GROUP 5

PROJECT

COMPBIOMED

GROUP 5

CLINICAL APPROACH: ARRHYTHMIAS

-Abnormal heart rhythm

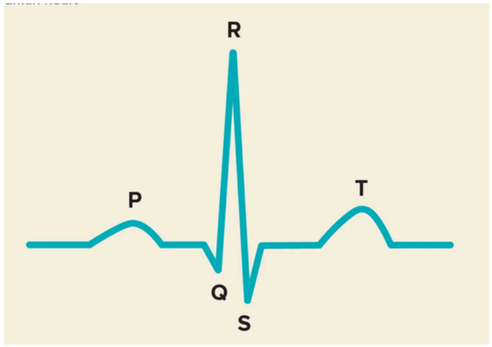


Image 1

Radiofrequency Ablation:
destroying or scarring tissue in the heart that is causing the abnormal electrical signals

Identifying the site of origin (SOO) of the OTVA

right ventricular outflow (RVOT) Septum

Commisures

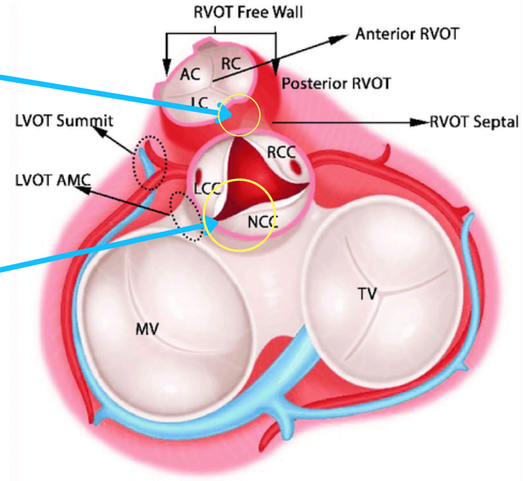


Image 4

RVOT septum: separates right ventricular outflow tract

Commissure: part of union of the leaflest

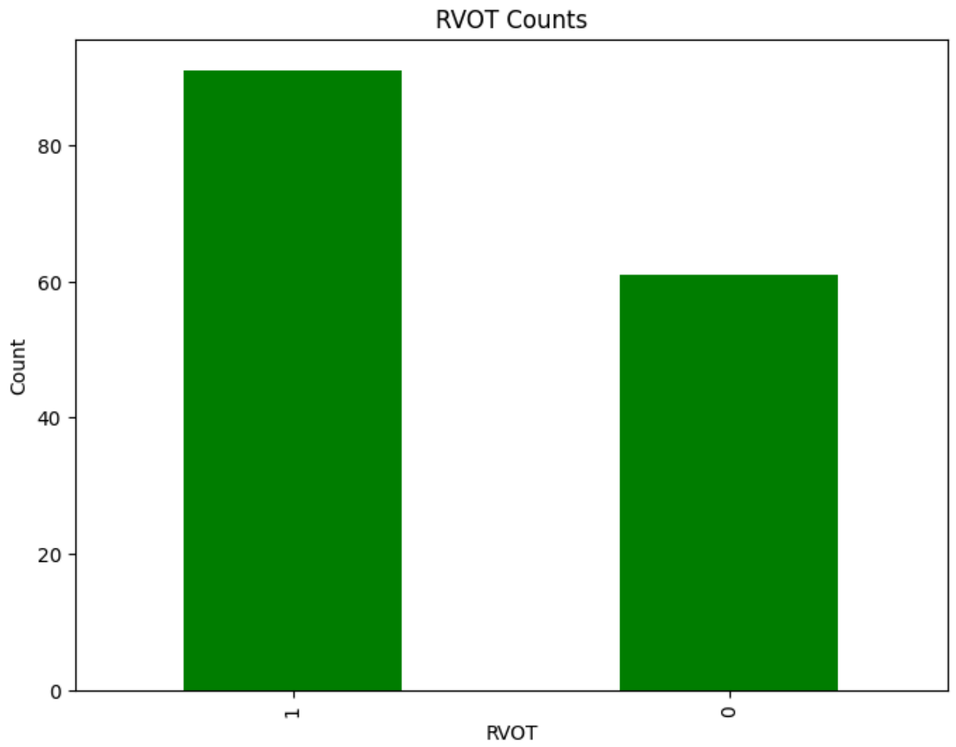
Image 1: Roland, J. (2022, May 31). Pulmonary embolism: ECG findings and what they mean. Healthline. https://www.healthline.com/health/pulmonary-embolism-ecg
Image 2,: Nicole, A. (2022, December 1). What it means if you have premature ventricular contractions (PVCs) on your EKG. GoodRx. https://www.goodrx.com/health-topic/heart/pvcs-on-ekg

INITIAL DATABASE

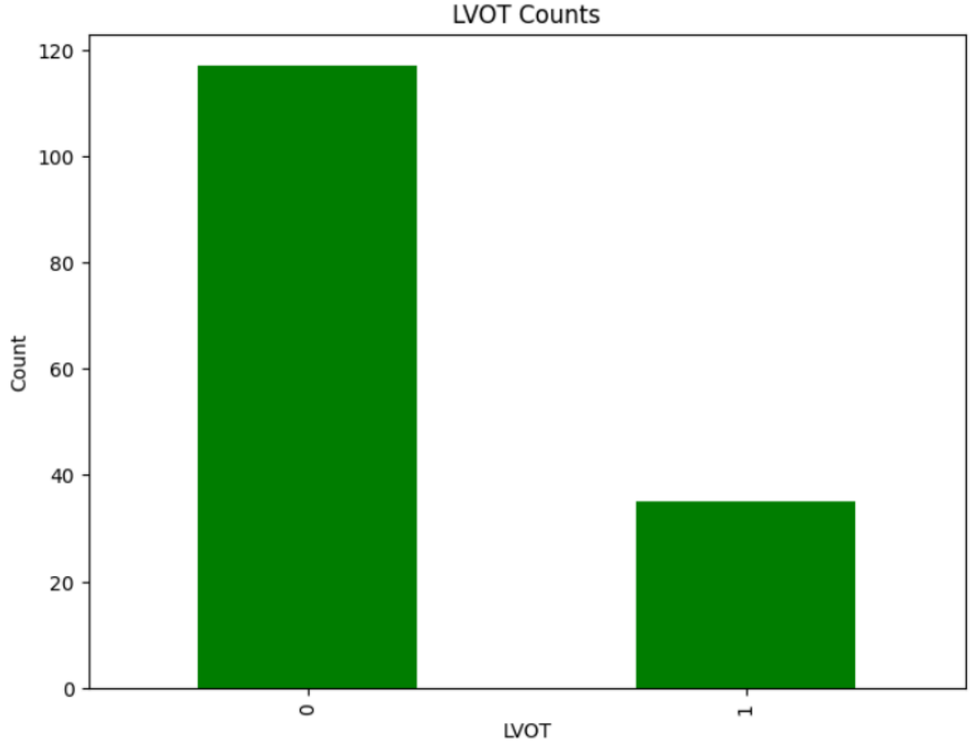
	Sex	HTA	Age	PVC_transition	SOO_chamber	Height	Weight	CLINICAL_SCORE	SOO	OTorigin	Structures	Simplified_SOO	classified_SOO
P186	Female	NaN	61.0	V1	Right ventricle	NaN	NaN	NaN	Unión mitroaórtica	0.0	{'2-LV': {'P36': {'I': [-0.075 -0.075 -0.072	LVOTSUBVALVULAR	LVOT
P245	Female	No	52.0	V3	RVOT	169.0	68.0	1.0	Pared libre anterior	1.0	{'2-RV': {'P157': {'I': [0. 0. 0. ...	RVOTFREEWALL	RVOT
P292	Female	No	69.0	V3	LVOT	156.0	70.0	1.0	RCC	1.0	{'2-AO': {'P55': {'I': [-0.063 -0.051 -0.03	RCC	NaN
P205	Female	No	66.0	V4	Right ventricle	176.0	63.0	1.0	M. papilar posteromedial	0.0	{'2-1-Rp-LV': {'P320': {'I': [-0.297 -0.288 -0...	RVOTFREEWALL	RVOT
P066	Female	Yes	46.0	V3	RVOT	160.0	79.0	1.0	RVOT septal	1.0	{'1-PA': {'P13': {'I': [-0.006 -0.003 -0.003	RVOTSEPTUM	RVOT

DATA OBSERVATION

```
RVOT
1    91
0    61
Name: count, dtype: int64
```

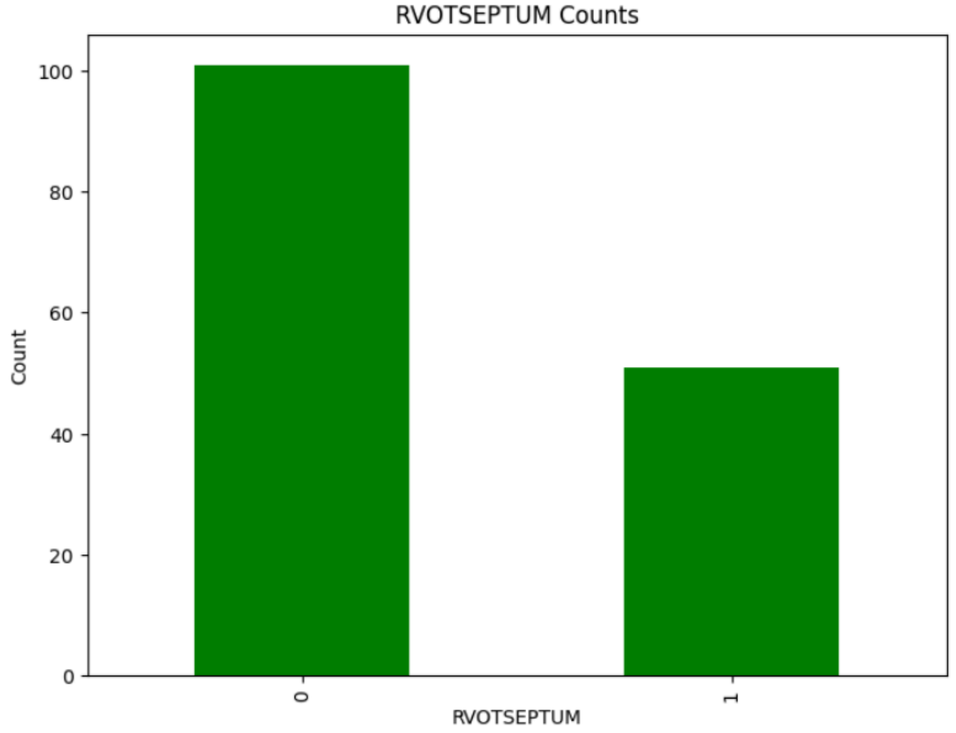



```
LVOT
0    117
1     35
Name: count, dtype: int64
```

