



# Machine learning in heart failure – diagnosis and treatment

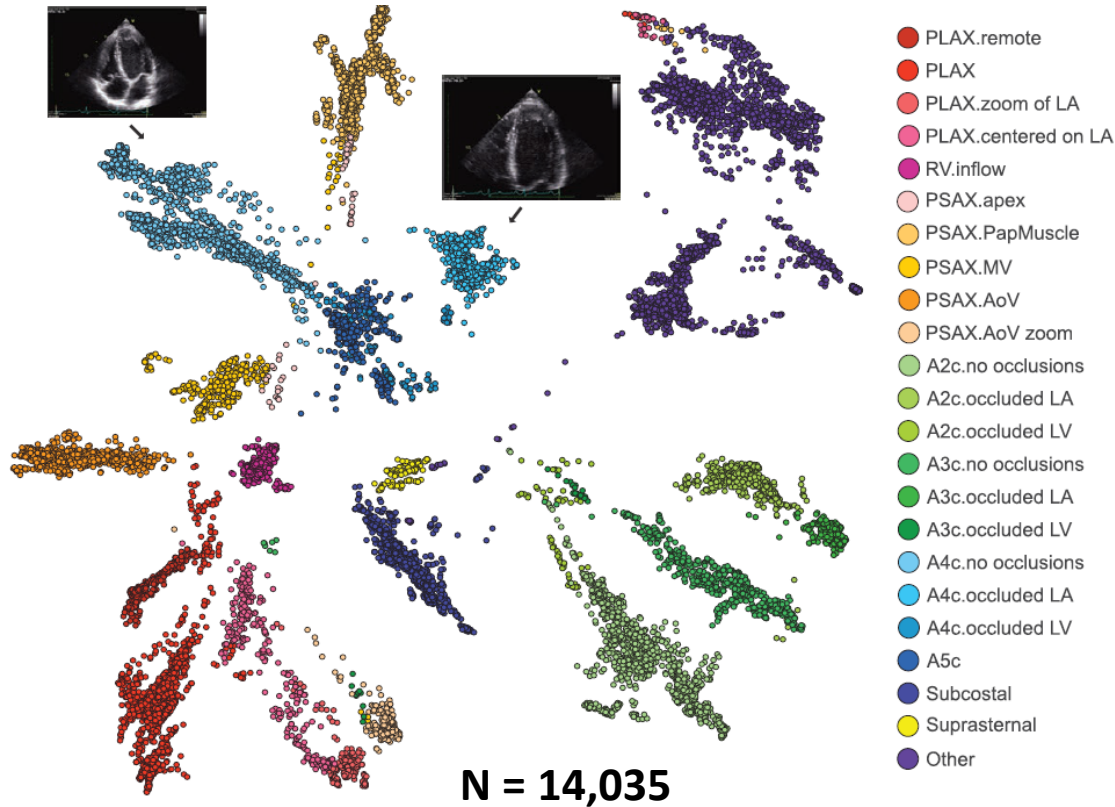
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# Using Machine Learning to Create a Self-Driving Echocardiographic Laboratory



View	Number of Images Used for Training	Segmented Area	IoU Accuracy
A2c	214	Left atrium blood pool	88.2
		Left ventricle blood pool	89.1
		Left ventricle myocardium	72.2
A3c	141	Left atrium blood pool	88.3
		Left ventricle blood pool	88.3
		Left ventricle myocardium	72.7
A4c	182	Left atrium blood pool	89.8
		Left ventricle blood pool	88.9
		Left ventricle myocardium	73.7
		Right atrium blood pool	88.1
		Right ventricle blood pool	83.3
PLAX	130	Left atrium blood pool	86.1
		Left ventricle blood pool	87.9
		Right ventricle blood pool	85.2
		Aortic root	86.4
		Anterior septum	76.8
		Posterior wall	74.9
PSAX	124	Left ventricle blood pool	79.6
		Left ventricle myocardium	74.0
		Right ventricle blood pool	64.6

