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An Evaluation of Efficacy of the Portsmouth Possum Scoring System for Predicting Morbidity and Mortality in Elective and Emergency Abdominal Surgeries

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Abstract

Background: Surgical risk assessment is crucial for predicting postoperative outcomes and optimizing patient care. The Portsmouth Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (P-POSSUM) has been widely used to estimate morbidity and mortality in surgical patients. This study evaluates the accuracy of P-POSSUM in predicting outcomes for patients undergoing elective and emergency abdominal surgeries at ASRAM, Eluru, Andhra Pradesh.

Methods: A prospective study was conducted on 150 patients undergoing abdominal surgeries. P-POSSUM scores were calculated based on physiological and operative parameters. The observed morbidity and mortality rates were compared with predicted values using statistical models, including the observed-to-expected (O:E) ratio and Receiver Operating Characteristic (ROC) curve analysis.

Results: The study included 150 patients (59.3% male, 40.7% female), with 75.3% under 60 years of age. Elective surgeries accounted for 72.7%, while 27.3% were emergency procedures. The observed mortality rate was 10%, and morbidity occurred in 96.7% of patients. ROC curve analysis demonstrated high predictive accuracy for mortality (AUC = 0.898) and moderate accuracy for morbidity (AUC = 0.742). The comparison of observed versus expected outcomes confirmed P-POSSUM's validity in mortality prediction, though morbidity estimation showed some variance.

Conclusion: P-POSSUM is a reliable tool for predicting mortality in abdominal surgeries, aiding in preoperative

risk assessment and perioperative management. While morbidity prediction requires refinement, the scoring system remains valuable for surgical risk stratification. Further studies are recommended to enhance its predictive accuracy for morbidity outcomes.

Keywords: P-POSSUM, surgical risk assessment, morbidity, mortality, abdominal surgery, predictive accuracy, ROC analysis.

Introduction

The results of a surgical procedure may vary a lot from patient to patient and is hard to precisely predict beforehand. These results range from no complications to mortality, which mostly due to unavoidable factors. Therefore, different Risk assessment systems have been developed to predict the risk throughout the past years. During the early 90's the Physiological and Operative Severity score for enumeration od Mortality and Morbidity (POSSUM) has been developed at Warrington Hospital, UK, which is easier and faster to apply for all surgical specialities both emergency and elective to predict the Mortality and Morbidity risk. This system takes into account a total of 18 parameters of which six are operative parameters and 12 are physiological parameters. (Table 1 & 2).

Improvements and variations pertaining to particular surgical procedures were introduced as a result of the POSSUM score's progression during a ten-year period. In this regard, Portsmouth POSSUM (P-POSSUM) provides a more accurate mortality prediction for gastrointestinal surgery groups of intermediate complexity by accounting for POSSUM's propensity to forecast an excess of mortality in low-risk patients.

Aims and Objectives

To evaluate the validity of Portsmouth Possum scoring system in predicting anticipated mortality and morbidity in patients undergoing elective and emergency abdominal surgeries in ASRAM, Eluru, West Godavari Dt., Andhra Pradesh.

Patients and Methods

Source of data

This prospective study was carried out on patients undergoing elective and emergency abdominal surgeries admitted in Department of general surgery of Alluri Sitarama Raju academy of medical sciences, Eluru, West Godavari District, Andhra Pradesh from September 2022 to June 2024**.**

Study Period

The study period was from September 2022 to June 2024 and the post-operative period of follow up is for 30 days after surgery.

Method of collection of data

Patients admitted under Department of general surgery and scheduled to undergo elective and abdominal surgical procedures was scored according to their physiological and operative findings using a proforma sheet

Inclusion criteria

Patients undergoing any of the following surgical procedures:

- Any laparotomy.
- Bowel resection.
- Cholecystectomy.
- Appendectomy.
- Ventral Hernia surgeries

Exclusion criteria

- Age less than 12 years
- Trauma.
- Follow-up period criteria not met

Patients were informed by the principal investigator regarding the aims and objectives of the study and a detailed informed written consent was obtained prior to inclusion into the study. The study protocol was approved by the ASRAM college institutional ethical clearance committee of this hospital. During hospitalization, relevant history was collected and appropriately investigated as deemed necessary using standard procedures. These patients were then scored depending on their physiological parameters and the intraoperative findings were noted and a final expected mortality rate was calculated.

