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Research Article

Influence of COPD on the Diaphragm and Muscles of the Lower Limbs

A Meridj*, R Belaala and Y Djeghri

Service of Pulmonology Military Regional University Hospital of Constantine, Algeria

More Information

*Address for correspondence: A Meridj, Service of Pulmonology Military Regional University Hospital of Constantine, Algeria, Email: amine.meridj@gmail.com

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Summary

Chronic obstructive pulmonary disease (COPD) is associated with numerous comorbidities, including muscle involvement which consists of changes in the structure and function of peripheral and respiratory muscles. Ultrasound can provide a non-invasive assessment of muscle damage. Ultrasound assessment of the quadriceps contractility index (Qci) is feasible, rapid, simple, and reliable. Numerous studies have demonstrated that Qci is linked to the severity of COPD, clinical symptoms, and respiratory muscle activity. Furthermore, ultrasound makes it possible to observe the dynamics of the diaphragm by measuring its amplitude, its contraction speed, and the duration of each contraction phase. Ultrasound examination of muscle damage in COPD could constitute a promising new tool to assess the severity of the disease.

Introduction

GOLD 2023 defines broncho-pneumopathy obstructive chronic disease (COPD) as a "Heterogeneous lung disease characterized by chronic respiratory symptoms (dyspnea, cough, expectoration and/or exacerbations) due to of the airways (bronchitis, bronchiolitis) and/or alveoli (emphysema) that cause persistent obstruction, often progressive, of the airflow" [1]. COPD is a major public health problem with the consequences it brings in terms of morbidity, mortality, and disability. Globally, it is estimated that 480 million people had COPD in 2019 [2] and this figure is underestimated [3]. According to the BOLD study, 10.1% of people over 40 would have COPD [4]. The increase in tobacco consumption in developing countries as well as the ageing population in the countries' industrial companies will lead to an increase in the prevalence of COPD in the next 30 years. By 2030, 4.5 million deaths from COPD are expected annually [5]. According to the Global Burden of Diseases, established by the World Health Organization, COPD is the third most deadly disease in the world. It was responsible for 3.23 million deaths in 2019 (5.7% of deaths) [3].

The cost of COPD is estimated in terms of health care and productivity loss of 48.4 billion euros per year for the EU countries. In France, the direct cost is estimated at the annual cost of the disease to be 3.5 billion euros [6]. In Algeria, according to the results of the Breathe study, the prevalence of COPD is estimated at 4% in the general population and 25% of smokers [7]. Smoking increases this prevalence which is 31.5% among smokers, 14.6% among Ex-smokers, and 2.5% for non-smokers [8].

COPD is associated with many comorbidities, including lung cancer, cardiovascular disease, osteoporosis, cachexia, and muscle involvement [9]. Muscular atrophy of skeletal muscles is an important general event of COPD. This dysfunction has multiple causes, including physical inactivity [10] and systemic inflammation [11]. Corticosteroid therapy systemic, hypoxemia, hypercapnia, hypersensitivity malnutrition, electrolyte disorders, heart failure, and hypogonadism are also involved [12].

Given the severity of the disease and population, it is estimated that 4 to 35% of patients with COPD have a loss of muscle mass [13,14]. A recent study found that 32% of patients with COPD had a strength of quadriceps below lower limits of normal and approximately 25% of patients in the GOLD I and II and 38% of patients at stage GOLD IV were affected by muscle weakness [15]. This muscle weakness has several serious consequences, including intolerance to the decline in quality of the financial year [16,17] life, and increased mortality [18]. In patients with a significant decrease in the airflow, the section decrease transverse to the middle of the thigh is associated with a 13 times higher relative mortality risk than the one observed in patients whose mass muscular is good [19].

The ultrasound evaluation of the Quadriceps contractility index (Qci) is feasible, fast, simple, and reliable. The Qci is related to the severity of COPD, clinical symptoms, and activity of the respiratory muscles. This measurement could be a promising new tool for assessing the severity of the disease [20].

