Anaesthesia 2015, 70, 1020–1027 doi:10.1111/anae.12991

Original Article

Postoperative morbidity survey, mortality and length of stay following emergency laparotomy*

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Summary

Thirty-day mortality following emergency laparotomy is high, and greater amongst elderly patients. Studies systematically describing peri-operative complications are sparse, and heterogeneous. We used the postoperative morbidity survey to describe the type and frequency of complications, and their relationship with outcomes for 144 patients: 114 < 80 years old, and 30 ≥ 80 years old. Cumulative postoperative morbidity survey scores and patterns of morbidity were similar (p = 0.454); however, 28-day mortality was higher in the elderly (10/30 (33.3%) vs 11/114 (9.6%), p = 0.008), and hospital stay was longer (median (IQR [range]) 17 (13–35 [6–62]) days vs 11 (7–21 [2–159]) days, p = 0.006). Regression analysis indicated that cardiovascular, haematological, renal and wound complications were associated with longer hospital stay, and that cardiovascular complications predicted mortality. The postoperative morbidity survey system enabled structured mapping of the number and type of complications, and their relationship with outcome, following emergency laparotomy. These results indicate that rather than a greater propensity to complications following surgery, it was the failure to tolerate these that increased mortality in the elderly.

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Accepted: 1 December 2014
**Presented in part at the 2nd Global Conference on Anaesthesia, Perioperative and Pain Medicine in the Cancer Patient, Melbourne, Australia; March 2014.*

Introduction

Patients undergoing emergency laparotomy experience high peri-operative risk. In the UK, 30-day mortality is one in seven overall, and for the elderly (age ≥ 80 years), almost one in four [1]. Although patients requiring emergency laparotomy are frequently elderly, with significant co-morbidity and additional high-risk insults such as sepsis [2], evidence suggests that intervention can improve outcomes. Khuri and colleagues found that most of the strongest predictors of mortality following major surgery were postoperative complications [3], and that the occurrence of any complication was a more important predictor than any pre- or intra-operative factor. Effectiveness of rescue in the event of complications is also known to be an important factor in survival [4].

Despite such evidence, the literature quantifying complications following emergency laparotomy is sparse and heterogeneous. To make advances in care, there is a need first for a robust understanding of the nature, type and incidence of postoperative complications in this high-risk patient group. The postoperative morbidity

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survey (POMS) is a simple method of detecting and quantifying postoperative complications [5]. Its design is suited to all types of surgery, and is based on identifying complications that prevent hospital discharge. Patients are assessed for diagnostic features in nine domains (pulmonary, infectious, renal, gastrointestinal, cardiovascular, neurological, haematological, wound and pain) at chosen time-points. It has been validated and used in a range of elective moderate and major surgeries, including general, urological, orthopaedic and cardiac surgery [6–9].

The primary aim of this study was to describe the type and incidence of postoperative complications following emergency laparotomy surgery, using a recognised system (POMS), in order to understand better where and how intervention may be targeted to improve outcomes. Secondary aims were to explore how outcomes (mortality and length of hospital stay) relate to age, pre-operative risk score and postoperative complications (as measured by the POMS).

Methods

Data for this paper were collected as part of an assessment of current practice, and implementation of best-practice guidelines. Approval for the project was granted by the Trust's Research and Development Department. The UK National Research Ethics Service confirmed that this type of study does not require formal ethical approval.

We prospectively followed up all patients undergoing emergency laparotomy in a medium-sized district general hospital between 8 April 2012 and 28 November 2012. Inclusion criteria were adult patients undergoing urgent or emergency abdominal surgery via a midline incision, with underlying gastrointestinal pathology. Exclusion criteria were age < 18 years, trauma, aortic aneurysmal leak or rupture, other vascular pathology (except mesenteric ischaemia), gynaecological pathology and procedures completed using an entirely laparoscopic approach.

Data were collected on postoperative days 3, 5, 10 and 28 by a dedicated nurse, and entered into a database designed for this purpose. Information was obtained from casenote review. Any patient who had been discharged home at each point of measurement was assumed to have no ongoing POMS-defined morbidity. Using the POMS methodology, a patient scores a maximum of one point for each organ system; for example, presence of a core temperature above 38 °C and use of antibiotics gives a score of one point in the infectious category.

Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity (P-POSSUM)-predicted mortality scores were calculated using an online tool [10]. Values used were those recorded at the end of surgery.

