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# Variations in mortality after emergency laparotomy: the first report of the UK Emergency Laparotomy Network

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## Editor's key points

- This is an important first report of the Emergency Laparotomy Network in the UK.
- The report provides evidence for high mortality in these patients.
- Also, crucially, the report points to the variability in care provided to this patient group.
- Areas of concern, and where improvements are required, include pre-optimization, consultant presence, and postoperative high dependency care.

**Background.** Emergency laparotomy is a common intra-abdominal procedure. Outcomes are generally recognized to be poor, but there is a paucity of hard UK data, and reports have mainly been confined to single-centre studies.

**Methods.** Clinicians were invited to join an 'Emergency Laparotomy Network' and to collect prospective non-risk-adjusted outcome data from a large number of NHS Trusts providing emergency surgical care. Data concerning what were considered to be key aspects of perioperative care, including thirty-day mortality, were collected over a 3 month period.

**Results.** Data from 1853 patients were collected from 35 NHS hospitals. The unadjusted 30 day mortality was 14.9% for all patients and 24.4% in patients aged 80 or over. There was a wide variation between units in terms of the proportion of cases subject to key interventions that may affect outcomes. The presence of a consultant surgeon in theatre varied between 40.6% and 100% of cases, while a consultant anaesthetist was present in theatre for 25–100% of cases. Goal-directed fluid management was used in 0–63% of cases. Between 0% and 68.9% of the patients returned to the ward (level one) after surgery, and between 9.7% and 87.5% were admitted to intensive care (level three). Mortality rates varied from 3.6% to 41.7%.

**Conclusions.** This study confirms that emergency laparotomy in the UK carries a high mortality. The variation in clinical management and outcomes indicates the need for a national quality improvement programme.

**Keywords:** emergency; general surgery; intra-abdominal; laparotomy; mortality; outcome; variation

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Despite being one of the most common urgent surgical procedures in the UK,[1] there is a scarcity of outcome data concerning postoperative mortality rates after emergency laparotomy. A recent single-centre study demonstrated an overall mortality rate of ~19%, with a considerably higher mortality rate of 42% in octogenarians.[2] The finding of a high mortality rate is supported by outcome data from a larger analysis of patients undergoing surgery in 94 UK acute Trusts,[3] which demonstrated that a relatively small proportion of the surgical population categorized as 'high-risk' accounted for over 80% of the postoperative deaths. Of the high-risk procedures, nearly 90% were emergencies, many of which are likely to have been an emergency laparotomy.

The term 'emergency laparotomy' describes an exploratory procedure for which the clinical presentation, underlying pathology, anatomical site of surgery, and perioperative management vary considerably. The total number of surgical procedures that can be coded within this emergency laparotomy population exceeds 400, reflecting the diverse nature of this surgical cohort.[4] The variation in surgical pathology, coupled with the limited time period in which to optimize co-morbidities, is likely to contribute significantly to postoperative morbidity and mortality.

In 2007, the Association of Surgeons of Great Britain and Ireland acknowledged that standards of care for emergency surgical admissions were often unsatisfactory. There was a failure to prioritize patients, inadequate senior input, and unsatisfactory allocation of infrastructure and manpower;[5] and they characterized emergency surgery as the 'Cinderella Service'. Patients admitted for high-risk elective surgery can expect to be provided with an extensive package of perioperative care; yet many emergency surgery patients may not receive an equal measure of resources,[1] despite being older and sicker.[4]

The Emergency Laparotomy Network[5] was established in January 2010 within the framework of NHS Networks. This free resource is dedicated to the sharing of ideas and problems within the NHS, with the aim of improving the service and care provided to patients. The current ELN membership consists of over 200 clinicians from more than 40 NHS hospitals in the UK. The ELN's broad aims are to bring together clinicians from relevant specialities in order to improve the outcome of patients undergoing emergency laparotomy. In order to establish a baseline and to provide a foundation for the Network, the Steering Committee designed and conducted a multicentre audit to measure non-risk-adjusted outcome after emergency laparotomy. The analysis of the pooled data has been returned to contributors, allowing them to identify and reflect upon their own outcomes. This paper presents a preliminary analysis of the results.

