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The effect of day of the week on short- and long-term mortality for emergency general surgery: a population-based cohort study

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ABSTRACT

Background: The effect of day of the week on outcome after hospital admission and elective surgery is the subject of debate. We sought to determine if day of the week of emergency general surgery alters short- and long-term mortality.

Methods: Observational study of all patients undergoing emergency general surgery in Scotland between 1 January 2005 and 31 December 2007, followed to 2012. Multilevel logistic and Cox proportional hazards regression were used to assess the effect of day of the week of surgery on outcome after adjustment for case-mix and risk factors. Primary outcome was perioperative mortality; secondary outcome was overall survival.

Results: We identified 50 844 patients, of whom 31 499 had an emergency procedure on Monday to Thursday and 19 345 on Friday to Sunday. Patients undergoing surgery at the weekend were younger (47.5 vs. 45.9 years; $p<0.001$) and had fewer comorbidities, but underwent riskier/more complex procedures ($p<0.001$). Patients operated on at the weekend were more likely to have been operated on sooner compared with weekday surgery (1.2 vs. 1.6 days; $p<0.001$). No difference in perioperative mortality (odds Ratio [OR] 1.00; 95% confidence interval [CI] 0.89−1.13; p=0.989) or in overall survival (hazard ratio [HR] 1.01; 95% CI 0.97-1.06, p=0.583) was observed if surgery was performed at the weekend. No difference in overall survival was associated with any particular day of surgery when compared to Wednesday, although a borderline lower perioperative mortality was seen on a Tuesday.

Conclusion: We did not demonstrate any significant difference in short- or long-term mortality following emergency general surgery at the weekend when compared to mid-week.

INTRODUCTION

Over 310 million surgical procedures are carried out worldwide each year (1) and this figure has increased rapidly over the last decade.(2) Estimates of overall perioperative mortality are low and estimated to be around 0.8% in the developed world.(3) However this is not the case in emergency general surgery where for certain procedures such as emergency laparotomy, higher mortality rates have been reported. Over a third of all surgical procedures carried out in the UK are classified as emergencies and mortality is increased 8-fold when compared to elective surgery.(4) Many more patients suffer complications which increase long-term mortality and costs.(5) Evidence exists of variation in surgical outcome between healthcare facilities (4,6) and organisational factors are implicated in the reasons for this. In particular, day of surgery or hospital admission has been associated with a worse outcome and remains a subject of intense debate.

North American and UK studies have demonstrated an association with mortality in patients undergoing elective surgery on Friday versus Monday, Tuesday or Wednesday.(7,8) An Australasian study showed increased mortality in patients admitted to the Intensive Care Unit (ICU) at the weekend compared with weekdays.(9) Similar effects have been described in other areas of healthcare including in-hospital cardiac arrest,(10) obstetrics,(11) and stroke.(12) In addition there is evidence suggesting increased mortality following emergency surgery associated with staffing levels and number of critical care beds, relative to provider size, which might be reduced at the weekend.(13)

For a “weekend effect” to exist in observational studies, patients presenting to hospital at weekends must either be sicker, care must be worse, or inadequate adjustment for confounding must exist. Organisational factors such as processes of care cannot be easily studied in clinical trials and observational studies must be relied upon. Moreover, the consequences of poor care at weekends might not be limited to short-term survival. Post-operative complications have been associated with poorer long-term survival. (4)

The aim of this study was to extend the current debate by addressing the following hypothesis: if patient care at the weekend were poor, this would be reflected in higher early mortality after emergency surgery together with poorer long-term survival resulting from increased morbidity. This is explored using high quality linked data including case-mix adjustment and access to reliable long-term outcomes.

METHODS

Ethics, Sponsorship and Indemnity

The Chairs of South East Scotland Research Ethics Committees 01 and 02 reviewed the study protocol and waived the need for a full ethics submission. The study underwent review by Information Services Division's Privacy Advisory Committee, which undertakes the role of Caldicott guardianship (Reference PAC 58/11). NHS Lothian acted as the study sponsor.

Patient Involvement

Patients were not involved directly with the design or conduct of this study, however a recent joint National Institute of Academic Anaesthesia and James Lind Alliance research priority setting exercise identified improvement of emergency surgical care as one of the top ten research priorities.(14)

Study Population and Data Sources

We used a cohort study design with data held by Information Services Division (ISD) Scotland. We extracted a complete record of surgical inpatient cases managed in Scotland between 1st Jan 2005 and 31st Dec 2007 from the ISD Scottish Morbidity Record (SMR01) database, with follow-up data until 30th September 2012. All adult patients undergoing inpatient general surgery were eligible for inclusion in this study. The Operating Procedure Coding System-4.2 (OPCS) (15) was used to identify general surgical procedures. For patients with more than one admission with an included surgical procedure during the three-year study period, we used only the first admission. The study was performed in accordance with the Strengthening the reporting of observational studies in epidemiology (STROBE) guidelines.(16)

The ISD database was internally consistent. We have previously validated these data (17) and on-going audit of diagnosis and operation codes performed centrally shows high accuracy.(18) We determined patient death with direct matching between patient episode data and records from the Registrar General of Scotland.

