Evaluation of a Modified POSSUM Scoring System for Predicting the Morbidity in Patients Undergoing Lumbar Surgery

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Abstract For most spine surgeons, operative intervention is common for the treatment of lumbar disc herniation, lumbar stenosis, lumbar fracture or lumbar spondylolisthesis. However, with the increase in lumbar surgery, the complication rate increases accordingly. Whereas the Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) scoring system has been widely used to predict morbidity in various surgical fields, the application of this system in lumbar surgery has not been reported. From January 2008 to January 2010, we recruited 158 patients (85 males and 73 females) with operation for lumbar disc herniation, lumbar stenosis, lumbar fracture, or lumbar spondylolisthesis. All patients were analyzed to compare the morbidity by a modified POSSUM scoring system. According to the modified POSSUM, the expected morbidity was 51 cases (32.3 %), whereas the observed mortality was 42 cases (26.6 %). The overall observed-to-expected ratio was 0.82, and the chi-squared test indicated no statistically significant difference between the expected and observed morbidities ($\chi^2=1.23$, $P=0.27$), suggesting that the modified POSSUM can accurately

estimate the outcome. The modified POSSUM scoring system we developed is a useful tool for predicting and evaluating morbidity in lumbar surgery. Further studies are required to investigate whether this scoring system can predict mortality.

Keywords POSSUM scoring · Audit · Morbidity · Lumbar surgery

Introduction

With the progressive increase in life expectancy and population growth, there is an increasing number of patients with lumbar disc herniation, lumbar stenosis, lumbar fracture, or lumbar spondylolisthesis, and almost all patients need surgery. However, surgery can be problematic because concomitant medical conditions increase operative risk. As a result, the post-operative complications of lumbar surgery increase accordingly. According to Kalanithi et al. [15], of the 66,601 patients with lumbar spondylolisthesis, 1 % had one or more in-hospital complications; the overall complication rate was 13 per 100 operations. Knight et al. [16] showed that 22.4 % of patients who needed direct lateral lumbar interbody fusion for degenerative conditions had experienced one mild or major complication. Thus, it is of great value to develop a scoring system for patients with lumbar surgery.

Previously, a simple way for evaluating surgical outcomes was to compare mortality with morbidity. However, this comparison does not take into account the severity of disease. Although age, gender, co-morbidity, and other factors are known to be associated with increased risk of post-operative complication, there is no sufficiently objective method of predicting the pre-surgery outcome. If the post-operative course

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can be predicted before surgery, this information would be useful in obtaining proper informed consent from the patients, in treatment planning, and in risk management. To evaluate the risk level of surgical operation, Copeland et al. [5] developed the Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) scoring system, in which 12 physiological and 6 operative factors are scored and subjected to logistic regression analysis to generate two equations to predict mortality and morbidity. Since this pioneering study, there have been various modifications to the scoring system in various surgical fields [2, 20, 21, 24]. In 2002, the original POSSUM equation (using a modified operation classification) was validated in orthopedic surgery [19].

For the diseases with higher risk such as lumbar disc herniation, lumbar stenosis, lumbar fracture, or lumbar spondylolisthesis, we need a scoring system that can accurately estimate the morbidity for the assessment of clinical outcome before operation. Here, we analyzed 158 patients undergoing lumbar surgery retrospectively to test whether POSSUM methodology can accurately predict morbidity in the patient subgroups.

Materials and Methods

This was a retrospective study with data collected from January 2008 to January 2010. In total, 158 patients (85 males and 73 females) were operated upon for lumbar disc herniation, lumbar stenosis, lumbar fracture, or lumbar spondylolisthesis. Those patients who did not undergo surgery and those with spinal tuberculosis, scoliosis, or spinal tumor were excluded. Data on pre-, intra-, and post-operative care were collected manually from hospital computers and paper records. The modified POSSUM scores were collected from the patients as described in Mohamed et al. [19].

The original POSSUM scoring system consists of a physiological score and an operative severity score (Tables 1 and 2). Each physiological datum is given a score between 1 and 8. The operative data were scored using a modified POSSUM system designed for lumbar surgery, which also was between 1 and 8. In the operative severity score, wound contamination, instead of peritoneal contamination, and operative magnitude were classified according to the spinal surgery. All data were entered into a Microsoft Excel XP®, and the scores were produced using the following equation, where R relates to morbidity:

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

A linear analysis, as Whiteley et al. [26], was used to evaluate the predictive properties of POSSUM. Patients were divided into different categories 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. The observed-to-expected (O:E) ratios of morbidity were calculated. The closer the O:E ratio is to 1.0, the better agreement with the morbidity rates the POSSUM has. All the data were assessed using the SPSS®16.0 (Windows version, Chicago, IL, USA). The Kolmogorov–Smirnov test and the student t test were applied to all the continuous variables, and categorical variables were compared using the chi-squared test (χ^2).

