

# Posterior myocardial infarction: are we failing to diagnose this?

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## ABSTRACT

**Introduction** Isolated posterior ST-elevation myocardial infarction (STEMI) accounts for up to 7% of STEMI. The diagnosis is suggested by indirect anterior-lead ECG changes. Confirmation requires presence of ST-elevation in posterior-leads (V7–V9). We investigated the ability of hospital doctors and paramedics to diagnose posterior STEMI (PMI).

**Methods** Doctors in the emergency department and acute medical unit at two teaching hospitals and West Midlands Ambulance Service Paramedics were asked to interpret a 12-lead ECG illustrating ST-depression and dominant R-wave in V1–V2 in the context of cardiac chest pain, and identify PMI as a potential diagnosis. Their ability to identify PMI was compared with their ability to diagnose anterolateral STEMI on a 12-lead ECG. We assessed whether doctors knew that posterior-leads were required to confirm PMI and whether doctors and nurses could position posterior-leads.

**Results** 44 of the 117 doctors (38%) identified PMI as a potential diagnosis. PMI was identified by 73% of registrars, 30% of senior house-officers and 18% of house-officers. 50% of doctors who identified potential PMI knew that posterior-leads were required to confirm the diagnosis. 20% of doctors correctly positioned these and 19% knew the diagnostic criteria for PMI (ST-elevation  $\geq 1$  mm in V7–V9). 13 of the 60 nurses (22%) in the emergency department and acute medical unit correctly positioned posterior-leads. Five of the 50 (10%) paramedics identified PMI as a potential diagnosis. Doctors and paramedics were significantly better at diagnosing anterolateral STEMI than PMI.

**Conclusions** A significant proportion of doctors and paramedics were unable to diagnose PMI. Hence, the majority of PMIs may be being missed. Routine use of posterior-leads in the standard assessment of patients with chest pain may identify up to an additional 7% of STEMI, allowing prompt reperfusion therapy, which would reduce morbidity and mortality.

## INTRODUCTION

The acute management of ST-elevation myocardial infarction (STEMI) is based on interpretation of the ECG. This is typically undertaken by doctors in the emergency department (ED) and acute medical unit. Increasingly, the ECG diagnosis is being made by paramedics, allowing them to pre-alert the ED or even initiate thrombolytic therapy in regions where primary angioplasty is unavailable.<sup>1</sup> Identification of ST-segment elevation or presumed new left-bundle branch block in combination with a history of cardiac chest pain results in prompt initiation of reperfusion therapy. Raised markers of myocardial necrosis (troponins, creatinine kinase) and regional wall motion abnormalities on

echocardiography are also seen, but the diagnosis does not require waiting for the presence of these.<sup>2,3</sup>

Isolated posterior STEMI (PMI) accounts for 3–7% of STEMI and is usually caused by occlusion of the left circumflex artery.<sup>4–6</sup> However, the standard 12-lead ECG is an insensitive tool in identifying PMI since it does not directly view the posterior wall. The typical ST-segment elevation seen in infarcts affecting other territories of the heart is therefore absent in PMI. It is hence easily misinterpreted.<sup>4,7</sup> American College of Cardiology guidelines suggest that indirect changes are seen in the anterior leads (ST depression  $\pm$  dominant R-wave in V1–V2) which should raise suspicion of PMI. Prompt use of ‘posterior’ ECG leads (V7–V9) demonstrating ST-segment elevation of  $\geq 1$  mm allows these changes to be distinguished from anterior ischaemia and the diagnosis of PMI to be made.<sup>4,8,9</sup>

Due to the necessity for correct placement and interpretation of additional ‘posterior’ leads, we postulated that doctors and paramedics would be less competent in diagnosing PMI than other STEMI. In addition, due to the paucity of use of posterior leads, we postulated that nursing staff would be less competent in positioning these leads than the ‘standard’ 12 leads. This could lead to PMI being missed, resulting in patients failing to receive reperfusion therapy.

