Using predicted 30 day mortality to plan postoperative colorectal surgery care: a cohort study†

M. Swart1,*, J. B. Carlisle1 and J. Goddard2

1Department of Anaesthesia and Perioperative Medicine, Torbay Hospital, Torquay, UK and 2Department of Anaesthesia, Salisbury District Hospital, Salisbury, UK

*Corresponding author. Email michael.swart@nhs.net

Abstract

Background. Preoperative identification of high-risk surgical patients might help to reduce postoperative morbidity and mortality. Using a patient’s predicted 30 day mortality to plan postoperative high-dependency unit (HDU) care after elective colorectal surgery might be associated with reduced postoperative morbidity.

Methods. The 30 day postoperative mortality was predicted for 504 elective colorectal surgical patients in a preoperative clinic. The prediction was used to determine postoperative surgical ward or HDU care. Those with a predicted 30 day mortality of 1–3% mortality, and thus deemed at intermediate risk, had either planned HDU care (n=68) or planned ward care (n=139). The main outcome measures were emergency laparotomy and unplanned critical care admission.

Results. There were more emergency laparotomies and unplanned critical care admissions in patients with a predicted 30 day mortality of 1–3% who went to an HDU after surgery compared with patients who went to a ward: 0 vs 14 (10%), P=0.0056 and 0 vs 22 (16%), P=0.0002, respectively.

Conclusions. Planned postoperative critical care was associated with a lower rate of complications after elective colorectal surgery.

Key words: cardiopulmonary exercise testing; colorectal surgery; critical care; perioperative care; risk assessment

Predicted 30 day postoperative mortality can be used to plan postoperative high-dependency unit (HDU) care. There are a number of validated prognostic models that predict 30 day mortality after surgery. There is a need to evaluate the impact that these models have on clinical decision making and patient outcome.

Torbay Hospital has a perioperative medicine clinic that uses shared decision making to help patients choose their preferred treatment option. The clinic is also used to estimate 30 day mortality after surgery and plan postoperative care. In 2009, we implemented an elective postoperative care pathway, based on the individual patient’s predicted 30 day mortality. A patient with a predicted 30 day mortality of <1% would be managed on the general surgical ward and those with a predicted 30 day mortality of 1% or more would have planned postoperative HDU care. This pathway resulted in an increase in cancellations of elective surgical patients on the day of surgery because of insufficient HDU resources; this was a negative experience for patients and staff. At the end of May 2010, the pathway was modified to ward care if the predicted mortality was <1% and planned HDU care if predicted mortality was 4% or more (surgery would be cancelled if an HDU bed was unavailable). Surgery proceeded in patients with a 30 day predicted mortality of 1–3% (i.e. intermediate risk), whether or not an HDU bed was available. The final decision on postoperative care depended on HDU bed availability and clinical assessment on the day of surgery.

†This Article is accompanied by Editorial Aew331.
Editor’s key points

- Unplanned admission to an intensive care unit is a widely acknowledged clinical indicator.
- Preoperative risk prediction can help guide appropriate postoperative care.
- Greater use of planned postoperative intensive care is likely to be cost-effective if it can reduce serious complications.
- This study found that intermediate-risk colorectal surgical patients admitted to the ward had a higher rate of serious complications.

The primary aim of the study was to assess the use of a 30 day predicted mortality in a perioperative medicine clinic to determine postoperative HDU care after elective colorectal surgery. A secondary aim was to measure the impact of planned HDU care on cost of hospital bed days.

Methods

The study cohort consisted of patients entering an elective surgical pathway. Before attendance at the perioperative medicine clinic, patients were telephoned to explain the purpose of the clinic and what to expect on the day (the cardiopulmonary exercise test). In addition, before the clinic they received by post a written explanation about the clinic and the exercise test and a consent form to sign for the exercise test. This included a specific question asking for their consent to use their anonymous data for audit, quality improvement, and research publication.

In the clinic, patients were informed of their most likely surgical pathway (ward, HDU, or the possibility of either ward or HDU depending on bed availability on the day of surgery).

