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Diagnosis of left atrial and left ventricular hypertrophies using a deep neural network

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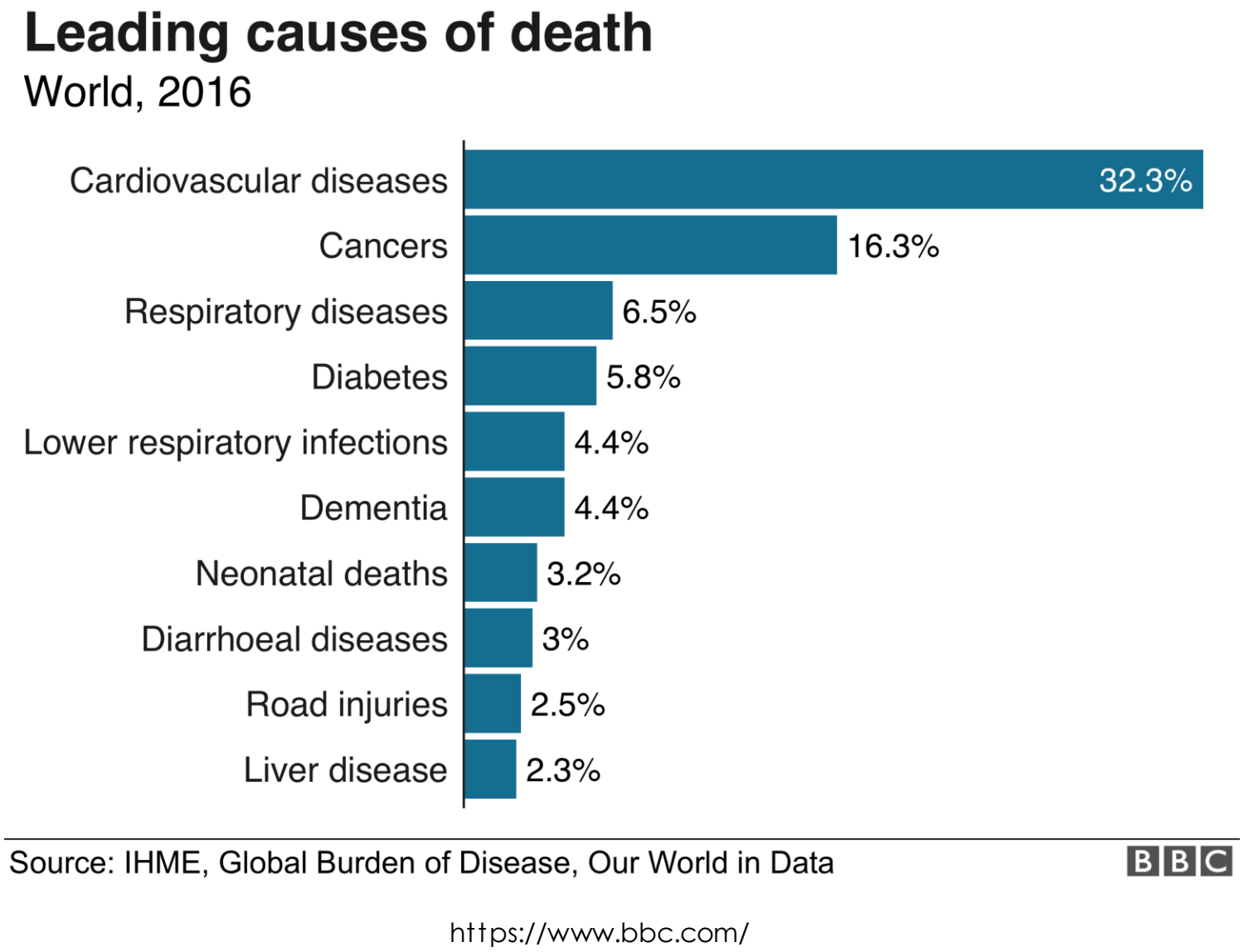
Introduction

- Cardiovascular diseases are the leading cause of death in the Russian Federation* and worldwide
- Correct interpretation of the electrocardiogram is of great clinical importance
- Existing methods of automatic diagnostics account for a significant number of errors

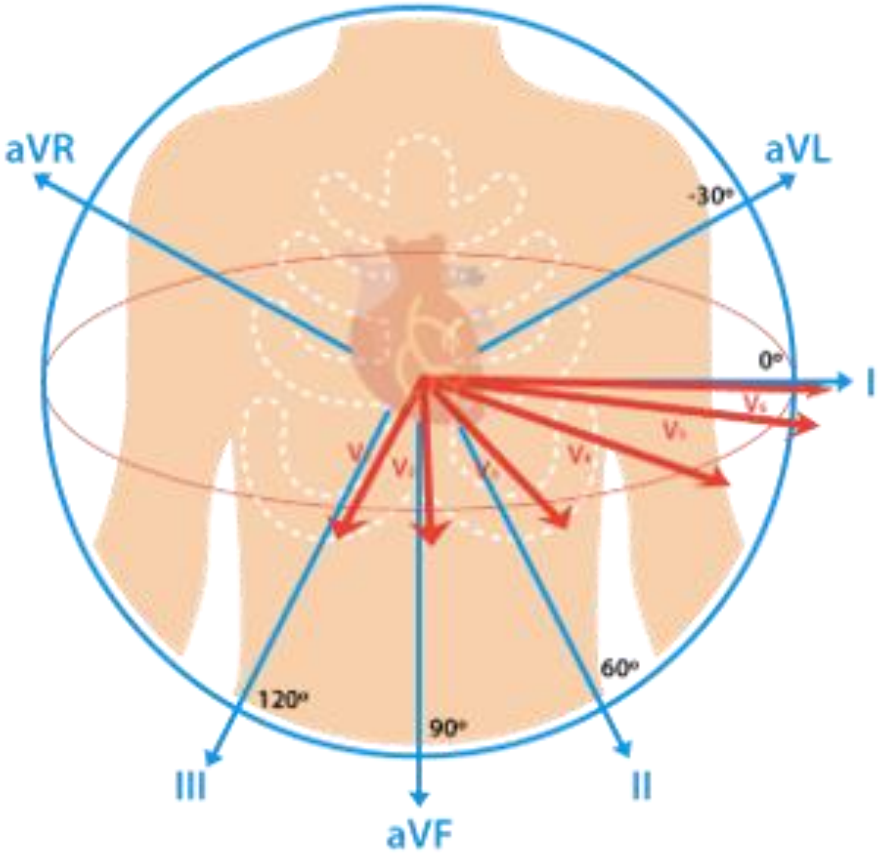
*According to russian ministru of health



