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EDITORIAL

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Diaphragmatic ultrasound in weaning ventilated patients: a reliable predictor?

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1. Introduction

Liberation from mechanical ventilation (MV) in the intensive care unit (ICU) remains time- challenging, as premature discontinuation increases the risk of weaning failure, necessitating reintubation, which by its turn destabilizes the patient. Similarly, unnecessary delay in extubation favors asynchrony, ventilator-associated pneumonia, barotrauma, and the list of associated complications remains non-exhaustive [1].

Successful liberation from MV is dependent on several factors, mainly adequate oxygenation, stable hemodynamics needing no or low-dose vasopressors, and intact neurologic status allowing complete clearance of airway secretions. Patients traditionally undergo spontaneous breathing trial (SBT); once judged to have passed the aforementioned criteria and exhibit a rapid shallow breathing index (RSBI) of less than 105 breaths/min/L, they are extubated [2]. However, more than 20% of these patients are re-intubated either due to unexpected cardiopulmonary destabilization, stagnating secretions, or even diaphragmatic dysfunction, as accessory muscles become more fatigued, unmasking the latter, despite an initially comforting RSBI [3].

The diaphragm is the major muscle of inspiration, its timely contraction and shortening should facilitate extubation [4]. Several studies demonstrated that their inadequacy is associated with weaning difficulties in patients who are mechanically ventilated or even weaning failure, defined as the requirement of invasive or noninvasive mechanical ventilation within 48 hours after extubation [3]. This so-called, diaphragmatic dysfunction is quite prevalent in the ICU setting, as it can emanate from diaphragm inactivity, desynchronized contractions, and exhaustion: this defines ventilation-induced diaphragmatic dysfunction (VIDD) [5]. Additionally, this muscle is exposed to metabolic injury from hypotension, hypoxia, and sepsis, all of which are notorious in critically ill patients [2], favoring dysfunction, as once established by Demoule et al. [6]. The most plausible hypothesis of this dysfunction remains the excessive diaphragmatic unloading during ventilation assistance, resulting in disuse [7]. Thus, exploring the functional status of the diaphragm might help distinguish who among ventilated patients will probably be successfully extubated, and who might not.

2. Body

Ultrasound is gaining popularity in critical care because of its ease, safety, the dynamic results obtained instantaneously, and its reproducibility, at least intra-individually [1]. And when applied to diaphragmatic function and dynamics, two sonographic predictors can be been deduced, aiding in the characterization of dysfunction [8]: the diaphragmatic excursion (DE), which measures the distance that the diaphragm can move during the respiratory cycle, and the diaphragm thickening fraction (DTF), which reflects variation in the thickness of the diaphragm during respiratory effort and is calculated as (thickness at end-inspiration – thickness at the end-expiration)/thickness at the end of expiration [1,4]. Diaphragmatic ultrasound can retrieve these two entities using the M-mode, when the probe is placed in the right midline of the axillary and the left axillary posterior line, on a supine patient [9], proportional assist ventilation allowing diaphragmatic effort to be estimated best [10].

2.1. Excursion

Diaphragm dysfunction was diagnosed by ultrasound if an excursion <10 mm or a paradoxical movement was observed [11]. It was found that DE correlates negatively with the APACHE II score, as well as with the duration of mechanical ventilation, and positively correlated with dynamic compliance [12]. Others also support DE as a reliable predictor of weaning success, with a cutoff of 1 cm [13,14]. Spadaro et al. proposed a ratio of diaphragm excursion over respiratory rate, that can even perform more reliably than the RSBI, diaphragm excursion alone and maximum inspiratory pressure, to predict weaning outcome [15]. However, others contradict this idea and still support RSBI and the other clinical parameters as the sole factors to expect successful weaning [16], as DE is the result of the sum of the patient's inspiratory effort and the pressure generated by the ventilator [17], refuting its use unless the patient is receiving no ventilator support, seated, and does not have altered abdominal/thoracic pressures [1], forces of inhalation and exhalation also should have the same intensity during the examination.

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2.2. Thickness

Diaphragmatic thickness was studied as an indicator that depicts diaphragmatic inhalation effort, and when it truly reflects active diaphragm contraction [1]; the pooled analysis demonstrated greater DTF in successfully extubated patients than with the failed counterpart [9]. Ferrari et al. proved that a cutoff value above 36% is the most reliable to judge successful extubation [11], while McCool and colleagues considered that a lower cutoff of 30% is also safe [18]. Additionally, Turton et al. defended using only DTF with a similar cutoff to decide extubation, replacing RSBI, the most common parameter used in this setting [19].

2.3. Excursion and thickness combined

As reported, views regarding the use of diaphragmatic ultrasound in assessing ventilated patients are divergent, especially when adopting the two predictors, combined. Soliman and colleagues argued that a right diaphragmatic motion >10.7 mm, and a right diaphragm contraction rate >21.32 mm/s can accurately predict a successful weaning outcome in elderly patients [20], especially when low RSBI erroneously predicts success before respiratory accessory muscles undergo exhaustion. Also, Zambon et al. authored a systematic review that reinforced the use of DE and DT in four clinical settings:

1. To diagnose dysfunction or paralysis in critically ill patients.
2. To predict weaning success/failure from mechanical ventilation.
3. To assess respiratory effort in mechanically ventilated patients.
4. To assess the progression of atrophy in ICU mechanically ventilated patients [21].

Others recommend the use of diaphragmatic thickness and depend less on DE as a tool for weaning success, since the latter, again, requires the absence of ventilation success [2]. Some completely refuted the idea of using either, as there was no association with reintubation or death within 7 days following extubation, recommending clinical assessment of cough strength to predict extubation success [22].

2.4. Lung ultrasound

Worth the mention, that while diaphragmatic dysfunction can precipitate weaning failure, other disorders that can affect pulmonary parenchyma such as edema, atelectasis, and pneumonia, render extubation more difficult to achieve, and ultrasound can be quite informative in this setting. Lung ultrasound can examine several parenchymal zones, in the upper and lower, anterior, lateral, and posterior chest wall, resulting in a score that goes from 0 to 36 [23], depending on the severity of aeration loss in these different areas [24]. Effectively, Soummer et al. demonstrated that a higher score correlates with a higher risk of weaning failure [25]; the cutoff is still debatable to help clinicians assess readiness for extubation [26].

3. Conclusion

There is a growing awareness that critical illness and mechanical ventilation are associated with diaphragmatic dysfunction, a pathological process that might impede liberation from ventilation, worsening the prognosis and survival rates in the critically ill. While we still rely on clinical parameters to allow extubation, we might have pitfalls, which incite us to search for other alternatives. Due to its ease of use, reproducibility, and accessibility, incorporating diaphragm ultrasound into this paradigm seems an attractive option, and allows for reaching an early, tentative preliminary diagnosis [27]. Many studies adopted diaphragmatic thickness and excursion in this context, demonstrated propitious results, and encouraged its use. However, the study of the diaphragm in its entirety is nonfeasible, as it is hindered by the surrounding air, adipose tissue, and other artifacts [8,28]. Also, effectiveness in weaning ventilated patients is lacking and debatable [29], necessitating larger studies and trials to try and integrate diaphragmatic ultrasound into the critical care guidelines. Perhaps, once passed RSBI, assessing diaphragmatic contractility in conjunction with echocardiography and lung ultrasound, as previously mentioned, is the most plausible option that we have till now, using it as a complement rather than a surrogate [4].

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Declaration of interest

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