# POSSUM - A Model for Surgical Outcome Audit in Quality Care

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**Summary**

Comparative surgical audit to monitor quality of care should be performed with a risk-adjusted scoring system rather than using crude morbidity and mortality rates. A validated and widely applied risk-adjusted scoring system, P-POSSUM (Portsmouth-Physiological and Operative Severity Score for the enUmeration of Mortality) methodology, was applied to a prospective series of predominantly general surgical patients at the Sarawak General Hospital, Kuching over a six months period. The patients were grouped into four risk groups. The observed mortality rates were not significantly different from predicted rates, showing that the quality of surgical care was at par with typical western series. The simplicity and advantages of this scoring system over other auditing tools are discussed. The P-POSSUM methodology could form the basis of local comparative surgical audit for assessment and maintenance of quality care.

*Key Words:* Comparative surgical audit, Quality of care, Complications, Scoring system

## Introduction

POSSUM (Physiological and Operative Severity Score for the enUmeration of Mortality) was first described by Copeland et al[1] in 1991 as a method of normalizing data so that direct comparison of patient outcome can be made despite differences in case-mix. After multivariate analysis of 48 physiological and 14 operative factors, the resulting 12 physiological and 6 operative factors were developed for scoring (Table I) and these scores are applied to an equation to obtain predicted mortality. Evaluation of the POSSUM surgical scoring system in the UK has shown that it has consistently overestimated the mortality rate in the lowest risk group[2, 3]. A modification to the predictor equation was later proposed as the Portsmouth-POSSUM (P-POSSUM)[3], claimed to produce a closer fit with the observed in-hospital mortality in the low-risk groups. P-POSSUM has recently been verified in Malaysia with a different population and possibly surgical practice[4].

**Local experience with P-POSSUM application**

This 6-month prospective study was carried out at the Sarawak General Hospital, Kuching, with a population of about 2 million. Six hundred and five consecutive cases were identified daily and scored as originally described[1] before operation using the 12 physiological factors (Table II) and at

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the end of the operation using the 6 operative factors (Table III). The risk of mortality, R, was calculated for the patients using the P-POSSUM equation[3] as follow:

P-POSSUM $\ln[R/(1-R)] = -9.065+(0.1692\times$ physiological score$) + (0.1550\times$ operative score$)$.

Four sizes of risk range which consist of 0-4%, 5-14%, 15-49% and >50% were chosen to give meaningful comparison between the observed deaths and predicted deaths. The 'linear' method of analysis was used rather than 'exponential' analysis because it was more straightforward and simpler[5]. In the 'linear' analysis, patients were divided into groups according to their predicted risk of death as in this study. To calculate the predicted number of deaths in each group, the number of patients falling into each mortality group was multiplied by the average risk of death. This type of 'linear' analysis was that used by the P-POSSUM proponents[2, 3]. This analysis allows each mortality group to be considered separately.

In the 'exponential' analysis as proposed by Copeland et al[1], a cut-off risk of death is considered in each stage of the calculation. All patients whose predicted risk falls above the cut-off are grouped together. Therefore if the cut-off level being analyzed is 80% risk of death, the number of predicted deaths in this group is the result of the number of patients with 80% or greater predicted risk of death, multiplied by 0.8. A difficulty arises if the calculated number of predicted deaths above this cut-off falls below the number calculated for a higher cut-off. In this situation a second calculation should begin again from the lower cut-off.

In our study groups, there was good match between observed and predicted mortalities when P-POSSUM was applied. The overall observed mortality was 6.4% as compare to the predicted mortality of 4.8%, which was statistically not significant (P=0.146 where $\chi^2$ tests were used to compare between observed and predicted deaths)[4].