https://www.bbc.com/

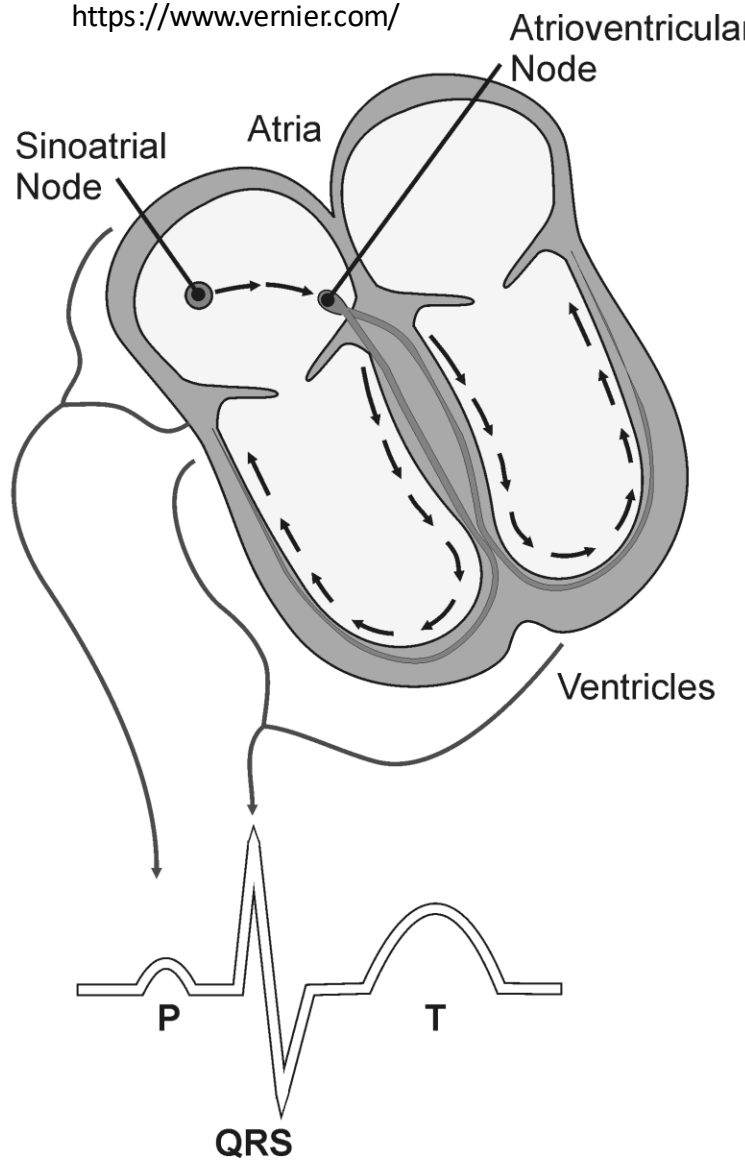
Introduction: Electrocardiography

https://www.cablesandsensors.com/



12-lead ECG allows viewing heart activity at different projections (angles)