Factors and co-variables

For each patient a full data extract was requested including age, sex, deprivation status (measured using quintiles of the Scottish Index of Multiple Deprivation),(19) surgical OPCS code, surgical status (elective vs. emergency classification), ICD10 (international classification of diseases, 10th revisions) diagnosis code, date of surgery, date of admission, and number of hospital admissions in the 5 years before the index hospital admission.

ICD10 codes were used to define diagnosis (malignant, trauma/injury, other). Models of co-morbidity scoring were explored using disease codes from ICD10. No single method resulted in better model performance. In final models, we used a count of co-morbidities that constitute the Charlson comorbidity index.(20) Operative complexity was defined as per the BUPA Schedule of Procedures.(21)

A mortality risk associated with each specific operation was determined and applied using data from Hospital Episode Statistics (HES). HES data are summary, population level data available from NHS administrative records in England. From this aggregate data, a summary of mortality rates by procedure during 2009 to 2010 was obtained as the most recent available, procedure level data. Procedures included in the study were identified and classified according to their 30-day mortality rate into pre-defined strata of low (<1%), moderate (1 to 9.9%) and high (>10%) risk groups. Season was defined by admission date (December to February, March to May, June to August, and September to November). Time to surgery was defined in whole days by procedure date minus admission date.

Day of week of procedure or admission was defined both for individual days (reference Wednesday) and as a binary variable (Monday-Thursday versus Friday-Sunday), as previously reported.

Outcomes measures

The primary outcome measure was *perioperative mortality*, defined as death occurring within 30 days of the index procedure or after 30 days but before hospital discharge. Time from surgery until death from any cause was termed *overall survival*.

Sensitivity Analysis

Two sets of sensitivity analyses were performed. In the first, we examined short- and long-term outcomes by *day of the week of admission* in patients having emergency general surgery. In the second, we examined *day of the week of procedure* for patients having *any* emergency surgical procedure (expanded emergency surgery cohort included procedures performed in orthopaedics, ear/nose/throat (ENT), gynaecology, ophthalmology, thoracic surgery and spinal surgery, while excluding cardiac surgery, neurosurgery, transplantation and the surgical management of burns).

Statistical Analysis

We examined initial univariable associations for categorical and continuous predictors respectively. Fixed effect binary logistic regression models were explored using variables determined to be statistically and clinically important. Variable selection methods incorporated likelihood ratio methods and overall model fit as determined by the Akaike Information Criterion (AIC). Health board of treatment was included as a random effect (random intercept) to account for patient clustering in final multilevel models. Predictive performance was quantified by the area under the receiver operator characteristic curve (c statistic). Bootstrap methods were used to derive confidence intervals in multilevel models unless otherwise indicated.

Cox proportional hazards regression was used to model overall survival. Health board was included as a random effect (frailty). The underlying hazard function was assessed graphically and seen to be constant, and no time dependent variables were specified. We assessed all two-way interactions which were included in final models if significant.

Normally distributed data was reported as mean (standard deviation [SD]) and non-normally distributed data as median (interquartile range [IQR]). All p-values were two-tailed and significance was set at $p<0.05$. All analyses were undertaken using STATA 13 (STATACorp, College Station, TX, USA) and R (R Foundation, Vienna, Austria).

RESULTS

Cohort

The initial study cohort consisted of 1 014 796 patients who had undergone a surgical procedure during the study period (Figure 1). This initial cohort excluded obstetrics, cardiac surgery, neurosurgery, transplantation and the surgical management of burns. Following exclusion of records relating to second or subsequent admissions, patients aged under the age of 16 years, patients with non-surgical or diagnostic procedural codes, patients with discordant operative or death dates and patients undergoing elective surgery, 104 416 patients remained. Following further restriction to patients having "general" surgical procedures i.e. abdominal or gastrointestinal procedures, or procedures on breast, endocrine or soft tissue, 50 844 patients remained in the final cohort. Records and dates of death ranged from the 3rd January 2005 to the 30th September 2012. Four-year follow up was available for all patients. 1468 (2.9%) patients died prior to hospital discharge and 5755 (11.3%) patients died before the end of the 4-year follow-up period.