## METHODS

During February 2010, we investigated the ability of doctors in the ED and acute medicine directorate (doctors undertaking acute/general medicine takes) at two teaching hospitals in Birmingham to diagnose PMI on the basis of an ECG. In addition we studied the ability of West Midlands Ambulance Service Paramedics to identify potential PMI on the standard 12-lead ECG as this would allow them to ‘pre-alert’ the ED of an incoming STEMI, facilitating rapid assessment and reperfusion of subsequently confirmed PMI.

### Ability of doctors to diagnose PMI

All junior doctors (house officers, senior house officers, registrar level) in the ED and acute medicine directorate were enrolled. Exclusion criteria included cardiology registrars and doctors who had attended cardiology courses covering ECG interpretation of STEMI due to their expected superior knowledge of diagnosing PMI on ECG.

Individual, face-to-face interviews were performed over a 48-hour period in the departments where doctors were working, to minimise the potential of contamination from doctors discussing and preparing for the study, and to ensure the

## Original article

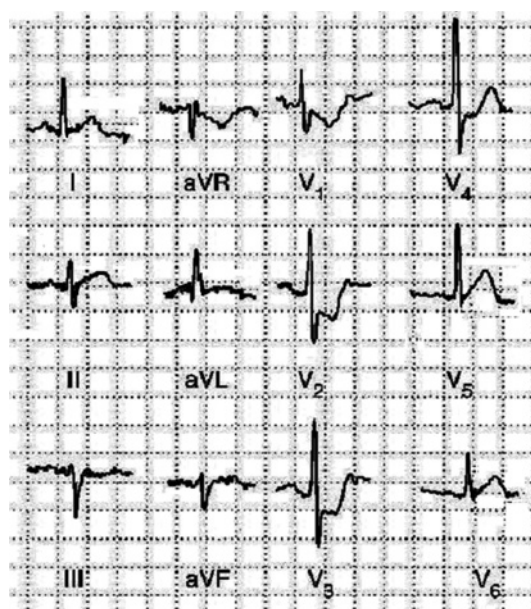
maximal response rate by including doctors on night-duty. Doctors were shown and asked to interpret a 12-lead ECG illustrating ST-depression and dominant R-wave in V1-V2 in the context of cardiac chest pain (figure 1). In accordance with American College of Cardiology guidelines, they were required to correctly identify PMI as a potential diagnosis. To study the ability of doctors to confirm the diagnosis of PMI, they were asked whether any extra leads, in addition to the standard 12 leads, are required (ie, posterior leads V7–V9) and their knowledge of the placement of posterior leads was assessed by asking them to label their position on a diagram of the chest and back. We then investigated whether they knew the diagnostic criteria for PMI on these leads (ST elevation  $\geq 1$  mm in V7–V9). Finally, to investigate whether doctors were less competent in diagnosing potential PMI than other STEMI (ie, those diagnosed routinely on the standard 12-lead ECG), we compared their ability to identify potential PMI against their ability to diagnose anterolateral STEMI on a 12-lead ECG illustrating ST elevation in V1-V6/AVL/I and reciprocal ST-depression in inferior leads in the context of cardiac chest pain (figure 2). Results were standardised and only deemed correct if PMI and anterolateral STEMI were stated as diagnoses on the two ECGs respectively. Responses were assessed by interviewers who were all of at least senior house officer level in the cardiology department

#### Ability of nursing staff to position posterior leads

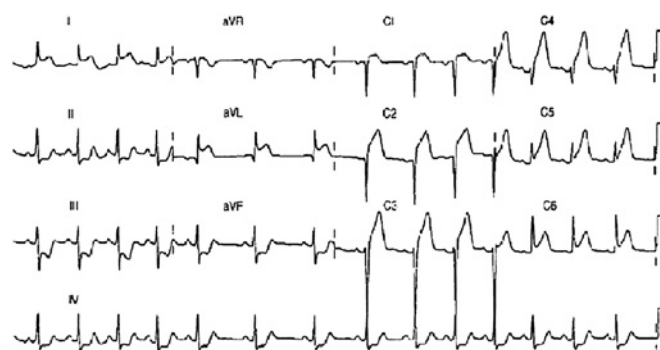
Nursing staff in the ED and medical assessment unit at the two hospitals were asked to label the position of posterior leads on a diagram of the chest and back. Cardiac specialist nurses were excluded in order to ensure results were generalisable, since they are not available in all hospitals.