Table 1: Physiological score

Parameters	Score 1	Score 2	Score 4	Score 8
Age (years)	≤60	61–70	≥71	-
Cardiac sign	No failure	Diuretic, digoxin, antianginal, or hypertensive therapy	Peripheral edema, warfarin therapy, or borderline cardiomegaly	Raised jugular venous pressure or cardiomegaly
Respiratory sign	No dyspnea	Dyspnea on exertion, mild chronic obstructive airway disease	Limiting dyspnea (one flight), moderate chronic obstructive airway disease	Dyspnea at rest (rate >30/min), fibrosis or consolidation
Systolic BP (mmHg)	110–130	131–170 / 100–109	≥171 / 90–99	≤89
Pulse (beats/min)	50–80	81–100 / 40–49	101–120	≥121 / ≤39
Glasgow coma score	15	12–14	9–11	≤8
Hemoglobin (g/dL)	13–16	11.5–12.9	10.0–11.4 / 17.0–18.0	≤9.9 / ≥18.1
White cell count (10^9/L)	4–10	11–20 / 3.1–4.0	≥20.1 / ≤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 / 5.1–5.3	2.9–3.1 / 5.4–5.9	≤2.8 / ≥6.0
Electrocardiogram	Normal	-	Atrial fibrillation (rate 60–90)	Any other abnormal rhythm, ≥5 ectopics/min or Q waves or ST/T wave changes

Table 2: Operative parameters

Parameter	Score 1 (Minor)	Score 2 (Moderate)	Score 4 (Major)	Score 8 (Major+)
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 contents, pus, or blood
Malignancy	None	Primary only	Nodal metastasis	Distant metastasis
Mode of surgery	Elective	Emergency resuscitation < 2 h possible, operation < 24 h after admission	-	Emergency (immediate surgery < 2 h needed)

Physiological score (12-88), Operative score (6-48)

For morbidity it was,

Log [R/1-R] = - 5.91 + (0.16 x physiological score) + (0.19 x operative score)

Where R = risk of morbidity.

For mortality it was,

Log [R/1-R] = - 7.04 + (0.13 x physiological score) + (0.16 x operative score)

Where R= Risk of mortality.

The patients were followed up for a 30-day period post-surgery and complication if any, were noted depending upon the following criteria as defined for POSSUM Scoring system.

- Minor bleeding: local haematoma requiring evacuation.
- Significant bleeding: postoperative bleeding requiring re- exploration.
- Chest infection: Cough with expectoration +/- pyrexia with radiological evidence.
- Wound infection: Wound gaping with serous or purulent exudates.
- UTI: Fever with positive microbial evidence.
- Deep infection: the presence of a peritoneal collection confirmed clinically or radiologically.
- Septicaemia: positive blood culture.
- Pyrexia of unknown origin: Sustained fever more than 3 days with negative for routine fever workup
- Wound dehiscence: superficial or deep wound breakdown.
- Deep venous thrombosis: when suspected, confirmed radiologically by venography.
- Cardiac failure: symptoms or signs of left ventricular or congestive cardiac failure
- Impaired renal function: arbitrarily defined as increase in blood urea > 5mmol/l from preoperative levels.
- Hypotension: a fall in systolic blood pressure below 90 mmHg for more than 2hours as determined by sphygmomanometer or arterial pressure transducer measurement.
- Respiratory failure: respiratory difficulty requiring emergency ventilation.
- Anastomotic leak: discharge of bowel content via the drain, wound or abnormal orifice.

Statistical Analysis: The expected mortality rate was obtained using linear regression analysis and the O:E ratio was calculated. Chi-square test was the applied to obtain the p value to note any significant difference between the predicted death rate and the actual outcome.

Results

A total of 150 patients who underwent elective and emergency abdominal surgical procedure at ASRAM Hospital, Eluru were included in the study.

