Intensive Care Med (2017) 43:562–563
DOI 10.1007/s00134-016-4618-7

IMAGING IN INTENSIVE CARE MEDICINE

Bedside multimodal imaging of hemidiaphragm palsy after spinal cord injury

M. Pozzi[1], G. Bellani[1,2*], A. Bronco[1] and G. Citerio[1,2]

A 13-year-old boy was admitted to the neurocritical care unit with left-side hemiparesis due to a SCIWORA (spinal cord injury without radiographic abnormalities). A centromedullary C2–T1 spinal cord lesion was present at MRI as shown in the Electronic Supplementary Material (ESM). During the ICU stay, he developed respiratory insufficiency requiring non-invasive mechanical ventilation and a retrocardiac consolidation appeared on the chest X-ray (see the ESM). We used electrical impedance tomography (PulmoVista®, Dräger, Germany) to study the distribution of ventilation, clearly identifying an area of no tidal impedance variation in the dependent region of the left lung consistent with severe hypoventilation in the lower left lobe (Fig. 1a). On the basis of the anatomical distribution of the spinal lesions, left hemidiaphragm palsy was suspected. We incorporated surface

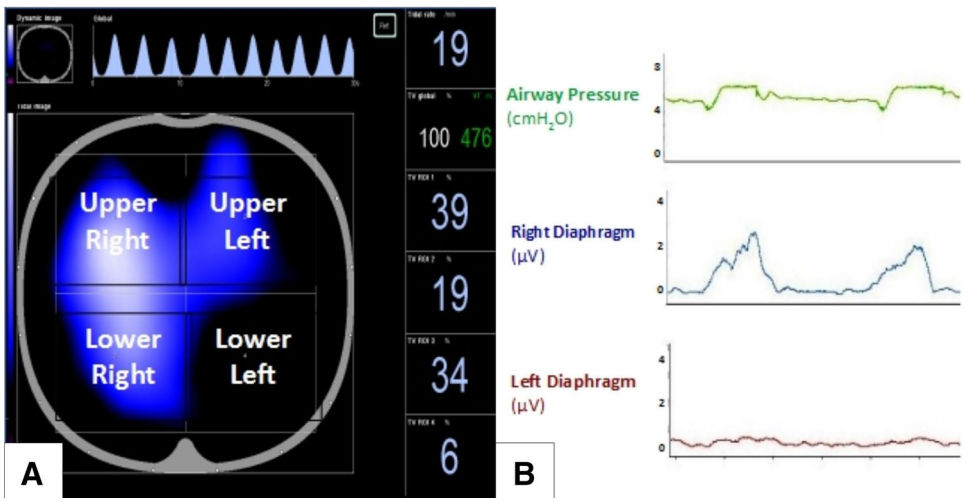

Fig. 1 **a** Electrical impedance tomography (EIT) showing a severe hypoventilation of the dependent regions of the left lung. A 16-electrode EIT belt was placed around the patient's chest at the 5th–6th intercostal spaces. The patient was connected to an Evita ventilator (Dräger Medical, Lübeck, Germany) in continuous positive airway pressure (CPAP) (PEEP 5 cmH_2O). The patient was kept supine and the backrest was positioned at an angle of 30°. Hypoventilation was documented as a zone of no electrical impedance variation during tidal breathing located in the lower left quadrant (*black*). Normally ventilated lung segments are displayed in *blue*. This finding may be consistent with different diagnoses, including no aeration due to segmental airway obstruction, atelectasis, pneumonia and spinal cord injury producing hemidiaphragm functional denervation. Additional evaluations were performed to confirm the diagnosis of hemidiaphragm palsy (see ESM). **b** Surface electromyography (sEMG) traces during CPAP showing airway pressure (*green*) and electrical activity from the right and left hemidiaphragms. While clearly organized electrical activity is detectable from the right hemidiaphragm (*blue*), no signal comes from the left hemidiaphragm (*red*)

*Correspondence: giacomo.bellani1@unimib.it
[1] School of Medicine and Surgery, University of Milan-Bicocca, Monza, Italy
Full author information is available at the end of the article

Springer

electromyography of the right and left hemidiaphragms in the further diagnostic work-up. While organized electrical activity was detectable from the right hemidiaphragm, it was absent from the left side and thus consistent with hemidiaphragm denervation (Fig. 1b). Hemidiaphragmatic dysfunction was also confirmed by ultrasonography, showing a thinner left hemidiaphragm with no inspiratory thickening (see the ESM). Application of the latest-generation technology at the bedside, combined with multimodal imaging, provides clinicians with a straightforward and visual approach to the diagnosis of diaphragm dysfunction after spinal cord injury.

Electronic supplementary material
The online version of this article (doi:10.1007/s00134-016-4618-7) contains supplementary material, which is available to authorized users.

Author details
[1] School of Medicine and Surgery, University of Milan-Bicocca, Monza, Italy.
[2] Department of Anesthesia and Intensive Care, San Gerardo Hospital, Monza, Italy.

Compliance with ethical standards

Conflicts of interest
The authors declare that they have no conflicts of interest.

Received: 12 October 2016 Accepted: 31 October 2016
Published online: 15 November 2016