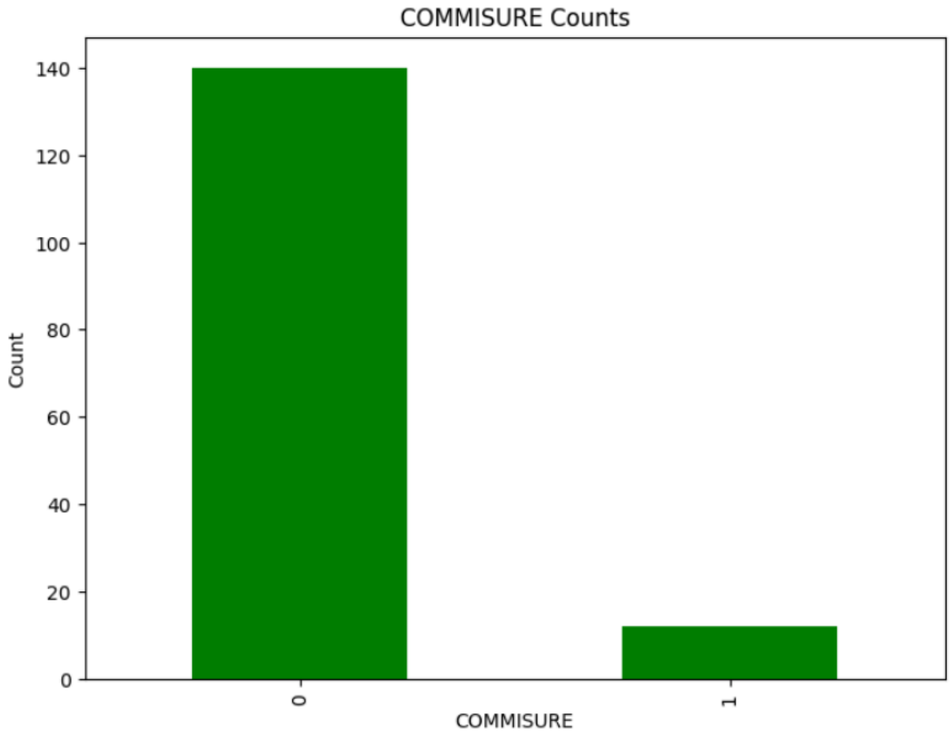


DATA OBSERVATION

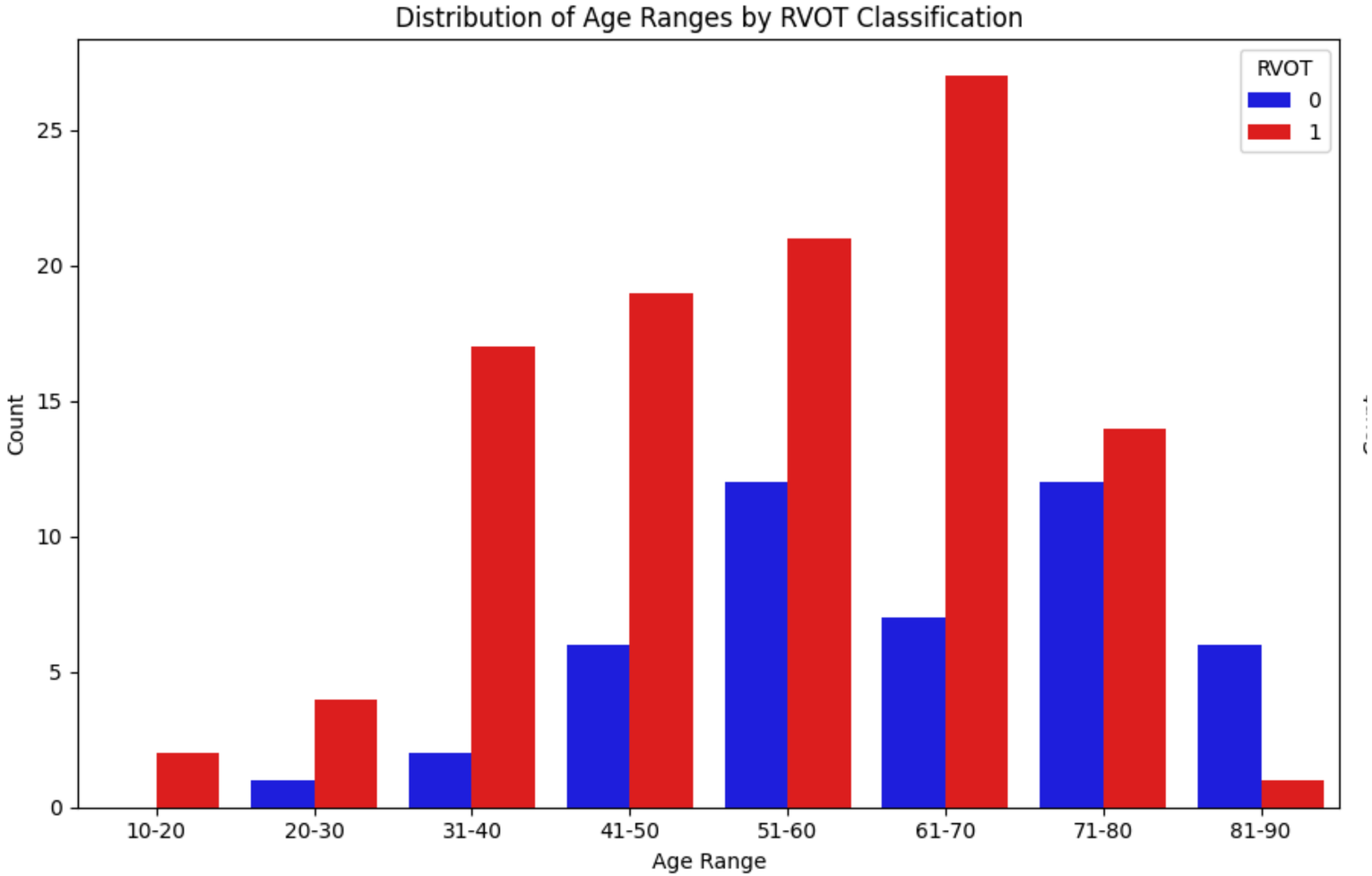
```
RVOTSEPTUM
0    101
1     51
Name: count, dtype: int64
```




```
COMMISURE
0    140
1     12
Name: count, dtype: int64
```



