Clinical Investigation

The P-POSSUM scoring systems for predicting the mortality of neurosurgical patients undergoing craniotomy: Further validation of usefulness and application across healthcare systems

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ABSTRACT

Background and Aims: Continuous audit of clinical practice is an essential part of making improvements in medicine and enhancing patient care. Validated tools are needed to gather evidence for comparisons. Recently, Physiological and Operative Severity Score for the enumeration of Mortality and morbidity (POSSUM) and Portsmouth-POSSUM (P-POSSUM) scores were evaluated in Indian patients undergoing elective craniotomy and it was concluded that P-POSSUM was highly accurate in predicting overall mortality. We wished to study whether this system could be used in a different country and health care system [United Kingdom, UK]. We have evaluated these scores in patients undergoing elective and emergency craniotomies in a tertiary centre in the UK. **Methods:** Data was collected from all neurosurgical patients who underwent craniotomy overone year. Preoperative variables were collected prior to induction of anaesthesia, and operative variables were also collected. Chi-square test was used for expected and actual mortality differences. Survivor and non-survivor demographics were compared by one-way ANOVA for continuous and Chi-square for categorical variables. **Results:** One hundred and forty-five patients were studied. Mean [SD] physiologic score of the patients was 18.83 [5.07], and mean [SD] operative score was 18.09 [3.75]. P-POSSUM was a better predictor for elective patients and for those undergoing immediate life-saving surgery. **Conclusion:** This study confirms and validates the findings of previous work that P-POSSUM is an accurate and reliable tool for estimating in-hospital mortality. It also confirms its usefulness in comparison of results across healthcare systems internationally. Larger scale evaluations may be needed to examine its usefulness in emergency procedures.

Key words: Craniotomy, mortality, neuroanaesthesia, outcome, P-POSSUM, prediction, scoring systems

INTRODUCTION

The continuous monitoring and audit of clinical practice is an essential part of making improvements in medical science and enhancing patient care. This is true also in the management of neurosurgical cases, but no validated comparative tool was available until 2008, when the Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity (POSSUM) and Portsmouth-POSSUM (P-POSSUM) scoring systems were evaluated in Indian patients undergoing elective craniotomy[1] and concluded that the P-POSSUM score was highly accurate in predicting overall mortality.

Copeland *et al.*[2] initially designed the POSSUM scoring system to evaluate morbidity and mortality in general surgical patients. It has also been modified

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as P-POSSUM to improve the score's accuracy.[3] The scores have since been extensively evaluated in many surgical disciplines.[4,5]

Although the POSSUM and P-POSSUM scores are based on objective physiological and operative criteria, these vary across populations and healthcare systems and cannot be immediately assumed to be valid across the countries. Variations in mortality scores have been demonstrated before during such comparative studies in differing geographical regions.[6] In fact, a fourfold difference in mortality in major surgical procedures was observed in UK and US patient population.[7]

We, therefore, evaluated the scores in patients undergoing elective and emergency craniotomies in a tertiary neurosurgical referral centre in the United Kingdom to investigate how both systems performed in a different population and to explore the possibility of whether or not the P-POSSUM and POSSUM scoring system needed any further modification to allow its application in such patients.

METHODS

Following approval from the local research ethical committee, data were collected from all neurosurgical patients undergoing craniotomy over a period of one year.

The POSSUM and P-POSSUM scores are calculated using the following equations, which are a combination of weighted variables of physiological and operative data obtained for individual patients:[2,3]

Predicted POSSUM mortality

ln [R/(1−R) = −7.04 + 0. 13 × physiological score + 0.16 x operative score;

where R is the predicted mortality score.

Predicted P-POSSUM mortality

ln [R/(1−R)] = −9.37 + 0.19 × physiological score + 0.15 x operative score;

We compared the observed in-hospital mortality with the predicted mortality obtained by a POSSUM calculator.[8] The online calculator records each of the 18 factors, which are weighted to a value of 1, 2, 4 or 8 depending on measured variables.

