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Evaluation of POSSUM for Patients Undergoing Pancreatoduodenectomy

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Abstract

Background Comparison of operative morbidity rates after pancreatoduodenectomy between units may be misleading because it does not take into account the physiological variable of the condition of the patients. The aim of the present study was to evaluate the Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) for pancreatoduodenectomy patients and to look for risk factors associated with morbidity in a high-volume center.

Methods Between January 1993 and April 2006, 652 patients underwent a pancreatoduodenectomy, 502 of them for malignant disease. POSSUM performance was evaluated by assessing the "goodness-of-fit" with the linear analysis method.

Results Overall, 332 of the 652 patients (50.9%) had one or more complication after pancreatoduodenectomy, and 9 patients (1.4%) died. POSSUM had a significant lack of fit using goodness-of-fit analysis. In multivariate analysis, one statistically significant factor associated with morbidity and not incorporated in POSSUM ($P < 0.05$) was identified: ampulla of Vater adenocarcinoma (OR = 1.73, 95% CI: 1.07–2.80).

Conclusions Overall, there is a lack of calibration of POSSUM among patients who undergo pancreatoduodenectomy.

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Introduction

The Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) has been successfully used as a tool to provide risk-adjusted operative morbidity and mortality rates for comparisons of surgeon and hospital performance [1–21]. Increased awareness of the hospital and surgeon volume effect has contributed to the use of such tools. The applicability has been further studied for various highly specialized procedures that include vascular [6, 9, 13, 22–26], pulmonary [27], head and neck [28, 29], orthopedic [30], emergency [7], esophageal [17], and liver procedures [5], and all of these applications have been derived from the original POSSUM [2].

There is limited literature on how POSSUM performs in patients undergoing pancreatoduodenectomy (PD). One study that used an adaptation, the Portsmouth-POSSUM, which analyzes mortality, found that this model appeared satisfactory for predicting mortality risk, but that the original POSSUM overestimated morbidity and mortality for PD [31]. These findings indicate that modifications are needed prior to further application. Furthermore, the study was hampered by the small number of patients and the fact that the Portsmouth-POSSUM does not analyze morbidity. Two more larger studies on original POSSUM for pancreatic surgery showed mixed results [32, 33].

The aim of the present study was to evaluate the predictive properties of POSSUM for morbidity in patients

undergoing PD for periampullary neoplasms, and to identify specific risk factors associated with morbidity. The adapted version of POSSUM, the Portsmouth-POSSUM, which is used in the prediction of mortality was not analyzed because mortality is generally very low in high-volume centers.

Patients and methods

All patients who underwent PD for malignant and benign disease from January 1993 to April 2006 were included. Patients were selected from our prospective database, and some of the variables needed to calculate POSSUM were collected retrospectively (Table 1). All patients were operated on by the same surgical staff during the study period.

Surgical procedure and complications

A PD was performed as previously described [34]. Briefly, an en bloc resection of the duodenum, pancreatic head, bile duct, and gallbladder was performed, and the pylorus was preferably preserved. Only lymph nodes surrounding the