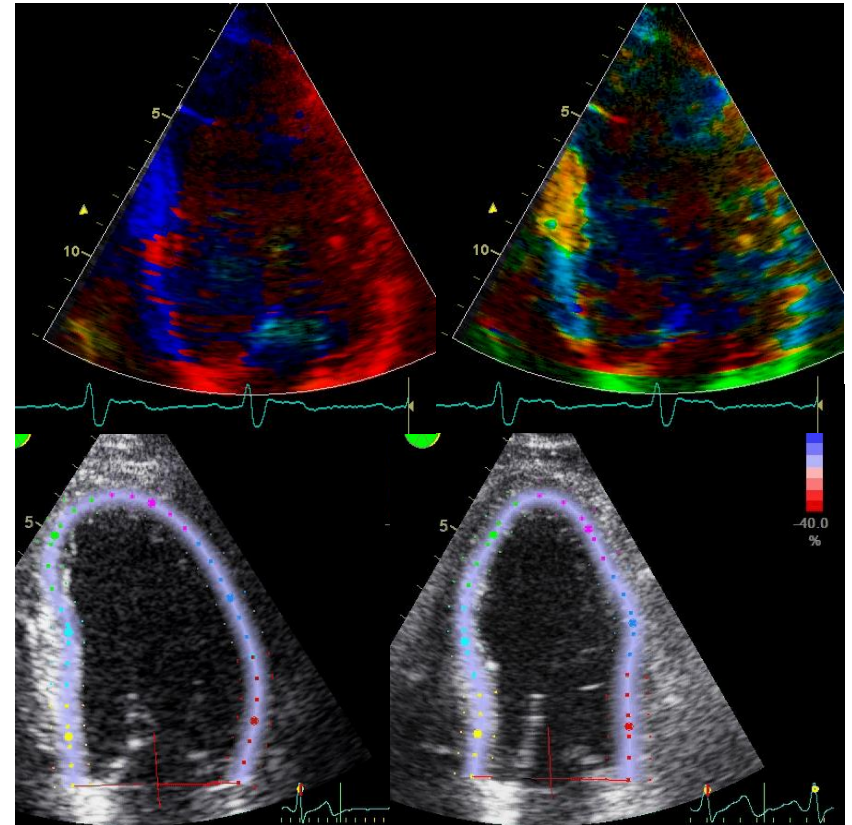
Zhang J et al, *Circ.* 2018; 138: 1623-35

D'hooge J & Fraser AG, *Circ.* 2018; 138: 1636-8

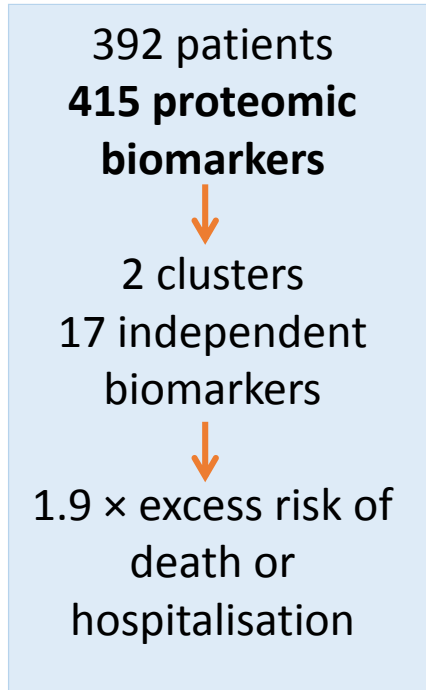
**Heart failure should be diagnosed by stress testing**