Preoperative physiological variables prior to induction of anaesthesia were collected from the clinical notes and investigations, and operative variables [Table 1] were collected after the surgery. The category 'major plus' was given to all craniotomies performed in our institution and 'peritoneal soiling', for obvious reasons, was scored as zero. Both the surgery and anaesthesia were performed either by consultants or by specialist registrars under supervision of consultants.

We obtained in-hospital mortality data from hospital mortality records. Patients were discharged from hospital at the discretion of the treating surgeon, as is usual practice in our institution.

Using the calculated POSSUM and P-POSSUM values, the observed to expected ratios were calculated where a value of 1 would represent the best prediction. Differences between expected and actual observed mortality were assessed by a Chi-square test.

Demographic values between survivors and non-survivors were compared by one-way ANOVA for continuous variables and Chi-square for categorical variables. Microsoft Excel worksheet statistics and SPSS 10.0 for Windows were used for analysing the data.

RESULTS

A total of 145 patients undergoing elective and emergency craniotomies had their clinical data analysed. The demographic details of these patients are given in Table 2.

The mean [SD] calculated physiologic score of the patients was 18.83 [5.07] and their mean [SD] operative score was 18.09 [3.75].

On comparing predicted and observed mortality with P-POSSUM and POSSUM, we noted that there was a statistically significant difference in the physiological

Table 1: Parameters used in POSSUM scoring system

Physiological parameters	Operative parameters
Age	Operative severity
Cardiac signs	Multiple procedures
Respiratory history	Total blood loss
Systolic blood pressure	Peritoneal soiling
Pulse	Presence of malignancy
Glasgow coma score	Mode of surgery
Haemoglobin	
White cell count	
Urea	
Sodium	
Potassium	
Electrocardiogram	

score (P = 0.005), the operative score (P = 0.005) in patients with observed in hospital mortality and survivors [Tables 3 and 4].

Fifteen patients (10.3%) died; this was identical to the P-POSSUM prediction. The difference between expected and observed frequencies over different predicted mortality range was not significant with P-POSSUM score (P = 0.122). We noted that the prediction of mortality by P-POSSUM was very accurate with an observed/predicted mortality ratio of 1.0 [Table 5].

The prediction of mortality with POSSUM score was poor in contrast to the favourable results achieved with P-POSSUM. The expected mortality according to POSSUM model was 28 patients (19.3%), which contrasts with the observed mortality of 15 patients. The goodness-of-fit Chi-square test just showed statistically significant difference between expected and observed frequencies based on POSSUM score (P = 0.047). The overall prediction of mortality by POSSUM was only 0.54.

We also compared the three categories of elective, emergency, immediate (within 24 hours of stabilization) surgeries using the P-POSSUM scoring system [Table 5]. This suggests that P-POSSUM was a better predictor for elective patients and for those undergoing immediate life-saving surgery although the difference was not significant [P = 0.06].

Table 2: Descriptive characters of the patients

Age in years (range)	60 (±10)
Sex	
Male	75
Female	70
Duration of surgery (h)	3.89±1.84
Mean (SD) POSSUM physiological score	18.83±5.07
Mean (SD) POSSUM operative score	18.09±3.75

SD – Standard deviation

Table 3: Comparison of P-POSSUM-predicted mortality with the observed mortality

P-POSSUM predicted mortality (%)	Total no	Mean predicted mortality rate	Predicted deaths	Observed deaths	Observed/ expected ratio
0-5	79	2.09	2	4	2.00
5.01-10	33	7.14	2	4	2.00
10.01-20	13	13.89	2	2	1.00
>20	20	44.64	9	5	0.56
0-100	145	10.17	15	15	1.00

χ^2=5.777778, d.f.=3, P=0.122937

Table 4: Comparison of POSSUM-predicted mortality with the observed mortality

POSSUM predicted mortality (%)	Total no	Mean predicted mortality rate	Predicted deaths	Observed deaths	Observed/ expected ratio
0-5	13	4.36	1	1	1.00
5.01-10	43	7.52	3	0	0.00
10.01-20	38	14.59	6	4	0.67
>20	51	36.47	19	10	0.53
0-100	145	19.27	28	15	0.54