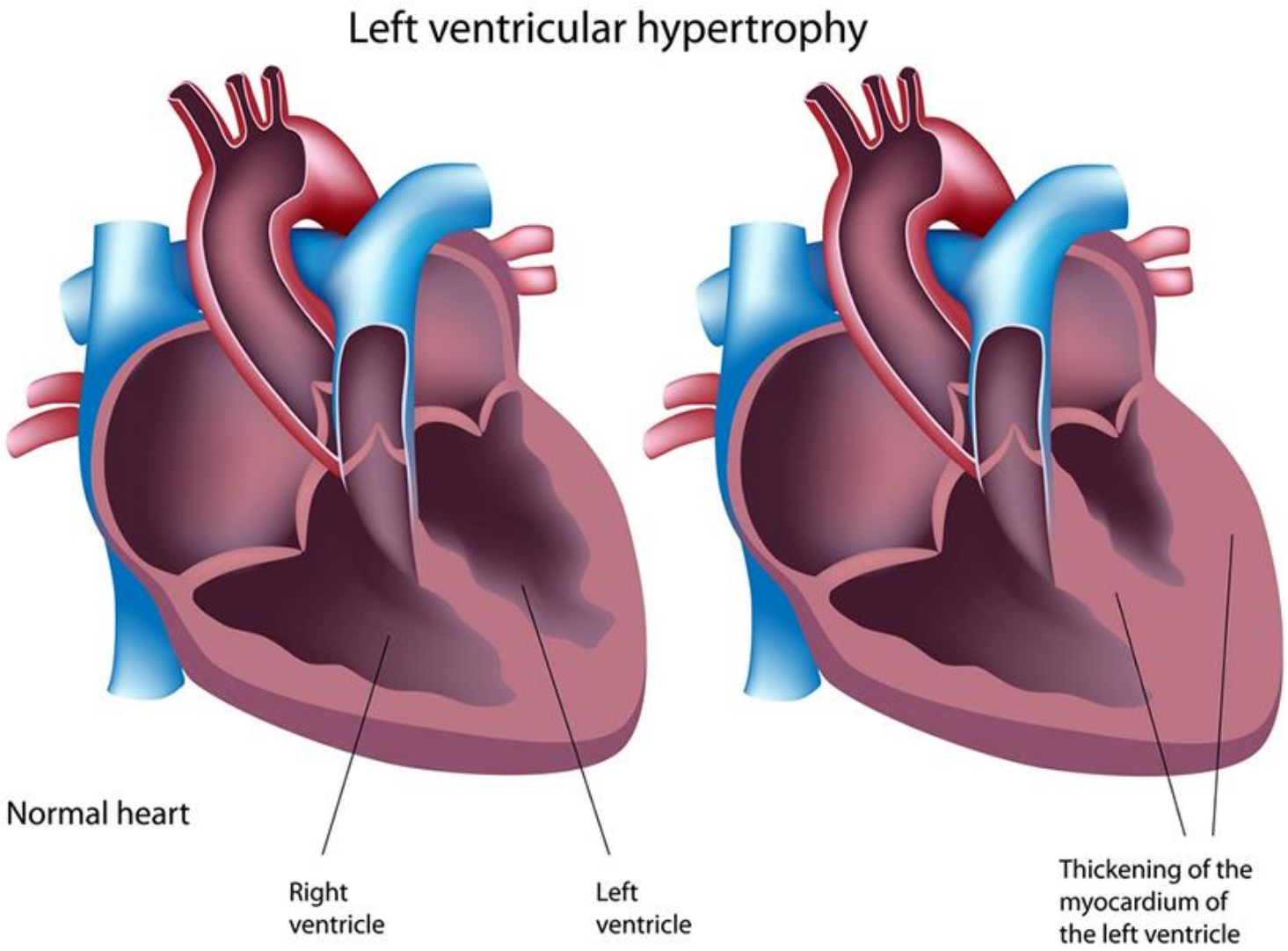
https://www.vernier.com/



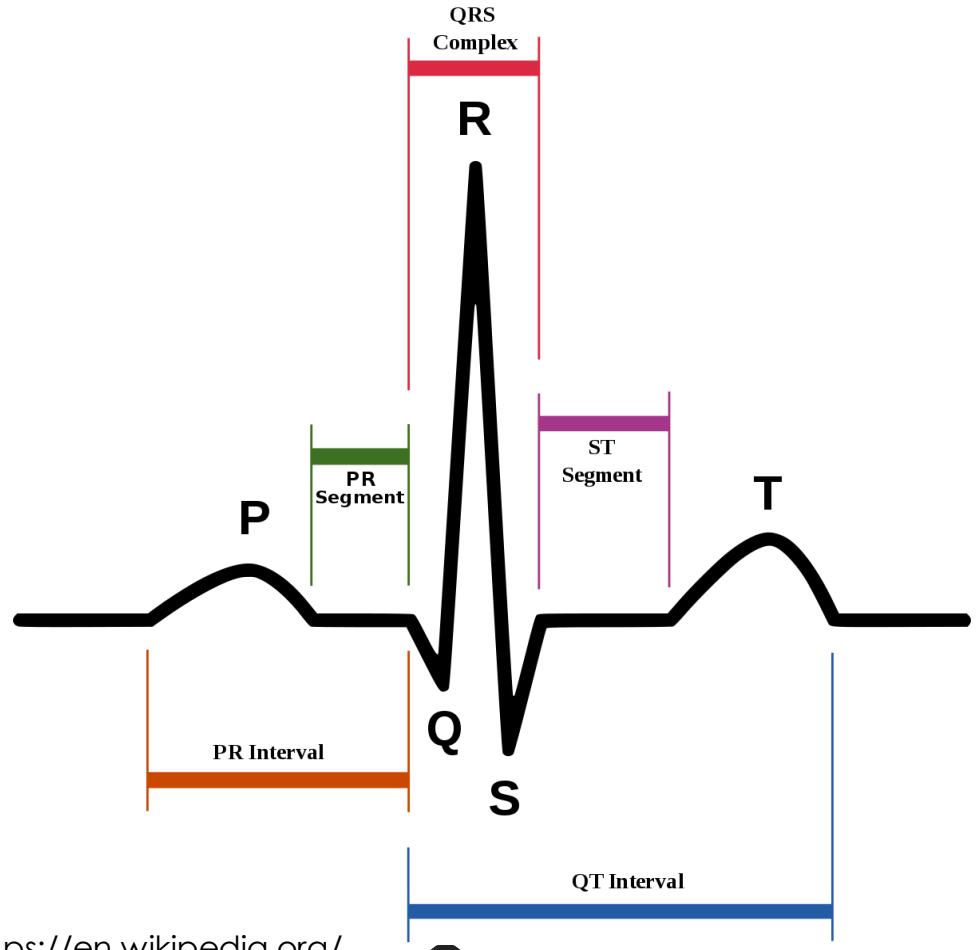
Resulting signal provides crucial information about pacemarker, conductivity etc.

LVH and LAH

- Left Ventricular Hypertrophy (LVH) is enlargement and thickening of the walls heart's main pumping c hamber (left ventricle)
- Left atrial hypertrophy (left atrial enlargement, LVH) refers to enlargement of the left atrium (LA) of the heart.



https://www.vikramhospital.com/



https://en.wikipedia.org/

Cornell product criteria (for LVH)

- $(R_{aVL} + S_{V3})$ • QRS duration > 2440 mVms

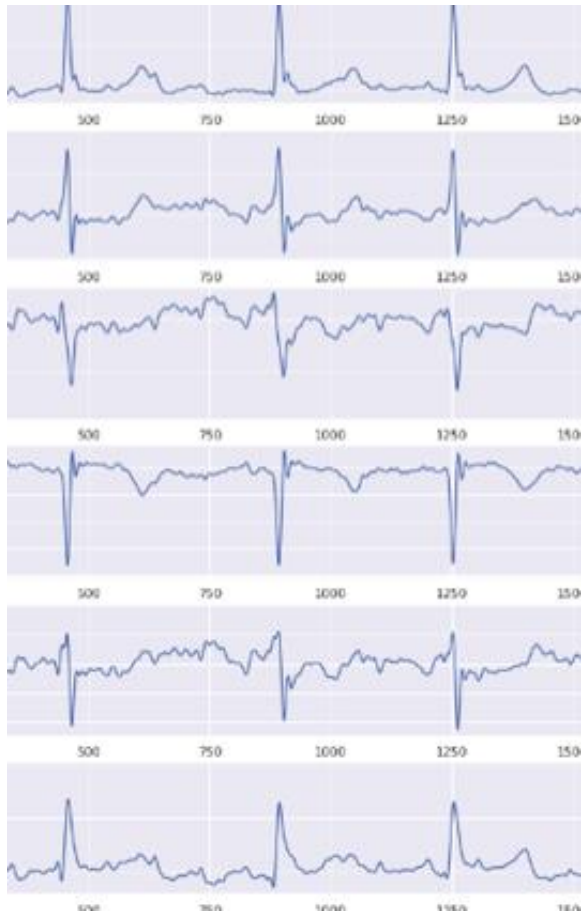
Presumably the best index. Sensitivity 51%, specificity 95%.

Cardiological criterea

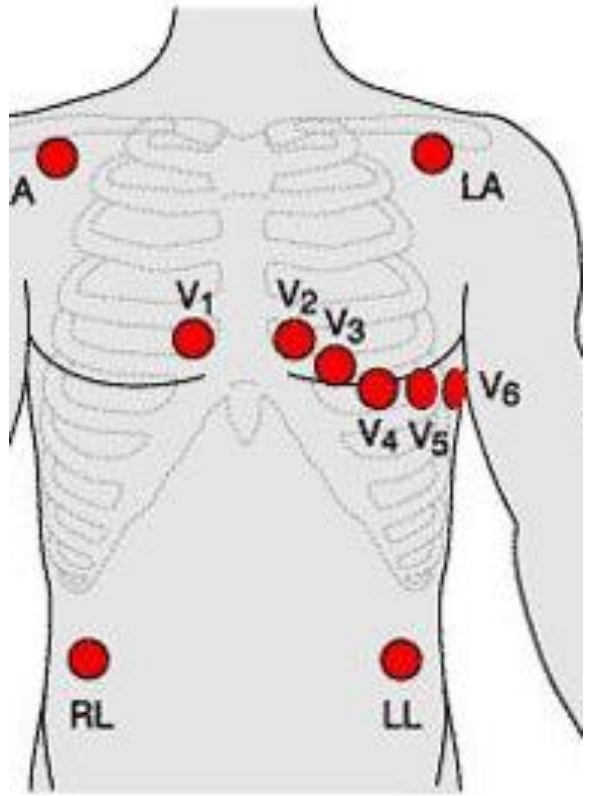
- LVH determination criteria are primarly based on analysis of R and S waves
- LAH determination relies on P wave analysis
- Most of the criterea have high diagnostic specificity, but low sensitivity

