitored by performing frequent follow up US examination at the bedside according to the clinical status (9).

The patients who underwent US-guided drainage of pleural effusion (thoracentesis) were informed about the nature of the procedure and a signed consent form was obtained from the patients. After identification of location of pleural effusion by US when the patient was in a sitting upright position, the largest and most accessible area of fluid accumulation was identified and the depth for the needle to penetrate was measured and deepest possible site in the dorsal part of the thorax was marked for pleural puncture. The area was cleaned with povidine iodine, followed by injection of 1% lidocaine intra-dermally,

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