We studied a cohort of patients undergoing elective colorectal surgery, whose planned postoperative care was determined by their predicted 30 day mortality. Postoperative care was provided on a 24-bed colorectal surgical ward, a 10-bed critical care unit (a combined adult general intensive care and HDU), or both. All sequential patients who were assessed before an elective colorectal resection, reversal of colostomy, or reversal of ileostomy between June 1, 2010 and August 31, 2013 were included in the study. Surgery occurred between June 2, 2010 and January 29, 2014.

In the clinic, the 30 day postoperative mortality was predicted with a calculator developed by one of the authors (J.B.C.). The following variables were included in the risk calculation: year seen in the clinic; age; sex; history of heart failure, myocar-dial infarction, stroke, renal failure, peripheral arterial disease, angina, or transient ischaemic attack; peak oxygen consumption; the ventilatory equivalent for carbon dioxide at the anaerobic threshold; and the proposed surgery. For patients who were unable to perform the cardiopulmonary exercise test, an estimate of their peak oxygen consumption and ventilatory equivalent for carbon dioxide was made by the doctor in the clinic based on clinical evaluation. The clinician prospectively categorized the patients into one of three groups based on the predicted 30 day mortality. If the predicted 30 day mortality was <1%, ward-based care was planned. For predicted 30 day mortalities of 1–3% (i.e. intermediate risk), an HDU bed was booked but surgery could proceed if an HDU bed was unavailable on the day of the operation. If the predicted 30 day mortality was 4% or more, an HDU bed was booked and surgery was expected to be cancelled if no HDU bed was available. The final plan for their postoperative care was determined on the day of surgery by the anaesthetist, critical care physician, and surgeon. The main factors that influenced this final plan were intraoperative events, the availability of an HDU bed, and clinical decision making on the day of surgery.

Prospectively collected data were accessed from the following sources: the preoperative assessment record; the anaesthetic record; the operation note; clinic letters; pathology and radiology records; the hospital discharge summaries; the enhanced recovery database; the HDU database; HDU charts; and the cancer multidisciplinary team (MDT) record. The written medical notes were reviewed to clarify any missing or ambiguous data. An emergency laparotomy was defined as a laparotomy that took place after elective colorectal surgery during the same hospital admission as the elective surgery. Planned critical care was defined as admission to the critical care unit from the operating theatre suite after elective surgery. Unplanned critical care was defined as admission to the critical care unit from the surgical ward after elective surgery either directly or via the operating theatre after emergency surgery. Bed days were counted from the day of admission to hospital until the day of discharge from hospital. To determine HDU and intensive care unit (ICU) bed days, the midnight count was used. An HDU bed day was Level 2 care in the critical care unit, whereas an ICU bed day involved invasive ventilation, Level 3 care. An estimated cost of postoperative care was made by calculating the average ward, HDU, and ICU bed days per patient for each group and then multiplying by the UK 2013 payment by results tariff (ward bed day £239, HDU bed day £793, and ICU bed day £1087).

Categorical variables are presented as a number (%), whereas continuous variables are presented as a mean (so). Categorical variables were analysed with Fisher’s exact test.

Results

We identified 592 patients referred to the perioperative medicine clinic between June 1, 2010 and August 31, 2013 by the colorectal surgical team; 504 went on to have surgery for an elective colorectal resection, reversal of colostomy, or reversal of ileostomy (Fig. 1 and Table 1). Eight patients in the <1% group who were expected to have ward care based on the preoperative assessment had planned postoperative critical care on the day of surgery. Two of these patients required vasopressors for hypotension, three had more extensive surgery than expected, and three were referred to the critical care unit by the anaesthetist on the day of surgery. Eight patients in the >4% group who were expected to have planned HDU care based on the preoperative assessment had planned postoperative care. This was either a decision on the day of surgery to proceed without a critical care bed or the critical care bed was no longer available at the end of the operation. The predicted 30 day postoperative mortalities were similar to the observed mortalities.