DATA OBSERVATION

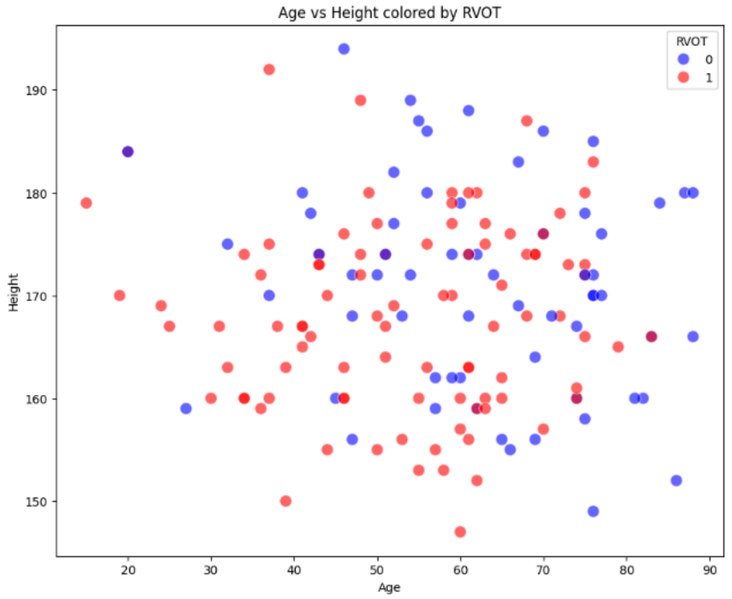


DATA OBSERVATION

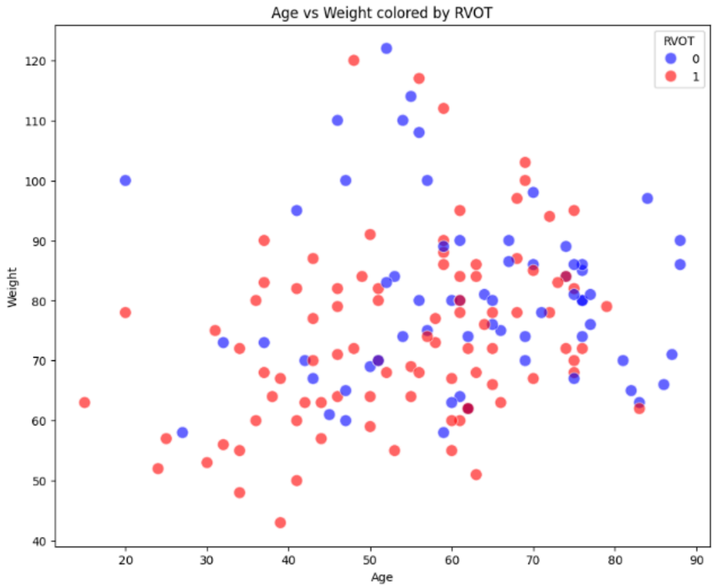
Red RVOT

Blue LVOT

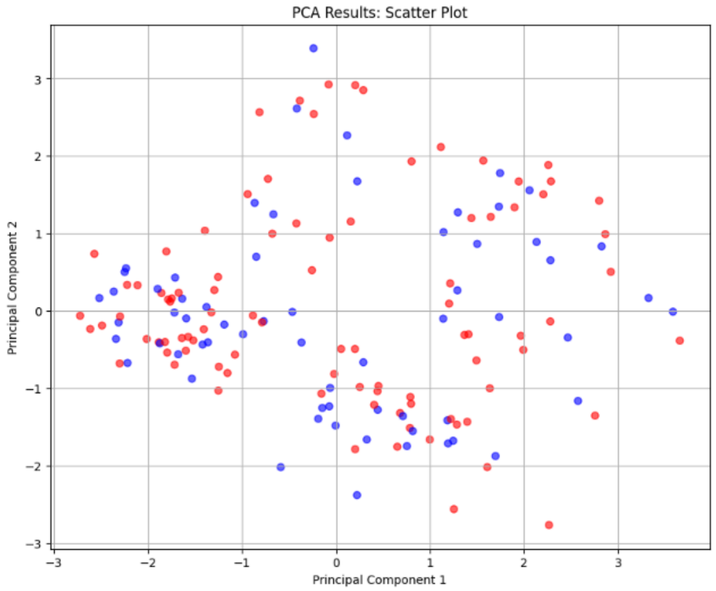
Age vs Height



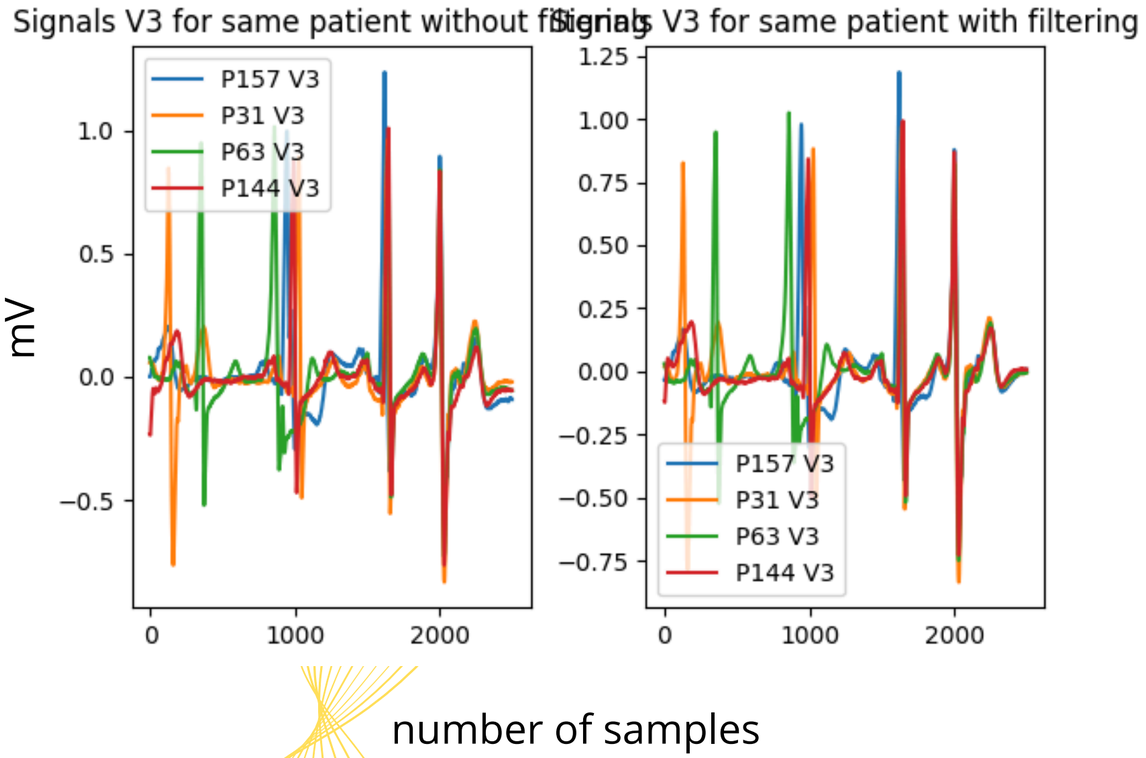
Age vs Weight



PCA



DATA PREPROCESSING

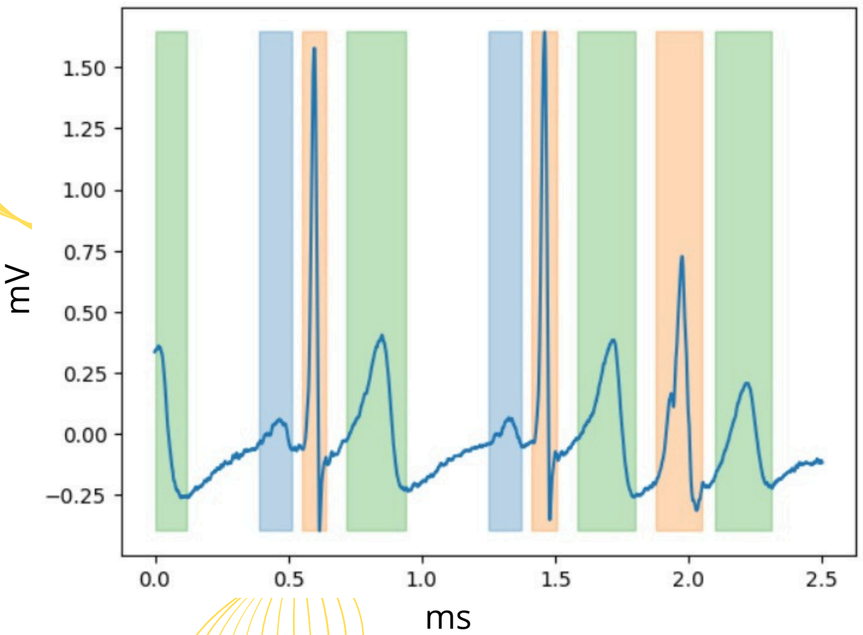


FILTERS

- High Pass Filter
- Low pass filter
- Detrend

Improve signal to noise ratio

DATA PREPROCESSING

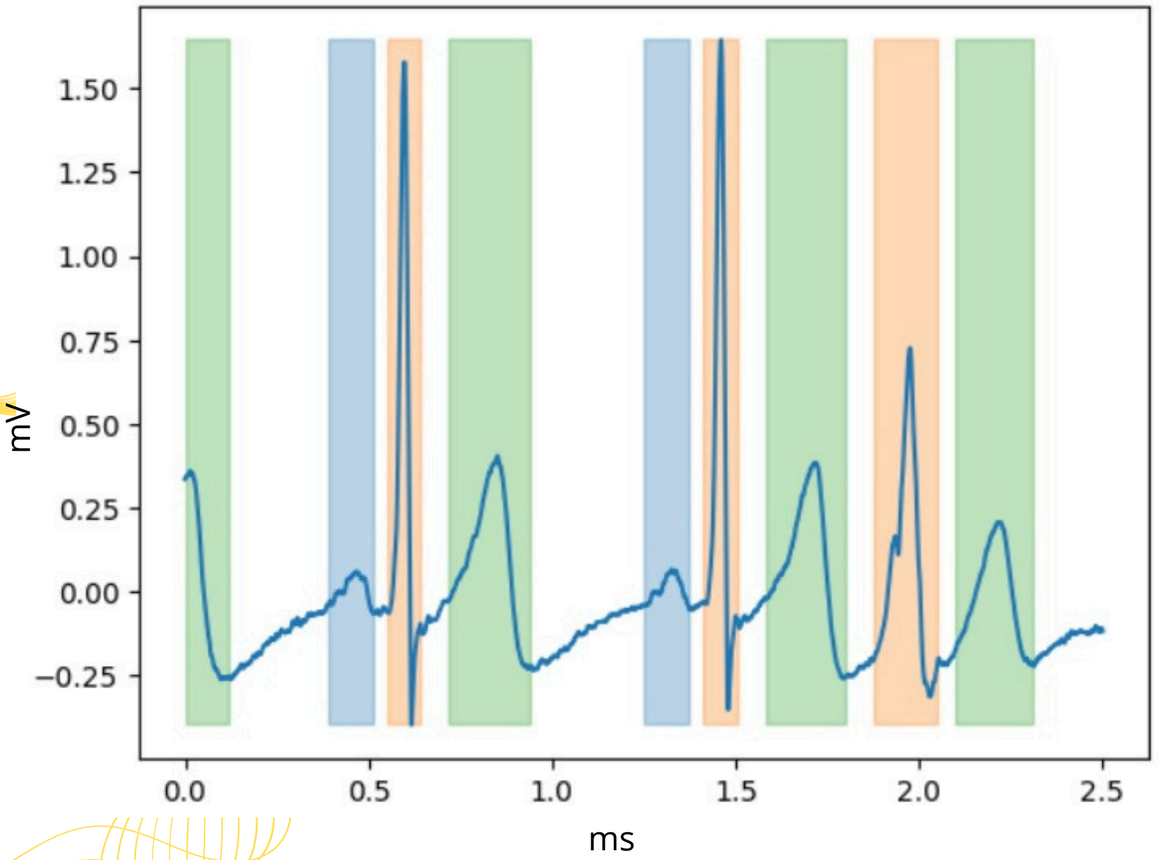


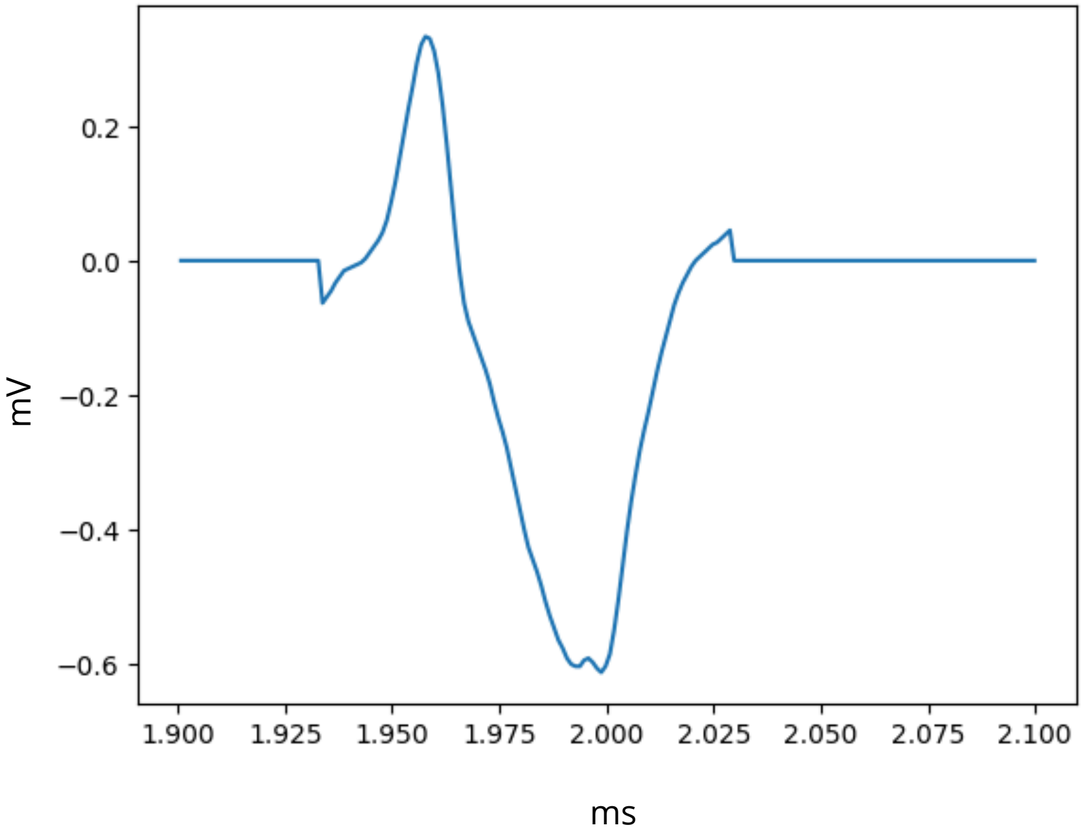
WHICH ZONE ARE WE INTERESTING?

QRS segment that is center at 2 ms

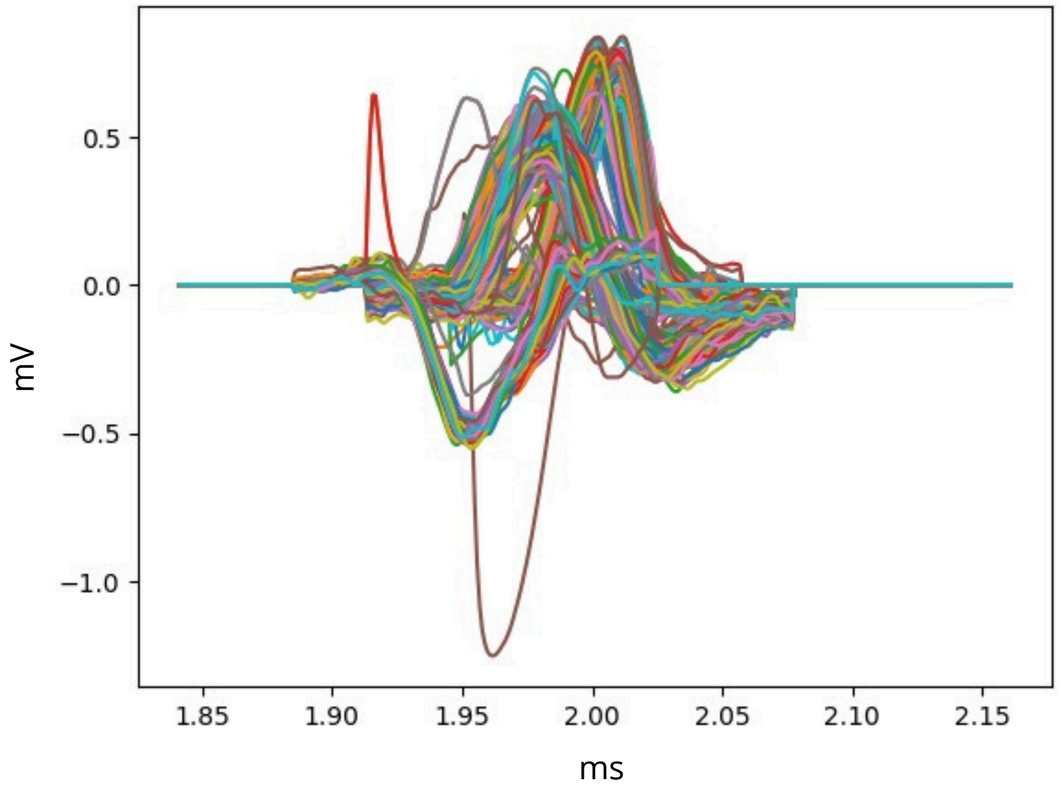
This time is chosen since the PVC is around the 2000 sample = 2ms