## Methods

Ethical guidance was sought from the local ethics committee of South Tees Hospitals NHS Foundation Trust, who confirmed that the project fulfilled the criteria of a clinical audit as defined in the National Research Ethics Service document 'Defining Research',[6] negating the requirement for the ethics committee approval.

Members of the UK Emergency Laparotomy Network were invited to submit prospective data on consecutive patients undergoing emergency laparotomy. Patients who had an emergency laparotomy between September 2010 and April 2011 were eligible for inclusion. Clinicians were asked to collect prospective anonymized data for a continuous period of 3 months within this time frame. The data set included a description of patient characteristics, timing of surgery, grade of clinical personnel in theatre, anatomical site of surgery, operative procedure, postoperative destination, length of stay, and 30 day mortality. Inclusion and exclusion criteria are shown in Supplementary Appendix 1. The design of the data set was a pragmatic attempt to focus on key issues that are likely to influence outcomes, and was intended to have a minimal impact upon the demands of the clinicians in the operating theatre. Thus, extensive detail about the anaesthetic care, surgical management, and the physiological derangement and sickness-severity of the patient was not sought. Likewise, detailed information about the timing of perioperative interventions was deliberately excluded because it was considered difficult to interpret without a large amount of supporting data. Full details of the data set are shown in Supplementary Appendix 2 and are available from the NHS Networks website of the Emergency Laparotomy Network.[5]

Data collection was carried out using a Microsoft Excel 2007 spreadsheet and returned to one of the authors (D.M.), who ensured that data were anonymized. Each hospital was designated by a unique two-letter code between AA and BK. To facilitate accurate and consistent data entry, participants were asked to select answers from a series of dropdown menus for each data field. Any apparent errors or inconsistencies in the data received were clarified with the submitting unit, and if no additional clarification was forthcoming, that data point was deleted from analysis. Hospitals were excluded from the analysis if they were unable to provide outcome data for more than 90% of the patients undergoing emergency laparotomy.

To avoid bias, and for the purposes of this report, patient characteristics and mortality calculations pertaining to repeat laparotomies have been excluded: the results reported relate to the primary emergency laparotomy for each patient.

Simple statistical analysis was performed within the Microsoft Excel program; the Fisher's exact test was performed using GraphPad Prism software (GraphPad Software, Inc., La Jolla, CA, USA); and the funnel plot was generated using methodology as described by Spiegelhalter,[7] with the standardized mortality ratio (SMR) defined as the ratio of observed to expected numbers of deaths in each hospital after adjusting for age group and gender variation.

## Results

Data were returned from 37 NHS hospitals. The results from two hospitals were excluded because outcome data were available for fewer than 50% of the patients. The remaining 35 hospitals reported outcome data for more than 90% of their patients and were included in the analysis. One thousand eight hundred and fifty-three patients underwent 1941 separate emergency laparotomies, with a median [inter-quartile range (IQR) (range)] of 46 [30.5–68.8 (8–184)] operations per hospital. Thirty-day mortality data were available for 1819 patients, and was 14.9%. Baseline and outcome characteristics of laparotomy patients are shown in Table 1.

There appeared to be a direct relationship between increasing age of the patient and 30 day mortality; from a mortality of just under 10% for a patient in their 50s, mortality increased by ~4% for each additional 10 yr of age. For patients aged 80 and over, the mortality was 24.4%.

Increased mortality was also associated with higher ASA physical status classification, with increased urgency of surgery, and with a need for a greater intensity of immediate postoperative care. More than 60% of the patients were aged 60 or over and had a mortality of >10%. Likewise, more than 60% of the patients were of ASA III or greater, and these patients also had a mortality in excess of 10%.

