Massimo Zambon
Luca Cabrini
Paolo Beccaria
Alberto Zangrillo
Sergio Colombo

Ultrasound in critically ill patients: focus on diaphragm

Accepted: 16 February 2013
Published online: 16 March 2013
© Springer-Verlag Berlin Heidelberg and ESICM 2013

Dear Editor,

We read with great interest the review of Matamis and co-workers about diaphragm evaluation with ultrasounds in critically ill patients [1]. We would like to add some considerations about three relevant issues.

The authors state that during assisted mechanical ventilation (namely pressure support ventilation, PSV), the diaphragmatic excursion measured with ultrasounds is the result of the sum of patient's effort and pressure support given by the ventilator. However, since diaphragmatic excursion is related to tidal volumes [2, 3], compliance of respiratory system plays an important role in diaphragmatic excursion. In fact, in a patient with low respiratory system compliance, the same pressure support added to the same patient's effort will result in a low tidal volume, causing a minor displacement of the diaphragm. On the other side, a respiratory system with higher compliance will show a higher tidal volume and a larger diaphragmatic excursion. We agree with the authors that the variable that better helps to quantify the impact of patient effort in the generation of tidal volumes is

the thickening fraction (TF = thickness at end-inspiration–thickness at end-expiration/thickness at end-expiration) [4].

Another crucial point is the role of PEEP on the diaphragmatic measurements. The expected effect of PEEP/CPAP both in invasive and non-invasive ventilation is to increase functional residual capacity (FRC), maintaining alveolar recruitment; the corresponding increase in lung volumes lowers diaphragmatic dome [5]. This effect can result in a decreased diaphragmatic excursion, not related to diaphragmatic dysfunction but to a caudal displacement of diaphragmatic dome at the end of expiration.

Finally, diaphragmatic excursion measurements with ultrasonography can vary widely with patient's position. Trans-diaphragmatic pressure is the result of the difference between abdominal and thoracic pressures: diaphragmatic muscular force acts against abdominal pressure, and the magnitude of this force is higher in the supine position than in semi-recumbent or in seated position. This effect is stronger in obese patients and in patients with intra-abdominal hypertension [6]. Hence, repeated measures should be taken in the same position to avoid pitfalls in evaluation of diaphragmatic function over time in the same patient.

Diaphragmatic ultrasounds is a very promising tool for respiratory function monitoring in ICU, and protocols that take into account diaphragmatic function may lead to improved outcomes such as reduction of time under mechanical ventilation; we therefore congratulate the authors for the exhaustive description of the technique and its clinical applications.

Conflicts of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

1. Matamis D, Soilemezi E, Tsagourias M, Akoumianaki E, Dimassi S, Boroli F, Richard JC, Brochard L (2013) Sonographic evaluation of the diaphragm in critically ill patients technique and clinical applications. *Intensive Care Med*. doi:10.1007/s00134-013-2823-1
2. Houston JG, Angus RM, Cowan MD, McMillan NC, Thomson MC (1994) Ultrasound assessment of normal hemidiaphragmatic movement: relation to inspiratory volume. *Thorax* 49:500–503
3. Cohen E, Mier A, Heywood P, Murphy K, Boulton J, Guz A (1994) Excursion-volume relation of the right hemidiaphragm measured by ultrasonography and respiratory airflow measurements. *Thorax* 49:885–889
4. Vivier E, Mekontso Dessap A, Dimassi S, Vargas F, Lyazidi A, Thille AW, Brochard L (2012) Diaphragm ultrasonography to estimate the work of breathing during non-invasive ventilation. *Intensive Care Med* 38:796–803
5. Beaumont M, Lejeune D, Marotte H, Harf A, Lofaso F (1997) Effects of chest wall counterpressures on lung mechanics under high levels of CPAP in humans. *J Appl Physiol* 83:591–598
6. Pelosi P, Luecke T, Rocco PR (2011) Chest wall mechanics and abdominal pressure during general anaesthesia in normal and obese individuals and in acute lung injury. *Curr Opin Crit Care* 17:72–79

M. Zambon (✉) · L. Cabrini · P. Beccaria · A. Zangrillo · S. Colombo
Department of Anesthesia and Intensive Care, Vita-Salute University and San Raffaele Hospital, Via Olgettina 60, 20132 Milan, Italy
e-mail: zambon.massimo@hsr.it
Tel.: +39-02-26433737
Fax: +39-02-26432200

L. Cabrini
e-mail: cabrini.luca@hsr.it

P. Beccaria
e-mail: beccaria.paolo@gmail.com

A. Zangrillo
e-mail: zangrillo.alberto@hsr.it

S. Colombo
e-mail: colombo.sergio@hsr.it