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Patient, health service factors and variation in mortality following resuscitated out-of-hospital cardiac arrest in acute coronary syndrome: Analysis of the Myocardial Ischaemia National Audit Project☆

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ABSTRACT

Aims: To determine patient and health service factors associated with variation in hospital mortality among resuscitated cases of out-of-hospital cardiac arrest (OHCA) with acute coronary syndrome (ACS).
Methods: In this cohort study, we used the Myocardial Ischaemia National Audit Project database to study outcomes in patients hospitalised with resuscitated OHCA due to ACS between 2003 and 2015 in the United Kingdom. We analysed variation in inter-hospital mortality and used hierarchical multivariable regression models to examine the association between patient and health service factors with hospital mortality.
Results: We included 17604 patients across 239 hospitals. Overall hospital mortality was 28.7%. In 94 hospitals that contributed at least 60 cases, mortality by hospital ranged from 10.7% to 66.3% (median 28.6%, IQR 23.2% to 39.1%)). Patient and health service factors explained 36.1% of this variation.

After adjustment for covariates, factors associated with higher hospital mortality included increasing serum glucose, ST-Elevation myocardial infarction (STEMI) diagnosis, and initial admission to a primary percutaneous coronary intervention (pPCI) capable hospital. Hospital OHCA volume was not associated with mortality. The key modifiable factor associated with lower mortality was early reperfusion therapy in STEMI patients.
Conclusion: There was wide variation in inter-hospital mortality following resuscitated OHCA due to ACS that was only partially explained by patient and health service factors. Hospital OHCA volume and pPCI capability were not associated with lower mortality. Early reperfusion therapy was associated with lower mortality in STEMI patients.

Introduction

Across Europe, the annual incidence of treated out-of-hospital cardiac arrest (OHCA) is 49 cases per 100,000 population [1]. Acute coronary syndrome (ACS) is a common cause of OHCA; where OHCA cause is recorded, approximately 76% of cases are attributed to cardiac aetiology [2]. Variation in OHCA mortality has been described between countries, Emergency Medical Service (EMS) systems and admitting hospitals [1–3].

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Regional cardiac arrest centres have been proposed as a strategy to reduce inter-hospital variation in OHCA mortality, but the quality of evidence supporting the concept is low [4,5]. Regionalised care systems are based on the premise that the benefit of immediate admission to a hospital with specialist facilities and expertise outweighs any risk associated with a potentially increased transport time. Such systems are already established in major trauma and stroke [6,7].

In OHCA, improved understanding of inter-hospital variation in mortality is essential to improve understanding of the potential value of regionalised care systems. The availability in England and Wales of the only nation-wide ACS registry (Myocardial Ischaemia National Audit Project, MINAP) provides a unique opportunity to better understand these factors. Our study objective was to identify if there was evidence of inter-hospital variation in mortality among resuscitated cases of OHCA caused by ACS in the UK, and to identify the patient and health service factors that might contribute to any variation.

Methods

Data source

MINAP is a national registry of patients admitted to hospital with acute coronary syndromes. Established in 1998, it provides a mechanism for participating hospitals to benchmark performance against national standards [8]. MINAP participation is mandatory, with all acute hospitals in England and Wales participating since 2003. Detailed care quality and clinical outcome data are collected at the hospital level, with entry validated through real-time checks and an annual hospital data validation review. This study linked MINAP to UK Office of National Statistics (ONS) data to provide information on patient social deprivation and enrich mortality data. MINAP identifies patients using their unique NHS number, which is pseudo-anonymised in the database. Patient identifiers (for example, date of birth) are encrypted prior to transfer to the central database, and are not released to researchers.

Patient eligibility

In this study, we included adult patients in the MINAP dataset where the initial cardiac arrest event occurred in the pre-hospital setting and where initial resuscitation attempts were successful leading to hospital admission. We excluded non-index (second or subsequent) cardiac arrests, events where the initial cardiac arrest event occurred in the in-hospital setting, and patients where the primary outcome was unknown.

Data definitions

For hospital-level data (volume, primary percutaneous coronary intervention (pPCI) capability, EMS distance), patients were categorised by the hospital to which they were first admitted. For hospital volume, the number of OHCA cases in each year at each hospital was calculated. Each patient was allocated to a volume category (low: 1–10 cases; medium: 11–24 cases; high: $\geq$25 cases) based on the hospital and year in which they were treated. We categorised patients as being treated in a pPCI capable hospital if it performed at least 100 pPCI procedures across all patients in the MINAP dataset in the year that the patient was admitted, as per UK guidance [9]. EMS distance was calculated as the Euclidian distance between the patient's home address and hospital. This assumed the OHCA event occurred at the patient's home, which is true for over 80% of UK OHCAs [2].

Reperfusion treatment was categorised as early or late. Thrombolysis was classified as early if call-to-needle time was up to 60 min, based on UK national standards [10]. PPCI was classified as early if door-to-balloon time was up to 90 min, based on the MINAP benchmark [11].

For sub-group analyses, we categorised patients, based on the MINAP variable 'ECG determining treatment,' as having STEMI (ST-elevation acute myocardial infarction or presumed new left bundle branch block (LBBB)) or NSTEACS (non-ST Elevation Acute Coronary Syndrome, which included all patients that did not meet the STEMI definition including unstable angina patients).

Outcome measures

The primary outcome was all-cause hospital mortality, as recorded in the MINAP dataset or, where this was incomplete, cross-referencing with ONS mortality data.

Sample size

Preliminary data supplied by MINAP led to a projected sample size of 14,310 eligible OHCA cases with a projected hospital mortality of 24%. Based on this, we calculated a 4% difference in mortality between categories within a predictor variable could be detected reliably with at least 90% power and a significance level of 0.05.

Statistical analysis

Multiple imputation using chained equations was used to reduce the bias associated with missing data in predictor variables (Supplementary Data Table S1), based on the approach used in previous MINAP analyses [12,13]. Case identification and sub-group allocation was undertaken prior to imputation. Twenty-five imputed datasets were generated.

After imputation, an unadjusted random effects logistic regression model was fitted to predict hospital mortality and obtain the estimate for the log of the odds ratio and the standard error for each imputed dataset. The inclusion of a random effects term for the hospital enabled variation between hospitals to be modelled. Estimates from each of the 25 imputed datasets were combined using the Rubin's rules to get an overall odds ratio estimate of mortality, 95% confidence interval and p-value [14]. We adopted a similar approach for the adjusted analysis. The model included all clinically relevant predictor variables, unless there was evidence of multi-collinearity due to two predictors being highly correlated or a variable was clearly confounded by an unmeasured variable.

Alongside data from the whole cohort, we report data from STEMI and NSTEACS sub-groups, and sensitivity analyses (complete case; admission between 2003 and 2008; admission between 2009 and 2015). This sensitivity analysis cut-off reflects the year (2009) that pPCI became the most commonly recorded reperfusion treatment in MINAP [11].

Data processing and descriptive analyses pre-imputation were performed using SPSS version 22 (IBM Corp, Armonk, NY, USA). The R statistical program (R: A language and environment for statistical computing, R development core team; R Foundation for Statistical Computing, Vienna, Austria) and associated packages (MICE and gamm4 packages) were used for multiple imputation, descriptive analysis after multiple imputation, and fitting models for hospital mortality.

Ethics/approvals

The study was undertaken in accordance with the Declaration of Helsinki. The University of Warwick Biomedical Research Ethics Committee approved the study. MINAP, as part of the National