Demographics and outcome

Patients undergoing surgery at the weekend were more likely to be male (11828 [61.1%] vs 18613 [59.1%]; p<0.001) to be younger (45.9 vs. 47.5 years; p<0.001) and have fewer comorbidities (Table 1). There were also differences in the type and complexity of surgery carried out, with more high-risk and complex surgery taking place at the weekend. Patients admitted at the weekend we more likely to be operated on sooner compared with weekday admission (1.2 vs. 1.6 days; p<0.001).

Mortality and survival analyses

In univariable analyses of the whole cohort, an association was seen between perioperative mortality and each of increasing age, female sex, Charlson co-morbidity score, deprivation, prior elective or emergency admission, diagnosis of cancer, operative risk, operative complexity, and season of admission (December to February) (Supplementary Table 2). Multilevel models confirmed that age, sex, comorbidity, deprivation, diagnosis, and operative risk/complexity were the most strongly associated with mortality.

In either univariable or multilevel models, no association was seen between weekend surgery and perioperative mortality (odds Ratio [OR] 1.00; 95% confidence interval [CI] 0.89−1.13; p=0.989) (Figure 2, Supplementary Table 2) or overall survival (hazard ratio [HR] 1.00; 95% CI 0.96-1.04, p=0.950) (Figure 2, Supplementary Figure 1, Supplementary Table 3). Similarly, when comparing each day of the week of surgery to Wednesday, no association was seen between weekend days and perioperative mortality or overall survival (Figure 2, supplementary tables 4 and 5). A borderline effect was seen with an apparent lower perioperative mortality on a Tuesday compared with Wednesday (supplementary table 4); the significance of this is not clear.

Sensitivity analysis

We repeated the above analysis for day of week of hospital admission. Admission on a weekend was associated with a numerically higher perioperative mortality (581/19 370 [3.0%] vs 887/31 474 [2.8%]), however this was not significant in univariable or multilevel models (OR 1.14; 95% CI 0.98-1.30; p=0.130) (Figure 2, Supplementary Table 6) or overall survival (HR 1.01; 95% CI 0.97-1.06; p=0.583) (Figure 3, Supplementary Table 7).

Perioperative mortality was lower in patients admitted on Tuesday (OR 0.80 95% CI 0.65-0.99; p=0.044) compared with Wednesday, however again no pattern through the week was observed (Figure 2, Supplementary table 8). No association was seen between overall survival and any particular day of admission compared to Wednesday (Figure 3, Supplementary Figure 2, Supplementary Table 9).

In a second set of sensitivity analyses, we repeated this investigation on all emergency surgical procedures, i.e. including other surgical specialties such as orthopaedics and gynaecology. No difference in perioperative mortality or overall survival was demonstrated between procedures carried out at weekends or during the week (Supplementary Tables 10-13).

DISCUSSION

In a cohort of over 50 000 patients undergoing emergency general surgery, no association was seen between day of the week of surgery and short- or long-term mortality in well-performing case-mix adjusted models. In our study, patients admitted at weekends were more likely to be operated on sooner than those admitted during the week. No patterns of association were seen between perioperative mortality or overall survival through the week for surgery or admission to hospital; a borderline lower perioperative mortality for surgery performed on a Tuesday may be spurious. In further sensitivity analyses in an expanded cohort of 104 016 patients undergoing emergency surgery, no association between day or surgery or admission and death was could be found.

The so-called “weekend effect” of increased mortality and complications associated with inpatient care on Saturday and Sunday has been reported in observational studies of emergency hospital admission,(22,23) surgery,(8,13,24) obstetrics,(11) and ICU admission (9) and our study challenges this belief. Commentators suggest that the availability of expertise and resources at the weekend, in particular access senior medical staff, may explain this phenomenon. However, it is important to consider not only the day of surgical procedure, but also the day of admission and the days on which postoperative care are delivered. A study of emergency general surgical admission UK hospitals suggested that increased mortality at the weekend persisted after adjustment for hospital structure and care process. More recently published research from the field of stroke medicine has suggested that the entire concept of “weekend effect” may be an oversimplification of complex patterns of variation in the quality of care which are spread over the entire week.(25)

The possibility of systematic bias or unmeasured confounding in observational studies of administrative data remains.(26) The former can be due issues with the quality of data collection, such as coding issues with Hospital Episodes Statistics data in the UK, or in exclusive use of data pertaining to certain subgroups of patients, such as Medicare, Non-Federal Acute Care, or Veterans Affairs databases, in the United States. Data completeness, quality, and the availability of data linkage for robust long-term outcomes are clearly also important. Study heterogeneity exists in approaches to aggregating data, for instance, whether Friday should be considered within the weekend group and different studies have used different definitions. Unmeasured confounding may arise from patient factors for which investigators are unable to adjust for using statistical modelling techniques. Particular issues, which have been raised in this setting, are patient selection and the possibility that patients undergoing surgery at the weekend have increased severity of illness than those presenting on weekdays. In emergency surgery the absence of diagnostic and physiological case-mix adjustment, which is routinely carried to benchmark cardiac surgery(27) and intensive care(28) outcomes, means this possibility cannot be excluded.

