Audits

Perioperative mortality score: data collection and cost

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SUMMARY
The perioperative mortality score aims to predict mortality in elderly patients undergoing noncardiac surgery using three preoperative risk factors (age, albumin and American Society of Anesthesiologists physical status) and then modify this risk assessment if any of three postoperative complications occur (unplanned intensive care unit admission, systemic inflammation and acute renal failure). In order to determine the cost of routine perioperative mortality score calculation in future research, we audited the incidence of clinician-initiated preoperative albumin, pre- and postoperative creatinine and postoperative white cell count testing in patients aged ≥70 years presenting for elective and emergency noncardiac surgery requiring at least overnight admission over a three-month period. We recruited 637 noncardiac surgical patients. All laboratory tests required for perioperative mortality score calculation were performed in only 47% of patients and the total cost of testing all untested patients was AS$12,057 (AS$18.927 per 1000 patients). Preoperative hypoalbuminaemia was present in 11% of tested patients, acute renal impairment in 24% of tested patients and high white cell count in 33% of tested patients. These results may be used to inform future research or clinical use of the score.

Key Words: anaesthesia, perioperative mortality, risk scoring, elderly, albumin, creatinine

Elderly patients having elective or emergency surgery are at significant risk of postoperative morbidity and death. In a recent study conducted at 23 hospitals in Australia and New Zealand (the REASON study), 30-day mortality in patients aged ≥70 years having noncardiac surgery requiring overnight admission was 6% and the rate of major complications was 19%, creating a significant burden for health services1. These figures echo those reported in the National Surgical Quality Improvement Program cohort, the most extensive database on perioperative outcomes for elderly surgical subjects maintained by the Department of Veterans Affairs in the USA2,3.

The perioperative mortality (POM) score4, developed by analysis of data from three of the hospitals in the REASON study5, is a novel bedside tool that aims to predict mortality in elderly patients undergoing noncardiac surgery. The score is cumulative and incorporates three preoperative risk factors (age, albumin and American Society of Anesthesiologists’ [ASA] physical status). This preoperative risk assessment can be modified if one or more of three postoperative factors occur (unplanned intensive care unit [ICU] admission, systemic inflammation and acute renal failure) (Table 1). That is, the score can be calculated preoperatively using the preoperative factors and then adjusted postoperatively if complications occur. The score has been validated in a separate cohort study in which the 30-day risk of mortality in patients with POM scores of <5, 5 to 10 and ≥10 was 1%, 7% and 26% respectively6. However, the sample size of this validation study was small and larger validations studies are required.
In clinical use, the POM score uses points as they become available in a cumulative fashion. For audit and research purposes, the complete POM score cannot be calculated unless the six data points are collected. Age and ASA physical status are routinely recorded in operating theatre databases. Unplanned ICU admission and sepsis are recorded as part of coding procedures postoperatively. However, although preoperative creatinine is commonly measured in elderly patients, preoperative serum albumin and postoperative serum creatinine are not routinely measured, and a raised white cell count is frequently required in order to establish the diagnosis of sepsis. Further validation studies or research using the score, or indeed use of the score in clinical practice, will therefore require additional testing and cost.

Therefore, as an aid to those considering further research with or clinical use of the POM score, we audited the incidence of preoperative albumin, pre- and postoperative creatinine and postoperative white cell count testing in patients aged ≥70 years presenting for elective and emergency noncardiac surgery requiring at least overnight admission over a three-month period. Our primary aims were: 1) to determine the percentage of patients aged ≥70 years presenting for elective and emergency noncardiac surgery who had the necessary laboratory investigations for calculation of the POM score, and 2) to determine potential costs of instituting measurement to enable calculation of POM scores in the “untested” patients.

**METHODS**

Ethics committee approval was obtained from the Royal Melbourne Hospital (a metropolitan teaching hospital) and Ballarat Base Hospital (a regional base hospital) before data collection commenced. As this activity constituted an audit, the requirement for patient consent was waived at both centres.

The hospital identification numbers, dates of birth and admission and discharge dates of all patients having surgery during July, August and September of 2009 were obtained from operating room records. The inclusion criteria for the study were: 1) age ≥70 years; 2) surgery undertaken in the main operating suite of the hospital; 3) overnight stay in the hospital following surgery and 4) non-cardiac surgery. Patients not meeting these criteria and those having gastrointestinal endoscopy in the main operating suite were excluded.