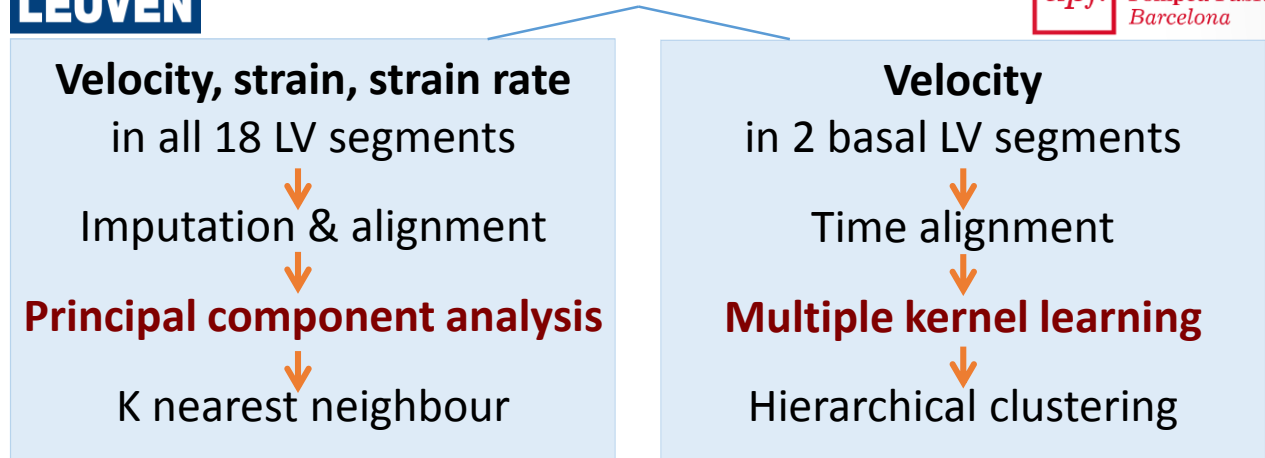
**Heart failure should be diagnosed objectively**