For patients with predicted 30 day postoperative mortalities between 1 and 3% who went to the ward, there were more emergency laparotomies (Table 2). The most common finding at the emergency laparotomy was an anastomotic leak.

There were more unplanned critical care admissions in those with predicted 30 day postoperative mortalities between 1 and 3% who had planned ward care. There were 14 unplanned critical care admissions that did not have an emergency...
The most common medical or non-surgical reason for unplanned critical care admission was pneumonia. Of these 14 patients, 10 were admitted with pneumonia, two with heart failure, one with atrial fibrillation, and one with a pelvic collection that was drained under radiological guidance. The overall estimated bed day cost was not increased in the predicted 30 day mortality group who had planned HDU care (Table 3).

The overall mean bed day cost per patient with a predicted 30 day of 1–3% who had planned HDU care was £3326 and for planned ward care was £3613.

HDU charts for the 68 patients with predicted 30 day postoperative mortalities between 1 and 3% who had planned HDU care were reviewed to identify treatments that were unavailable on the ward. Of these, 64 had an invasive arterial line, with blood gases and arterial lactate measured, and 29 had drug administrations only available in the HDU [24 received

**Table 1** Characteristics of the cohort of 504 patients who underwent elective colorectal surgery, categorized by the predicted mortality in the first postoperative month from the perioperative medicine clinic. Values in parentheses are percentages unless otherwise indicated. HDU, high-dependency unit. *P*-value for 1–3% and HDU care vs 1–3% and ward care for ASA $= 0.047$ (Fisher’s exact test)

<table>
<thead>
<tr>
<th>Predicted 30 day mortality</th>
<th>&gt;4%</th>
<th>1-3%</th>
<th>&lt;1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>HDU (n = 116)</td>
<td>HDU (n = 68)</td>
<td>HDU (n = 139)</td>
</tr>
<tr>
<td>Age [yr; mean (SD)]</td>
<td>79 (7.5)</td>
<td>71.2 (6.7)</td>
<td>72.3 (7.5)</td>
</tr>
<tr>
<td>Creatinine [μmol litre$^{-1}$; mean (SD)]</td>
<td>98.0 (34.6)</td>
<td>83.5 (22.8)</td>
<td>82.2 (16.0)</td>
</tr>
<tr>
<td>Hb [g dl$^{-1}$; mean (SD)]</td>
<td>11.9 (2.0)</td>
<td>12.7 (1.6)</td>
<td>13.0 (1.8)</td>
</tr>
<tr>
<td>ASA</td>
<td>69 (59)</td>
<td>38 (56)</td>
<td>82 (60)</td>
</tr>
<tr>
<td>I</td>
<td>0</td>
<td>38 (56)</td>
<td>81 (58)</td>
</tr>
<tr>
<td>II</td>
<td>47 (41)</td>
<td>23 (34)</td>
<td>55 (40)</td>
</tr>
<tr>
<td>III</td>
<td>69 (59)</td>
<td>7 (10)</td>
<td>3 (2)*</td>
</tr>
<tr>
<td>Predicted 30 day deaths (n)</td>
<td>8</td>
<td>1.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Actual 30 day deaths (n)</td>
<td>8</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Fig 1 Diagram of patient flow. HDU, high-dependency unit.

Colorectal surgical patients referred for 30-day postoperative mortality prediction

Patients who underwent surgery: colorectal resection, ileostomy or reversal of colostomy (n=504)

Predicted postoperative 30-day mortality > 4% (n=116)

Predicted postoperative 30-day mortality 1-3% (n=207)

Predicted postoperative 30-day mortality < 1% (n=181)

Planned HDU (n=108)
Planned Ward (n=8)
Postoperative care

Planned HDU postoperative care (n=68)

Planned Ward postoperative care (n=139)

Planned Ward (n=173)
Planned HDU (n=8)
Postoperative care

Laparotomy. The most common medical or non-surgical reason for unplanned critical care admission was pneumonia. Of these 14 patients, 10 were admitted with pneumonia, two with heart failure, one with atrial fibrillation, and one with a pelvic collection that was drained under radiological guidance. The overall estimated bed day cost was not increased in the predicted 30 day mortality group who had planned HDU care (Table 3). The overall mean bed day cost per patient with a predicted 30 day of 1–3% who had planned HDU care was £3326 and for planned ward care was £3613.

