Role of Chest Ultrasonography in Acute Respiratory Distress

Thesis

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List of Abbreviations

AHRF	:	Acute hypoxemic respiratory failure
AIS	:	Alveolar-interstitial syndrome
ALI	:	Acute Lung Injury
ARDS	:	Acute respiratory Distress syndrome
CPE	:	Cardiogenic pulmonary edema
ICU	:	Intensive Care Unit
NPE	:	Non cardiogenic pulmonary edema
ULCS	:	Ultrasound lung cometails
US	:	Ultrasound

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Abstract

Role of chest ultrasonography in differentiating between acute cardiogenic pulmonary edema and acute respiratory distress syndrome

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Introduction

Sometimes it is difficult to differentiate between acute cardiogenic pulmonary edema (APE) and acute respiratory distress syndrome (ARDS) on clinical basis only. Chest ultrasonography (CUS) may be helpful in providing ultrasonographic pleuropulmonary signs, which aids in such differentiation.

Aim

The aim of this study was to evaluate the role of CUS in differentiating between ARDS and APE through the characterization of comparative peculiar ultrasonographic pleuropulmonary signs.

Patients and methods

On admission, CUS was performed in Ain Shams University Hospital and Al-Abbassia Chest Hospital ICUs on 28 consecutive patients who presented with ARDS (15 cases) or APE (13 cases). CUS examination focused on the detection of the following pleuropulmonary signs in both ARDS and APE: alveolar–interstitial syndrome (AIS), pleural line abnormalities, absent or reduced lung sliding, consolidation, and pleural effusion.

Results

AIS was found in 100% of patients with ARDS and in 100% of patients with APE. Pleural line abnormalities were observed in 100% of patients with ARDS and in 0% of patients with APE (P=0.001). Absent or reduced lung sliding was observed in 100% of patients with ARDS and in 0% of patients with APE (P=0.001). Consolidations were present in 93.3% of patients with ARDS in 7.5% of patients with APE (P=0.001). Pleural effusion was present in 40% of patients with ARDS and in 76.9% of patients with APE (P=0.049).

All pleuropulmonary signs, except the presence of AIS, presented a statistically significant difference in presentation between ARDS and APE, resulting peculiar ultrasonographic pleuropulmonary signs of ARDS.

Conclusion

CUS represents a useful tool for differentiating ARDS from APE in ICU patients. In fact, the presence of absent or reduced lung sliding, pleural line abnormalities, and lung consolidations on a background of AIS seems diagnostic of ARDS.

Keywords:

Acute cardiogenic pulmonary edema, acute respiratory distress syndrome, chest ultrasonography.

Introduction

Examination of the thorax is a rapidly developing application of ultrasound (US) and may be used to evaluate a wide range of peripheral parenchymal, pleural and chest wall diseases. The technique is particularly used to be bedside test in the intensive care unit, where suboptimal radiography may mask or minimize clinically significant abnormalities and where differentiation of pleural from parenchymal changes can be confusing [71].

Chest US can help in rapid treatment of acute respiratory failure in intensive care units when rapid decisions are needed and especially when patients' transport is a big difficult. Therefore, it can be considered an attractive complementary diagnostic tool and one of the most promising techniques for the management of critically ill patient with ARF [15].

Acute respiratory failure, which is frequently encountered in ICUs, remains a major cause of morbidity and mortality [23]. Furthermore, there are often situations of severe respiratory distress in which an urgent diagnosis is required within minutes to direct potentially life-saving therapy.

Management of such critically ill patients requires imaging techniques [(4).]

Aim of the Work

The aim of the present work is to evaluate the ability of chest ultrasonography in the detection of characteristic Pleuropulmonary signs of **ALI (Acute Lung Injury)/ARDS (Acute respiratory distress) (non-cardiogenic pulmonary oedema)** as compared to sonographic signs of **APE (Acute Pulmonary Oedema)** in patients who are presented with acute dyspnea to respiratory I.C.U at Ain Shams University hospitals and Al Abassia Chest Hospital From the period between December 2013 to December 2014

Diagnostic ultrasonography is the only clinical imaging technology currently in use that does not depend on electromagnetic radiation. This modality is based on the properties of sound waves, and hence the mechanical and acoustic properties of tissues. Diagnostic ultrasound is mechanical energy that causes alternating compression and rarefaction of the conducting medium, traveling in the body as a wave usually at frequencies of 2-10MHz. In general it is assumed that the speed of sound in tissue is constant at 1,540m/s [(42).]