#### Ability of paramedics to identify potential PMI on the standard 12-lead ECG

Paramedics were asked to interpret the 12-lead ECG illustrating ST-depression and dominant R-wave in V1-V2 in the context of cardiac chest pain (figure 1) and correctly identify PMI as



**Figure 1** The 12-lead ECG illustrating potential posterior ST-elevation myocardial infarction as evidenced by ST-depression and dominant R-wave in leads V1-V2, in the context of chest pain, which doctors and paramedics were asked to interpret.



**Figure 2** The 12-lead ECG illustrating anterolateral ST-elevation myocardial infarction as evidenced by ST-elevation in leads V1-V6/AVL/I and reciprocal ST-depression in inferior leads (II/III/AVF), in the context of chest pain, which doctors and paramedics were asked to interpret.

a potential diagnosis. We then asked whether they would subsequently pre-alert the accident and emergency team of a potential STEMI based on this 12-lead ECG. Finally, to investigate whether they were less able to diagnose PMI than other STEMI, their ability to identify potential PMI was compared against their ability to diagnose anterolateral STEMI on a 12-lead ECG illustrating ST elevation in V1-V6/AVL/I and reciprocal changes inferiorly (figure 2). The ability of paramedics to position posterior leads was not assessed since the current Joint Royal Colleges Ambulance Liaison Committee (JRCALC) allow paramedics to assess chest pain using the *standard* 12-lead ECG only.

The primary outcome measures were the proportion of doctors and paramedics able to identify potential PMI on the 12-lead ECG showing ST depression and dominant R wave in V1-V2 in the context of chest pain. All other measures were secondary outcomes.

#### Statistical analysis

Data analysis was undertaken using Microsoft Excel. Sample size calculation revealed that analysis of 107 doctors was required (a total of 145 junior doctors across the two hospitals) to compare the ability of the grades of junior doctors to diagnose PMI to 95% CI. Percentage values were calculated with  $\pm 95\%$  CI. Two-tailed  $\chi^2$  testing using Yates' Correction was used to compare the ability of the grades of doctors to diagnose potential PMI on the 12-lead ECG (figure 1); and the ability of doctors and paramedics to diagnose potential PMI and anterolateral STEMI (figure 2). Statistical significance was assumed where  $p < 0.05$ .

## RESULTS

#### Ability of doctors to diagnose PMI

In all, 117 doctors were surveyed. The response rate was 81% (117/145). Fifty-seven were from the ED, and 60 from the medical admissions unit. There were 30 specialist registrars, 54 senior house officers and 33 house-officers. Of the 117 doctors, 44 (38%) identified that PMI was a potential diagnosis when asked to analyse the 12-lead ECG illustrated in figure 1. The ability of doctors to identify potential PMI improved with their level of experience (table 1). Specialist registrars were significantly better than senior house officers ( $p=0.0003$ ) and house officers ( $p<0.0001$ ). Of the 44 doctors, 22 (50%) who identified PMI as a potential diagnosis knew that posterior leads were then required to confirm the diagnosis. Of the 117 doctors, 23 (20%) correctly positioned posterior leads and 22 of 117 (19%) knew

**Table 1** Investigation of doctors' and paramedics' ability to diagnose posterior ST-elevation myocardial infarction (PMI)

Question	Doctors total	House officers	Senior house officers	Registrars	Paramedics
Able to identify potential PMI on 12-lead ECG showing ST depression + dominant R wave in V1-V2 in context of chest pain?	44 of 117 (38%)	6 of 33 (18±4.0%)	16 of 54 (30±5.9%)	22 of 30 (73±6.1%)	5 of 50 (10±6.8%)

the diagnostic criteria of PMI (table 1). Of the 117 doctors, 108 (92%) correctly identified anterolateral STEMI when asked to analyse the 12-lead ECG illustrated in figure 2. Their ability to diagnose potential PMI was significantly lower ( $p<0.001$ ).

