Age-dependent improvements in survival after hospitalisation with acute myocardial infarction: an analysis of the Myocardial Ischemia National Audit Project (MINAP)

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Abstract

Background: recent studies report an age-dependent decline in mortality after acute myocardial infarction (AMI).
Objective: to investigate age-dependent improvements in survival after hospitalisation with AMI.
Design: population-based cohort study using data from the Myocardial Ischaemia National Audit Project.
Subjects: a total of 583,466 patients with AMI admitted to 247 hospitals between 1 January 2003 and 31 December 2010.
Methods: six-month relative survival (RS) was calculated from the ratio of observed to expected survival using an age-, sex- and biennial year-matched population from the Office for National Statistics. Risk-adjusted mortality rates (RMAR) were estimated using shared frailty regression. Data were stratified by age group, AMI phenotype [(ST-elevation myocardial infarction, STEMI) and non-STEMI, (NSTEMI)] and period of admission to hospital.
Results: for STEMI, there was an increase in RS for patients aged 65–80 years (84.8 versus 89.2%) and those over 80 years (68.0 versus 71.8%), but not for patients aged 18 to <65 years (96.4 versus 96.9%). For NSTEMI patients aged 18 to <65 years RS was higher, but stable (95.5 versus 96.8%) and improved for patients aged 65–80 years (83.2 versus 88.5%) and patients aged >80 years (68.3% versus 75.5%). Likewise, RMAR improved for patients aged ≥65 years, were stable and higher for patients <65 years.
Conclusions: there were significant improvements in survival after hospitalisation with AMI in the older but not younger patients. The scope for further reductions in mortality is likely to be much greater for older than younger patients with AMI.

Keywords: acute myocardial infarction, survival, age, MINAP, older people

Introduction

Recent studies report a decline in early mortality after acute myocardial infarction (AMI). While improvements in quality of care have been described for all age groups [1], it is apparent that there are age-dependent differences in the temporal trends [2, 3]. To date, however, investigations into the impact of age on survival after AMI have been constrained to analyses of all-cause mortality early after hospitalisation. Such approaches, which do not consider longer-term outcomes or adjustment for age-dependent background risk of death, are limited when nowadays mortality rates after AMI approach 5% [4]. Using a national heart attack registry, the Myocardial Ischaemia National Audit Project (MINAP), this study aimed to report age-dependent trends in survival after hospitalisation with AMI over an eight year period.

Materials and methods

Setting and design

This study was based on data on acute coronary syndromes from MINAP, in which participation is mandated for all
hospitals in England and Wales. Each MINAP entry provides details of the patient journey across ~122 fields [5]. Data entry is subject to routine on-line error checking and there is a mandatory annual data validation exercise for each hospital. Data were collected prospectively at each hospital by a secure electronic system, electronically encrypted and transferred on-line to a central database developed by the Central Cardiac Audit Database (CCAD). CCAD is part of the National Clinical Audit Support Programme (NCASP) which is part of the National Institute for Cardiovascular Outcomes Research (NICOR). MINAP is overseen by a multi-professional steering group representing the stakeholders and the NICOR executive [5, 6]. As such, this study includes data, collected on behalf of the British Cardiovascular Society under the auspices of NICOR, in which patient identity is protected.

Patients

The study population (sampling frame) was drawn from 583,466 patients with AMI admitted to one of 247 hospitals. Patients were eligible for study if they were hospitalised between 1 January 2003 and 31 December 2010, aged at least 18 years and had at least 6-month follow-up to all-cause death or censorship. For those with multiple admissions, we used the earliest record. The AMI phenotype was categorised as ST-elevation myocardial infarction (STEMI) and non-STEMI (NSTEMI). The diagnosis of STEMI and NSTEMI was made by local clinicians using their judgement of presenting symptoms, clinical examination and the results of investigations recorded in MINAP. Patients were also categorised into three groups according to age on admission (i) young 18 to <65 years, (ii) old 65–80 years and (iii) older >80 years, respectively. Temporal trend analyses were performed by comparing period of admission to hospital for the following biennial calendar years: 2003–4, 2005–6, 2007–8 and 2009–10.

