HEART ATTACK DETECTION VIA COMPUTATIONAL ELECTROCARDIOGRAPHIC ANALYSIS

Jennings, M.[1], Regan, Brian.[2], Owen, K.[1], Zhang, X.[1], Josephine McIvor, M.[1], Burtenshaw, D.[2], Ó Maolmhuaidh, F.[2], McLaughlin, J.[1], Finlay, DD.[1]

[1] Ulster University, UK

[2] Dublin City University, Ireland

email: Jennings-m5@ulster.ac.uk

INTRODUCTION

Myocardial infarction (MI) and circulatory disease are responsible for 27% of deaths in the United Kingdom (British Heart Foundation 2020). It is possible to detect ST-elevation (STEMI) using the electrocardiogram (ECG). The 12-lead ECG is the most popular diagnostic tool for this purpose (Thygesen et al. 2018). It has a high specificity to STEMI detection; however, it is often insensitive resulting in many false negative classifications. Previous research has introduced ambulatory monitors using smartphone devices, but these have large amplitude errors when transformed to the 12-lead ECG (Guldenring et al. 2018). Our work aims to introduce a novel lead system suitable for ambulatory monitoring of the ST-segment ECG changes while investigating its efficacy to ischaemia detection.

MATERIALS AND METHODS

Short-spaced leads (SSL) offer a more convenient diagnostic platform compared to the 12-lead ECG. An SSL-based system is suitable for patch based ECG development also. A dataset of 352-node body surface potential maps (BSPM) was used, consisting of recordings from patients undergoing elective percutaneous coronary angioplasty (PCTA) (n=44). Each patient had two recordings taken: one at baseline and one during peak balloon inflation (PBI) in one of three coronary arteries. All possible bipolar lead combinations with electrode spacing below 100 mm were computed from the BSPM. ST-changes observed 40 ms after the J-point were noted for each lead of each recording. The amplitude difference between baseline and PBI for each lead were ranked in descending order. The lead showing the highest median absolute ST-segment changes (SSL_{ST}) was chosen as the base of our patch-based lead system.

All lead combinations in the vicinity of the chosen SSL_{ST} were computed (n=6) to form a patch (All SSL). The lead spatially orthogonal to SSL_{ST} is referred to as SSL_{orth}. To investigate the efficacy of different combinations of SSLs to detect ischaemic-type ECG changes, a machine learning approach was adopted. The J-point amplitude for each SSL were extracted and annotated for baseline (false) and PBI (true) reflecting healthy and ischaemic states respectively. Three SSL combinations were used. A Naïve Bayes classifier utilising 10-fold cross validation was used in the default configuration for validate the SSL performance.

For comparison, J-point amplitudes of the 12-lead ECG were extracted from the same recordings where current diagnostic criteria were applied including age and sex metadata.

RESULTS

The chosen SSL_{ST} showed a median ST-segment amplitude change of 125 µV. For each coronary artery, the median ST-segment amplitude changes were 134 µV, 65 µV, and 166 µV for LAD, LCX, and RCA arteries respectively. SSL_{ST} electrode positions are shown in Figure 1 (white) with the precordial chest leads (black).

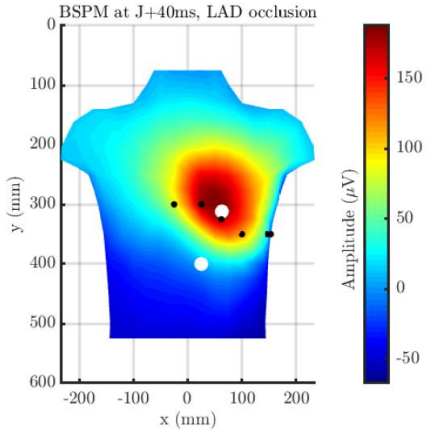

Figure 1 Median BSPM at J+40 ms during LAD occlusion. White = SSL, black = V-leads

Table 1 shows the performance of the SSL using a Naïve Bayes classifier. The most favourable result was using only SSL_{ST}. For comparison, the 12-lead ECG had a sensitivity and specificity of 62% and 93% respectively.

Table 1 Naïve Bayes classifier performance for each SSL combination in detecting ischaemic-type ECG changes

	Short Spaced Lead (SSL) Combination		
	SSL_{ST}	SSL_{ST} & SSL_{orth}	All SSL
Sensitivity (%)	86.7	84.4	82.2
Specificity (%)	71.1	66.7	66.7
F1 Score (%)	80.4	77.6	76.3

DISCUSSION

Our analysis shows an SSL-based lead system can detect ischaemic-type ECG changes. It has a higher sensitivity with fewer electrodes than the 12-lead ECG. However, the SSL is limited by lower spatial resolution across the torso and so limited specificity in the default classifier configuration.

REFERENCES

British Heart Foundation, UK Factsheet, 2020.

Thygesen, K. et al., J. Am. College of Cardiology, 72(18): 2231–2264, 2018.

Guldenring, D. et al., J. ECG, 51(1): 859-859, 2018.

Horacek, BM. et al., J. ECG, 41(6):508-517, 2008.