Comparative performance of Boey, peptic ulcer perforation, and American Society of Anesthesiologists scores in predicting outcomes in patients with perforated peptic ulcer

Original Article

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ABSTRACT

Background: Perforated peptic ulcer (PPU) is a surgical emergency associated with significant morbidity and mortality. Accurate and early identification of high-risk individuals is crucial in risk stratification. The primary aim of this study is to validate three of the most commonly used scoring systems concerning PPU: Boey, peptic ulcer perforation score (PULP), and American Society of Anesthesiologists (ASA).

Patients and Methods: This is a prospective, cohort analytic study of patients presenting to a tertiary emergency hospital requiring surgical intervention for PPU from November 2020 to April 2021. Data included patients' demography, clinical, laboratory, and intraoperative findings, postrepair 30-day morbidity and mortality. Receiver-operating characteristic (ROC) curve analysis was used to compute the area under the curve (AUC), cutoff point, sensitivity, and specificity for each of the three scores.

Results: This study included 52 patients with a mean age of 45.21 and male predominance. Morbidity and mortality were 48.1% (n=25) and 17.3% (n=9), respectively. The AUC for ASA, Boey, and PULP for morbidity was 62.4, 69.8, and 69.4%, respectively. From the measured parameters, only the intraoperative perforation size was significantly associated with post-PPU 30-day morbidity. Concerning mortality, the AUC for ASA, Boey, and PULP was 84.5, 86.6, and 93.5%, respectively. Age, creatinine and lactate, time from perforation to admission/surgery, and perforation size were all significantly associated with mortality.

Conclusion: PULP is the best prognostic tool for PPU patients and can be used to evaluate both morbidity and mortality.

Key Words: American Society of Anesthesiologists, boey, peptic ulcer, perforation, peptic ulcer perforation, scoring systems.

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INTRODUCTION

Peptic ulcer disease (PUD) refers to a break through the mucosa of the upper digestive tract that extends to the submucosal layers[1]. While initially asymptomatic, clinical manifestations of peptic ulcers can range from mild dyspepsia to severe complications[2]. Perforated peptic ulcer results in the highest mortality rate related to PUD[3]. The pathogenesis of ulcer formation is related to an imbalance between the protective mechanisms and ulcerogenic factors. However, why some ulcers perforate while others do not is still baffling. The anterior wall of the duodenum accounts for 60% of ulcers, whereas the antrum and lesser curvature of the stomach each accounts for 20%[4].

Delaying surgical intervention can significantly affect mortality[5], leading to the development of scoring systems to stratify risk and improve outcomes[6]. Nonspecific scoring systems are general scores of comorbidities and hence can be used with many diseases including perforated peptic ulcer (PPU). They include the American Society of Anesthesiologists (ASA) physical status classification, which was developed in 1963 to assess anesthetic risk[7] (Table 1). Other nonspecific systems include the Charlson comorbidity index, Mannheim peritonitis index (MPI), the acute physiology and chronic health evaluation II (APACHE II) score, simplified acute physiology score II (SAPS II), and physiological and operative severity score for the enumeration of mortality and morbidity (POSSUM) score[8].

While some of the nonspecific scoring systems showed promising results in defining the prognosis of perforated peptic ulcers, they all lack the advantage of being specific to PPU patients. ASA is subjective, lacks clear definitions, and fails to consider age and interval of perforation[9]. MPI is complex and may not be feasible in acute settings[10],

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while APACHE II, SAPS II, and POSSUM are complex systems[11].

Specific scoring systems were specifically conceived for PPU. The Boey scoring system, the first scoring system developed in 1982, identifies PPU-associated mortality by assessing three parameters: delay in surgery after the onset of symptoms greater than 48 h, shock upon admission (BP <100 mmHg), and comorbidity (cardiorespiratory disease, renal failure, diabetes mellitus, and hepatic precoma). Mortality rate increases with increased risk factors and scores[12]. The system was later modified to delay surgery by 24 h in Hong Kong[13].

The PULP scoring system was developed in 2012. It incorporates elements of both the Boey score and the ASA system (Table 2). According to the PULP score, a minimum score of 0 and a maximum score of 18 can be achieved. The optimal cutoff point of this system was set at 7 points, above which the patient is at high risk with mortality greater than 25%, and below that the risk is less than or equal to 25%[14].

The Boey system, with 93.8% accuracy, has been criticized for not considering age and crude shock definition[10,14–16]. The PULP system, with seven variables making it difficult for older age or severely sick individuals, has setbacks like not reflecting the total duration of abdominal contamination[6,17,18]. Thus, this study aims to evaluate the validity and accuracy of scoring systems in predicting the morbidity and mortality associated with perforated peptic ulcers in correlation with the initial presentation of the patients.

