The Value of POSSUM & P-POSSUM as Surgical Audit Tool Predicting Morbidity and Mortality in Emergency Laparotomy

Acil Laparotomide Morbidite ve Mortaliteyi Tahmin Eden Cerrahi Denetim Aracı Olarak POSSUM & P-POSSUM'un Değeri

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ABSTRACT

Introduction: Improvement of surgical outcomes in emergency laparotomy surgery remained dubious. Physiology and Operative Severity Score for the enumeration of Mortality (POSSUM) and Portsmouth-POSSUM (P-POSSUM) have been validated in multiple studies. The objective of this study is to determine the value of both as surgical audit tool predicting the morbidity and mortality of emergency laparotomy in a single tertiary centre in Malaysia.
Methods: A retrospective review was performed in Hospital Universiti Sains Malaysia after obtaining ethical approval. All adult subjects that underwent emergency abdominal surgery from 2012 until 2015 were reviewed. Data collected were subjects' demography, clinical-pathological profiles and clinical pathway characteristics. Expected morbidity and mortality were calculated using POSSUMs risk prediction model and subsequently compared against the observed outcome. The risk prediction model was analyzed using Hosmer and Lemeshow Goodness of Fit statistical test. **Results:** Eighty-three (83) subjects were analyzed in this study. The proportion of 30-day in-hospital morbidity was 44 (53.0%) subjects and in-hospital mortality was 12 (14.5%) subjects. Eighteen subjects that developed in-hospital morbidity had suffered a respiratory complication. The observed-to-expected ratio of POSSUM predicting morbidity was 0.9 and P-POSSUM predicting morbidity was 0.8. However, using Hosmer and Lemershow Goodness of Fit statistical analysis, the p-value of less than 0.05 showed both POSSUM and P-POSSUM predicted poor morbidity and mortality across all risk stratifications in this population.
Conclusions: POSSUM and P-POSSUM are not suitable for surgical audit tool in this centre because both produce a poor prediction of in-hospital morbidity and mortality in emergency laparotomy.

Keywords: Laparotomy; morbidity; mortality; risk stratification; surgery

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ÖZET

Giriş: Acil laparotomi cerrahisinde cerrahi sonuçların iyileştirilmesi şüpheli kalmıştır. Mortalite (POSSUM) ve Portsmouth-POSSUM (P-POSSUM) sayımı için Fizyoloji ve Operatif Şiddet Skoru birçok çalışmada doğrulanmıştır. Bu çalışmanın amacı, Malezya'daki tek bir üçüncü basamak merkezde acil laparotominin morbidite ve mortalitesini tahmin eden cerrahi denetim aracı olarak değerini belirlemektir.
Yöntemler: Etik onay alındıktan sonra Hospital Universiti Sas Malaysia'da retrospektif bir inceleme yapıldı. 2012'den 2015'e kadar acil karın ameliyatı geçiren tüm yetişkin denekler gözden geçirildi. Toplanan veriler deneklerin demografisi, klinik-patolojik profilleri ve klinik yol özellikleriydi. Beklenen morbidite ve mortalite, POSSUMs risk tahmin modeli kullanılarak hesaplandı ve daha sonra gözlemlenen sonuçla karşılaştırıldı. Risk tahmin modeli, Hosmer ve Lemeshow Uyum İyiliği istatistiksel testi kullanılarak analiz edildi.
Bulgular: Bu çalışmada seksen üç (83) kişi analiz edildi. 30 günlük hastane içi morbidite oranı 44 (%53,0), hastane içi mortalite 12 (%14,5) kişiydi. Hastane içi morbidite gelişen 18 denek bir solunum komplikasyonu geçirmişti. POSSUM'un morbiditeyi tahmin eden gözlenen-beklenen oranı 0,9 ve P-POSSUM'un morbiditeyi öngören oranı 0,8'di. Bununla birlikte, Hosmer ve Lemershow Uyum İyiliği istatistiksel analizi kullanılarak, 0,05'in altındaki p değeri hem POSSUM hem de P-POSSUM'un bu popülasyondaki tüm risk sınıflandırmalarında zayıf morbidite ve mortalite öngördüğünü gösterdi.
Sonuçlar: POSSUM ve P-POSSUM bu merkezde cerrahi denetim aracı olarak uygun değildir, çünkü her ikisi de acil laparotomide hastane içi morbidite ve mortaliteyi kötü tahmin etmektedir.