Results

Morbidity consisted of at least one in-hospital complication, and a total of 42 patients had one or more complications. The most common complication was dural tear and hematoma, followed by pulmonary, renal, and cardiac complications. Deep vein thrombosis, wound infection, seroma, and stress ulcer occurred in <1 % of patients.

In the complication group (42 cases), the mean physiological score was 15.39 ± 2.78 and the mean operative severity score was 17.10 ± 4.05 . In the non-complication group (116 cases), the mean physiological score was 12.59 ± 4.21 and the mean operative severity score was 15.12 ± 4.82 . In terms of both scores, there was no statistically significant difference between the two groups ($P > 0.05$).

Through a linear analysis to compare predicted morbidity with observed morbidity, the expected morbidity according to the modified POSSUM was 51 cases (32.3 %), while the observed mortality was 42 cases (26.6 %). The highest predicted risk was 87.9 %, and the lowest predicted risk was 6.5 %. The O:E morbidity ratio ranged from 0 to 1.67 (the highest ratio was for the 10–20 % morbidity risk cohort, and the lowest was for the 0–10 % morbidity risk cohort). The predictive value of the modified POSSUM was strongest for the 70–80 % (O:E ratio 1.00) and >80 % (O:E ratio 1.00) morbidity risk cohort. As shown in Table 3, the overall O:E ratio was 0.82, suggesting that POSSUM agreed well with the observed morbidity. The chi-squared test revealed no statistically significant difference between expected and observed morbidities ($\chi^2 = 1.234$, $P = 0.267$), suggesting that the modified POSSUM can accurately estimate outcome.

Discussion

For most spine surgeons, operative intervention is very common for the treatment of lumbar disc herniation, lumbar stenosis, lumbar fracture, or lumbar spondylolisthesis. The operation safety is the most important factor, but with the increase in lumbar surgery, the complication rate increases

Table 1 POSSUM physiological score

Variable	Score			
	1	2	4	8
Age (years)	≤60	61–70	≥71	
Cardiac signs and/or chest radiograph	Normal/normal	On cardiac drugs or steroid	Edema warfarin/borderline cardiomegaly	Raised JVP/cardiomegaly
Respiratory signs and/or chest radiograph	Normal/Normal	SOB exertion/mild COAD	SOB stairs/moderate COAD	SOB rest/any other change
Systolic BP (mmHg)	110–130	131–170, 100–109	≥171	≤89
Pulse rate (beats/min)	50–80	81–100, 40–49	101–120	≥121, ≤39
Coma score	15	12–14	9–11	≤8
Blood urea (mmol/l)	<7.5	7.6–10	10.1–15	≥15.1
Blood Na ⁺ (mmol/l)	≥136	131–135	126–130	≤125
Blood K ⁺ (mmol/l)	3.5–5	3.2–3.4	2.9–3.1	≤2.8
Hb (g/100 ml)	13–16	11.5–12.9, 16.1–17	10–11.4, 17.1–18	≤9.9, ≥18.1
WCC (×10 ¹² /l)	4–10	10.1–20, 3.1–3.9	≥20.1, ≤3	
ECG	Normal		AF (60–90)	Any other change

Adopted from Copeland et al. [3]. For some variables, signs may be assessed clinically and/or by changes in the results of chest X-ray film. *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

accordingly. Several studies have reported on complication rates in various types of patients undergoing operative treatment in the lumbar region [3, 15, 23]. Major complications of lumbar surgery include blood loss, dural tear, hematoma, deep vein thrombosis, wound infection, seroma, stress ulcer, abdominal distension, urinary retention, and pulmonary embolism [9, 12]. Other complications due to surgical approach, operative position, and surgical instrument are not discussed in the present study [7, 14]. Hirose et al. [13] suggested that morbidity and mortality rates are essential

outcome measures to evaluate the quality of medical care. Surgical risk must be assessed carefully and conveyed to patients. Therefore, to reduce and prevent the occurrence of early complications, it is necessary to develop a scoring system that can predict the risk of post-operative complications of lumbar surgery.