PATIENTS AND METHODS:

This cohort analytic study involved 52 patients with suspected PPU in the tertiary hospital, Kasr Alainy Teaching Hospital Emergency Department from November 2020 to April 2021. Patients over 18 years old undergoing Graham's patch open surgical repair were included, excluding those with a history of repaired PPU, perforated viscus other than gastric or duodenal ulcers, sealed PPU, surgical procedures other than Graham's patch repair, laparoscopic PPU repair, and conservative management. Patients were diagnosed using a variety of clinical, laboratory, and radiographic techniques. Regardless of the study's scoring system, a consultant decided for surgery. Preoperatively, both Boey and PULP scores were recorded for each patient. The ASA score, which is a component of the PULP score, was also separately documented and assessed in the study (Table 1).

Calculating the points for each scoring system

Patients were scored using Boey and PULP scoring systems as shown in (Table 3). PULP scoring based on factors such as comorbid diseases, steroids use, time from perforation to admission, shock on admission (defined as BP below 100 mm Hg systolic and heart rate above 100 beats per minute), liver cirrhosis, serum creatinine, age, and ASA score. Boey scoring is based on the onset of symptoms, shock on admission (defined as BP below 100 mm Hg only), and associated comorbidities (defined as cardiorespiratory disease, renal failure, diabetes mellitus, and hepatic precoma). Each patient received a maximum of 3 points in Boey and 18 points in PULP, with a minimum of 0 points in both systems. It is important to differentiate that the Boey system considers the time of onset of symptoms till surgery (not admission as the PULP system).

Postoperative management and follow-up of patients:

Postoperative management involved routine antibiotics, intravenous proton-pump inhibitors (PPI) and analgesics (paracetamol), nasogastric tube insertion, and removal of intraabdominal drains. Patients were monitored for ICU admission, complications, mortality, and discharge during hospital admission and within a 30-day interval after discharge. Post discharge, patients were followed up with clinic and phone follow-ups.

Post discharge, all patients were followed up for a period of 30 days by at least one clinical follow-up 1 week post discharge and at least one phone call 30 days' post discharge.

Statistical methods

Data were analyzed using the statistical package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA). Data was summarized using mean, standard deviation, median, minimum, and maximum in quantitative data and using frequency and percentage for categorical data. Comparisons between quantitative variables were done using the nonparametric Mann–Whitney test. For comparing categorical data, χ^2 test was performed. Exact test was used instead when the expected frequency is less than 5. Optimal cutoff for each continuous variable and risk scores were calculated by the receiver operating characteristics (ROC) curve analysis with assessment of the area under the curve (AUC) and its 95% confidence interval (CI). *P values* less than 0.05 were considered statistically significant. An AUC value of greater than 0.8 is considered excellent, while an AUC of 0.70–0.80 is considered acceptable, and a value of 0.5 equals the flip of a coin. Sensitivity and specificity with 95% CI are given for the optimal cutoff value as defined by the ROC analysis. The optimal cutoff value was calculated using the Youden index (defined as 'sensitivity + specificity – 1').

Table 1: American Society of Anesthesiologists classification[7]

Class	Definition
I	Patient is a completely healthy fit patient.
II	Patient has mild systemic disease (controlled)
III	A patient with severe systemic disease (uncontrolled)
IV	A patient with severe systemic disease that is a constant threat to life
V	A moribund patient who is not expected to survive without the operation

Table 2: Peptic ulcer perforation scoring system (Møller *et al*., 2012)

Variables	Points
Age > 65 years	3
Comorbid active malignant disease or AIDS	1
Comorbid liver cirrhosis	2
Concomitant use of steroids	1
Shock on admission*	1
Time from perforation to admission > 24 h	1
Serum creatinine > 1.47 mg/dl	2
ASA score 2	1
ASA score 3	3
ASA score 4	5
ASA score 5	7

*Shock on admission is defined as blood pressure less than 100 mm Hg and heart rate greater than 100 beats per min.

Table 3: Summary of Boey and peptic ulcer perforation scores

Variables	Boey points	PULP points
Age > 65 years	–	3
Comorbid active malignant disease or AIDS	–	1
Comorbid liver cirrhosis	–	2
Concomitant use of steroids	–	1
Shock on admission*	1	1
Time from perforation to admission/ surgery > 24 h**	1	1
Serum creatinine > 1.47 mg/dl	–	2
ASA score***	1	1
2	–	1
3	–	3
4	–	5
5	–	7
Total score	**3**	**18**

*Shock defined as only BP less than 100 mmHg in Boey and BP less than 100 mmHg and pulse greater than 100 bpm in PULP.
**Defined as time of perforation to admission in Boey and to surgery in PULP, respectively.
***ASA in Boey defined as cardiorespiratory disease, renal failure, diabetes mellitus, and hepatic precoma; -- not defined.

