

# **Characterizing Precordial Doppler Audio in Patients Receiving Agitated Saline Injection During Echocardiography**

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## **Introduction**

Precordial doppler ultrasound is one of the many tools anesthesiologists can use to monitor patients that are undergoing a variety of intracranial procedures in the sitting semi-setting or reverse Trendelenburg positions, which carry risk for venous air embolism (VAE). Incorporation of a software component that could independently monitor the precordial doppler ultrasound and alert the anesthesiologist of possible air entrainment via doppler signal interrogation would provide an excellent opportunity for earlier detection and treatment of a VAE. Generation of such a piece of software necessitates the collection of data to characterize the various potential sound qualities of VAE. Therefore, the goal of this study is to record and characterize precordial doppler ultrasound audio in patients who undergo echocardiogram with agitated saline microbubble test, which is a small VAE.

## **Methods**

With IRB approval, patients undergoing elective bubble studies at UF Health Gainesville for other indications were consented and enrolled in the study. A precordial doppler ultrasound was placed over the right atrium/ventricle of the study participant's during the echocardiography exam. The doppler audio was continuously recorded before, during and after the injection of agitated saline. The recordings were analyzed using Audacity (Muse Group) to measure transient changes in doppler intensity and frequency before, during and after the microbubble study.

## **Results**

14 patients were recruited for the study. Data was evaluated for normality and met assumptions. A paired t-test was used to compare pre and post injection doppler intensity. Mean normalized standard deviation of post injection sound intensity (0.0311) was significantly higher than that of pre injection (0.0059) (p-value 0.0065) (SE: 0.00831) (Table 1). A matched pairs t-test was used to compare mean pre-injection doppler frequency per heartbeat with mean post-injection doppler frequency per heartbeat at the maximum doppler intensity. Results shows that mean post-injection frequency (859 Hz) was found to be significantly higher than mean pre-injection frequency (417 Hz) ( $p < 0.0001$ ) (Table 1).

## **Discussion**

Standard deviation of the mean was chosen as the method to compare changes in doppler intensity due to the symmetry the data had with the x axis (the average intensity over time would have been near 0). The standard deviation of the doppler data between patients was high, which we suspect is a result of a combination of probe placement, patient variability and potential variability of agitated saline quality, which is a limitation in our study. We also noted that despite clear heart sounds pre injection of agitated saline, doppler probe placement on the patient's right sternal border sometimes failed to produce significant changes in doppler audio intensity. Additionally, when attempted, probe placement on the patient's left sternal border was able to consistently pick up significant changes in doppler audio, even

when placement on the right side on the previous attempt had failed to. Despite a high standard deviation, the results show a clear and quantifiable distinction between absent vs present bubbles with a transient fivefold increase in doppler intensity and a twofold increase in doppler frequency at peak intensities (Figures 1 and 2). This data could be used to drive alarm parameters in monitoring software for VAE. Future work will look at integrating these doppler parameters into software detect and alert for early VAE.

Sound Quality Analyzed	Trials	Average Normalized Standard Deviation $\pm$ Standard Deviation	P-value (Paired t-test)	Sound Quality Analyzed	Trials	Mean $\pm$ Standard Deviation (Hz)	P-value (Paired t-test)
Intensity	Pre-Injection (n = 14)	0.0059 $\pm$ 0.0071	0.019	Frequency	Pre-Injection (n = 14)	417 $\pm$ 123	< 0.001
	Post-Injection (n = 14)	0.0311 $\pm$ 0.0252			Post-Injection (n = 14)	859 $\pm$ 51	