## k-means cluster analysis



## Quantitative stress echocardiography for LV longitudinal function, N = 156

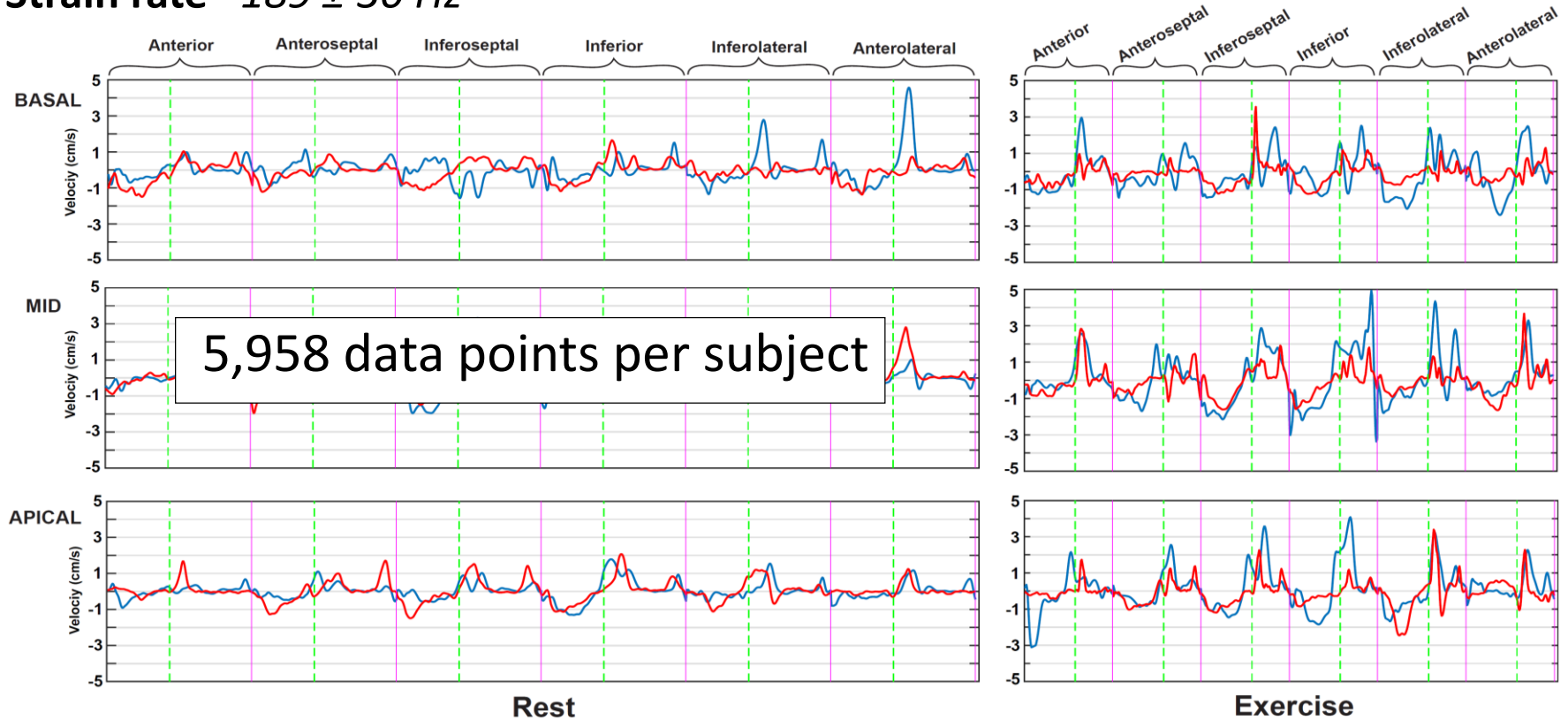


## Interpretation, visualisation of learned patterns

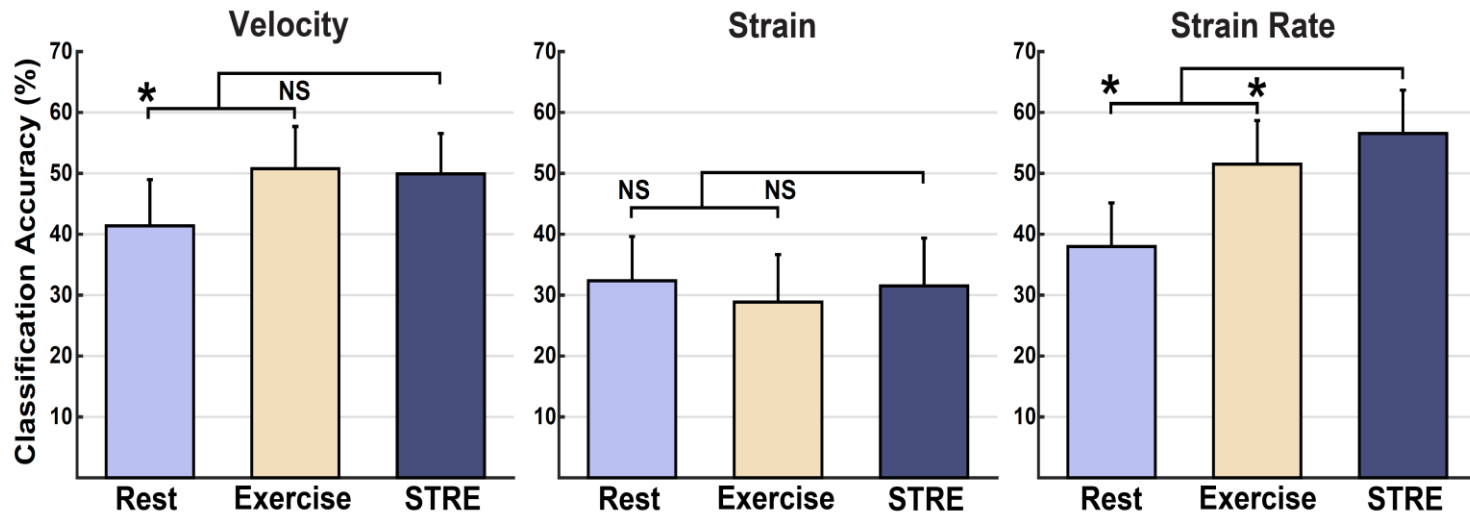
*Sanchez-Martinez S et al, Med Image Anal. 2017; 35: 70-82*  
*Sanchez-Martinez S et al, Circ Cardiovasc Imaging. 2018; 11: e007138*  
*Tabassian M et al, J Am Soc Echocardiogr. 2018; 31: 1272-84*

