**Ultrafast Ultrasound Plane Wave Imaging As a Novel non-Invasive Technique to Assess Diaphragm Contractility in Response to Phrenic Nerve Magnetic Stimulation**

**Rationale**
Measuring twitch transdiaphragmatic pressure (Pdi) elicited by cervical magnetic stimulation (CMS) is considered as the reference method for the standardized evaluation of diaphragm function. Yet, the measurement of Pdi requires esophageal and gastric catheter-balloons that are rarely used because of their invasiveness. Ultrafast ultrasound (US) is a non-invasive imaging technique enabling frame rates high enough to capture transient events such as evoked muscle contractions. More specifically, ultrafast US allows the quantification of transient velocities using radio frequency-based speckle tracking. Previous works have shown that maximal tissue velocity linearly increased with stimulation intensity. This technique is yet to be applied on the diaphragm. Also, the relationship between diaphragm tissue velocity and the pressure it generates during stimulation is unknown.

**Aims**
- Investigate the effect of stimulation intensity on diaphragm tissue velocity (Vdi_max)
- Determine the relationship between diaphragm tissue velocity and Pdi

**Methods**
- **Thirteen healthy adults**
  - 8 females
  - 5 males
- **9 angles (7° to 7° with a 2° incremental step)**
- **9 kHz frame rate**
- **30 to 100% of stimulation intensity in a randomized order**

**Results**
Typical M-Mode images at three intensity levels are presented. Vdi_max and Pdi were similarly affected by the increase in stimulation intensity.

**Discussion & Conclusion**
We demonstrated that ultrafast US may be used to image diaphragm behavior following CMS. Diaphragm tissue velocity is strongly correlated with twitch transdiaphragmatic pressure. This non-invasive approach opens prospect for a fully non-invasive assessment of diaphragm contractility in clinical populations. Indeed, the relative decrease or increase in Pdi over time could be predicted thanks to the ultrasound-derived metrics such as diaphragm tissue velocity.

**References:**
- Delfour et al., Assessment of the mechanical properties of the musculoskeletal system using 2-D and 3-D very high frame rate ultrasound. IEEE Trans Ultrasound Ferroelectr Freq Control
- Gronlund et al., Imaging two-dimensional mechanical waves of skeletal muscle contraction. Ultrasound Med Biol
- Loupas et al., An axial velocity estimator for ultrasound blood flow imaging, based on a full evaluation of the Doppler equation by means of a two-dimensional autocorrelation approach. IEEE Trans Ultrasound Ferroelectr Freq Control

**Acknowledgements:**
The PND fellowship of TP is funded by the Fondation EDF that is supporting the ResPMyo project, which includes the current study. This study was also supported by the Association Française Contre Les Myopathies (AFM). The authors would like to thank all the participants who took part in this study.