ORIGINAL ARTICLE

Closing the mortality gap after a myocardial infarction in people with and without chronic obstructive pulmonary disease

Kieran J Rothnie, Liam Smeeth, Emily Herrett, Neil Pearce, Harry Hemingway, Jadwiga Wedzicha, Adam Timmis, Jennifer K Quint

ABSTRACT

Objective Patients with chronic obstructive pulmonary disease (COPD) have increased mortality following myocardial infarction (MI) compared with patients without COPD. We investigated the extent to which differences in recognition and management after MI could explain the mortality difference.

Methods 300 161 patients with a first MI between 2003 and 2013 were identified in the UK Myocardial Ischaemia National Audit Project database. Logistic regression was used to compare mortality in hospital and at 180 days postdischarge between patients with and without COPD. Variables relating to inhospital factors (delay in diagnosis, use of reperfusion and time to reperfusion/use of angiography) and use of secondary prevention were sequentially added to models.

Results Mortality was higher for patients with COPD both in hospital (4.6% vs 3.2%) and at 180 days (12.8% vs 7.7%). After adjusting for inhospital factors, the effect of COPD on inhospital mortality after MI was reduced for both ST-elevation myocardial infarctions (STEMIs) and non-STEMIs (STEMIs OR 1.24 (95% CI 1.10 to 1.41) to 1.13 (95% CI 0.99 to 1.29); non-STEMIs OR 1.34 (95% CI 1.24 to 1.45) to 1.16 (95% CI 1.07 to 1.26)).

Conclusions Delayed diagnosis, timing and use of reperfusion treatment or β blockers after an MI, and that not prescribing β blockers to patients with COPD impacts on mortality. Little is known about potential differences in prescribing of other secondary prevention medicines, inhospital treatment or on the effects that any differences in these potentially modifiable factors may have on mortality.

METHODS

Data source The MINAP database is a registry of all admissions for MI and other ACS to hospitals in the UK. The dataset includes information on patient demographics, comorbidities, drugs on admission, initial diagnosis, final diagnosis, inhospital drug treatment, timing of reperfusion therapies, inhospital outcome and drugs given on discharge.

We included all patients with a first diagnosis of ST-elevation myocardial infarction (STEMI) from January 2003 to June 2013 or non-ST-elevation myocardial infarction (non-STEMI) from January 2004 to December 2012. Records were excluded if they did not have a patient unique identifier, if patients had missing values for presence of obstructive airway disease or smoking history or if Office of National Statistics (ONS) mortality data were missing.

INTRODUCTION

People with chronic obstructive pulmonary disease (COPD) are at higher risk of cardiovascular disease and are known to have poorer medium and longer-term outcomes after myocardial infarction (MI) compared with people without COPD, however, findings for inhospital mortality have been mixed. The heterogeneity in findings on inhospital mortality may be due to differences in treatment practices. COPD is currently the third leading cause of death worldwide. As up to one-third of deaths in people with COPD are due to cardiovascular disease, reducing deaths after MI in this population is important. In addition, there is a lack of evidence for the effectiveness of treatments in those with comorbidities.

Recent years have seen improvements in outcomes for patients after MI. However, several recent studies have continued to report poorer mortality for patients with COPD after an MI. Although the reasons for increased mortality after MI in patients with COPD are likely to include biological factors related to COPD, differences in recognition and management between patients with and without COPD may play a role. Recent work has demonstrated that patients with COPD are less likely to receive reperfusion treatment or β blockers after an MI, and that not prescribing β blockers to patients with COPD impacts on mortality.

Little is known about potential differences in prescribing of other secondary prevention medicines, inhospital treatment or on the effects that any differences in these potentially modifiable factors may have on mortality.

METHODS

Data source The MINAP database is a registry of all admissions for MI and other ACS to hospitals in the UK. The dataset includes information on patient demographics, comorbidities, drugs on admission, initial diagnosis, final diagnosis, inhospital drug treatment, timing of reperfusion therapies, inhospital outcome and drugs given on discharge.
Exposure identification

The obstructive airway disease variable in MINAP does not differentiate between COPD and asthma. In order to identify patients with COPD for this analysis, a strategy was developed and tested in a subset of the data linked with data from the Clinical Practice Research Datalink (CPRD). CPRD is a large UK clinical database of primary care medical records which includes over 5.5 million active patients (8% of the population). Around half of the CPRD records have been linked to the MINAP database through the CALIBER linkage scheme. Patients with COPD can be identified in CPRD through the use of validated diagnostic codes. Using this subset of linked data, we developed a strategy for identifying COPD patients in MINAP using CPRD-identified COPD as a reference standard. In this subset of data, patients with COPD were identified using a combination of MINAP-recorded obstructive airway disease and a smoking history (ex or current smoker). This strategy resulted in adequate identification of patients with COPD in MINAP with agreement of 90.9%.