SEGMENTATION OF BEATS





SEGMENTATION OF BEATS



100 signals from the same lead (V3) of a few patients

DATABASE UNDERSTANDING

	Sex	HTA	Age	Height	Weight	DM	DLP	Smoker	Sleep_apnea	CLINICAL_SCORE	LVOT	RVOT	RVOTSEPTUM	COMMISURE	avg_max_val	index_max_val	length_seg
1	Female	No	52.0	169.0	68.0	No	No	No	No	1.0	0	1	0	0	0.894	55	55.0
2	Female	No	69.0	156.0	70.0	No	Yes	No	No	1.0	0	0	0	0	0.975	65	65.0
3	Female	No	66.0	176.0	63.0	No	No	No	No	1.0	0	1	0	0	0.363	41	41.0
4	Female	Yes	46.0	160.0	79.0	No	No	No	No	1.0	0	1	1	0	0.681	83	83.0
6	Male	No	84.0	179.0	97.0	No	No	No	No	2.0	0	0	0	0	1.038	86	86.0

Normalization

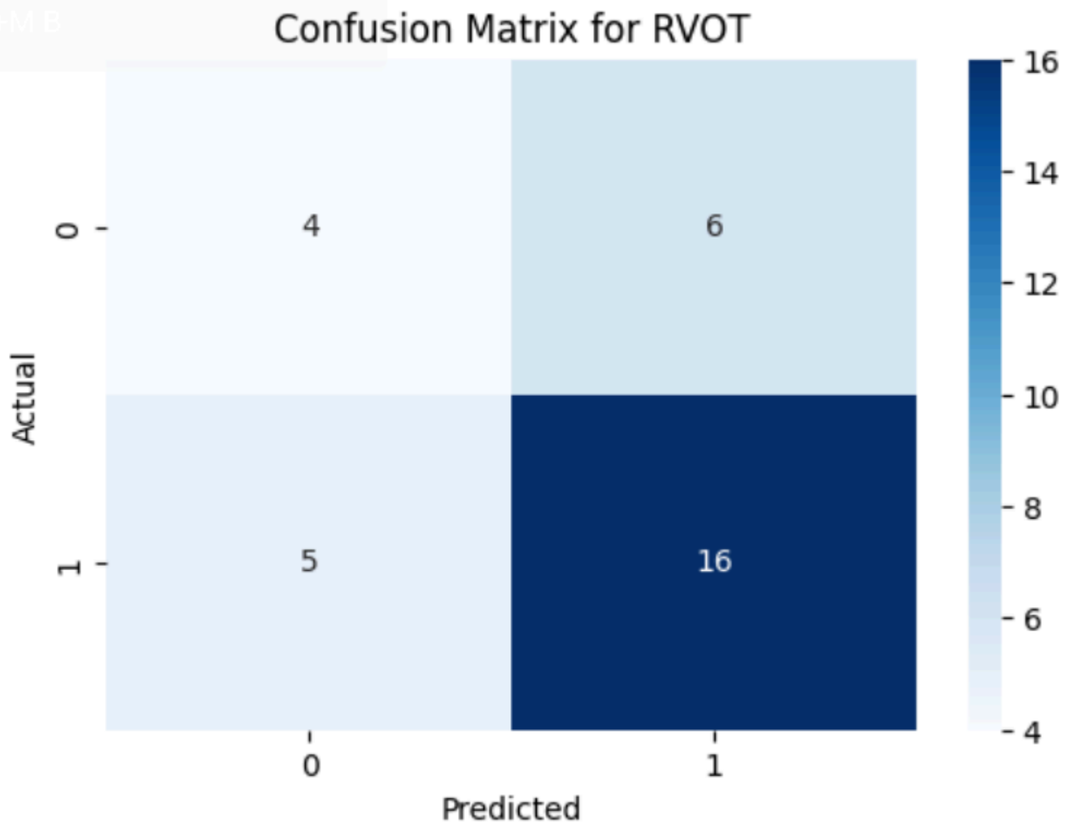
	Sex	HTA	Age	Height	Weight	DM	DLP	Smoker	Sleep_apnea	CLINICAL_SCORE	LVOT	RVOT	RVOTSEPTUM	COMMISURE	avg_max_val	index_max_val	length_seg
1	0	0	0.506849	0.468085	0.316456	0	0	0	0	0.333333	0	1	0	0	0.250482	0.272727	0.272727
2	0	0	0.739726	0.191489	0.341772	0	1	0	0	0.333333	0	0	0	0	0.276493	0.333333	0.333333
3	0	0	0.698630	0.617021	0.253165	0	0	0	0	0.333333	0	1	0	0	0.079961	0.187879	0.187879
4	0	1	0.424658	0.276596	0.455696	0	0	0	0	0.333333	0	1	1	0	0.182081	0.442424	0.442424
6	1	0	0.945205	0.680851	0.683544	0	0	0	0	0.666667	0	0	0	0	0.296724	0.460606	0.460606

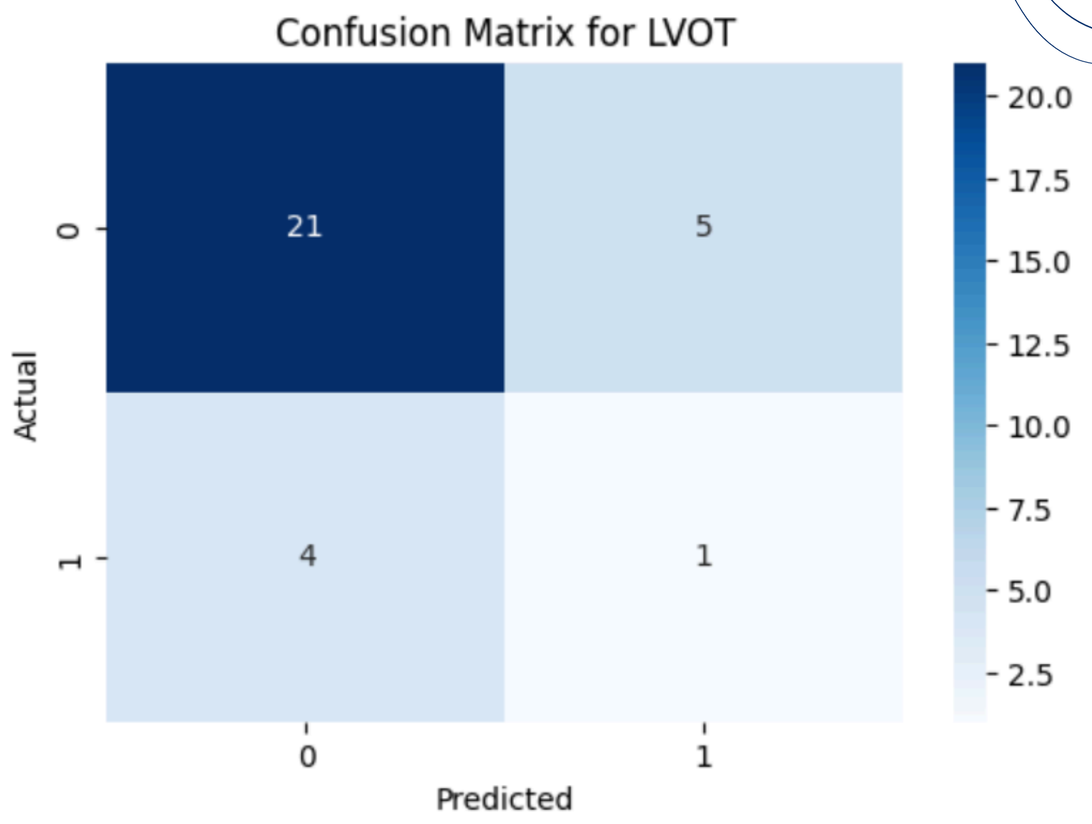
- Removing Nan values

ML ACCURACY RESULTS

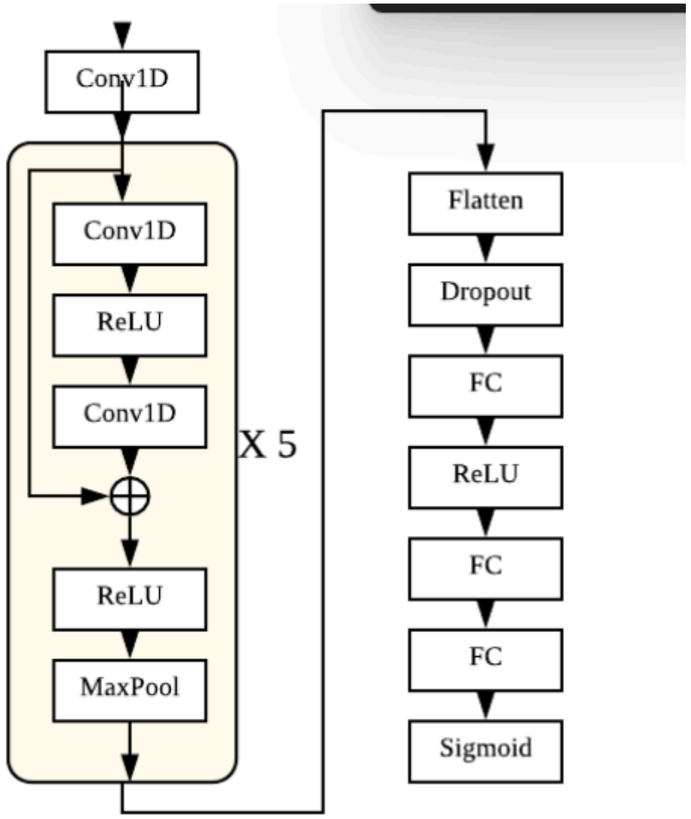
	RVOT ML	LVOT ML
KNN	0.65	0.71
Logistic Regression	0.71	0.77
SVC	0.74	0.84
Random Forest	0.65	0.68
XGBoost	0.71	0.71