The majority of patients were admitted directly to general surgery teams; 11.5% of the patients were admitted to a medical team and had a significantly higher mortality (Fisher's exact test of medicine *vs* general surgery; two-tailed $P=0.0115$). Specialities other than general surgery or medicine represented only a small proportion of cases but had a

**Table 1** Baseline characteristics and mortality data. *Characteristic-specific denominator figures for mortality calculations not shown: proportions refers to the number of cases with both characteristic *and* mortality data available. †Mortality for that particular characteristic. ‡Recent surgery defined as within 30 days (elective or emergency laparotomy).

| Characteristic | *n* (%) | 30 day mortality* (%)† |
|---|---|---|
| All patients | 1845 (100) | 271 (14.9) |
| Age band | | |
| Total patients with data (*n*) | 1845 | 1819 |
| <20 | 25 (1.4) | 0 (0) |
| 20–29 | 101 (5.5) | 0 (0) |
| 30–39 | 95 (5.1) | 4 (4.3) |
| 40–49 | 160 (8.7) | 14 (9.0) |
| 50–59 | 256 (13.9) | 24 (9.4) |
| 60–69 | 400 (21.7) | 56 (14.0) |
| 70–79 | 466 (25.3) | 92 (20.0) |
| 80–89 | 305 (16.5) | 70 (23.6) |
| 90–99 | 37 (2.0) | 11 (31.4) |
| Gender | | |
| Total patients with data | 1845 | 1819 |
| Male | 879 (47.6) | 139 (16.0) |
| Female | 966 (52.4) | 132 (13.9) |
| Admitting speciality | | |
| Total patients with data | 1845 | 1819 |
| General surgery | 1541 (83.5) | 206 (13.6) |
| Medicine | 213 (11.5) | 43 (20.4) |
| Gynaecology | 28 (1.5) | 2 (7.4) |
| Vascular | 14 (0.8) | 9 (64.3) |
| Orthopaedics | 11 (0.6) | 5 (45.5) |
| Urology | 22 (1.2) | 2 (9.1) |
| Other | 16 (0.9) | 4 (26.7) |
| Urgency | | |
| Total patients with data | 1807 | 1782 |
| Expedited (days) | 230 (12.7) | 19 (8.3) |
| Urgent (h) | 1352 (74.8) | 184 (13.8) |
| Immediate (min) | 225 (12.5) | 63 (28.3) |
| Laparotomy, a complication of recent surgery,‡ patients with data=1528 | 238 (15.6) | 34 (14.5) |
| ASA physical status | | |
| Total patients with data | 1705 | 1680 |
| I | 113 (6.6) | 0 (0) |
| II | 565 (33.1) | 23 (4.1) |
| III | 643 (37.7) | 85 (13.4) |
| IV | 332 (19.5) | 111 (33.6) |
| V | 52 (3.0) | 36 (69.2) |
| Consultant staff present in theatre | | |
| Surgeon, *n*=1840 | 1359 (73.9) | 210 (15.6) |
| Anaesthetist, *n*=1835 | 1209 (65.9) | 187 (15.6) |
| Goal-directed fluid therapy | | |
| Total patients with data | 1626 | 1599 |
| Used | 235 (14.5) | 44 (18.9) |
| Not used | 1391 (85.6) | 199 (14.6) |
| Postoperative placement, total *n*=1789 | | |
| Total patients with data | 1789 | 1765 |
| Level 1 (ward) | 700 (39.1) | 46 (6.7) |
| Level 2 (HDU) | 523 (29.2) | 52 (10.1) |
| Level 3 (ICU) | 527 (29.5) | 160 (30.7) |
| Extended recovery (PACU) | 39 (2.2) | 5 (13.5) |

**Table 2** Time of day, seniority of medical staff, and 30 day mortality. *Time of anaesthetic induction

| Time of day* | *n* | Consultant anaesthetist present (%) | Consultant surgeon present (%) | 30 day mortality (%) |
|---|---|---|---|---|
| 08:00–17:59 | 1044 | 75.2 | 80.8 | 14.2 |
| 18:00–23:59 | 442 | 54.8 | 67.7 | 17.8 |
| 00:00–07:59 | 152 | 40.8 | 61.8 | 20.3 |

high mortality. No adjustment for age, gender, surgery, or ASA was made in these mortality calculations.

