Respiration 2014;88:519–520
DOI: 10.1159/000367870

Authors' Reply

Andrea Smargiassi^a, Riccardo Inchingolo^a, Francesco Faita^b,
Linda Tagliaboschi^a, Alessandro Di Marco Berardino^a,
Salvatore Valente^a, Giuseppe Maria Corbo^a

^aPulmonary Medicine Department, Università Cattolica del
Sacro Cuore, Rome, and ^bInstitute of Clinical Physiology,
National Research Council, Pisa, Italy

We read the letter from Trovato et al. [1] that commented on our paper entitled 'Ultrasonographic assessment of the diaphragm in chronic obstructive pulmonary disease patients: relationships with pulmonary function and the influence of body composition – a pilot study' [2]. We thank the authors for giving us the opportunity to clarify some issues.

The authors question the possibility of measuring millimetric modification of the diaphragm in the zone of apposition (ZOA). The technique used was similar, with the modifications discussed in our report, to that already presented by Ueki et al. [3] in 1995, and the ability to measure diaphragm thickness was even reported as far back as 1985 [4]. Therefore, we have to confirm that our study was conducted using B-mode assessment, and that M-mode assessment was used only to measure diaphragm excursion using the technique of Testa et al. [5]. This issue needs to be clarified because the authors state that M-mode is not yet ready to use in pneumology. However, other authors also motivated by the original findings of Ueki et al. [3] and Cohn et al. [4] have published interesting papers on diaphragm thickening and thicknesses in ZOA in mechanically ventilated subjects and cystic fibrosis patients [6, 7]. Recently, two important papers have been published [8, 9] showing the possibility of using these measurements in critical care settings to predict extubation and discontinuation of mechanical ventilation. These preliminary works further strengthen the concept that the echographic assessment of the diaphragm might be a useful tool for clinicians (and not only pneumologists). Thus, other clinicians are using a similar echographic technique to reach relevant conclusions. As clearly reported within the discussion in our paper, and in the title itself, we wish to emphasize that this was a pilot study [2] of 32 patients presenting our data and experience with these measurements made for the first time, to the best of our knowledge, on COPD patients considering body composition and respiratory functional tests, with all the limitations reported.

Technically speaking, we can report that working with B-mode images instead of M-mode signals helps in recognizing the edges of the diaphragm by means of manual calipers. Moreover, the resolution of the images (10-pixels/mm) means that two structures – 3 and 4 mm in thickness, respectively – can be differenti-

ated by simply recognizing the difference of 10 pixels between them.

Additionally, we do not agree with Trovato et al. [1] when they state that reproducibility is not important for evaluating the reliability of the technique, especially for the proposed approach, which entails the evaluation of changes in the measurement between three physiologically different conditions. Indeed, a strong reproducibility is more important than an acceptable absolute accuracy for clinical adoption of the technique. Finally, we would like to note that a very comparable approach for the manual measurement of similar anatomical structure by calipers was reported by Pignoli et al. [10] in 1986, when they introduced a technique to measure carotid intima-media thickness by means of calipers manually placed on B-mode ultrasound images with a precision of 0.1 mm.

Moreover, in support of these considerations, we note that in a previous work published by the authors of the letter [11] a millimetric measure of the pleural line even using a convex probe has already been provided. We do not recognize the possibility of reporting the thickness of the pleural line in normal subjects because that is simply an interface between 2 means, with a high difference in acoustic impedance.

As far as the interpretation of body composition measurements are concerned, we need to clarify that among the variables tested, fat-free mass (FFM) was found to be the better determinant of the diaphragm thicknesses in a linear regression model and not in absolute terms. The influence of respiratory functional tests adjusted for FFM on echographic measurements was performed using a multiple regression analysis.

The BMI showed a good relationship in our population with the thicknesses of the diaphragm. Why should obesity relate to a reduction in the thickness of the diaphragm? We have found that the greater the BMI, the greater the diaphragm thickness can be. On the other hand, it can be reasonably speculated, as Trovato et al. [1] state, that obesity could influence the mechanics of the diaphragm. In fact, in our work the BMI did not show any linear relationship with diaphragm thickenings, whilst other parameters, like hyperinflation, appear to be more significant. It can be speculated that severe obesity might be a 'protective' factor reducing hyperinflation and diaphragm basal position with restrictive modifications in COPD patients. Actually, by computing the BODE index [12], low BMI is related to a worse prognosis and high BMI to a better prognosis. In our study, the BODE index was closely related to inspiratory capacity/total lung capacity, the importance of which in diaphragmatic thickenings was discussed in our study [2]. However, we agree that obesity, without airflow limitation and hyperinflation, needs to be evaluated for its effects on diaphragm kinetics in comparison with normal subjects, but this was not the aim of our study, which focused on COPD patients.

Finally, we can agree with the fact that the ZOA could be sub-optimal in several cases for ultrasound acquisition, especially in severe obesity with the attenuation of ultrasound images using lin-

ear probes. Moreover, it may be difficult to assess the ZOA and diaphragmatic thickenings and it may require expertise. These can be limitations of the echographic technique itself (like a suboptimal acquisition in echocardiography), and they depend on the characteristics of patients and expertise of operators. We did not state that ultrasonography is the easiest technique to manage and interpret diaphragmatic behavior, but it could be useful and promising.

In conclusion, we very much appreciate the letter of Trovato et al. [1] and hope that these and other preliminary works could better define the eventual role of diaphragmatic assessment in chest ultrasonography in order to ameliorate clinical practice.

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