RESULTS:

Our study comprised 52 patients fulfilling our inclusion criteria. Most of the patients (n=49) were males representing 94.2%. Ages ranged from 18 to 83 years with a mean of 45.21±14.59 years. Most patients were found to be cigarette smokers (88.5%), coffee users (96.2%), and NSAID users (acute or chronic) (84.6%).

Characteristics and investigation results were recorded for our study group. Only two patients had a difference from the time of onset of symptoms to admission and to surgery. Most patients (53.8%) had small-sized perforations (1 cm and below). After evaluating the scores given for the study participants, we found that the maximum score for Boey (3 points) was recorded in three patients, whereas the maximum scores for PULP and ASA were not recorded in any patients with scores of 12 and 4 points, respectively, being the highest recorded. The cutoff point '7' set by Møller *et al*. was used to split the patients into two groups 0–7 and 8–18 regarding the PULP score where most of our study patients (81%) belonged to the 0–7 group[14] (Tables 4, 5).

Post-PPU repair 30-day morbidity and mortality were 48.1% (25 morbidities) and 17.31% (9 mortalities). The most common complications were surgical site infections (SSI) 17.3%, leakage, and atelectasis each 7.69%, and ileus and pneumonia each 3.85%.

ICU admissions had a significant impact on morbidity with 72.2% of the ICU admissions developing morbidities. Also, intraoperative perforation shows a statistically significant difference (*P-value = 0.019*), where the larger the size the higher the morbidity. However, neither laboratory findings, time from onset of symptoms to admission/ surgery greater than 24 h, liver cirrhosis nor ASA score showed a significant P value in association with postrepair 30-day morbidity. For mortality-associated results, we encountered nine mortalities in our study accounting for 17.31% of all cases. All the mortality cases were admitted to the ICU. (Table 6) shows the actual number of mortality and morbidity cases in relation to the scores given by each scoring system.

Correlation between scoring systems and mortality

Finally, ROC analysis was also used to compare the three scoring systems regarding mortality (Table 7, Fig. 1). While PULP had the largest area under the curve (AUC), the ASA score had the highest specificity (97.7%) in comparison to 93% for PULP. Boey had the second most significant AUC but was way below PULP (86.6 vs. 93.5%, respectively). The cutoff point of the PULP score on the Youden index for our study was comparable to that of Møller *et al*. (7.5 vs. 7, respectively)[14].

Regarding Boey score, the mortality rates were 0, 14.3, 28.6, and 100% for 0, 1, 2, and 3 points, respectively. These are partially comparable to the original Boey *et al*. findings (0, 10, 45.5, and 100%)[13].

Septic shock emerged as the primary direct factor leading to mortality in the group of nine patients. This finding potentially elucidates the significant correlation between mortality rates and lactate levels, a widely recognized parameter in cases of sepsis. All patients who succumbed were admitted to the intensive care unit after surgery. Among these individuals, seven passed away within 72 h following the surgical procedure, while two others expired within 1 week after surgery, having undergone a reexploration due to concerns about leakage.

Correlation between scoring systems and morbidity

ROC analysis was also used to compare the three scoring systems regarding 30-day morbidity (Fig. 2). While PULP had a slightly higher sensitivity than Boey; both had comparable specificity of only 59.3%. ASA score, however, had very weak sensitivity and specificity when it comes to predicting morbidity.

Table 4: Characteristics of all perforated peptic ulcer patients (continuous variables)

Variable	Mean	Standard Deviation	Median	Minimum	Maximum
Hb	14.75	2.27	14.80	8.20	19.70
Creatinine	1.79	1.40	1.13	0.65	6.70
TLC	13.75	7.24	12.52	1.30	36.20
Lactate	3.26	3.13	2.00	0.50	13.00
Pulse	100.87	17.56	100.00	60.00	130.00
Systolic BP	114.32	21.53	110.00	80.00	170.00
Diastolic BP	72.66	14.10	70.00	40.00	110.00

Table 5: Characteristics of all perforated peptic ulcer patients (categorical variables)