# Concatenated traces of segmental myocardial function – Normal subject vs. Patient with heart failure with normal EF

Strain rate  $189 \pm 30$  Hz

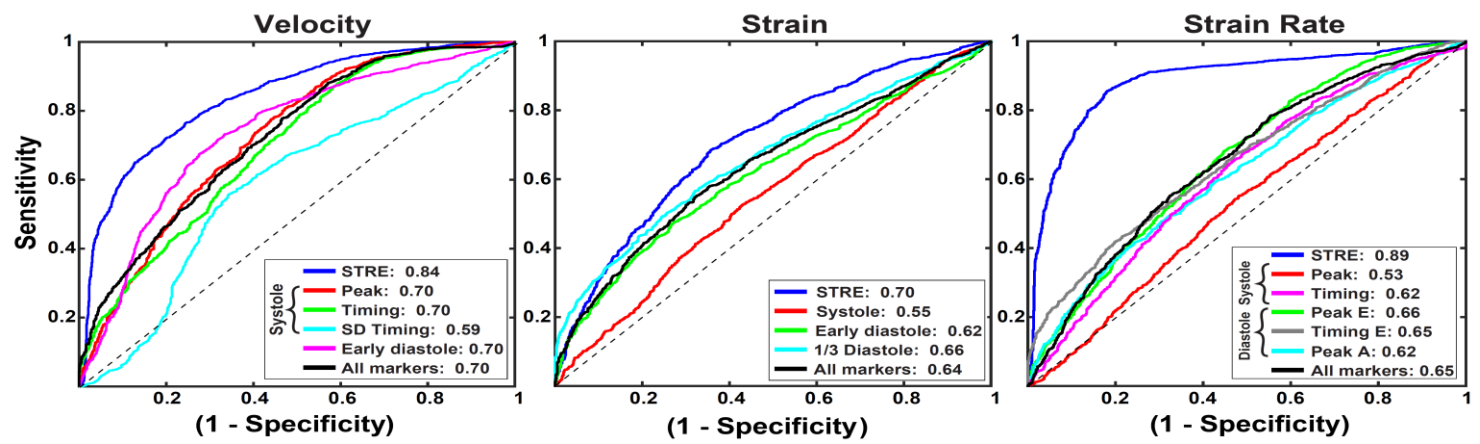


# Accuracy of PCA modeling and KNN classifier: which test is best?