KNN Confusion Matrix





CNN MODEL FOR BINARY CLASSIFICATION

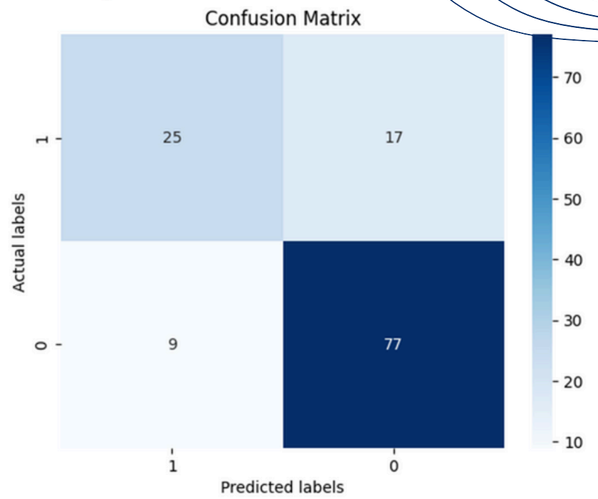


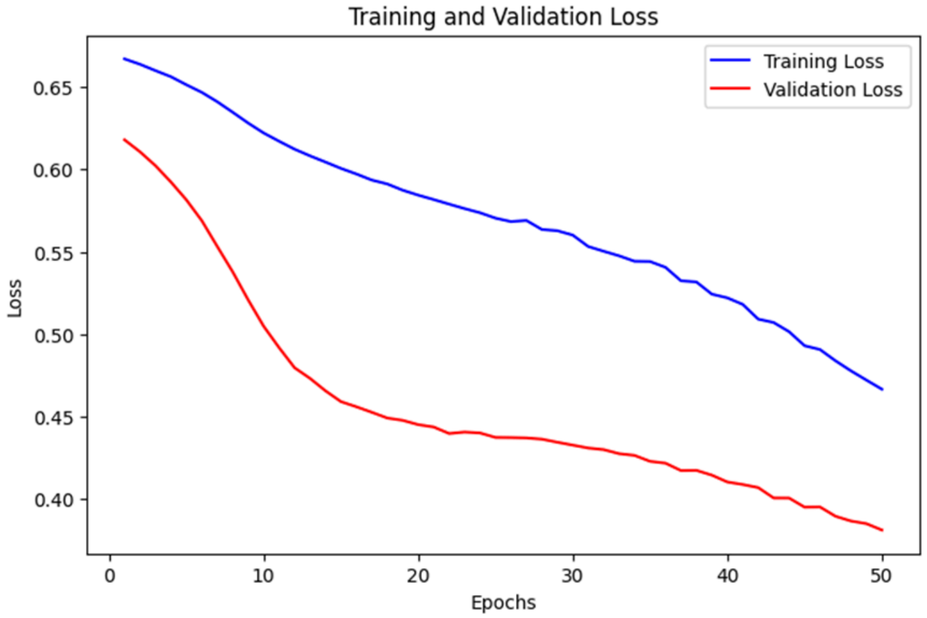
EPOCHS = 100
LR = 1E-6
BATCH_SIZE = 128
INPUT SHAPE : (N,12,200)

RESULTS FOR RVOT CLASSIFICATION

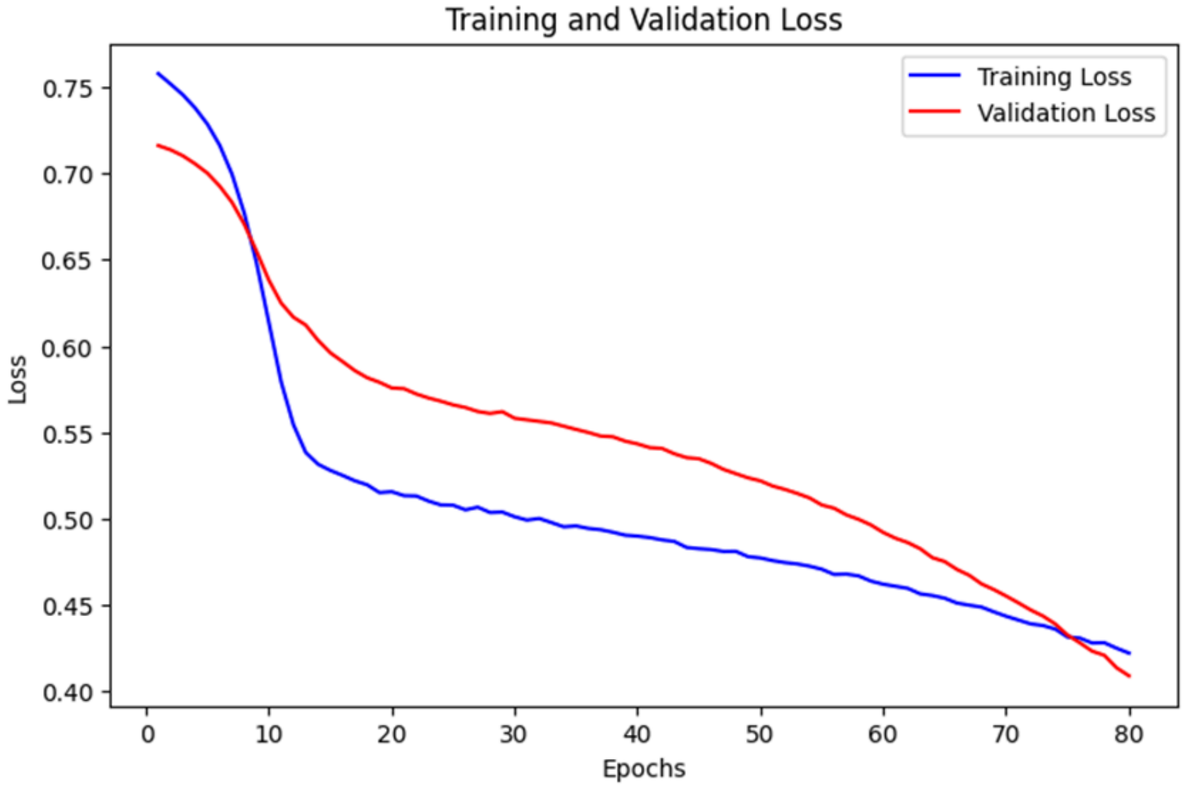
```
Epoch 12: Training Loss: 0.6123, Validation Loss: 0.4797, Validation Accuracy: 73.25%
Epoch 13: Training Loss: 0.6083, Validation Loss: 0.4732, Validation Accuracy: 73.01%
Epoch 14: Training Loss: 0.6045, Validation Loss: 0.4656, Validation Accuracy: 73.13%
Epoch 15: Training Loss: 0.6007, Validation Loss: 0.4591, Validation Accuracy: 73.08%
Epoch 16: Training Loss: 0.5973, Validation Loss: 0.4560, Validation Accuracy: 73.01%
Epoch 17: Training Loss: 0.5936, Validation Loss: 0.4526, Validation Accuracy: 73.13%
Epoch 18: Training Loss: 0.5912, Validation Loss: 0.4491, Validation Accuracy: 73.06%
Epoch 19: Training Loss: 0.5874, Validation Loss: 0.4477, Validation Accuracy: 72.94%
Epoch 20: Training Loss: 0.5844, Validation Loss: 0.4451, Validation Accuracy: 73.04%
Epoch 21: Training Loss: 0.5817, Validation Loss: 0.4437, Validation Accuracy: 72.99%
Epoch 22: Training Loss: 0.5790, Validation Loss: 0.4397, Validation Accuracy: 73.15%
Epoch 23: Training Loss: 0.5763, Validation Loss: 0.4406, Validation Accuracy: 72.96%
Epoch 24: Training Loss: 0.5737, Validation Loss: 0.4400, Validation Accuracy: 73.15%
Epoch 25: Training Loss: 0.5705, Validation Loss: 0.4374, Validation Accuracy: 73.13%
Epoch 26: Training Loss: 0.5684, Validation Loss: 0.4372, Validation Accuracy: 73.06%
Epoch 27: Training Loss: 0.5691, Validation Loss: 0.4370, Validation Accuracy: 73.20%
Epoch 28: Training Loss: 0.5636, Validation Loss: 0.4363, Validation Accuracy: 72.99%
Epoch 29: Training Loss: 0.5628, Validation Loss: 0.4344, Validation Accuracy: 73.58%
Epoch 30: Training Loss: 0.5602, Validation Loss: 0.4327, Validation Accuracy: 76.54%
Epoch 31: Training Loss: 0.5532, Validation Loss: 0.4309, Validation Accuracy: 76.73%
Epoch 32: Training Loss: 0.5504, Validation Loss: 0.4299, Validation Accuracy: 77.11%
Epoch 33: Training Loss: 0.5476, Validation Loss: 0.4275, Validation Accuracy: 79.71%
Epoch 34: Training Loss: 0.5443, Validation Loss: 0.4264, Validation Accuracy: 82.22%
Epoch 35: Training Loss: 0.5441, Validation Loss: 0.4228, Validation Accuracy: 84.26%
Epoch 36: Training Loss: 0.5406, Validation Loss: 0.4217, Validation Accuracy: 86.72%
Epoch 37: Training Loss: 0.5324, Validation Loss: 0.4172, Validation Accuracy: 87.83%
Epoch 38: Training Loss: 0.5317, Validation Loss: 0.4174, Validation Accuracy: 87.57%
Epoch 39: Training Loss: 0.5243, Validation Loss: 0.4145, Validation Accuracy: 86.74%
Epoch 40: Training Loss: 0.5221, Validation Loss: 0.4103, Validation Accuracy: 86.86%
Epoch 41: Training Loss: 0.5181, Validation Loss: 0.4088, Validation Accuracy: 87.29%
Epoch 42: Training Loss: 0.5092, Validation Loss: 0.4069, Validation Accuracy: 86.79%
Epoch 43: Training Loss: 0.5071, Validation Loss: 0.4006, Validation Accuracy: 86.25%
Epoch 44: Training Loss: 0.5015, Validation Loss: 0.4005, Validation Accuracy: 85.25%
Epoch 45: Training Loss: 0.4930, Validation Loss: 0.3950, Validation Accuracy: 85.09%
Epoch 46: Training Loss: 0.4907, Validation Loss: 0.3951, Validation Accuracy: 84.61%
Epoch 47: Training Loss: 0.4839, Validation Loss: 0.3895, Validation Accuracy: 84.30%
Epoch 48: Training Loss: 0.4778, Validation Loss: 0.3866, Validation Accuracy: 84.56%
Epoch 49: Training Loss: 0.4722, Validation Loss: 0.3850, Validation Accuracy: 84.11%
Epoch 50: Training Loss: 0.4666, Validation Loss: 0.3811, Validation Accuracy: 83.88%
```

