

# Predicting the Effectiveness of Cardiac Resynchronization Therapy Using Natural Language Processing

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## Cardiac Resynchronization Therapy (CRT)

Guidelines:

Patient with cardiomyopathy on GDMT for ≥3 mo or on GDMT and ≥40 d after MI, or with implantation of pacing or defibrillation device for special indications

LVEF ≤35%

Evaluate general health status

Comorbidities and/or frailty limit survival with good functional capacity to <1 y

Continue GDMT without implanted device

Acceptable noncardiac health

Evaluate NYHA clinical status

NYHA class I

• LVEF ≤30%

• QRS ≥150 ms

• LBBB pattern

• Ischemic cardiomyopathy

• QRS ≥150 ms

• Non-LBBB pattern

NYHA class II

• LVEF ≤35%

• QRS ≥150 ms

• LBBB pattern

• Sinus rhythm

• LVEF ≤35%

• QRS 120-149 ms

• LBBB pattern

• Sinus rhythm

• LVEF ≤35%

• QRS ≥150 ms

• Non-LBBB pattern

• Sinus rhythm

• QRS ≥150 ms

• Non-LBBB pattern

NYHA class III & Ambulatory class IV

• LVEF ≤35%

• QRS ≥150 ms

• LBBB pattern

• Sinus rhythm

• LVEF ≤35%

• QRS 120-149 ms

• LBBB pattern

• Sinus rhythm

• LVEF ≤35%

• QRS ≥150 ms

• Non-LBBB pattern

• Sinus rhythm

• LVEF ≤35%

• QRS 120-149 ms

• Non-LBBB pattern

• Sinus rhythm

NYHA class IV (stage D)

• Refractory symptoms or dependence on intravenous inotropes

• Device not indicated except in selected patients listed for transplantation or with LV assist devices

• If device already in place, consider deactivation of defibrillation

Anticipated to require frequent ventricular pacing (>40%)

Atrial fibrillation, if ventricular pacing is required or QRS criteria above are met and rate control will result in near 100% ventricular pacing with CRT

52.6% Success

(Tracy et al. 2014)

CRT guidelines are weak predictors of clinical success for unknown reasons

## MGH Dataset

Frequency of Occurances of New Data in Cohort

Number of sentences in unstructured notes

Number of structured entries

Number of Pieces of Information

Days Since Implant Procedure

Discipline	Size	Characteristics	Patients:	907
Medicine	Large	Extremely Varied	Structured Forms:	245K
Machine Learning	Small	Unlabeled	Doctor's Notes:	3100K
			Structured Fields:	44M
			Sentences in Notes:	26M

## Our Models

Structured:

ICD9 Diagnosis Hierarchy:

7: Disease of Circulatory System

7.2: Heart Disease

7.2.2: Cardiomyopathy

Medical Encounters:

Inpatient: Yes

Length of Stay: 3 days

Num. of Diagnoses: 7

Recent Labs:

Group: CO2

Value: 32.0

Flag: High

Free Text:

Clinical Value Extraction (CVE):

QRS

LBBB

EF

SR

NYHA

NICM

Bigram Bag of Words:

"beta blockers": 6

"daily vitamin": 0

....

...

...

Paragraph Vectors:

Classifier

Average/Concatenate

Paragraph Matrix

Paragraph id

the

cat

sat

(Le & Mikolovich, 2014)

## Model Performance

Model	Precision	Recall	F1 Score	Accuracy
Clinical Performance	.526	1*	.689*	.526
Tracy et. al 2014 Decision Tree	.590	.300	.397	.538
Structured Data Only	.565	.543	.551	.546
CVE	.626	.593	.608	.593
CVE + Structured	.604	.601	.602	.578
CVE + BOW Bigram	.610	.705	.652	.612
CVE + Structured + BOW Bigram	.603	.621	.609	.583
CVE + Structured + Paragraph Vectors	.600	.592	.594	.585

\*Clinical performance has artificially high Recall and F1 scores because our dataset only contains patients that were prescribed CRT, meaning there were no negative clinical predictions

NLP techniques improve prediction precision by ~9%

## Findings

back pain

symptom that is often an early warning sign of heart attack

father died

indicative of an inherited genetic condition

pleased to

expression of sentiment

beta blockers

when included in notes, indicates that drug did not work for the patient

his visit

gender is a strong predictor

best bigram predictors

Highest scoring bigrams point out interesting predictors, expected symptoms and new findings

## Conclusions & Future Work

Conclusions

NLP on clinical notes improves precision by ~9%

Initial results suggest unsophisticated techniques perform as well as state-of-the-art

Our algorithms highlight interesting predictors, expected symptoms and new findings

Future Work

Perform exhaustive search over hyperparameter and feature spaces to improve performance

Verify clinical findings suggested by our results