Follow-up and mortality

We determined 6 month all-cause death rates from the date of hospitalisation through linkage to the Office for National Statistics (ONS) by the Medical Research Information System, part of the National Health Service (NHS) Information Centre, using each patient’s unique NHS number.

Statistical analysis

Characteristics of the study population were determined using estimated proportions and 95% confidence intervals (CIs). For survivors of the hospital stay, drug combinations were computed as following: (i) dual antiplatelet therapy (DAPT) with aspirin and clopidogrel, (ii) three-drug treatment with aspirin or clopidogrel and beta-blockers and (iii) five-drug treatment with aspirin, clopidogrel, beta-blockers, statin and ACE inhibitors [7]. Relative survival to 6 months was calculated from the ratio of observed to expected survival using an age-, sex- and calendar period-matched population from the Office for National Statistics UK interim life-tables [8, 9]. Excess mortality was calculated as the difference between the expected and observed (un-adjusted) survival estimates.

We also estimated adjusted survival using Weibull-accelerated failure-time regression models [10]. The models were fitted by age group, sex, type of AMI and by the provision of evidence-based care in hospital. Adjustments were made for variables from the mini-GRACE risk score (which includes admission systolic blood pressure and heart rate; electrocardiographic ST-segment deviation, cardiac arrest and elevated cardiac enzymes, chronic renal failure and chronic heart failure) [11]. As there was a higher prevalence of diabetes mellitus among patients overtime, adjustment was also made to incorporate this factor. To account for variation at the hospital-level, random-effects (shared frailty) models were fitted [12]; this assumed that, patients admitted to the same hospital experienced a similar quality of care. Model outputs were used to estimate risk-adjusted mortality rates (RAMR). All analyses were conducted using STATA IC version 12.0 (Stat Corp LP, TX, USA).

Ethics

NICOR, which includes MINAP (Ref: NIGB: ECC 1-06 (d)/2011), has support under section 251 of the NHS Act 2006. Under NHS research governance arrangements, formal ethical approval was not required for this study.

Results

There were 240,090 (41.1%) patients with STEMI and 343,376 (58.9%) patients with NSTEMI. Younger aged 18 to <65 years more frequently were male (79.2%) and had a diagnosis of STEMI (53.2%). Patients aged >80 years were more often female (53.4%) and NSTEMI (72.6%).

Patient characteristics by period of admission and age group

Table 1 shows that from 2003 to 2010, the prevalence of diabetes mellitus, chronic renal failure and a history of previous AMI increased. Notably, patients were also more frequently admitted under a care of Consultant Cardiologist. For patients who survived the hospital stay, there was an increase in the prescription of secondary preventative medication on discharge. For instance, the five-drug combination increased between 2003 and 2010 although the three-drug combination was the most frequent over the study period.

The characteristics of the patients discharged according to their age group are summarised in Table 2. From 2003 to 2010, older compared with the younger patients presented more frequently with co-morbid conditions, including chronic heart failure, chronic renal failure and previous AMI, but less often had prior percutaneous coronary intervention (PCI). During the hospital stay, older compared with
the younger patients were less likely to be admitted to a Coronary Care Unit, be under the care of a Consultant Cardiologist and less frequently received evidence-based medications after hospital discharge than younger patients.

Results demonstrated that although the prescription of medications increased over the study period, older patients were least likely to receive either combined or individual drugs (Tables 1 and 2).

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Table 1. Patient characteristics by period of admission to hospital

