



Research Article

## SONOGRAPHIC EXAMINATION OF CONGENITAL AND ACQUIRED DISEASES OF THE CHEST IN PAEDIATRICS

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### ABSTRACT

Thoracic ultrasound is an important non-invasive procedure that can provide a substantial amount of information in the examination of children. The most effective use of ultrasound in paediatrics requires knowledge of the latest scanning techniques as well as a clear understanding of the detected characteristic symptoms of various chest diseases.

### KEYWORDS

Ultrasound-guided lung and complications of pneumonia (necrosis or abscess) in children.

## INTRODUCTION

Thoracic ultrasound is an important non-invasive procedure that can provide a substantial amount of information in the examination of children. Because of its comprehensive accessibility, relative ease of use, ability to perform the examination in real time, lack of need for sedation or dissemination of harmful ionising radiation, ultrasound has an important role as a secondary (after conventional X-ray) examination of the chest in children that is performed to detect and further characterize disease. In some cases, ultrasound may be used instead of other scanning techniques, including computed tomography (CT), especially in unstable patients.

The most effective use of ultrasound in pediatrics requires knowledge of the latest scanning techniques, a clear understanding of the identified characteristic symptoms of various congenital and acquired chest diseases affecting the lung parenchyma, pleura, mediastinum, diaphragm and chest wall. This article reviews chest ultrasound technique, normal anatomy, and the characteristic symptoms of common thoracic diseases in children and infants as detected on ultrasound images.

## SCANNING TECHNIQUE

A reliable clinical history should be obtained before starting the scan to allow the ultrasound examination to be carried out with the correct focus. The three main technical factors that influence the quality of a chest ultrasound scan

include (1) choice of transducer, (2) patient positioning and (3) scanning approach.

### Choice of transducer

The choice of transducer depends on the patient's physique and the location of the abnormality. In the case of infants, children and patients with superficial neoplasms, high-frequency transducers (7.5 to 17.0 MHz), provided they are more deeply penetrating, will provide high-quality images with high resolution. Because infants have less subcutaneous fat than older children and adults, high-frequency transducers can often be used to visualize body parts that, in the case of older patients, involve lower frequency and therefore lower resolution. Given that the ribs are a significant barrier to ultrasound beam penetration through the thorax, using as small a transducer as possible increases the number of acoustic windows available. In this case, sector and vector transducers are preferred.

Real-time seroscale ultrasound scanning is the main technique of chest ultrasound in paediatrics and is used to examine most abnormalities. Colour Doppler scanning helps to distinguish vascular neoplasms from non-vascular neoplasms. Spectral analysis provides quantitative and qualitative measurements of blood flow in the lower neck as well as visualising the vessels of the thorax.

### Patient Position

Optimizing the acoustic window for scanning the desired object requires the appropriate patient position. The effectiveness of different acoustic windows differs considerably between infants and adults. Early on (before ossification of the sternum and ribs), the cartilage from which they are formed serves as an excellent acoustic window, particularly for examining mediastinal structures. With age and progression of ossification of the thoracic cartilage, the sternum becomes an impassable barrier to ultrasound beams, which limits the ability to visualise intrathoracic structures and often suggests the use of alternative scanning modes (CT, MRI) for a complete examination.

Although chest ultrasound is most commonly performed while the patient is lying or sitting, a number of alternative positions can optimise visualisation of certain chest structures and improve visibility of the supraclavicular and suprapubic areas.

Raising the patient's arms above the head, for example, enlarges the intercostal spaces, making the intercostal windows more visible. Ultrasound of the patient in an upright position, using the posterior examination technique, allows optimal visualisation of the posterior aspect of the chest and small pleural effusions with a balloon structure. In addition, organs located in the upper abdomen (liver, spleen) are ideal acoustic windows for examination of the lower thorax.

The use of towels and cushions allows the patient to feel more comfortable during the examination and also facilitates the imaging process for diagnosis.

