

## Original Article

# Risk-Adjusted Analysis of Patients Undergoing Emergency Laparotomy Using POSSUM and P-POSSUM Score: A Prospective Study

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ABSTRACT

**Background:** Comparison of operative morbidity rates after emergency laparotomy between units may be misleading because it does not take into account the physiological variables of patients' conditions. Surgical risk scores have been created, and the most commonly used is the Physiological and Operative Severity Score for the enumeration of Mortality (POSSUM) or one of its modifications, the Portsmouth-POSSUM (P-POSSUM), usually requires intraoperative information.

**Objective:** The objective of this study is to evaluate the POSSUM and P-POSSUM scores in predicting postoperative morbidity and mortality in patients undergoing emergency laparotomy. **Methodology:** This is a prospective, cross-sectional, and hospital-based study that was conducted at J.L.N. Medical College and Hospital, Ajmer, Rajasthan, India, from April 2017 to December 2017. Adult patients who presented at the causality and underwent emergency laparotomy were included in the study. Observed and predicted mortality and morbidity were calculated using POSSUM and P-POSSUM equations, and statistical significance was calculated using Chi-square test. **Results:** A total of 100 patients were included in this study, with a mean age of  $42.83 \pm 18.21$  years. The observed (O) mortality was 12 (12.0%), while POSSUM predicted 40 (40%) and P-POSSUM 27 (27%). The O/E ratio for POSSUM was 0.29 and for P-POSSUM was 0.44, and this means that they both overestimate mortality. When the results were tested by Chi-square test, the *P* value was found to be 0.55 and 0.85 for POSSUM and P-POSSUM, respectively, which showed no significant correlation for observed and expected mortality. The observed morbidity was 69 (69%), while POSSUM expected morbidity was 79 (79%), O/E ratio is 0.87, and this again overestimates the morbidity. POSSUM is overpredicting the rate of morbidity, and test of correlation showed no significance with *P* = 0.75. **Conclusion:** POSSUM and P-POSSUM were found to overestimate mortality and morbidity in our patient's population.

**KEYWORDS:** *Observed morbidity, observed mortality, operative score, physiological score, Physiological and Operative Severity Score for the enumeration of Mortality and Portsmouth-Physiological and Operative Severity Score for the enumeration of Mortality, predicted morbidity, predicted mortality*

## INTRODUCTION

Urgent or emergency laparotomy is a common procedure having mortality rate considerably greater than that of elective laparotomy.<sup>[1]</sup> Measuring the outcome of emergency laparotomy is crucial for both the patient and health providers, in which improvement in the health service can be achieved.

Comparison of morbidity and mortality rates is an essential component of surgical audit. For a good audit, it is important to compare the risk-adjusted mortality and morbidity rates instead of crude rates as the outcome is directly related to

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the risks associated with surgery. For this purpose, several risk scoring systems have been devised.<sup>[2]</sup> Physiological and Operative Severity Score for the enumeration of Mortality (POSSUM) was first described by Copeland *et al.*<sup>[3]</sup> in 1991 as a method of normalizing data so that direct comparison of patient's outcome can be made despite differences in case mix.<sup>[4]</sup> It uses 12 physiological factors and 6 operative factors for the score. Depending on the severity of abnormality, each factor is assigned 1, 2, 4, or 8 points. The point's score for the physiological 12 factors of the patient is summed to obtain the total physiological score (PS). Similarly, the operative score (OS) is obtained by the summation of points of the variables of the OS. The risk of mortality of an individual patient is then calculated using the formula:  $\text{Log} [(R/1 - R)] = -7.04 + 0.13 \times \text{PS} + 0.16 \times \text{OS}$ ; where PS denotes the physiological score, OS denotes the operative severity score and R is the predicted risk of mortality.<sup>[5]</sup>

The objective of this study was to assess the overall predictive value of POSSUM for morbidity and mortality compared with Portsmouth-POSSUM (P-POSSUM) in patients undergoing laparotomy. The mortality of all the patients can be calculated using the linear method of analysis as described by Copeland, elaborated in detail by Wijesinghe *et al.*<sup>[6]</sup> Later, a modification to the predictor equation had been proposed as the P-POSSUM<sup>[7]</sup> that was claimed to produce a closer fit with the observed inhospital mortality in low-risk groups.<sup>[4]</sup> In India, P-POSSUM had been verified with a different population and possibly surgical practice.<sup>[8]</sup>

