Original Article

Bull Emerg Trauma 2019;7(3):223-231.

Bulletin of Emergency And Trauma

Prognostic Value of P-POSSUM and Osteopenia for Predicting Mortality After Emergency Laparotomy in Geriatric Patients

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Received: February 4, 2019
Revised: May 13, 2019
Accepted: May 16, 2019

ABSTRACT

Objective: To evaluate the Portsmouth-Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity (P-POSSUM) in comparison with other risk factors for mortality including osteopenia as an indicator for frailty in geriatric patients subjected to emergency laparotomy.
Methods: All geriatric patients (≥65 years) undergoing emergency laparotomy at a single university hospital between 1/2015 and 12/2016 were included in this cohort study. Demographics and outcomes were retrospectively collected from medical records. Association between prognostic markers and 30-day mortality was assessed using Poisson and backward stepwise regression models. Prognostic value was assessed using receiver operating characteristic (ROC) curves.
Results: 209 patients were included with a mean age of 76 ± 7.3 years. American Society of Anesthesiologists (ASA) classification, age, indication and type of surgery, hypotension, transfusion requirement and current malignancy proved to be statistically significant predictors of 30-day mortality. P-POSSUM mortality was statistically significant in the backward stepwise regression (incidence rate ratio=1.58, 95% CI: 1.16–2.15, p=0.004) while osteopenia was not. P-POSSUM had poor prognostic value for 30-day mortality with an area under the ROC curve (AUC) of 0.59. The prognostic value of P-POSSUM improved significantly when adjusting for patient covariates (AUC=0.83).
Conclusion: P-POSSUM and osteopenia alone hardly predict 30-day mortality in geriatric patients following emergency laparotomy. P-POSSUM adjusted for other patient covariates improves the prediction.

Keywords: Emergency surgery; Emergency Laparotomy; Geriatric; Mortality.

Please cite this paper as:
Ah R, BChir MB, Cao Y, Geijer H, Taha K, Pourhossein-Sarmeh S, Talving P, Ljungqvist O, Mohseni S. Prognostic Value of P-POSSUM and Osteopenia for Predicting Mortality After Emergency Laparotomy in Geriatric Patients. *Bull Emerg Trauma*. 2019;7(3):223-231. doi: http://dx.doi.org/10.29252/beat-070303.

Introduction

The global population is evolving with a progressively increasing life expectancy. The geriatric population is the fastest growing subgroup in most developed countries. In 2017, the average life expectancy in Sweden was 84 and 81 years for women and men, respectively [1]. The aging population challenges healthcare services. Increasing age increases the risk of post-operative complications and mortality following surgery [2]. The risk of death after surgery has been shown to increase in the presence of a post-operative complication, which is more significant than a high pre-operative risk profile [3, 4]. In addition, after traumatic insults, geriatric patients have a higher mortality risk for a longer period of time [5shock, multiple organ failure, and severe head injury. Mortality in this series increased beginning at age 56 years, and that increase was independent of the ISS. The mortality rate increased from 7.3% (patients 46--55 years of age, 6preexisting disease, and complications as well as injury severity. METHODS: Records from 5,139 adult patients from a Level I trauma center were retrospectively reviewed. Injury Severity Score (ISS]. Patients over the age of seventy have demonstrated a mortality rate of over 20% following emergency laparotomy [7]. The causality profile for such observations is complex but is likely due to factors including comorbidity burden, weakened physiological reserves and general frailty.

