N-Terminal Pro-Brain Natriuretic Peptide in combination with the 80-lead Body Surface Map Improves Detection of Acute Inferior Myocardial Infarction with Right Ventricular Involvement

MJ Daly, NA McKeag, CJ McCann, C Cardwell, IS Young, J Adgey

The Heart Centre, Royal Victoria Hospital, Belfast UK

Abstract

Right ventricular myocardial infarction with an acute inferior infarction remains a diagnostic challenge and is associated with increased rates of morbidity and mortality necessitating rapid myocardial reperfusion for their reduction.

In this study, we have shown that in patients with acute inferior-territory myocardial infarction, the early combination of Body Surface Potential Mapping and serum N-terminal pro-Brain Natriuretic peptide identifies those with right ventricular involvement - a group where early reperfusion is paramount.

1. Introduction

Acute myocardial infarction (AMI) involving only the right ventricle (RV) is a rare event [1], however its involvement in the context of inferior AMI is much more common [1, 2]. Typically, right ventricular myocardial infarction (RVMI) occurs following occlusion of the right coronary artery proximal to the acute marginal branches [1, 3] and results in RV dysfunction [1]. RVMI is associated with increased rates of morbidity and mortality [2, 4, 5], i.e. increasing risk of shock, ventricular tachycardia/fibrillation, atrioventricular block and death, when compared to those with isolated inferior AMI [4]. Early diagnosis of RVMI is imperative, as its management differs substantially from that of left ventricular infarction by nature of differing pathophysiology [3], however accurate diagnosis of inferior AMI with RV involvement continues to pose a significant problem [2].

Regarding clinical diagnosis, the triad of hypotension, clear lung fields and elevated jugular venous pressure in a patient with inferior AMI is virtually pathognomonic of RVMI [2, 3]. ST-segment elevation (STE) ≥0.1mV in lead V_{4R} remains the most predictive finding for RVMI using the standard 12-lead electrocardiogram (ECG) [1, 2, 3] and is a strong independent predictor of major complications and in-hospital mortality [1, 6]. However, body surface potential mapping (BSPM) has been previously shown to significantly improve STE detection in patients with inferior AMI and RV or posterior involvement, when compared to 12-lead ECG with additional RV (V_{2R}, V_{4R}) and posterior leads (V_7 and V_9) [7, 8]. In addition, plasma levels of B-type natriuretic peptide (BNP), a cardiac neurohormone specifically secreted from the ventricles in response to volume expansion and pressure overload [2, 9], have been shown to be elevated in pulmonary embolism [10] and be significantly higher in inferior AMI with RV involvement when compared to isolated inferior AMI [2].

We hypothesize that the combination of BSPM and plasma NT-proBNP will improve the diagnosis of RVMI complicating inferior-wall AMI.

2. Methods

2.1. Study population

Between January 2003 and January 2006 we retrospectively studied all patients admitted to our coronary care unit using either the emergency department or mobile coronary care unit (MCCU). Patients were excluded from analysis if they were unable to provide informed consent or had any of the following: conditions precluding STE on ECG, i.e. left bundle branch block defined as QRS duration ≥ 120ms, QS or rS wave in lead V_1 and slurred R waves in leads I and V_5 or V_6 [11], right bundle branch block defined as QRS duration ≥ 120ms, rSR' complex in leads V_1 and V_2 and S waves in leads I and V_5 or V_6 [11], left ventricular hypertrophy defined as a sum of the R wave in leads V_5 or V_6 and S wave in V_1 ≥ 3.8mV [12], digitalis therapy or ventricular pacing (247 patients); had received fibrinolytic therapy, nitrates or glycoprotein IIb/IIIa inhibitors prior to initial ECG or BSPM; prior history of coronary artery bypass grafting (CABG) surgery; BSPM recorded >15mins after initial 12-lead ECG; left ventricular ejection fraction <55%; severe valvular disease; or renal impairment (eGFR<30ml/hr). Those who fulfilled the following criteria were studied:

1. Typical ischaemic-type chest discomfort of ≥20minutes duration, occurring at rest and within 12 hours of onset of symptoms
2. Twelve-lead ECG and BSPM available at first medical contact
3. Blood sampled for NT-proBNP at first medical contact
4. Blood sampled for cardiac troponin T (cTnT) ≥ 12hrs post-symptom onset
5. Coronary angiography during index hospitalization

2.2. Twelve-lead ECG analysis

A 12-lead ECG was recorded at first medical contact (25mm/s and 10mm/mV). ST segment shifts were measured at the J-point for STE and 80ms after the J-point for STD using the preceding TP segment as a baseline [13] by a cardiologist who was blinded to all other clinical data. STE consistent with AMI (STEMI) was defined using the Minnesota code 9-2 [14] as ≥0.1mV STE in one or more of leads I, II, III, aVL, aVF, V_5, V_6 or ≥0.2mV STE in one or more of leads V_1 – V_4. Acute inferior-territory STEMI (AIMI) was defined by STE ≥0.1mV in at least two of leads II, III, or aVF.