## METHODOLOGY

This was a prospective cross-sectional study that includes patients who fulfilled the criteria of inclusion in the study (all patients operated for emergency laparotomy >18 years of age), from five general surgical units at J.L.N Hospital from April 2017 to December 2017. The exclusion criteria of this study were as follows:

1. Age <18 years
2. Daycare surgery
3. Routine surgery
4. Follow-up criteria cannot be fulfilled, i.e., patient absconds, and contact cannot be done.

Patients were informed regarding the aim and objective of this study, and a detailed informed written consent was taken before inclusion in the study. The study protocol was approved by the Ethical Committee of our institute. PS was collected preoperatively for all patients following resuscitation; in some patients, electrocardiogram and chest X-ray were not requested, and patients allocated at the least score in the lowest category. Pathological score was calculated after surgery and sometimes after

the results of histopathology appeared. Follow-up of the patients was done 30 days postoperatively either at the refer clinic or through the telephone, and morbidity was collected and also mortality within that period was defined as a final outcome measure.

## Definition of postoperative complications

- Wound hemorrhage: Local hematoma requiring evacuation
- Deep hematoma: Postoperative bleeding requiring re-exploration
- Chest infection: Production of purulent sputum with positive bacteriological cultures, with or without chest radiography changes or pyrexia, or consolidation seen on chest radiograph
- Wound infection: Wound cellulitis or the discharge of purulent exudates
- Urinary infection: The presence of >105 bacteria/ml with the presence of white cells in the urine, in previously clear urine
- Deep infection: The presence of an intra-abdominal collection confirmed clinically or radiologically
- Septicemia: Positive blood culture
- Pyrexia of unknown origin: Any temperature above 37.0°C for more than 24 h after the original pyrexia following surgery (if present) had settled, for which no obvious cause could be found
- Wound dehiscence: Superficial or deep wound breakdown
- Deep venous thrombosis and pulmonary embolus: When suspected, confirmed radiologically by venography or ventilation/perfusion scanning or diagnosed at postmortem
- Cardiac failure: Symptoms or signs of left ventricular or congestive cardiac failure which required alteration from preoperative therapeutic measures
- Impaired renal function: Arbitrarily defined as increase in blood urea >5 mmol/L from preoperative levels
- Hypotension: A fall in systolic blood pressure <90 mmHg for >2 h as determined by sphygmomanometer or arterial pressure transducer measurement
- Respiratory failure: Respiratory difficulty requiring emergency ventilation
- Anastomotic leak: Discharge of bowel content through the drain, wound, or abnormal orifice.

## Statistical methods

The expected mortality rate was obtained using linear analysis and the O:E ratio was calculated. Chi-square test was then applied to obtain the *P* value to note any significant difference between the predicted death rate and actual outcome. Rate of increment in deaths for each

risk factor was calculated based on the hypothesis that deaths were linearly related with the score for each of the studied risk factors, and *t* test was applied to validate this hypothesis.

## RESULTS

A total of 100 participants were included in the study, with a mean age of  $42.83 \pm 18.21$  years. Male gender 86 (86.0%) was predominant, while female was 14 (14.0%) with M:F ratio of 6.1:1, and most of the patients were below the age of 60 years (85.0%).