In addition to whole-group analysis, data were analysed in two subgroups: patients < 80 years of age and those ≥ 80. This threshold is in line with earlier studies of this topic, which have either examined patients in groups < or ≥ 80 years [11], made additional examination of those ≥ 80 [12], or solely examined those ≥ 80 [13, 14]. Endpoints for the study at each of the four postoperative measurements were: mortality; time to discharge; rate of any inpatient morbidity; and incidences of individual system morbidity as per the POMS.

We made two adjustments to the POMS scoring. First, when scoring the renal element, we excluded the presence of a urinary catheter alone as a diagnostic criterion, i.e. a patient would only qualify if they developed oliguria or a rise in serum creatinine. This was deemed necessary to give a more accurate view of postoperative renal morbidity for this patient group, who were likely to require continued urethral catheterisation for reasons other than renal dysfunction (e.g. poor mobility). Secondly, we did not include pain in our POMS, as our data collection methods were not aligned with the POMS definition for pain data.

Data were analysed using SPSS 21 (IBM Corp, New York, USA). Categorical data were compared using contingency table analysis (chi-squared or Fisher's exact test); continuous data were largely non-normally distributed and analysed using the Mann–Whitney U-test. Spearman's correlation was used to assess relationships between pre-/peri-operative risk stratification, postoperative morbidity, and length of stay. Results of statistical analysis were considered significant at a p value of 0.05 or less.

Results

One hundred and forty-four patients, including 30 aged ≥ 80 years, were eligible for inclusion. Mean

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(SD) age was 65 (16) years. Although ASA scores were significantly higher in the elderly group (median (IQR [range]) 3 (2–3 [2–5]) vs 3 (2–3 [1–5]); p = 0.003) there was no significant difference in P-POSSUM-predicted mortality scores between the two age groups (p = 0.072). Detailed results are shown in Table 1.

Overall 28-day mortality (the final POMS assessment day) was 13.9% (Table 2). Mortality was significantly higher, and hospital stay was significantly longer, in the elderly group (Table 2).

Kaplan–Meier survival analysis showed significantly reduced survival for the elderly group (log-rank p = 0.009; survival curves shown in Fig. 1). Data used in this analysis were limited to inpatient deaths.

Table 1 Characteristics of patients undergoing emergency laparotomy. Values are number or median (IQR [range]).

	Number of patients
Age < 80 years: ≥ 80 years	114: 30
Male: female	71: 73
ASA score	
1/2/3/4/5	12/48/46/31/7
ASA physical status	3 (2–4 [1–5])
P-POSSUM-predicted mortality;%	9.05 (3–27[0.8–96.4])
Surgical procedure*	
Stoma formation (alone or part of wider procedure)	43
Small bowel resection	22
Adhesiolysis only	18
Right hemicolectomy	18
Hartmann's procedure	16
Hernia repair	9
Take-down anastomosis, stoma formation	7
Exploration only	5
Ileocaecal resection	5
Duodenal ulcer oversew	5
Abscess washout	4
Gastric ulcer oversew	4
Subtotal colectomy	4
Appendicectomy	4
Small bowel oversew	3
Sigmoid colectomy	3
Splenectomy	2
Other large bowel resection	2
Volvulus reduction	2
Small bowel incision for stone	2
Tumour debulking	2
Open/close, non-viable	2
Other	7

P-POSSUM, Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity.
*A total of 189 procedures were performed on 144 patients.

The proportion of patients with POMS-defined morbidity was highest on day 3, and reduced at each successive time-point. For patients ≥ 80 years old, 100% of inpatients had POMS-defined morbidity on day 3, decreasing to 75% by day 28. For the younger group, inpatient morbidity ranged from 95% (day 3) to 75% (day 28). On all postoperative days the proportion of remaining inpatient with morbidity was similar in both age groups (p = 0.583, 0.734, 1.000 and 1.000 for days 3, 5, 10 and 28, respectively).

Almost all patients experienced at least one POMS-defined morbidity: 30 (100%) patients aged ≥ 80 years, and 110 (96%) patients aged < 80 years. Median (IQR [range]) cumulative POMS score was 3 (2–4 [0–8]); there was no significant difference between the two age groups (p = 0.454). Figure 2 shows the distribution of cumulative POMS scores for the postoperative period.