Physiological score

Out of the total 150 participants, the majority (75.3%) are under 60 years. A smaller proportion (17.3%) falls within the 61-70 age range, while the remaining 7.3% are above 71 years old. 59.3% are male, and 40.7% are female, indicating a higher representation of males in the study. A significant majority (73.3%) have no cardiovascular failure. About 21.3% are under various therapies including diuretics, anti-anginal, digoxin, or antihypertensive therapy. A small percentage (5.3%) show raised Jugular Venous Pressure (JVP), while no cases of peripheral edema on warfarin therapy are reported. 83.3% of participants exhibit no dyspnea. Dyspnea on exertion is reported in 11.3% of cases, and 5.3% have dyspnea at rest with a respiration rate over 30 per minute. There are no cases of limiting dyspnea. The majority (80%) have blood pressure readings between 110-130 mm Hg. 14% have readings between 131-170/100-109 mm Hg, while a small proportion has either very high (4%) or very low (2%) readings. A large majority (83.3%) have pulse rates between 81-100 beats per minute. Higher pulse rates (101-120) are seen in 14.7%, and only 2% have pulse rates over 121 or below 39 beats per minute. 86% of participants scoring 15, indicating normal consciousness. 14% score between 12 and 14, while no participants score below 12. The largest group (67.3%) has haemoglobin levels between 11.5-12.9 or 16.1-17. Smaller groups have levels between 10-11.4 or 17.1-18 (8.7%), and less than 9.9 or more than 18.1 (6%). The white blood cell (WBC) count distribution shows that 80% of participants have counts between 4-10. Counts between 10.1-20 or 3.1-4 are seen in 10% each. Blood urea levels indicate that 86% of participants have levels between 7.6-10, while 14% have levels above 15.1. There are no participants with levels below 7.5 or between 10.1-15. The majority (85.3%) have sodium levels greater than 136 mmol/L. Lower sodium levels (131-135) are seen in 9.3%, with even fewer participants having levels between 126-130 (4.7%) or below 125 (0.7%). Most participants (90%) have potassium levels between 3.5-5 mmol/L. Levels between 3.2-3.4 or 5.2-5.3 are seen in 8.7%, and very few (1.3%) have levels between 2.9-3.1 or 5.4-5.9. Normal ECG findings are reported in 88.7% of participants. Atrial fibrillation (rate 60-90) is seen in 6%, and other abnormal rhythms or significant ECG changes are observed in 5.3%.

Table 3: distribution based on physiological score:

	Min.	Max.	Mean ± SD
Physiological score	15	45	19.94 ± 7.69
Physiological score	15	45	19.94 ± 7.69

The distribution of physiological scores is within a range of 15 to 48 with a mean score of 19.94 ± 7.69.

Operative score: Most operations are categorized as moderate (72%). Major operations constitute 28%, with no minor or major plus operations reported. Most participants (89.3%) underwent a single procedure, 8.7% underwent two procedures, and 2% underwent more than two procedures. Blood loss of 100-500 ml is the most common (53.3%). Less than 100 ml is lost in 31.3% of cases, while significant blood loss (501-999 ml and over

1000 ml) occurs in 10.7% and 4.7% of cases, respectively. Most participants (82.7%) have major peritoneal soiling. Local pus is observed in 14%, and free bowel content pus or blood in 3.3%. No cases are reported with no soiling. Malignancy is absent in 83.3% of participants. Primary malignancies are found in 16.7%, with no cases of nodal or distant metastases. Most surgeries (72.7%) are elective. Emergency surgeries performed within 24 hours of admission constitute 27.3%, with no immediate emergency surgeries performed. The operative score ranges from 8 to 29, with a mean of 11.28 ± 4.73.

Table 4: distribution based on Operative score:

	Min.	Max.	Mean ± SD
Operative score	8	29	11.28 ± 4.73

Mortality is reported in 10% of participants, with the remaining 90% surviving.

Table 5: Mortality

Mortality	Frequency	Percentage
Yes	15	10%
No	135	90%
Total	150	100%

Morbidity is present in 96.7% of participants, with only 3.3% having no morbidity.

Table 6: Morbidity

Morbidity	Frequency	Percentage
Yes	145	96.7%
No	5	3.3%
Total	150	100%

Statistical Analysis

Table 7: The expected mortality rate calculated by given formula compared with the observed mortality rate

	Observed mortality	Expected mortality
<20%	2	2
21-40%	2	2
41-60%	1	1
61-80%	5	5
>80%	5	3

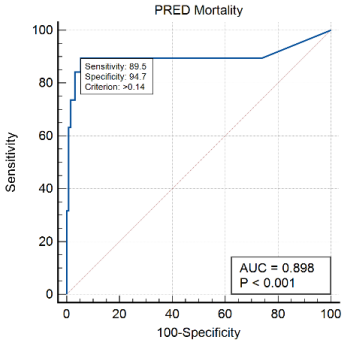

Figure 1: ROC curve for predicted mortality rate

The Area under ROC Curve (AUC) is 0.898 for predicting mortality, with a sensitivity and specificity of 89.47% and 94.66% respectively. The Observed and expected mortality rates across different risk categories, shows statistically significant differences with a Chi square test value of 95.88 (p=0.0001).

