BJA

British Journal of Anaesthesia, ■ (■): 1–10 (2018)

doi: 10.1016/j.bja.2018.06.026
Advance Access Publication Date: xxx
Clinical Investigation

CLINICAL INVESTIGATION

Development and internal validation of a novel risk adjustment model for adult patients undergoing emergency laparotomy surgery: the National Emergency Laparotomy Audit risk model

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Abstract

Background: Among patients undergoing emergency laparotomy, 30-day postoperative mortality is around 10–15%. The risk of death among these patients, however, varies greatly because of their clinical characteristics. We developed a risk prediction model for 30-day postoperative mortality to enable better comparison of outcomes between hospitals.
Methods: We analysed data from the National Emergency Laparotomy Audit (NELA) on patients having an emergency laparotomy between December 2013 and November 2015. A prediction model was developed using multivariable logistic regression, with potential risk factors identified from existing prediction models, national guidelines, and clinical experts. Continuous risk factors were transformed if necessary to reflect their non-linear relationship with 30-day

Editorial decision: 20 June 2018; **Accepted:** 20 June 2018

mortality. The performance of the model was assessed in terms of its calibration and discrimination. Interval validation was conducted using bootstrap resampling.

Results: There were 4458 (11.5%) deaths within 30-days among the 38 830 patients undergoing emergency laparotomy. Variables associated with death included (among others): age, blood pressure, heart rate, physiological variables, malignancy, and ASA physical status classification. The predicted risk of death among patients ranged from 1% to 50%. The model demonstrated excellent calibration and discrimination, with a C-statistic of 0.863 (95% confidence interval, 0.858–0.867). The model retained its high discrimination during internal validation, with a bootstrap derived C-statistic of 0.861.

Conclusions: The NELA risk prediction model for emergency laparotomies discriminates well between low- and high-risk patients and is suitable for producing risk-adjusted provider mortality statistics.

Keywords: emergency laparotomy; postoperative mortality; risk adjustment; postoperative outcome

Editor's key points

- Valid and reliable risk prediction models can guide clinical practice and better inform benchmarking.
- Some perioperative risk factors are modifiable, or at least alert clinical teams to the need for higher levels of care for high-risk patients.
- This NELA risk model is recommended for healthcare quality evaluations for patients undergoing emergency laparotomy.

Each year, approximately 33 000 patients undergo emergency laparotomy surgery in the UK.[1] Patients requiring an emergency laparotomy present with various conditions (such as perforation, ischaemia, abdominal abscess, bleeding, or obstruction) and have an urgent need for clinical assessment to ensure appropriate perioperative management.[2,3] As emergency laparotomy is a common procedure with high postoperative mortality, there is potential to prevent a substantial number of deaths by benchmarking the performance of providers. However, without risk adjustment, hospital outcomes might not be comparable, and benchmarking may create unwelcome incentives including an aversion to selecting high-risk patients for surgery.[4–7]

Various models are available to estimate the short-term risk of death after emergency bowel surgery, including: the Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity (P-POSSUM) model,[8–12] the Biochemistry and Haematology Outcome Model (BHOM),[13] the Surgical Outcome Risk Tool (SORT),[14] and others.[3,15–24] Systematic reviews[25,26] of such models have identified substantial limitations in their design because they were often derived using small, single-site studies, were restricted to specific populations, or both. This makes it difficult to draw general conclusions about their performance.

In response to the limitations of pre-existing prediction models, we undertook to develop a new model for calculating the risk-adjusted 30-day mortality of care providers performing emergency laparotomy using data on more than 38 000 patients from the UK National Emergency Laparotomy Audit (NELA).[27] The resulting model was intended for use in producing risk-adjusted postoperative mortality of hospitals, clinical teams, or both, and thereby support benchmarking and quality improvement.

Methods

We used data submitted to NELA from 186 NHS hospitals in England and Health Boards in Wales between December 1, 2013 and November 30, 2015. NELA was commissioned by the Healthcare Quality Improvement Partnership (HQIP) and funded by NHS England and the Welsh government, and this study was undertaken as part of the work by the Audit to evaluate the outcomes after emergency laparotomy achieved by English and Welsh NHS hospitals. Patients were eligible for inclusion in NELA if their emergency procedure involved the stomach, small or large bowel, or rectum for conditions such as perforation, ischaemia, abdominal abscess, bleeding, or obstruction (see Supplementary material). Procedures for appendicitis, vascular surgery, trauma, or obstetric emergencies were outside the scope of the Audit. Data collection was approved by the Confidentiality Advisory Group under section 251 of the NHS Act 2006.

The participating NHS hospitals in England and Wales submitted data on 43 566 patients. This represented approximately 70% of patients recorded in Hospital Episode Statistics[27] as having an eligible emergency laparotomy during the 2 yr period. Patient records with missing values for one or more risk factors were removed (n=4736), leaving 38 830 patients with complete data for inclusion in the analysis (Fig. S1).

To derive 30-day all-cause postoperative mortality, patient records were linked to the Office for National Statistics (ONS) death register. For NELA patients who could not be linked to an ONS record (63 cases, 0.1%), the study used their 30-day (in-hospital) mortality available within the NELA data set. This was considered acceptable because, among patients with dates of death in both the NELA and ONS data sets, the dates were the same for 98.6% of patients.

Selection and definition of risk factors

Potential risk factors were identified from previous reviews of existing prediction models,[25] from national guidelines, and from consulting with clinical experts. Decisions about their inclusion into the risk model was based on the following criteria[28]—that the risk factors: (1) were routinely measured in clinical practice, (2) were beyond the control of the provider, (3) reflect patient risk immediately before surgery, and (4) were completely recorded or likely to be missing at random in the data set.

The candidate risk factors are listed in Table 1. The factors cover basic patient characteristics, preoperative laboratory