Table 1 Physiological and operative severity assessment for the POSSUM system

Score	1	2	4	8
Physiological assessment				
Age (years)	≤60	61–70	≥71	NA
Cardiac signs and/or	Normal	Cardiac drugs or steroids	Edema; warfarin	Raised JVP
CXR	Normal	NA	Borderline cardiomegaly	Cardiomegaly
Respiratory signs and/or	Normal	SOB exertion	SOB stairs	SOB rest
CXR	Normal	Mild COAD	Moderate COAD	Any other change
Systolic BP (mm Hg)	110–130	131–170	≥171	≤89
		100–109	90–99	
Pulse (Beats/min)	50–80	81–100	101–120	≥121
		40–49		≤39
Coma score	15	12–14	9–11	≤8
Urea nitrogen (mmol/l)	<7.5	7.6–10	10.1–15	≥15.1
Na (mEq/l)	≥136	131–135	126–130	≤125
K (mEq/l)	3.5–5	3.2–3.4	2.9–3.1	≤2.8
		5.1–5.3	5.4–5.9	≥6.0
Hb (g/dl)	13–16	11.5–12.9	10–11.4	≤9.9
		16.1–17	17.1–18	≥18.1
WCC × 10^{12}/l	4–10	10.1–20	≥20.1	NA
		3.1–3.9	≤3	
ECG	Normal	NA	AF (60–90)	Any other change
Operative severity assessment				
Operative magnitude	Minor	Intermediate	Major	Major+
No. of operations within 30 days	1	NA	2	>2
Blood loss per operation(ml)	<100	101–500	501–999	>1,000
Peritoneal contamination	No	Serous	Local pus	Free bowel content, pus or blood
Presence of malignancy	No	Primary cancer only	Node metastases	Distant metastases
Timing of operation	Elective		Emergency resuscitation possible, operation <24 h	Emergency immediate, operation <2 h

POSSUM formula: Ln R/1 − R = −7.04 + (0.13 × physiological score) + (0.16 × operative severity score)

In some variables, signs may be assessed clinically and/or by changes in results on chest X-ray film (CXR)

NA not applicable, *JVP* jugular venous pressure, *SOB* shortness of breath, *COAD* chronic obstructive airway disease, *BP* blood pressure, *Na* sodium, *K* potassium, *Hb* hemoglobin, *WCC* white blood cell count, *ECG* electrocardiogram, *AF* atrial fibrillation

pancreas anteriorly and posteriorly, in the hepatoduodenal ligament, and right of the common hepatic artery and portal vein and superior mesenteric vein were removed. If limited involvement of the portal vein or superior mesenteric vein was found, a (wedge) resection of the vein was performed with curative intent. The three anastomoses were generally made by bringing the proximal jejunal limb up along the retroperitoneum behind the mesenteric vessels or through the mesocolon. The pancreaticojejunostomy was generally constructed as an end-to-side anastomosis with a single-layer 3-0 PDS running suture including the pancreatic duct. The hepaticojejunostomy was performed by a single-layer 3-0 PDS running suture, as was the gastrojejunostomy/duodenojejunostomy. Morbidity was re-evaluated according to the criteria described by Copeland et al. [2].

Delayed gastric emptying, pancreatic leakage, and postpancreatectomy hemorrhage were registered according to recently suggested definitions established by the International Study Group of Pancreatic Surgery in the present study [35, 36].

Statistical analysis

A linear analysis was used to evaluate the predictive properties of POSSUM. For linear analysis as described by Whiteley et al. [18], patients were divided according to their predictive risk of morbidity. The number of patients falling into each such category was multiplied by the average risk of morbidity to give the predicted morbidity of that group. This type of analysis allows each group to be considered separately.

Statistical calculations were performed with SPSS software (Chicago, IL). A value of $P < 0.05$ was considered significant. If missing data of a variable did not exceed 10% it was imputed in the database to maximize data extraction. A separate "missing data analysis" was performed to ensure that the data were missing at random. Analysis of specific risk factors associated with morbidity was done by the univariate method. Binominal variables where compared with the chi-square test. Categorical variables were compared with a reference variable by logistic regression. Continuous variables were also analyzed by logistic regression.

Results

The 652 two consecutive patients who underwent PD for various disorders during the study period were included in the present study (Table 2). There were nine postoperative deaths (1.4%). One or more complications were seen in 332 of 652 patients (50.9%). Missing data of the analysed variables never exceeded 10%.

