Introduction:
Pleural pressure (Ppl) is estimated by measuring esophageal pressure (Pes) with an esophageal balloon. To validate the correct position and inflation volume of the balloon, a positive or negative pressure occlusion test is used, considered valid when the ratio between oscillations in Pes (ΔPes) versus airway-pressure (ΔPaw) are equivalent. We investigated the impact of two different compression/decompression rates during chest compression.

Methods:
We studied 8 pigs with injured lungs, paralyzed and supine. An esophageal balloon was placed at the lower portion of esophagus and a Ppl sensor (wafer-type, flat balloon) was placed at most dependent lung region. Both devices were inflated with minimal (non-stressed) volume derived from in-vitro and in-vivo PV curves. Two rates of thoracic compression (slow and fast) were tested and recorded at different PEEP levels. Plots of Pes/Paw and Ppl/Paw were fitted into a hysteresis and linear-regression model.

Results:
70 repeated measurements were performed in 8 animals (PCV mode, PEEP = 12±3 cmH2O and VT = 6 ml/kg). The compression-time for slow maneuver was 0.49 ± 0.10 s, vs. 0.19 ± 0.04 for the fast one. Plots of Ppl/Paw showed small hysteresis, with phase angles of 1 vs. 3 grad for slow vs. fast maneuvers. In contrast, plots of Pes/Paw showed higher hysteresis, with phase angles of 3 vs. 32 grad (slow vs. fast)(Figure 1). The slope of the regression line for Pes/Paw plots was consistently higher for slow compressions (0.98 ± 0.08), as compared to fast ones (0.84 ± 0.05). A good agreement between ΔPes and ΔPaw (Figure 2) was found during slow maneuvers, but not during the fast ones.

Conclusion:
Slow chest compressions must be used when checking position/inflation of esophageal balloon. The fast maneuver produces hysteresis and underestimation of ΔPes (but not in direct ΔPpl). Pes monitoring at high respiratory rates may be problematic.

References:
Representative model between slow chest compression with time of velocity 0.61 seconds versus fast chest compression with 0.20 seconds. a) Behavior of hysteresis between Paw with Pes. b) Behavior of hysteresis between Paw and direct Ppl measurement.

Image 2:

Bland-Altman plots showing the agreement between $\Delta\text{Pes}$ and $\Delta\text{Paw}$ in two different strategies: a) slow chest compression and b) fast chest compression