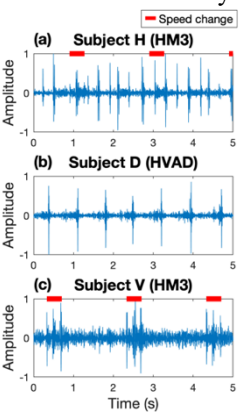
Heart Sound Analysis in Individuals Supported with Left Ventricular Assist Devices: A First Look

Xinlin J Chen[1], Leslie M Collins[1], Priyesh A Patel[2], Ravi Karra[3], Boyla O Mainsah[1]

[1]Duke University; [2]Atrium Health; [3]Duke University Medical Center
North Carolina, USA

Aims: Left ventricular assist devices (LVADs) have emerged as a treatment for end-stage heart failure. However, LVAD recipients face high hospital readmission rates due to recurring complications. Analyses of precordial sounds may facilitate remote monitoring of LVAD recipients for early detection of complications, potentially improving patient outcomes. Heart sounds provide insight into cardiac function, and abnormal heart sound detection has been demonstrated in LVAD-free individuals. However, precordial sounds of LVAD recipients are dominated by LVAD-generated sounds that obscure underlying heart sounds. The goal of this study was to develop a signal processing pipeline to mitigate LVAD sounds and analyze *intrinsic* precordial sounds in LVAD recipients to identify acoustic signatures of cardiac activity.

Methods: A dataset of digital recordings of precordial sounds, acquired from 24 LVAD recipients at Duke University Hospital, was analyzed. Sixteen subjects had a HeartMate 3 (HM3) and eight subjects had a HeartWare VAD (HVAD). Adaptive filtering was employed to separate LVAD and intrinsic sounds in the recordings of precordial sounds. Unsupervised clustering of power spectral features extracted from acoustic signals was performed using Uniform Manifold Approximation and Projection. Spectrograms were computed to analyze the time-frequency characteristics of the signals.



Time domain signals (5 seconds) of intrinsic precordial sounds, with LVAD type indicated.

Results: We identified three categories of intrinsic precordial sounds with temporal and/or spectral characteristics that are indicative of heart sounds: (a) sounds with a 25-120 Hz frequency band (e.g., subject H); (b) a faint, 20-50 Hz sound followed by a stronger, 50-200 Hz sound (e.g., subject D); and (c) 'triple' energy bursts with a frequency band of 20-100Hz occurring every two seconds (e.g., subject V). Notably, these triple energy bursts were synchronized with the programmed speed changes of the HM3 LVAD.

Conclusion: This study provides the first preliminary evidence for the potential utility of exploring acoustic analysis to remotely monitor cardiac function in LVAD recipients.