Table 2 shows a breakdown of start times of cases and the proportion of cases where the senior anaesthetist and the surgeon present were at a consultant level, together with 30 day mortality. Senior clinicians do not necessarily attend together: in patients aged 60 or over, only 53.3% of the cases were undertaken by both a consultant surgeon and a consultant anaesthetist, with a corresponding figure for patients who were ASA III or greater of 56.0%.

There was little evidence of a disparity between the availability of critical care resources after emergency laparotomy and the perceived clinical need. Of the patients who were felt to need intensive [intensive care unit (ICU)] care immediately after surgery, 99% were transferred to a level 3 bed. Similarly, 89% of those who were judged to require a high-dependency [high-dependency unit (HDU)] bed received this level of care, with a further 4% receiving level 2 care in an ICU bed. Mortality in patients returning to the ward (level 1) was 6.7%, HDU 10.1%, and ICU 30.7%. 2.2% of patients were cared for after operation in an extended recovery area [post-anaesthesia care unit (PACU)], and this group had a mortality of 13.5%. For the group of patients aged 60 or greater, and of ASA III or more (~50% of all patients), 22% returned to the general ward after operation and had a mortality of 17.8%.

Postoperative length-of-stay data were available for 1736 patients. The median [IQR (range)] postoperative length of stay for all patients was 11 days [6–21 (0–216)], with a median stay of 12 days for patients returning to a general ward and 19 days for patients who initially received level 3 support.

With increasing urgency of the case, there was a decrease in elapsed times from admission to booking and from booking to the start of anaesthesia. The median [IQR (range)] admission to booking times in days for expedited, urgent, and immediate cases were 3 [1–8 (0–113)], 1 [0–4 (0–299)], and 1 [0–3 (0–137)], respectively; and the median [IQR (range)] booking to start times in hours for expedited, urgent, and immediate cases were 21.6 [15.0–30.6 (0–177.5)], 4.0 [2.0–11.2 (0–243.9)], and 1.3 [0.7–2.3 (0–30.1)], respectively.

Table 3 shows a variation between hospitals in the use of goal-directed fluid management; the location of immediate postoperative care; and the seniority of anaesthetic and surgical clinical staff in theatre at the time of surgery, together with non-adjusted 30 day mortality.

The funnel plot (Fig. 1) shows an age-adjusted mortality ratio for each unit plotted against the number of cases, together with $\pm$2.0 and 3.0 standard deviations (SD).

## Discussion

This is the first report of the UK National Emergency Laparotomy Network and includes data from 35 NHS hospitals representing ~25% of the UK hospitals that take unselected general surgical admissions.[8]

There are more than 400 OPCS codes describing surgery that could come under the umbrella term of 'emergency laparotomy', making problematic the use of hospital coding data to study this group of patients.[4] We grouped all cases that met a pragmatic and clinical definition of emergency laparotomy, enabling us to compare the variation in key aspects of care and outcomes between different NHS hospitals. Previous publications have confirmed the high mortality rates within this group of patients, but extrapolation to a wider NHS population is potentially flawed: either because the published data are from a single centre,[2] from overseas,[9] or retrospective in nature.[3] This prospective study sought to highlight variations in outcomes within the UK.

Our data confirm a high mortality from emergency laparotomy in the UK. The overall figure of 14.9% represents a heterogeneous group of patients and includes cases of varying complexity and sickness-severity. Higher mortalities are evident in subgroups, including those of the high ASA status and the elderly. Nonetheless, this is a mortality figure that would be unthinkable for common major elective general surgery [colorectal resection (2.7%),[10] oesophagectomy (3.1%),[11] gastrectomy (4.2%),[11] and liver metastasis resection (1%)].[12]

Our mortality findings are in line with the results from the NCEPOD report from 2011.[13] Mortality among patients classified as 'high-risk' by anaesthetists undergoing non-elective intra-abdominal surgery was 13.2%, but patients undergoing colorectal resection without primary anastomosis had the highest mortality (20.4%) of all patient groups in the study.

