Identifying acute myocardial infarction: effects on treatment and mortality, and implications for National Service Framework audit

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Summary

Background: The National Service Framework (NSF) for Coronary Heart Disease requires annual clinical audit of the care of patients with myocardial infarction, with little guidance on how to achieve these standards and monitor practice.

Aim: To assess which method of identification of acute myocardial infarction (AMI) cases is most suitable for NSF audit, and to determine the effect of the definition of AMI on the assessment of quality of care.

Design: Observational study.

Methods: Over a 3-month period, 2153 consecutive patients from 20 hospitals across the Yorkshire region, with confirmed AMI, were identified from coronary care registers, biochemistry records and hospital coding systems. The sensitivity and positive predictive value of AMI patient identification using clinical coding, biochemistry and coronary care registers were compared to a ‘gold standard’ (the combination of all three methods).

Results: Of 3685 possible cases of AMI singled out by one or more methods, 2153 patients were identified as having a final diagnosis of AMI. Hospital coding revealed 1668 (77.5%) cases, with a demographic profile similar to that of the total cohort. Secondary preventative measures required for inclusion in NSF were also of broadly similar distribution. The sensitivities and positive predictive values for patient identification were substantially less in the cohorts identified through biochemistry and coronary care unit register. Patients fulfilling WHO criteria (n=1391) had a 30-day mortality of 15.9%, vs. 24.2% for the total cohort.

Discussion: Hospital coding misses a substantial proportion (22.5%) of AMI cases, but without any apparent systematic bias, and thus provides a suitably representative and robust basis for NSF-related audit. Better still would be the routine use of multiple methods of case identification.

Introduction

The National Service Framework (NSF) for Coronary Heart Disease requires annual clinical audit of a number of aspects of the management of patients with myocardial infarction, including reperfusion treatment and prescription of secondary preventative therapeutic strategies.1 It sets targets/standards of care, but provides less guidance as to how to achieve these standards and at the same time monitor practice. With the advent of clinical governance, a statutory duty for quality of care is
lodged with hospital Trust Chief Executives. Highly publicized cases such as Bristol and Shipman have painted a bleak picture of hostility, mistrust and falling public regard for doctors and the health care system. \(^2\) Exposure to ‘poor medical care’, as suggested by publicly available hospital league tables, has led to a demand for greater confidence in the accuracy and subsequent analysis of the core data collected. Hospital league tables based on ‘crude data’, have done little to dispel concern that inappropriate comparisons continue to be made, especially with inadequate control for case-mix.\(^3\)-\(^6\) It is likely that such comparisons will continue, given the lack of inclusion of variables into the NSF core dataset that might allow for case-mix correction. The requirement for quality data focuses attention on information abstracted from patient records by clerical staff as part of the hospital discharge coding system. Variations in the completeness and accuracy of abstraction may result in spurious differences in the published results, with inappropriate judgements being made.

The quality of coding information has previously been assessed in relation to stroke diagnosis and surveillance,\(^7\),\(^8\) infectious disease\(^9\) and fibrosing alveolitis.\(^10\) To date, no reports have been published regarding the reliability of acute myocardial infarction data within the NHS. However, unpublished data from Norris and colleagues in the Southern Heart Attack Response (SHARP) Group have shown that the sensitivity of hospital clinical coding to identify cases of AMI defined by conventional criteria was only 80%, with a positive predictive value of 87% (RM Norris, unpublished data, 1999). Studies from the USA and Canada have demonstrated positive predictive values of 92%\(^11\) and 89%,\(^12\) respectively, for AMI identification via coding, with variations in sensitivity apparent between individual centres.\(^13\) Australian studies have shown a sensitivity of 78.9% and a positive predictive value of 65.6% for non-fatal MIs.\(^14\)

The definition applied for myocardial infarction may also affect apparent event rates. In patients aged 65–74 years, the United Kingdom Heart Attack study group demonstrated a 20% shortfall between official rates based on death certification and estimates made according to strict clinical and pathological criteria.\(^15\) Aziz and colleagues recently reviewed their 30-day AMI mortality rates, following concern that figures published by the Department of Health for their centre (Wirral Hospital) ranked them amongst the worst in England.\(^16\) After applying the stricter World Health Organization definition, they found an apparent 37% reduction in AMI 30-day mortality (from 15.5% to 9.7%) in patients aged 35–74 years.