Data utilized

- 12 leads for each sample
- 4 seconds, 500 Hz
- 64,000 records in total
- Free-form text markup
- The markup contains errors



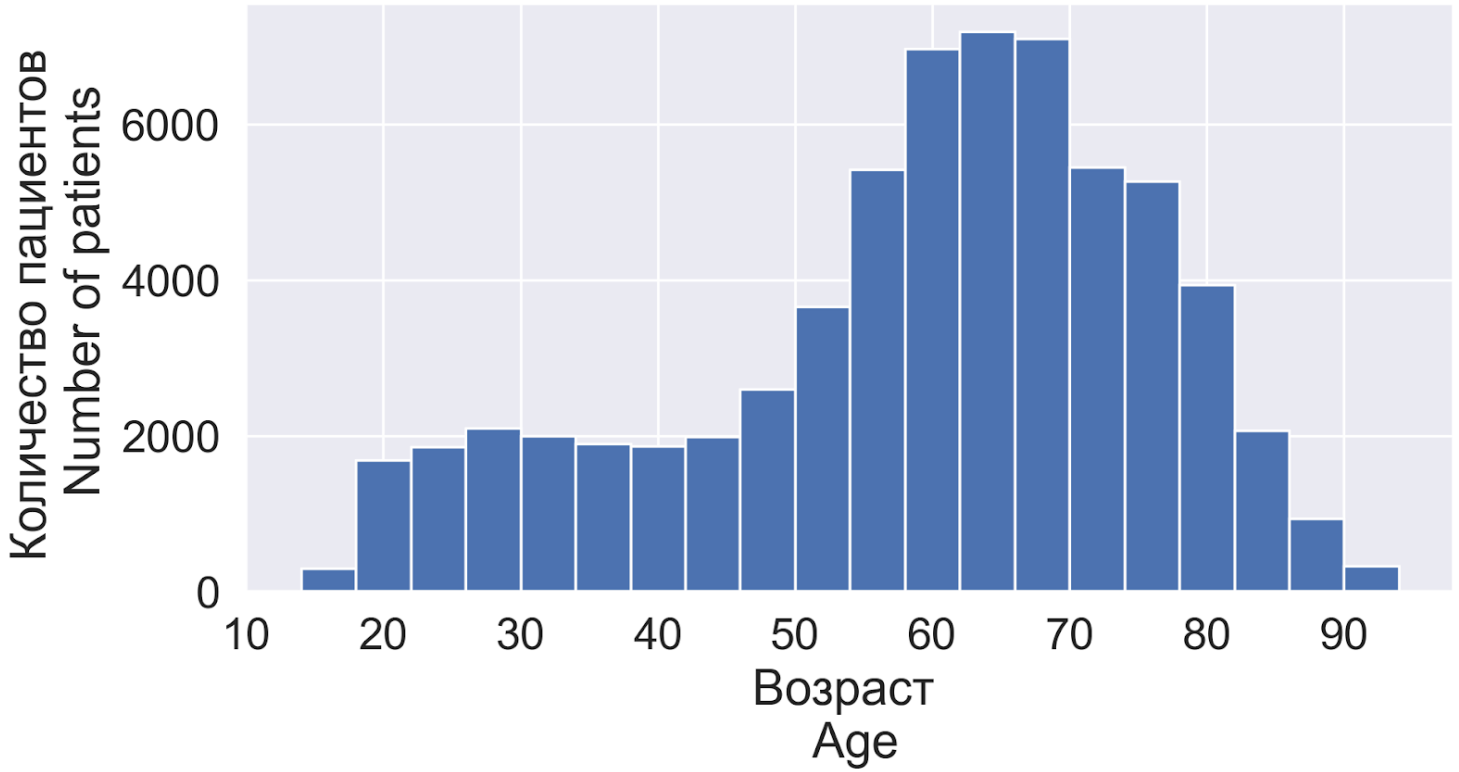
https://www.pinterest.co.uk/



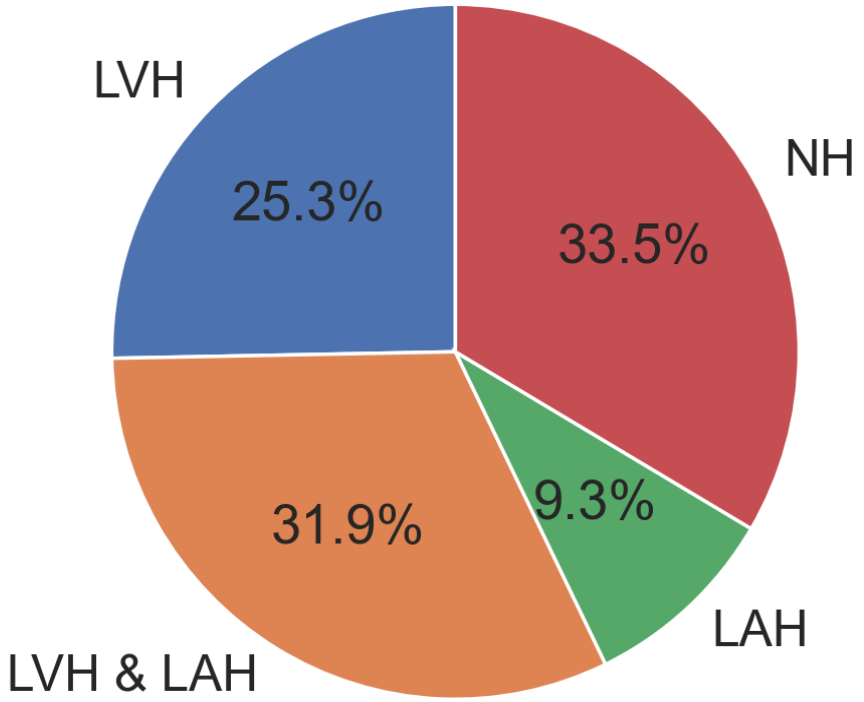
Sample signal