The association between increasing mortality and rising age is, while perhaps intuitive, striking in its clarity. Almost one-third of those aged 90 or above died by day 30 after operation, which may be lower than many would predict. In contrast, patients in their 30s had a mortality of 4.2%, although this still represents a significant risk. The decision to operate on an elderly patient with significant co-morbidities is always difficult; in the 2010 report of the Scottish Audit of Surgical Mortality, the most common cause of an assessor's concern was that in retrospect, the operation should not have been performed.[14]

In collaboration with other professional groups and the Department of Health (DoH), The Royal College of Surgeons (RCS) have recently published recommendations on standards of care for the emergency patient, and these highlight the need to identify 'high risk' within clinical pathways.[15 16] The recommendations equate high risk with a predicted mortality of $\geq$10%, and our study shows that this group includes

**Table 3** Process and mortality variations between hospitals. GDFT, goal-directed fluid therapy; IQR, inter-quartile range. *No data supplied

| Hospital | Number (*n*=1853) | Proportion consultant surg. (%) (*n*=1840) | Proportion consultant anaes (%) (*n*=1835) | GDFT (%) (*n*=1626) | Postoperative placement (%) (*n*=1789) | | | | 30 day mortality (%) (*n*=1819) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Level 1 | Level 2 | Level 3 | PACU | |
| **Median** | **46** | **73.9** | **64.1** | **9.1** | **43.9** | **22.6** | **30.3** | **0.0** | **14.9** |
| **Range** | **8–184** | **40.6–100** | **25–100** | **0–63.0** | **0–68.9** | **0–74.5** | **9.7–87.5** | **0–35.0** | **3.6–41.7** |
| **IQR** | **30.5–68.8** | **60–5–81.9** | **55.8–76.3** | **0.6–21.7** | **27.4–55.2** | **11.4–33.4** | **22.5–37.9** | **0–0** | **11.0–22.2** |
| AA | 32 | 46.9 | 84.4 | 9.4 | 12.9 | 35.5 | 51.6 | 0.0 | 12.5 |
| AC | 23 | 60.9 | 60.9 | 9.1 | 52.2 | 8.7 | 34.8 | 4.3 | 9.1 |
| AD | 36 | 97.2 | 77.8 | 0.0 | 41.7 | 30.6 | 27.8 | 0.0 | 22.2 |
| AE | 106 | 74.5 | 66.0 | 21.7 | 61.3 | 9.4 | 29.2 | 0.0 | 10.4 |
| AG | 50 | 48.0 | 47.9 | 12.0 | 44.0 | 22.0 | 34.0 | 0.0 | 14.0 |
| AH | 17 | 76.5 | 35.3 | 11.8 | 23.5 | 52.9 | 23.5 | 0.0 | 23.5 |
| AI | 63 | 40.6 | 46.9 | 0.0 | 43.8 | 28.1 | 28.1 | 0.0 | 12.7 |
| AJ | 60 | 60.0 | 28.3 | 41.7 | 25.4 | 42.4 | 32.2 | 0.0 | 21.7 |
| AK | 94 | 88.3 | 62.8 | 7.4 | 19.1 | 41.5 | 38.3 | 1.1 | 19.0 |