Outcome definitions

Recognition and management

Delay in diagnosis of MI, reperfusion after a STEMI, use of angiography in hospital after a non-STEMI and discharge on secondary prevention drugs were investigated. Two definitions of delay in diagnosis were investigated for patients with a final diagnosis of STEMI: (1) delay in diagnosis of definite STEMI (defined as those who did not have an initial diagnosis of definite STEMI) and (2) delay in diagnosis of ACS (defined as those whose initial diagnosis was not STEMI, probable MI or ACS). For those patients with a final diagnosis of non-STEMI, one definition for delay in diagnosis was investigated: delay in diagnosis of ACS (defined as those whose initial diagnosis was not STEMI, probable MI or ACS).

Mortality outcomes

The UK ONS collects data on all recorded deaths in England and Wales. MINAP is linked with ONS mortality data, which provides data on vital status at 180 days postdischarge. Mortality at 180 days postdischarge was assessed for those who survived until discharge.

Statistical analysis

Demographic and clinical characteristics were tabulated for patients with COPD and non-COPD patients. All analyses were stratified by type of MI (STEMI or non-STEMI). The models were adjusted for smoking status, age, sex and calendar year, comorbidities including prior angina, cerebrovascular disease, chronic kidney failure, diabetes, congestive heart failure, hypertension, hyperlipidaemia, peripheral vascular disease, previous percutaneous coronary intervention (PCI) and previous coronary artery bypass graft and cardiovascular drugs (ACE inhibitor or angiotensin receptor blocker, β blocker, statin and thienopyridine) use on admission. Following the suggested practice for missing data in MINAP missing values for comorbidities and drugs on admission were recoded to ‘no’. Other variables were not recoded and analyses were conducted on the basis of complete case analysis. Data were analysed using Stata V.13.0. Analysis was conducted in three parts:

1. Describing the problem: differences in mortality after MI between patients with COPD and non-COPD patients
2. Possible inhospital explanations: differences in recognition and management after an MI between patients with COPD and non-COPD patients
3. Accounting for differences in mortality after MI between patients with COPD and non-COPD patients in terms of hospital processes

In order to investigate to what extent differences in diagnosis and treatment of patients with COPD after an MI might account for differences in mortality, variables relating to inhospital processes investigated in (2) were sequentially added to mortality models created in (1) with reference to a directed acyclic graph (see online supplementary material). Attributable risk of death due to COPD following MI was calculated before and after adjustment for inhospital processes using the formula (OR-1)/OR x 100.

RESULTS

Characteristics of participants

Of the 300 146 patients with first MI identified over the period, 34 027 (11.3%) had COPD. The inclusion and exclusion of records in the MINAP database are detailed in figure 1. The characteristics of the patients included in the study are detailed in table 1. Mortality was higher for patients with COPD both inhospital (4.6% vs 3.2%) and at 180 days (12.8% vs 7.7%).

ST-elevation myocardial infarctions

1. Describing the problem: differences in mortality after MI between patients with COPD and non-COPD patients

After adjusting for age, sex, smoking status, calendar year, comorbidities and drugs on arrival, mortality in patients with COPD was higher than non-COPD patients in hospital (OR 1.24, 95% CI 1.10 to 1.41), and 180 days after discharge (OR 1.45, 95% CI 1.33 to 1.59).

2. Possible inhospital explanations: differences in recognition and management after an MI between patients with COPD and non-COPD patients

Differences in diagnosis and inhospital recognition management are presented in table 2. Patients with COPD who had a STEMI were more likely to have an initial diagnosis other than definite STEMI (OR 1.24, 95% CI 1.19 to 1.30) or ACS (OR 1.32, 95% CI 1.42 to 1.62). After a STEMI, patients with COPD were less likely to have pPCI (OR 0.87, 95% CI 0.83 to 0.92). There was no evidence that patients with COPD were less likely to receive thrombolysis (OR 0.96, 95% CI 0.91 to 1.10).