Three morbidity categories were prominent: infectious; pulmonary; and gastrointestinal; each occurring in > 60% of patients postoperatively. The incidence of POMS morbidity by category on each postoperative day is shown in Fig. 3. The most common sources of morbidity for the whole postoperative period are shown in Table 3. The incidence and pattern of POMS complications were notably similar in both age groups.

The ASA score and P-POSSUM-predicted mortality showed significant positive correlation with both length of stay (ρ = 0.447 and 0.559 respectively; p < 0.0005 for both), and cumulative POMS score (ρ = 0.350 and 0.483 respectively; p < 0.0005 for both). A weaker correlation was observed between duration of surgical procedure and length of stay (ρ = 0.230; p = 0.010). The ASA score and P-POSSUM-predicted mortality were significantly correlated (ρ = 0.641; p < 0.0005).

Median (IQR [range]) ASA score was significantly higher in non-survivors (4 (3–4 [2 –5]) than survivors (3 (2–3 [1–5]; p < 0.0005), as was P-POSSUM-predicted mortality (median [range] 31.7 (19.3–67.5 [3.5–96.4])% vs 6.5 (2.3–21.5 [0.8–95.3])%, respectively; p < 0.0005). Operative duration was not significantly different between survivors and non-survivors (p = 0.751).

Linear regression was performed to assess the predictive value of the individual POMS morbidities on length of stay. Goodness of fit of the model is

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Table 2 Outcomes of patients at 28 and 30 days postoperatively, and length of stay of 30-day survivors. Values are number (proportion or 95% CI) or median (IQR [range]). Odds ratios compare age groups (< and ≥ 80 years).

	All patients (n = 144)	Age < 80 years (n = 114)	Age ≥ 80 years (n = 30)	Odds ratio		p value
Outcomes at 28 and 30 days postoperatively						
Died before postoperative day 28	20 (13.9%)	11 (9.6%)	9 (30.0%)	0.249	(0.092–0.676)	0.008
Discharged before postoperative day 28	98 (68.1%)	84 (73.7%)	14 (46.7%)	0.313	(0.136–0.716)	0.005
Died before postoperative day 30	21 (14.6%)	11 (9.6%)	10 (33.3%)	0.214	(0.080–0.570)	0.003
Length of stay of survivors; days	12 (7–23 [2–159])	11 (7–21 [2–159])	17 (13–35 [6–62])			0.008

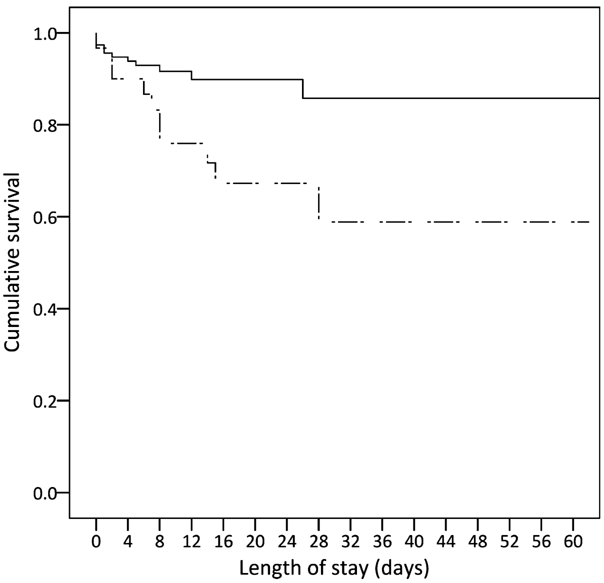

Figure 1 Kaplan–Meier survival curves for patients < 80 years old (solid line) and ≥ 80 years old (dashed line). Analysis includes data up to the longest length of stay but shown to day 60 only for convenience.

described by the adjusted R^2 value; this value was highest (0.434 – suggesting 43% of the change in length of stay is predicted by this model) when four variables were included: cardiovascular; haematological; renal; and wound. Variables not reaching statistical significance in this model were pulmonary, infectious, gastrointestinal and neurological domains.

The relative value of each of the four included variables is represented by a B value, which was highest for cardiovascular (22.7), followed by haematological (15.5), then renal (14.9) and finally wound (8.8). Values suggest the effect a POMS complication may have on length of stay, if all other complications are held constant (e.g. 23 days for a cardiovascular complication).