Table 2 Characteristics of patients undergoing surgery for periampullary neoplasms

	($n = 652$)
Gender	
Male	359 (55)
Female	293 (45)
Median age (range)	69 (23–91)
Procedure	
Pyloric preserving pancreatoduodenectomy	548 (84.1)
Kausch-Whipple pancreatoduodenectomy	104 (16)
Number of patients who underwent vascular resection	67 (10)
Pathology	
Pancreatic adenocarcinoma	233 (35.7)
Ampullary adenocarcinoma	157 (24.1)
Distal common bile duct adenocarcinoma	91 (14)
Pancreatitis	72 (11)
Other malignant	46 (7)
Other benign	26 (4)
Duodenum adenocarcinoma	14 (2)
Tubulovilleus adenoma	13 (2)
Overall complications	332 (50.9)
Delayed gastric empting	139 (21.3)
Intra-abdominal abscess	98 (15)
Pulmonary	72 (11)
Pancreaticojejunostomy leakage	59 (9)
Wound infection	46 (7)
Hemorrhage	46 (7)
Urinary tract infections and renal	45 (7)
Cardiac	39 (6)
Hepaticojejunostomy leakage	20 (3)
Miscellaneous	34 (5)
Number of patients who underwent a relaparotomy	65 (10)
Median intensive care stay in days (range)	1 (0–84)
Median overall postoperative hospital stay in days (range)	15 (6–222)
Hospital stay for patients	
With complications	22 (6–222)
Without complications	13 (6–55)
Mortality	9 (1.4)
Macroscopically radical resection in case of malignancy	336/502 (66.9)

Numbers between parentheses are percentages unless indicated otherwise

By means of linear analysis to compare predicted morbidity with observed morbidity, an O:P ratio of 0.88 was found (Fig. 1). POSSUM under-predicts actual morbidity in patients who are at low risk, and it over-predicts actual morbidity in patients who are deemed to be at high risk.

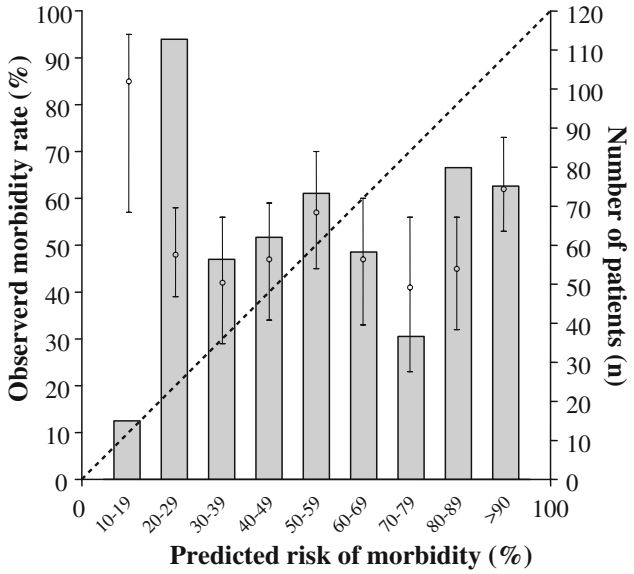

Fig. 1 Calibration curve of surgical morbidity (symbols with 95% confidence interval) showing significant deviation from the diagonal line, which represents a perfect predictive ability when the observed to expected ratio is 1.00. The bars represent the number of patients in each risk group. (O:P ratio = 0.88, $\chi^2 = 30.24$, 8 degrees of freedom, $P < 0.001$, indicating significantly poor fit)

The model had a significant poor fit ($\chi^2 = 30.24$; 8 degrees of freedom [df]; $P < 0.001$).

Preoperative and perioperative variables associated with morbidity

The results of the univariate and multivariate analyses for preoperative and perioperative variables associated with morbidity are shown in Table 3. One factor from the original POSSUM was found to be an independent predictors of morbidity in the present data set, this was pulmonary history (Odds Ratio [OR] 2.05, 95% Confidence Interval [CI] 1.15–3.67). Stepwise logistic regression also found that ampulla of Vater adenocarcinoma (OR 1.73, 95% CI 1.07–2.80) was independently associated with morbidity. This factor is not incorporated in POSSUM.