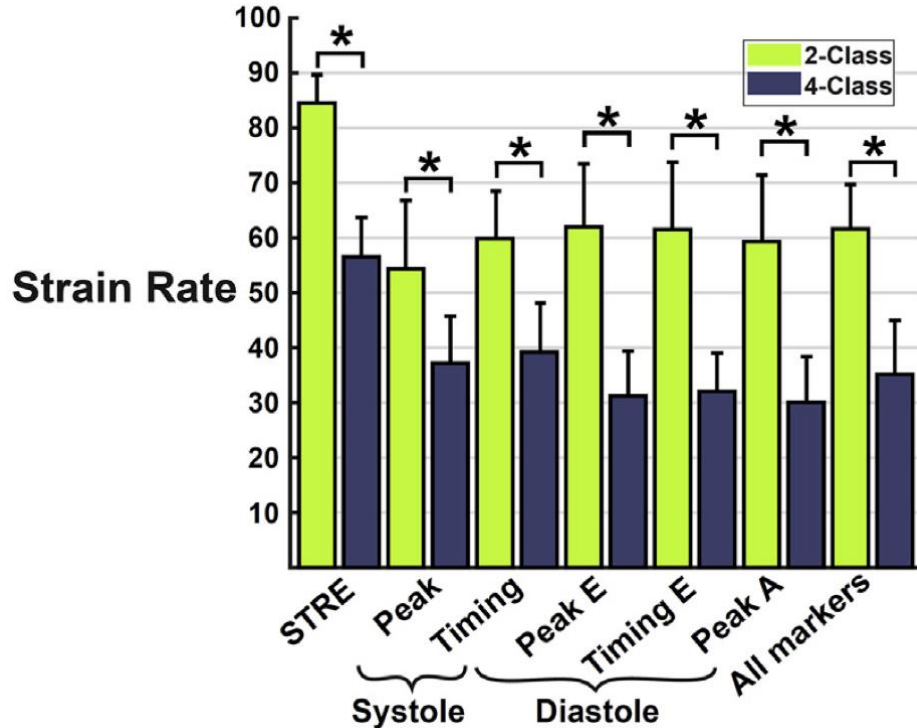


- Healthy
- Hypertensive
- Breathless
- HFPEF

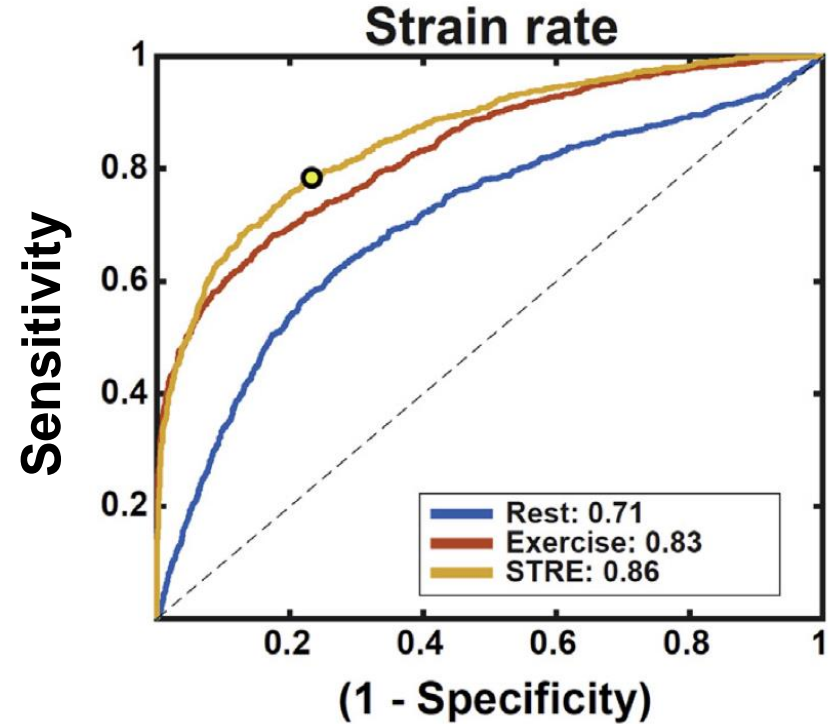
*Tabassian M et al,  
J Am Soc  
Echocardiogr.  
2018; 31: 1272-84*