The EMMACE study was commissioned as part of the NHS Research and Development programme, specifically to evaluate contrasting methods of patient identification. Many studies have reported selected data either for patients admitted to coronary care units or for those identified by hospital discharge coding. We wished to evaluate these two approaches to case identification, in addition to a third method based on cardiac enzyme registries from chemical pathology departments. Our intention was to obtain a dataset that was acceptable to clinicians and epidemiologists alike. To contrast with the ‘virtual world’ of patients included in clinical trials, we sought to describe all cases of myocardial infarction consecutively admitted to 20 adjacent, acute hospitals in the UK. EMMACE has also provided a unique opportunity to evaluate the potential usefulness and also the variation in the quality, of discharge coding.

**Methods**

The EMMACE project was supported by a NHS Research and Development grant, being carried out on behalf of the Yorkshire Cardiology Working Group. We obtained ethical approval and the co-operation of all consultants and clinical audit departments in 20 adjacent centres in the former Yorkshire region to which patients with AMI were acutely admitted.

**Patient population**

Patients admitted over a three-month period (1 September to 30 November 1995) to 20 adjacent hospitals in the former Yorkshire Region with suspected acute myocardial infarction, were identified using three independent methods: clinical coding, chemical pathology databases (raised cardiac enzymes) and coronary care unit (CCU) registers. To avoid double counting, only the first episode of admission for acute myocardial infarction was included in the analysis.

**Clinical coding**

Patients admitted with a final primary or secondary diagnosis of AMI (READ code 630 or ICD 10 code I121) were identified via hospital coding computer databases.

**Cardiac enzymes**

Using a manual or computerized search of chemical pathology databases, all patients in whom a measurement of cardiac enzymes (creatinine kinase CK, CK-MB isoenzyme, or LDH/AST) greater than or
equal to twice the upper limit of the local normal range, were identified. The sampling period was extended by three days to 3 December 1995 to permit detection of serial measurements for patients admitted on the last day of the sample period.

**Coronary care unit**

At each centre, the CCU admission book or database was reviewed to identify all patients admitted with a suspected diagnosis of AMI. The majority of centres in our study had separate units designated as a CCU; however, three centres relied on beds in an intensive care setting, and one used monitored beds in a general ward. For the purposes of this study these were also classified as CCU beds.

Data from each source were collected independently from the other sources used. Subsequent case records of all identified patients were sought to permit validation of the AMI diagnosis. A patient was considered valid if the discharge diagnosis of the attending physician stated AMI. Once the diagnosis of AMI was confirmed, data was abstracted by the research assistants (BMJ, CM), using prospectively defined criteria for each variable. Accuracy and reproducibility was assessed by double data abstraction for a 10% sample from each research assistant. The case record forms were further reviewed by the clinical coordinator (RJS) before entry onto a secure database.

The sensitivity and positive predictive values (PPVs) of the different methods of AMI patient identification were ascertained using the three methods combined to produce a ‘gold standard’. The suitability of each method of patient identification was compared using an assessment of inhospital care, in addition to describing variations of such care between individual centres. The capture-recapture technique, based on log linear modelling, was used to estimate the number of patients that may have potentially been missed by all three methods, assuming independence of each method.

The effect of different AMI definitions on the assessment of patient care and outcome was also examined. Patients fulfilling strict World Health Organization criteria were compared to those who were given a final diagnosis of AMI by their attending physician. The ability of each of the three identification methods to detect patients defined by these AMI diagnostic criteria was further evaluated.