#### Ability of nursing staff to position posterior leads

Sixty nurses were surveyed (29 from the ED and 31 from the medical admissions unit). Of the 60 nurses, 13 (22%) could correctly position posterior leads.

#### Ability of paramedics to identify potential PMI on the standard 12-lead ECG

Five of the 50 (10%) paramedics surveyed identified potential PMI on the 12-lead ECG, and 7 (14%) would pre-alert the ED based on the ECG. Of the 50 paramedics, 46 (92%) correctly identified anterolateral STEMI when asked to analyse the 12-lead ECG shown in figure 2. Their ability to diagnose potential PMI was significantly lower ( $p<0.001$ ).

## DISCUSSION

### Ability of doctors to diagnose PMI

Our study has illustrated that a significant proportion of hospital doctors are unable to diagnose PMI. We have also shown that they are significantly less competent in diagnosing potential PMI than STEMIs where ST-elevation is seen in the standard 12-lead ECG (eg, anterolateral STEMI). This is particularly the case in the more junior grades (house officers, senior house officers). Only 50% of doctors who identified PMI as a potential diagnosis on the 12-lead ECG knew that posterior leads were then required to confirm the diagnosis of PMI. This finding is in accordance with a survey of Canadian physicians, in which only 11% of cardiologists and 9% of emergency physicians routinely used posterior leads.<sup>10</sup>

Both doctors and nurses were unfamiliar with positioning of posterior leads (V7–V9). It is important that nursing staff can correctly position posterior leads in suspected acute PMI.<sup>3 4 11</sup> Invariably, the initial ECG(s) will be performed by nursing staff in the ED or acute medical unit who may be less familiar with posterior lead placement than their colleagues on the coronary care unit. This carries the potential for PMI to be missed. Therefore, doctors should also be able to position posterior and right-ventricular ECG leads, as they may be called upon to advise nursing staff on their correct positioning. Right-ventricular infarction is associated with 40% of inferior STEMI. The routine

use of preload-reducing agents such as nitrates, diuretics and opioids in the absence of diagnosing associated right-ventricular involvement can worsen the haemodynamic compromise commonly associated with right-ventricular infarction.<sup>12–14</sup>

### Clinical implications of failure to diagnose PMI

Isolated PMI accounts for up to 7% of STEMIs.<sup>4–6</sup> The Myocardial Infarction National Audit Project Database estimates an annual incidence of approximately 60 000 myocardial infarcts in England and Wales.<sup>15</sup> Hence, rather than receiving prompt reperfusion therapy for PMI (thrombolysis or primary angioplasty within 30 or 90 min respectively),<sup>2</sup> up to 4200 patients will be being treated incorrectly as non-STEMIs based on delayed raised markers of cardiac necrosis and receive suboptimal initial therapy (antiplatelet therapy and low molecular weight heparin).<sup>16</sup>

The clinical consequences of PMIs are often serious and disproportionate to their relatively low myocardial mass loss. This may be a result of the potential for PMI to cause mitral regurgitation (MR). Matetzky and colleagues illustrated that MR was present in 69% of patients with isolated PMI, and was moderate or severe in one third of these.<sup>4 17</sup> MR is known to be an independent predictor of long-term heart failure and mortality post myocardial infarction.<sup>18</sup>

