Original Article

Physiological and operative severity score for the enumeration of mortality and morbidity scoring systems for assessment of patient outcome and impact of surgeons' and anesthesiologists' performance in hepatopancreaticobiliary surgery

ABSTRACT

Context: The physiological and operative severity score for the enumeration of mortality and morbidity (POSSUM) is a scoring system used to predict morbidity and mortality.

Aims: We compared the physiological and operative risk, the expected morbidity and mortality, and the observed postoperative mortality among patients operated by different surgeons and anesthetized by different anesthesiologists.

Settings and Design: This was a retrospective, single center study.

Subjects and Methods: The anesthetic records of 159 patients who underwent hepatopancreaticobiliary surgery were analyzed for the physiological and operative severity, POSSUM morbidity, POSSUM and Portsmouth POSSUM (P-POSSUM) mortality scoring systems, observed mortality in 30-days, 3, 6, and 12 months postoperatively, duration of surgery, and units of packed red blood cells (PRBC) transfused. These variables were compared among patients operated by five different surgeons and anesthetized by seven different anesthesiologists.

Statistical Analysis: One-way analysis of variance was used for normally and Kruskal–Wallis test for nonnormally distributed responses. Differences in percentages of postoperative mortality were assessed by Chi-squared test.

Results: The physiological severity, POSSUM morbidity, POSSUM and P-POSSUM mortality scores, and observed mortality at 1, 3, 6, and 12 months postoperatively did not differ among patients operated by different surgeons and anesthetized by different anesthesiologists. Duration of surgery ($P < 0.001$), PRBC units transfused ($P = 0.002$), and operative severity ($P = 0.001$) differed significantly among patients operated by different surgeons.

Conclusions: The physiological severity score, POSSUM and P-POSSUM scores did not differ among patients operated by different surgeons and anesthetized by different anesthesiologists. The different operative severity scores did not influence the observed mortality in the postoperative period.

Key words: Hepatopancreaticobiliary surgery; perioperative morbidity; perioperative mortality; physiological and operative severity score for the enumeration of mortality and morbidity scoring; surgeon

Access this article online	
Website: www.saudija.org	Quick Response Code
DOI: 10.4103/1658-354X.203025	

How to cite this article: Fassoulaki A, Chondrogiannis K, Staikou C. Physiological and operative severity score for the enumeration of mortality and morbidity scoring systems for assessment of patient outcome and impact of surgeons' and anesthesiologists' performance in hepatopancreaticobiliary surgery. Saudi J Anaesth 2017;11:190-5.

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Introduction

Surgical morbidity and mortality can be prevented or diminished by implementing meticulous preoperative assessment, optimization of clinical condition, careful anesthetic and surgical management, and appropriate postoperative support. Prediction of postoperative outcome using various risk scores is quite important since patient's physiological status indicates to some extend his/her ability to endure the insult of surgery and to recover uneventfully.

A number of variables are used in scores predicting patient's surgical morbidity and mortality. The American Society of Anesthesiologist scoring system is based only on clinical criteria and classifies patients into one of six categories.[1,2] It is widely used in the preoperative assessment because it is simple and easy to apply. However, intraoperative adverse events and postoperative complications related to anesthetic and surgical management, reflecting - at least partly - the anesthesiologist's and surgeon's performance, are not taken into account.

The physiological and operative severity score for the enumeration of mortality and morbidity (POSSUM) is used to assess and standardize the quality of care. It is based on 12 physiological variables measured before surgery and on six operative and postoperative variables, with each variable being scored by a four-grade exponential scale as 1, 2, 4, and 8.[3] Although POSSUM surgical scoring system is an evidence-based scoring system, it has been found that it may overpredict mortality by a factor of two in high-risk patients, a factor of six in low-risk patients (those with a death risk ≤10%), and a factor of seven in very low-risk patients (those with a death risk ≤5%).[4,5] To correct the overprediction in mortality, Whiteley *et al*. used logistic regression and modified the equation accordingly [Appendix 1].[4] The revised scoring system, named "Portsmouth" POSSUM (P-POSSUM) surgical scoring system, when implemented prospectively, provided an expected mortality very close to the in-hospital observed or actual mortality.[5]

The present study was designed to implement variables and scoring systems postoperatively, to observe and predict patient's outcome and also to compare these variables between patients' groups receiving surgical and perioperative care by different surgeons and different anesthesiologists.