In adjusted results, differences in time to reperfusion have been expressed in terms of exponentiated linear regression coefficients which, in this case, represent ratios of geometric means. The relationship between COPD and time to reperfusion was found to be different depending on whether diagnosis of MI was delayed (p value for interaction <0.001). The median time to reperfusion was 43.7 min longer for patients with COPD compared with non-COPD patients among those who had a delay in diagnosis (median time to reperfusion 152.9 min (IQR, 1104...
74.3–705.6 min) for patients with COPD, and 109.2 min (IQR, 50.2–260.0 min) for non-COPD patients. This difference remained on adjusted analysis and corresponded to 47% (95% CI 15% to 88%) longer time to reperfusion for patients with COPD with delayed diagnosis of MI, compared with non-COPD patients with delayed diagnosis of MI. There was no difference in time to reperfusion between patients with COPD and non-COPD patients among those without a delay in diagnosis (see details in online supplementary appendix). Patients with COPD were less likely to receive any of the secondary prevention drugs, apart from thienopyridines, on discharge compared with non-COPD patients, β blockers significantly more so than other drugs (OR 0.26 (95% CI 0.25 to 0.27)).

3. Accounting for differences in mortality after MI between patients with COPD and non-COPD patients in terms of hospital processes

When compared with the result found in (1), inhospital mortality was reduced after adjusting separately for both diagnostic delay (OR 1.20 (95% CI 1.06 to 1.36)) and time to reperfusion and use of pPCI (OR 1.11 (95% CI 0.94 to 1.31; table 3)). After adjusting for all inhospital factors, the OR for mortality was 1.13 (95% CI 0.99 to 1.29). For mortality at 180 days, the OR was 1.45 (95% CI 1.33 to 1.59) after adjusting for age, sex, smoking, calendar year, drugs used on admission and comorbidities, and was 1.45 (95% CI 1.31 to 1.61) after additionally adjusting for diagnostic delay, use of pPCI and time to reperfusion. Adjusting for use of secondary prevention drugs on discharge substantially reduced ORs for 180 day mortality compared with models only adjusting for inhospital factors (OR 1.25 (95% CI 1.11 to 1.41)).

After adjusting for inhospital processes, the estimated attributable risk of inhospital death following a STEMI due to COPD in patients with COPD decreased from 19.4% (95% CI 9.1% to 29.1%) to 11.5% (95% CI −1.0% to 22.4%). After adjusting for inhospital processes, the estimated attributable risk for death at 180 days due to COPD in patients with COPD following a STEMI decreased from 31.0% (95% CI 24.8% to 37.1%) to 20.0% (95% CI 9.9% to 29.1%).

Non-ST-elevation myocardial infarctions

1. Describing the problem: differences in mortality after MI between patients with COPD and non-COPD patients

After adjusting for age, sex, smoking status, calendar year, comorbidities and drugs on arrival, mortality in patients with COPD was higher than non-COPD patients in hospital (OR 1.34 (95% CI 1.24 to 1.45)) and 180 days after discharge (OR 1.56 (95% CI 1.47 to 1.65)).

2. Possible inhospital mechanisms: differences in diagnosis and management after an MI between patients with COPD and non-COPD patients

Results from the comparison of treatment and diagnosis after a non-STEMI are presented in table 4. Patients with COPD were more likely to have an initial diagnosis other than ACS after a non-STEMI (OR 1.46 (95% CI 1.41 to 1.50)). After a non-STEMI, patients with COPD were less likely to receive angiography in hospital (OR 0.69 (95% CI 0.66 to 0.71)).
Patients with COPD were less likely to receive any of the secondary prevention drugs on discharge, apart from thienopyridines, compared with non-COPD patients, β blockers significantly more so than other secondary prevention drugs (OR 0.25 (95% CI 0.24 to 0.25)).

3. Accounting for differences in mortality after MI between patients with COPD and non-COPD patients in terms of hospital processes

When compared with results found in (1), inhospital mortality was reduced after adjusting separately for both delay in diagnosis (OR 1.29 (95% CI 1.19 to 1.39)) and use of angiography (OR 1.18 (95% CI 1.09 to 1.29); table 5). After adjusting for both delay in diagnosis and use of angiography the OR for inhospital mortality seemed to explain some of the mortality difference after a non-STEMI at 180 days. For mortality at 180 days, the OR was reduced from 1.56 (95% CI 1.47 to 1.65) to 1.37 (95% CI 1.31 to 1.44). Use of secondary prevention also seemed to explain some of the gap in mortality at 180 days. Compared with the model which only adjusted for inhospital processes, the OR for mortality at 180 days, the OR was reduced from 1.37 (95% CI 1.31 to 1.44) to 1.26 (95% CI 1.17 to 1.35).