Discussion

In the present study POSSUM failed to accurately predict morbidity. The results of the study cast serious doubt on the reproducibility of POSSUM in highly specialized procedures such as pancreatoduodenectomy. Modifications are needed prior to its application for a comparative audit in pancreatic surgery in high-volume centers.

Auditing instruments for evaluation of treatment outcome and quality of care between hospitals are required nowadays. Predicting morbidity with POSSUM has been evaluated in a general surgical population to enable a fair comparison between the population of individual surgeons and individual hospitals. The POSSUM system has recently undergone significant critical appraisal [37]. Copeland et al. [2], who described the original system and its application to general surgical patients, have reinforced its application for auditing outcomes in general and orthopedic surgery, comparing outcomes between units and for comparison of surgeons within an individual department, as well as monitoring for a change in an individual surgeon's performance over a period of years. There is no question concerning the usefulness of POSSUM for general surgery.

Khan et al. [31] were the first to evaluate POSSUM for pancreatic surgery, and they found that the model overestimated morbidity in a low-volume hospital. Their study was limited by the small number of patients. A more recent and lager study performed by Pratt et al. [33] found that the original POSSUM was a good predictor of morbidity and that the model had an excellent fit. Their study was conducted in a high-volume center, and they used the same statistical analysis methods applied in the present study. A possible reason for the different findings in our study and theirs could be the use of different definitions for what constitutes a postoperative complication. For example, the International Study Group on Pancreatic Fistula found that several definitions for pancreatic leakage after pancreaticodoudenectomy exist, and the reported range of 2–50% underscores this variation [36]. This is also the case for delayed gastric emptying and postoperative hemorrhage [35, 38]. Together these three complications represent the majority of complications after pancreatic surgery, and differences in definition could explain the varied results of POSSUM.

In contrast, another large study performed by Tamijmarane et al. [32] found that POSSUM underestimated morbidity. Their study was performed in a high-volume hospital. The present study is the largest to date, and it found that POSSUM overestimates morbidity and has a significant lack of fit.

There are some known drawbacks to POSSUM [39], where pitfalls may be encountered in both data collection and data analysis. Data collection seems like a straightforward process, but methods have to be standardized if results are going to be reproducible. The physiological score is obviously subject to change over time, especially in nonelective urgent procedures. This was not a factor in the present study, which involves only elective procedures. Another problem could arise if the surgeon were to select the worst physiological score in order to show a positive result. Again, this is virtually impossible in the present study because the procedures were all performed electively, and the patients are presumed to have been

Table 3 Univariate and multivariate analysis of variables found to be significantly associated with morbidity

	Patients ($n = 652$)	No. of complications	Univariate unadjusted odds ratio (95% CI)	Multivariate adjusted odds ratio (95% CI)
Age (per 10-year increment)			1.18 (1.02–1.37)	
Sex				
Female	293	132 (45.1)	1.00	
Male	359	199 (55.4)	1.51 (1.06–2.15)	
BMI (per point increment)			1.05 (1.01–1.10)	
Hypertension				
No	628	305 (48.6)	1.00	
Yes	24	15 (63)	1.63 (1.04–2.55)	
Cardiac history				
No	616	296 (48.1)	1.00	
Yes	36	22 (61)	1.74 (1.13–2.70)	
Pulmonary history				
No	552	267 (48.4)	1.00	
Yes	100	68 (68)	2.29 (1.32–3.98)	2.05 (1.15–3.67)
Blood loss (per 100 ml increment)			1.02 (1.00–1.04)	
Type of tumor				
Pancreatic adenocarcinoma	233	107 (46)	1.00	
Ampulla of Vater adenocarcinoma	157	93 (59)	1.72 (1.08–2.73)	1.73 (1.07–2.80)
Distal bile duct adenocarcarcinoma	91	41 (45)	0.96 (0.55–1.68)	
Pancreatitis	72	34 (47)	1.05 (0.57–1.94)	
Duodenum adenocarcinoma	14	9 (64)	2.36 (0.69–8.10)	
Other malignancy	46	22 (48)	1.06 (0.53–2.14)	
Other benign	26	15 (58)	1.53 (0.64–3.67)	
Tubulovillus adenoma	13	10 (77)	4.71 (0.97–22.81)	