In contemporary healthcare systems, geriatric patients frequently undergo emergency general surgery. It is therefore highly relevant to validate robust outcome predictors of this patient group in order to avoid futile care measures. In this vulnerable group of patients, abdominal surgery may result in complications and extended intensive care stays. It is therefore vital to be able to provide pre-operative predictors of survival in order to facilitate valid medical decisions. Historically, this process has used age as a marker of general physical strength and thereby likelihood of survival. Nevertheless, age suffers many limitations as a major predictor of outcome following surgery [2]. In recent years, several scoring instruments have been developed to predict mortality of the surgical patient including POSSUM (Physiological and Operative Severity Score for the enumeration of Mortality and morbidity) [8a Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity, is described. This system has been devised from both a retrospective and prospective analysis and the present paper attempts to validate it prospectively. Logistic regression analysis yielded statistically significant equations for both mortality and morbidity (P < 0.001] which was modified, improved and renamed P-POSSUM (Portsmouth - POSSUM) [9”author”:[{“dropping-particle”:””,”family”:”Prytherch”,”given”:”D R”,”non-dropping-particle”:””,”parse-names”:false,”suffix”:””},{“dropping-particle”:””,”family”:”Whiteley”,”given”:”M S”,”non-dropping-particle”:””,”parse-names”:false,”suffix”:””},{“dropping-particle”:””,”family”:”Higgins”,”given”:”B”,”non-dropping-particle”:””,”parse-names”:false,”suffix”:””},{“dropping-particle”:””,”family”:”Weaver”,”given”:”P C”,”non-dropping-particle”:””,”parse-names”:false,”suffix”:””},{“dropping-particle”:””,”family”:”Prout”,”given”:”W G”,”non-dropping-particle”:””,”parse-names”:false,”suffix”:””},{“dropping-particle”:””,”family”:”Powell”,”given”:”S J”,”non-dropping-particle”:””,”parse-names”:false,”suffix”:””}],”container-title”:”The British journal of surgery”,”id”:”ITEM-1”,”issue”:”9”,”issued”:{“date-parts”:[[“1998”,”9”]]},”language”:”eng”,”page”:”1217-1220”,”publisher-place”:”England”,”title”:”POSSUM and Portsmouth POSSUM for predicting mortality. Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity.”,”type”:”article-journal”,”volume”:”85”},”uris”:[“http://www.mendeley.com/documents/?uuid=122697b8-c8b1-4703-a32e-8127fb095f54”]}],”mendeley”:{“formattedCitation”:”⁹”,”plainTextFormattedCitation”:”9”,”previouslyFormattedCitation”:”⁹”},”properties”:{“noteIndex”:0},”schema”:”https://github.com/citation-style-language/schema/raw/master/csl-citation.json”}], ASA (American Society of Anaesthesiology) [10], APACHE (Acute Physiology and Chronic Health Evaluation) [11the authors describe the development and initial validation of acute physiology and chronic health evaluation (APACHE], and physical frailty as measured through osteopenia and sarcopenia [12, 13Setting, and Participants: A retrospective cohort constructed from a state trauma registry was linked to the statewide death registry and Comprehensive Hospital Abstract Reporting System for readmission data analyses. Admission abdominopelvic CT scans from patients 65 years and older admitted to the intensive care unit of a single level I trauma center between January 2011 and May 2014 were analyzed to identify patients with sarcopenia and/or osteopenia. Patients with a head Injury Severity Score of 3 or greater, an out-of-state address, or inadequate CT imaging or who died within 24 hours of admission were excluded. Exposures: Sarcopenia and/or osteopenia, assessed via total cross-sectional muscle area and bone density at the L3 vertebral level, compared with a group with no sarcopenia or osteopenia. Main Outcomes and Measures: One-year all-cause mortality. Secondary outcomes included 30-day all-cause mortality, 30-day readmission, hospital length of stay, hospital cost, and discharge disposition. Results: Of the 450 patients included in the study, 269 (59.8%]. Previous studies have demonstrated both strengths and weaknesses in these instruments, however, as of yet there is no consensus as to which one is more reliable in the geriatric population or how the instruments compare to each other in mortality predictive ability. This study aims to assess the performance of P-POSSUM and predictors of frailty in calculating 30-day mortality for geriatric patients undergoing emergency laparotomy. The study hypothesis was a significant correlation between P-POSSUM and osteopenia with poor outcomes.

Materials and Methods

Patient Inclusion

Ethical approval for this study was obtained from the institutional review board of Uppsala County (Ref. 2017/421). All geriatric patients (65 years of age and older) undergoing emergency laparotomy were identified between January 1st, 2015 and December 31st, 2016 from the surgical registry of Orebro University Hospital in Orebro, Sweden. Hospital electronic medical records were used to obtain information about age, sex, body mass index (BMI), diagnosis according to the International Statistical Classification of Diseases (ICD) 10th version, blood tests and vital signs on admission, transfusion requirements, Charlson Comorbidity Index (CCI) score, American Society of Anaesthesiologists (ASA) classification, post-operative complications, hospital length of stay (LOS), and 30-day mortality. Primary outcome of interest was to assess the predictive ability of P-POSSUM, osteopenia, and sarcopenia.