Table 8: The expected morbidity rate calculated by given formula compared with the observed morbidity rate:

	Observed morbidity	Expected morbidity
<20%	0	0
21-40%	79	84
41-60%	33	28
61-80%	10	10
>80%	23	23

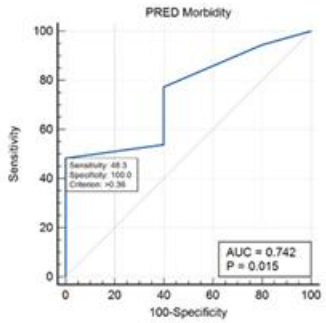

Figure 2: ROC curve for predicted morbidity rate.

The Area under ROC Curve (AUC) is 0.742 for predicting morbidity, with a sensitivity and specificity of 48.28% and 100% respectively. The observed and expected morbidity rates are compared, with the data showing no statistically significant discrepancies across the different risk categories.

Discussion

The Portsmouth Physiological and Operative Severity Score for the enumeration of Mortality and morbidity (P-POSSUM) is a widely used risk-adjusted scoring system designed to predict mortality and morbidity in surgical patients. This discussion compares the validity of the P-POSSUM system as reported in various studies with the findings from our study.

In our study, the P-POSSUM system demonstrated an area under the ROC curve (AUC) of 0.898 for predicting mortality, indicating excellent predictive accuracy. The sensitivity and specificity were 89.47% and 94.66%, respectively, which underscores the model's robustness in our patient cohort.

Jha et al. evaluated the P-POSSUM system in a cohort of patients undergoing emergency laparotomy in a tertiary care setting in Kathmandu, Nepal. They reported that the observed-to-expected (O: E) ratio for mortality was 1.18, indicating a good fit for predicting postoperative outcomes. Their study also highlighted a significant fit between observed and expected mortality rates (p = 0.833), suggesting that P-POSSUM is a reliable tool in predicting outcomes in their population. These findings are consistent with our results, supporting the system's validity across different settings.

Shekar et al. assessed the P-POSSUM system's validity in predicting mortality and morbidity in patients undergoing emergency laparotomy. They found an AUC of 0.836 for mortality, which is slightly lower than our study but still indicates a good predictive ability. The O:E ratio for mortality in their study was 0.84, reflecting a close alignment between predicted and observed outcomes. However, they noted that P-POSSUM overpredicted morbidity, with an O:E ratio of 0.79, suggesting room for improvement in morbidity predictions. Our study's AUC of 0.898 and better alignment of observed versus predicted mortality reinforce the robustness of P-POSSUM.

Anbarasu et al. conducted a study on 100 patients undergoing laparotomy and found an overall mortality rate of 11%, with an O:E ratio of 0.85, similar to our findings. They concluded that P-POSSUM is a reliable predictor of mortality but indicated that the system slightly over predicted morbidity (O: E = 0.78, p = 0.089). These results align closely with our findings, demonstrating the system's efficacy in predicting mortality but suggesting potential refinements for morbidity predictions.

Das et al. evaluated the P-POSSUM system in patients undergoing emergency laparotomy and found it to be an accurate predictor of mortality with an O:E ratio close to 1. They highlighted the system's applicability in different surgical settings and populations, similar to our findings. However, they noted discrepancies in morbidity predictions, emphasizing the need for localized adjustments to improve predictive accuracy.

Several other studies, including those by Hong et al. and Tekkis et al., have demonstrated the validity of P-POSSUM in various surgical contexts, including vascular, colorectal, and gastrointestinal surgeries. These studies consistently report good predictive accuracy for mortality with O:E ratios close to 1, reinforcing the system's reliability. However, like our findings, these studies also point out that morbidity predictions can be

less accurate, suggesting the need for continuous refinement and validation in diverse clinical settings.

The comparison of the P-POSSUM system's validity across multiple studies, including our own, indicates that it is a robust tool for predicting mortality in surgical patients. Continuous validation and refinement in various clinical settings are essential to enhance the system's overall predictive accuracy.

Conclusion

The P-POSSUM scoring system proves to be a robust and reliable tool for predicting postoperative mortality in patients undergoing laparotomy. Our study found it to have excellent predictive accuracy for mortality, with high sensitivity and specificity. However, consistent with findings from other studies, the P-POSSUM system over predicts morbidity to some extent.

The Insights gathered emphasize the critical importance of comprehensive preoperative evaluations and tailored perioperative management strategies to mitigate risks and enhance patient outcomes. Factors such as age, cardiovascular and respiratory status, blood pressure, pulse rate, haemoglobin levels, white blood cell count, blood urea, electrolyte levels, ECG findings, physiological and operative scores, number of procedures, total blood loss, peritoneal soiling, presence of malignancy, and mode of surgery all significantly influence patient prognosis.

