EIT measurement of pulmonary artery pressure in neonatal lambs

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Abstract: Pulmonary artery pressure (PAP) is inversely related to the pulse arrival time (PAT) of the EIT signal in the lungs. The goal of this study is to evaluate whether PAT-based EIT measures can accurately monitor directly-measured PAP in newborn lambs. Early results show good correlations and trending ability, although the technique is sensitive to belt placement and signal quality.

1 Introduction

While non-invasive measurements of arterial pressure are routine, few techniques exist to measure PAP. We are motivated by the value in (especially premature) neonatal medicine, where hypoxic vasoconstriction of immature pulmonary arteries is a key clinical challenge. While PAP can be measured with ultrasound, it requires a high level of expertise, is not possible in all patients, and cannot provide continuous readings. Recently, the EIT-measured PAT has been shown to correlate well with ultrasound measures in healthy adults [1]. Our goal in this study is to evaluate EIT-based PAP measures against invasive measures in neonatal lambs.

2 Methods

Healthy (2–4 days old, 2.57 ± 0.49 kg) lambs were anesthetized, ventilated, and placed in prone position, while EIT data were acquired with a 32-electrode belt (protocol details in [2]). A Swan-Ganz catheter was placed in the pulmonary artery and pressure waveforms and ECG signals were acquired and synchronized to the EIT data. Data were analyzed using the algorithm of [1]; briefly, in each 2-minute window, an average PAT in the lung region was calculated from an ECG-gated average EIT image sequence. PAP was estimated from the PAT values using linear regression.

3 Results and Discussion

At the time of writing, data were acquired in eight animals with four more experiments planned. Four data sets were rejected due to electrode errors or missing data. Representative data for one animal are shown (Fig 1), illustrating good correspondence between PAP measures, except in the last phase of the protocol, in which the epinephrine caused a decreased duration of the pre-ejection period. Overall, correspondence between PAP measures was high, with an average correlation $r = -0.810$ (range -0.762 – -0.872).

We consider these initial results to be very promising and hope to be able to report similar results with the full experimental set. A non-invasive, continuous, EIT-based measure of PAP would provide vital clinical data for the management of many newborns. For example, such PAP monitoring would help titrate iNO treatment in real time, helping especially avoid the risk of right ventricular failure and shock.

References

[1] M Proença *et al* Physiol Meas, 37:713–726, 2016

[2] Sage *et al*, Frontiers Physiology, 9:1723, 2018.

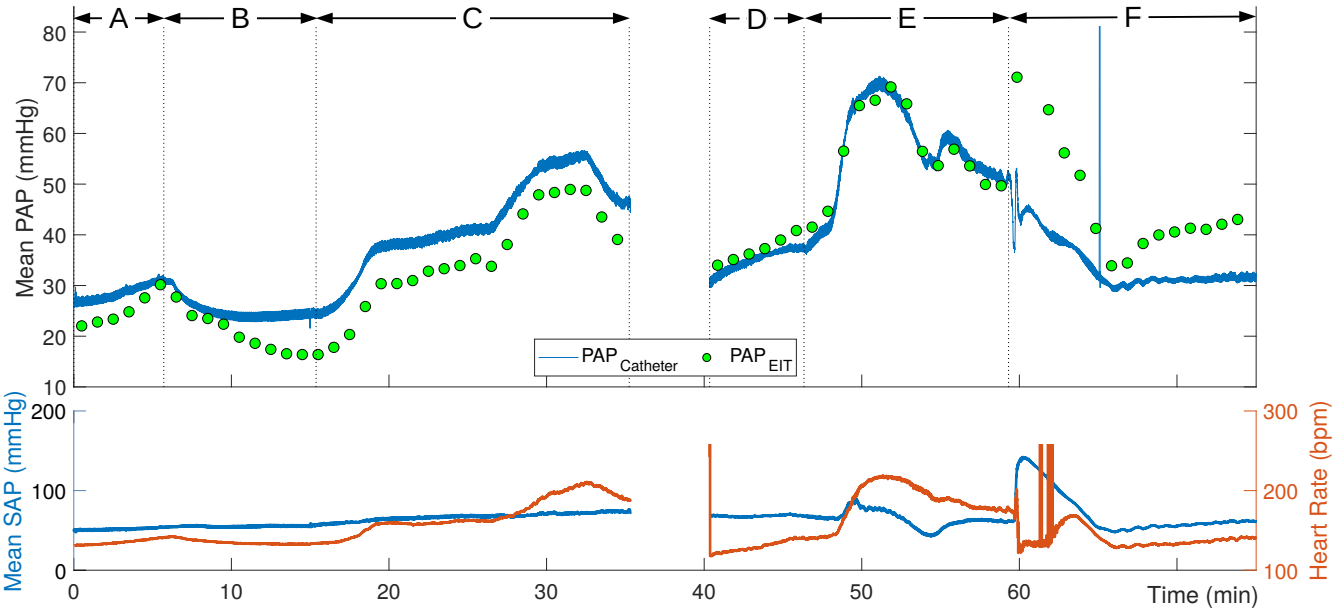

Figure 1: PAP and PAP_{EIT} (top row) and systemic arterial pressure (SAP) and HR data (bottom row) for a representative animal. A: FiO_2=21% B: FiO_2=100%, C: FiO_2=12–14%, D: FiO_2=21%, E: FiO_2=12–14%+hypoventilation, F: FiO_2=100%+epinephrine.