2.3. BSPM analysis

The BSPM comprises a flexible plastic anterior and posterior electrode harness and a portable recording unit (Heartscape Technologies, Inc.). The anterior harness contains 64 electrodes, including 3 proximal bipolar limb leads (Mason-Likar position) and a posterior harness with 16 electrodes. This lead configuration enables recording of 77 unipolar ECG signals with respect to the Wilson central terminal. During the interpretation process the electrodes are defined to represent anterior, lateral, inferior, high right anterior, right ventricular and posterior epicardial regions [12]. All 80 leads were manually checked and those of unacceptable quality, i.e. where noise or movement artefact disallowed recognition of QRST variables, were marked and substituted using linear grid interpolation. Any BSPM with >6 leads requiring interpolation were disregarded and these patients excluded from analysis. Printouts were obtained from the processed BSPM of the 80-lead ECG and a colour-contour map displaying the amount of STE at the J point (ST0 isopotential map). The result of the PRIME™ diagnostic algorithm was noted. Using the 80-lead BSPM and colour-contour map, a single cardiologist familiar with BSPM interpretation and blinded to the clinical details, 12-lead ECG and PRIME™ diagnostic algorithm result coded the BSPM diagnosis as AMI or non-AMI and defined the infarct location. STE was measured from the ST0 point and defined by the following thresholds: anterior ≥0.2mV elevation; lateral/inferior/high right anterior/right ventricular ≥0.1mV elevation; posterior ≥0.05mV elevation; with infarct-location described by the ST0 isopotential colour-contour map.

2.4. Acute myocardial infarction

Diagnosis of AMI was made when cTnT ≥0.03μg/L.

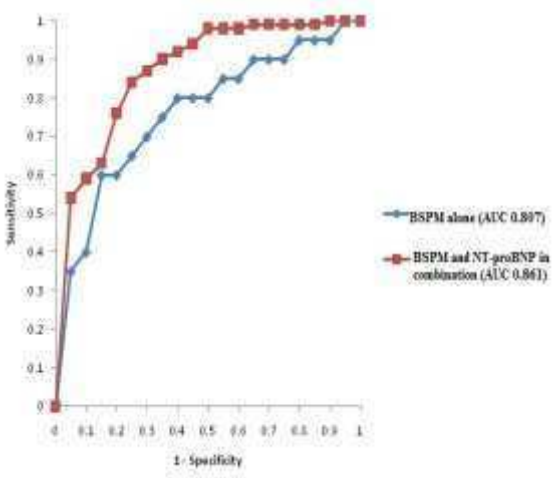
2.5. Coronary angiography

All patients underwent coronary catheterization during index admission. All coronary angiograms were evaluated by one cardiologist blinded to all other clinical data. Definition of RVMI was by angiographic occlusion of the right coronary artery (RCA) proximal to the origin of the first major RV branch.

3. Results

During the study period, 407 patients (age 62 ± 13; 70% male) fulfilled the study criteria. Of these, 72 (18%) had STEMI, defined as STE satisfying the Minnesota criteria in combination with cTnT ≥0.03μg/L. Of those patients with STEMI, 39 (54%) patients had STE in a distribution consistent with AIMI. RVMI, i.e. angiographic occlusion of the RCA proximal to the first major RV branch at angiography, complicated 24 (62%) of those with AIMI.

On analysis of those with AIMI, plasma levels of NT-proBNP were significantly higher in those with RVMI than in those without, i.e. 996 ng/L v 305 ng/L respectively (p=0.006). Receiver operated characteristic (ROC) analysis revealed NT-proBNP ≥ 373 ng/L to be most discriminating for RVMI, with sensitivity 79% and specificity 87% for the diagnosis. Of those with AIMI, the c-statistic for distinguishing RVMI from non-RVMI using NT-proBNP alone was 0.761 (95%CI: 0.609 – 0.913) and BSPM alone was 0.807 (95%CI: 0.713 – 0.882) [Figure 1]. Using the combination of BSPM and NT-proBNP the c-statistic was 0.861 (95%CI: 0.728 – 0.995; p<0.001) [Figure 1].



AUC = area under curve

Figure 1. Receiver Operated Characteristic curve for RVMI diagnosis using BSPM alone and BSPM and NT-proBNP in combination

4. Conclusion

As shown in this study, ~50% of STEMI occur in the inferior-territory, with ~50% of these having right ventricular involvement. BSPM has been shown to be superior to the standard 12-lead ECG with additional right-sided precordial leads for RVMI detection in previous work [7, 8] and in this study has c-statistic 0.807 for the diagnosis. NT-proBNP has been shown to be significantly higher in those with RVMI than in those with isolated AIMI (p=0.006) in this work, and has clear diagnostic value when used in combination with BSPM at presentation (c-statistic 0.861; p<0.001).

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Address for correspondence:

Dr. Michael J Daly
Cardiology Research Department
The Heart Centre
Royal Victoria Hospital
Grosvenor Road
Belfast UK
BT12 6BA

Email: michaeljdaly@hotmail.com