Electrode placement

Data distribution

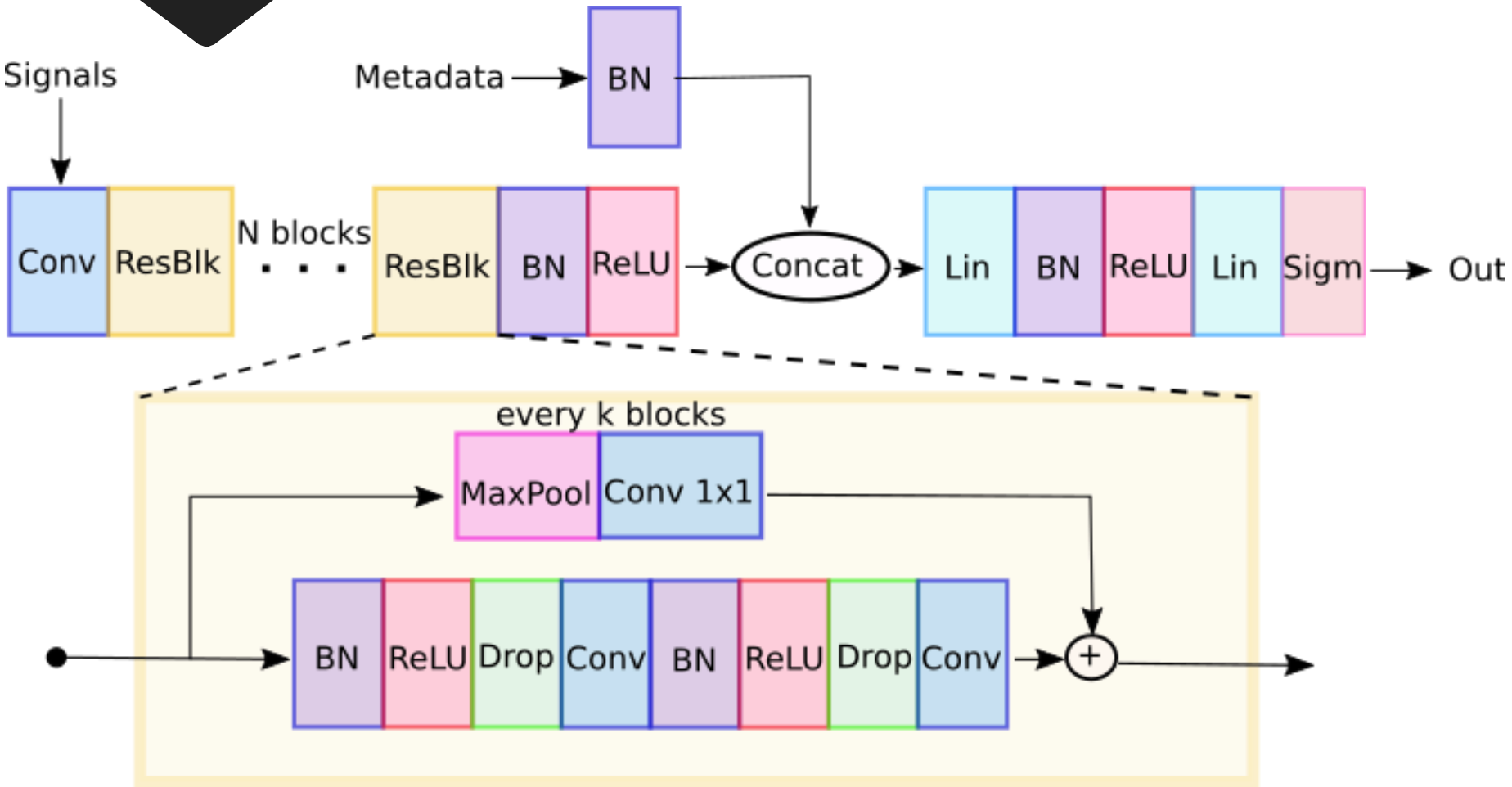


Distribution of patients by age.



LVH & LAH – LAH and LVH at the same time
NH – LAH and LVH are absent

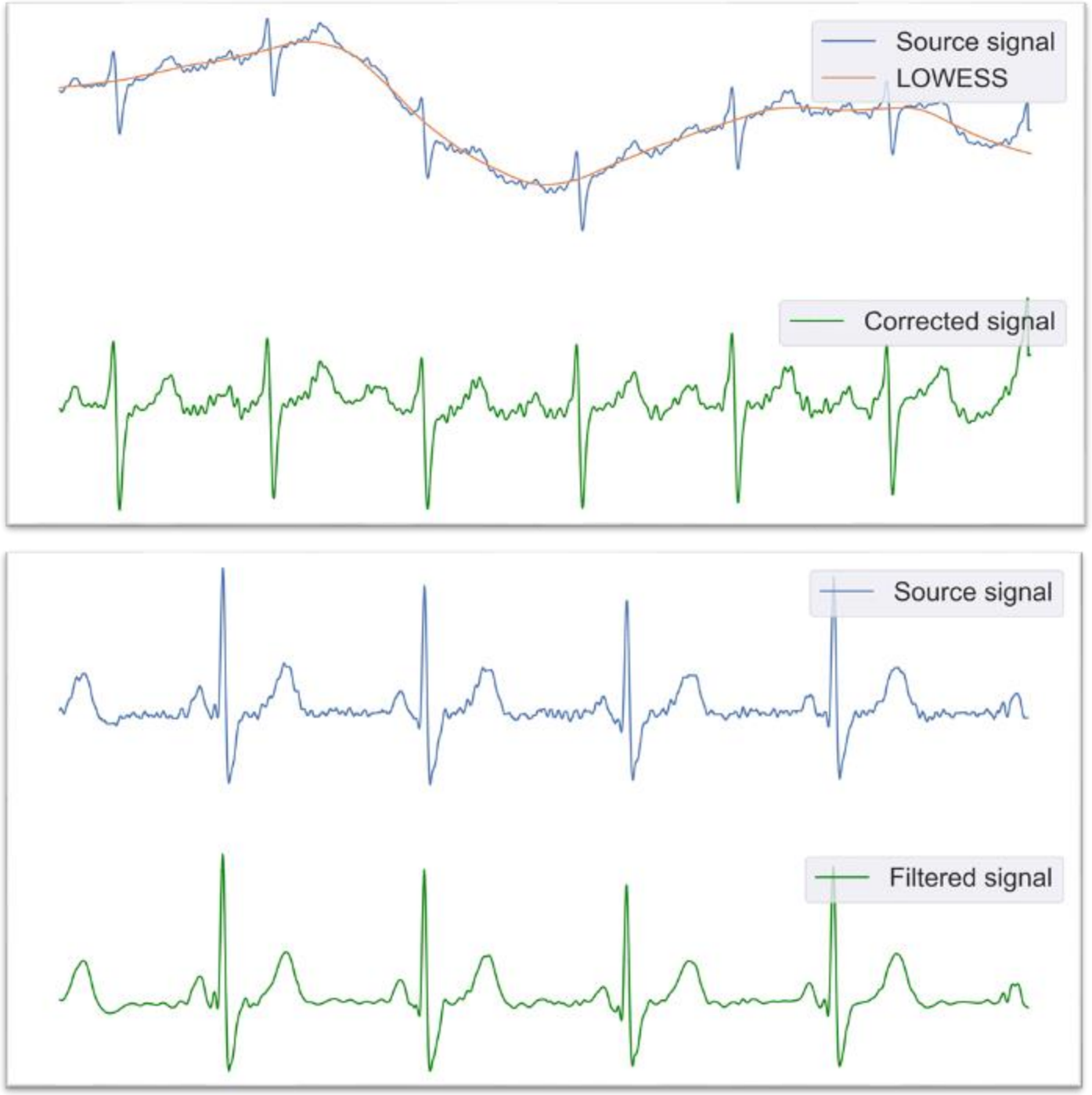
Convolutional neural network for ECG classification



