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M-Mode Ultrasound as a Portable Alternative to Fluoroscopy in Evaluation of Diaphragmatic Motion: Technical Note

Stuti Chandola[1] Manisha Jana[1] Priyanka Naranje[1] Ashu Seith Bhalla[1]

[1] Department of Radiodiagnosis and Interventional Radiology, All Indian Institute of Medical Sciences, New Delhi, India

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Address for correspondence Manisha Jana, MD, DNB, FRCR, Department of Radiodiagnosis and Interventional Radiology, All Indian Institute of Medical Sciences, New Delhi 110029, India (e-mail: manishajana@gmail.com).

Abstract

Diaphragmatic structure and function assessment can be performed using grayscale as well as M-mode ultrasound. This article discusses the application of M-mode ultrasound in the assessment of diaphragmatic dysfunction.

Keywords
- diaphragm
- M mode
- ultrasound

Introduction

Thoracic ultrasound (US) applications are undergoing rapid expansion. Beginning with limited use in large masses for solid-cystic differentiation and expanding to evaluation of the lungs in critically ill patients, the scope of thoracic US has multiplied exponentially. The evaluation of diaphragm is one such example.

Traditionally, evaluation of diaphragm motion was performed under fluoroscopy. However, unlike US, the major drawback of fluoroscopy is that it cannot be performed as a bedside procedure. B-mode US can assess diaphragmatic contractility as well as measure thickness. M-mode ultrasound can add an objective component by measuring the diaphragmatic excursion.

We came across a 2-month-old infant, patient of esophageal atresia-tracheoesophageal fistula, where a postoperative radiograph showed unilateral elevation of right hemidiaphragm (►**Fig. 1A**). B- and M-mode US revealed complete absence of movement on the right hemidiaphragm (►**Fig. 1B**, ►**Video 1**, online only), whereas the left hemidiaphragm showed normal excursions of 12 mm (►**Fig. 1C**, ►**Video 2**, online only). A diagnosis of right diaphragmatic palsy was suggested. On conservative management, the child showed minimal improvement.

Video 1

M mode US of the right hemidiaphram showing complete absence of movement. Online content including video sequences viewable at: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0042-1758200.

Video 2

M mode US of the left hemidiaphragm showing normal excursion. Online content including video sequences viewable at: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0042-1758200.

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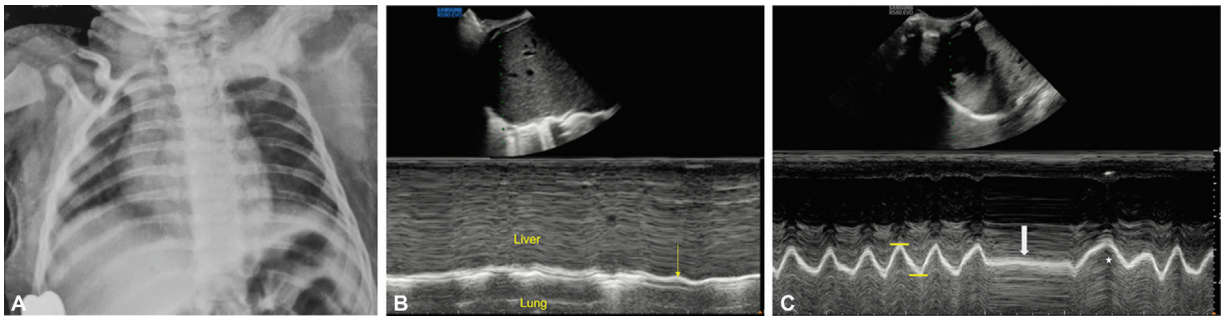

Fig. 1 (**A**) Chest radiograph showing mild right hemidiaphragm elevation. (**B**) M mode tracing of the right hemidiaphragm showing near complete absence of diaphragmatic excursion (arrow). (**C**) M mode tracing of the left hemidiaphragm shows normal excursions in quiet breathing, apnea during crying (block arrow), followed by increased depth of inspiration (asterisk). The points of measurement has been shown with solid lines.