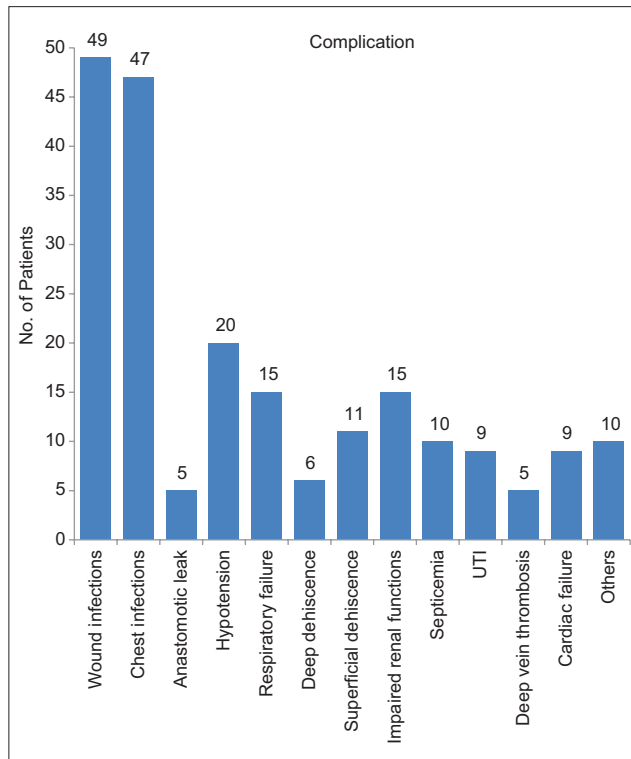


Figure 1: Postoperative complications

Preoperative diagnosis was equally seen, intestinal obstruction (28), abdominal trauma (15), and peritonitis (57). While intraoperative diagnosis were found, with peptic perforation 41 (41% case), small intestine perforation 06 (6% case), appendicular perforation 01 (1% case), intestinal obstruction 24 (24 % case), malignancy 04 (4% case), obstructed hernia 01 (1% case), trauma 15 (15% case), other 08 (8% case).

Most common complications after surgery were wound infection (49%) followed by chest infection (47%), hypotension (20%), respiratory failure (15%), impaired renal function (15%), superficial dehiscence (11%), septicemia (10%), urinary tract infection (9%), cardiac failure (9%), deep dehiscence (6%), anastomotic leak (5%), and deep vein thrombosis (DVT) (5%) [Figure 1].

Mean PS was  $26.53 \pm 9.6$  and most of the patients had PS of 13–55, and mean OS was  $19.98 \pm 4.34$  and most of the patients had the score of 16–23 in correlation of mortality.

The observed morbidity was 69 (69%), while POSSUM expected morbidity was 79 (79%), O/E ratio is 0.87, and this overestimates the morbidity. POSSUM is overpredicting the rate of morbidity, and test of correlation showed no significance with  $P = 0.75$  [Table 1].

Table 2: Causes of death in the study population (n=100)

Cause	Frequency (%)
Cardiac failure	5 (5)
Respiratory failure	3 (3)
DVT/PE	2 (2)
Acute renal failure	1 (1)
Septicemia	1 (1)
Total	12 (12)

DVT/PE: Deep venous thrombosis/pulmonary embolus

Table 1: Comparison between observed and expected morbidity rate using Physiological and Operative Severity Score for the enumeration of Mortality scoring system

Predicted morbidity rate	Total number	Mean predicted morbidity rate	Expected number of morbidity (expected)	Observed number of patients with complications (observed)	Observed:expected ratio
≤10	0	0	0	0	-
10-20	0	0	0	0	-
20-30	1	29.30	0	1	0
30-40	4	37.97	2	1	0.5
40-50	6	47.63	3	3	1.0
50-60	8	53.63	4	4	1.0
60-70	6	64.21	4	4	1.0
70-80	17	75.71	13	12	0.92
80-90	20	84.36	17	10	0.58
90-100	38	96.47	36	34	0.94
100	100	79.22	79	69	0.87

$P=0.75$

**Table 3: Comparison of observed and expected mortality rate using Physiological and Operative Severity Score for the enumeration of Mortality scoring system**

Predicted mortality rate	Total number	Mean predicted mortality rate	Expected number of death (expected)	Observed number of death (observed)	Ratio (observed/expected)
≤10	7	7.41	0	0	-
10-20	18	12.81	2	0	-
20-30	25	24.86	6	0	-
30-40	11	34.12	4	1	0.25
40-50	11	44.72	5	1	0.2
50-60	6	55.23	3	0	-
60-70	1	67.90	1	0	-
70-80	2	75.65	1	0	-
80-90	7	85.84	6	2	0.33
90-100	12	94.03	11	8	0.72
0-100	100	40.51	40	12	0.29