Subjects and Methods

After obtaining approval from the Institutional Review Board (M-89-24-11-2011), the anesthetic records of 159 patients admitted to a University Hospital for hepatectomy, pancreatoduodenectomy or Whipple surgery from January 2001 to December 2010 were examined retrospectively. In the study, we included patients whose surgeon and anesthesiologist had performed at least ten hepatopancreaticobiliary operations. The names of both surgeons and anesthesiologists were replaced by code numbers by a resident in Anesthesia Department; thus, the investigators were blinded to the names of the surgeon and the anesthesiologist corresponding to different patients.

Patients' age, sex, body weight, height, duration of surgery, units of packed red blood cells (PRBCs) transfused, the anesthesiologist who provided the anesthesia, and the surgeon who performed the operation were recorded. Information on the survival status of patients at the time of the study was obtained through a telephone interview.

Based on data available from the patients' anesthetic records, the physiological and operative severity, the POSSUM morbidity, the POSSUM and P-POSSUM mortality were calculated (http://www.vasgbi.com/riskscores.htm).[4] The above scores are based on the severity of physiological and surgical variables and use algorithms to calculate the expected perioperative risk [Appendix 1].

The primary end-point of the study was the 30-day postoperative mortality in patients operated by different surgeons. The aim of the study was to assess the performance of different surgeons who operated on the 159 patients, comparing the observed mortality in 30 days, 3, 6, and 12 months after surgery. The expected POSSUM morbidity, POSSUM mortality, and P-POSSUM mortality of the patients' records included in the study were calculated, and comparisons between the surgeons were performed. The duration of surgery and the units of PRBCs transfused were compared between surgeons as well. The same variables were also calculated and compared among patients who received anesthesia and perioperative care by different anesthesiologists.

Statistical analysis

The mean values and standard deviations or the median values with minimum and maximum for all variables are reported. To assess differences in patients' characteristics, physiological and operative severity, POSSUM morbidity, and POSSUM and P-Possum mortality, among surgeons who operated on them and among anesthesiologists who provided anesthesia, Kruskal–Wallis test for nonnormally distributed responses and one-way analysis of variance for normally distributed responses were carried out. If a significant effect was found, *post hoc* comparisons (adjusted for Bonferroni correction)

were carried out to assess the individual differences regarding patients' outcome between the surgeons and the anesthesiologists as well. To assess differences in PRBC units transfused, the median test was used. A Chi-squared test was used to assess surgeons' and anesthesiologists' differences in the percentages of 30-days, 3, 6, and 12 months postoperative mortality. All analyses were performed by the use of Statistical Package for the Social Sciences (SPSS, version 11.0), SPSS Inc., Chicago, Illinois, USA.

Results

Data from 159 patients were initially identified and analyzed. Demographic characteristics, expressed as mean ± standard deviation, were as follows: age 65 ± 11.3 years, body weight 73 ± 14.5 kg, height 168 ± 12.1 cm. Regarding the gender, 67.3% of patients were men and 32.7% were women. Fifty-six (35%) patients underwent a Whipple operation, 22 (14%) pylorus-preserving pancreaticoduodenectomy, and 81 (51%) underwent hepatic surgery. Eleven patients had redo operations, five of them due to postoperative bleeding, and six for other reasons.

Patients operated by different surgeons had similar characteristics. Five surgeons (numbers 1, 2, 3, 4, and 5) with 67, 29, 16, 11, and 13 procedures, respectively, were found to differ significantly regarding the duration of surgery ($P < 0.001$). Surgeon 1's duration of surgery was shorter than that of surgeons 2, 3, and 5 [Table 1]. The number of PRBC units transfused also differed between the surgeons ($P = 0.002$). Surgeon 1's patients received less PRBC units compared to patients operated by surgeons 3 and 4, while Surgeon 2's patients received less units of blood compared to Surgeon 4's patients [Table 1]. The operative severity also differed between the five surgeons ($P = 0.001$). Physiological severity, POSSUM morbidity, POSSUM and P-POSSUM mortality, and observed 30-day postoperative mortality did not differ among the patients who were operated by any one of the five surgeons [Table 1]. Similarly, no difference was found in the 3-, 6- and 12-month postoperative mortality among the patients operated by the five surgeons.

