

Is it possible to exclude a diagnosis of myocardial damage within six hours of admission to an emergency department? Diagnostic cohort study

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BMJ 2001;323:372-4

Abstract

Objective To assess the clinical efficacy and accuracy of an emergency department based six hour rule-out protocol for myocardial damage.

Design Diagnostic cohort study.

Setting Emergency department of an inner city university hospital.

Participants 383 consecutive patients aged over 25 years with chest pain of less than 12 hours' duration who were at low to moderate risk of acute myocardial infarction.

Intervention Serial measurements of creatine kinase MB mass and continuous ST segment monitoring for six hours with 12 leads.

Main outcome measure Performance of the diagnostic test against a gold standard consisting of either a 48 hour measurement of troponin T concentration or screening for myocardial infarction according to the World Health Organization's criteria.

Results Outcome of the gold standard test was available for 292 patients. On the diagnostic test for the protocol, 53 patients had positive results and 239 patients had negative results. There were 18 false positive results and one false negative result.

Sensitivity was 97.2% (95% confidence interval 95.0% to 99.0%), specificity 93.0% (90.0% to 96.0%), the negative predictive value 99.6%, and the positive predictive value 66.0%. The positive likelihood ratio was 13.9 and the negative likelihood ratio 0.03.

Conclusions The six hour rule-out protocol for myocardial infarction is accurate and efficacious. It can be used in patients presenting to emergency departments with chest pain indicating a low to moderate risk of myocardial infarction.

Why we carried out this study

The gold standard for diagnosing myocardial damage is either measurement of troponin T concentration at 48 hours or serial electrocardiography and serial measurements of cardiac enzymes. We wanted to compare an emergency department protocol that was designed to rule out the possibility of myocardial damage within six hours with this gold standard. The protocol consisted of serial measurements of creatine kinase MB mass and continuous monitoring of ST segment changes.

If it proved possible to approximate the gold standard within six hours of patients' presentation in an emergency department, this would have important clinical and economic implications. It would allow early discharge of patients who were shown not to be at risk of myocardial infarction and it would facilitate early treatment of those who required it.

The background

Chest pain accounts for 2-4% of all new presentations at emergency departments in the United Kingdom.^{1 2} Current best practice requires that all patients with a possible cardiac problem be admitted for at least 12-24 hours for further tests.^{4 5} In the United Kingdom only 30% of such patients are admitted for this period of time, whereas 70% are discharged; in the United States around 60% are admitted.^{1 6}

Acute myocardial infarctions are missed in about 3.5% of patients admitted to emergency departments in the United States, and such patients are subsequently discharged. In the United Kingdom recent evidence shows that around 6% of patients discharged from emergency departments may have prognostically important myocardial damage.⁷ Although many interventions, including drugs and surgery, can reduce mortality, patients benefit only if they can be correctly identified.^{6 8 9} Mortality in patients who are discharged with missed acute myocardial infarctions is four times greater than in those who are admitted to hospital.¹⁰

What were the main findings?

Our study showed that the six hour diagnostic protocol effectively ruled out myocardial damage with sufficient clinical efficacy to allow both rapid identification and safe discharge in a group of 292 patients over the age of 25 who attended the emergency department with chest pain. The protocol identified 47 patients who had abnormal creatine kinase MB mass concentrations and six who had abnormal ST segment changes. These patients were "protocol positive." Eighteen of these 53 patients subsequently turned out to be negative according to the gold standard. The remaining 239 patients were classified as "protocol negative." Only one of these patients was subsequently found to be positive according to the gold standard. She had a slightly increased troponin T concentration at 48 hours. On review at one month she was well, with no electrocardiographic evidence of myocardial damage (table).

The diagnostic sensitivity of the six hour protocol was 97.2% (95% confidence interval 95.0% to 99.0%), the specificity 93.0% (90.0% to 96.0%), the negative predictive value 99.6%, and the positive predictive value 66.0%. The positive likelihood ratio was 13.9 and the negative likelihood ratio 0.03.