Radiology

Osteopenia and sarcopenia were assessed by a consultant radiologist using the most recent (but never older than 30 days prior to the date of surgery) computed tomography (CT) for measurements of bone density and muscle area. If both a low-dose and a normal-dose radiation CT were performed within 30 days before surgery, the normal-dose CT was chosen. Most studies were performed with intravenous contrast media. Sarcopenia was measured as total skeletal muscle area in a transaxial CT slice, 3 or 5 mm thick, at the L3 vertebral level. The computer programme ImageJ was used for segmentation of all tissue with an attenuation between -29 and 150 Hounsfield Units (HU). When the segmentation erroneously included other tissue such as bowel or subcutaneous oedema, this was edited manually with the CT image as reference. For sarcopenia, skeletal muscle index thresholds of 52.4 cm^2/m^2 for men and 38.5 cm^2/m^2 for women were used [14]. Body surface area was calculated from weight and height according to the Du Bois formula [15]; body surface area (m^2) = $0.007184 \times W^{0.425} \times H^{0.725}$. In the same CT slice, the bone density was measured as the average HU in a 1.5-2 cm^2 region of interest in the trabecular part of the L3 vertebra. Osteopenia was defined as HU <100[12]Setting, and Participants: A retrospective cohort constructed from a state trauma registry was linked to the statewide death registry and Comprehensive Hospital Abstract Reporting System for readmission data analyses. Admission abdominopelvic CT scans from patients 65 years and older admitted to the intensive care unit of a single level I trauma center between January 2011 and May 2014 were analyzed to identify patients with sarcopenia and/or osteopenia. Patients with a head Injury Severity Score of 3 or greater, an out-of-state address, or inadequate CT imaging or who died within 24 hours of admission were excluded. Exposures: Sarcopenia and/or osteopenia, assessed via total cross-sectional muscle area and bone density at the L3 vertebral level, compared with a group with no sarcopenia or osteopenia. Main Outcomes and Measures: One-year all-cause mortality. Secondary outcomes included 30-day all-cause mortality, 30-day readmission, hospital length of stay, hospital cost, and discharge disposition. Results: Of the 450 patients included in the study, 269 (59.8%.

Statistical Methods

Patients demographics and clinical outcomes were analysed using descriptive statistical methods. Continuous data are summarized as mean (standard deviation, SD) or median [interquartile range, IQR], wherever suitable, and categorical and ordinal data are presented as percentages. Differences between groups were tested using Student's t-test or Mann-Whitney U test for continuous or ordinal data, wherever suitable, and using χ^2 test or Fisher's exact test for categorical data. A log transformation was carried out for the following variables: C-reactive protein (CRP), creatinine, and P-POSSUM for mortality and morbidity.

Associations between 30-day mortality and patient covariates were evaluated using Poisson regression model with robust standard errors. Potential confounding was adjusted for by including the following covariates in the model: gender, age, known cardiac or pulmonary conditions, the presence of a cancer diagnosis, Charlson comorbidity index (CCI), BMI, heart rate, systolic blood pressure, haemoglobin levels, log transformed CRP (logCRP) and creatinine (logCreatinine), number of procedures, requirement for packed red blood cell (PRB) transfusion, indication for surgery and surgical procedure, physiology score, operative severity score, log transformed morbidity and mortality P-POSSUM (logMorbidity P-POSSUM and logMortality P-POSSUM), osteopenia, ASA classification, surgery indication and procedure. Only a handful of patients from the complete data set met the criteria for sarcopenia. Therefore, this variable and its potential role as a possible predictor of mortality was excluded from the analyses. Variable selection was also conducted using a backward stepwise method with significance level of 0.10 for removal from the regression model and significance level of 0.05 for addition to the regression model. For categorical or ordinal variables presented as dummy variables in the stepwise regression analysis, the original variable would be kept in the final model if any of the derived dummy variables were found to be statistically significant.

In Poisson regression analysis, missing data were multiply imputed by using the iterative Markov chain Monte Carlo method. Five imputed data sets were generated. The estimates from the five data sets were combined according to Rubin's rules [16]. A two-sided p value of less than 0.05 was considered statistically significant. The prognostic value of P-POSSUM and osteopenia were evaluated using sensitivity, specificity and area under receiver operating characteristic (ROC) curve. Youden's J statistic was used to find optimum cut-off point on ROC curve. Difference between the areas under ROC curves (AUCs) was tested using χ^2 test. All analyses were conducted in the statistical software packages R 3.5.0 (R Core Team, R Foundation for Statistical Computing, Vienna, Austria) and Stata 15.1 (StataCorp, College Station, TX, USA).