Variables involving seven consultant anesthesiologists who provided anesthesia and perioperative care to ten or more patients were also compared. The number of PRBC units transfused, physiological and operative severity, POSSUM morbidity, POSSUM and P-POSSUM mortality, and 30-day postoperative mortality did not differ significantly [Table 2]. Similarly, the longer term mortality, thus in 3, 6, and 12 months postoperatively, did not differ among patients anesthetized by the seven anesthesiologists involved.

Discussion

Our results showed that the physiological severity, the POSSUM morbidity, POSSUM and P-POSSUM mortality, the observed mortality in 30 days and in 3, 6, and 12 months postoperatively did not differ among patients who were operated by different surgeons or received anesthesia by different anesthesiologists.

The impact of anesthesiologists' and surgeons' performance on patients' outcome is unclear and not consistent with the short- and long-term survival. Other factors may also influence patients' outcome after major surgery. Regarding pancreaticoduodenectomy, it has been suggested that high volume hospitals are associated with low mortality rates compared to low-volume hospitals.[6] However, the POSSUM scoring systems have been validated and proposed to compare the surgical practice.[7]

Tamijmarane *et al*. evaluated P-POSSUM mortality in 241 patients scheduled for pancreatoduodenectomy with

Table 1: Duration of surgery (min), number of transfused units of packed red blood cells, physiological and operative severity, POSSUM morbidity, POSSUM mortality, P-POSSUM mortality, and observed 30-day postoperative mortality of patients corresponding to each of the five surgeons

Surgeon (*n*)	Duration (min)	PRBC units	Physiology severity	Operative severity	POSSUM morbidity	POSSUM mortality	P-POSSUM mortality	30-day mortality (%)
1 (67)	191±78	1 (0-8)	20.25±8.2	12.07±3.8	45.7±24.45	12.4±12.2	6.7±10.6	6/67 (9)
2 (29)	270±131	2 (0-10)	19.7±4.2	13.6±2.6	47.2±25.2	11.8±10.1	4.0±3.9	1/29 (3.4)
3 (16)	367±149	2 (0-10)	22.9±6.8	15.3±3.15	62.3±23.8	21.1±17.4	11.5±16.6	0/14 (0)
4 (11)	253±116	5 (0-10)	18.45±4.63	15.9±3.33	50.6±21.7	13.9±12.3	5.0±6.7	2/11 (18.2)
5 (13)	289±109	2 (0-10)	20±4.7	13.7±2.5	47.9±19.1	11.4±6.8	4.5±3.9	0/13 (0)
χ^2 and *F*	χ^2=25.055	χ^2=17.279	*F*=0.83	*F*=5.36	*F*=1.595	*F*=1.933	*F*=2.16	χ^2=5.282
df	4	4	4	4	4	4	4	4
P	<0.001	0.002	0.508	0.001	0.18	0.109	0.077	0.260

*Duration: Surgeon 1 versus surgeon 2, 3, and 5: P=0.045, P=0.027, and P=0, Among surgeons for PRBCs: Surgeon 1 versus surgeons 3, 4, and 5: P=0.011, P=0.001, and P=0.048, Surgeon 2 versus surgeon 4: P=0.005, Physiological severity: No difference, Operative severity: Surgeon 1 versus surgeons 3 and 4 – P=0.007 and P=0.007, respectively, POSSUM mortality: No difference, P-POSSUM mortality: No difference, 30-day mortality: No difference. PRBC: Packed red blood cell; POSSUM: Physiological and operative severity score for the enumeration of mortality and morbidity; P-POSSUM: Portsmouth physiological and operative severity score for the enumeration of mortality and morbidity

Table 2: Number of transfused units of packed red blood cells, physiological and operative severity, POSSUM morbidity, POSSUM and P-POSSUM mortality, and observed 30-day postoperative mortality of patients among the seven anesthesiologists