## NORMAL ANATOMY

### Lungs

Compared to other types of scans (CT, MRI), normally air-filled lungs limit chest ultrasound. Oxygen-filled lungs reflect ultrasound beams, resulting in reflection artifacts distal to the border of the chest wall. Normal pleura is visualised as an echogenic border with the chest wall, and normally oxygen-filled lungs should move freely up and down during breathing, giving the sign of 'lung sliding'. This respiratory movement also has a specific appearance when scanning in M mode, which is called the "seashore sign". Reflection artifacts that appear in the depth of the lung, due to their characteristic appearance, are called "A-lines", which run horizontally through the image (see Figure 2). "B-lines" or "comet tails" artefacts are light reflection artefacts, in the form of vertical hyperechogenic lines that run perpendicular to the ultrasound probe at regular intervals of about 7 mm in length, moving synchronously with the movement of the lung (see Figure 3). They are usually visualised in the lower lobe of the lung, and their appearance is due to differences in acoustic impedance between water and air. However, the presence of multiple B lines, particularly in the upper lobes of the lung, is an abnormality and is usually a sign of edema.

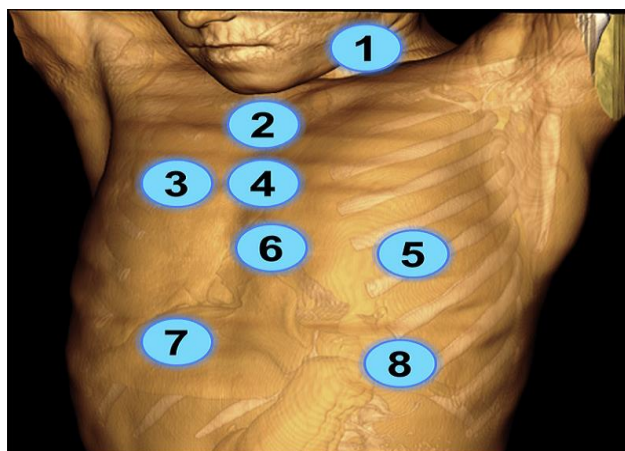


Figure 1. Types of scans. Standard acoustic windows include: (1) supraclavicular, (2) suprapubic, (3) paragrardinal, (4) transcostal (5) intercostal (6) subcostal (7) subdiaphragmatic and (8) paraspinal.

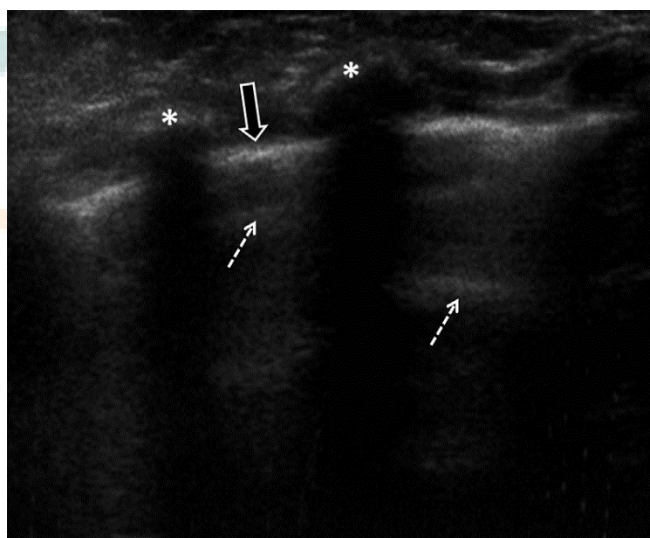
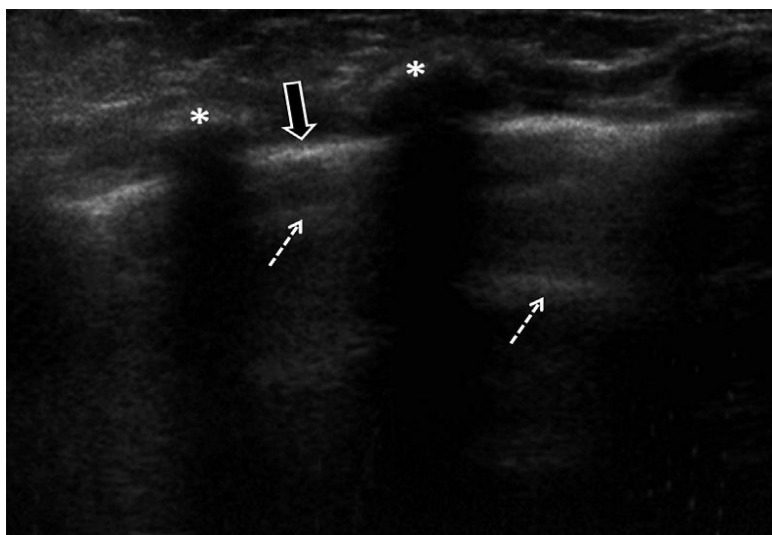