After adjusting for inhospital processes, the estimated attributable risk for inhospital death following a non-STEMI due to COPD in patients with COPD decreased from 25.4% (95% CI 19.4% to 31.0%) to 13.8% (95% CI 6.5% to 21.6%). After adjusting for inhospital processes, the estimated attributable risk for death at 180-days due to COPD in patients with COPD following a non-STEMI decreased from 35.9% (95% CI 32.0% to 39.4%) to 20.6% (95% CI 14.5% to 25.9%).

**DISCUSSION**

**Summary of main findings**

For STEMs, some of the in inhospital mortality difference between patients with COPD and non-COPD patients may be attributable to delays in diagnosis and use of and increased time to...
We also showed that the effect of delay in diagnosis of MI on time to reperfusion was greater in patients with COPD compared with non-COPD patients. Patients with COPD were more likely to have a delay in diagnosis and the effect of this delay in diagnosis in time to reperfusion was more severe for them than non-COPD patients. The reason for the delay in diagnosis of MI in patients with COPD may be because symptoms of MI in patients with COPD may be incorrectly attributed to their COPD rather than an MI.

We found that after a non-STEMI, patients with COPD were less likely to receive angiography in hospital than non-COPD patients, and this explained some of the excess inhospital and 180-day mortality. This may explain the increased inhospital mortality in hospital that we found for non-STEMIs at longer time periods up to 6 months may be attributable to decreased use of secondary prevention medicines, especially β blockers, but not in hospital processes. For non-COPD, some of the difference in inhospital mortality may be attributable to delays in diagnosis and decreased use of angiography shortly after MI. Some of the increased mortality for non-STEMIs at longer time periods up to 6 months may be attributable to decreased use of secondary prevention medicines, and to inhospital delays in diagnosis and decreased use of angiography in hospital.

**Interpretation and comparison with other studies**

Several studies have shown both the increased risk for death following MI for people with COPD and differences in management. These studies specifically showed reduced use of secondary prevention and pPCI after a STEMI in patients with COPD, and we also showed that the effect of delay in diagnosis of MI on time to reperfusion was greater in patients with COPD compared with non-COPD patients. Patients with COPD were more likely to have a delay in diagnosis and the effect of this delay in diagnosis in time to reperfusion was more severe for them than non-COPD patients. The reason for the delay in diagnosis of MI in patients with COPD may be because symptoms of MI in patients with COPD may be incorrectly attributed to their COPD rather than an MI.

We found that after a non-STEMI, patients with COPD were less likely to receive angiography in hospital than non-COPD patients, and this explained some of the excess inhospital and 180-day mortality. This may explain the increased inhospital mortality in hospital that we found for non-STEMIs at longer time periods up to 6 months may be attributable to decreased use of secondary prevention medicines, especially β blockers, but not in hospital processes. For non-COPD, some of the difference in inhospital mortality may be attributable to delays in diagnosis and decreased use of angiography shortly after MI. Some of the increased mortality for non-STEMIs at longer time periods up to 6 months may be attributable to decreased use of secondary prevention medicines, and to inhospital delays in diagnosis and decreased use of angiography in hospital.