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Period of admission to hospital proportion (95% confidence interval), %</th>
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<tbody>
<tr>
<td>AMI phenotype</td>
<td></td>
</tr>
<tr>
<td>STEMI</td>
<td>43.4 (43.1–43.7)</td>
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<tr>
<td>NSTEMI</td>
<td>56.6 (56.3–56.9)</td>
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<tr>
<td>Past medical history</td>
<td></td>
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<tr>
<td>Diabetes mellitus</td>
<td>12.1 (11.9–12.2)</td>
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<tr>
<td>Chronic heart failure</td>
<td>4.7 (4.6–4.8)</td>
</tr>
<tr>
<td>Chronic renal failure</td>
<td>2.5 (2.4–2.5)</td>
</tr>
<tr>
<td>Previous PCI</td>
<td>3.7 (3.6–3.8)</td>
</tr>
<tr>
<td>Previous AMI</td>
<td>19.5 (19.3–19.7)</td>
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<tr>
<td>In-hospital management</td>
<td></td>
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<tr>
<td>First ward: coronary care unit</td>
<td>55.9 (55.7–56.2)</td>
</tr>
<tr>
<td>First ward: cardiology</td>
<td>3.5 (3.4–3.6)</td>
</tr>
<tr>
<td>Admitting consultant: cardiologist</td>
<td>32.8 (32.6–33.1)</td>
</tr>
<tr>
<td>Median (IQR) length of stay, days</td>
<td>7 (7)</td>
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<tr>
<td>Medications at discharge from hospital</td>
<td></td>
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<tr>
<td>Aspirin</td>
<td>93.7 (93.5–93.8)</td>
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<tr>
<td>Clopidogrel</td>
<td>47.2 (45.7–48.7)</td>
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<tr>
<td>Beta-blockers</td>
<td>87.0 (86.8–87.2)</td>
</tr>
<tr>
<td>ACE-inhibitors</td>
<td>82.6 (82.4–82.9)</td>
</tr>
<tr>
<td>Statin</td>
<td>88.3 (88.2–88.8)</td>
</tr>
<tr>
<td>Two-drug combination (DAPT)</td>
<td>45.3 (43.8–46.8)</td>
</tr>
<tr>
<td>Three-drug combination</td>
<td>80.8 (80.6–81.0)</td>
</tr>
<tr>
<td>Five-drug combination</td>
<td>74.3 (74.1–74.6)</td>
</tr>
</tbody>
</table>

Table 2. Patient characteristics by age group

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Age group proportion (95% confidence interval), %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;65 years</td>
</tr>
<tr>
<td>AMI phenotype</td>
<td></td>
</tr>
<tr>
<td>STEMI</td>
<td>53.2 (52.9–53.4)</td>
</tr>
<tr>
<td>NSTEMI</td>
<td>46.8 (46.6–47.1)</td>
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<tr>
<td>Past medical history</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>13.3 (13.2–13.5)</td>
</tr>
<tr>
<td>Chronic heart failure</td>
<td>1.6 (1.5–1.6)</td>
</tr>
<tr>
<td>Chronic renal failure</td>
<td>1.7 (1.6–1.7)</td>
</tr>
<tr>
<td>Previous PCI</td>
<td>8.2 (8.0–8.3)</td>
</tr>
<tr>
<td>Previous AMI</td>
<td>15.8 (15.6–15.9)</td>
</tr>
<tr>
<td>In hospital management</td>
<td></td>
</tr>
<tr>
<td>First ward: coronary care unit</td>
<td>64.0 (63.8–64.2)</td>
</tr>
<tr>
<td>First ward: cardiology</td>
<td>5.9 (5.8–6.0)</td>
</tr>
<tr>
<td>Admitting consultant</td>
<td>51.1 (50.9–51.4)</td>
</tr>
<tr>
<td>Median (IQR) length of stay, days</td>
<td>5 (4)</td>
</tr>
</tbody>
</table>
Relative survival trends

Based on life table estimates, the expected 6-month survival was 99.8, 98.6, and 94.4% for patients aged 18 to <65, 65–80 and >80 years, respectively. The excess 6-month mortality was 4.1, 13.7 and 30.0% for STEMI patients aged 18 to <65, 65–80 and >80 years, respectively. The excess 6-month mortality was 4.0, 14.1 and 26.9% for NSTEMI patients aged 18 to <65, 65–80 and >80 years, respectively.

Figure 1 shows that for STEMI, compared with the patients aged <65 years (96.4% in 2003–04 versus 96.9% in 2009–10) where no survival difference was noted over the study period, patients aged 65–80 years (84.8% in 2003–04 versus 89.2% in 2009–10) and >80 years (68.0% in 2003–04 versus 71.8% in 2009–10) demonstrated a significant improvement in survival rates. Similar trends were seen for patients with NSTEMI. Patients aged <65 years had higher but stable survival rates (95.5% in 2003–04 versus 96.8% in 2009–10) compared with patients aged 65–80 years (83.2% in 2003–04 versus 88.5% in 2009–10) and patients aged >80 years (68.3% in 2003–4 versus 75.5% in 2009–10).