This analysis was repeated using POMS morbidities at day 3; patterns were similar, but with renal complications having a greater effect. The adjusted R^2 for the model was 0.390. From day 5 onwards, the analysis was less useful (R^2 values < 0.2), and hence was not pursued.

Contingency tables were used to explore associations between POMS categories and 28-day mortality. For POMS morbidities occurring on any follow-up day, cardiovascular ($p < 0.0005$) and renal ($p = 0.024$) categories were associated with increased mortality. Day-3 complications significantly associated with mortality were cardiovascular ($p = 0.015$) and neurological ($p = 0.036$). Day-5 complications showing significant association were cardiovascular ($p < 0.0005$) and haematological ($p = 0.030$). No significant associations were found for complications occurring on days 10 or 28.

Since such univariate analysis does not consider inter-variable effects, logistic regression was then used to assess the value of the relevant POMS categories in predicting 28-day mortality. Running this model using complications occurring on any follow-up day, only cardiovascular complications were associated with increased mortality, with an odds ratio for survival of 0.045 (95% CI 0.009–0.230; $p < 0.0005$). Running the model using complications occurring specifically on days 3 and 5, cardiovascular complications were again associated with increased mortality: events on day 3 showed an odds ratio for survival of 0.147 (95% CI 0.036–0.603; $p = 0.008$), and day 5 events showed an odds ratio for survival of 0.018 (95% CI 0.003–0.102; $p < 0.0005$).

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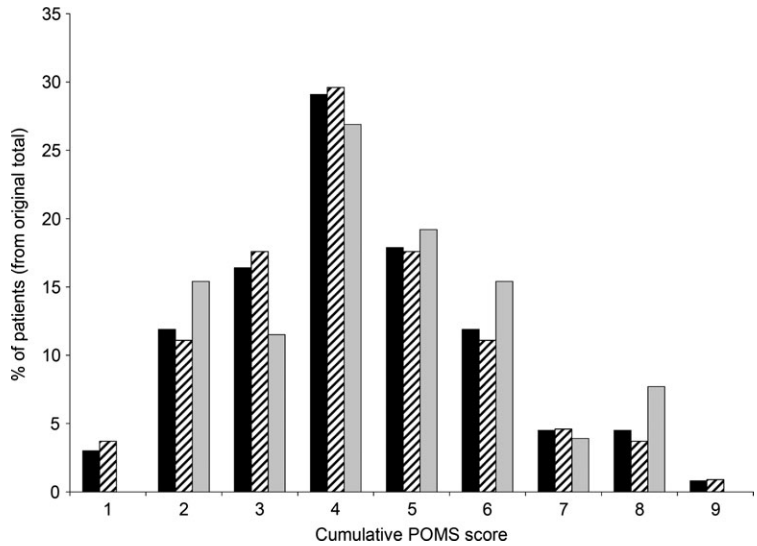

Figure 2 Cumulative postoperative morbidity survey (POMS) score at any point during the study period, for all patients (■), patients < 80 years (▨), and patients ≥ 80 years (□).

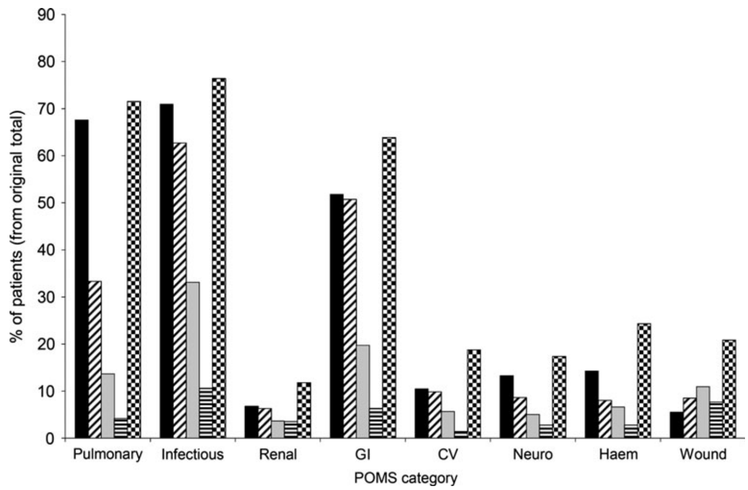

Figure 3 Incidence of postoperative morbidity survey (POMS) morbidity by category on postoperative day 3 (■), day 5 (▨), day 10 (□), day 28 (▤), and at any point (▩). GI, gastrointestinal; CV, cardiovascular; neuro, neurological; haem, haematological.