Results

In total 209 patients with a mean age of 75.6 (7.3) years were included in the study. There was an equal split between men and women. The average CCI score was 5.77 (2.36) and the most common ASA class was 3 (53.3%). The most common indication for surgery was bowel obstruction which occurred in 119 (56.9%) patients and the most common surgical procedure during laparotomy was bowel resection occurring in 82 patients (39.2%). Post-operative complications ranged between 5.3%-36.1% with infection being the most common type of complication (Table 1). Median [IQR] length of hospital stay was 12 (7, 21) days and the 30-day mortality rate was 31.1% (Table 1). When comparing patients who died within 30 days of surgery to those who survived beyond this point, there were some significant differences. Patients who died within 30 days were on average slightly older (78.66 vs. 74.19 years, p<0.001), had a higher average CCI (6.63 vs. 5.38, p<0.001), higher frequency of ASA class ≥ 4 (30.4% vs. 10.1%, p<0.001), higher average creatinine levels on admission (108.50 vs. 78.00 µmol/L, p=0.003), higher PRB transfusion requirements (58.5% vs. 32.6%, p=0.001) and higher proportion of osteopenia (59.0% vs. 41.0%, p=0.029).

Univariable analysis identified the following factors to be significantly associated with 30-day mortality: age, CCI, systolic blood pressure, logCRP, logCreatinine, blood transfusion, osteopenia, and the surgical indication being ischaemia (Table 2). Furthermore, multivariable analysis with backward stepwise selection identified the following variables as significantly associated with 30-day mortality: age (IRR=1.05, 95% CI: 1.02, 1.08), logMortality P-POSSUM (IRR=1.58, 95% CI: 1.16, 2.15), ischaemia as the indication for surgery (IRR=1.94, 95% CI 1.05, 3.57), PRB transfusion (IRR=1.66, 95% CI: 1.13, 2.42), and cancer (IRR=1.57, 95% CI: 1.01, 2.44) (Table 3).

Variables demonstrating significant associations with mortality were entered into prognostic value assessment. Mortality P-POSSUM, morbidity P-POSSUM and osteopenia on their own (models 3, 4, 5 in Figure 1 and Table 4), all demonstrated poor prognostic value for 30-day mortality with area under ROC curve (AUC) of 0.49, 0.47, and 0.59 respectively (Table 4, Figure 1). Additionally, the prognostic tests either demonstrated poor sensitivity (mortality P-POSSUM and morbidity P-POSSUM) or both poor sensitivity and specificity (osteopenia). When adjusted for other statistically significant covariates, the models with mortality P-POSSUM, morbidity P-POSSUM or both showed much improved prognostic value with AUC>0.80 and both sensitivity and specificity >75% (Table 4, Figure 1). Further, there was a statistically significant improvement in the performance of multivariable Poisson regression models including important covariates compared to mortality P-POSSUM, morbidity P-POSSUM, or osteopenia alone (χ^2=77.00, p<0.001) (Table 4).

Discussion

The ability to reliably predict a patient's survival is of great relevance in the emergency surgical setting to facilitate appropriate care. Several previous studies have found that prognostic factors such as general frailty and the development of severe post-

Table 1. Demographics and clinical outcome split into total cohort, patients who survived beyond 30 days of surgery and patients who died <30 days of surgery

		All patients (n=209)	Alive after 30 days (n=144)	Dead in 30 days (n=65)	*p*
Sex, n (%)	Female	104 (49.8)	71 (49.3)	33 (50.8)	0.963
	Male	105 (50.2)	73 (50.7)	32 (49.2)	
Age, mean (SD)		75.58 (7.29)	74.19 (6.88)	78.66 (7.27)	<0.001
Cardiac condition, n (%)	No	83 (39.7)	59 (41.0)	24 (36.9)	0.688
	Yes	126 (60.3)	85 (59.0)	41 (63.1)	
Pulmonary condition, n (%)	No	136 (65.1)	97 (67.4)	39 (60.0)	0.381
	Yes	73 (34.9)	47 (32.6)	26 (40.0)	
Charlson comorbidity index, mean (SD)		5.77 (2.36)	5.38 (2.25)	6.63 (2.39)	<0.001
ASA[a] class, n (%)					

