

# Sonographic evaluation of the diaphragm morphology and function in the critically ill

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## The accuracy and usefulness in interpreting the diaphragm morphology and diaphragm kinetics in clinical settings of the critical illness

Diaphragmatic dysfunction is associated with adverse events and outcome. Respiratory insufficiency, hypoxia, prolonged mechanical ventilation, and longer hospital length of stay (1,2) have been reported. Diaphragm disuse and atrophy begins early in mechanically ventilated patients (3). Although the aetiology is poorly defined, myofibril and mitochondrial disruption have been suggested in animal literature (4). Surface ultrasound is a feasible, rapid and a reproducible tool for assessing diaphragmatic function and may be the method of choice for investigating diaphragmatic kinetics (5). But the inability to obtain images in some patients due to anatomical, pathologic, and technical reasons remains a major limitation.

In this review, Zambon *et al.* (6) reviewed the current literature for accuracy and usefulness of diaphragmatic ultrasound in 875 critically ill patients across 20 studies. Two aspects were discussed. The accuracy and usefulness interpreting the diaphragm morphology and diaphragm kinetics in clinical settings was measured. The review was limited by the heterogeneous nature of the publications, with inclusion of pediatric as well as adult patients, and half of the publications comparing ultrasound assessments with a variety of alternative measurement modalities such

as fluoroscopy, pressure measurements and a rapid shallow breathing index. The analysis was reported against four settings common in ventilated intensive care patients. In this context, the authors needed to be cautious in the interpretation of their findings. What appears to be clear is that a bed side noninvasive ultrasound examination is rapid, repeatable and convenient and therefore should be considered in chronically ventilated patients. The accuracy and usefulness appears to be beneficial, but further study in larger and more homogenous cohorts is required.

There was no standardized approach described across all publications and so two acoustic windows were described by these authors. The lateral intercostal window located at the zone of apposition, using high frequency linear probe. The thickness and thickening fraction of the right hemidiaphragm during inspiration is then measured (7-9). The diaphragm was defined as a hyperechoic layer between the pleura and the peritoneum. Measurements were reported using 2-D and M-mode technology. This technique was described to assess the muscular contractility in spontaneously breathing patients. In practice however, despite the improved resolution; the field depth of the linear probe is limited and not practical on day-to-day use, particularly in obese patients. Furthermore, in conditions like critical illness myopathy using the right hemidiaphragm to represent the entire diaphragm may be acceptable. In certain settings such

as weaning or diaphragm workload evaluation, however, assessing an isolated segment of hemidiaphragm function may not be sufficient or adequate (10).

The anterior subcostal window, using a lower frequency probe for measuring diaphragmatic excursion requires the ultrasound beam to be perpendicular to the posterior part of the diaphragm, with the probe directed cranially and dorsally. The technique is easily performed and learned. Furthermore, assessing the posterior region of the diaphragm is logical as the posterior region of the diaphragm is usually 40% more contractile compared to the anterior region (11). However, the anterior window is often faced with stomach and bowel gas, impeding the signal and the direction of the ultrasound beam may not fall perpendicularly on the craniocaudal axis. If the angle of the ultrasound beam exceeds 20° from the perpendicular, the measurements may be inaccurate (12). If further validated by studies, similar methods may be extended to wider applications as a bedside method in clinical practice.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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