The HDU charts for the 68 patients with predicted 30 day postoperative mortalities between 1 and 3% who had planned HDU care were reviewed to identify treatments that were unavailable on the ward. Of these, 64 had an invasive arterial line, with blood gases and arterial lactate measured, and 29 had drug administrations only available in the HDU [24 received...
vasopressor (metaraminol) and five received magnesium sulphate to treat atrial fibrillation.

**Discussion**

In this cohort of patients, there was an association between emergency laparotomy and unplanned critical care admission after elective colorectal surgery with their place of immediate postoperative care.

The emergency laparotomy rate after elective colorectal surgery has been reported as 4.5%. In our cohort, the lower-risk patients (predicted 30 day mortality <1%) who went to the surgical ward had an emergency laparotomy rate of 1.1%. The higher-risk patients (predicted 30 day mortality >4%) who went to the HDU had an emergency laparotomy rate of 4.3%. For the intermediate-risk group (predicted 30 day mortality 1–3%), those who had planned postoperative ward care had a 10% emergency laparotomy rate. The HDU resources are limited. The use of a 30 day predicted mortality to determine the use of the postoperative HDU after elective colorectal surgery may help to use this resource optimally.

The estimated cost of postoperative care was similar for the group with a predicted 30 day mortality of 1–3% whether they had planned HDU care or planned ward care. The additional cost of planned HDU care was offset by the cost of unplanned ICU care. Unplanned admissions to a critical care unit after surgery are attributable to postoperative morbidity and cost more per patient than planned HDU care.

Unplanned critical care has been associated with a higher mortality than planned critical care. The group of patients with a predicted mortality of <1% who predominantly had planned ward care had a 1.7% incidence of unplanned critical care. This may be an acceptable incidence given the limited resource for HDU care in the UK. The group of patients with a predicted mortality of 1–3% who had planned ward care had a 16% incidence of unplanned critical care. This is probably not an acceptable incidence. Unplanned critical care admission was not possible for the patients who had planned HDU care until they had returned to the surgical ward; therefore, you would expect a difference in this outcome variable but not by this amount.

The colorectal surgical literature does not identify an association between postoperative care and postoperative complications. Postoperative complications after elective colorectal surgery have a negative economic and long-term quality-of-life impact. There may be a benefit from attending a perioperative medicine clinic, estimating postoperative predicted mortality, and planning postoperative HDU care.

We have found an association between reduced postoperative morbidity and postoperative HDU care, but no difference in mortality. This is probably because the incidence of emergency laparotomy and unplanned admission to critical care is greater than postoperative 30 day mortality. The mean length of planned HDU care was 1.4 days, but most of the postoperative

---

**Table 2** Emergency laparotomy after elective surgery in 504 colorectal patients, categorized by the predicted mortality in the first postoperative month from the perioperative medicine clinic. Values in parentheses are percentages. HDU, high-dependency unit. *P-value for 1–3% and HDU care vs 1–3% and ward care = 0.0056 (Fisher’s exact test)

<table>
<thead>
<tr>
<th>Predicted 30 day mortality</th>
<th>&gt;4%</th>
<th>&gt;1–3%</th>
<th>&lt;1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative destination</td>
<td>HDU (n = 116)</td>
<td>HDU (n = 68)</td>
<td>Ward (n = 139)</td>
</tr>
<tr>
<td>Emergency laparotomy after elective surgery</td>
<td>5 (4)</td>
<td>0</td>
<td>14 (10)*</td>
</tr>
<tr>
<td>Findings at laparotomy</td>
<td>Anastomotic leak</td>
<td>4 (3)</td>
<td>0</td>
</tr>
<tr>
<td>Ischaemic bowel</td>
<td>0</td>
<td>0</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Small bowel perforation</td>
<td>0</td>
<td>0</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Small bowel obstruction</td>
<td>0</td>
<td>0</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Pelvic collection</td>
<td>0</td>
<td>0</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Colitis and faecal peritonitis</td>
<td>1 (1)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