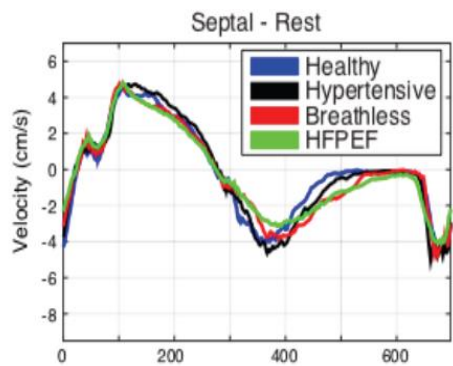


## Machine learning identifies breathless subjects



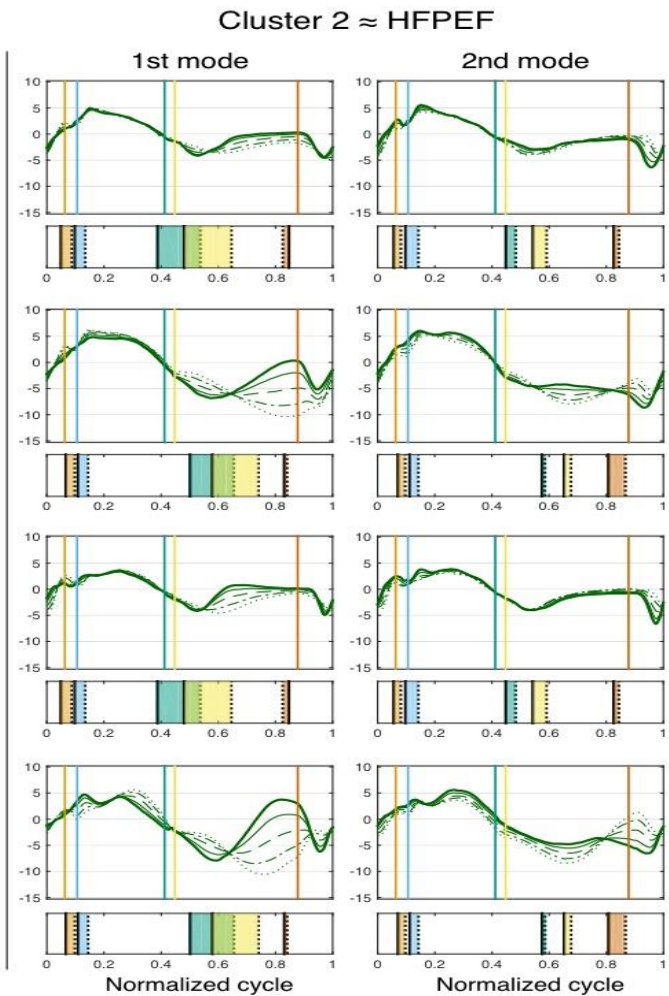
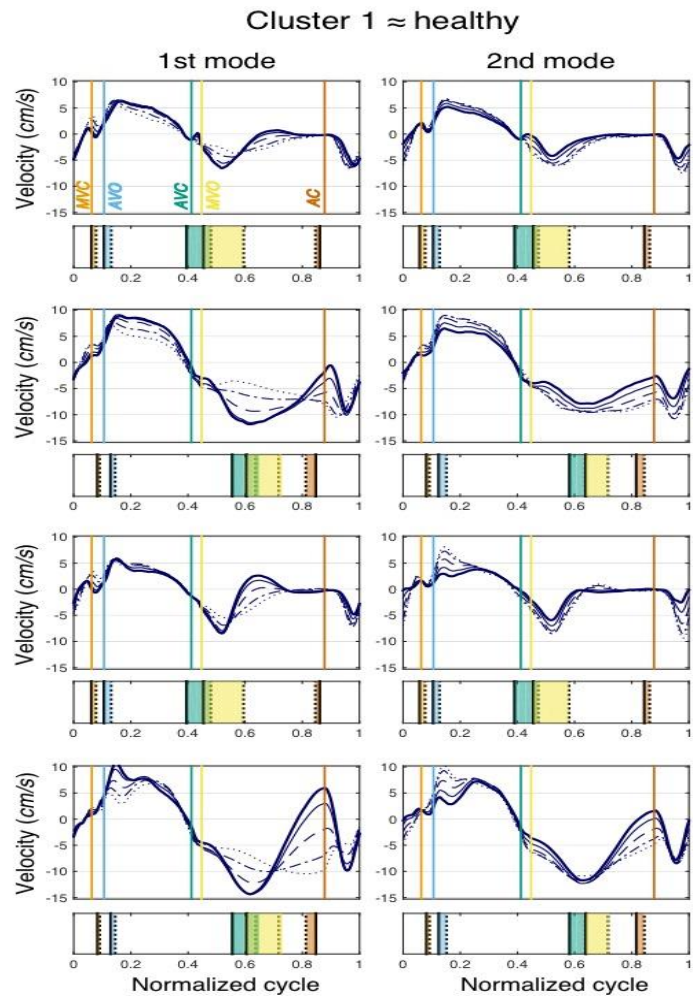
## Machine learning identifies poor 6 minute-walk distance