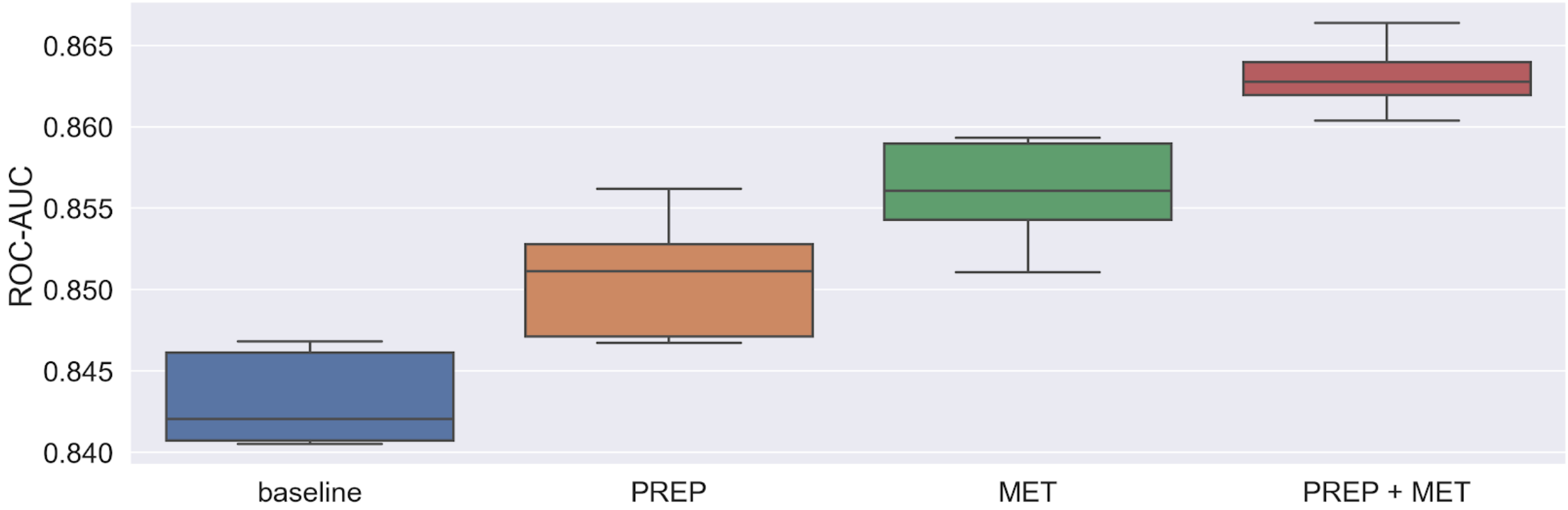
Model architecture

Signal preprocessing

- LOWESS based baseline correction
- High frequency noise filtering based on DWT decomposition



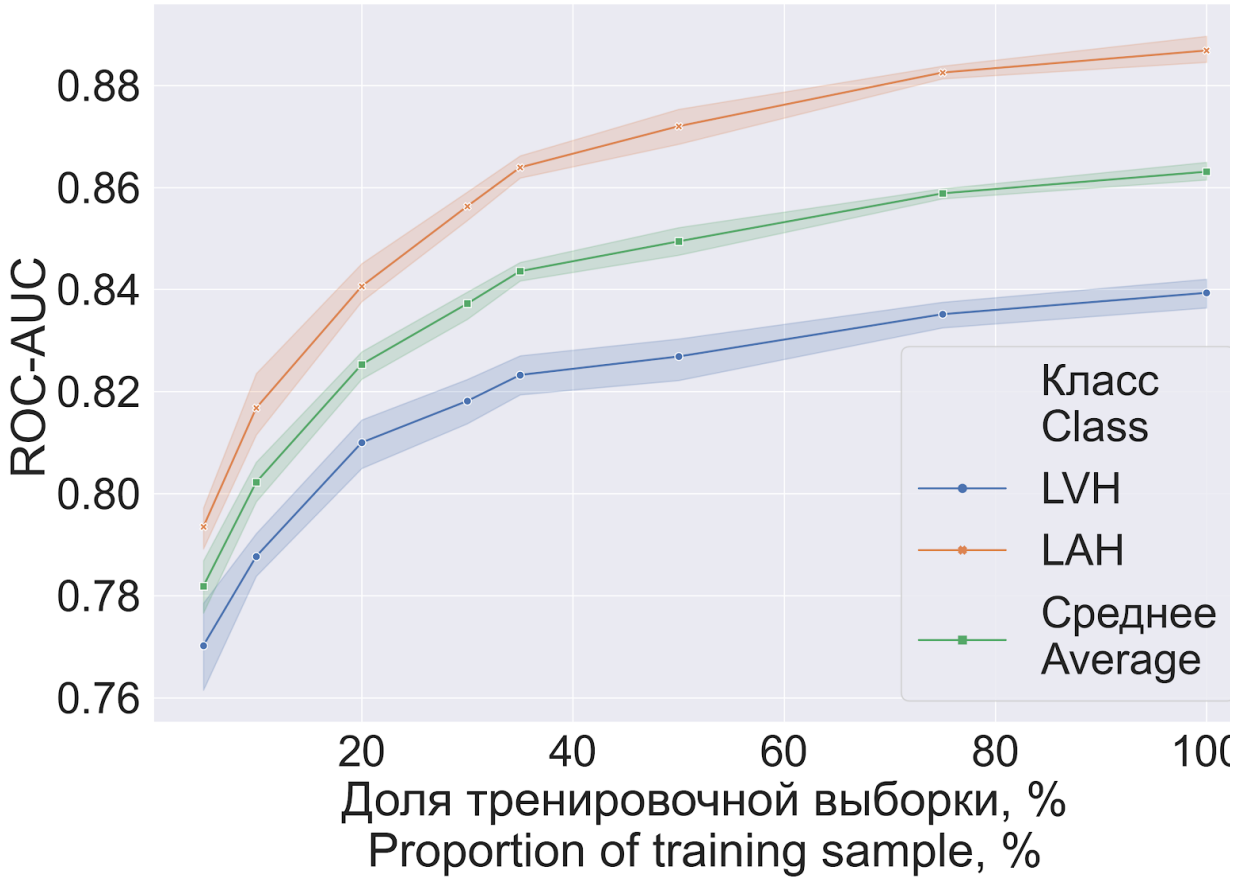
Class-average area under the ROC curve, depending on the methodology (5-fold cross-validation)