Variable	Count (n)	Percentage %
Time from onset of symptoms to admission >24 h		
Y	22	42.3
N	30	57.7
Time from onset of symptoms to surgery >24 h		
Y	24	46.2
N	28	53.8
Intraoperative perforation size		
0.5–1 cm	28	53.8
1–2 cm	22	42.3
>2 cm	2	3.8
Shock		
Y	14	26.9
N	38	73.1
Liver cirrhosis		
Y	4	7.7
N	48	92.3
ICU admission		
Y	18	34.6
N	34	65.4
ASA score		
1	3	5.8
2	31	59.6
3	11	21.2
4	7	13.5

Boey score		
0	21	40.4
1	14	26.9
2	14	26.9
3	3	5.8
PULP score		
0–7	42	80.8
8–18	10	19.2

Table 6: Relation between perforated peptic ulcer patients scores with morbidity and mortality (categorical variables)

	Morbidity				
	Y=25		N=27		
Variable	Count	%	Count	%	*P* value
ASA score					
1	1	33.3	2	66.7	0.230
2	12	38.7	19	61.3	
3	8	72.7	3	27.3	
4	4	57.1	3	42.9	
Boey score					
0	5	23.8	16	76.2	0.030
1	9	64.3	5	35.7	
2	9	64.3	5	35.7	
3	2	66.7	1	33.3	
PULP score					
0–7	20	47.6	22	52.4	1
8–18	5	50.0	5	50.0	
Variable		Mortality			
	Y=9		**N=43**		
	Count	%	Count	%	*P* value
ASA score					
1	0	0	3	100.0	< 0.01
2	2	6.5	29	93.5	
3	3	27.3	8	72.7	
4	4	57.2	3	42.8	
Boey score					
0	0	0	21	100.0	< 0.01
1	2	14.3	12	85.7	
2	4	28.6	10	71.4	
3	3	100.0	0	0	
PULP score					
0–7	3	7.1	39	92.9	< 0.01
8–18	6	60	4	40	

Table 7: Mortality optimal cutoff and accuracy indices of the three scoring systems*

			95% CI				
Variable	AUC	*P* value	Lower Bound	Upper Bound	Cutoff	Sensitivity %	Specificity %
PULP score	0.935	< 0.01	0.858	1.012	7.5	77.8	93
Boey score	0.866	< 0.01	0.750	0.981	1.5	77.8	76.7
ASA score	0.845	< 0.01	0.672	1.018	3.5	66.7	97.7

* Based on receiver-operating characteristics (ROC) curve analysis for mortality.
AUC, area under the curve; CI, confidence interval.

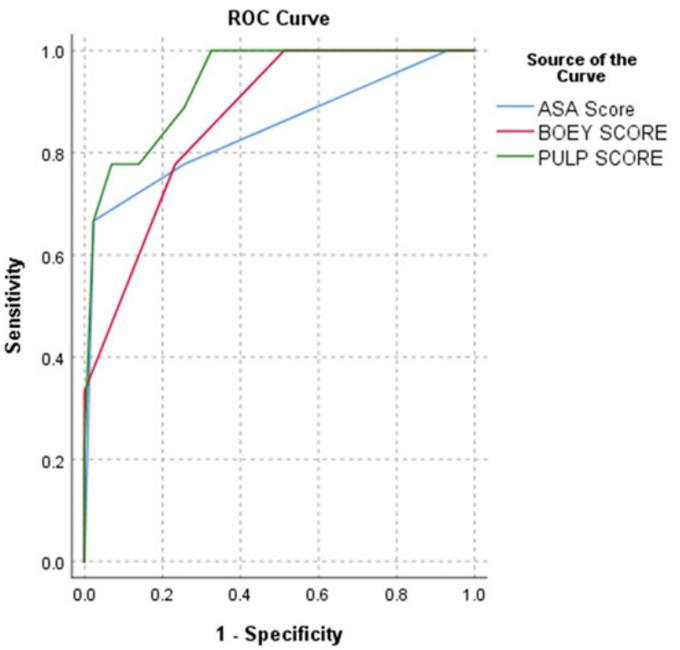

Fig. 1: Receiver-operating characteristics curves for peptic ulcer perforation, Boey, and American Society of Anesthesiologists show the area under the curve for mortality.

