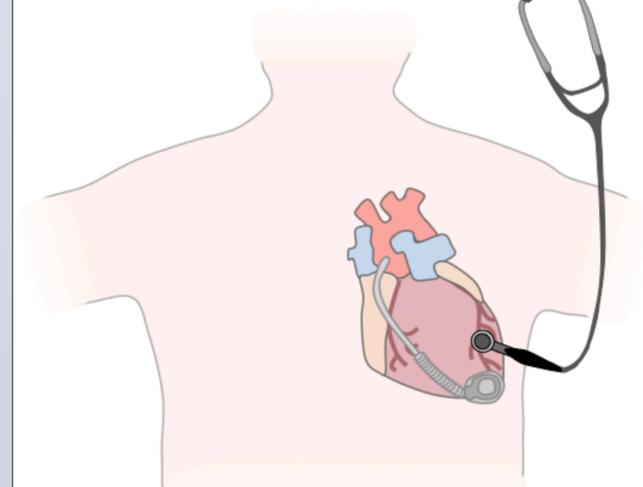
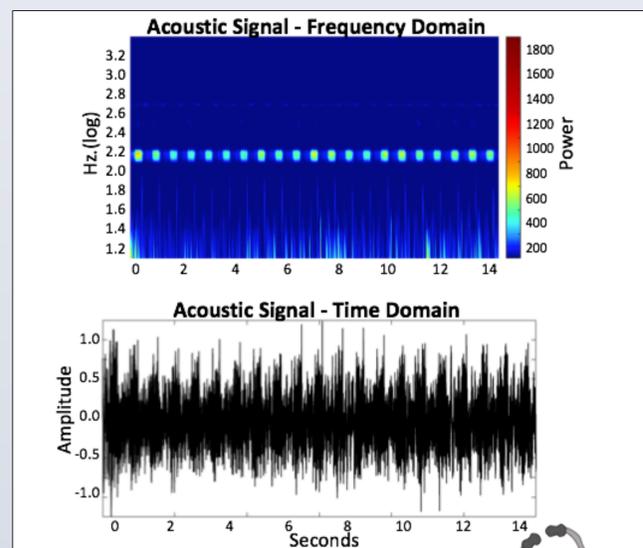