Overall, the study underscores the utility of the P-POSSUM system in surgical risk assessment and the need for ongoing research and refinement to maintain its efficacy in diverse clinical environments.

References

1. Copeland GP, Jones D, Walters MP. POSSUM: a scoring system for surgical audit. British Journal of Surgery. 1991 Mar;78(3):355-60.
2. Yii MK, Ng KJ. Risk-adjusted surgical audit with the POSSUM scoring system in a developing country. British Journal of surgery. 2002 Jan;89(1):110-3.
3. Copeland GP. Assessing the surgeon: 10 years' experience with the POSSUM system. Journal of Clinical Excellence. 2000;2(3):187-90.
4. Whiteley MS, Prytherch DR, Higgins B, Weaver PC, Prout WG. An evaluation of the POSSUM surgical scoring system. Journal of British Surgery. 1996 Jun;83(6):812-5.
5. Sagar PM, Hartley MN, Mancey-Jones B, Sedman PC, May J, Macfie J. Comparative audit of colorectal resection with the POSSUM scoring system. British journal of surgery. 1994 Oct;81(10):1492-4.
6. Saklad M. Grading of patients for surgical procedures. Anaesthesia. 1992; 2:281-4.
7. Hartley MN, Sagar PM. The surgeon's' gut feeling 'as a predictor of post-operative outcome. Annals of the Royal College of Surgeons of England. 1994 Nov 1;76(6 Suppl):277-8.
8. Markus PM, Martell J, Leister I, Horstmann O, Brinker J, Becker H. Predicting postoperative morbidity by clinical assessment. Journal of British Surgery. 2005 Jan;92(1):101-6.
9. Goldhill DR. Preventing surgical deaths: critical care and intensive care outreach services in the postoperative period. British journal of anaesthesia. 2005 Jul 1;95(1):88-94.

10. Owens WD, Felts JA, Spitznagel Jr EL. ASA physical status classifications: a study of consistency of ratings. Anaesthesiology. 1978 Oct 1;49(4):239-43.
11. Wolters U, Wolf T, Stützer H, Schröder T. ASA classification and perioperative variables as predictors of postoperative outcome. British journal of anaesthesia. 1996 Aug 1;77(2):217-22.
12. Sutton R, Bann S, Brooks M, Sarin S. The Surgical Risk Scale as an improved tool for risk-adjusted analysis in comparative surgical audit. Journal of British Surgery. 2002 Jun;89(6):763-8.
13. Neary WD, Prytherch D, Foy C, Heather BP, Earnshaw JJ. Comparison of different methods of risk stratification in urgent and emergency surgery. Journal of British Surgery. 2007 Oct;94(10):1300-5.
14. Brooks MJ, Sutton R, Sarin S. Comparison of Surgical Risk Score, POSSUM, and p-POSSUM in higher-risk surgical patients. Journal of British Surgery. 2005 Oct;92(10):1288-92.
15. Goldman L, Caldera DL, Nussbaum SR, Southwick FS, Krogstad D, Murray B, Burke DS, O'malley TA, Goroll AH, Caplan CH, Nolan J. Multifactorial index of cardiac risk in noncardiac surgical procedures. New England Journal of Medicine. 1977 Oct 20;297(16):845-50.
16. Detsky AS, Abrams HB, McLaughlin JR, Drucker DJ, Sasson Z, Johnston N, Scott JG, Forbath N, Hilliard JR. Predicting cardiac complications in patients undergoing non-cardiac surgery. Journal of general internal medicine. 1986 Jul 1;1(4):211-9.
17. Lee TH, Marcantonio ER, Mangione CM, Thomas EJ, Polanczyk CA, Cook EF, Sugarbaker DJ, Donaldson MC, Poss R, Ho KK, Ludwig LE. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation. 1999 Sep 7;100(10):1043-9.
18. Halm EA, Browner WS, Tubau JF, Tateo IM, Mangano DT. Echocardiography for assessing cardiac risk in patients having noncardiac surgery. Study of Perioperative Ischemia Research Group. Ann Intern Med. 1996;125(6):433–441.
19. Rohde LE, Polanczyk CA, Goldman L, Cook EF, Lee RT, Lee TH. Usefulness of transthoracic echocardiography as a tool for risk stratification of patients undergoing major noncardiac surgery. Am J Cardiol. 2001;87(5):505–509.
20. Prause G, Ratzenhofer-Comenda B, Pierer G, Smolle-Juttner F, Glanzer H, Smolle J. Can ASA grade or Goldman's cardiac risk index predict peri-operative mortality? A study of 16,227 patients. Anaesthesia. 1997;52(3):203–206.
21. Knaus WA, Zimmerman JE, Wagner DP, Draper EA, Lawrence DE. APACHE-acute physiology and chronic health evaluation: a physiologically based classification system. Crit Care Med. 1981;9(8):591–7.
22. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med. 1985;13 (10):818–829.
23. Goffi L, Saba V, Ghiselli R, Necozione S, Mattei A, Carle F. Preoperative APACHE II, and ASA scores in patients having major general surgical operations: prognostic value and potential clinical applications. Eur J Surg. 1999;165(8):730–735.
24. Barie PS, Hydo LJ, Fischer E. Utility of illness severity scoring for prediction of prolonged surgical critical care. J Trauma. 1996;40(4):513–518.