Septal at rest

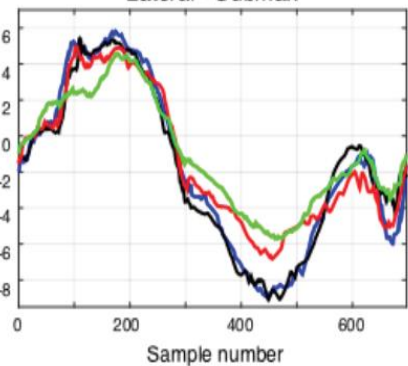
Septal at submax



Lateral at rest

Lateral at submax

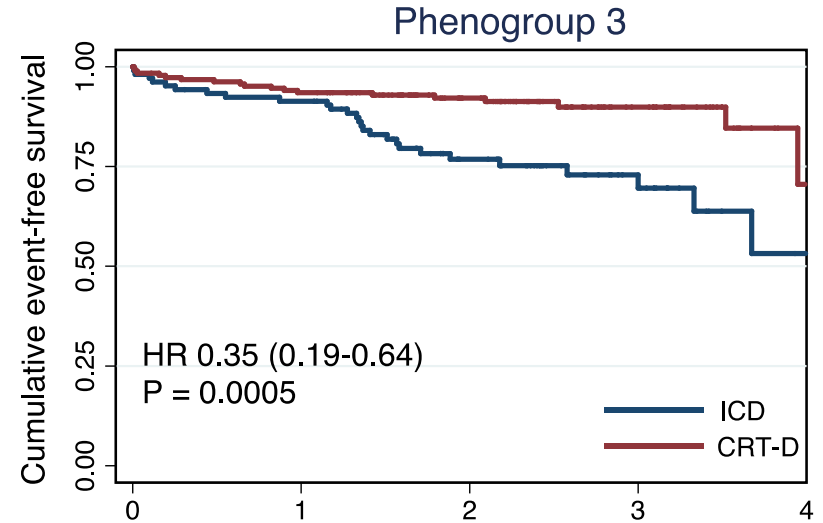
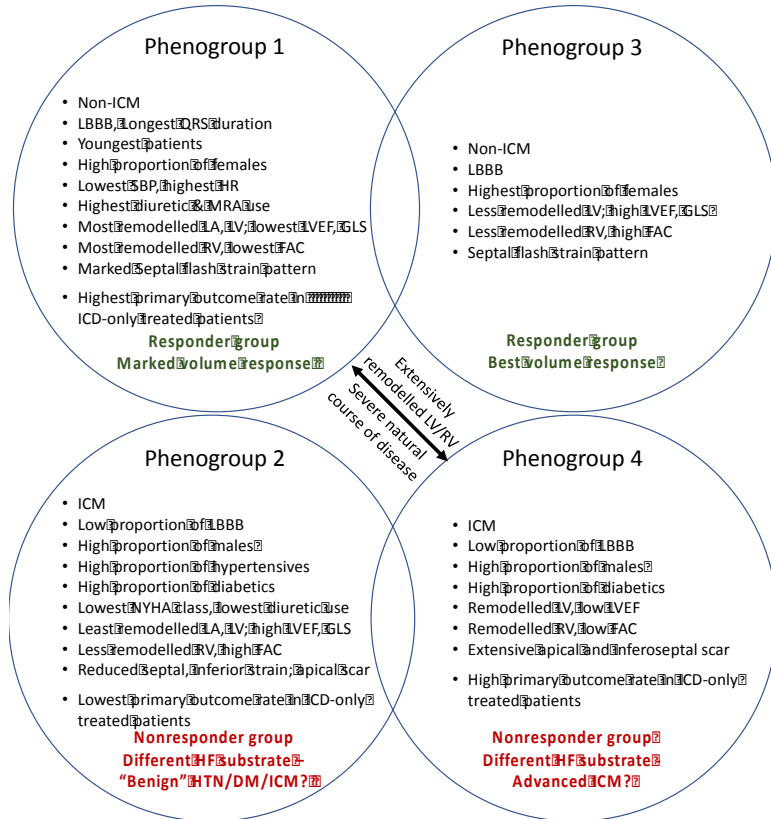
Lateral - Submax





# Machine learning to identify phenotypes of heart failure & response to treatment

1106 patients (LVEF  $\leq$  30%, QRS  $\geq$  130 ms, NYHA class  $\leq$  II) in MADIT-CRT



Number at risk

ICD	105	96	94	74	51	34	22	6	4
CRT-D	186	178	173	147	111	67	40	17	5

## **My clinical perspective on machine learning ..**

- Alternative to expert acquisition and interpretation
- An extension of analytical methods to cope with big data
- Dependent on quality of data and validity of training set
- Machine learning will not always be correct
- Outputs should be reproducible and interpretable
- Outputs should be clinically relevant / translatable
- Clinicians need to understand / collaborate / direct ..