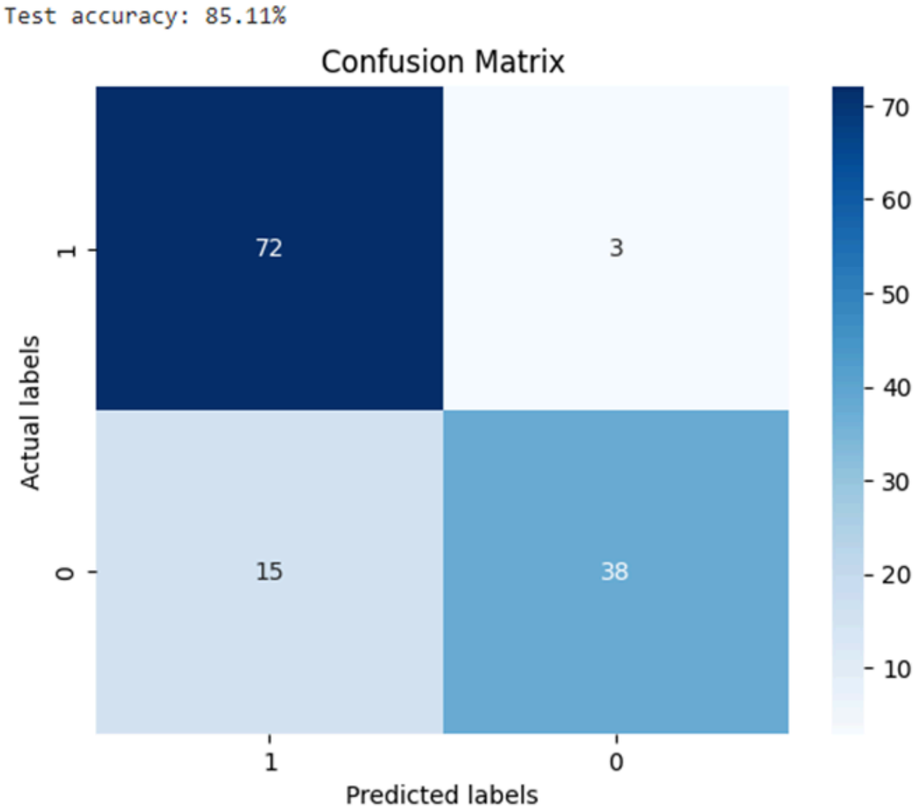
```
Test accuracy: 83.95%
```



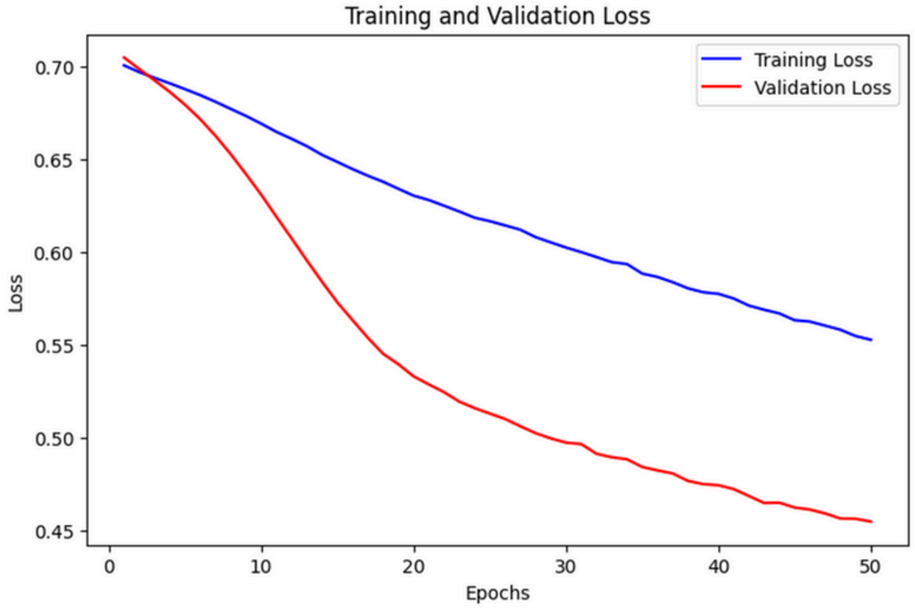


RESULTS FOR LVOT CLASSIFICATION

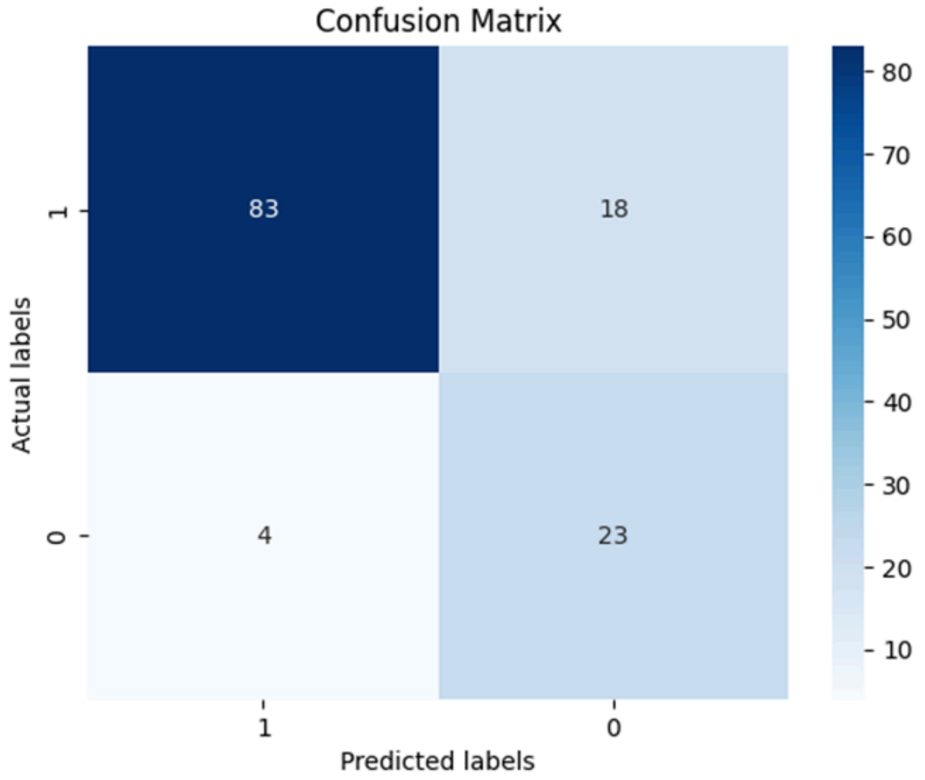




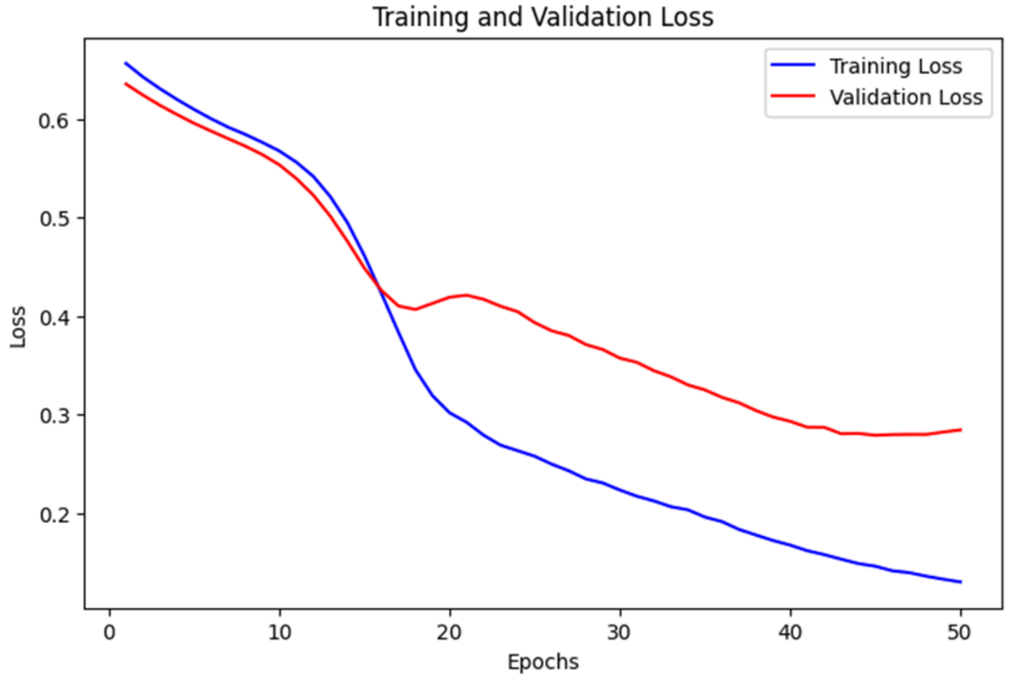
RESULTS FOR RVOTSEPTUM CLASSIFICATION



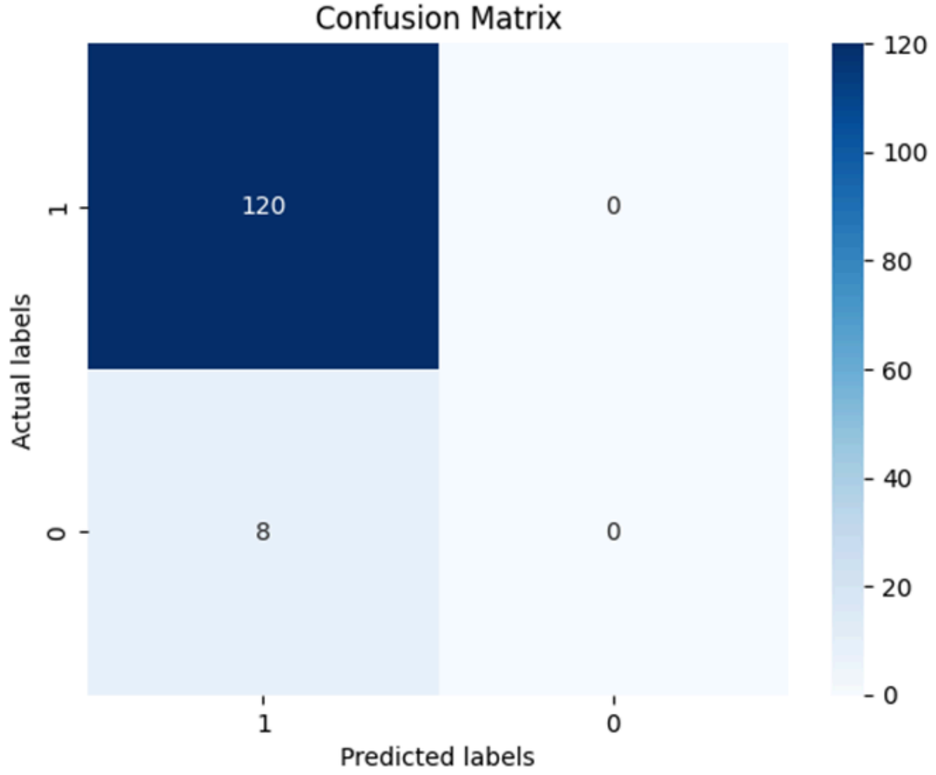
Test accuracy: 83.79%



RESULTS FOR COMMISURE CLASSIFICATION



Test accuracy: 92.78%



CONCLUSION

SOME IDEAS IN ORDER TO IMPROVE THE RESULTS

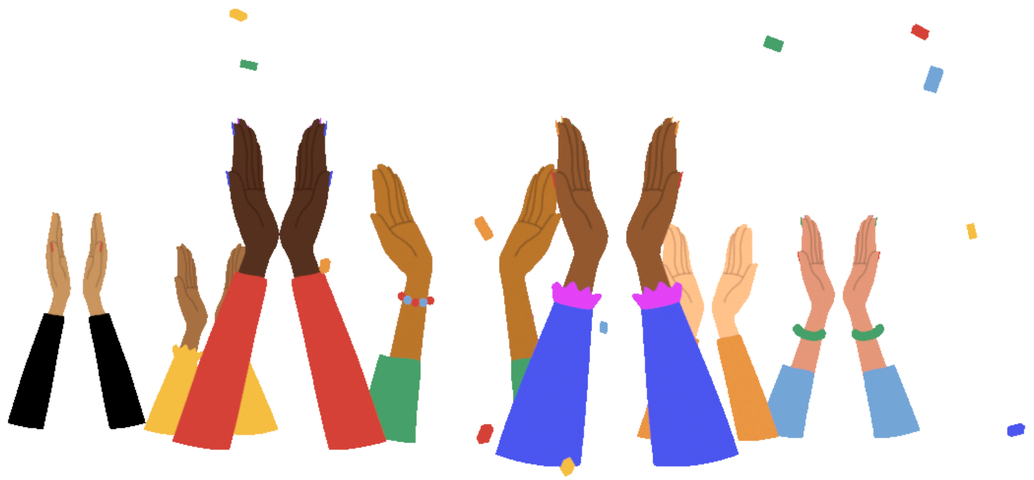
USE SEGMENTATION (GPU?)