25. Beck DH, Taylor BL, Millar B, Smith GB. Prediction of outcome from intensive care: a prospective cohort study comparing Acute Physiology and Chronic Health Evaluation II and III prognostic systems in a United Kingdom intensive care unit. Crit Care Med. 1997;25(1):9–15.
26. Zimmerman JE, Kramer AA, McNair DS, Malila FM. Acute Physiology and Chronic Health Evaluation (APACHE) IV: hospital mortality assessment for today's critically ill patients. Crit Care Med. 2006;34(5):1297–1310.
27. Zimmerman JE, Kramer AA, McNair DS, Malila FM, Shaffer VL. Intensive care unit length of stay: Benchmarking based on Acute Physiology and Chronic Health Evaluation (APACHE) IV. Crit Care Med. 2006;34(10):2517–2529.
28. Harrison DA, Parry GJ, Carpenter JR, Short A, Rowan K. A new risk prediction model for critical care: the Intensive Care National Audit & Research Centre (ICNARC) model. Crit Care Med. 2007;35 (4):1091–1098.
29. Le Gall JR, Lemeshow S, Saulnier F. A new Simplified Acute Physiology Score (SAPS II) based on a European/North American multicenter study. JAMA. 1993;270(24):2957–2963.
30. Capuzzo M, Valpondi V, Sgarbi A, Bortolazzi S, Pavoni V, Gilli G, et al. Validation of severity scoring systems SAPS II and APACHE II in a single-center population. Intensive Care Med. 2000;26(12):1779–1785.
31. Metnitz PG, Valentin A, Vesely H, Alberti C, Lang T, Lenz K, et al. Hiesmayr M. Prognostic performance and customization of the SAPS II: results of a multicenter Austrian study. Simplified Acute Physiology Score. Intensive Care Med. 1999;25(2):192–197.
32. Le Gall JR, Neumann A, Hemery F, Bleriot JP, Fulgencio JP, Garrigues B, et al. Mortality prediction using SAPS II: an update for French intensive care units. Crit Care. 2005;9(6):R645–R652.
33. Moreno RP, Metnitz PG, Almeida E, Jordan B, Bauer P, Campos RA, et al. SAPS 3–From evaluation of the patient to evaluation of the intensive care unit. Part 2: Development of a prognostic model for hospital mortality at ICU admission. Intensive Care Med. 2005;31(10):1345–1355.
34. Cuthbertson BH, Boroujerdi M, McKie L, Aucott L, Prescott G. Can physiological variables and early warning scoring systems allow early recognition of the deteriorating surgical patient? Crit Care Med. 2007;35(2):402 – 409.
35. Subbe CP, Kruger M, Rutherford P, Gemmel L. Validation of a modified Early Warning Score in medical admissions. QJM. 2001;94(10):521–526.
36. Goldhill DR. The critically ill: following your MEWS. QJM. 2001;94(10):507–510.
37. Teres D, Lemeshow S, Avrunin JS, Pastides H. Validation of the mortality prediction model for ICU patients. Crit Care Med. 1987;15(3):208–213.
38. Shann F. Mortality prediction model is preferable to APACHE. BMJ. 2000;320(7236):714.
39. Higgins TL, Teres D, Copes WS, Nathanson BH, Stark M, Kramer AA. Assessing contemporary intensive care unit outcome: an updated Mortality Probability Admission Model (MPM0-III). Crit Care Med. 2007;35(3):827–835.