**Table 2** Differences in recognition and treatment of STEMIs between patients with COPD and non-COPD patients

<table>
<thead>
<tr>
<th>Inhospital treatment and diagnosis</th>
<th>COPD (N %)</th>
<th>Non-COPD (N %)</th>
<th>Unadjusted OR (95% CI)</th>
<th>Minimally adjusted OR (95% CI)</th>
<th>Adjusted OR (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial diagnosis other than definite STEMI (for final diagnosis is STEMI)</td>
<td>3080 (23.9)</td>
<td>24 752 (19.9)</td>
<td>1.26 (1.21 to 1.32)</td>
<td>1.23 (1.23 to 1.34)</td>
<td>1.24 (1.19 to 1.30)</td>
</tr>
<tr>
<td>Initial diagnosis other than ACS</td>
<td>1186 (9.2)</td>
<td>7398 (6.0)</td>
<td>1.59 (1.50 to 1.71)</td>
<td>1.68 (1.64 to 1.73)</td>
<td>1.52 (1.42 to 1.62)</td>
</tr>
<tr>
<td>Primary PCI</td>
<td>4108 (31.8)</td>
<td>44 177 (35.6)</td>
<td>0.84 (0.81 to 1.87)</td>
<td>0.69 (0.67 to 0.71)</td>
<td>0.87 (0.83 to 0.92)</td>
</tr>
<tr>
<td>Thrombolysis</td>
<td>5449 (42.6)</td>
<td>52 414 (42.7)</td>
<td>0.99 (0.96 to 1.03)</td>
<td>1.00 (0.96 to 1.03)</td>
<td>0.96 (0.91 to 1.10)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time to reperfusion</th>
<th>COPD (median IQR)</th>
<th>Non-COPD (median IQR)</th>
<th>Unadjusted exponentiated regression coefficient (95% CI)</th>
<th>Minimally adjusted exponentiated regression coefficient (95% CI)</th>
<th>Adjusted exponentiated regression coefficient (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to reperfusion from admission (overall)</td>
<td>37.1 (21.8–67.7)</td>
<td>35.0 (21.8–63.4)</td>
<td>1.07 (1.04 to 1.09)</td>
<td>1.05 (1.03 to 1.07)</td>
<td>1.04 (1.02 to 1.07)</td>
</tr>
<tr>
<td>Time to reperfusion from admission (initial diagnosis other than STEMI)</td>
<td>152.9 (74.3–705.6)</td>
<td>109.2 (50.2–260.0)</td>
<td>1.44 (1.24 to 1.67)</td>
<td>1.35 (1.16 to 1.58)</td>
<td>1.47 (1.15 to 1.88)</td>
</tr>
<tr>
<td>Time to reperfusion from admission (initial diagnosis STEMI)</td>
<td>35.0 (21.8–63.4)</td>
<td>35.0 (21.8–61.2)</td>
<td>1.04 (1.01 to 1.06)</td>
<td>1.03 (1.01 to 1.05)</td>
<td>1.03 (1.00 to 1.05)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discharge treatment</th>
<th>COPD (n (%))</th>
<th>Non-COPD (n (%))</th>
<th>Unadjusted OR (95% CI)</th>
<th>Minimally adjusted OR (95% CI)</th>
<th>Adjusted OR (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge on β blockers</td>
<td>5776 (44.7)</td>
<td>94 784 (76.4)</td>
<td>0.25 (0.24 to 0.26)</td>
<td>0.25 (0.24 to 0.26)</td>
<td>0.26 (0.25 to 0.27)</td>
</tr>
<tr>
<td>Discharge on ACE inhibitor or angiotensin receptor blocker</td>
<td>9579 (74.2)</td>
<td>96 508 (77.8)</td>
<td>0.83 (0.79 to 0.86)</td>
<td>0.87 (0.83 to 0.91)</td>
<td>0.89 (0.85 to 0.93)</td>
</tr>
<tr>
<td>Discharge on aspirin</td>
<td>10 344 (80.1)</td>
<td>102 925 (82.9)</td>
<td>0.83 (0.79 to 0.87)</td>
<td>0.87 (0.83 to 0.92)</td>
<td>0.90 (0.85 to 0.94)</td>
</tr>
<tr>
<td>Discharge on statin</td>
<td>10 373 (80.4)</td>
<td>102 785 (82.8)</td>
<td>0.85 (0.81 to 0.89)</td>
<td>0.88 (0.84 to 0.93)</td>
<td>0.91 (0.86 to 0.95)</td>
</tr>
<tr>
<td>Discharge on thienopyridine</td>
<td>7799 (60.4)</td>
<td>77 543 (62.5)</td>
<td>0.91 (0.88 to 0.95)</td>
<td>0.96 (0.92 to 1.01)</td>
<td>0.98 (0.94 to 1.03)</td>
</tr>
</tbody>
</table>

*Adjusted for age, sex, smoking status and year.
†Adjusted for age, sex, smoking status, calendar year, drugs on admission and comorbidities.

ACS, acute coronary syndromes; COPD, chronic obstructive pulmonary disease; STEMI, ST-elevation myocardial infarction.

