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Title: A new ultrasonographic device for within-breath measurements of diaphragm thickness during breathing

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Body: Preliminary studies have shown the possibility to use ultrasounds (US) to measure diaphragmatic thickness (DT). In order to allow accurate and operator-free US measurements of within-breath DT during tidal breathing, we have designed and prototyped an innovative US device composed by a single piezo-element probe (SPEP, 7.5 MHz) able to generate and detect radio frequency (RF) echo signals of the pleural and peritoneal membranes of the diaphragm. The prototype was tested on a phantom and successively on 6 healthy subjects (3M, 3F), who were studied in supine position during spontaneous quiet breathing at rest. The SPEP was fixed by adhesive tape on the lateral ribcage (9th or 10th intercostal space) and data were acquired continuously and synchronously with a pneumotachograph. The in-vitro validation showed an accuracy of ± 0.05 mm. In average, DT thickness was 1.55 ± 0.17 and 1.9 ± 0.21 mm, respectively at end-expiration and end-inspiration. DT variations during tidal breathing were in average 0.35 ± 0.05 mm with different patterns of within-breath DT changes (see figure for a representative example). In conclusion, the SPEP device: a) is characterized by measurement accuracy able to detect the small changes of DT during quiet breathing; b) allows an operator-free method to monitor DT during breathing and to study different patterns of DT variations, corresponding to different timing of diaphragm activation.