1		4 (2.0)	3 (2.2)	1 (1.6)	<0.001
2		54 (27.1)	47 (34.1)	7 (11.5)	
3		106 (53.3)	74 (53.6)	32 (52.5)	
4		32 (16.1)	14 (10.1)	18 (29.5)	
5		3 (1.5)	0 (0.0)	3 (4.9)	
BMI[b], mean (SD)		24.93 (4.76)	25.05 (5.11)	24.66 (3.81)	0.616
Heart rate, mean (SD)		85.75 (18.37)	85.82 (18.14)	85.60 (19.00)	0.937
Systolic blood pressure, mean (SD)		129.96 (23.16)	133.11 (22.48)	122.98 (23.29)	0.003
GCS[c], mean (SD)		14.96 (0.39)	14.94 (0.47)	15.00 (0.00)	0.344
Haemoglobin, mean (SD)		124.04 (23.66)	125.52 (22.51)	120.83 (25.89)	0.186
CRP[d], median [IQR]		63.00 [17.50, 178.00]	58.00 [12.50, 186.50]	92.00 [45.00, 172.50]	0.140
Creatinine, median [IQR])		85.00 [68.00, 125.00]	78.00 [65.00, 112.50]	108.50 [71.50, 142.75]	0.003
Surgery indication, n (%)					0.116
Ileus/obstruction		119 (56.9)	86 (59.7)	33 (50.8)	
Perforation		45 (21.5)	30 (20.8)	15 (23.1)	
Ischaemia		19 (9.1)	9 (6.2)	10 (15.4)	
Infection		5 (2.4)	5 (3.5)	0 (0.0)	
Bleeding		8 (3.8)	4 (2.8)	4 (6.2)	
Other		13 (6.2)	10 (6.9)	3 (4.6)	
Number of procedures, n (%)					0.456
1		141 (67.8)	100 (69.9)	41 (63.1)	
2		47 (22.6)	28 (19.6)	19 (29.2)	
3		13 (6.2)	10 (7.0)	3 (4.6)	
4		5 (2.4)	3 (2.1)	2 (3.1)	
5		2 (1.0)	2 (1.4)	0 (0.0)	
Surgical procedure, n (%)					0.351
Resection		82 (39.2)	51 (35.4)	31 (47.7)	
Adhesiolysis		38 (18.2)	31 (21.5)	7 (10.8)	
Stoma formation		46 (22.0)	30 (20.8)	16 (24.6)	
Other		25 (12.0)	19 (13.2)	6 (9.2)	
Bowel repair		14 (6.7)	10 (6.9)	4 (6.2)	
Vascular		4 (1.9)	3 (2.1)	1 (1.5)	
Cancer, n (%)	No	111 (53.1)	81 (56.2)	30 (46.2)	0.229
	Yes	98 (46.9)	63 (43.8)	35 (53.8)	
Transfusion, n (%)	No	124 (59.3)	97 (67.4)	27 (41.5)	0.001
	Yes	85 (40.7)	47 (32.6)	38 (58.5)	
Physiology Score, mean (SD)		23.65 (6.64)	23.68 (6.07)	23.58 (7.80)	0.925
Operative Severity Score, mean (SD)		14.73 (2.91)	14.80 (2.81)	14.57 (3.12)	0.590
Morbidity P-POSSUM, median [IQR]		66.60 [48.00, 84.23]	67.90 [50.70, 83.60]	66.60 [43.30, 85.90]	0.529
Mortality P-POSSUM, median [IQR]		6.55 [2.80, 15.55]	6.50 [2.90, 14.05]	6.60 [2.50, 17.90]	0.741
Osteopenia, n (%)	No	104 (53.3)	79 (59.0)	25 (41.0)	0.029
	Yes	91 (46.7)	55 (41.0)	36 (59.0)	
Post-operative infection, n (%)	No	133 (63.9)	91 (63.2)	42 (65.6)	0.857
	Yes	75 (36.1)	53 (36.8)	22 (34.4)	
Post-operative heart failure, n (%)	No	198 (94.7)	137 (95.1)	61 (93.8)	0.958
	Yes	11 (5.3)	7 (4.9)	4 (6.2)	
Post-operative MI[e], n (%)	No	197 (94.3)	136 (94.4)	61 (93.8)	1.000
	Yes	12 (5.7)	8 (5.6)	4 (6.2)	
Post-operative arrhythmia, n (%)	No	165 (78.9)	119 (82.6)	46 (70.8)	0.078
	Yes	44 (21.1)	25 (17.4)	19 (29.2)	
Post-operative AKI[f] requiring dialysis, n (%)	No	191 (91.4)	135 (93.8)	56 (86.2)	0.122
	Yes	18 (8.6)	9 (6.2)	9 (13.8)	
Hospital LOS[g], median [IQR[h]]		12.00 [7.00, 21.00]	11.00 [7.00, 21.50]	13.00 [7.50, 20.25]	0.996

[a]ASA: American Society of Anaesthesiologists; [b]BMI: Body Mass Index; [c]GCS: Glasgow Coma Scale; [d]CRP: C-Reactive Protein; [e]MI: Myocardial Infarction; [f]AKI: Acute Kidney Injury, [g]LOS: Length of Stay, [h]IQR: Interquartile Range; [i]SD: Standard Deviation