**Table I: POSSUM: physiological and operative parameters**

| Physiological parameters | Operative parameters |
|---|---|
| Age (years) | Operative severity |
| Cardiac history | Multiple procedures |
| Respiratory history | Total blood loss (ml) |
| Blood pressure | Peritoneal soiling |
| Pulse rate | Presence of malignancy |
| Glasgow coma score | Mode of surgery |
| Haemoglobin (g/%) | |
| White cell count (x $10^{12}$/l) | |
| Urea | |
| Plasma sodium (mmol/l) | |
| Plasma potassium (mmol/l) | |
| Electrocardiogram | |

**Table II: Physiological score (to be scored at the time of surgery**

| | Score | | | |
|---|---|---|---|---|
| | 1 | 2 | 4 | 8 |
| Age (years) | ≤60 | 61-70 | ≥71 | |
| Cardiac signs | No failure | Diuretic, digoxin, antianginal or hypertensive therapy | Peripheral oedema, warfarin therapy | Raised jugular venous pressure |
| Chest radiograph | | | Borderline cardiomegaly | Cardiomegaly |
| Respiratory history | No dyspnoea | Dyspnoea on exertion | Limiting dyspnoea (one flight) | Dyspnoea at rest (rate ≥30/min) |
| Chest radiograph | | Mild COAD | Moderate COAD | Fibrosis or consolidation |
| Blood pressure (systolic) (mmHg) | 110-130 | 131-170<br>100-109 | ≥171<br>90-99 | <br>≤89 |
| Pulse (beats/min) | 50-80 | 81-100<br>40-49 | 101-120 | ≥121<br>≤39 |
| Glasgow coma score | 15 | 12-14 | 9-11 | ≤8 |
| Haemoglobin (g/100ml) | 13-16 | 11.5-12.9<br>16.1-17.0 | 10.0-11.4<br>17.1-18.0 | ≤9.9<br>≥18.1 |
| White cell count ( x $10^{12}$/l ) | 4-10 | 10.1-20.0<br>3.1-4.0 | ≥20.1<br>≤3.0 | |
| Urea (mmol/l) | ≤7.5 | 7.6-10.0 | 10.1-15.0 | ≥15.1 |
| Sodium (mmol/l) | ≥136 | 131-135 | 126-130 | ≤125 |
| Potassium (mmol/l) | 3.5-5.0 | 3.2-3.4<br>5.1-5.3 | 2.9-3.1<br>5.4-5.9 | ≤2.8<br>≥6.0 |
| Electrocardiogram | Normal | | Atrial fibrillation (rate 60-90) | Any other abnormal rhythm or >5 ectopics/min, Q waves or ST/T wave changes |

COAD, Chronic obstructive airways disease

**Table III: Operative severity score. (Definitions of surgical procedures with regard to severity are guidelines; not all procedures are listed and the closest should be selected)**

| | Score | | | |
|---|---|---|---|---|
| | 1 | 2 | 4 | 8 |
| Operative severity * | 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 |
| Presence of malignancy | None | Primary only | Nodal metastases | Distant metastases |
| Mode of surgery | Elective | | Emergency resuscitation of >2 h possible # Operation < 24 h after admission | Emergency (immediate surgery <2 h needed) |

* Surgery of moderate severity includes appendicectomy, cholecystectomy, mastectomy, transurethral resection of prostate; major surgery includes any laparotomy, bowel resection, cholecystectomy with choledochotomy, peripheral vascular procedure or major amputation; major + surgery includes any aortic procedure, abdominoperineal resection, pancreatic or liver resection, oesophagogastrectomy; # indicates that resuscitation is possible even if this period is not actually utilized.

## Discussion

To provide quality care, every surgeon and hospital need to have a benchmark as the 'gold standard' for comparison. POSSUM was developed as an adjunct to surgical audit[1] to allow assessment of this quality of care. It allowed comparison of the audits of different patient population by taking into account variations in the physiological condition of patients at surgery and the extent of surgical intervention or severity of operation.

POSSUM scoring system was devised from logistic regression of surgical patients in the UK. As with other investigators [2, 3, 6, 7] we have found that the original POSSUM equation application on our series of patients yielded a poor performance on mortality study. It over estimated the overall mortality by 1.7 times and the lowest risk group by 9.3 times. The 0-4% risk group formed the bulk of surgical patients and certainly would erroneously reflect exceptional surgical results if not interpreted properly. In comparison, the P-POSSUM equation produced a close fit between the observed and predicted mortality in our settings.