When a pulse of ultrasound energy is incident upon the body, it interacts with the tissue in a variety of ways. Some of the incident energy is directed back towards the source and is detected. The time delay between the energy going into the body and returning to the ultrasound probe determines the depth from which the signal arises, with longer times corresponding to greater depths. This information is used in the creation of an image. Other factors that make the tissues distinguishable on a screen are their slightly different acoustical properties; one is known as the acoustic impedance [(21).]

Acoustic Shadowing and Artifacts:-

In biologic tissues the speed of the sound is lowest in gas, faster in fluid, and fastest in bone, where the molecules are more closely packed. There is no ionizing radiation. The sound pulses transmitted into the body can be reflected, scattered, refracted or absorbed as mentioned previously. Absorption or attenuation is the loss of acoustic energy by conversion to heat energy, more prevalent in bone than soft tissue, and more prevalent in soft tissue than in fluid. It is a key cause of acoustic shadowing. Where there is a distinct loss of the echoes behind an imaged structure, the shadow has a relatively sharp border behind a bone [52].

Diagnostic Ultrasound Equipments: how the image is produced

1- Echogenicity Ultrasound images are displayed on a gray scale. The strongest echo appears white while it is black when no sound wave is reflected from the organs.

Depending on the reflected wave amplitude, the following terms are used to define echogenicity. When no sound wave is reflected and the image appears black it is anechoic as in pleural effusion.

It is iso echoic when the echoes are of comparable amplitude with the surrounding tissue as with kidneys or spleen. It is hyper echoic when echoes are stronger than the surrounding tissue as in diaphragm, and hypo echoic when it is weaker than that from the surrounding tissue [(7).]

Regarding diagnostic ultrasound equipment, ceramic crystals in the transducer deform and vibrate when electronically stimulated to produce the sound pulses.

Echoes that return to the transducer disrupt these crystal elements and produce an electric pulse, which is processed into an image [(29).]

The size of the probe is vital in real-time interventional procedures. A smaller probe will leave more room for needle insertion during real-time vascular access, thoracentesis, tube thoracostomy or percutaneous biopsy.

There are primarily three types of transducers used in thoracic imaging, e.g. linear array, curvilinear array and a phased array. **Linear array transducers** have piezoelectric crystals arranged in a linear sequence on the transducer head. Parallel pulses are generated forming a line of sight perpendicular to the transducer face with a large footprint (part of transducer in contact with body surface). It produces a rectangular display. **A linear array 7.5- to 10-MHz** transducer with a thyroid preset is best to visualize superficial structures of the neck. This is also useful for vascular access or to determine pleural thickening, pleural masses or sub pleural parenchymal lesions of lung. These high frequency transducers provide an excellent high-resolution image of superficial structure but are not ideal for deeper tissue examination.

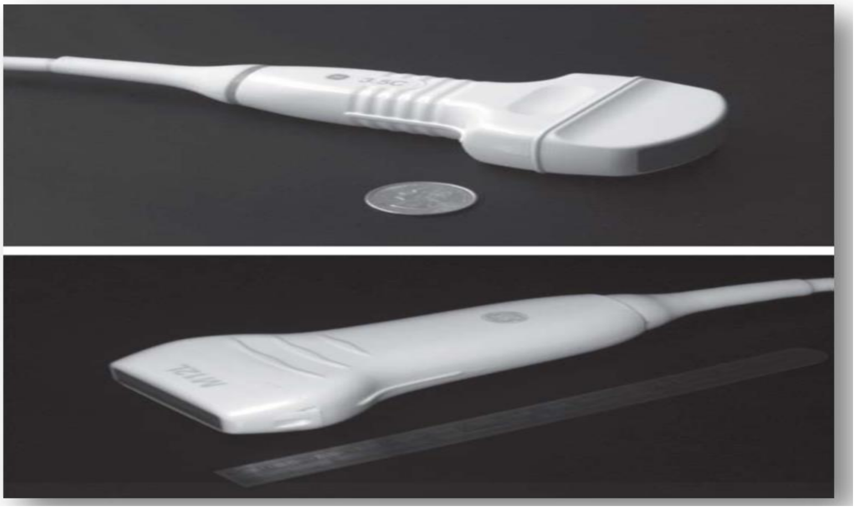

Fig. (1) Types of probes used in chest US (Curvilinear, linear)

a. A 3.5**C** (bandwidth 2-5MHz) convex phased array probe.
b. An M12**L** linear array probe (bandwidth 5-13MHz).