Table 2. Incidence rate ratios of univariable analysis using Poisson regression

Variable	**IRR[a] (95% CI[b])**	***p***
Male	0.96 (0.64, 1.44)	0.845
Age	1.06 (1.03, 1.08)	**<0.001**
Cardiac condition	1.13 (0.74, 1.72)	0.583
Pulmonary condition	1.24 (0.83, 1.87)	0.297
CCI[d]	1.15 (1.07, 1.23)	**<0.001**
BMI[c]	0.99 (0.95, 1.03)	0.572
Heart rate	1.00 (0.99, 1.01)	0.937
Systolic blood pressure	0.99 (0.98, 0.99)	**0.004**
Haemoglobin	0.99 (0.99, 1.00)	0.209
logCRP[e]	1.16 (1.02, 1.32)	**0.027**
logCreatinine	1.57 (1.13, 2.18)	**0.007**
Number of operations	1.02 (0.81, 1.30)	0.842
Cancer	1.32 (0.88, 1.98)	0.178
PRB[f] Transfusion	2.05 (1.36, 3.09)	**0.001**
Physiology Score	1.00 (0.97, 1.03)	0.932
Operative Severity Score	0.98 (0.91, 1.06)	0.618
logMorbidity P-POSSUM	0.73 (0.44, 1.21)	0.224
logMortality P-POSSUM	0.98 (0.80, 1.20)	0.843
Osteopenia	1.65 (1.07, 2.52)	**0.022**
Post-operative infection	0.93 (0.60, 1.43)	0.738
ASA[g] class		
1	Ref	
2	0.52 (0.083, 3.26)	0.484
3	1.21 (0.22, 6.79)	0.830
4	2.25 (0.34, 12.68)	0.358
5	4.00 (0.73, 21.93)	0.110
Surgery indication		
Ileus/obstruction	Ref	
Perforation	1.20 (0.73, 2.00)	0.476
Ischaemia	1.90 (1.13, 3.18)	**0.015**
Infection	N/A	N/A
Bleeding	1.80 (0.85, 3.83)	0.125
Other	0.83 (0.30, 2.35)	0.728
Surgical procedure		
Resection	Ref	
Adhesiolysis	0.49 (0.24, 1.01)	0.052
Stoma formation	0.92 (0.57, 1.49)	0.736
Other	0.64 (0.30, 1.35)	0.237
Bowel repair	0.76 (0.32, 1.81)	0.531
Vascular	0.66 (0.12, 3.71)	0.638

[a]IRR: Incidence Rate Ratio, [b]CI: Confidence Interval, [c]BMI: Body Mass Index, [d]CCI: Charlson's Comorbidity Index, [e]CRP: C-Reactive Protein, [f]PRB: Packed Red Blood cells; [g]ASA: American Society of Anaesthesiologists

operative complications are of greatest importance in affecting clinical outcomes [17, 18the number of very elderly patients (age ≥80 years]. In order to avoid age discrimination and to guide appropriate clinical decision-making, predictive tools have been developed. While P-POSSUM is a widely used system, it is a general surgical predictive tool which is not specifically aimed at the geriatric population. The predictive tool has been criticised for overestimating expected mortality and for not taking aspects such as surgeon-related variables into account [19, 20POSSUM scoring was attempted on admission in all patients under the care of two consultant surgeons over a six-month period. Scores were awarded only if all investigations necessary for POSSUM were performed; investigations unnecessary for effective treatment were not performed. 815 patient discharges were recorded over the six-month period, with 521 patients undergoing operative procedures. Of those undergoing an operation, scores could be allocated in only 155 (30%]. Alternative systems such as the measurement of frailty have therefore received focus. There is, however, currently no consensus as to which system to use in the elderly.