P=0.55

**Table 4: Comparison between observed and expected mortality rate using Portsmouth-Physiological and Operative Severity Score for the enumeration of Mortality scoring system**

Predicted mortality rate	Total number	Mean predicted mortality rate	Expected number of death (expected)	Observed number of death (observed)	Ratio (observed/expected)
≤10	42	5.01	2	0	-
10-20	25	14.34	4	2	0.5
20-30	5	26.28	1	0	-
30-40	7	34.12	2	0	-
40-50	1	45.40	0	0	-
50-60	0	0	0	0	-
60-70	3	66.03	2	0	-
70-80	3	75.33	2	1	0.5
80-90	7	85.97	6	5	0.83
90-100	7	94.37	6	4	0.66
Total	100	26.71	27	12	0.44

P=0.85

**Table 5: Comparison of mortality and morbidity with other studies**

Study group	Our study 2017	Mohil <i>et al.</i> , 2004 <sup>[13]</sup>	Tekkis <i>et al.</i> , 2000 <sup>[11]</sup>	Midwinter <i>et al.</i> , 1999 <sup>[16]</sup>	Wijesinghe <i>et al.</i> , 1998 <sup>[6]</sup>	Jones <i>et al.</i> , 1992 <sup>[14]</sup>
Number of patients	100	120	505	221	312	117
Observed	12	16	56	14	9	13
Deaths						
Expected	40	-	108	-	49	16
Deaths						
POSSUM						
Expected	27	-	57	27	26	-
Deaths						
P-POSSUM						
Observed	69	62	-	126	-	59
Morbidity						
Observed:expected ratio	0.29	0.39	0.52	-	0.18	0.82
POSSUM mortality						
Observed:expected ratio	0.44	0.66	0.89	1.28	0.35	-
P-POSSUM mortality						
χ <sup>2</sup> POSSUM	2.1	10.79	44.8	24.04	32.45	-

Contd...

Table 5: Contd...

Study group	Our study 2017	Mohil <i>et al.</i> , 2004 <sup>[13]</sup>	Tekkis <i>et al.</i> , 2000 <sup>[11]</sup>	Midwinter <i>et al.</i> , 1999 <sup>[16]</sup>	Wijesinghe <i>et al.</i> , 1998 <sup>[6]</sup>	Jones <i>et al.</i> , 1992 <sup>[14]</sup>
$\chi^2$ P-POSSUM	1.23	5.33	3.34	9	10.6	-
P	0.55	0.148	<0.001	<0.001	0.001	<0.002
POSSUM						
P	0.85	0.619	0.05	0.17	0.003	-
P-POSSUM						

Data were not studied or found. POSSUM: Physiological and Operative Severity Score for the enumeration of Mortality, P-POSSUM: Portsmouth-POSSUM

Table 6: Comparison of result between other published studies and our study

Study	Field studied	Number of patients	Observed/expected ratio POSSUM	Observed/expected ratio P-POSSUM
Whitely <i>et al.</i> , 1996, UK <sup>[9]</sup>	General surgery	1485	0.411	1.000
Prytherch <i>et al.</i> , 1998, UK <sup>[7]</sup>	General surgery	10000	0.411	0.960
Yii and Ng <i>et al.</i> , 2002, Malaysia <sup>[8]</sup>	General surgery	605	0.581	1.271
Organ <i>et al.</i> , 2002, Australia <sup>[17]</sup>	ICU-general surgery	229	-	0.561
Bennett-Guerrero <i>et al.</i> , 2003 <sup>[18]</sup>	General surgery-UK	1056	-	0.974
	General surgery-US	1539	-	0.268
Mohil <i>et al.</i> , 2004, India <sup>[13]</sup>	Emergency laparotomy	120	0.62	0.88
Brooks <i>et al.</i> , 2005, UK <sup>[19]</sup>	General surgery	949	0.667	1.151
Chieng <i>et al.</i> , 2010, Malaysia <sup>[20]</sup>	Laparotomy-overall	381	0.366	0.721
	Laparotomy-ICU	104	0.555	0.916
	Laparotomy-emergency	199	0.336	0.603
Our study 2017	Laparotomy-emergency	100	0.290	0.440

Data were not studied or found. ICU: Intensive Care Unit, POSSUM: Physiological and Operative Severity Score for the enumeration of Mortality, P-POSSUM: Portsmouth-POSSUM

The mortality rate in this study was 12 (12%), and the most common cause of death in our study is cardiac failure which included 5 patients (5%), followed by respiratory failure 3 (3%), then DVT/pulmonary embolism 2 (2%), and both acute renal failure and septicemia account for 1 patient for each (1%) [Table 2].