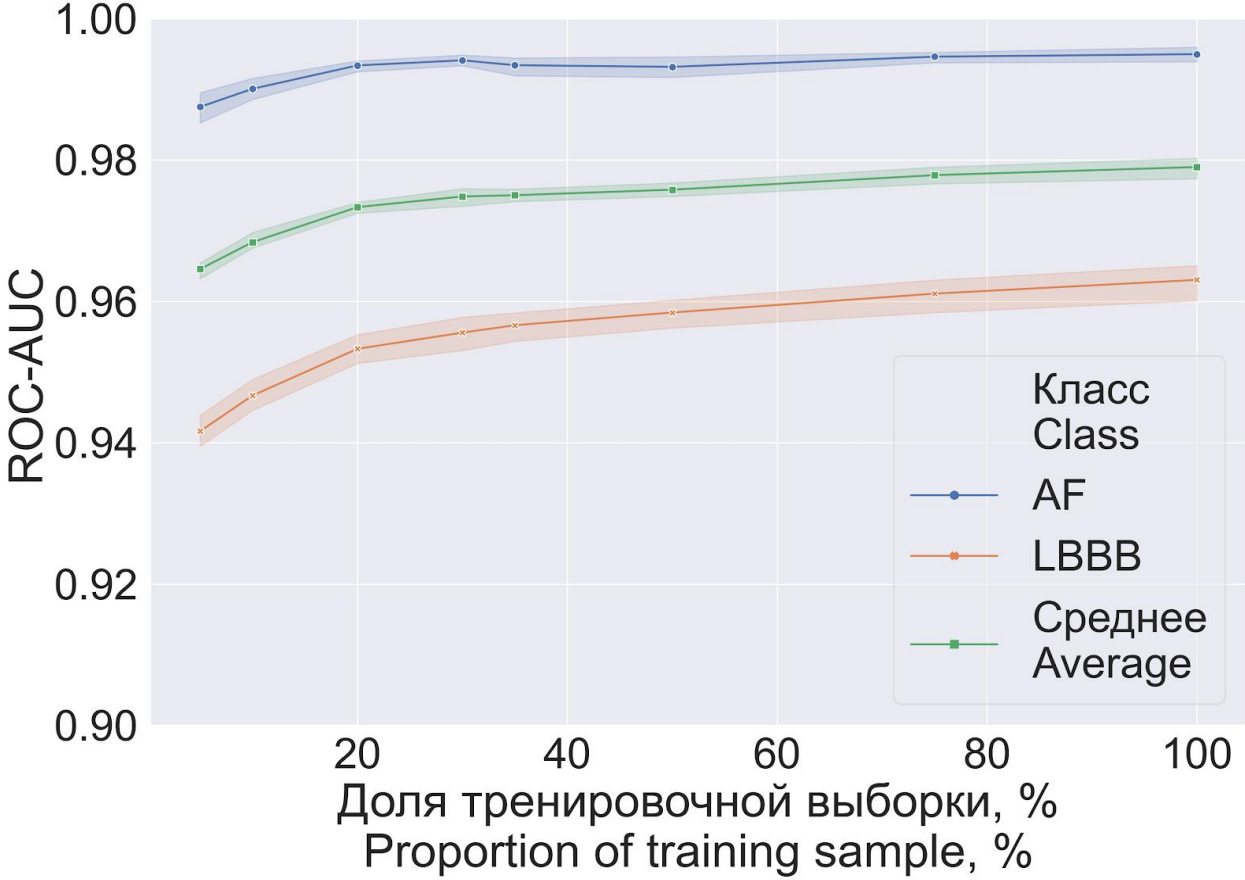


- baseline — baseline model
- PREP — added signal preprocessing
- MET — metadata inclusion

The applied techniques allowed to significantly improve classification performance of the neural network

Dependence of ROC AUC on the size of the training sample (Comparison with Atrial Fibrillation and Left Bundle Branch Block)