40. Haga Y, Wada Y, Takeuchi H, Kimura O, Furuya T, Sameshima H, et al. Estimation of physiologic ability and surgical stress (E PASS) for a surgical audit in elective digestive surgery. Surgery. 2004;135(6):586–594.
41. Oka Y, Nishijima J, Oku K, Azuma T, Inada K, Miyazaki S, et al. Usefulness of an estimation of physiologic ability and surgical stress (E-PASS) scoring system to predict the incidence of post-operative complications in gastrointestinal surgery. World J Surg. 2005;29(8):1029–1033.
42. Khuri SF, Daley J, Henderson W, Hur K, Gibbs JO, Barbour G, et al. Risk adjustment of the post-operative mortality rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. J Am Coll Surg. 1997;185(4):315–327.
43. Aust JB, Henderson W, Khuri S, Page CP. The impact of operative complexity on patient risk factors. Ann Surg. 2005;241(6):1024– 1027.
44. Hadjianastassiou VG, Tekkis PP, Poloniecki JD, Gavalas MC, Goldhill DR. Surgical mortality score: risk management tool for auditing surgical performance. World J Surg 2004; 28:193–200.
45. Protopapa KL, Simpson JC, Smith NC, Moonesinghe SR. Development, and validation of the Surgical Outcome Risk Tool (SORT). Br J Surg 2014; 101:1774–83.
46. Sutton R, Bann S, Brooks M, Sarin S. The Surgical Risk Scale as an improved tool for risk-adjusted analysis in comparative surgical audit. Br J Surg 2002; 89:763–8.
47. Donati A, Ruzzi M, Adrario E, Pelaia P, Coluzzi F, Gabbanelli V, Pietropaoli P. A new and feasible model for predicting operative risk. Br J Anaesth 2004; 93:393–9.
48. Copeland GP, Jones D, Walters M. POSSUM: a scoring system for surgical audit. Br J Surg. 1991;78(3):355–360.
49. Copeland GP. The POSSUM system of surgical audit. Arch Surg. 2002;137(1):15–19.
50. Lagarde SM, Maris AK, de Castro SM, Busch OR, Obertop H, van Lanschot JJ. Evaluation of O-POSSUM in predicting in hospital mortality after resection for oesophageal cancer. Br J Surg. 2007;94(12):1521–1526.
51. Tekkis PP, McCulloch P, Poloniecki JD, Prytherch DR, Kessaris N, Steger AC. Risk-adjusted prediction of operative mortality in oesophagogastric surgery with O-POSSUM. Br J Surg. 2004;91 (3):288–895.
52. Senagore AJ, Warmuth AJ, Delaney CP, Tekkis PP, Fazio VW. POSSUM, p-POSSUM, and Cr-POSSUM: implementation issues in a United States health care system for prediction of outcome for colon cancer resection. Dis Colon Rectum. 2004;47(9):1435– 1441.
53. Vather R, Zargar-Shoshtari K, Adegbola S, Hill AG. Comparison of the possum, P-POSSUM and Cr-POSSUM scoring systems as predictors of post-operative mortality in patients undergoing major colorectal surgery. ANZ J Surg. 2006;76(9):812–816.
54. Whiteley MS, Prytherch DR, Higgins B, Weaver PC, Prout WG. An evaluation of the POSSUM surgical scoring system. Br J Surg. 1996;83(6):812–815.
55. Shekar N, Debata PK, Debata I, Nair P, Rao LS, Shekar P, RAO LS. Use of POSSUM (Physiologic and Operative Severity Score for the Study of

Mortality and Morbidity) and Portsmouth-POSSUM for Surgical Assessment in Patients Undergoing Emergency Abdominal Surgeries. Cureus. 2023 Jun 23;15(6).