Anahtar Sözcükler: Laparotomi; hastalık; mortalite; risk sınıflandırması; ameliyat

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INTRODUCTION

Emergency laparotomy is a surgical procedure of gastrointestinal tract which is potentially life-threatening that requires prompt investigation and management. It is associated with high rates of morbidity & mortality worldwide (1-9). Many factors are contributing to these poor outcomes (10). In general, the factors that responsible for the development of these poor outcomes are essentially the biological mechanisms and the quality of the surgical care provided (11).

In emergency laparotomy, there is less time for planning and optimization before emergency surgery compared to elective surgery. Many cases are severely ill and in poor physiological condition. Delivering quality surgical outcome in patient underwent emergency laparotomy is a challenging process. There was a minimal improvement of morbidity and mortality outcome in this high-risk surgery (12). There are the needs to refocus on quality improvement on emergency laparotomy surgery (7,12,13).

A surgical audit is paramount to improve the outcome of emergency laparotomy. Risk-adjusted analysis using a risk prediction model is a widely gain practice worldwide as surgical audit tools to improve outcomes. Various risk prediction models have been developed to accurately predict surgical outcome. Physiology and Operative Severity Score for the enumeration of Mortality (POSSUM) and The Portsmouth Physiology and Operative Severity Score for the enumeration of Mortality (P-POSSUM) have been validated in multiple studies (14-25). This study examined POSSUM and P-POSSUM value as surgical audit tool in predicting morbidity and mortality in emergency laparotomy in a single tertiary centre in one of the states in Malaysia.

MATERIALS and METHODS

A total number of 162 subjects who underwent emergency laparotomy in Hospital Universiti Sains Malaysia from 2012 to 2015 were identified from the record office. Convenience sampling was performed in which 83 subjects that fulfilled the inclusion criteria were included in the study as to the intended sample size. All subjects above the age of 18 years old that underwent emergency abdominal surgeries via midline abdominal incision were reviewed. Surgery for appendicectomy, vascular and gynaecology-related surgery was excluded. Ethical approval of this study (USM/JEPeM/16040159) was obtained from the Human Research and Ethics Committee, School of Medical Sciences, University Sains Malaysia.

All relevant data were entered into the data collection form by the principal investigator. Data collected were subjects' demography, clinical-pathological profiles and clinical pathway characteristics. The observed "in-hospital morbidity" and "in-hospital mortality" were recorded yes and no for each subject. "In-hospital morbidity" is defined as a case that developed a clinically significant non-fatal complication that occurred while the patient in the hospital. "In-hospital mortality" is death that occurred while the patient in the hospital, regardless of time from surgery for an all-cause of mortality. For each subject, the physiological and operative parameters were then scored according to POSSUM risk prediction model. The physiological score was taken from data as close to emergency operation and the operative score was taken from operative notes. The total score was calculated using an online calculator to obtain the expected morbidity and mortality. According to Table 1, the performance of POSSUM risk prediction model was assessed in predicting morbidity for emergency laparotomy. The observed morbidity was compared against expected morbidity using Hosmer and Lemeshow Goodness of Fit statistical analysis (26). Meanwhile, the performance of P-POSSUM risk prediction model was assessed in predicting mortality for emergency laparotomy. The observed mortality was compared against expected mortality using Hosmer and Lemeshow Goodness of Fit statistical analysis (26).