Several scores for predicting post-operative risk have been proposed [1, 4, 10, 18], such as RISK-VAS, Barthel index, Goldman cardiac risk index, and Charlson comorbidity index. However, these scoring systems do not

Table 2 POSSUM operative severity score

Variable	Score			
	1	2	4	8
Magnitude	Minor	Intermediate	Major	Major+
Number of operative	1		2	>2
Total blood loss (ml)	<100	101–500	501–999	>1,000
Contamination	None	Incised wound	Minor contamination or necrotic tissue	Gross contamination or necrotic tissue
Presence of malignancy	None	Primary only	Node metastases	Distal metastases
Timing of operation	Elective		Emergency resuscitation possible <48 h	Emergency immediate <6 h

Adopted from Copeland et al. [3]

Table 3 Comparison of predicted morbidity with observed morbidity

Risk band (%)	Number of patients	Mean risk (%)	Predicted complications	Observed complications	Observed/expected ratio
0–10	7	8.26	1	0	0
10–20	43	15.04	6	7	1.67
20–30	31	24.69	8	5	0.63
30–40	27	34.73	9	7	0.78
40–50	23	44.63	10	8	0.80
50–60	15	54.60	8	7	0.86
60–70	8	63.95	5	4	0.80
70–80	2	72.01	1	1	1.00
>80	3	83.50	3	3	1.00
Total	158	32.28	51	42	0.82

provide an expected value of morbidity that can be compared to the observed one. The POSSUM scoring system is distinct from these systems because it allows a fair comparison between groups based on the ratio. The POSSUM scoring system was first designed by Copeland et al. [5] as a post-operative, general surgical, audit tool, and it includes physiological and operative severity assessments. Physiological assessment includes patient age, Glasgow coma score, the presence of cardiac and respiratory symptoms, vital signs (systolic blood pressure and pulse), serum biochemistry evaluation (urea nitrogen, sodium, and potassium), hematological parameters (white blood cell count and hemoglobin), and electrocardiograph (ECG) and chest radiograph findings. Operative assessment includes the operation magnitude, number of operations, total blood loss, contamination, malignancy, and the operation timing. Each datum was classified into four grades based on exponentially increasing levels of severity (1, 2, 4, and 8). The scores of these two components were entered into one equation that calculates a risk of morbidity.

Since then, the POSSUM scoring system has been widely used, but there is a debate about whether this system overestimates or underestimates the risk, especially mortality [6, 11, 25]. Until 2002, it was applied to the orthopedic surgery only. The system uses the same physiological assessment and predictive equations but has a modified classification of operations from the original POSSUM. However, recently, there is some debate about the utility of this system. Wright et al. [27] found that POSSUM can accurately predict mortality and morbidity in patients with femoral neck fractures, and as an audit tool, it would provide a more objective comparison and an unbiased interpretation of results given the changes in patient management. According to Kurita et al. [17], POSSUM and O-POSSUM show satisfactory discriminatory power in receiver operating curve analysis, and O-POSSUM is useful in assessing the systemic status of patients with pressure ulcers. However, Ramanathan et al.

[22] concluded that POSSUM overpredicts mortality in hip fracture patients, consistent with Young et al. [28]. Therefore, it should be used with caution whether as an audit tool or for pre-operative triage.

In this study, we improved the POSSUM scoring system to meet the need of lumbar surgery. The modifications comprised two parts: the type of “magnitude” (which reflects the characteristics of lumbar surgery), and “contamination” (which reflects the state of wounds rather than the original rating of peritoneal contamination). We found that this modified system accurately estimated the overall post-operative morbidity.

However, we found some drawbacks of POSSUM in practice. First, different definitions of post-operative complications result in different findings. Second, missing data are another important issue. de Castro et al. [8] suggested that some tests in POSSUM are not indicated for otherwise healthy individuals, so these variables were scored as 1 in their study. Third, it is difficult to establish the classification of ECG abnormalities and the exact operative blood loss. The system does not include liver function, blood glucose, nutritional status, and hemobilirubin, all of which also seriously affect the prognosis. Last, it remains unclear whether exponential analysis or linear analysis is better for POSSUM. All these issues are worthy of further investigation.

Conclusion

The modified POSSUM scoring system is a useful tool for predicting and evaluating morbidity in lumbar surgery. We believe this would provide a fairer system of comparison and would also allow an unbiased interpretation of results. Further studies with this outcome prediction model are also warranted in predicting and evaluating mortality in lumbar surgery.

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