**Results**

We identified 3685 patients as possible cases of AMI by one or more of the identification methods; 2153 had either a physician’s final diagnosis of myocardial infarction recorded in the case records or were validated by the researchers as AMI. Of these 2153, clinical coding identified 1668: sensitivity 77.5% (95% CI 76.5–78.4%); specificity 88.6% (95% CI 87.2–90%); PPV 90.8% (95% CI 89.6–91.9%); negative predictive value (NPV) 73.1% (95% CI 71.9–74.2%). The biochemistry database identified 1569; sensitivity 72.9% (95% CI 71.7–74.1%); specificity 23.5% (95% CI 21.8–25.2%); PPV 57.9% (95% CI 57–58.9%); NPV 37.4% (95% CI 34.7–40.2%). The CCU registers identified 1121; sensitivity 52.1% (95% CI 50.9–53.1%); specificity 84.3% (95% CI 82.6–85.8%); PPV 82.7% (95% CI 80.9–84.4); NPV 54.9% (95% CI 53.8–55.9%).

Capture/recapture calculations suggested that approximately 85 cases (95% CI 65–107) were potentially missed by all three sources.

Table 1 shows demographic and risk-factor characteristics, treatment modalities and 30-day mortality of all AMI patients, as well as those identified on the basis of clinical coding, biochemistry records, CCU registries and WHO criteria. Compared to the cohort of all patients, CCU-identified individuals were younger (mean age 67 vs. 71 years), more likely to be male (66% vs. 61%) and had higher rates of thrombolysis (71% vs. 42%) and lower 30-day mortality (20% vs. 24%).

There were no significant differences in the use of secondary preventative strategies (aspirin, beta-blockers, ACE-inhibitors and statins) in patients identified by clinical coding or biochemistry, but a trend towards higher rates of use was identified in the CCU cohort.

Table 2 shows numbers and 30-day mortality for patients fulfilling WHO criteria for AMI, as identified by each audit source. It also details those patients within these criteria that were not revealed by each method. The patients found by CCU or biochemistry registers had a greater proportion fulfilling these criteria (80.5% and 75.8% respectively), compared to coding (66.5%) and the total cohort (64.6%). In all groups, those selected based on WHO criteria had significantly lower 30-day mortality, and were more likely to be male and younger. They were also less likely to have had an in hospital ‘cardiac arrest’, defined as either ‘failed resuscitation’ or ‘found dead but resuscitation not attempted’, compared to those not fulfilling WHO criteria (16.2% vs. 28.5%; p<0.0001 χ²).

There were 567 patients identified by coding, labelled as acute myocardial infarction according to the physicians final diagnosis, but who did not fulfil the WHO criteria. Of these, 163 (28%) died by day 2 and 243 (43%) by day 30. This was significantly
higher than the 30-day mortality rate in WHO-defined patients (15.9%) and in the overall cohort (24.2%). While sudden death was not directly recorded, of the 163 patients dying within the first 2 days following admission, 122 (75%) were labelled as ‘cardiac arrest’ (failed resuscitation or found dead but not resuscitated), 86 (53%) had no preceding cardiac symptoms recorded in the notes and 25 (15.3%) received defibrillation. The majority (65%) of the patients dying by the second day following admission were under the care of general or elderly care physicians, although 14% were surgical patients.

Table 1 Baseline characteristics and crude treatment rates for patients identified by each audit method and by WHO criteria

<table>
<thead>
<tr>
<th>WHO criteria</th>
<th>Clinical coding</th>
<th>CCU register</th>
<th>Cardiac enzymes</th>
<th>All methods</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>1668</td>
<td>1121</td>
<td>1569</td>
<td>2153</td>
<td>1391</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>70.6</td>
<td>67.4</td>
<td>70</td>
<td>70.7</td>
<td>69.0</td>
</tr>
<tr>
<td>Male sex</td>
<td>60%</td>
<td>66%</td>
<td>63%</td>
<td>61%</td>
<td>64.3%</td>
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<tr>
<td>Thrombolysis</td>
<td>45%</td>
<td>71%</td>
<td>45%</td>
<td>42%</td>
<td>57.6%</td>
</tr>
<tr>
<td>30-day mortality</td>
<td>24.4%</td>
<td>20.1%</td>
<td>19.9%</td>
<td>24.2%</td>
<td>15.9%</td>
</tr>
<tr>
<td>Alive at discharge</td>
<td>1261</td>
<td>896</td>
<td>1257</td>
<td>1628</td>
<td>1170</td>
</tr>
</tbody>
</table>