As described by Wijesinghe et al, the patients' predicted risk of death was calculated from POSSUM and P-POSSUM scores using the respective equations (26). Patients were divided into groups according to their predicted risk of death: less than 10, 10–19, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, 80–89 and greater than 90 per cent (26). The number of patients falling into each mortality group was multiplied by the average risk of death to give the predicted number of deaths in that group (26). During analysis of POSSUM in predicting morbidity, 83 subjects were divided into 10 groups according to its predicted morbidity risk range (decile) as in Table 1. The number of observed morbidities were compared with the number expected morbidity within that risk range. The ratio denoted as an observed-to-expected ratio (O:E ratio). For analysis of P-POSSUM in predicting mortality, 83 similar subjects were divided into 10 groups but now divided according to its predicted mortality risk range (decile) as in Table 1. The number of observed mortality was compared with the number of expected mortality within that risk range. Chi-square X^2 test (Hosmer and Lemeshow, Goodness of Fit) were calculated to detect any difference between observed & expected. As described by Hosmer and Lemeshow, a p-value >0.05 indicates the good performance of the risk prediction model that fits the observed data.

Ethical approval and informed consent

The ethical approval of this study (USM/JEPeM/16040159) was obtained from Human Research and Ethics Committee, School of Medical Sciences, University Sains Malaysia. All patients provided informed written consent.

Table 1: Comparison of Morbidity by POSSUM and Mortality by P-POSSUM (n=83)

Range of Risk group into Deciles (Expected Morbidity) in %	No. of Patient in The Range Group	No. of Expected Morbidity [a]	No. of Observed Morbidity	Observed : Expected O: E (Ratio)
Observed and Expected Morbidity by POSSUM [b]				
≤ 10	1	1	0	0
> 10 to ≤ 20	5	3	0	0
> 20 to ≤ 30	0	0	0	0
> 30 to ≤ 40	8	4	2	0.5
> 40 to ≤ 50	0	0	0	0
> 50 to ≤ 60	11	6	4	0.7
> 60 to ≤ 70	6	3	2	0.7
> 70 to ≤ 80	9	5	3	0.6
> 80 to ≤ 90	23	12	17	1.4
> 90 to ≤ 100	20	11	16	1.5
Total	83	45	44	0.9
Observed and Expected Mortality by P-POSSUM [c]				
≤ 10	13	2	1	0.5
> 10 to ≤ 20	17	3	1	0.3
> 20 to ≤ 30	16	2	3	1.5
> 30 to ≤ 40	18	3	2	0.7
> 40 to ≤ 50	5	1	0	0
> 50 to ≤ 60	3	1	1	1.0
> 60 to ≤ 70	6	1	2	2.0
> 70 to ≤ 80	3	1	1	1.0
> 80 to ≤ 90	1	1	0	1.0
> 90 to ≤ 100	1	1	1	0.8
Total	83	25	12	0.8

[a] No. of expected morbidity = mean predicted probabilities in the group x no. of patient in the group. Rounded to the nearest whole number.
[b] Chi square test: F-stat(df) = 22.73 (7), p-value = 0.002
[c] Chi square test: F-stat(df) = 12.28 (7), p-value = 0.023

RESULTS

From 83 adult subjects reviewed, 56 (67.5%) were male and 27 (32.5%) were female. The age of the patients ranged from 18 to 99 years with a mean age of 49.8 years (SD = 24.8). Almost all subjects were of Malay ethnicity. The demographic background of the patients was further summarized in Table 2. There was heterogeneity of underlying pathologies on subjects. Fifty-three (63.8%) subjects were no trauma-related and 30 (36.1%) subjects were trauma-related. The mean age of patient from trauma was 29.3 (SD = 14.3) and from the non-trauma group were 59.6 (SD = 22.7) as summarized in Table 2.