To use POSSUM scoring properly, it is important to take into consideration the two methods of analyses. The analytical methodology was not clearly described in the original POSSUM publication by Copeland et al[1]. This has led to inaccurate prediction especially in the low risk groups when applications were attempted by others[2, 3, 6, 7]. This led to the modification of the mortality equation or P-POSSUM equation[3]. The P-POSSUM equation proponents claimed to produce a closer fit of the observed with the predicted mortality in the low-risk groups. Subsequent clarification of the two methods of analyses as the 'linear' and 'exponential' analyses respectively[5] should encourage appropriate application. POSSUM does not take into consideration certain factors that may have impact on surgical care and outcome such as surgical experience/seniority, anaesthetic expertise, duration of operation, organ system being operated on and duration of stay after surgery. In the study from the University of Otago[8], logistic regression analysis showed that duration of operation, operation category, inpatient status (operative stay) and organ system in which the procedure was carried out were the strongest predictors of postoperative morbidity. Although not directly comparable, the operative severity score components of POSSUM such as total blood loss, peritoneal soiling, presence of malignancy, number of procedures and operative severity score indirectly reflect the duration of operation, affect the postoperative stay and the organ system operated on. Surgical expertise may influence the amount of blood loss and peritoneal soiling. Despite these apparent deficiencies, POSSUM scoring system with the P-POSSUM equation for mortality produced a close fit with 'linear' analysis and these variables might not be as significant contributors to mortality as to morbidity.

There are many scoring systems developed over the years for risk-adjusted mortality and morbidity rates. A comprehensive review of the currently available scoring systems relevant to general surgical practice was published recently[9]. A simple and useful classification of physical status from the American Society of Anesthesiologists (ASA) has been used widely. Although it is not intended as a risk indicator, it is effective as a pointer of the clinical severity and prognosis. The Goldman Cardiac Risk Index was designed specifically to predict the risk of a cardiac complication occurring following non-cardiac surgery. However it predicts only specific morbidity and as such has not found wide application.

A better known scoring system is the Acute Physiology And Chronic Health Evaluation (APACHE) system which has been extensively used in the intensive care setting. This scoring system requires much more complex accumulation of data and generally applied to fairly sick patients. For routine application whereby most surgical patients are of the low-risk group, this system is not as favourable.

The Physiological and Operative Severity Score for enUmeration of Mortality and morbidity (POSSUM) was found to be the most appropriate score for routine surgical practice[9]. The POSSUM scoring system requires collection of simple physiological and operative scores within the scope of basic surgical cares. This has obvious advantages over more sophisticated scoring systems such as the APACHE. The linear comparison analysis using the P-POSSUM equation is straightforward and easy to apply, which is relevant in developing countries with limited resources. This system is applicable to the Malaysian setting. It allows comparative audit to monitor our quality of care to achieve the best possible results.

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## References

1. Copeland GP, Jones D, Walters M. POSSUM: a scoring system for surgical audit. Br J Surg 1991; 78: 355-60.
2. Whiteley MS, Prytherch D, Higgins B, Weaver PC, Prout WG. An evaluation of the POSSUM surgical scoring system. Br J Surg 1995; 83: 812-15.
3. Prytherch D, Whiteley MS, Higgins B, Weaver PC, Prout WG, Powell SJ. POSSUM and Portsmouth POSSUM for predicting mortality. Br J Surg 1998; 85: 1217-220.
4. Yii MK, Ng KJ. Risk-adjusted surgical audit with the P-POSSUM scoring system in a developing country. Br J Surg 2002: 89: 110-13.
5. Wijesinghe LD, Mahmood T, Scott DJA, Berridge DC, Kent PJ, Kester RC. Comparison of POSSUM and the Portsmouth predictor equation for predicting death following vascular surgery. Br J Surg 1998; 83: 209-12.
6. Tekkis PP, Kocher HM, Bentley AJ, Cullen PT, South LM, Trotter GA, Ellul JP. Operative mortality rates among surgeons: comparison of POSSUM and P-POSSUM scoring systems in gastrointestinal surgery. Dis Colon Rectum 2000; 43: 1528-532.
7. Midwinter M, Tyherleigh M, Ashley S. Estimation of mortality and morbidity risk in vascular surgery using POSSUM and Portsmouth predictor equation. Br J Surg 1999; 86: 471-74.
8. Pillai SB, van Rij AM, Williams S, Thomson IA, Putterill MJ, Greig S. Complexity and risk-adjusted model for measuring surgical outcome. Br J Surg 1999; 86: 1567-572.
9. Jones HJS, de Cossart L. Risk scoring in surgical patients. Br J Surg 1999; 86: 149-57.