χ^2=7.929825, d.f.=3, P=0.047485

Table 5: Comparison of P-POSSUM data for urgency of surgery

	Total no	Mean predicted mortality rate	Predicted deaths	Observed deaths	Observed/ expected ratio
Elective patients	113	8	9	8	0.89
As soon as possible	18	12	2	5	2.50
Immediate life saving	14	29	4	2	0.50
Total	145	10.17	15	15	1.00

χ^2=5.611111, d.f.=2, P=0.060473

DISCUSSION

Auditing of practice and comparison of mortality data is essential to ensure that patients are well informed of risks and to improve quality of care in hospitals. Several surgical outcome scores have been devised to help with this issue, such as the Surgical Apgar Score,[9] APACHE II,[10] but the POSSUM[2] [Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity] and P-POSSUM [Portsmouth-POSSUM][3] scores remain the most studied and most validated across specialities and patient populations.

The POSSUM and P-POSSUM scores have been validated across many surgical procedures, but not until recently in craniotomies, which is an integral and important part of neurosurgical practice. The first validated and published tool[1] was reported from an Indian neurosurgical population in 2008. when it was shown that that both the POSSUM and the P-POSSUM scores can be used to predict mortality accurately, with P-POSSUM being the stronger score.

This study set out to validate the scores in another patient population [India] to see whether the P-POSSUM score could be used across different health care systems and patient populations, when compared to the UK. This would add weight to the tool and allow it to be used across geographical and healthcare boundaries. This is important as a general comment about predictive scores or models is one of universal applicability. However, that needed testing under clinical conditions, which is what this study has done.

We, therefore, adhered to the method of the original study[1] and collected all data just prior to surgery as that is more likely to affect outcomes than data collected at admission. We also selected in-hospital mortality as the end point as in the original study, as this reflects clinical practice individualised to the surgical and anaesthetics teams.

Overall, 15 patients (10.3%) in the study died; this was identical to the P-POSSUM prediction of mortality. The difference between expected and observed frequencies over different predicted mortality range was not significant with P-POSSUM score ($P = 0.122$). In common with work in other surgical specialities, P-POSSUM was accurate at predicting overall risk rather than risk across the subgroups. This is identical to what has been shown before.[1,4] We would, therefore, recommend its use in this context.

The prediction of mortality with POSSUM score was poor in contrast to the favourable results achieved with P-POSSUM. The expected mortality according to POSSUM model was 28 patients (19.3%), which contrasts with the observed mortality of 15 patients. Prediction of mortality by POSSUM was only 0.54.

We also compared the three categories of elective, immediate (within 24 hours of stabilization) or emergency surgery using the P-POSSUM scoring system [Table 5]. This suggests that P-POSSUM was a better predictor for elective patients and for those undergoing immediate life-saving surgery although the difference was not significant [$P = 0.06$.]. We feel that this was due to the smaller number of patients in these categories and this deserves further work.

There may be some shortcomings to this study. Our patients were discharged home at the discretion of the surgical team, a process that lacks standardisation. We accepted that this was a more real reflection of surgical practice than to adopt other end points, such as 28-day mortality. Additionally, a comparison of elective, stabilized and emergency patients did not reveal a significant difference, although this may be due to the small number of emergency procedures ($n = 14$) in our centre over the year. The original work that validated P-POSSUM for craniotomies study did not include emergency patients and as there was a small number only in our study population this time, it is not possible to draw any firm conclusions at this time.

A variation of the POSSUM score for neurosurgical patients has been produced recently.[11] However, this is not specific for craniotomies, and includes minor 'neurosurgical' procedures such as carpal tunnel decompression. More importantly, it has not been validated outside of the Australian population and system, whereas this study supports a familiar and a most popular and recognised system to demonstrate that it can be used across countries.

Therefore, it will be simpler to adopt the P-POSSUM score into neurosurgical practice as it stands, rather than trying to improvise that and again looking at the validity of the new scoring system.

CONCLUSION

We conclude that P-POSSUM, but not POSSUM, is a useful scoring system that can be used comparing mortality data for neurosurgical patients undergoing craniotomy in different populations and healthcare systems (India and the UK). Although P-POSSUM seems to be a useful predictor in the emergency situation also, we would recommend further large scale work for its validation.

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