**Table 3** Mortality after STEMI

<table>
<thead>
<tr>
<th>Model</th>
<th>Adjusted for age, sex, smoking status and year</th>
<th>Adjusted for model 1 variables and drugs on arrival</th>
<th>Adjusted for models 1 and 2 variables and diagnostic delay</th>
<th>Adjusted for models 1 and 2 variables and use of reperfusion and time to reperfusion</th>
<th>Adjusted for models 1–4 variables and secondary prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR (95% CI)</td>
<td>Adjusted for model 1 (Model 2)</td>
<td>Adjusted for models 1 and 2 (Model 3)</td>
<td>Adjusted for models 1–4 (Model 5)</td>
<td>Adjusted for models 1–4 (Model 6)</td>
<td>Adjusted for models 1–4 (Model 6)</td>
</tr>
<tr>
<td>Adjusted</td>
<td>1.27 (1.16 to 1.39)</td>
<td>1.24 (1.10 to 1.41)</td>
<td>1.20 (1.06 to 1.36)</td>
<td>1.11 (0.94 to 1.31)</td>
<td>1.13 (0.99 to 1.29)</td>
</tr>
</tbody>
</table>

All Odds ratios compare patients with COPD with non-COPD patients.
COPD, chronic obstructive pulmonary disease; STEMI, ST-elevation myocardial infarction.

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180-day mortality. Use of angiography is driven by risk scoring, and patients at moderate and higher risk of death within 6 months should be offered angiography within 96 h of admission to hospital after a non-STEMI.\(^\text{19}\) It is unclear why, as a population, although patients with COPD are at a higher risk of mortality they are less likely to receive angiography in hospital.

After both STEMI and non-STEMI, patients with COPD were less likely to be prescribed secondary prevention medicines than non-COPD patients. This may only have been to a clinically relevant degree for β blockers. It is known that patients with COPD are less likely to be prescribed β blockers after an MI, and that prescribing them improves survival.\(^\text{11}\) This study has demonstrated that the increased mortality associated with not prescribing secondary prevention medicines could explain some of the mortality gap up to 6 months at the population level.

We found that recognition of MI in patients with COPD was impaired compared with non-COPD patients. However, all patients included in this analysis were eventually diagnosed with MI. This suggests that patients with COPD may be at higher risk of having a completely missed MI. Indeed, recent work has suggested that as many as 1 in 12 patients admitted to hospital would have been collected. In addition, ideally information on COPD severity and cause of death would have been collected from all hospitals in the UK which admit patients for ACS. As secondary prevention treatment is known to be different for patients with COPD compared with non-COPD patients, only using first MIs allowed us to assess the effect of COPD on mortality after an MI without bias due to differences in previous treatment. Another strength of this study was our ability to separate factors which could explain increased inhospital mortality from increased mortality following discharge. If patients with COPD were more likely to die in hospital, as we found, the reasons that they did not receive certain treatments may have been because they were more likely to die before they received these treatments compared with non-COPD patients. In order to avoid this bias, for mortality at 180 days, we only analysed data for those who had survived until at least discharge. This also allowed the potential contribution of secondary prevention to the mortality gap to be investigated.

One of the limitations of this study is potential misclassification of COPD status. The strategy used to identify may have misclassified asthmatic smokers as patients with COPD, and may have misclassified patients with COPD as non-COPD patients. However, the prevalence of COPD in our study is similar to that of previous work in similar settings.\(^\text{3,10,16,22}\) The presence of asthmatics in our COPD group and patients with COPD in the non-COPD group is likely to have biased our findings towards the null. However, this would not change our findings. In addition, a sensitivity analysis, which compared mortality for asthmatic patients compared with non-asthmatic patients found that mortality was not increased in the asthmatic group (see online supplementary material). One of the limitations of using an audit database such as MINAP is the lack of available data which would not have been collected at hospital admission. Ideally, information on COPD severity and cause of death would have been collected. In addition, ideally information on socioeconomic status would have been available as this is a

**Table 4** Differences in recognition and inhospital treatment of non-STEMIs between patients with COPD and non-COPD patients

