The ‘Dark Side’ of Chronic Obstructive Pulmonary Disease

Americo Testa^a Rosangela Giannuzzi^b

^aDepartment of Internal Medicine and Endocrinology, ‘Madonna delle Grazie’ Clinic, Velletri, and

^bDepartment of Emergency Medicine, ‘A. Gemelli’ University Hospital, Rome, Italy

Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality worldwide, accounting for a major healthcare problem. It is characterized by incompletely reversible airway obstruction with airway inflammation and remodeling as initial pathological lesions. Accordingly, functional and anatomical changes in different compartments of the lungs occur, leading to air trapping and pulmonary hyperinflation and imposing an excessive load on the respiratory muscles. Other than these complex mechanical lung changes, increasing evidence indicates that COPD results in important systemic manifestations due to inflammation, gas exchange abnormalities, nutritional imbalance, comorbidity and chronic steroid administration, which might affect skeletal muscle performance, including diaphragm function [1].

Spirometry has universally been recognized as the gold standard for the diagnosis of COPD. However, it is accepted that a single measurement of FEV₁ incompletely represents the complex clinical picture of COPD. Therefore, the evaluation of additional parameters is recommended in order to assess the respiratory and systemic consequences of COPD [2].

The diaphragm is the principal generator of tidal volume in normal subjects at rest. A reduction in diaphragm mobility has been identified in patients with COPD and has been associated with a decline in pulmonary function parameters. Therefore, the assessment of diaphragmatic

contraction, either thickness or flattening or motion, could provide relevant information on respiratory mechanics and functional capacity to improve diagnosis formulation and evaluate the progression of COPD. Traditional respiratory functional tests mainly assess *downstream* airflow limitations in COPD patients. By contrast, the diaphragm represents the less explored ‘side’ of the COPD, being affected by the *upstream* effects of airway obstruction (local overload), other than systemic imbalance.

In this issue of *Respiration*, Smargiassi et al. [3] propose ultrasonography (US) in detecting diaphragm thickness and thickening at different lung volumes in a consecutive series of patients with COPD. The relationship between US measurements and parameters of respiratory function and body composition is computed. All diaphragm thickness measures are found positively related to fat-free mass. As regards lung volumes, diaphragm thickness at total lung capacity is found to be closely related to the inspiratory capacity. Moreover, there is a significant negative association between the values for diaphragm thickening and the air trapping indices. The authors propose that the assessment of the diaphragm is a useful tool to study the progression of the disease in COPD patients in terms of lung hyperinflation and loss of fat-free mass.

The utility of US in the evaluation of diaphragm function in COPD has previously been established, and it will

certainly continue to increase in the future. Kawamoto et al. [4] described flattening and decreased motion of the diaphragm, as well as its prolonged expiratory time in COPD patients. Dos Santos Yamaguti et al. [5] suggested that diaphragmatic excursion, measured by B-mode US, could be mainly delayed by airway obstruction and air trapping rather than by respiratory muscle strength or pulmonary hyperinflation. Wook et al. [6] related the reduction in diaphragm mobility to hypercapnia. Recently, Zanforlin et al. [7] proposed the maximum expiratory diaphragmatic excursion and forced expiratory diaphragmatic excursion in the first second, measured using M-mode US, as physiopathological analogues of vital capacity and FEV₁, respectively.

Techniques traditionally employed to diagnose diaphragmatic weakness are invasive or associated with radiation and require patient displacement (electromyography, fluoroscopy and computed tomography), or are indirect, time-consuming and uncomfortable procedures (transdiaphragmatic pressure measurements and plethysmography) or highly complex and expensive investigations (dynamic magnetic resonance imaging). The US use in the qualitative and quantitative evaluation of the diaphragm is a constantly evolving application from the early 1970s. Afterwards, several B- and M-mode US methods were proposed by directly measuring diaphragmatic thickness [8] or diaphragmatic motion [9]. Apart from the different US approaches, the majority of authors emphasized the value of US in studying diaphragm function either in healthy subjects or ventilated patients, as well as

its value in identifying idiopathic diaphragm paralysis or in revealing diaphragm dysfunction resulting from surgical procedures or neuromuscular diseases and finally in assessing the potential recovery of diaphragm function.

Recent technological advances have greatly facilitated the increase in 'point-of care' US, and its use is increasingly more widely spread, since it provides a bedside, noninvasive and low-cost examination [10]. Other than traditional pleural effusion, the use of lung US grew with the detection of pneumothorax, lung contusion, pneumonia, acute cardiogenic pulmonary edema, acute respiratory distress syndrome and pulmonary thromboembolism [11], and its routine use in respiratory disorders is recommended in various clinical settings to provide physicians with rapid information. Indeed, US could be considered a convenient method in the evaluation of obstructive airway diseases complementing the established standard methods in outpatient clinics and the emergency setting.

One century after the 'technological revolution' of the stethoscope, it seems the right time for US to become a component of the physical examination, and so to complete 'traditional descriptive medicine' with 'visual quantitative medicine'.

Financial Disclosure and Conflicts of Interest

We declare that we have no competing interest.

References

- 1 Barnes PJ, Celli BR: Systemic manifestations and comorbidities of COPD. *Eur Respir J* 2009;33:1165–1185.
- 2 Pellegrino R, Viegi G, Brusasco V, et al: Interpretative strategies for lung function tests. *Eur Respir J* 2005;26:948–968.
- 3 Smargiassi A, Inchingolo R, Tagliaboschi L, Di Marco Berardino A, Valente S, Corbo GM: Ultrasonographic assessment of the diaphragm in COPD patients: relationships with pulmonary function and the influence of body composition – a pilot study. *Respiration* 2014;87:364–371.
- 4 Kawamoto H, Kambe M, Kuraoka T: Evaluation of the diaphragm in patients with COPD (emphysema dominant type) by abdominal ultrasonography. *Nihon Kokyuki Gakkai Zasshi* 2008;46:271–277.
- 5 Dos Santos Yamaguti P, Paulin E, Shibao S, et al: Air trapping: the major factor limiting diaphragm mobility in chronic obstructive pulmonary disease patients. *Respirology* 2008;13:138–144.
- 6 Wook H, Kim TO, Lee BR, et al: Influence of diaphragmatic mobility on hypercapnia in patients with chronic obstructive pulmonary disease. *J Korean Med Sci* 2011;26:1209–1213.
- 7 Zanforlin A, Smargiassi A, Inchingolo R, di Marco Berardino A, Valente S, Ramazzina E: Ultrasound analysis of diaphragm kinetics and the diagnosis of airway obstruction: the role of the M-mode index of obstruction. *Ultrasound Med Biol* 2014, Epub ahead of print.
- 8 Summerhill EM, El-Sameed YA, Glidden TJ, McCool FD: Monitoring recovery from diaphragm paralysis with ultrasound. *Chest* 2008;133:737–743.
- 9 Testa A, Soldati G, Giannuzzi R, Berardi S, Portale G, Gentiloni Silveri N: Ultrasound M-mode assessment of diaphragmatic kinetics by anterior transverse scanning in healthy subjects. *Ultrasound Med Biol* 2011;37:44–52.
- 10 Moore CL, Copel JA: Point-of-care ultrasonography. *N Engl J Med* 2011;364:749–757.
- 11 Reissig A, Copetti R, Kroegel C: Current role of emergency ultrasound of the chest. *Crit Care Med* 2011;39:839–845.