Once the study cohort was finalised, the following information was obtained from each hospital’s databases: 1) ASA physical status; 2) type of surgery; 3) elective or emergency status; 4) preoperative serum albumin concentration (measured on the day closest to surgery and within three months of operative day); 5) preoperative serum creatinine concentration (measured on the day closest to surgery and within three months of operative day); 6) postoperative serum creatinine concentrations (measured before hospital discharge, all recorded values) and 7) postoperative white cell counts (measured before hospital discharge, all recorded values). Hypoalbuminaemia was defined as a serum albumin <30 g/l. Acute renal impairment was defined as an increase in serum creatinine more than 20% above the preoperative value. An increased white cell count was defined as >12,000 cells/μl. The cost of measuring albumin, creatinine and white cell count was defined using the Australian Commonwealth Medical Benefits Schedule (A$17.80 for the panel including albumin and for the panel including creatinine; A$17.05 for the panel including white cell count). The cost per 1000 patients was also calculated.

Continuous data were graphed to assess their distributions. As all continuous data were skewed, the data were summarised using median (range) and compared using the Wilcoxon rank-sum test. Analyses were conducted using Stata 10.1 (Stata Corporation, College Station, TX, USA). All P values are two-sided and P <0.05 was considered statistically significant.

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**TABLE 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Status</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>70-79</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>80-89</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>6</td>
</tr>
<tr>
<td>ASA physical status</td>
<td>I-II</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>15</td>
</tr>
<tr>
<td>Albumin</td>
<td>&lt;30</td>
<td>2.5</td>
</tr>
<tr>
<td>Unplanned ICU admission</td>
<td>Yes</td>
<td>4</td>
</tr>
<tr>
<td>Systemic inflammation*</td>
<td>Yes</td>
<td>3</td>
</tr>
<tr>
<td>Acute renal impairment**</td>
<td>Yes</td>
<td>2.5</td>
</tr>
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</table>

POM=perioperative mortality, ARF=acute renal failure, ASA=American Society of Anesthesiologists, ICU=intensive care unit. *A new finding of at least two of temperature >38.3°C or <36°C, white cell count >12,000 cells/μl, respiratory rate >20 breaths/min, heart rate >90 beats/min; or a positive blood culture alone. **A creatinine increase >20% of pre-operative value or admission to ICU for renal replacement therapy.
RESULTS
A total of 637 patients were included in the study (426 [67%] from the Royal Melbourne Hospital and 221 [33%] from the Ballarat Base Hospital). Patients were aged 77 (70 to 96) years, 53% were male, 60% were ASA physical status 3 to 5 and 37% underwent emergency surgery.

Albumin was measured preoperatively in 358 patients (56%). Creatinine was measured preoperatively in 543 patients (85%) and postoperatively in 484 patients (76%). White cell counts were measured postoperatively in 479 patients (75%). Only 47% of patients had all laboratory testing required to calculate the POM score (i.e. preoperative albumin and creatinine and postoperative creatinine and white cell count).

The estimated cost of conducting these tests in untested patients was A$4966 for preoperative albumin (n=279; A$7796 per 1000 patients), A$1673 for preoperative creatinine (n=94; A$2627 per 1000 patients), A$2723 for at least one postoperative creatinine (n=153; A$4275 per 1000 patients) and A$2694 for at least one postoperative white cell count (n=158; A$4229 per 1000 patients). The total cost for both hospitals of testing all untested patients was $12,057 (A$18,927 per 1000 patients).

Hypoalbuminaemia was present in 40 preoperative patients (11%) with available preoperative albumin measurement. The incidence of hypoalbuminaemia was higher among tested emergency patients than tested elective patients (Table 2). Acute renal impairment developed in 105 patients with pre- and postoperative creatinine measurements (22%). A high white cell count was detected in 159 of patients in whom white cell count was measured postoperatively (33%).

DISCUSSION
Our study of 637 noncardiac surgical patients aged ≥70 years demonstrated that all laboratory tests required for POM score calculation were performed in only 47% of patients and that the total cost for both hospitals of testing all untested patients was A$12,057 (A$18,927 per 1000 patients). These results may be used to inform future research or clinical use of the score. Abnormal test results were common in tested patients with preoperative hypoalbuminaemia present in 11% of tested patients, acute renal impairment in 24% of tested patients and high white cell count in 33% of tested patients.

A minority of patients in our audit had all the tests required to calculate the POM score. The main reason for failure of complete testing was lack of preoperative albumin measurement. Much evidence exists regarding the prognostic value of hypoalbuminaemia in medical conditions, such as malignancy, liver and renal disease, sepsis and pre-eclampsia. Preoperatively, hypoalbuminaemia