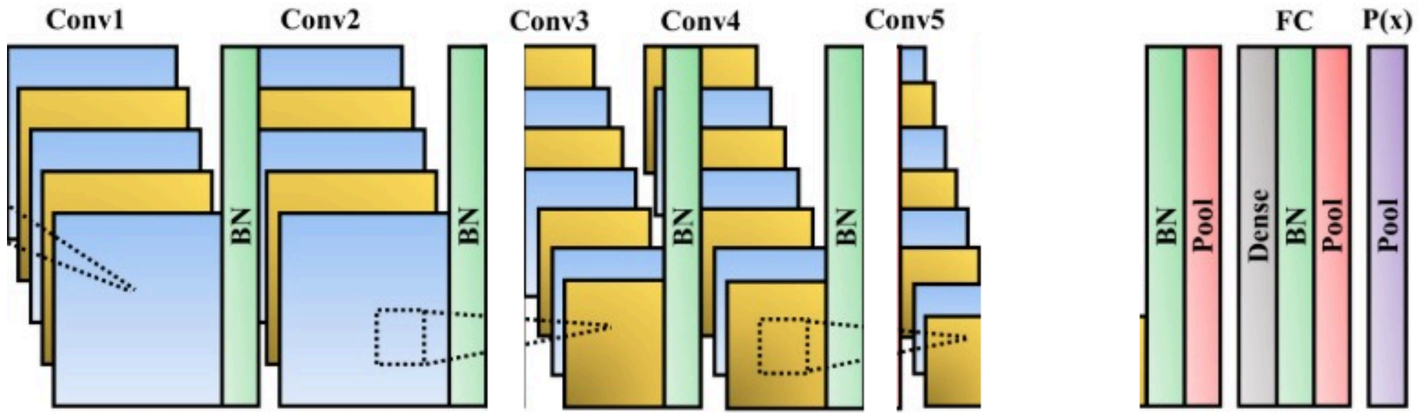
USE PRE-TRAINED MODELS

USE DATA AUGMENTATION

WEIGHTING BOTH ML AND DL MODELS TO EXPLOIT ALL INFO

THANK YOU FOR YOU ATTENTION!!





WHAT WE HAD?

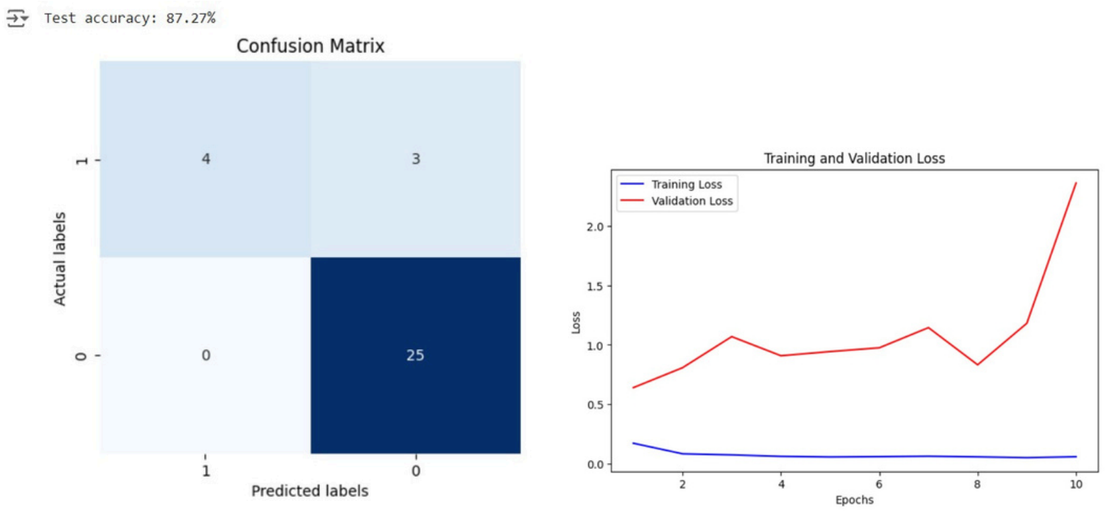
2 Binary Classification Models

```
epochs = 10
lr = 1e-4
batch_size = 32
hidden_sizes = [64, 128, 256, 512, 1024, 10]
```

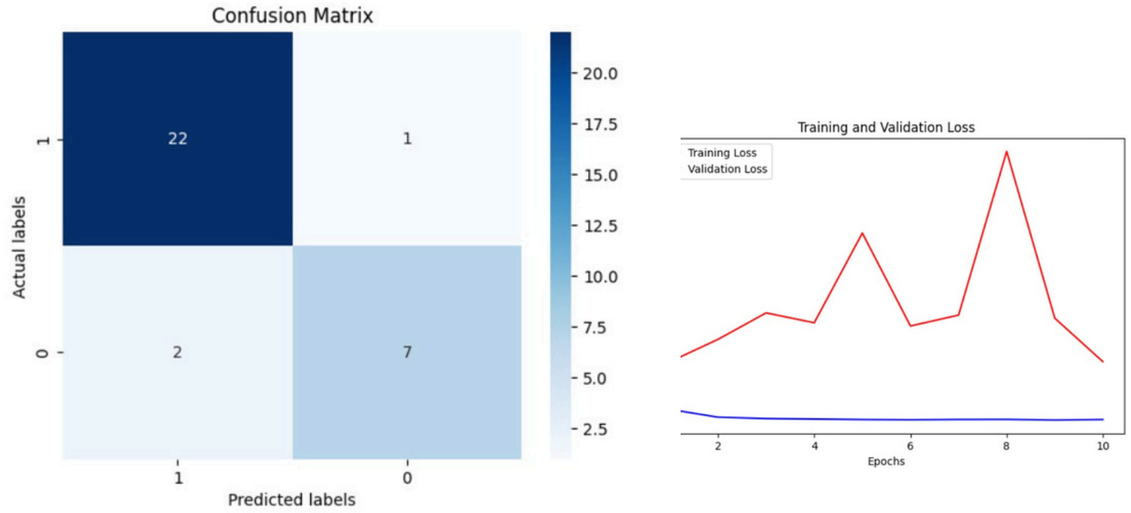
Input shape : (n,12,400)

Image from Jun, T. J., Nguyen, H. M., Kang, D., Kim, D., Kim, D., & Kim, Y. H. (2018). ECG arrhythmia classification using a 2-D convolutional neural network. arXiv preprint arXiv:1804.06812.

RIGHT SELECTION



LEFT SELECTION



FOR RVOT 87% ACCURACY

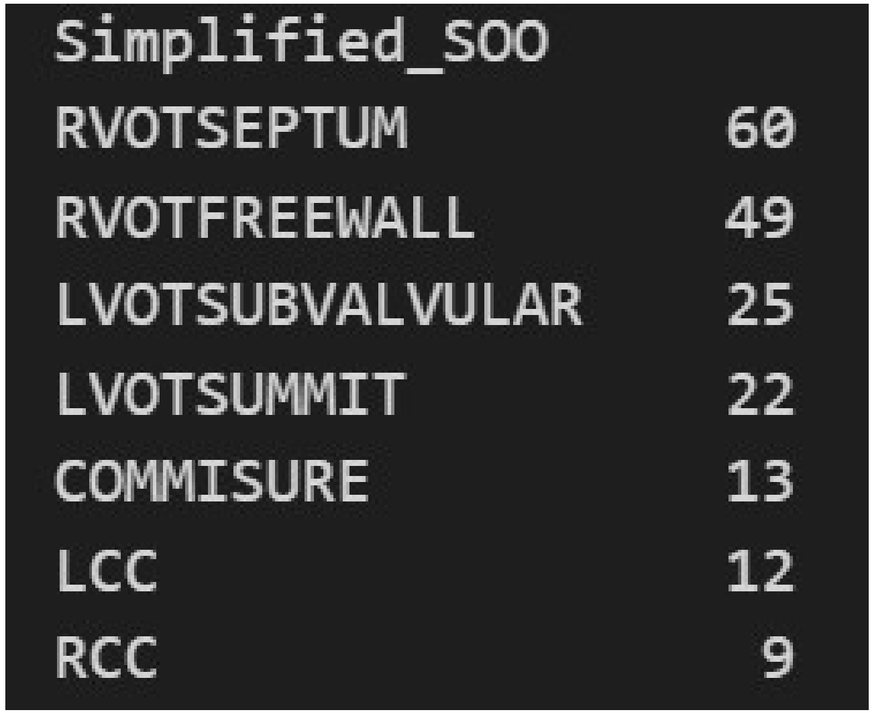
LVOT 81% ACCURACY

Hidden size	Batch	Epoch	Learning rate	Accuracy	Dropout value	Optimizer
[400,300,100]	32	10	1,00E-04	56,11%	0,5	adam
[50,100,100]	16	10	1,00E-04	67,55%	0,5	adam
[600,400,100]	16	10	1,00E-04	67,55%	0,5	adam
500,300,50	16	10	1,00E-04	61%	0,5	adam