| AL | 35 | 54.3 | 55.9 | 0.0 | 28.6 | 40.0 | 31.4 | 0.0 | 8.6 |
| AM | 45 | 80.0 | 84.4 | 2.3 | 60.0 | 22.2 | 15.6 | 2.2 | 6.7 |
| AN | 60 | 78.3 | 50.0 | 3.6 | 11.7 | 10.0 | 43.3 | 35.0 | 23.3 |
| AO | 66 | 69.7 | 75.8 | 28.8 | 54.5 | 4.5 | 28.8 | 12.1 | 12.3 |
| AP | 24 | 70.8 | 25.0 | 0.0 | 66.7 | 16.7 | 16.7 | 0.0 | 16.7 |
| AQ | 25 | 96.0 | 100.0 | 37.5 | 26.1 | 4.3 | 69.6 | 0.0 | 41.7 |
| AR | 71 | 58.0 | 88.4 | 11.8 | 67.1 | 22.9 | 10.0 | 0.0 | 11.3 |
| AS | 11 | 72.7 | 63.6 | 9.1 | 63.6 | 0.0 | 36.4 | 0.0 | 18.2 |
| AT | 38 | 73.7 | 71.1 | 0.0 | 55.3 | 7.9 | 36.8 | 0.0 | 28.9 |
| AU | 85 | 95.3 | 71.8 | 27.1 | 12.9 | 51.8 | 35.3 | 0.0 | 12.9 |
| AV | 69 | 85.1 | 74.2 | 7.4 | 40.3 | 25.4 | 34.3 | 0.0 | 12.3 |
| AW | 51 | 56.0 | 60.8 | 21.6 | 38.0 | 26.0 | 36.0 | 0.0 | 25.5 |
| AX | 136 | 52.9 | 56.6 | 34.8 | 61.8 | 18.0 | 19.1 | 1.1 | 7.4 |
| AY | 8 | 100.0 | 62.5 | 37.5 | 0.0 | 12.5 | 87.5 | 0.0 | 25.0 |
| AZ | 27 | 44.4 | 55.6 | 63.0 | 29.6 | 44.4 | 25.9 | 0.0 | 22.2 |
| BA | 38 | 73.7 | 65.8 | 0.0 | 44.7 | 13.2 | 42.1 | 0.0 | 22.9 |
| BB | 45 | 68.9 | 93.3 | 4.5 | 68.9 | 20.0 | 11.1 | 0.0 | 4.4 |
| BC | 37 | 78.4 | 86.5 | 0.0 | 40.5 | 2.7 | 56.8 | 0.0 | 27.8 |
| BD | 28 | 67.9 | 67.9 | 0.0 | 53.6 | 25.0 | 21.4 | 0.0 | 3.6 |
| BE | 52 | 94.2 | 98.1 | 9.6 | 28.8 | 32.7 | 38.5 | 0.0 | 15.7 |
| BF | 184 | 97.8 | 82.1 | 24.5 | 7.6 | 74.5 | 17.9 | 0.0 | 7.6 |
| BG | 26 | 80.8 | 73.9 | * | 60.0 | 28.0 | 12.0 | 0.0 | 23.1 |
| BH | 77 | 74.0 | 33.8 | 0.0 | 57.1 | 16.9 | 26.0 | 0.0 | 27.3 |
| BI | 45 | 91.1 | 57.8 | 11.1 | 35.6 | 26.7 | 37.8 | 0.0 | 13.3 |
| BJ | 58 | 65.3 | 50.0 | 4.1 | 49.0 | 10.2 | 28.6 | 12.2 | 13.3 |
| BK | 31 | 77.4 | 64.5 | 6.5 | 45.2 | 45.2 | 9.7 | 0.0 | 9.7 |

patients aged over 60, or those assessed as ASA Class III or higher. Seventy-eight per cent of the patients with data for 30 day mortality met either one or both of these criteria.

Length of stay varied greatly and increased with post-operative dependency in this study. The detail about the eventual discharge destination of the survivors of emergency laparotomy was beyond the scope of our audit, but it is likely that a significant proportion of patients required enhanced levels of support in the community. Prolonged lengths of stay are likely to reflect significant morbidity and a slow recovery after surgery. The cost of emergency laparotomies is high, both financially for the hospital and physically and emotionally for the patient and their family.