---

**Table 3** Critical care admissions and bed days after elective surgery in 504 colorectal patients, categorized by the predicted mortality in the first postoperative month from the perioperative medicine clinic. Values in parentheses are percentages. HDU, high-dependency unit; ICU, intensive care unit. Cost in UK pounds sterling (£). *P-value for 1–3% and HDU care vs 1–3% and ward care = 0.00015 (Fisher’s exact test)

<table>
<thead>
<tr>
<th>Predicted 30 day mortality</th>
<th>&gt;4%</th>
<th>&gt;1–3%</th>
<th>&lt;1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative destination</td>
<td>HDU (n = 116)</td>
<td>HDU (n = 68)</td>
<td>Ward (n = 139)</td>
</tr>
<tr>
<td>Planned critical care</td>
<td>108 (93)</td>
<td>68 (100)</td>
<td>0</td>
</tr>
<tr>
<td>Unplanned critical care</td>
<td>10 (9)</td>
<td>0</td>
<td>22 (16)*</td>
</tr>
<tr>
<td>Ward bed days [mean (SD)]</td>
<td>11.1 (9.10)</td>
<td>8.46 (5.87)</td>
<td>11.6 (12.0)</td>
</tr>
<tr>
<td>HDU bed days [mean (SD)]</td>
<td>1.44 (1.48)</td>
<td>1.38 (0.73)</td>
<td>0.36 (1.21)</td>
</tr>
<tr>
<td>ICU bed days [mean (SD)]</td>
<td>0.56 (2.63)</td>
<td>0.04 (0.21)</td>
<td>0.47 (2.44)</td>
</tr>
<tr>
<td>Combined ward, HDU, and ICU bed day cost per patient [mean (SD)]</td>
<td>£4391 (4685)</td>
<td>£3236 (1710)</td>
<td>£3613 (4841)</td>
</tr>
</tbody>
</table>
complications were identified >3 days after the elective surgery. It is possible that the use of vasopressors instead of fluid to treat hypotension and a more prompt treatment of atrial fibrillation resulted in better perfusion to the colorectal anastomosis. The treatment received in the first 24–48 h after the surgery may reduce the incidence of anastomotic leaks. There will be a time lag between the anastomotic leak and its diagnosis. To make a diagnosis of an anastomotic leak, you first observe a change in a patient’s clinical condition over time, followed by obtaining a computed tomographic scan, and you may then need an emergency laparotomy to confirm the diagnosis.

In the present study, there is potential bias that may affect both internal and external validity. Internal validity may be compromised by the following factors: no randomization or blinding; and no prospectively planned time point to assess the data or assessment of sample size. External validity is compromised by the following factors: single-centre study; length of stay and total cost could alter with a larger sample size; and the preoperative and postoperative care may not be replicable in a different environment.

There are few prospective controlled trials on admission to a higher care area, such as an HDU or a coronary care unit. To study postoperative HDU care, we need first to define the high-risk surgical patient population and then define the postoperative care given. We can then use prospective randomized controlled trials to evaluate specific components of postoperative HDU care. These might include arterial blood gas and lactate monitoring, the use of peripheral vasopressors, such as metaraminol, to maintain a normal blood pressure, and treatment of postoperative fast atrial fibrillation.

We recommend that the threshold for planned HDU care after elective colorectal surgery should be a predicted mortality in excess of 1% in the first postoperative month.

Authors’ contributions

Substantial contribution to the conception, design, acquisition of data, or analysis and interpretation of data; contribution to the drafting of the paper and approval of the submitted version: M.S., J.B.C., J.G.

Declaration of interest

None declared.

References


Handling editor: P. S. Myles