Normal diaphragmatic motion is periodic, well evaluated at the lateral chest wall close to the 'zone of apposition' near the costal attachment of diaphragm. Various studies have described the normal range of excursion between 1.8 ± 0.3 cm in adult males and 1.6 ± 0.3 cm in females during quiet breathing.[1–6] The range can be variable in children. Periods of apnea followed by increased depth of inspiration can also be seen in children during crying. This in itself can act as a surrogate of the fluoroscopic 'sniff test' in children or infants.

The 'paradoxical movement' is typically described in diaphragmatic palsy, wherein the diaphragm shows upward excursion during inspiration.[1] However, absent or reduced excursion of diaphragm have also been reported.[5] Elevated hemidiaphragm may be a result of eventration as well, which, on US, shows normal/reduced excursion (►**Fig. 2A–C**). In case of extreme thinning of musculature in eventration, excursions may be imperceptible, but not paradoxical.

Technical parameters to be kept in mind include selection of appropriate transducer, depth, and way of measurement. While a high frequency linear transducer (5–12 MHz) is preferred for neonates, infants, and small children, a low-frequency curvilinear (3–5MHz) or a micro convex (3–12 MHz) transducer may be used in older children and adults. The transducer should be placed in the epigastrium in a transverse plane, with an upward angulation. This position is ideal for simultaneous evaluation of both diaphragms and comparison of both sides helps in easy identification of abnormality (►**Video 3**, online only). Each hemidiaphragm should also be assessed separately along the intercostal plane, which enables superior M-mode interrogation. Both hemidiaphragm should be evaluated anterior to posteriorly, in different intercostal planes, to avoid any focal abnormality. Diaphragmatic continuity and thickness should be evaluated on B-mode, and excursion on M-mode. While performing, the depth of imaging should not be kept too large, as multiple other anatomical structures might come in the M-mode waveform and create difficulty in interpretation. The excursion should be measured from the zenith of the upward curve (inspiration) until the nadir of the downward curve (expiration). It is easier to evaluate right diaphragm, as the liver acts as an acoustic window. On left side, it might be difficult as spleen size is variable. Examination should not be performed with the ventilator connected; as this will reflect the ventilatory parameters rather than spontaneous diaphragmatic movement,

Video 3

Transverse M mode US from the epigastrium reveal simultaneous visualization of both hemi diaphragms. Online content including video sequences viewable at: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0042-1758200.

M-mode evaluation of diaphragmatic excursion is especially useful in infants and children as they have a thinner thoracoabdominal musculature. As an adjunct to B mode

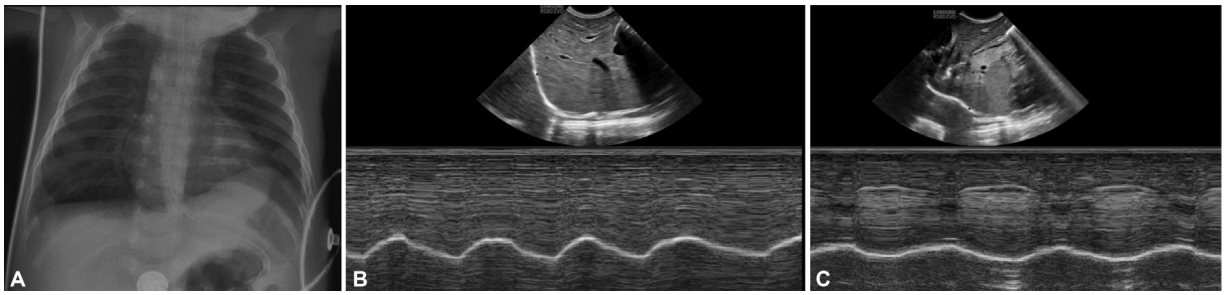

Fig. 2 (**A**) Chest radiograph of an infant with left sided eventration showing elevated left hemidiaphragm. (**B**) M-mode tracing of the right hemidiaphragm showing normal excursion. (**C**) M-mode tracing of left hemidiaphragm showing reduced excursions.

evaluation, it adds confidence and objective measurement of diaphragmatic movement.

Conflict of Interest
None declared.

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