Discussion

Overall 30-day mortality in our study was 14.6%, consistent with the 14.9% observed by the UK Emergency Laparotomy Network (ELN). For the elderly (≥ 80 years), 30-day mortality was 33.3% (24.4% in the ELN), confirming the findings of previous studies that these patients' peri-operative mortality risk is amongst the highest of any surgical group [11, 15, 16]. Median length of stay was 12 days (mean 20.4 days), with four patients having hospital stays > 90 days. These data confirm the economic impact of these cases on hospitals, in addition to the patients' personal costs.

Our analysis shows very high rates of POMS-defined morbidity compared with studies of elective patients. When comparing our findings on postoperative days 3 and 5 with those of Grocott and colleagues [6], the incidence of morbidity was far higher (in some cases more than eight times) in all categories, except for gastrointestinal. Of particular note in our study is

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Table 3 Postoperative morbidity survey categories ranked in order of cumulative frequency. Values are proportions of the original patient total.

All patients		Patients < 80 years		Patients ≥ 80 years	
Infectious	76.4%	Infectious	79.0%	Infectious	66.7%
Pulmonary	71.5%	Pulmonary	72.8%	Pulmonary	66.7%
Gastrointestinal	63.9%	Gastrointestinal	64.9%	Gastrointestinal	60.0%
Haematological	24.3%	Haematological	22.8%	Haematological	30.0%
Wound	20.8%	Wound	21.9%	Neurological	26.7%
Cardiovascular	18.8%	Cardiovascular	17.5%	Cardiovascular	23.3%
Neurological	17.4%	Neurological	14.9%	Wound	17.7%
Renal	11.8%	Renal	11.4%	Renal	13.3%

that the incidence, extent and distribution of morbidity were the same in both age groups. In marked contrast, Kaplan–Meier analysis showed significantly reduced survival in the elderly group. Mortality was threefold higher in elderly patients, and those who survived had markedly longer hospital stays than younger patients. Thus, elderly patients have poorer outcomes, but not because of an increase in postoperative complications. While the purpose of this study is not to determine causality, it would seem that elderly patients (who are likely to have less physiological reserve), have less ability to recover from complications when they occur.

The POMS-defined complication observed most commonly overall was infectious, for which the criteria were: a temperature of 38 °C or more in the previous 24 h; or currently receiving antibiotic therapy. At 72 h postoperatively, patients would no longer be receiving prophylactic antibiotics, thus actual or presumed infection was being treated. This was a group of patients in whom peritoneal soiling may have occurred.

Pulmonary complications were the next most common overall, and were equally as common as infectious complications amongst elderly patients. This indicates that the majority of patients were receiving either supplementary oxygen or respiratory support at 72 h following surgery.

The next most prevalent source of morbidity was gastrointestinal, with more than half of all patients experiencing a complication on postoperative days 3 and 5. This is a difficult group of complications to address: gut dysfunction is common following abdominal surgery, and may be relatively benign (e.g. ileus following surgical handling), but sinister causes such as anastomotic dehiscence need to be identified early, in order to avoid more severe complications [17].

Our data indicate that cardiovascular morbidity was infrequent (sixth most common category), but was strongly associated with poor outcome. Regression analysis suggested that cardiovascular complications may be the strongest predictor of both mortality and increased length of stay. This correlates with the findings of the VISION study, that early elevation of serum troponin following non-cardiac surgery was the strongest predictor of 30-day mortality [18]. The POMS definition for cardiovascular morbidity includes requirement for vasoactive drug support, correlating with previous observations that early postoperative use of vasoactive drugs is strongly associated with mortality [15].

Another relatively rare morbidity – renal – predicted the next greatest increase in length of stay, particularly when present on postoperative day 3. Adverse outcomes in patients experiencing postoperative acute kidney injury (AKI) are well-documented: Weingarten and colleagues observed increased length of hospital stay in patients developing AKI following major orthopaedic surgery [19], and the REASON study reported increased mortality in elderly patients developing AKI following non-cardiac surgery [20].