Anesthesiologist/ number of patients (*n*)	PRBCs	Physiological severity	Operative severity	POSSUM morbidity	POSSUM mortality	P-POSSUM mortality	Mortality 30 days (%)
1 (36)	2 (0-10)	36±22.0	36±14.7	58±22.4	17.2±13.5	8.6±11.6	5/36 (13.9)
2 (13)	2 (0-8.0)	17.9±3.1	13.6±2.6	39.6±18.0	8.7±6.4	2.6±2.7	0/13 (0)
3 (19)	2 (0-4.0)	22.5±6.0	12.7±2.3	49±22.0	13.05±12.7	7.2±11.8	1/18 (5.3)
4 (22)	2 (0-5.0)	22.2±6.8	12.9±1.7	51±22.6	14.3±12.9	8.0±11.9	1/21 (4.8)
5 (10)	2.5 (0-8.0)	19.6±3.8	14.3±2.3	48.9±16.2	11.3±6.0	3.9±2.96	1/9 (11.1)
6 (14)	0 (0-5.0)	19.4±4.5	13.0±2.2	47.8±27.0	11.8±11.5	3.9±3.3	0/14 (0)
7 (17)	2 (0-10)	20.2±5.7	14.1±2.6	48.9±24.1	14.0±13.1	6.63±9.8	0/17 (0)
χ^2 and *F*	χ^2=6.591	*F*=1.646	*F*=1.95	*F*=1.232	*F*=1.037	*F*=0.988	χ^2=7.043
df	6	6	6	6	6	6	6
P	0.36	0.140	0.078	0.295	0.405	0.437	0.317

PRBCs: Packed red blood cells; POSSUM: Physiological and operative severity score for the enumeration of mortality and morbidity; P-POSSUM: Portsmouth Physiological and Operative Severity Score for the Enumeration of Mortality and morbidity

or without pylorectomy and with or without resection of adjacent viscera.[8] The overall observed mortality and morbidity during the first 30 days were close to 8% and 45%, respectively, higher than the values predicted by the P-POSSUM scoring system.[8]

Pratt *et al*. studied 326 patients subjected to pancreatic resection implementing POSSUM prospectively.[9] The investigators reported an observed-to-expected ratio for morbidity close to 1, which was strongly correlated with preoperative hemoglobin concentration, intraoperative blood loss, and age. POSSUM appears to be a reliable scoring system for the surgical outcome.[9] Khan *et al*. studied a series of fifty patients who had pancreatoduodenectomy in a specialist center and reported retrospectively an observed mortality of 4% versus a predicted POSSUM mortality of 26% and a P-POSSUM mortality of 6%.[10] The observed morbidity was 46% versus a value of 76% predicted by POSSUM. The investigators concluded that for a specialist center, POSSUM overestimates both morbidity and mortality.[10]

In a retrospective study of 259 patients who underwent major hepatectomy for hepatocellular carcinoma, there was a rate of 6.2% postoperative deaths compared to 14.2% as predicted by POSSUM and 4.2% as predicted by P-POSSUM.[11] Thus, P-POSSUM appears to be a reliable predictor for surgical mortality, while POSSUM overestimates mortality associated with major hepatic surgery.[11]

The morbidity and mortality rates may vary significantly among patients who have been operated by different surgeons. However, these differences may be attenuated when the morbidity and mortality rates are corrected for the individual patient's risk using the POSSUM scoring system. In fact, Sagar *et al*. reported a variation from 13.6%–30.6% in morbidity and from 4.5% to 6.9% in mortality rates among five surgeons. When calculating the observed-to-expected ratio by dividing the observed number of patients who had an adverse event by the expected number of patients with the adverse event, there was no difference among the five surgeons.[12]

We applied expected POSSUM morbidity and mortality scores to major upper abdominal surgery, thus pancreatoduodenectomy and hepatectomy, which may be associated with high morbidity and major blood loss. The observed 30-day mortality was close to the expected P-POSSUM mortality and confirms previous studies validating the P-POSSUM scoring system.[5,8]

The primary outcome of the study, thus the observed 30-day postoperative mortality, and the mortality observed over the following months did not differ among the five surgeons, despite the difference in the operative severity. Since the predicted POSSUM morbidity and mortality scores include physiological and surgical variables, to compare surgeons for the surgical outcome, it may be useful to consider patients' operative severity separately as this is directly related to surgeon's performance.