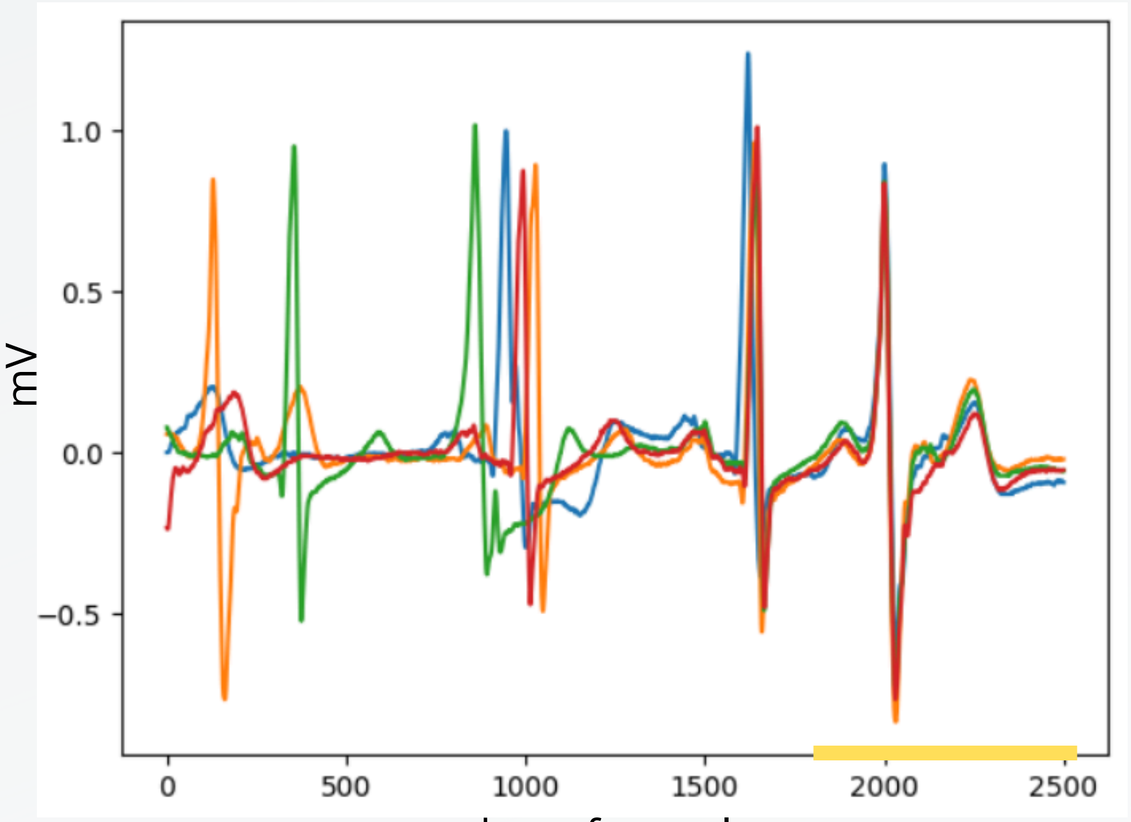
DATABASE UNDERSTANDING

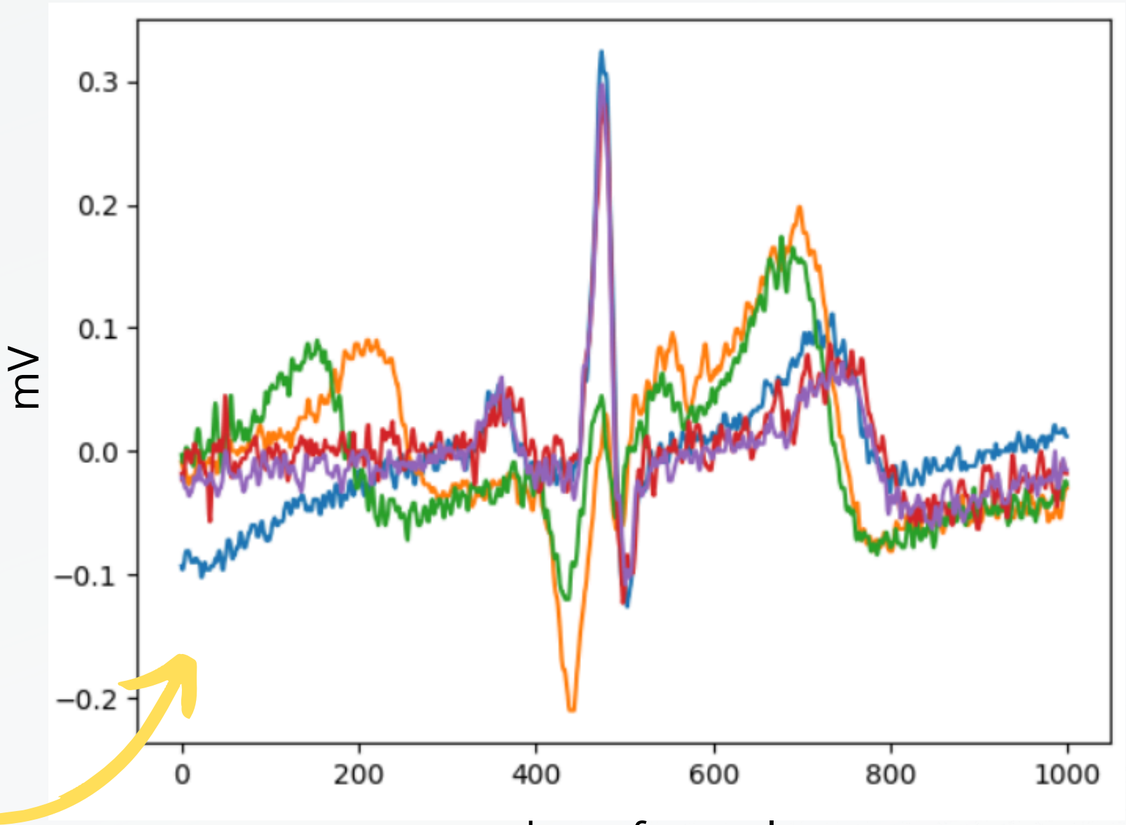
BINARY SEPARATION

	Sex	HTA	Age	SOO_chamber	Height	Weight	Simplified_SOO	RVOTSEPTUM	COMMISURE
P186	Female	NaN	61.0	Right ventricle	NaN	NaN	LVOTSUBVALVULAR	0	0
P245	Female	No	52.0	RVOT	169.0	68.0	RVOTFREEWALL	0	0
P292	Female	No	69.0	LVOT	156.0	70.0	RCC	0	0
P205	Female	No	66.0	Right ventricle	176.0	63.0	RVOTFREEWALL	0	0
P066	Female	Yes	46.0	RVOT	160.0	79.0	RVOTSEPTUM	1	0



DATABASE UNDERSTANDING





EXTRA BEAT LOCATION

RIGHT/LEFT SELECTION

Weighted Hybrid Score

CLINICAL POINTS

Clinical condition	*Points awarded*
• Male	+1
• Hypertension	+1
• Age >50 y.o.	+1

+

ECG POINTS

R/S OTVA Transition	*Points awarded*
• V1	+3
• V2	+2
• V3 & R-V3 >1mV	+1
• V3 & R-V3 <1mV	-1
• V4	-2
• V5	-3
• V6	-4

Score ≤ 1 → RVOT origin

Score ≥ 2 → LVOT origin

78% Accuracy

FIRST RESULTS

We are not taking into account yet the V3 voltage. We are not sure to be filtering correctly because there are only 9/190 patients with V3 & R-V3 >1mV.

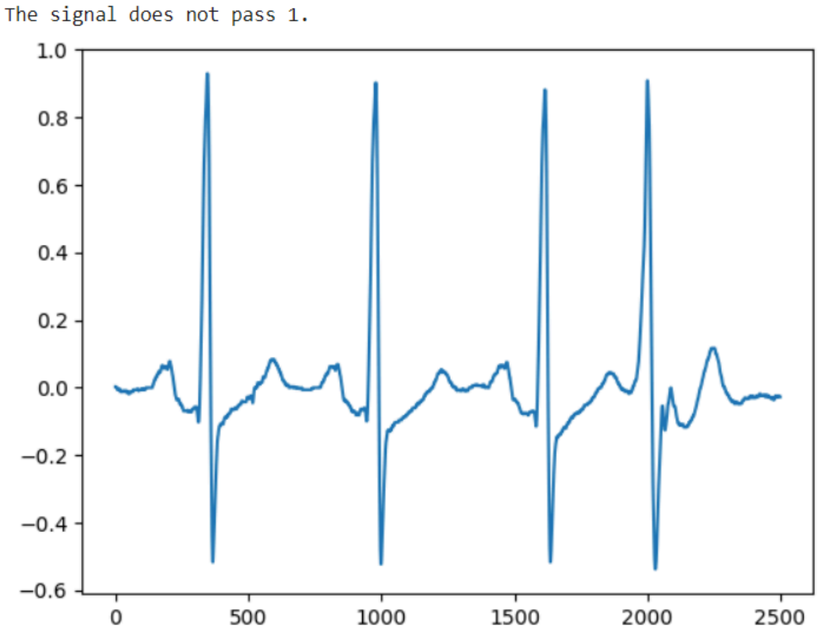
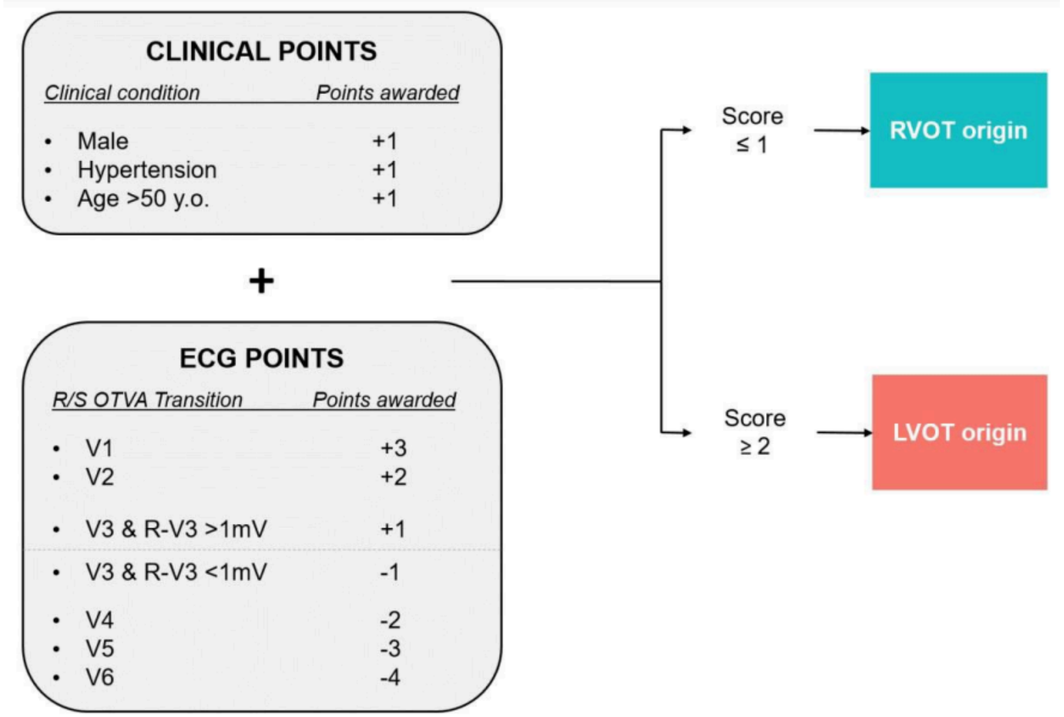


Image: Penela, D., Falasconi, G., Carreño, J. M., Soto-Iglesias, D., Fernández-Armenta, J., Acosta, J., Martí-Almor, J., Benito, B., Bellido, A., Chauca, A., Scherer, C., Viveros, D., Alderete, J., Silva, E., Ordoñez, A., Francisco-Pascual, J., Rivas-Gandara, N., Meca-Santamaria, J., Franco, P., … Berruezo, A. (2023). A hybrid clinical and electrocardiographic score to predict the origin of outflow tract ventricular arrhythmias. Journal of Interventional Cardiac Electrophysiology: An International Journal of Arrhythmias and Pacing, 66(8), 1877–1888. https://doi.org/10.1007/s10840-023-01507-x

RIGHT/LEFT SELECTION

ML with BHS characteristics



The idea is to consider the points as features to train the model.

NEXT STEP ANALYSIS TO FURTHER COMPARATION

Image: Penela, D., Falasconi, G., Carreño, J. M., Soto-Iglesias, D., Fernández-Armenta, J., Acosta, J., Martí-Almor, J., Benito, B., Bellido, A., Chauca, A., Scherer, C., Viveros, D., Alderete, J., Silva, E., Ordoñez, A., Francisco-Pascual, J., Rivas-Gandara, N., Meca-Santamaria, J., Franco, P., … Berruezo, A. (2023). A hybrid clinical and electrocardiographic score to predict the origin of outflow tract ventricular arrhythmias. Journal of Interventional Cardiac Electrophysiology: An International Journal of Arrhythmias and Pacing, 66(8), 1877–1888. https://doi.org/10.1007/s10840-023-01507-x