Table 2: Demographic and Clinico-pathological Data (n=83)

Variables	Frequency (%)	
Age (years) [a]	49.8 (24.8)	
Age group (years)		
18 – 30	28 (33.7)	
31 – 40	7 (8.4)	
41 – 50	6 (7.2)	
51 – 60	8 (9.6)	
61 – 70	11 (13.3)	
>70	23 (27.7)	
Gender		
Male	56 (67.5)	
Female	27 (32.5)	
Ethnicity		
Malay	82(98.8)	
Chinese	1 (1.2)	
Indian	0 (0.0)	
Others	0 (0.0)	
	Trauma	**Non-Trauma**
Age (years) [a]	29.3 (14.3)	59.6 (22.7)
Mortality [b]	1 (3.7)	10 (18.8)
Morbidity	10 (37.0)	34 (64.2)

[a] Mean (SD)
[b] Subject that had both mortality and morbidity were considered as in mortality group

The preoperative indication for surgery, intraoperative findings and primary operative procedures are dependent upon the type of pathology involved. For non-trauma related, the most common preoperative indication for emergency laparotomy was a perforated gastric ulcer, involving 17 (20.5%) of subjects where primary perforated gastric ulcer repairs were performed. For trauma-related, blunt abdominal trauma leading to small bowel perforation was commonest involving 14 (17%) of subjects where small bowel resection and primary anastomosis were done. The summarized findings were shown in Table 3-5.

Table 3: Preoperative Indication for Performing Emergency Laparotomy (n=83)

Variables	Frequency (%)
Trauma	
Blunt abdominal trauma (hemodynamic instability)	15 (18.1)
Blunt abdominal trauma (perforated viscus)	12 (14.5)
Penetrating abdominal Trauma	1 (1.2)
Others	2 (2.4)
Non Trauma	
Perforation	24 (28.9)
Peritonitis (unknown cause)	11 (13.3)
Acute intestinal obstruction	11 (13.3)
Strangulated hernia	4 (4.8)
Abdominal abscess	1 (1.2)
Others	2 (2.4)

Table 4: Intraoperative Findings at Emergency Laparotomy (n=83)

Variables	Frequency (%)
Trauma	
Small bowel perforation	14 (16.9)
Splenic injury	7 (8.4)
Liver injury	3 (3.6)
Renal injury	1 (1.2)
Diaphragmatic injury	1 (1.2)
Mesenteric injury	1 (1.2)
Retroperitoneal hematoma	1 (1.2)
Others	2 (2.4)
Non Trauma	
Perforated gastric ulcer	17 (20.5)
Left sided malignant bowel obstruction	4 (4.8)
Adhesive small bowel obstruction	5 (6.0)
Strangulated hernia	4 (4.8)
Perforated duodenal ulcer	3 (3.6)
Gastrointestinal tuberculosis	3 (3.6)
Right sided colon tumor	2 (2.4)
Caecal tumor perforation	1 (1.2)
Malignant small bowel obstruction	1 (1.2)
Rupture liver abscess	1 (1.2)
Others	12 (14.4)

Table 5: Primary Operative Procedures at Emergency Laparotomy (n=83)

Variables	Frequency (%)
Trauma	
Small Bowel Resection and Anastomosis	10 (12.0)
Splenectomy	7 (8.4)
Liver packing/hemostasis	3 (3.6)
Primary Repair of Small Bowel Perforation	3 (3.6)
Mesenteric injury repair	1 (1.2)
Diaphragmatic injury repair	1 (1.2)
Nephrectomy	1 (1.2)
Defunctioning ileostomy	1 (1.2)
Others	3 (3.6)
Non Trauma	
Perforated gastric ulcer repair	17 (20.5)
Small Bowel Resection and Anastomosis	7 (8.4)
Hartmann procedure	7 (8.4)
Adhesiolysis	4 (4.8)
Defunctioning sigmoid colostomy	3 (3.6)
Perforated duodenal ulcer repair	3 (3.6)
Right hemicolectomy	3 (3.6)
Sigmoid colectomy	2 (2.4)
Open and Close	2 (2.4)
Defunctioning ileostomy	1 (1.2)
Peritoneal lavage	1 (1.2)
Others	3 (3.6)

Overall, a total of 36 (43.4%) of subjects had computed tomography (CT) of the abdomen as an adjunct before surgery. However, when they were categorized into trauma and non-trauma, only 12 (22.6%) subjects of non-trauma pathology had a CT abdomen before laparotomy. The mean duration of time for clinical decision for laparotomy to operating theatre for trauma was 2.1 hours (SD = 1.8) and for non-trauma were 5.8 (SD = 4.5). The mean of a total length of hospital stay was 10 (SD = 5.7) days for trauma and 9.0 (SD = 7.5) days for non-trauma. Twenty-one (70.0%) of trauma subjects within trauma group required at least one day of post-operative ICU admission and 39 (69.8%) of non-trauma subjects within non-trauma group required at least one day of postoperative ICU admission. No patient had preoperative ICU admission for stabilization among the subjects reviewed. The summarized findings were shown in Table 6.