How did we perform the study?

We identified consecutive patients who came to Manchester Royal Infirmary's emergency department with chest pain between 20 October 1997 and 30 October 1998. We included patients if they were aged over 25, the chest pain had lasted less than 12 hours,



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there was no history of trauma, and no other medical cause of chest pain had been identified. We excluded patients if they had electrocardiographic evidence of acute myocardial infarction or myocardial ischaemia, were hypotensive, had an arrhythmia, or required admission for another medical or social reason. We also excluded patients if the protocol was not followed or they did not consent to participate. We used a diagnostic cohort study design.

All the patients underwent 12 lead electrocardiography for assessment of their chest pain. They were given aspirin 300 mg (unless an absolute contraindication existed), and an intravenous cannula was placed.

The diagnostic test series consisted of serial measurements of creatine kinase MB mass and continuous 12 lead ST segment monitoring for six hours. If chest pain had lasted less than three hours we measured creatine kinase MB mass three hours after onset, six hours after onset, and after six hours of monitoring. If chest pain had lasted three to 12 hours we measured creatine kinase MB mass on arrival and three hours later. Creatine kinase MB mass was considered to give a positive result if there was an absolute concentration greater than 5 µg/l or an increase of 3 µg/l between consecutive samples.

ST segments were continuously monitored, and the alarm on the monitor was set to go off after a change in ST segment elevation or depression of greater than 2 mm in any one single lead or 1 mm in any three leads. The printout was interpreted by the clinician responsible for the patient. At the end of the monitoring period a 12 lead electrocardiogram was produced.

The patient was classified as protocol positive if there was a positive test result for creatine kinase MB mass or if an important change occurred in the ST segment. Patients were protocol negative if there was a negative test result for creatine kinase MB mass and no important change occurred in the ST segment.

Patients were admitted to hospital under the care of the acute medical team if they were either protocol positive or developed another medical or social reason for admission. All other patients were discharged to the care of their general practitioners with an advice card that explained the result and outlined reasons for seeking further care.

Patients who were discharged were asked to return after two days for measurement of troponin T concentrations. If they failed to do so they were contacted by telephone and asked to return for the test. Inpatients either had troponin T concentration measured 48 hours after admission or were screened for myocardial infarction according to the World Health Organization's criteria.³ A troponin T concentration of greater than 0.1 µg/l indicated myocardial damage.

Overall, 383 patients who attended with chest pain underwent the full protocol (figure). Twenty six were excluded or withdrew from the study and 65 had no gold standard measure of outcome. Sixty one of these 65 patients were traced four weeks or more after discharge. All were still alive, and none had had a myocardial infarction.

An outcome on the gold standard test was available for 292 patients: 288 had appropriately timed measurements of troponin T concentration and four underwent serial electrocardiography and serial measurements of cardiac enzymes.

Number of patients categorised as positive or negative by rule-out protocol (serial measurement of creatine kinase MB mass and continuous monitoring of ST segment changes) and by gold standard (troponin T concentration at 48 hours or serial electrocardiography and cardiac enzymes over 24 hours)

| Result in chest pain assessment unit | Gold standard | | Total |
|--------------------------------------|---------------|----------|-------|
| | Positive | Negative | |
| Positive | 35 | 18 | 53 |
| Negative | 1 | 238 | 239 |
| Total | 36 | 256 | 292 |

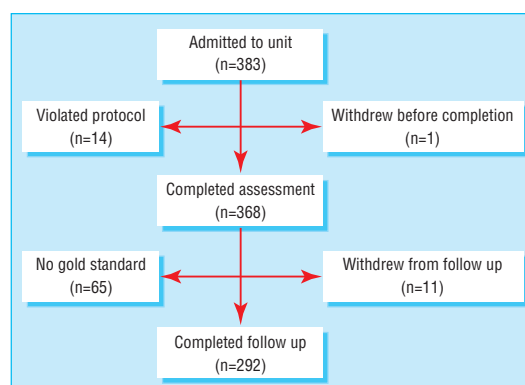
Why are these results important?