<table>
<thead>
<tr>
<th>Discharge treatment</th>
<th>COPD N (%)</th>
<th>Non-COPD N (%)</th>
<th>Unadjusted OR (95% CI)</th>
<th>Minimally adjusted OR* (95% CI)</th>
<th>Adjusted OR (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial diagnosis other than MI</td>
<td>9551 (45.2)</td>
<td>50 365 (35.5)</td>
<td>1.50 (1.46 to 1.54)</td>
<td>1.68 (1.64 to 1.73)</td>
<td>1.46 (1.41 to 1.50)</td>
</tr>
<tr>
<td>Angiography in hospital</td>
<td>8629 (40.9)</td>
<td>74 304 (52.2)</td>
<td>0.77 (0.76 to 0.79)</td>
<td>0.63 (0.61 to 0.65)</td>
<td>0.69 (0.66 to 0.71)</td>
</tr>
<tr>
<td>Discharge on β blockers</td>
<td>6632 (31.4)</td>
<td>925 059 (64.9)</td>
<td>0.25 (0.24 to 0.26)</td>
<td>0.24 (0.23 to 0.25)</td>
<td>0.25 (0.24 to 0.25)</td>
</tr>
<tr>
<td>Discharge on ACE inhibitor or angiotensin receptor blocker</td>
<td>12 762 (60.4)</td>
<td>89 368 (63.0)</td>
<td>0.90 (0.87 to 0.92)</td>
<td>0.91 (0.88 to 0.94)</td>
<td>0.94 (0.91 to 0.97)</td>
</tr>
<tr>
<td>Discharge on aspirin</td>
<td>15 234 (72.1)</td>
<td>106 652 (75.1)</td>
<td>0.86 (0.83 to 0.88)</td>
<td>0.88 (0.85 to 0.91)</td>
<td>0.87 (0.84 to 0.94)</td>
</tr>
<tr>
<td>Discharge on statin</td>
<td>15 141 (71.7)</td>
<td>104 804 (73.8)</td>
<td>0.87 (0.87 to 0.93)</td>
<td>0.90 (0.87 to 0.93)</td>
<td>0.90 (0.87 to 0.93)</td>
</tr>
<tr>
<td>Discharge on thienopyridine</td>
<td>11 277 (53.4)</td>
<td>78 233 (55.1)</td>
<td>0.90 (0.87 to 0.93)</td>
<td>0.95 (0.91 to 0.96)</td>
<td>0.97 (0.94 to 1.01)</td>
</tr>
</tbody>
</table>

*Adjusted for age, sex, smoking status and calendar year.†Adjusted for age, sex, smoking status, calendar year, drugs on admission and co-morbidities. COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; STEMI, ST-elevation myocardial infarction.

**Table 5** Mortality after non-STEMI. All ORs compare patients with COPD with non-COPD patients

<table>
<thead>
<tr>
<th>Discharge treatment</th>
<th>COPD N (%)</th>
<th>Non-COPD N (%)</th>
<th>Unadjusted OR (95% CI)</th>
<th>Minimally adjusted OR* (95% CI)</th>
<th>Adjusted OR (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhospital mortality</td>
<td>1.40 (1.30 to 1.52)</td>
<td>1.34 (1.24 to 1.45)</td>
<td>1.29 (1.19 to 1.39)</td>
<td>1.18 (1.09 to 1.29)</td>
<td>1.16 (1.07 to 1.26)</td>
</tr>
<tr>
<td>180-day mortality</td>
<td>1.63 (1.56 to 1.70)</td>
<td>1.56 (1.47 to 1.65)</td>
<td>1.45 (1.38 to 1.52)</td>
<td>1.43 (1.34 to 1.50)</td>
<td>1.37 (1.31 to 1.44)</td>
</tr>
</tbody>
</table>

*Adjusted for age, sex, smoking status and calendar year.†Adjusted for age, sex, smoking status, calendar year, drugs on admission and co-morbidities. COPD, chronic obstructive pulmonary disease; STEMI, ST-elevation myocardial infarction.
potential confounder for the relationship between COPD and mortality after MI. Future studies should investigate the relationship between COPD severity and explanations for the mortality gap in patients with COPD after MI and cause of death in patients with COPD following MI.

Conclusions
Patients with COPD appear to receive poorer treatment after an MI compared with non-COPD patients. These differences in recognition and treatment of MI seem to explain some of the mortality gap between patients with COPD and non-COPD patients both in-hospital and at 6 months postdischarge. Delayed diagnosis, timing and use of reperfusion of a STEMI, use of angiography after a non-STEMI and use of secondary prevention medicines are all potential explanations for the mortality gap after MI in people with COPD.

What is already known on this subject?
People with chronic obstructive pulmonary disease (COPD) have both a higher risk for myocardial infarction (MI) and poorer long-term outcomes following MI. Previous studies have also shown that patients with COPD are less likely to receive β blockers on discharge after an MI and are less likely to receive PCI after an ST-elevation myocardial infarction (STEMI). Findings for differences in inhospital mortality have been mixed, with some studies finding higher mortality for patients with COPD and some studies finding no difference. The heterogeneity in findings may be due to differences in treatment practices. The extent to which differences in treatment can explain differences in mortality at the population level, the ‘mortality gap’, is unclear.