Unlike elective surgery, many risk factors are not amenable to modification at the time a patient requires emergency laparotomy. Age, co-morbidity, and the underlying pathology cannot be altered, but the way the *process* of care is provided *may* be varied according to the needs of the patient. Ensuring prompt assessment, early resuscitation, and timely access to theatre, with senior staff involvement and appropriate levels of postoperative care are all potentially modifiable factors. The 2011 NCEPOD report found that

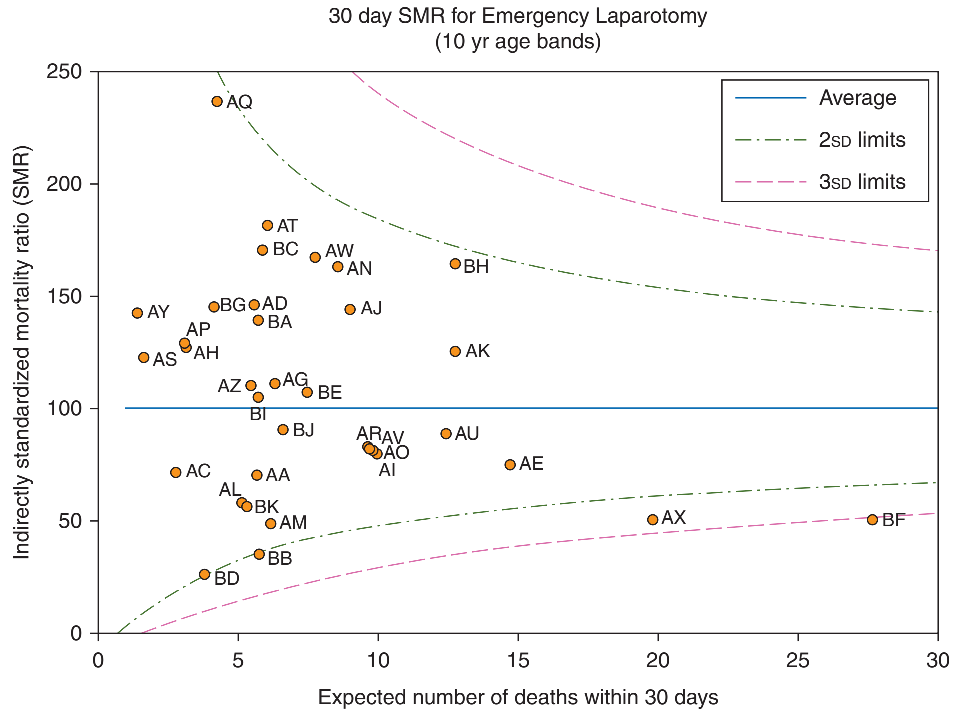


**Fig 1** SMR for emergency laparotomy.

20% of non-elective cases incurred delays in getting to the operating theatre.[13] Detailed analysis of contributing factors leading to delay was beyond the scope of the audit, but we were able to demonstrate a wide range of time periods between booking for theatre and induction of anaesthesia. The RCS recommendations emphasize that definitive surgery is undertaken with an urgency that is escalated according to the degree of illness, particularly the severity of sepsis.[15] Surgery should be commenced as soon as possible after adequate preparation in order to reduce suffering, morbidity, mortality, and cost.

The NCEPOD reports from 1991 to 1992[17] and 1995 to 1996[18] made specific recommendations to increase the involvement of consultants during urgent or emergency colorectal resection. In the most recent NCEPOD report,[13] the assessors judged that in only 1% of all (elective and non-elective) cases was the level of the surgeon inappropriate, but that this rose to 4.7% for anaesthetists. In our study, the majority of patients underwent surgery with the direct supervision of a consultant surgeon (73.8% of cases), an anaesthetist (65.8% of cases), but in only 50% of all cases did patients undergo surgery in the presence of both a consultant surgeon *and* a consultant anaesthetist. Furthermore, the proportion of cases receiving consultant-delivered care decreased for those operations beginning after 6 p.m., with a further reduction for those cases starting after midnight, despite the fact that it seems reasonable to assume that many patients in the out-of-hours group were sicker than those for whom surgery was deferred. Best practice is that a consultant surgeon and a consultant anaesthetist are present for all cases with a predicted mortality of more than 10%,[15 16] and the time of day should not affect the standard of care. Hospitals need to adjust their processes to ensure that delays in assessment, imaging, and preparedness do not increase the likelihood of high-risk procedures being undertaken out-of-hours. A comparison has been made with outcomes in the USA, which may be better than the UK for similar major surgical procedures.[19] There are many differences between the two health-care systems making direct comparisons difficult, but recent payment changes in the USA ensure that the named qualified surgeon must be present at operation to receive payment for the case.