We have shown that a six hour protocol designed to rule out myocardial damage is both clinically accurate and efficacious in an unselected inner city population in the United Kingdom. The protocol reduces unnecessary admissions and inappropriate discharges and can also facilitate early thrombolysis in some patients who might otherwise not receive it.

Traditionally, myocardial infarction is ruled out by combining serial measurements of cardiac enzymes with serial electrocardiograms. Although accurate and sensitive (96.2%), this approach requires admission to hospital for a minimum of 24 hours and is therefore neither cost effective nor timely.⁴ Ideally, one test would either rule out or rule in myocardial infarction, but no such test is available.

We chose a troponin T concentration of greater than 0.1 µg/l at two days as a gold standard marker for myocardial damage. Several studies have shown that an increase of the troponin T concentration to this level is a strong independent marker of risk in patients with chest pain.^{11 12} Although a higher cut-off concentration could have been chosen to define acute myocardial infarction, the lower level was used to increase the sensitivity of the test and to minimise the number of false negative results.

Although ST segment monitoring is used in many coronary and intensive care units and during anaesthesia,^{13 14} its utility for diagnosing chest pain has not been evaluated in an emergency department. Of the six patients with changes in their ST segment during the protocol, two had evolving myocardial infarctions and both subsequently received thrombolysis after confirmatory 12 lead electrocardiography. The inclusion of ST segment monitoring in the protocol allowed the earliest possible identification of the two evolving acute myocardial infarctions and therefore



Trial profile

What is already known on this topic

In emergency departments in the United Kingdom only 30% of patients with chest pain indicating a low to moderate risk of myocardial infarction are admitted to hospital

Some 6% of those discharged have undiagnosed myocardial damage

What this study adds

An emergency department based chest pain assessment unit using a protocol to rule out myocardial damage is sensitive enough to allow safe discharge of patients at low to moderate risk of myocardial infarction within six hours

Such units can also reduce the number of patients admitted unnecessarily

expedited thrombolysis, a time dependent intervention.

Over 80% of available patients had a gold standard test in our study. The populations served by an inner city emergency department such as the Manchester Royal Infirmary are highly mobile and diverse; many of the patients who did not return were homeless, non-local, or migrant. Although 100% follow up is desirable, this test was evaluated in a real life population, and exclusion of patients who were not local or those who were homeless would have introduced bias by affecting the spectrum of disease.

Funding: This study was supported by a grant from the North West office of the NHS Executive (RDO/21/11).

Competing interests: None declared.

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Targeting deprived areas within small areas in Scotland: population study

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BMJ 2001;323:374-5

Geographical measures of deprivation show wide variations in the socioeconomic characteristics of populations who live in small areas. This variation has led governments over the years to target deprived areas within these small areas with the aim of improving the residents' circumstances. A large number of initiatives based on such areas, including health action zones, employment zones, and social inclusion partnerships, have recently been introduced in the United Kingdom. In Scotland, some health boards target resources towards areas at the most deprived extreme of the Carstairs deprivation scale, which ranges from -7.5 (most affluent) to 12.9 (most deprived).¹

In 1979, Townsend argued that an area based approach should not be central to improving the conditions of people in poverty.² Using Holtermann's earlier work,³ Townsend concluded that the spatial concentration of aspects of deprivation could be low.

This paper examines whether this observation still applies 22 years later.

Methods and results

The number of unemployed people was extracted from the 1991 census small area statistics tables for the 1001 postcode sectors of Scotland. For each postcode sector, the number of households with a gross annual income below £10 000 (low income households) was taken from estimates of income in 1997.⁴ The sectors were ranked from the most deprived to the least deprived using the Carstairs deprivation scale.¹ For each sector in turn, starting with the most deprived sector, I calculated cumulative totals for the number of unemployed people, expressing them as a percentage of the total unemployed people in Scotland (n=249 074), and the number of low income households, expressing them as