The observed (O) mortality was 12 (12%), while POSSUM predicted 40 (40%) and P-POSSUM 27 (27%). The O/E ratio for POSSUM is 0.29 and for P-POSSUM is 0.44, and this means that they both overestimate mortality. When the results tested by Chi-square goodness-of-fit as proposed by Hosmer and Lemeshow,  $P = 0.55$  and  $P = 0.85$ , for POSSUM and P-POSSUM, respectively, which showed no significant correlation for observed and expected mortality [Tables 3 and 4].

## DISCUSSION

The basic tenet in medical care has been to provide quality care to the patient to cause reduction in adverse outcome. It is by comparing the adverse outcome rates that we can assess the adequacy of care provided to the patient and evolve new treatment strategies. However, comparison using crude mortality rates can be misleading as it cannot adequately account for the patient's general

condition and the disease process for which he was subjected to surgery.

To overcome this shortcoming POSSUM, a risk-adjusted scoring system was proposed.<sup>[3]</sup> P-POSSUM, a modification of POSSUM, has been proposed as a better scoring system as it better correlates with the observed mortality rate,<sup>[7,9]</sup> but P-POSSUM has to be correlated to the general condition of the local population for it to be effective.<sup>[7-12]</sup> This is especially true in patients in developing countries such as India where the general health of the population is poor; malnutrition is a common problem and presentation frequently delayed.<sup>[12,13]</sup>

Fair comparison of surgical result must take into account the difference in the case mix. POSSUM was developed as a surgical auditing tool for assessment of the quality of surgical care.<sup>[3]</sup> It allowed comparison of the audits of different patient population by taking into account variations in the physiological conditions of the patients at surgery and the extent of surgical intervention or severity of surgery. The original POSSUM equation for mortality prediction was subsequently modified to the P-POSSUM equation. The P-POSSUM equation produced a closer fit with observed inhospital mortality in low-risk group,

and the comparison between the observed and predicted mortality rates was easier to perform using linear rather than exponential analysis.<sup>[6]</sup>

In our study, we assessed the validity of POSSUM and P-POSSUM in 100 major general surgeries by comparing the observed mortality rate and morbidity rate with expected mortality rate and morbidity rate. A total of 100 cases of emergency laparotomies were studied in patient admitted in general surgery department from April 2017 to December 2017. The study size which is compared to Mohil *et al.*, Jones *et al.*, and Shuhaiber *et al.* was 120, 117, and 118, respectively.<sup>[13-15]</sup> Male gender 86 (86.0%) was predominant, while female was 14 (14.0%) with M:F ratio of 6.1:1, which is compared to Parihar *et al.* with ratio of 2.3:1. In our study, most of the patients were below the age of 60 years (85.0%) and median age of 40.0 years (range: 18–86 years) which is similar to Parihar *et al.* (87.5%). In our study, group consisted of the following cases (indication of emergency laparotomy): peptic perforation (41 cases), small intestine perforation (6 cases), appendicular perforation (1 case), intestinal obstruction (24 cases), malignancy (4 cases), obstructed hernia (1 case), trauma (15 cases), and others (8 cases). Parihar *et al.* found that appendicular pathology is most cause for emergency laparotomy in developing countries 29.1%.<sup>[12]</sup> Physiological parameter, operative parameter, and 30-day mortality were collected. Predicted mortality and morbidity for each patient were calculated using POSSUM and P-POSSUM equations. Patients were stratified into risk group, and observed and predicted deaths were compared. Accuracy of prediction was assessed using Chi-squared analysis. The mean PS was 26.53 + 9.6 and OS was 19.98 + 4.34. The observed 30-day mortality was 12.0% (the total crude mortality rate being 12.0%) and morbidity (postoperative complication) was 69.0%. The predicted deaths using POSSUM and P-POSSUM analyzing were 40 and 27, respectively, compared to 12 observed deaths.<sup>[6]</sup> Applying linear analysis for POSSUM and P-POSSUM, observed and expected mortality ratio (O:E) were 0.29 and 0.44, respectively. In Mohil *et al.* and Wijesinghe *et al.* (O:E), POSSUM and P-POSSUM is 0.39 and 0.66 And 0.18 and 0.35.<sup>[6,13]</sup> On analysis, there was found to be no statistically significant difference between the observed and expected mortality rates according to POSSUM ( $\chi^2 = 2.1$ , degree of freedom = 3,  $P = 0.55$ ), This is consistent with other studies as reported by Mohil *et al.*<sup>[13]</sup> is 0.148 and according to P-POSSUM ( $\chi^2 = 1.23$ , degree of freedom = 3,  $P = 0.85$ ) similar to Mohil *et al.*<sup>[13]</sup> and Midwinter *et al.*<sup>[16]</sup> is 0.619 and 0.17 [Table 5]. The