Discharge medication

<table>
<thead>
<tr>
<th>WHO criteria</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>n</td>
<td>1391</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>69</td>
</tr>
<tr>
<td>Male sex</td>
<td>64%</td>
</tr>
<tr>
<td>Thrombolysis</td>
<td>58%</td>
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<tr>
<td>30-day mortality</td>
<td>16%</td>
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<tr>
<td>Total cohort</td>
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</tr>
<tr>
<td>CCU</td>
<td>16%</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>16%</td>
</tr>
<tr>
<td>Coding</td>
<td>15%</td>
</tr>
</tbody>
</table>

Discharge medication

Aspirin 88% 77% <0.001
Beta-blocker 45% 33% <0.001
ACE-inhibitor 39% 33% 0.02
Statin 10% 3% <0.001

Calculation of discharge medication rates is based on the numbers of patients defined by each method and who survived to discharge.

Figure 1 illustrates the relationship between the three audit methods with regard to the identification of patients. Only 35% of all AMI patients were identified by all three methods. Overall, clinical coding identified a greater proportion of AMI patients (77.5%), compared to coronary care unit (52%) and biochemistry registers (73%). Clinical coding also had the lowest rate of false-positive case identification (10%), compared to coronary care unit (17.3%) and biochemistry registers (41.8%).

Figure 2 examines the proportions of patients identified by each audit method in the 20 hospitals studied. A substantial variation across hospitals was seen with all methods used. The percentage of patients identified by CCU registers varied from 20% to 80%, illustrating that in all 20 hospitals, many patients with myocardial infarction (minimum of 20%) were not admitted to a specialist unit. Biochemistry enzyme registers were computerized in all but one hospital (5% of cases identified). Nevertheless, even the best hospital system failed to identify 15% of cases. Discharge coding identified between 30% and 96% of patients with myocardial infarction. Notably, the two hospitals that identified >50% of cases, were the two of the smallest hospitals studied (79 and 30 patients, compared to mean of 108). This probably reflects the relative lack of resources and also perceived low priority for accuracy and completeness of discharge coding, in the NHS in 1996. Subsequent introduction of the National Service Framework for Coronary Artery Disease and also the MI National Audit Project, has since helped to raise the profile of this activity. Nevertheless, these data clearly illustrate the value of using multiple overlapping methods of case identification.
Conclusions

The main purpose of audit is to provide high quality data analyses with which to monitor the required standards and to allow clinicians and other health care providers to evaluate the performance of their units. Complicated risk models adjusting for case-mix are non-utilitarian, and other performance indicators (for example, measurements of successful resuscitation) may be robust comparators, but will not provide the information required for NSF audit. We believe that, in addition to case-mix, which can be simply adjusted for, a uniformity of definition of AMI and audit methodologies needs to be agreed. The recent National Service Framework for Coronary Artery Disease has, to some extent made the latter easier by the development of a core dataset for myocardial infarction. However, the approach to determination of AMI cases needs to be agreed upon. We have shown that three independent methods of identification of AMI patients can lead to significantly differing results. This is particularly demonstrated by the use of the coronary care unit registry for patient identification. If auditors were to restrict themselves to this approach they would identify just over half of the AMI population, consisting of a greater proportion of younger, male patients who had received thrombolysis and whose 30-day mortality was considerably reduced. These individuals also appear to have a trend towards improved secondary preventative therapies.