What might this study add?
This study aimed to determine whether differences in inhospital treatment and discharge between patients with and without COPD could explain all or some of the difference in mortality for both in-hospital and at 180 days postdischarge at the population level. We found that delayed diagnosis of MI, decreased use of reperfusion and increased time to reperfusion after a STEMI, decreased use of angiography after a non-STEMI and decreased use of secondary prevention medicines might all explain some of the mortality gap for people with COPD after an MI.

How might this impact on clinical practice?
We have found that differences in potentially modifiable inhospital processes may explain some of the mortality gap between patients with and without COPD after an MI. Clinicians need to be aware that it may be easier to miss MI in people with COPD and may need to be aware of more unusual presentations of MI in people with COPD. In addition, our results suggest that patients with COPD may benefit from more aggressive treatment after an MI.

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6Herrett E, Smeeth L, Walker L, et al. Myocardial Ischaemia National Audit Project (MINAP) database. MINAP data are available for research purposes from the National Institute for Cardiovascular Outcomes Research upon application to the MINAP Academic Group.

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REFERENCES


Supplementary appendix

Sensitivity analyses

As a sensitivity analysis, mortality after an MI was investigated comparing those who, for the purposes of this study, we presumed had asthma (those with a record of obstructive airway disease but no smoking history).

Additional analysis in optimal and sub-optimal care groups

We also compared mortality at 180 days for COPD patients and non-COPD patients within strata of optimal care, adjusted for age, sex, year, smoking status and co-morbidities. For STEMI, patients were categorised as having optimal care if they had no delay in diagnosis, use of reperfusion and use of secondary prevention. For non-STEMI, patients were categorised as having optimal care if they had no delay in diagnosis, use of angiography in-hospital, and use of secondary prevention. Sub-optimal care was defined as any factor missing from optimal care. We compared optimally treated COPD patients to optimally treated non-COPD patients; and non-optimally treated COPD patients to non-optimally treated non-COPD patients. We also compared mortality between those with optimal care and non-optimal care at 180 days among COPD patients.

Results

Difference in time to reperfusion between COPD patients and non-COPD patients among those without a delay in diagnosis

The difference in time to reperfusion between COPD and non-COPD patients was not apparent among patients who did not have a delay in diagnosis (median time to reperfusion 35.0 minutes (IQR, 21.8-63.4) for COPD patients, and 35.0 minutes (IQR, 21.8-61.2) for non-COPD patients).
Adjusted analysis also showed no difference in time to reperfusion for COPD patients compared to non-COPD patients among those who did not have a delay in diagnosis (ratio of geometric means 1.03, 95% CI 1.00 to 1.05).

**Sensitivity analysis with asthmatic patients**

When in-hospital mortality after an MI was investigated for people who we presume to have asthma were compared to non-asthmatics, no difference in mortality was found in analysis adjusted for age, sex, smoking status, calendar year, co-morbidities and drugs on arrival (OR 1.05, 95% CI 0.89-1.24 for STEMIs; OR 1.05, 95% CI 0.91-1.22 for non-STEMIs).

**Additional analysis in optimal and sub-optimal care groups**

After a STEMI, the effect of COPD on mortality at 180 days in the non-optimal care group (OR 1.39, 1.29-1.51; non-optimally treated COPD patients compared to non-optimally treated non-COPD patients) was comparable to that in the optimal care group (OR 1.44, 1.08-1.94; optimally treated COPD patients compared to optimally treated non-COPD patients). After a non-STEMI, the effect of COPD on mortality at 180 days in the non-optimal care group (OR 1.53, 1.45-1.61; non-optimally treated COPD patients compared to non-optimally treated non-COPD patients) was lower than that in the optimal care group (OR 1.80, 1.36-2.37; optimally treated COPD patients compared to optimally treated non-COPD patients). Among COPD patients, having optimal treatment was associated with lower risk of death at 180 days after both a STEMI (OR 0.31, 0.23-0.42; optimally treated COPD patients compared to non-optimally treated COPD patients) and a non-STEMI (OR 0.34, 0.26-.43; optimally treated COPD patients compared to non-optimally treated COPD patients).