The results of our study contrast with two recent studies of surgical care surgery where the odds ratios of death were significantly higher if surgery was undertaken at the weekend.(8,13) Aylin and colleagues attribute the increased mortality associated with elective operating at weekends to reduced availability of staffing and other resources. The majority of small amount of elective surgery taking place at weekends in NHS hospitals is "waiting list initiative" surgery, which is usually highly selected to be low risk and undertaken exclusively by consultants. Emergency procedures performed at weekends may be miscoded as elective, and care must be taken to examine the procedures associated with death to ensure they were indeed scheduled. Anomalous surgical procedures performed at weekends can be coded as "elective", such as "insertion of tracheostomy" in very unwell patients in ICU. It would be expected that these "elective" procedures would be associated with higher mortality.

Emergency surgery is undertaken at any time, on any day of the week, by both junior and consultant staff, for patients at high risk of death or complications. It would be expected therefore that any structural effect resulting from reduced availability of staff or resources would be more apparent in these procedures than in elective surgery. Yet no effect was seen in this study.

It is possible that emergency care pathways are now well developed and consistent throughout the week in most hospitals resulting in less variation in care. Patients undergoing complex elective surgery on Friday may suffer from reduced levels of care at the weekend and it may be postoperative care at the weekend rather than day of admission or surgery which are responsible for the weekend effect phenomenon in this setting. However, in our emergency surgery cohort, no effect of postoperative care on short- and long-term outcomes was seen.

A more recent study of mortality after emergency general surgical admission investigated the effect of hospital structure and processes, including the day of the week of admission in 156 NHS Trusts in England.(13) This study found increased mortality following admission on Saturday and Sunday which persisted after correction for staffing levels and other hospital processes. Our study differs from this in two key areas. Firstly, we included all patients having emergency general surgery procedures, rather than emergency admissions for general surgery conditions, which includes high-risk conditions not typically requiring surgery such as pancreatitis. Secondly, in our study patients undergoing surgery at the weekend had a shorter time from admission to surgery, suggesting that they were sicker and required more urgent intervention. Although we saw a numerically higher perioperative mortality for patients admitted on Friday to Sunday, this was not significant in either univariable or multilevel models.

Strengths of our study are that we used complete, linked, national level data with low incidence of missing or incomplete data and used robust methodology to adjust for case-mix and surgical factors. To our knowledge complete data at a national level, examining the association between day of the week of emergency surgery and long-term outcome has not previously been reported.

A weakness of this study is that it is smaller cohort than other recently published work examining day of the week on surgical care in the UK, increasing the risk that the study was underpowered. Other limitations are common to other epidemiological studies using large administrative databases: our findings may be subject to bias and unmeasured confounding. Only first admissions in the 3-year period were included to allow long-term follow-up. As readmissions are often sicker and have more comorbidities, this may have introduced selection bias. In the case of weekend surgical admissions, many factors may be in-play including the availability of beds (in particular critical care beds) access to imaging, and increased risk necessitating weekend surgery identified by the treating clinician. These have previously been associated with poorer outcomes after emergency surgery(4) and are not reliably captured in baseline demographic data such as ours.

In summary, we were unable to identify a “weekend effect” associated with day of surgery for emergency surgery either for perioperative or long-term mortality. Time to surgery was shorter for those undergoing surgery at the weekend and this may reflect increased severity of illness of those presenting at the weekend or simply reduced competition with elective cases for theatre time. The cost and practicalities of undertaking prospective studies in organisational aspects of healthcare delivery mean that large observational studies and meta-data can offer a useful alternative. Such studies often include large numbers of patients and have high statistical power. However, in common with other aspects of surgical care, for example routine ICU admission following surgery, (29–31) data from large epidemiological studies can be conflicting. Large prospective cohort studies using sophisticated techniques such as instrumental variable analysis may be able to answer these questions more accurately in the future.

CONCLUSION

In a national data-linkage cohort study of patients undergoing emergency surgery in Scotland, we are unable to demonstrate an association with day of the week of surgery and postoperative mortality.

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Declaration: All authors contributed to the conception, data analysis, interpretation of results and preparation of the manuscript. MAG, EMH and NIL take responsibility for the integrity of the data and the presentation of results. They affirm that that the manuscript is an honest, accurate, and transparent account of the study being reported and that no important aspects of the study have been omitted.

Data sharing: We will consider data access requests from bona fide researchers providing they seek permission from and comply with Information Services Division (ISD) NHS Scotland data governance policies.

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