Adjusted survival trends

Age-dependent improvements in 6-month adjusted survival were consistent with those of the relative survival estimates. For STEMI, RAMR (95% CI) remained stable at 97.0% (96.9–97.0%) for patients aged 18 to <65 years and 74.1% (73.9–74.4%) for patients aged >80 years. There were, however, improvements in RAMR (95% CI) from 87.5% (87.2–87.7%) in 2003–04 to 89.2% (89.0–89.4%) in 2009–10 for STEMI patients aged 65–80 years.

For NSTEMI, RAMR (95% CI) was 96.2% (96.1–96.3%) in 2003–04 and 96.9% (96.9–97.0%) in 2009–10 for patients aged 18 to <65 years. Patients aged 65–80 years showed improvements in adjusted 6-month survival (95% CI) from 86.3% (86.1–86.4%) in 2003–04 to 89.3% (89.2–89.4%) in 2009–10. Adjusted 6-month survival (95% CI) also improved from 74.4% (74.1–74.7%) in 2003–4 to 77.6% (77.4–77.7%) in 2009–10 for patients aged >80 years.

Discussion

This study is one of the first to use both parametric and relative survival analysis to consider temporal trends in the 6-month outcomes of patients hospitalised with AMI. It is also one of few to stratify the analyses by age group and AMI phenotype. In doing so, it has shown that though there were improvements in 6-month survival in England and Wales between 2003 and 2010; such improvements were not consistent across all patient cohorts. That is, the survival rates in younger patients with AMI were high and did not demonstrate improvements over time. In contrast, older patients with AMI had lower rates of survival, but demonstrated significant improvements. Therefore, the scope for further reductions in mortality is likely to be much greater for older than younger patients with AMI.

Although the provision of medications for the management of AMI increased over the study period, we found that there were age-dependent differences in the rates of prescription. We found, as with others, that the older patients were less likely to receive guideline recommended evidence-based treatments for the management of AMI [2, 13]. Data from a large observational study conducted in Portugal revealed that evidence-based medicines were more likely to be offered to younger patients with a mean difference of ~20% between young and old patients [7]. Several studies have shown that
the failure to provide such interventions is associated with higher mortality rates and greater morbidity [15–17]. This study highlights that there is a risk-treatment paradox in the older population with AMI [13]. This is important when those at higher risk have more to gain, than those at lower risk, from guideline recommended therapies [18] and when inconsistencies in quality of care may be construed as avoidable years of life lost due to ischaemic heart disease [19].

The GRACE risk score is a tool [20] recommended by the National Institute for Health and Care Excellence (NICE), European Society of Cardiology and in the North American guidelines for the evaluation of patients with an acute coronary syndrome [21,22]. These international guidelines recommend specific care interventions stratified by an estimated level of risk. Our investigation shows that the older population, who by virtue of their age are higher risk [23], were less likely to receive recommended therapies. This, in turn, was associated with lower survival estimates and higher excess mortality. While some patients may not have received care interventions based because it was not deemed appropriate by healthcare professionals, this study excluded cases if the medication was contra-indicated, not applicable, not indicated or the treatment declined, we only studied patients who were eligible for care. It is probable, therefore, that the older patients in this study were not formally risk stratified and consequently not offered guideline recommended care. A more systematic application of a risk scoring system to all patients hospitalised with AMI may enhance the provision of evidence-based therapies and reduce mortality.

For younger patients (aged 18 to <65 years) with AMI, survival was excellent and remained essentially unchanged over time. With this in mind it is probable that, within the bounds of currently available interventions, a performance plateau in survival has been achieved for this group [6]. It is likely that only with much greater advances in treatments for AMI (such as for the management of cardiogenic shock) that a reduction in mortality rates will ensue among this group. On the other hand, compared with the background population, there were improvements in survival over time among patients aged 65 and over. Indeed, the improvements in survival among patients aged 80 years and over contests the plateau in survival has been achieved for this group [6]. It is possible that a temporal change in diagnostic thresholds have led to a lower risk cases of AMI [29] and this may have impacted on improvements in survival rates. Indeed, we noted a shift in the proportions of STEMI to more NSTEMI in the latter years. As with any national registry, missing data are evident in MINAP. The results of this study were, however, confirmed through missing data sensitivity analysis and as previously reported using MINAP; missingness does not substantially alter the model effects or clinical interpretation [30]. Although life status was missing for 3.3% of patients, there were no substantial differences in the age distribution of these patients.

