POTENTIAL UTILITY OF CHANGES IN ENTROPY AS AN ADJUNCT TO THE ELECTROCARDIOGRAPHY DIAGNOSIS OF REVERSIBLE MYOCARDIAL ISCHAEMIA

Master Degree of Medical Science

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Electrocardiography and Detection of Myocardial Ischemia: Recent Developments

Thesis Abstract

Background

The 12-lead electrocardiogram (ECG) is a pivotal clinical investigation for evaluations of disorders of myocardial electrophysiology and function. Myocardial ischemia is generally diagnosed on the basis of clinical history, combined with ST segment shifts and T wave changes on resting 12-lead ECG. The ECG is also used as a monitoring tool for assessment of resolution of transmural ischemia following emergency treatment. Because this technology is easy, noninvasive, and inexpensive, it represents a convenient central investigative modality.

On the other hand, the 12-lead ECG exhibits very low predictive accuracy for the diagnosis of ischemia in the absence of concurrent symptoms. Even if ECG monitoring is combined with treadmill exercise, the sensitivity and positive predictive accuracy for detection of myocardial ischemia are only around 50% - 75%. Therefore, information from the ECG, combined with exercise test, does not usually have a large influence on clinical decision-making.

A number of imaging techniques may be combined with pacing-induced tachycardia or pharmacological stress in order to improve the diagnostic accuracy of such provocative tests for ischemia beyond the level provided by continuous ECG monitoring alone. These include echocardiography, nuclear imaging with single photon emission computed tomography (SPECT) or positron emission tomography (PET) and magnetic resonance imaging. All add to the diagnostic accuracy of the provocative tests performed, but involve considerably incremental costs. The question therefore arises: is it possible to refine continuous ECG analysis during

provocative testing in such a way that the diagnostic accuracy of the procedure can be improved?

The majority of clinical studies has examined the accuracy or otherwise of the diagnosis of myocardial ischemia utilizing fluctuation of the ST segments during either “spontaneous” ischemia or during provocative manoeuvres (e.g. exercise). As previously stated, the diagnostic accuracy of such analyses tends to be mediocre; when subjected to utility evaluation under Bayesian considerations, they often add little to history/physical examination. However, a number of potential refinements of 12-lead ECG analysis have been proposed, in order to improve both detection and as well as localization and quantitation of ischemia. These include evaluation of a variety of the component waveforms of both the QRS complex and the ST segment of the ECG.

Current experiments

The currently described series of investigations arose from preliminary findings that myocardial ischemia in a canine model was associated with transient fluctuations in QRS entropy. Both evaluations performed related to the hypothesis that reversible myocardial ischemia causes transient increases in entropy within QRS complexes and ST segments of the human 12-lead ECG. A series of preliminary experiments suggested that such changes did indeed occur, mainly within the ST segment.

The first series of experiments performed compared conventional continuous ST segment analysis within the 12-lead ECG is vs. continuous evaluation of entropy-derived parameters for the localization of ischemia induced by balloon inflation during non-emergency coronary angioplasty. In a series of 103 patients, localization of ischemia was similarly accurate for the entropy-based method and the ST segment assessment method. Ischemic

zones were correctly localized by these approaches in 88% and 80% of cases, respectively (p not significant). There was poor concordance between the extent of ST elevation and changes in ST segment entropy. In a small subset of patients with complete bundle branch block and/or ST depression on resting ECG (n=22), entropy-based localization of ischemia was possible in 55% of cases compared with 41% via ST segment assessment (difference not significant). Post hoc analysis revealed that entropy fluctuations arose throughout the ST segment rather than predominantly at the J-point.

The second series of experiments was carried out on patients undergoing pacing-induced provocation of possible myocardial ischemia, with scanning via myocardial perfusion imaging (SPECT) examination. As with the first series, 12-lead ECG recording and ST trend monitoring were performed during the pacing procedure. The ST segment deviation and the entropy-based analyses were used for localization of possible ischemia. Data analyses were correlated with myocardial perfusion imaging results. A total 43 patients were studied. Categorization of ischemia via ST segment assessment had only 30% concordance with myocardial perfusion imaging results, while entropy-based analyses had 58% concordance. Therefore neither “conventional” (i.e. ECG-based ST segment analysis) nor novel entropy-based analyses are currently of clinical utility for detection of tachycardia-induced ischemia.

List of Abbreviations

ACEi	Angiotensin Converting Enzyme inhibitor
ACS	Acute Coronary Syndrome
AMI	Acute Myocardial Ischemia
APD	Action Potential Duration
ATP	Adenosine TriPhosphate
AV	Atrial-Ventricle
CABG	Coronary Artery Bypass Grafting
CAD	Coronary Artery Disease
CRP	C – Reactive Protein
CX	Circumflex
DBP	Diastolic Blood Pressure
ECG	Electrocardiography
ECHO	Echocardiography
EF	Ejection Fraction
ETT	Exercise Tolerance Testing
GTN	Glyceryltrinitrate
H2O2	Hydrogen Peroxide
IHD	Ischemia Heart Disease
LAD	Left Anterior Descending
LDL	Low Density Lipoprotein
LV	Left Ventricle
MBq	Mega Becquerel’s
METS	Metabolic Equivalents
MI	Myocardial Infarction
MPI	Myocardial Perfusion Imaging
MRI	Magnetic Resonance Imaging

PCI	Percutaneous Coronary Intervention
PCWP	Pulmonary Capillary Wedge Pressure
PET	Positron Emission Tomography
RAZs	Reduced Amplitude Zones
RCA	Right Coronary Artery
RMS	Root Mean Square
SAECG	Signal-Averaged Electrocardiography
SBP	Systolic Blood Pressure
SPECT	Single Photon Emission Computed Tomography
UA	Unstable Angina

Statement

This work contains no material which has been accepted for the award of any other degree or diploma in any university or tertiary institution and , to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Jinlin Zhao
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