Figure 2. Transverse sonogram of the left lung shows no visible anatomy due to the reflection of the ultrasound beam by the air-filled lung. Rib shadowing (asterisk) is visible in the centre of the image. Echogenic septa between the lung and pleura (arrow) and horizontally oriented reflection artifacts (A-lines) deep in the lung (white arrows) are indicated



**Figure 3. B-lines.** A sagittal sonogram of the left upper quadrant shows B-lines ("pulmonary rockets") about 7 mm apart, which correspond to subpleural, intrathecal oedema (arrows).

### The Mediastinum

The thymus occupies a dominant position in the mediastinum of children and begins to diminish in adolescence. Despite its central location in the anterior mediastinum, the normal pediatric thymus can extend upward into the neck, or back into the middle and posterior mediastinum, and sometimes forward to the level of the diaphragm. The thymus has a characteristic homogeneous appearance on the sonographic image, with linear and dotted echogenic foci (see Figure 4). Compared with the thyroid gland and liver, the thymus is moderately hypoechogenic. The thymus in the newborn has a quadrangular shape, but becomes triangular in older children. Despite its considerable size in children, the normal gland does not interfere with the boundaries of adjacent

mediastinal structures and does not produce a significant acoustic effect.

### Diaphragm

The diaphragm separates the thoracic cavity from the abdominal cavity, consists of transverse striated muscles and is innervated by the diaphragm nerve. As the key muscle in the respiratory system it plays an important role in the normal physiology of breathing. The right or left diaphragmatic cupula as a smooth echogenic line is very easy to identify, they border the liver and spleen respectively. Near the midline the fibrous stems of the diaphragm are seen, which are relatively hypoechogenic. Visualisation of the left diaphragmatic dome may be impaired by

gastric and intestinal gas. Infiltration of fluid into the stomach by the oral route, or via a nasogastric tube, may improve visualisation of the diaphragm.

The respiratory excursion is easily visualised by real-time scanning. The middle and posterior third of the diaphragm have a wider range of motion than the anterior one. Examination in the longitudinal plane optimizes visualization by reflecting structures both within the thorax and intra-abdominally. Evaluation of changes in diaphragm thickness during breathing provides additional measurements of diaphragm function.

### Thoracic Wall

The superficial location and relatively small amount of subcutaneous fat allows excellent examination of the chest wall in children by ultrasound. The unbony cartilage in infants and children allows ultrasound to easily pass through. With age, ossification limits ultrasound penetration. Despite this, the superficial soft tissue structures of the chest wall (muscle, fat and connective tissue) continue to be well visualised with high-frequency transducers.

### CONCLUSIONS

Proper patient positioning and the use of suitable acoustic windows enhance the effectiveness of chest ultrasound.

- Ultrasound is preferred for the characterization of pleural effusion.

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