One may argue that pancreatoduodenectomy and hepatectomy are combined and analyzed together for both mortality and morbidity; however, POSSUM has not been developed for a particular surgical procedure. POSSUM does not include variables assessing directly the surgeon or the anesthesiologist. Nevertheless, some variables included in the operative severity score – such as blood loss, multiple procedures, and peritoneal soiling- are related to the surgical technique. For this reason, the operative severity score may be a good index to compare the competence among surgeons. Anesthesiologist's performance is not included in the POSSUM scoring systems and is unfortunate that no

scoring system considers variables related to the performance of the anesthesiologist.

The present single center audit is the first study using a scoring system to take into account patients' severity and comorbidities to assess and compare surgeons' competence regarding the outcome after major abdominal surgery.

Limitations are the retrospective, single center nature of the study, and the relatively small number of cases included. The limited number of patients of this study may be a reason that the difference in operative severity between surgeons had no influence in the observed 30-day postoperative mortality.

Conclusion

The physiological severity score, the POSSUM and P-POSSUM scores did not differ among surgeons or anesthesiologists included in the present study. The difference in the operative severity scores among surgeons may reflect differences in surgical skills, but in the present study, had no effect on the final outcome as assessed by the 30-day postoperative mortality. A scoring system to compare audit among anesthesiologists' performance is missing and should be probably considered in the near future.

Acknowledgment

The authors would like to thank Dr. Andreas Karakatsanis, MD, for his contribution to obtaining information for patient survival status and Mrs. Katerina Dimitriou for her contribution in data statistical analysis.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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Appendix 1

Physiological severity

The variables used to calculate the physiological severity include:

- Age: <61, 61–70, >70
- Cardiac signs: No failure, diuretic, digoxin, antianginal therapy, antihypertensive therapy, peripheral edema, warfarin therapy, borderline cardiomegaly, raised jugular venous pressure
- Respiratory: No dyspnea, dyspnea on exertion, limiting dyspnea (one flight), moderate chronic obstructive airways disease (COAD), dyspnea at rest (rate >30/min), fibrosis or consolidation
- Systolic blood pressure (mmHg): ≤89, 90–99, 100–109, 110–130, 131–170, ≥171
- Pulse (beats/min): ≤40, 40–49, 50–80, 81–100, 10–120, ≥120
- Glasgow coma scale: 15, 12–14, 9–11, ≤8
- Hemoglobin (g/dl): ≤9.9, 10–11.4, 11.5–12.9, 13–16, 16.1–17, 17.1–18, ≥18.1
- White cell count ($\times 10^9$/L): ≤3.0, 3.1–4, 4.1–10, 10.1–20.0, ≥20.1
- Urea (mmol/L): ≤7.5, 7.6–10, 10.1–15.0, ≥15.1
- Sodium (mmol/L): ≥136, 131–135, 126–130, ≤125
- Potassium (mmol/L): ≤2.9–3.1, 3.2–3.4, 3.5–5.0, 5.1–5.3, 5.4–5.9, ≥6.0
- Electrocardiography: Normal, atrial rate 60–90/min, any other abnormal rhythm or ≥5 ectopic beats/min; Q or ST/T changes.

Operative severity

The variables used to calculate the operative severity score include:

- Minor, moderate, major, major+
- Multiple procedures: 1, 2, 2+
- Total blood loss (ml): ≤100, 101–500, 501–999, ≥1000
- Peritoneal soiling: None, minor (serous fluid), local pus, free bowel content, pus or blood
- Malignancy: Yes/no
- Mode of surgery: Elective, emergency: Resuscitation of >2 h possible, operation within 24 h, Emergency: Immediate surgery, within 2 h.

The predicted risk of morbidity using the physiological and operative severity score for the enumeration of mortality and morbidity (POSSUM) surgical scoring system is:[3]

$$R/(1 - R) = -5.91 + (0.16 \times \text{physiological score}) + (0.19 \times \text{operative severity score})$$

where R is predicted risk.

The predicted risk of mortality using the POSSUM surgical scoring system is:[3]

$$R/(1 - R) = -7.04 + (0.13 \times \text{physiological score}) + (0.16 \times \text{operative severity score}).$$

The predicted risk of mortality using the "Portsmouth" POSSUM predictor equation is:[4]

$$\ln (R/[1 - R]) = -9.37 + (0.19 \times \text{physiological score}) + (0.15 \times \text{operative severity score}).$$