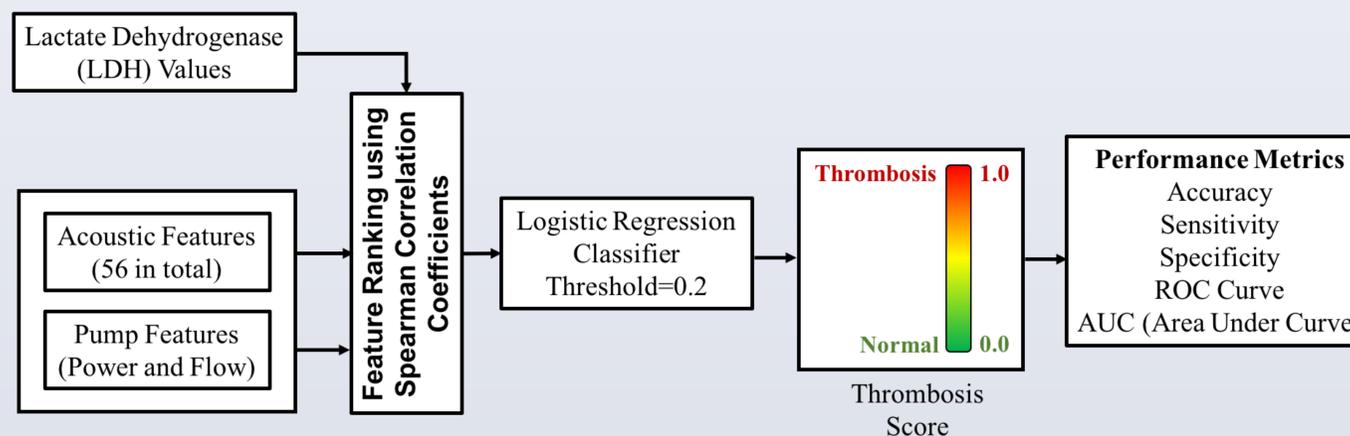
## BACKGROUND

- In many studies, it has been shown that the acoustical signatures of VADs can provide salient information regarding thrombosis state.
- Various features should be extracted from these acoustical signals for further processing (such as thrombosis state classification).
- The performance of biosignal classification hinges on feature selection, yet in many cases such features are selected ad hoc with an empirical, black box approach.
- Combining heterogeneous data streams – specifically physiologically meaningful blood biomarkers and biosignal features – can potentially enhance this selection process.



## METHODS

- A total of 27 LVAD sound recordings were obtained from patients with LVADs before developing thrombosis and during thrombosis using a digital stethoscope (EKO Core).
- Presence of hemolysis and degradation of device performance can indicate pump thrombosis. Elevated lactate dehydrogenase (LDH) level is one of the hemolysis signs.
- The analysis consisted of the following steps:
  - Extracting acoustic features (time-frequency domains, acoustic/speech and nonlinearity features) from all recordings.
  - Calculating the Spearman correlation of each feature (acoustic and pump) with abnormal LDH to select the 10 most correlated features.
  - Training two logistic regression classifiers - one with all features and another with the top 10 features.



### Spearman Correlation:

- Spearman correlation assesses monotonic relationships between variables.
- The correlation of each feature (acoustic and pump) with LDH levels were calculated (These correlation coefficients can take values between 1 and -1; where 1 is positive correlation, -1 is negative correlation and 0 is no correlation). The absolute value of these correlation coefficients were taken and ranked to get the top 10 most correlated features.

### Our hypothesis:

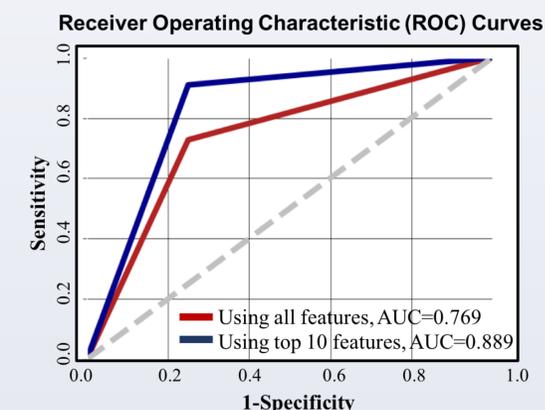
*The features which are highly correlated with LDH levels perform better in thrombosis state classification.*

### Thrombosis Score Calculation:

- The scoring procedure was performed twice:
  - Using all features (56 acoustic features + pump power and flow)
  - Using the top 10 features.
- Using logistic regression classifier, a thrombosis score was calculated to place the recordings on a scale ranging from 0 (normal) to 1 (thrombosis).
- These scores were then compared to the actual thrombosis classes (normal or healthy) to calculate the performance metrics (accuracy, sensitivity, specificity, and the AUC of ROC).

## RESULTS

- Using the features which have high correlations with LDH yielded higher performance compared to using all features.



### Performance Metrics

	Before Ranking	After Ranking
Accuracy	74.7%	81.5%
Sensitivity	72.7%	90.9%
Specificity	75.0%	75.0%
AUC	0.769	0.889

## CONCLUSION

- Remote monitoring of HF patients can reduce HF exacerbation and hospitalization, however there is a need for a robust non-invasive analysis framework.
- The most important part of biosignal analysis is feature selection, thus a standardized feature selection algorithm should be developed to assist clinical decisions.
- We proposed that the correlation coefficients between the extracted features and blood biomarkers can be used to rank and select the most prominent features.
- While this work focuses on the problem of detecting pump thrombosis in patients with LVADs, the same methodology could be applied to other physiological signal analysis.

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