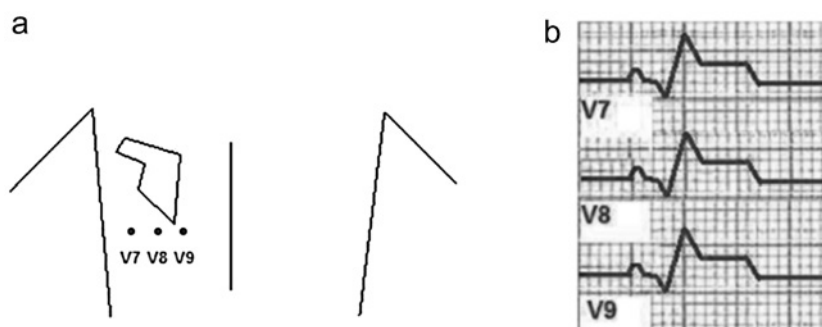
Reperfusion therapy has potential complications. The use of posterior leads could avoid the inappropriate use of reperfusion therapy where PMI is merely suspected on the basis of ST-depression in leads V1-V2, and where the diagnosis is in fact anterior-wall ischaemia.

### Pre-hospital thrombolysis and PMI—potential for improvement?

JRCALC guidelines allow pre-hospital thrombolysis in STEMI as defined by ST elevation in at least two leads or new left-bundle branch block on the standard 12-lead ECG only.<sup>1</sup> Hence, this excludes PMI. Training paramedics on the use of posterior leads and the diagnosis of PMI, and its inclusion in JRCALC guidelines could further improve the outcomes seen with pre-hospital thrombolysis. Indeed, a recent study into the pre-hospital management of chest pain revealed that 64% of paramedics surveyed felt that they had received insufficient training to identify ECG abnormalities.<sup>19</sup>

The majority of paramedics in our study were unable to diagnose PMI. Even in regions where thrombolysis has been replaced by primary angioplasty, an ability to diagnose PMI by

**Figure 3** (A) Position of the posterior ECG leads. These are obtained by repositioning leads V4–V6 posteriorly, at the level of the original V4 lead. V7 (from V4) is at the left posterior axillary line, V8 (from V5) is level with this in the left midscapular line and V9 (from V6) is level with this at the left spinal border. (B) ST-elevation of  $\geq 1$  mm in V7 to V9 confirming the presence of acute posterior ST-elevation myocardial infarction.



paramedics could improve outcomes by allowing them to pre-alert the ED and cardiology teams. This has been shown to reduce the time to primary angioplasty, thus improving clinical outcomes.<sup>20 21</sup>

### Study limitations

This study is limited by the fact that doctors at only two hospitals and paramedics in only one service (West Midlands) were assessed. However, to improve the generalisability of our results, we have tried to ensure a good sample size of junior doctors of all grades. In addition, the current knowledge and training of paramedics throughout the UK on PMI was assumed to be similar since current JRCALC guidelines do not discuss the diagnosis of PMI.

### Conclusions

Emphasis needs to be placed on diagnosing PMI during doctors', nurses' and paramedics' training. This is particularly the case for junior doctors and therefore the initial ECGs for patients presenting with chest pain should be analysed by a doctor of registrar level or above. Paramedics should pre-alert the ED of a potential incoming STEMI (PMI) where patients have chest pain in conjunction with ST depression in leads V1-V2 on the 12-lead ECG, since JRCALC guidelines do not allow currently allow use of additional leads. Posterior leads (V7-V9, figure 3) should be assessed in *all* patients presenting with chest pain and ST-depression in leads V1-V2 on arrival to the ED. Identification of patients with chest pain who require reperfusion therapy is a major aim in emergency medicine. Increased use of posterior leads and recognition of changes indicating PMI will reveal more patients with PMI who will benefit from prompt reperfusion.

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**Competing interests** None.

**Contributors** JNK conceived the idea, designed the study, conducted the analyses at Sandwell & West Birmingham Hospitals NHS Trust and wrote the manuscript. AC and EM conducted the analyses at Sandwell & West Birmingham Hospitals NHS Trust. JMK and CV reviewed and helped revise the manuscript.

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