Natural Language Processing for Identification of Hypertrophic Cardiomyopathy Patients from Cardiac Magnetic Resonance Reports

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Objectives

Determine if information regarding hypertrophic cardiomyopathy (HCM) can be accurately retrieved from cardiac magnetic resonance (CMR) reports using natural language processing (NLP).

Background

CMR imaging is used for diagnosis and risk stratification of HCM. Manual annotation of information from CMR is time-consuming. NLP is an artificial intelligence method for automating extraction of information from narrative text.

Methods

We identified 200 HCM patients who had CMR reports from 1998 to 2018. These patients were randomly allocated into training (100 patients with 185 CMR reports) and testing sets (100 patients with 206 reports). An NLP system with 2 tiers was developed; the first extracted information regarding HCM diagnosis while second extracted categorical or numeric concepts for HCM classification. NLP performance was compared with gold-standard manual annotation.

Results

NLP algorithms achieved very high performance across all concepts with mean positive predictive value (PPV) = 0.96. An outlier was the performance for abstracting the presence of an apical pouch from CMR reports, which had noticeably lower PPV= 0.78 which be attributed to the low number of cases with this finding.

Table: Performance metrics for each NLP algorithm compared with gold standard

Phenotypic characteristic	Sensitivity	Specificity	PPV	F-1 score	NPV	Accuracy
HCM diagnosis	0·98	1·00	1·00	0·99	0·98	0·99
HCM morphologic subtype	0·98	0·99	0·97	0·97	0·99	0·99
Systolic anterior motion of mitral valve	0·97	0·95	0·98	0·97	0·91	0·96
Mitral regurgitation	0·95	0·87	0·95	0·95	0·87	0·93
Presence of LV obstruction	0·94	0·95	0·98	0·96	0·84	0·94
Location of obstruction (LVOT, mid-ventricular)	0·93	0·91	0·96	0·95	0·84	0·92
Apical pouch	1·00	0·97	0·78	0·88	1·00	0·98
Left ventricular delayed enhancement	0·93	0·88	0·95	0·94	0·85	0·92
Left atrial enlargement	0·98	1·00	1·00	0·98	0·97	0·99
Right atrial enlargement	0·94	0·99	0·94	0·94	0·99	0·98
Maximal LV wall thickness	0·95	1·00	1·00	0·97	0·5	0·95
LV mass	0·99	0·94	0·99	0·99	0·99	0·98
LV mass index	0·98	0·93	0·98	0·98	0·98	0·96
LV ejection fraction	0·98	0·92	0·98	0·98	0·98	0·98
RV ejection fraction	1·00	0·97	1·00	1·00	1·00	0·99

Table 1 Legend: HCM = hypertrophic cardiomyopathy, LV = left ventricular, LVOT = left ventricular outflow tract, NPV = negative predictive value, PPV = positive predictive value, RV = right ventricular.

Discussion

- The results reported herein are important as they suggest that NLP algorithms are sufficiently accurate that they may be deployed not only in research settings but also for potential point-of-care clinical applications.
- In the present study, though the phenotypic characteristics extracted were developed specifically for HCM, many are also useful for the diagnosis and evaluation of other diseases.
- Given the large volume of electronic health record narrative reports in contemporary clinical practice, automated methods to assist providers with data extraction, summarization and synthesis have the potential to greatly improve clinical workflow and NLP will be integral to those efforts.
- Importantly, CMR also identifies phenotypic features of HCM which suggest high-risk of sudden cardiac death such as extensive delayed myocardial enhancement or extreme hypertrophy.
- In the future, we envision deployment of NLP algorithms to create a dynamic interface to support real-time extraction of HCM diagnosis and phenotypic characteristics from CMR reports which will drive clinical decision support systems to assist providers by displaying relevant information for evaluation and risk stratification of HCM patients which may automatically input to prognostic models at the point-of-care.

Conclusions

The algorithms developed can be translated to clinical decision support systems to increase efficiency and contribute to improved quality of care.