observed and expected morbidity POSSUM was 69 and 79. POSSUM morbidity (O:E) ratio 0.87 was obtained, and there was no significant difference between the predicted and observed values ( $\chi^2 = 1.87$ , degree of freedom = 6,  $P = 0.75$ ) [Table 1].

The results of this study are consistent with the other published papers in that POSSUM overpredicts the number of deaths and P-POSSUM serves as a better scoring system in predicting death as a whole [Table 6]. Sagar PM *et al.* concluded that The physiological severity score, POSSUM and P-POSSUM scores did not differ among patients operated by different surgeons and anesthetized by different anesthesiologists.<sup>[10]</sup>

Wound infection (49 cases, 49.0%) and chest infections (47 cases, 47.0%) accounted for the majority of complications [Figure 1]. Similar results were obtained by Mohil *et al.* (35% and 20%, respectively).<sup>[13]</sup> Wound infections could be attributed to the large number of patients who had gross peritoneal contamination resulting from hollow visceral perforation resulting in local contamination of the incision site. A raised diaphragm, upper abdominal incision, and gross peritoneal contamination result in higher rates of chest infections in our group.

On analyzing the risk factors, we found positive rate of increment with all the risk factors studied, but it was found to be statistically significant with respect to electrocardiogram ( $P = 0.001$ ), serum potassium ( $P = 0.01$ ), blood pressure ( $P = 0.02$ ), and respiratory system ( $P = 0.001$ ). A positive rate of increment of death per score was obtained which suggested association of malignancy with adverse outcome, but statistically, this association was found to be nonsignificant ( $P = 0.10$ ). Various factors such as decreased immunity, cachexia, ischemia, impaired homeostasis, blood loss, uraemia, leukocytosis, toxemia, and hyponatremia could be attributed to the effect of these factors on postoperative mortality rate. Therefore, adequate and prompt correction can definitely be expected to cause a decrease in adverse outcome rates. Tekkis *et al.* and others found that total blood loss was not significant enough to alter their statistical analysis in their study, but their study predominantly involved elective cases (66%) in a super-specialty setting.<sup>[11]</sup>

## CONCLUSION

P-POSSUM is a better overall predictor of mortality in patients undergoing laparotomy in this hospital compared to POSSUM. POSSUM and P-POSSUM were found to overestimate mortality and morbidity in our patient's population. However, further refinement is needed to improve its predictive value in specific areas and increase its utility in our local setting.

### Limitations of study

Although POSSUM and P-POSSUM have been validated in different countries and studies, both have their own limitations.

- POSSUM physiology score may change with time
- The operative severity score is not available until the operation has been undertaken; thus, POSSUM cannot be used to prevent a patient from undergoing a potentially curative procedure
- The OS has an element of subjective assessments, such as the amount of blood loss and degree of peritoneal soiling
- The organ system operated on and duration of stay after operation which might be expected to have considerable influence on the outcome
- Factors such as hospital resources, the availability, and training of medical staffs had a significant impact on the postoperative outcome (mortality and morbidity) of patients.

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### Conflicts of interest

There are no conflicts of interest.

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