Table 6: Clinical Pathway Characteristics (n=83)

Variables	mean (SD)	
	Trauma	**Non Trauma**
Availability of CT Abdomen Prior to Surgery		
Yes [a]	24 (80.0)	12 (22.6)
No [a]	6 (20.0)	41 (77.4)
Mean Duration of Time: Clinical Decision to Surgical Operation (hour)		
All subjects	2.1 (1.8)	5.8 (4.5)
Mortality group	1.1 (0.0)	5.9 (2.9)
Morbidity group	2.4 (1.7)	6.1(4.2)
No morbidity no mortality group	3.0 (2.3)	5.8 (3.7)
Mean Length of Hospital Stay (day)		
All subjects	10.0 (5.7)	9.0 (7.5)
Mortality group	10.0 (0.0)	8.4 (4.9)
Morbidity group	11.6 (5.6)	12.0 (6.2)
No morbidity no mortality group	9.4 (5.4)	6.7 (2.8)
Mean Length of ICU Stay (day)		
Mortality Group		
Subject had ICU admission [a]	1 (100)	10 (4.9)
Mean length of ICU stay (day)	10.0 (0.0)	4.3 (3.4)
Morbidity Group		
Subject had ICU admission [a]	8 (80.0)	28 (82.4)
Mean length of ICU stay (day)	4.9 (4.3)	4.1 (3.9)
No Morbidity No Mortality Group		
Subject had ICU admission [a]	11 (64.7)	9 (42.9)
Mean length of ICU stay (day)	1.5 (1.1)	0.7 (0.1)

[a] Frequency (%)

Forty-four (53.0%) of subjects were found of having at least one postoperative complication post-emergency laparotomy. Eighteen (21.7%) subjects had respiratory complications. When divided the subjects according to predicted morbidity risk range (decile), the majority of subjects are within 80 to 100 % of risk range. As in Table 1, the O:E ratio was placed between 0.6 to 0.7 in moderate risk range, while in high-risk range, it under predict between 1.4 to 1.5. The p-value for the performance of POSSUM in predicting morbidity in across risk range is <0.05 (p-value = 0.002) which indicates the risk prediction model poorly predicts in-hospital morbidity. Table 1 summarized the analysis according to Hosmer and Lemeshow Goodness of Fit as described by Wijesinghe et al (26). There were 12 (14.5%) subjects in-hospital mortality post-emergency laparotomy. The O:E ratio varies across all risk range. The p-value for the performance of P-POSSUM in predicting mortality in the high-risk range is <0.05 (p-value = 0.023) which indicates the risk prediction model poorly predicts in-hospital mortality. Table 6 summarized the analysis.

DISCUSSION

POSSUM risk prediction model was developed by Copeland in 1991 as a surgical audit tool for general surgical procedure to enable fair comparative audit in the National Health Service (NHS) in the United Kingdom (UK) (27). It is a risk-adjusted analysis that takes account physiological status and the nature of the operation. Prytherch et al subsequently modified the predictor equation with P-POSSUM to overcome the overprediction of original POSSUM within low-risk categories (28). The POSSUMs risk prediction model has evolved and developed over the decades. Analysis by Wijesinghe et al on both POSSUM and P-POSSUM scoring systems showed POSSUM can accurately predict mortality with correct analysis method while P-POSSUM is the adequately accurate risk prediction model for predicting morbidity (26). The risk prediction model has been validated in multiple studies across various type of surgical operations (29).