<table>
<thead>
<tr>
<th>Predictor</th>
<th>n (%)</th>
<th>Univariate OR (95% CI)</th>
<th>P value</th>
<th>Multivariate OR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>70-79 years</td>
<td>169 (43)</td>
<td>1.52 (1.10-2.10)</td>
<td>0.01</td>
<td>1.10 (0.77-1.58)</td>
<td>0.61</td>
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<tr>
<td>≥80 years</td>
<td>128 (53)</td>
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<tr>
<td>Gender</td>
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</tr>
<tr>
<td>Female</td>
<td>145 (48)</td>
<td>0.89 (0.65-1.21)</td>
<td>0.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>152 (45)</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>ASA status</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>I-II</td>
<td>90 (35)</td>
<td>1.87 (1.33-2.64)</td>
<td>&lt;0.0001</td>
<td>1.90 (1.07-3.37)</td>
<td>0.03</td>
</tr>
<tr>
<td>III</td>
<td>152 (51)</td>
<td>3.58 (2.12-6.04)</td>
<td>&lt;0.0001</td>
<td>3.80 (2.61-5.52)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>IV-V</td>
<td>55 (66)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>135 (34)</td>
<td></td>
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<tr>
<td>Emergency</td>
<td>162 (69)</td>
<td>4.39 (3.10-6.20)</td>
<td>&lt;0.0001</td>
<td>2.77 (1.90-4.03)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Site</td>
<td></td>
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<tr>
<td>Regional</td>
<td>63 (30)</td>
<td>2.86 (2.02-4.07)</td>
<td>&lt;0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metropolitan</td>
<td>234 (55)</td>
<td></td>
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</tbody>
</table>

POM=perioperative mortality, OR=odds ratio, CI=confidence interval, ASA=American Society of Anesthesiologists.
acts as a nonspecific marker of chronic disease
or malnutrition and therefore worse outcome\(^6\). However, its under-utilisation as a preoperative
marker of poorer prognosis is not surprising when
the prevailing ethos of preoperative assessment
emphasises a clinical assessment of cardiovascular
fitness for surgery\(^4\). Based on the proven prognostic
value of albumin in the perioperative period\(^1\)\(^3\), we believe that preoperative albumin should be
measured in all elderly patients regardless of whether
risk scoring is contemplated.

Abnormal test results were common in our
patient population. Preoperative hypoalbuminaemia
was present in 11% of tested patients and acute
postoperative renal impairment was frequently
detected (22% of tested patients). Both were more
commonly encountered in emergency patients
than elective patients, which is consistent with the
higher rates of comorbidity and increased surgical
complexity in these patients. However, all these
results should be interpreted with caution as testing
was not protocolised and the incidences in untested
patients are unknown.

The total cost of testing all untested patients was
A$12,057 (A$18,927 per 1000 patients). The greatest
additional expense would accrue from universal
measurement of preoperative albumin (A$4966
[A$7796 per 1000 patients]). These results could
be used in planning a further evaluation study or
clinical use of the score. For ease of comparison, our
costings are based on Medicare reimbursement,
which may be discounted to a greater or lesser extent
in Australian public hospitals. In addition, the cost
of additional tests when several tests are already
ordered (e.g. adding albumin to urea, creatinine and
electrolytes) is actually less than when ordering the
test alone. Finally, we have not included the labour
costs of collecting the samples, which vary greatly
according to the variety of tests ordered in each
patient. The overall cost of additional testing
therefore may be less than quoted in this paper.

The strength of our audit lies in the
comprehensiveness with which we were able to
collect data for the laboratory testing components of
the POM score. Via our database records, we were
able to audit every elderly patient who underwent
surgery requiring at least overnight admission in a
three-month period. We also audited the ordering
of laboratory tests and calculated what proportion
of patients was actually being tested in a reliable way.
This exercise revealed that laboratory testing in both
hospitals was often a relatively ‘ad hoc’ process. There
were not only omissions but multiple duplications so
that the cost of testing untested patients for one or
other variable could readily be recouped by limiting
the frequency of repeat testing of variables that are
unlikely to change on a daily basis.

The two other POM score variables (namely the
clinical findings that define systemic inflammation
and the incidence of unplanned ICU admission)
were beyond the scope of our electronic audit as in
our hospitals this would have required a detailed
chart review of every patient. Furthermore, we did
not measure postoperative mortality or complications
and therefore cannot estimate whether the increased
cost of testing could be justified on the basis of
reduced postoperative cost because of better risk
stratification. This requires a sophisticated cost-
benefit analysis. Finally, we included the laboratory
test measured on the day closest to surgery and
within three months of the operative day, because
this represented the typical timeframe of attendance
at preoperative clinics in our hospitals. However,
90% of patients had an albumin measurement within
one month of surgery, and albumin, as a chronic-
phase indicator of health status, does not change
rapidly (except in acute illness where it is likely to be
re-measured).

In conclusion, our audit revealed that current
laboratory testing in elderly patients undergoing
noncardiac surgery in our hospitals was not
adequate to enable routine calculation of the POM
score in 53% of patients. This represents a significant
barrier to retrospective research using the POM
score and prospective estimation of risk in individual
patients. The costs of additional testing need to
be taken into account in the planning of further
validation studies or clinical use of the score. Based
on the National Surgical Quality Improvement
Program\(^2\)\(^3\) and REASON\(^1\) studies, preoperative
albumin should be tested routinely in elderly surgical
patients.

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