Haematological and wound complications completed the list of POMS categories associated with longer hospital stay. This was observed when considering POMS-defined complications across the entire postoperative period, and also specifically on postoperative day 3. Whilst the relatively small number of patients in this study preclude drawing firm conclu-

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sions, it is possible that the occurrence of these complications (cardiovascular, renal, haematological and wound) in the early postoperative period following emergency laparotomy will help predict length of hospital stay. Similarly, the occurrence of cardiovascular complications in the early postoperative period appears to have a predictive value for mortality. Taking these findings further, improvements in care to reduce the occurrence of these complications might lead to shorter hospital stays, although this study cannot confirm this.

In contrast to the elective setting, pre-operative optimisation of emergency surgical patients is challenging. However, peri-operative optimisation of chronic conditions (e.g. anaemia or ischaemic heart disease), and vigilant postoperative monitoring to enable prevention, early detection and early intervention when complications do occur, may be of benefit. It is likely that such high levels of care can only be provided in the critical care setting. There is already evidence that this group of patients benefit from ICU/HDU admission [11].

We found that both ASA score and P-POSSUM-predicted mortality scores were significantly correlated with cumulative POMS score, length of hospital stay and mortality. While this study was not designed to assess the validity of these tools in this patient group, the associations are reassuring for practising clinicians. They are also in line with a recent systematic review of risk stratification that found these tools (and also the Surgical Risk Scale [21]) to be the most useful predictors of outcome in major surgery [22].

We could find no record of use of the POMS for measuring complications following emergency general surgery, and thus comparison with other studies is difficult. Major infective complications during the early postoperative period were seen in 72% of patients undergoing emergency laparotomy at a UK teaching hospital [23]. This is similar to the 76% we observed by day 28. The same group reported wound complications in 22% of patients (21% in our group), and renal complications (AKI) totalling 13% (12% in our patients). They reported 14% mortality at 30 days, compared with our rate of 14.6%. Further comparison is limited by incompatibility in presentation of data.

There are three limitations to our study. Firstly, there are intrinsic limitations to the POMS methodology [6]. The greatest of these is redundancy of information – a single complication may register in several domains simultaneously. A pulmonary thromboembolism is a thrombotic event (‘cardiovascular’), causing requirement for supplemental oxygen (‘pulmonary’), and may result in delirium (‘neurological’). Moreover, criteria for certain categories are more specific than others. For example, the cardiovascular domain has the most specific definition in terms of diagnostic results or therapies, and this category showed the strongest statistical associations. Categories with less specific criteria (e.g. gastrointestinal) may have been less likely to yield significant associations. There is also an assumption of causality (that POMS morbidity is preventing hospital discharge), and of complete data capture (that patients who have been discharged do not have POMS morbidity). However, the POMS is easily measured, uses objective definitions, is reproducible and is acceptable to patients. In addition, the definitions in the survey are designed to capture the type of events and medical interventions that require in-patient hospital stay. Secondly, we modified the POMS by excluding bladder catheterisation from our definition of ‘renal’ morbidity. While this definition appears suitable for an elective population, we observed many patients who remained catheterised because of pre-existing morbidity or poor mobility. We judged that including such patients would overstate genuine ‘renal morbidity’. We were unable to include pain data in the POMS, as our data collection was not aligned with the POMS definition. This will lead to an overall underestimation of cumulative POMS scores in our population. Thirdly, our cohort of patients aged ≥ 80 years is rather small; despite this, we have identified large and statistically significant differences in mortality and length of hospital stay between these and younger patients.

In summary, we have used a morbidity score in a high-risk patient group, to map the type and incidence of complications following emergency laparotomy in a structured manner. This enables a logical and systems-based approach to quantifying morbidity. We have also studied correlation between pre-operative risk scores (ASA, P-POSSUM) and out-

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comes. Our basic data are comparable with other recently published data, suggesting that our findings are likely to be generalisable. Using the POMS methodology, we found no significant difference between patients aged < 80 years and those ≥ 80 years in terms of the total number of organ systems in which morbidity occurred, or in their distribution. The commonest morbidities were infective, pulmonary and gastrointestinal. Our findings indicate that some of the less common morbidities (cardiovascular, renal, haematological and wound) may have a greater impact on recovery than those that occur more commonly. Despite similar patterns of postoperative morbidity, the groups differed markedly in mortality rate and duration of hospital stay.

Acknowledgements

We thank Professor Paul Myles for his assistance with statistical analysis. This work was funded by the Regional Innovation Fund of the South West Strategic Health Authority. We gratefully acknowledge the contribution of our friend and colleague John Murphy who sadly died during the preparation of this manuscript.

Competing interest

No competing interests declared.

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