The diaphragm is the main muscle of inspiration during resting breathing [21]. It is a striated skeletal respiratory muscle, having a rhythmic activity, permanent, involuntary, but adjustable by cortical activity. It is a resilient muscle, characterized by high oxidation capacity, a high proportion (60%) of fatigue-resistant fibers, and a lot of capillaries [22].

Dysfunction of the diaphragmatic muscles plays a significant role in the pathogenesis of respiratory distress in patients with COPD [23]. Traditionally, the weakness of the diaphragm due to its shortening is caused by hyperinflation, which places the diaphragm at a mechanical disadvantage [24]. However, several more recent studies show that participation in other phenomena, such as intrinsic alterations of the diaphragm [25,26] may be the reason. In patients with COPD, it has been found that there is a transition to a higher proportion of Type I fibers compared to healthy subjects [27]. Type I fibers produce a force that is lower than that of Type II fibers, which improves fatigue resistance [25].

Exogenous oxidative stress is caused by exposure to cigarette smoke, biomass, and air pollution, oxidative stress endogenous resulting from cell activation inflammation in the lung and reduction of antioxidants leads to an increase in oxidative stress in the lungs. This is a significant factor in the pathophysiology of COPD and its evolution, as well as in the increased risk of exacerbations acute. Increased oxidative stress in the lungs of patients with COPD leads to chronic inflammation, a decrease in the anti-inflammatory effects of corticosteroids, rapid aging of the lungs, fibrosis peripheral respiratory tract, and a hyperproduction of mucus [28]. Oxidative stress plays an important role in the pathophysiology of COPD [29,30]. Some studies have shown the association between stress oxidative and the severity of COPD leading to medical comorbidities and muscular dysfunction [31].

Several tools to evaluate the diaphragm directly or indirectly: Measurement of inspiratory pressure and transdiaphragmatic pressure by magnetic or electrical stimulation of the phrenic nerve, EMG, or imaging. The evaluation is not diaphragm selective or invasive in nature and the very complexity of these tools limits their use [32].

In pneumology, ultrasound is still little used in diaphragm exploration but it offers many advantages: it is non-invasive, quick, and easy-to-use especially at the bedside for patients with exacerbations of COPD, especially with devices portable and ultra-portable [33,34]. This provides the possibility of structural analysis and function of two hemi-diaphragms distinct [35,36].

Two components of diaphragm function are commonly assessed by ultrasound [32]:

- Subcostal diaphragm excursion anterior and lateral thoracic (EXdi).
- The thickening fraction of the diaphragm measured at the diaphragm apposition area on the thoracic cage (TFdi).

Thus, thanks to ultrasound, it is possible to observe directly the dynamics of the diaphragm by measuring its amplitude, its contraction rate, and the duration of each contraction phase. Being non-irradiant, this examination can be repeated as many times as possible to follow the time-lapse diaphragmatic kinetic [37].

Conclusion

Ultrasound has marked advantages over other techniques used to assess diaphragmatic function, and quadriceps also COPD, for example, it is non-invasive and does not use ionizing radiation, but is feasible, reproducible, and affordable in the patient's bed. In addition, there is compelling evidence in the literature for the usefulness of ultrasound to assess diaphragmatic function in various clinical settings (stable COPD, exacerbation COPD). It is assumed that in the future, the use of ultrasound diaphragmatic and quadriceps by pulmonologists and reanimators and even doctors re-educator will be omnipresent and will have new applications in the diagnosis and follow-up of patients with COPD.

Future directions

As the ultrasound reference values for the diaphragm and measurements for quadriceps are not well defined; further studies establishing reference values are required for diaphragm thickness and excursion, the thickness and contractile index of the quadriceps.

The calculated values should consider the respiratory cycle phase, body habitus, race, and ethnicity, among others. Ultrasound of the diaphragm and quadriceps in COPD can help predict and study the natural history of COPD. It may also help us to better understand the diagnostic, therapy, and prognostic protocols for these patients.

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