Thirty-day mortality rate in the current study was 31.1% reflecting the high mortality risk following emergency laparotomy in the elderly population. This figure is in line with previous mortality rates for elderly patients following abdominal surgery: when considering patients aged 80 and above Clarke

Table 3. Incidence rate ratios of multivariable analysis with backward stepwise selection using Poisson regression

Variable	IRR[a] (95% CI[b])	*p*
ASA[c] Class	Ref	.
1	Ref	.
2	0.45 (0.11, 1.88)	0.275
3	0.86 (0.24, 3.08)	0.811
4	1.13 (0.30, 4.27)	0.853
5	3.13 (0.78, 12.59)	0.108
Age	1.05 (1.02, 1.08)	**<0.001**
logMorbidity P-POSSUM	0.28 (0.13, 0.61)	**0.001**
logMortality P-POSSUM	1.58 (1.16, 2.15)	**0.004**
PRB[d] Transfusion	1.66 (1.13, 2.42)	**0.009**
Cancer	1.57 (1.01, 2.44)	**0.044**
Systolic blood pressure	0.99 (0.98, 1.00)	0.053
Surgery indication		
Ileus/obstruction	Ref	.
Perforation	1.17 (0.69, 2.00)	0.555
Ischaemia	1.94 (1.05, 3.57)	**0.034**
Infection	N/A	N/A
Bleeding	2.19 (0.94, 5.09)	0.070
Other	1.31 (0.48, 3.59)	0.603
Surgical procedure		
Resection	Ref	.
Adhesiolysis	0.50 (0.24, 1.03)	0.061
Stoma formation	0.98 (0.63, 1.51)	0.908
Other	0.42 (0.21, 0.83)	0.013
Bowel repair	0.82 (0.38, 1.73)	0.594
Vascular	0.40 (0.12, 1.29)	0.126

[a]IRR: incidence rate ratio; [b]CI: confidence interval; [c]ASA: American Society of Anaesthesiologists; [d]PRB: Packed Red Blood

et al., [21] demonstrated 38% mortality (compared to the overall mortality rate of 20%) and Saunders et al. demonstrated a death rate of 24.4% [7]. Diagnostic test analysis demonstrate that mortality P-POSSUM show weak predictive value in the current geriatric patients with an AUC of only 0.49. Additionally, the discriminatory ability of mortality P-POSSUM to identify those who died as deceased was very poor with a sensitivity score of 0.11. Osteopenia did demonstrate a slight improvement with moderate prognostic value with an AUC of 0.59 and sensitivity of 0.60. The current study design is unable to fully offer an account for this difference, but one possible explanation could be the fact that P-POSSUM does not take frailty into account whereas osteopenia is, by many, considered to be a marker of general frailty.

Further complexity is added to the subject of frailty by the fact that no generally accepted definition for the term exists. The concept does, however, commonly include some combination of weight loss, muscle wasting, loss in grip-strength and limited physical activity in a typical day [22]. The presence of frailty in elderly surgical patients has previously been emphasised and linked to poorer clinical outcomes [22]. The development of a frailty index for geriatric patients undergoing emergency surgery has been explored with some success. Joseph and colleagues found that the frailty index demonstrated a strong prediction for developing major complications and did this independently of age and ASA classification [23].

Furthermore, our results suggest that mortality P-POSSUM requires the additional information of ASA classification, age, surgical indication and procedure as well as PRB transfusion requirements, systolic blood pressure on admission and information on any concurrent cancer diagnosis in order to achieve a strong predictive power (AUC=0.83, sensitivity and specificity >0.75). This finding adds to the discussion of complexity when it comes to reliably predicting mortality amongst the elderly. However, it should be pointed out that these are all variables which are available directly at admission and it is therefore feasible to apply pre-operatively. Some of these variables are already taken into consideration in P-PUSSOM calculation (age, systolic blood pressure, and malignancy status), but how the additional variables (ASA classification, indication of surgery and type of procedure, and blood transfusion) would be combined with or into P-POSSUM in a mortality prediction calculator remains to be answered. A possible alternative is to assess whether a recalibration of P-POSSUM in the geriatric population would result in sufficiently improved predictive power.

To the best of our knowledge previous comparative validations of P-POSSUM and osteopenia are scant in the literature. However, the current study has multiple limitations inherent to its retrospective nature and limited sample size. Firstly, sarcopenia had to be excluded as a prognostic indicator due to

