ABSTRACT TITLE: OPTOACOUSTIC MEASUREMENT OF BLOOD OXYGENATION IN THE LEFT INNOMINATE VEIN

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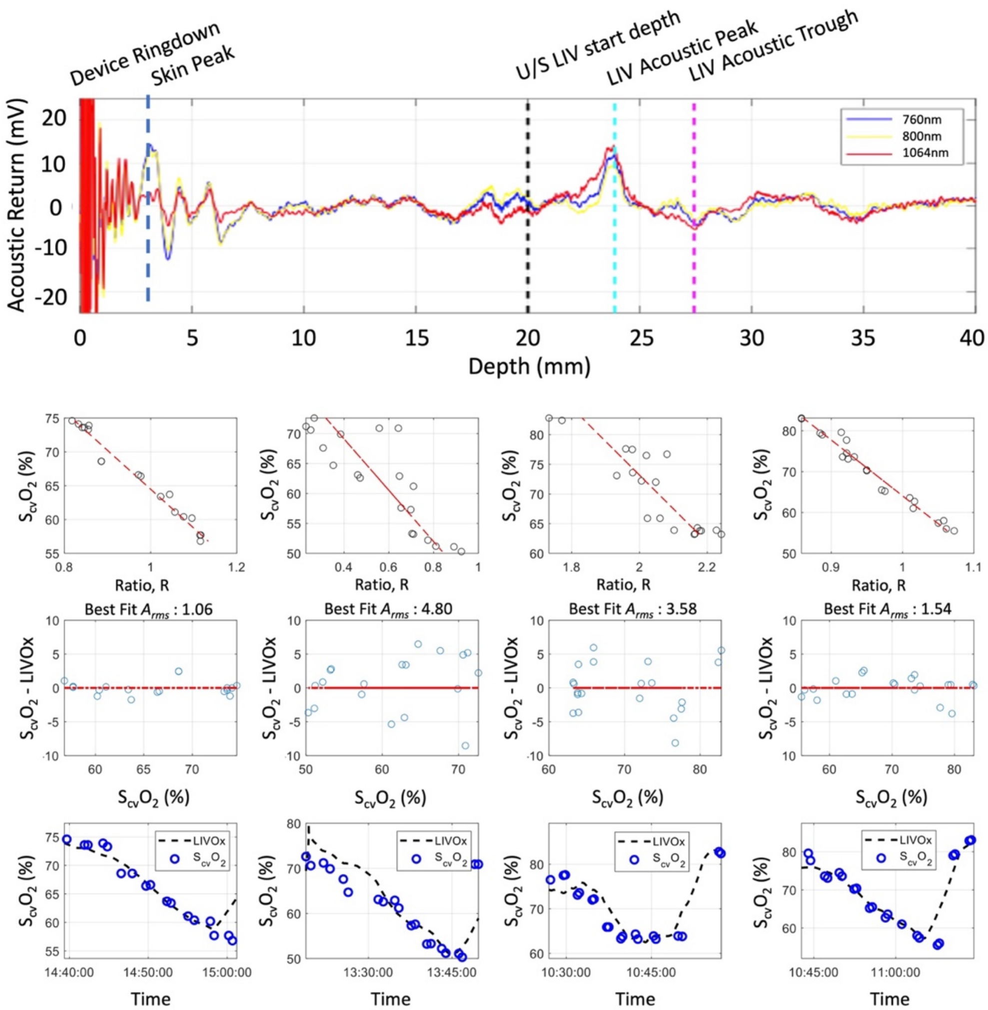
Background/Introduction: The standard of care for treatment of shock, consisting of empirical management based on BP, HR and intermittent measurements of serum lactate, could be enhanced by a rapid, noninvasive continuous monitor of the adequacy of O_2 delivery that could be used as soon as shock is suspected and continued throughout therapy. We hypothesize that *immediate, noninvasive* assessment of O_2 saturation in the left innominate vein ($S_{LIV}O_2$), a proxy for $S_{cv}O_2$, will facilitate diagnosis, provide useful prognostic information and permit immediate, rather than delayed, treatment. Towards this goal, we have developed an optoacoustic device (LIVOx™) to measure $S_{LIV}O_2$.

Methods: Since the Summer of 2022, we have been conducting an IRB-approved, single site, non-randomized, study at Duke University to measure the accuracy of an investigational monitor of $S_{LIV}O_2$ compared to blood reference values. To date, 16 healthy, adult volunteers, aged 18 - 45 years old, have been enrolled after informed consent. Subjects were selected to obtain a representative range of gender and skin pigmentation. For each subject, the inspired oxygen concentration was lowered in stepwise fashion to produce a controlled oxygen desaturation sequence. At each plateau, serial LIV blood samples were drawn from a central venous catheter placed in the left internal jugular vein and advanced to the LIV and analyzed by a CO-oximeter.

Results: Analysis of the acoustic traces obtained features consistent with the skin and LIV depths identified during prior ultrasound imaging (see figure, top). Four traces with an LIV peak exhibiting the lowest variation in peak position and highest peak to peak amplitude were selected for further analysis. Results from these traces are shown in a plot matrix (see figure, bottom). The scatter plots (top) show the localized light absorbance ratio (760nm / 1064nm) against reference saturation. This ratio linearly increases as saturation falls with an order of magnitude comparable to that expected for S_PO_2 (where ratio, R≈0.5-2 for sats 100-50%). Best fit calibration curves, created retrospectively for each subject, have been used to generate a 'best case' modified Bland Altman plot for each subject. The pooled Arms for these four subjects is 3.14 % — individual measurements are provided with their respective plots. The bottom row of the matrix shows a real-time simulation of device output with CO-oximeter values overlayed.

Conclusion: Preliminary analysis indicates the potential for the non-invasive optoacoustic measurement of $S_{LIV}O_2$. Acoustic return amplitudes provide absorbance features at depths confirmed as LIV locations by ultrasonic measurement with absorbance ratios comparable to those measured by other oximetry devices. Future work will center on stabilizing the sensor design for improved targeting of the LIV and increasing the data pool to allow the generation of a single calibration curve suitable for all patients.



Top: Sample acoustic profile for 3 laser wavelengths (Acoustic vel. = 1540 m/s).
Bottom: Results matrix for 4 study subjects with CO-oximeter reference v absorbance ratio, R (top); modified Bland Altman (middle); and device time trace (bottom).