Numbers in parentheses are percentages unless indicated otherwise

Factors analyzed in univariate analysis that were not significant include: diabetes, American Society of Anesthesiologists classification, surgeon's experience, classical Whipple or pylorus-preserving pancreatoduodenectomy, transsection with surgical knife or linear stapler, use of multicomponent fibrin sealant, single or Roux-en-Y jejunal loop, one- or two layer anastomosis, drainage of pancreatic or biliary duct, packed cells transfused, use of octreotide and microscopic completeness of pancreatic resection plane in case of malignancy. Pancreatic texture was not scored regularly and was therefore omitted from the analysis

physiologically stable throughout the preoperative assessment. Furthermore, patients selected for a pancreatic resection are always subjected to intensive screening.

Missing data is another important problem in data collection. Some tests included in the POSSUM are not indicated in otherwise healthy individuals. Performing all these preoperative investigations is not in keeping with the hospital guidelines affecting the present study population. Therefore this study, like many others, scored these variables as 1. However, missing data never exceeded 10% of the variables analysed in the present study. Also, analysis of the missing variables, including sole analysis of patients with the complete POSSUM work-up, showed that these data were indeed missing at random and did not influence the fit of the model.

Problems in data analysis can be due to the homogeneous nature of some variables. The operative score in the present study is homogeneous because the POSSUM is calculated for one procedure and thus does not vary much. In addition, all patients had the same operative severity score and the same mode of surgery—consistent with a single procedure—and they also had the same peritoneal soiling score. Only blood loss and the presence of malignancy differed among these patients.

Another point of discussion is which analysis method is best suited for POSSUM. Copeland et al. [2] have shown that exponential analysis continues to be predictive of mortality associated with general surgery. With linear analysis, small sample size can result in inaccurate results, and large samples will allow more accurate analysis of goodness-of-fit. Thus in the present study linear analysis was used because of the large sample size. Of interest, exponential analysis of the data from the present study (results not shown) yielded similar results.

Other highlighted potential pitfalls in the use of the POSSUM system include the classification of ECG

abnormalities and the difficulty in establishing the exact operative blood loss [10].

Many patients undergoing surgery for periampullary neoplasms have major co-morbidity, which could strongly influence their risk of postoperative morbidity. This characteristic is not apparent in the POSSUM score in the present study because multivariate analysis did not find an association between these variables and postoperative morbidity. Technical complications do not seem to be influenced by preoperative factors, but they can reflect the extent of surgery and, perhaps, the surgeon's judgment. And as found in the present study and noted by many other authors, the degree of fibrosis of the pancreatic remnant (e.g., nondilated duct) seems to contribute significantly to the morbidity rate [40–46].

For most surgeons, their area of expertise dictates their highest-risk operative procedures. And many specialists have adapted POSSUM scoring as a way of allowing for case mix in their complex, high-risk operations. Separate equations have also been developed in specialized procedures. However, most adapted models are pending external validation. [The question remains if the specialized surgeons cannot suffice with regression analysis of their "case-mix" in order to compare individual or hospital results.]

The outcome of the present study raises the question of whether a specialized POSSUM score has any place in pancreatic surgery because it is questionable whether an adequate model can be developed. It is also doubtful whether surgeons and clinicians are waiting for another "adapted model," as logistic regression analysis of their own data can be used for a similar purpose. Furthermore, the use of models that overpredict or underpredict morbidity may have grave consequences. Nevertheless, surgical audits are of the utmost importance, and if the use of POSSUM is desirable, our results point to a need for a new equation based on the variables that are unique to this procedure.

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