Identification via biochemistry registers, in particular those based on elevations of the ‘older’ cardiac enzymes (i.e. CK, LDH, AST, etc.) will not rule out those patients with alternative reasons for such raised levels. An audit based on troponin registers might provide a more representative sample population, but at present it is likely that some centres may be measuring troponins only in cases of clinical doubt, and rely to a greater extent on the ‘older’ cardiac enzymes for routine diagnosis. With the advent of the recent consensus document of the joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction, a greater emphasis has been placed on the use of troponins, increasing sensitivity of diagnostic criteria, and potentially resulting in greater identification of AMI cases.

The use of clinical coding as a method of patient identification for audit is probably the least labour-intensive, and picks up the greatest numbers of AMI cases, compared to the other methods used in isolation. When compared to a ‘gold standard’ cohort of patients collectively identified by hospital coding, CCU and biochemistry registers, there appears to be negligible systematic bias in the demographic details, treatment modalities, numbers fulfilling stricter AMI criteria and 30-day mortality rates. Clinical coding missed 1 in 5 patients hospitalized with a subsequent diagnosis on discharge of acute myocardial infarction, but it was the most sensitive and specific of the individual data sources used.

The uptake of treatments prescribed to our cohort of AMI patients is broadly similar to that reported by the UKHAS investigators (1994–1995), who also identified patients via coding. Interestingly, we did identify higher rates of ACE-inhibitor use (36% vs. 30%), presumably a reflection of the gradual
implementation of the increasing evidence base for these compounds at the time.

Each of the three audit methods identified a significant number of cases not revealed by the other two. However, according to the capture-recapture technique, a further 3.6% may have been missed altogether.

The application of clinical trials to day-to-day clinical practice is made particularly difficult when they recruit highly selected patients fulfilling narrow entry criteria and study insufficient end-points to permit study of patient subgroups (e.g. females, the elderly). Similarly, the tighter the diagnostic criteria for AMI used (WHO criteria vs. physicians final diagnosis), the fewer the patients identified, and the lower the mortality. This lower mortality appears to be due, in large part, to fewer cardiac arrests in the WHO-defined group. Conversely, it follows that if cardiac arrest is the presenting symptom of AMI, the WHO criteria are less likely to be fulfilled.

We argue, pragmatically, that it is more sensible to be inclusive, and thus suggest the use of clinical coding based on the physicians final diagnosis, for identification of patients for National Service Framework-related audit. This approach is apparently without systematic bias, and appears easier and less time-consuming than validating to stricter criteria, but does not take into account individual weaknesses of coding systems, clerical interpretation, time delay for coding or the under-funding (or not) of the coding departments. These factors may have been, in part responsible for the variations in pick-up rates of AMI patients by coding seen between our 20 hospitals.

We have evaluated methods for identification of patients with a clinical diagnosis of acute myocardial infarction, based broadly on the WHO definition that requires two of the following to be present: (i) typical chest pain; (ii) progressive diagnostic ECG changes; (iii) raised cardiac enzymes. We have not studied patients who might be classified as having had an acute myocardial infarction based on the more recent definition. Consequently, it may be inappropriate to extrapolate from our observations to consideration of these patients. Furthermore, it is quite likely that the quality of discharge coding procedures will vary both between, and also within (over time) hospitals not included in the EMMACE Study. Nevertheless, we believe that when performed to a high standard, clinical coding at discharge represents an imperfect yet acceptable basis for audit. As the diagnostic precision may vary for conditions other than myocardial infarction, we would not recommend that our specific observations be considered generalizable to other disease states.

Clinical governance provides a framework for improving and safeguarding services to encourage excellence in clinical care. This includes provision of good data and information to allow the highlighting of differences in outcome, shortfalls in standards, comparison between centres and time trends. Its implementation will require not only appropriate adjustment for case-mix, but also an
agreed disease definition and a uniform approach towards AMI patient identification. We suggest that case identification using hospital coding systems represents a robust and representative basis for auditing the quality of routine patient care. Even better than this would be the routine use of multiple methods of case identification.

References