56. Anuar AH, Hashim MN, Zakaria Z, Wan Zain WZ, Syed Abdul Aziz SH, Hashim Isa Merican SR, Ramely R, Wan Mokhter WM, Mohamad IS, Hayati F, Sahid Nik Lah NA. The Value of POSSUM & P-POSSUM as Surgical Audit Tool Predicting Morbidity and Mortality in Emergency Laparotomy. Gazi Medical Journal. 2023 Jan 1;34(1).
57. Jones H, Gendre A, McHugh A, Hintze J, O'Sullivan B, Martin F, McConn-Walsh R, O'Neill JP, Shine N. Use of the Portsmouth Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity ('P-POSSUM') to predict morbidity in patients undergoing surgery with reconstruction for temporal bone malignancy. The Journal of Laryngology & Otology. 2022 Dec;136(12):1271-4.
58. Maitra S, Sankar S, Chowdhury A, Mandal M. Efficacy of the P-POSSUM scoring system in prediction of post-operative mortality and morbidity in patients undergoing emergency exploratory laparotomy in a tertiary institute in East India. Asian Journal of Medical Sciences. 2022 Apr 1;13(4).
59. Roy VK, Roy SS, Kumar M, Sinha S, Gopa K. Comparative analysis of P-POSSUM score at admission and pre-operatively in predicting postoperative mortality in patients undergoing emergency laparotomy. The Southeast Asian Journal of Case Report and Review. 2022;9(2):30-34.
60. Kumar L, Singh S, Pratap D, Singh KK, Nayak S, Kumar S, Tripathi U. Comparison of predictive values of Mannheim peritonitis index, acute physiology and chronic health evaluation-II and Portsmouth-POSSUM scoring systems for prognosis of mortality in patients with perforation peritonitis. International Journal of Research in Medical Sciences. 2022 May;10(5):1059.
61. Garg N, Bandi A. Evaluation of predictive value of P-POSSUM score in patients operated for acute abdomen and comparison of scoring at admission and pre-operatively. Indian Journal of Surgery. 2021 Feb;83(1):188-93.
62. Karan N, Siddiqui S, Sharma KS, Pantvaidya GH, Divatia JV, Kulkarni AP. Evaluation and validation of Physiological and Operative Severity Score for the enumeration of mortality and morbidity and Portsmouth-POSSUM scores in predicting morbidity and mortality in patients undergoing head and neck cancer surgeries. Head & Neck. 2020 Oct;42(10):2968-74.
63. Hu ZW, Xin RQ, Xia YJ, Jia GP, Chen XX, Wang S. Application of POSSUM and P-POSSUM in surgical risk assessment of elderly patients undergoing hepatobiliary and pancreatic surgery. Clinical Interventions in Aging. 2020 Jul 12:1121-8.
64. Paul VA, Anusha A, Chandra AS. Evaluation of the validity of POSSUM and P-POSSUM score in predicting the risk of morbidity and mortality respectively in patients undergoing emergency laparotomy. International Surgery Journal. 2020 Sep 23;7(10):3224-9.
65. Cao Y, Bass GA, Ahl R, Pourlotfi A, Geijer H, Montgomery S, Mohseni S. The statistical importance of P-POSSUM scores for predicting mortality after emergency laparotomy in geriatric patients. BMC Medical Informatics and Decision Making. 2020 Dec; 20:1-1.

66. Anbarasu K, Chandak R. Efficacy of the P-POSSUM scoring system as a prognostic indicator in patients undergoing emergency laparotomy. International Surgery Journal. 2019 Sep 26;6(10):3600-7.
67. Echara ML, Singh A, Sharma G. Risk-Adjusted Analysis of Patients Undergoing Emergency Laparotomy Using POSSUM and P-POSSUM Score: A Prospective Study. Nigerian Journal of Surgery. 2019;25(1):45-51.
68. Thirunavukkarasu S, Subramanian AM. Efficacy of the P-POSSUM scoring system in prediction of post-operative mortality and morbidity in patients undergoing emergency laparotomy in a tertiary institute. International Surgery Journal. 2018 Jun 25;5(7):2523-7.
69. Jha MK, Sibakoti YC, Devkota H. Evaluation of P-POSSUM Scoring System in Patients Undergoing Emergency Laparotomy. Medical Journal of Shree Birendra Hospital. 2017 Dec 23;16(2):28-36.
70. Tyagi A, Nagpal N, Sidhu DS, Singh A, Tyagi A. Portsmouth physiological and operative severity score for the Enumeration of Mortality and morbidity scoring system in general surgical practice and identifying risk factors for poor outcome. Journal of natural science, biology, and medicine. 2017 Jan;8(1):22.
71. Mathai A, Bhagavan KR, Shishira R. Portsmouth Possum Scoring in General Surgery, identifying Risk Factors for low outcome And Predicting Post Operative Mortality. IOSR Journal of Dental and Medical Sciences. 2017;16(2):33-40.
72. Pinho D, Pinho S, Carvalho M, Soares M, Cavaleiro C. POSSUM and P-POSSUM: Predictors of Morbidity and Mortality in Laparoscopic Roux-En-Y Gastric Bypass. J Anesth Clin Res. 2017;8(700):2.
73. Hota PK, Yellapragada H. Assessment of surgical outcome in emergency gastrointestinal surgeries using PPOSSUM score. Int J Res Med Sci. 2017 Jul;5(7):3007-11.
74. Jain AK, Sharma D. A prospective study of risk stratification in patients undergoing emergency laparotomy with POSSUM and P-POSSUM. International Surgery Journal. 2016 Dec 13;3(1):207-10.