It is reassuring that a critical care bed was forthcoming in almost all occasions when it was requested for postoperative care. The variation between hospitals in the rate of admission to HDU or ICU needs to be better understood, but by and large the apparent demand for postoperative care in HDU or ICU was met. As expected, the mortality was highest among those patients who required ICU support after operation, and considerably lower among those sent to HDU. In the absence of an agreed clinical standard for admission to level 2 and 3 care after emergency laparotomy, it is difficult to interpret the variation between hospitals, but the rate of referral to critical care in this study appears inappropriately low when compared with the observed mortality of 6.7% for those discharged to a general ward. Surgical mortality is influenced by the ability of a hospital to recognize and 'rescue' surgical patients who have developed a complication,[20] and early recognition and management of complications is likely to be better in a critical care unit than on a normal ward.[21] The significant mortality rate in the group of patients sent to a general ward after operation does raise the possibility that the team caring for the patient at the time of surgery did not appreciate the risks of serious complications arising after discharge from recovery.

Goal-directed fluid therapy was used in fewer than 15% of emergency laparotomies. There is now substantial evidence to support its use in elective colorectal surgery,[22–25] and it is recommended that patients undergoing non-elective major abdominal surgery should receive fluid to achieve an optimal stroke volume during and for the first 8 h after surgery.[22] An elevated lactate is known to predict a poor outcome in high-risk patients,[26] and the use of flow-based technologies to optimize tissue perfusion in the perioperative period may be indicated in the majority of the patients undergoing emergency laparotomy.

Our results demonstrate a wide variation in both the number of cases undertaken and the non-adjusted mortality rates between the 35 hospitals reporting data. It is unreasonable to compare different units simply in terms of mortality, as a significant difficulty with our study design was the limited ability to stratify risk in any detail according to sickness-severity. In the 3 month period during which clinicians were asked to collect data, it is possible that some units undertook an unusual proportion of cases with greater complexity or co-morbidity than normal, introducing unfavourable bias into their outcome data. Furthermore, some hospitals may have had difficulties accurately identifying which patients died within 30 days: indeed, the data from two hospitals were excluded from the mortality comparisons as the proportion of cases with outcomes recorded was too small.

Age is a well-recognized risk factor for postoperative mortality. After age and gender adjustment, all units have an SMR that is within 2 SDs from the mean; while two units appear to have exceptionally good outcomes, with SMRs of almost 3 SDs from the mean. There is an impression that units undertaking a greater number of cases have better outcomes, and there may be a benefit from examining the processes of care provided by these hospitals in order to identify why their outcomes are particularly good.

In conclusion, we have presented the first report of the Emergency Laparotomy Network and shown in a national, multicentre, and prospective audit that non-risk-adjusted mortality from emergency laparotomy is 14.9%, rising to 24.4% in those aged 80 or over. We have demonstrated a wide variation between units in the seniority of surgical and anaesthetic staff present during surgery, the use of critical care immediately after operation, and raw mortality. The weaknesses of our data collection include the limited ability to stratify risk for individual patients, and not attempting to independently verify that participating clinicians identified all eligible cases of emergency laparotomy during the 3 month data collection.

Standards of care for unscheduled surgical patients have been published by the RCS in collaboration with the DoH and other professional groups, and these should be used to drive service improvement for those patients undergoing emergency laparotomy. Our findings warrant further effort to collect risk-stratified data from a wider proportion of NHS hospitals undertaking emergency abdominal surgery, and quality improvement programmes aimed at reducing postoperative morbidity are likely to be cost effective.

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## Declaration of interest

All five authors are members of the steering group of the Emergency Laparotomy Network.

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