POSSUM risk prediction model performance in emergency general surgery and emergency laparotomy surgery have been validated in multiple studies (3,14-24,30-41). In Malaysia, Yii et al in 2001 investigated POSSUM risk prediction model on the surgical cohort that includes all elective and emergency general surgical procedure and in 2006, Chieng et al studied POSSUM risk prediction model for both elective and emergency laparotomy (3,19). Both studies were conducted in a main tertiary centre of their respective state in Malaysia, validating POSSUM in their respective surgical cohort. However, it cannot be immediately assumed to be valid across varying population and healthcare systems. It is known, there were marked variation of surgical outcome between centres (1,2). In emergency laparotomy especially, these variations may be due to different biological mechanisms and how the quality of healthcare provided (10). With that premises, this study aimed to investigate the value of POSSUM risk prediction model in Hospital Universiti Sains Malaysia, a tertiary centre in one of the states in Malaysia to assess suitability as a surgical audit tool.

There were 12 (14.5%) subjects died following emergency laparotomy in this study. Although previous similar studies had different mortality endpoint definition with varying proportion of mortality in their studies, in general, the range of in-hospital mortality or 30-day mortality was between 9.0 to 21.3% (1,3,30-34). P-POSSUM satisfactorily predicted mortality in this study with O:E ratio of 0.9. However, when analyzed using Chi-Square X^2 test (Hosmer and Lemeshow, Goodness of Fit) to detect differences between observed and expected mortality, the risk prediction model does not fit the observed data with a p-value less than 0.05 (p-value = 0.023). For observed in-hospital morbidity, there were 44 (53.0%) subjects developed complications following emergency laparotomy. The range of in-hospital morbidity for other similar studies was between 24.0 to 71.0% (3,31-33). POSSUM over predicted morbidity in this with O:E ratio of 0.8. The differences between observed and expected mortality, analyzed using Chi-Square X^2 test found the p-value of less than 0.05 (p-value = 0.002), meaning the risk prediction model does not fit the observed data.

Previous works that investigated POSSUM risk prediction model in a specific surgical cohort of emergency laparotomy were done in various geographical and healthcare systems, for examples as in New Delhi in India, Peshawar in Pakistan, Sudan, and Gulu in Uganda had found that POSSUM was able to predict morbidity and mortality (33-36). However, this study found out that POSSUM risk prediction model overpredicted morbidity and mortality for emergency laparotomy was unsuitable in our tertiary centre. The inability of POSSUM risk prediction model to predict morbidity and mortality in this study was similar with a study done by Sunil (42). Establishing the exact causes why POSSUM does not predict well in this surgical cohort in comparison with majority finding of other studies is difficult. One possible reason could be the inclusion of trauma pathology in the study cohort. Many previous studies that validated POSSUM in emergency laparotomy had excluded trauma pathology in their surgical cohort. It is possible that in trauma, there are other factors outside POSSUM parameter that have an impact on the outcome that has not taken into account such as adequacy of resuscitation and duration of time for surgical intervention when clinically indicated. The other reason could be a lack of standardization on data entry and interpretation. The physiological and operative parameter required to score has an element of subjective assessment (29,43). In a healthcare system that is not used to POSSUM parameter, there could be inter-observer variation. For example, are the interpretations of electrocardiogram (ECG) or the amount of blood loss which can be different between two observers. This study would also depend on the quality of documentation of the case record and operative notes. Any incomplete or missing data of the parameter will be assumed at the lowest value of 1 in the scoring, which potentially affect the accuracy of this study.

The limitations of this research included that this study were conducted retrospectively in a single tertiary centre, hence generalization of this study finding to other population was limited. A further large prospective study needed to validate the finding of this study adding the knowledge on the usability of POSSUMs risk prediction model in emergency laparotomy in this centre.

CONCLUSION

The poor result of both POSSUM and P-POSSUM for predicting in-hospital morbidity and mortality suggested that the risk prediction model is not suitable as a surgical audit tool in emergency laparotomy in this tertiary centre. A further large prospective study is needed to evaluate the success of POSSUM and P-POSSUM.

Conflict of interest

No conflict of interest was declared by the authors.

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