Ultrasonography: Friendly tool for weaning from ventilatory support

Abdullah Arshad[1], Inam Ul Haq[2], Waqas Ahmad Kazi[2]

From the Dept of
[1]144 Medical Battalion, c/o Pak Army Code-45.
[2]Pakistan International Hospital, DHA - 2, Main G.T. Road, Islamabad (Pakistan).

Correspondence: Dr Abdullah Arshad, M.B.B.S., Graded Anesthetist, 144 Medical Battalion, c/o Pak Army Code-45; E-mail: paediatric.anaesthesiologist@gmail.com

Key words: Diaphragm; Diaphragmatic dysfunction; Respiratory measurement; Respiratory muscles; Mechanical ventilation; Weaning failure; Ventilator weaning; Ultrasonography

Citation: Arshad A, Haq IU, Kazi WA. Ultrasonography: Friendly tool for weaning from ventilatory support. Anaesth Pain & Intensive Care 2016;20(3):366-367

Failure to wean off from artificial ventilatory support is associated with an increased patient morbidity and mortality, with a big psychological impact on the relatives. It is defined as the incapacity to maintain or generate spontaneous breathing for at least two days, without any form of ventilatory support following the removal of an airway device such as an endotracheal tube.[1] Ventilator-induced diaphragmatic dysfunction, co-existing thoracic and abdominal pathology, muscular dystrophy or respiratory muscle myopathy in the setting of nutritional deprivation or secondary to prolonged use of steroids and neuromuscular blockers, or co-existing cardiac disease are the most common inciting factors.[2-4]

Spontaneous breathing trials to wean off from mechanical ventilation may fail in approximately one fifth of the admitted patients. A valuable use of ultrasonography in the critical care setting is the assessment of the mechanical working of the diaphragm in such patients. The diaphragm plays a major role in enabling the individual patients to resume breathing spontaneously.

Ultrasonographically, the diaphragm is imaged as a three layered part containing two parallel echoic lines separated by a hypoechoic structure between them. Some authors have reported five instead of three diaphragmatic layers – two outer bright parallel layers of the parietal pleura and peritoneum with an irregular bright layer due to connective tissue and vessels within the echo poor diaphragm muscle layer[5].

The diaphragm normally moves caudad and cephalad on inspiration and expiration respectively. When paralyzed, it remains either static or may exhibit paradoxical movement. In the clinical setting of weakness, the diaphragm moves in the correct direction of movement but with limited excursion. The latter can be evaluated with motion mode ultrasonography. Hemi-diaphragms can be ultrasonographically visualized through the liver or spleen windows[5]. Air containing pulmonary spaces can be an unfortunate hinderance.[6] Prolonged diaphragmatic dysfunction is associated with exhaustion of respiratory muscle as a result of a loss of physiological equilibrium between respiratory demand and supply[8]. Reversibility and impact of diaphragmatic dysfunction are unknown[9]. A large number of diagnostic tools have been inculcated in the medical practice over time to study diaphragm dysfunction. These include procedures like phrenic nerve conduction study, fluoroscopy, and trans-diaphragmatic pressure measurement. These have some limitations, e.g. exposure to ionizing radiation, high costs, low availability, invasiveness, and the need for patient transportation and technically skilled operators.

Ultrasonography is a ubiquitous, cost-effective and portable technology. Motion mode ultrasonography has shown promising results in screening out patients at high probability of difficulty weaning.[4] It allows electronic capture of structures lying cephalad and caudad with respect to the diaphragm. Assessment of diaphragmatic excursion by calculating hepatic or splenic downward displacements during spontaneous breathing trials, diaphragm motion and diaphragm thickening fraction by ultrasound have emerged as novel techniques.

Nevertheless, it is beset with some potential limitations viz-a-viz operator dependency and an absolute paucity of quantifiable reference indices for diaphragm parameters in patients with diaphragmatic dysfunction attributable to pulmonary or neuromuscular disease. Non-visualization of a hemi-diaphragm has been reported as a procedure failure with frequencies ranging between 28–63%. Albeit, proper positioning utilizing a subcostal approach have marvelously reduced these to as low as 0.71%.[4]

Diaphragmatic excursion has a questionable role as regards to the functional evaluation of its contractile limits during assisted mechanical ventilation. It is greatest in the supine than in the sitting or standing positions[4]. More recently in spontaneous breathing trials, employment of motion mode ultrasonograms has revealed weaning failure owing to decreased diaphragm excursion in equal proportion to the rapid shallow breathing index cases.[5] The cut off of diaphragm excursion for predicting weaning failure is 1.4 cm and 1.2 cm for the right and left hemi-diaphragms respectively, and less excursion (<1 cm) is consistent with a greater chance of weaning failure[6]. Two potential impediments to successful visualization include the right lung's downward excursion and the miniature window offered by the spleen.[4]

Ultrasonographic assessment of diaphragm thickening necessitates proper mandatory breath holding phases so as to acquire perfect views of the different layers of the diaphragm throughout the respiratory cycle. This task requires perfect mastery of skills which is almost impossible in ICU patients.[6] Larger prospective multicenter studies at national level, may encompass parameters such as the age, weight and sex of the study subjects as well as to study the timings at which these non-invasive ultrasonograms should be undertaken post admission.

Conflict of Interest: There is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

REFERENCES

1. Ferrari G, De Filippi G, Elia F, Panero F, Volpicelli G, Aprà F. Diaphragm ultrasound as a new index of discontinuation from mechanical ventilation. Crit Ultrasound J. 2014;6(1):8. doi: 10.1186/2036-7902-6-8.
2. Khanna AK. Weaning from prolonged mechanical ventilation: The complete picture. Indian J Anaesth. 2012;56(1):102–3. doi: 10.4103/0019-5049.93566.
3. Ahmadpour-Kacho M, Zahedpasha Y, Hadipoor A, Akbarian-Rad Z. Early surgical intervention for diaphragmatic paralysis in a neonate; report of a case and literature review. Iran J Pediatr. 2011;21(1):116-20.
4. Boussuges A, Gole Y, Blanc P. Diaphragmatic Motion Studied By M-Mode Ultrasonography: Methods, Reproducibility, And Normal Values. Chest. 2009;135(2):391-400.
5. Sarwal A, Walker FO, Cartwright MS. Neuromuscular Ultrasound for Evaluation of the Diaphragm. Muscle Nerve. 2013;47(3):319–29.
6. Zanforlin A, Bezzi M, Carlucci A, Di Marco F. Clinical applications of diaphragm ultrasound: moving forward. Minerva Med. 2014 Nov 14.

★★★★★