**Conclusion**

For patients hospitalised with AMI in England and Wales between 2003 and 2010, improvements in 6-month survival were age dependent. In contrast to younger patients with AMI (aged <65 years), older patients (aged 65 years and over) demonstrated significant improvements in survival rates. However, older patients, in whom survival and excess mortality was higher than among younger patients, were less likely to receive evidence-based medications. Further reductions in mortality are likely to be much greater for older than younger patients with AMI and this may be achievable through the systematic application of international guideline recommended risk score tools.

**Key points**

- Temporal improvements in survival after AMI are age dependent.
- Survival among patients aged <65 years was high and remained unchanged overtime.
- Survival among patients aged >65 was lower than in patients aged <65 years, but improved over time.
- There were age-dependent inequalities in the provision of evidence-based care.
- A reduction in inequalities in the provision of guideline recommended therapies for the management of AMI may allow further improvements in the survival of patients aged >65 years who are hospitalised with AMI.

**Strengths and limitations**

This study is one of the first to demonstrate that relative survival has an important application in cardiovascular health sciences research, particularly in the study of survival in older patients [25]. This is because survivorship after acute coronary syndrome is increasing and the over half of the cases of acute coronary syndrome who present to hospital are older people [26]. The results of this study are supported by its large sample size. Even so, there are limitations to our research. MINAP does not capture every case of AMI in England and Wales [27] or record information on all patient characteristics that may have influenced treatment decisions or outcomes. MINAP is, however, except for the Swedish heart attack registry [28], the only country in the world with continuous national recording of ACS mandated in all hospitals [5]. It is possible that a temporal change in diagnostic thresholds have led to a lower risk cases of AMI [29] and this may have impacted on improvements in survival rates. Indeed, we noted a shift in the proportions of STEMI to more NSTEMI in the latter years. As with any national registry, missing data are evident in MINAP. The results of this study were, however, confirmed through missing data sensitivity analysis and as previously reported using MINAP; missingness does not substantially alter the model effects or clinical interpretation [30]. Although life status was missing for 3.3% of patients, there were no substantial differences in the age distribution of these patients.
Conflicts of interest

None declared.

Ethical approval

The National Institute for Cardiovascular Research (NICOR) which includes the Myocardial Ischaemia National Audit project (MINAP) (Ref: NIGB: ECC 1-06 (d)/2011) has support under section 251 of the National Health Service (NHS) Act 2006. Ethical approval was not required under NHS research governance arrangements for the project.

Funding

MINAP is funded by the Health Quality Improvement Partnership (HQIP). C.P.G. is funded by the National Institute for Health Research (NIHR/CS/009/004) as a Clinician Scientist and Honorary Consultant Cardiologist. No specific funding was received for this study. All authors are independent of their funding.

Study design

Cohort study.

References


Received 18 September 2013; accepted in revised form 30 October 2013

National audit of continence care: adherence to National Institute for Health and Clinical Excellence (NICE) Guidance in older versus younger adults with faecal incontinence

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Abstract

Background: previous UK National Audits of Continence Care showed low rates of assessment and treatment of faecal incontinence (FI) in older people.

Objective: the 2009 audit assessed adherence to the National Institute for Health and Clinical Excellence guidelines on management of FI and compared care in older versus younger patients.

Methods: fifteen older (65+) and 15 younger (18–65) patients with FI were to be audited in hospital (inpatient or outpatient), primary care (PC) and care home sites.

Results: data were submitted for n = 2,930 cases from 133 hospitals, n = 1,729 from 97 PC surgeries and n = 693 from 63 care homes. Bowel history was not documented in 41% older versus 24% younger patients in hospitals and 27 versus 19% in care homes.