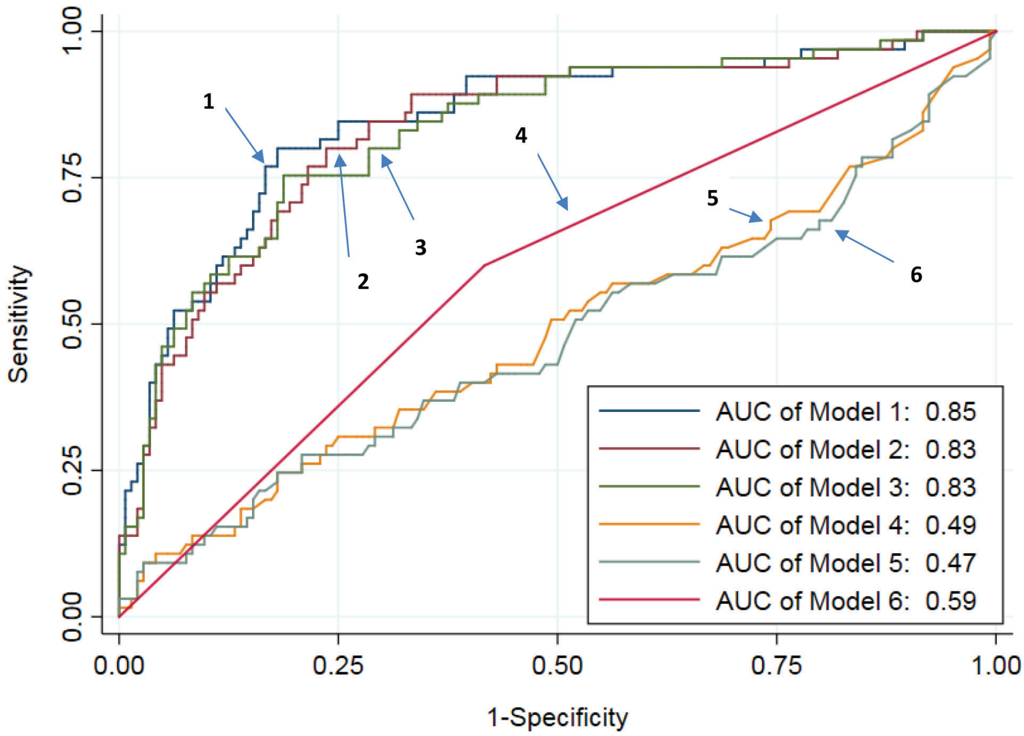

Fig. 1. Area under ROC curves
Model 1 covariates: ASA, age, logMorbidity P-POSSUM, logMortality P-POSSUM, surgery indication, PRB transfusion, cancer, systolic blood pressure, surgical procedure
Model 2 covariates: ASA, age, logMortality P-POSSUM, surgery indication, PRB transfusion, cancer, systolic blood pressure, surgical procedure
Model 3 covariates: ASA, age, logMorbidity P-POSSUM, surgery indication, PRB transfusion, cancer, systolic blood pressure, surgical procedure
Model 4 covariate: logMortality P-POSSUM
Model 5 covariate: logMorbidity P-POSSUM
Model 6 covariate: Osteopenia

Table 4. Comparison of areas under ROC[b] curves

	Youden's J	Sensitivity[a]	Specificity[a]	AUCc	SE[d] of AUC[c]	95% CI[e] of AUC[c]	
Model 1	0.62	0.80	0.82	0.84	0.03	0.79, 0.91	χ^2=77.00
Model 2	0.56	0.80	0.76	0.83	0.03	0.78, 0.90	P <0.001
Model 3	0.57	0.75	0.81	0.83	0.03	0.77, 0.89	
Model 4	0.07	0.11	0.96	0.49	0.05	0.40, 0.58	
Model 5	0.07	0.28	0.79	0.47	0.05	0.38, 0.56	
Model 6	0.18	0.60	0.58	0.59	0.04	0.52, 0.66	

[a]At optimum cut-off point based on Youden's J statistic; [b]ROC: Receiver operating characteristic, [c]AUC: Area under ROC curve, [d]SE: Standard error, CI: Confidence interval
Model 1 covariates: ASA, age, logMorbidity POSSUM, logMortality POSSUM, surgery indication, PRB transfusion, cancer, systolic blood pressure, surgical procedure
Model 2 covariates: ASA, age, logMortality POSSUM, surgery indication, PRB transfusion, cancer, systolic blood pressure, surgical procedure
Model 3 covariates: ASA, age, logMorbidity POSSUM, surgery indication, PRB transfusion, cancer, systolic blood pressure, surgical procedure
Model 4 covariate: logMortality POSSUM
Model 5 covariate: logMorbidity POSSUM
Model 6 covariate: Osteopenia

the lack of patients in the study population meeting CT criteria for sarcopenia. Secondly, due to the lack of information on performance status prior to hospital admission we were unable to compare the prognostic value of P-POSSUM and osteopenia to a frailty index.

In the current investigation, P-POSSUM and osteopenia alone proved to be poor predictors of 30-day mortality in geriatric patients following emergency laparotomy. P-POSSUM adjusted for other patient covariates improve outcome prediction.

Conflicts of Interest: None declared.

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