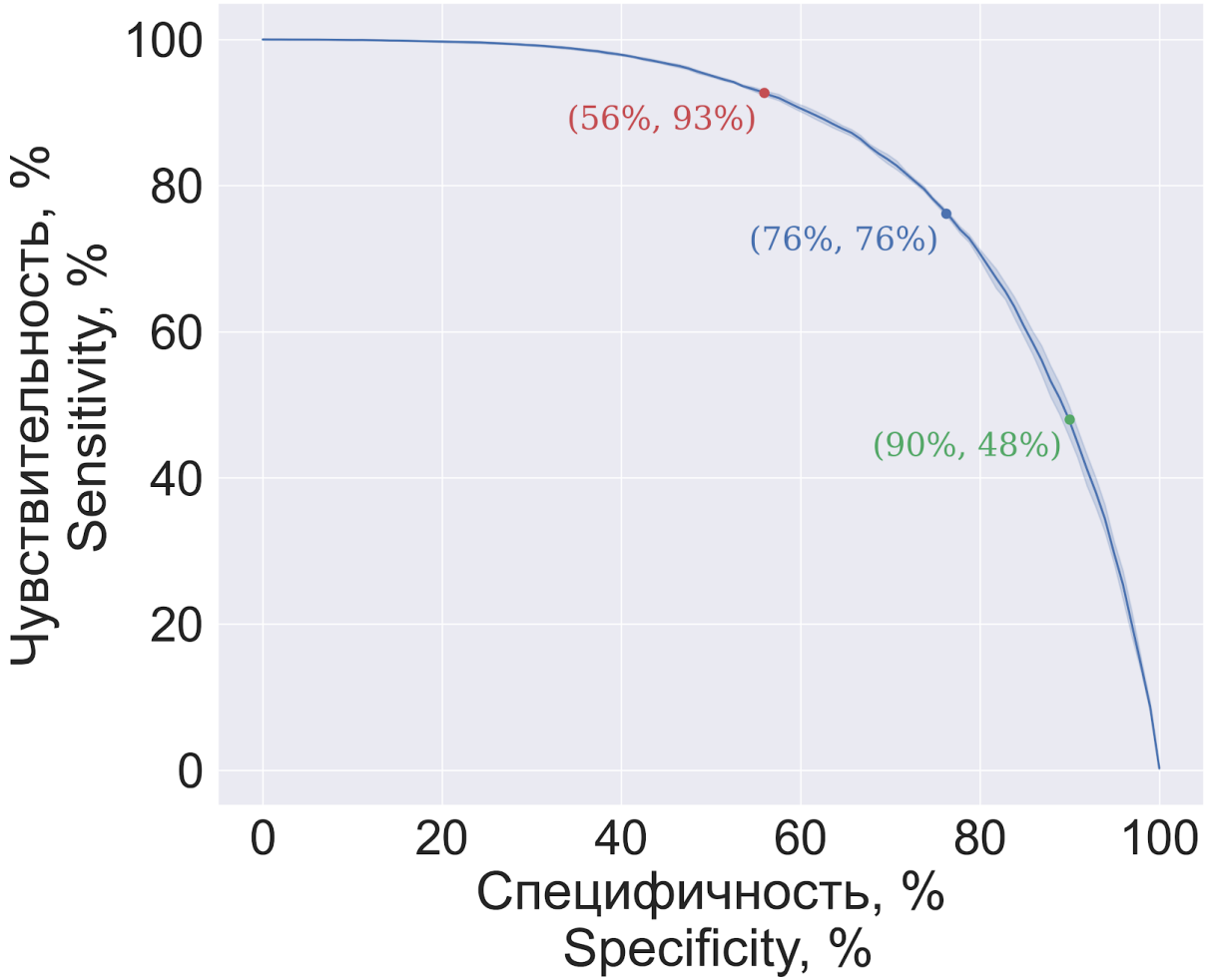


Classification performance (5-fold cross-validation)

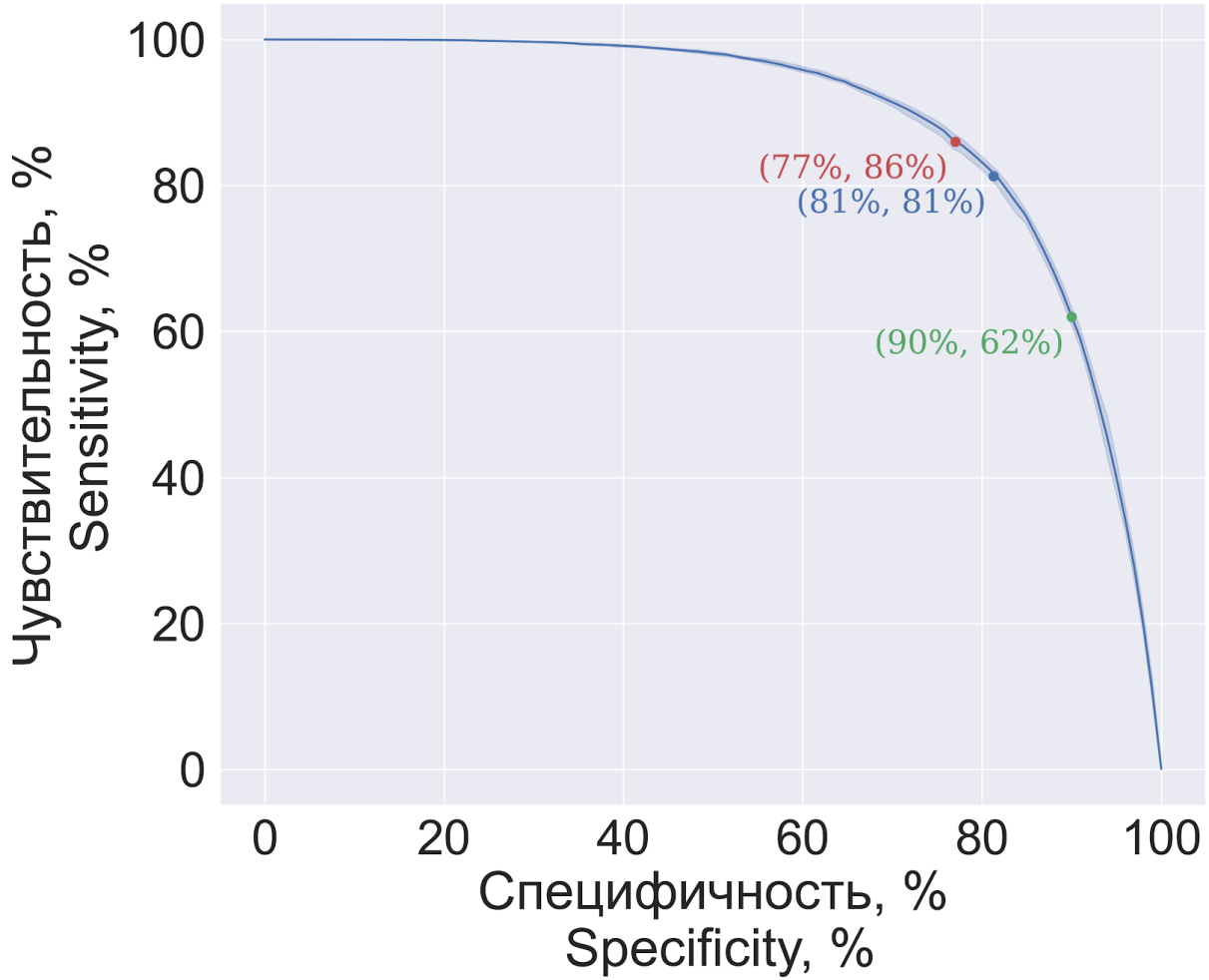
Class	ROC-AUC	Sensitivity	Specificity	F1-score
LVH	84.0 ± 0.6%	48.2 ± 1.6%	90.0 ± 3.0%	82.1 ± 0.6%
LAH	88.9 ± 0.7%	62.4 ± 0.2%	90.0 ± 1.2%	78.3 ± 1.1%

The results are comparable to the best criteria utilized in clinical practice (specificity is around 90% and sensitivity is around 30-60%)

Sensitivity-specificity curves and their characteristic points



Left Ventricular Hypertrophy



Left Atrial Hypertrophy

Thank for your attention!