**Table 1.** Intensity and frequency analyzed before versus after microbubble saline injection

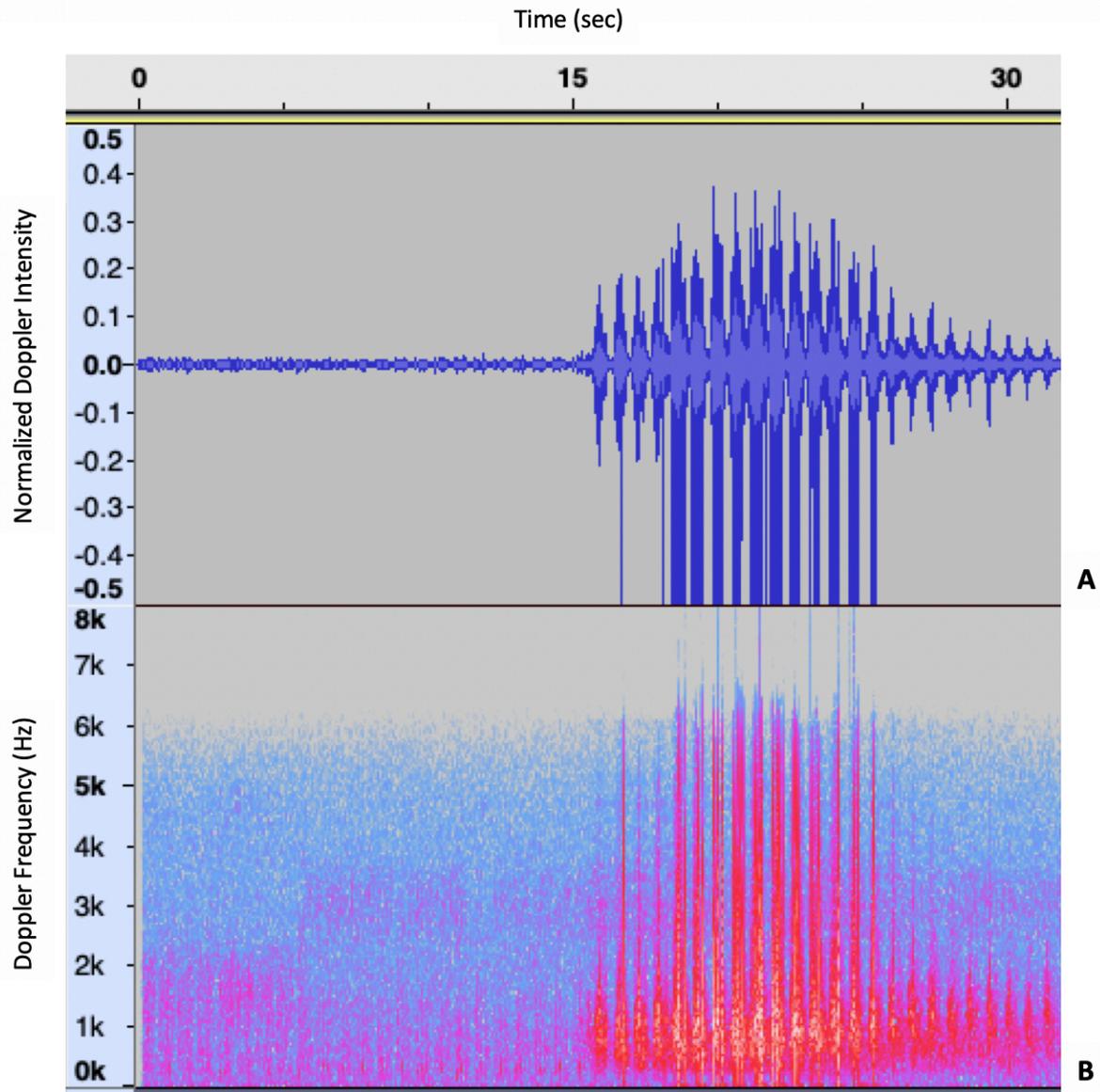


Figure 1. Intensity and frequency plots of trial 4. (A) Plot of normalized intensity vs. time (sec) and (B) plot of frequency (Hz) vs. time (sec). Transient increases in doppler intensity and frequency can be clearly distinguished post-agitated saline administration.

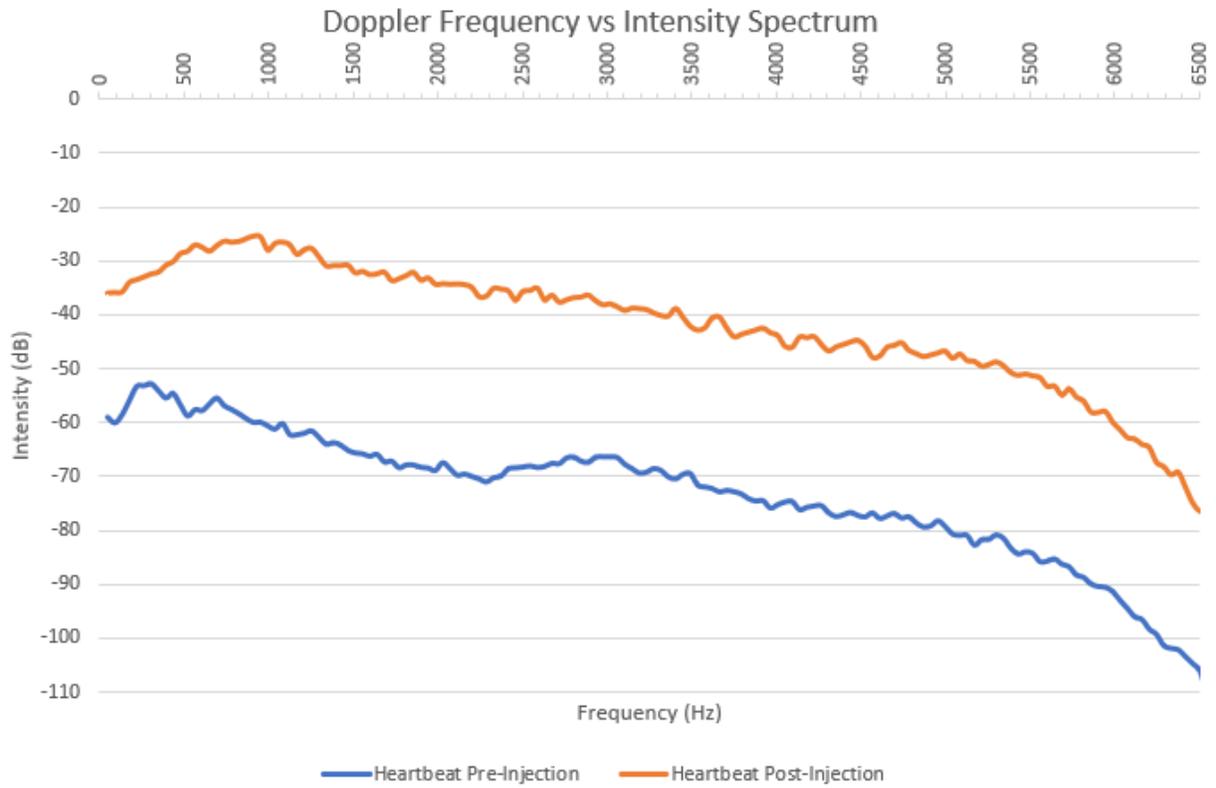


Figure 2. Doppler Frequency vs Intensity for Trial 4. Clear shifts in doppler frequency and intensity can be noticed during the presence of microbubbles after administration of agitated saline.