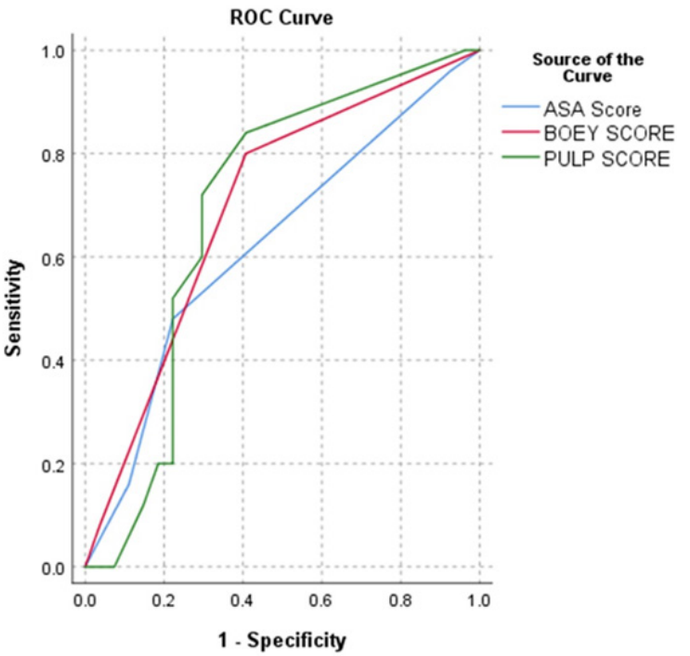

Fig. 2: Receiver-operating characteristics curves for peptic ulcer perforation, Boey, and American Society of Anesthesiologists showing the area under the curve for 30-day morbidity.

DISCUSSION

Our study included 52 cases of PPU with a mean age was 45.21, lower than that reported by Lohsiriwat *et al*. (52 years)[19] and Menekse *et al*. (50.6 years)[6] and higher than Qatar's Saafan *et al*. study, where the average was 37.41[20]. Our age group range agrees with the review by Søreide *et al*., which described the average age of PPI in African and Arab countries as 40 years[4].

Despite almost equal gender distribution in developed countries, African and Arab countries still have males ratios 6-13 times higher than females[4]. Our male-to-female ratio was 16 : 1. This ratio is comparable to other studies, such as Saafan *et al*., who had no females at all in their study of 152 perforated duodenal ulcer patients[20] and Pakistan's 99% male[21]. Similarly, a 6:1 ratio was found in a Turkish patients' study[6]; however, a study in Denmark had 55% female PPU patient sample[14].

Our study showed a high morbidity rate (48.1%) in post-PDU repair patients, significantly higher than previous studies in Qatar (10.5%)[20], Singapore (11.4%)[22], Turkey (24.2%)[6], and Thailand (30%)[19], while Norway showed even higher rates (52%)[23]. The current study's high rates might be attributed to open surgery, which is associated with higher morbidity and mortality[24,25]. Pulse rate at admission, intraoperative defect size, and postoperative ICU admission were significantly associated with 30-day morbidity, while perforation on admission greater than 24 h, liver cirrhosis, and other laboratory findings were not. The significance of pulse and intraoperative defect size was also demonstrated by Menekse *et al*. (2015). Conversely, the nonsignificance of other parameters such as creatinine[20,23] and TLC[6] is comparable to other studies. Meanwhile, the significance of creatinine level was demonstrated in some studies[3,6]. Regarding Hb levels, Saafan *et al*. found a novel finding not previously described, corelation between low hemoglobin and 30-day morbidity[20]. In our study, the average Hb was 14.75±2.27, which fell within normal range[26] and was nonsignificantly related to morbidity.

Our study found a 17.3% mortality rate in 52 patients. We had a wide range of mortalities. (Table 8) summarizes various studies and their findings. With age being a significant parameter, it was found to be an independent risk factor for mortality, with 42.8% of patients aged over 65 years dying (PULP definition for high age risk, over 65 years). Many other papers explicitly discussed the relationship between age and mortality as an independent risk factor[10,19,27–31].

Also, a significant correlation was found between diastolic blood pressure and mortality which matches with the findings of others[6], but systolic blood pressure and pulse did not show any significance. Other studies have found similar findings regarding insignificant systolic blood pressure[32], while others were not consistent[6].

We found a clear correlation between creatinine and lactate levels, and mortality. Regarding creatinine, which is a crucial parameter in the PULP score and indicates other underlying pathologies, many studies supported our finding[3,6,23]. Lactate, a key parameter in sepsis[33,34], is also significant. Some studies agree with our finding showing lactate as a significant factor for mortality prediction[31].

Unlike its relation to morbidity, delayed admission/surgery from symptom onset was significantly associated with mortality, with the time from symptom onset to surgery being more significant than to hospital admission, which indicates that the couple of hours taken to prepare the patient for surgery were of significance. Our findings were supported by Menekse *et al*. and Thorsen *et al*.; although, they only measured the time from onset of symptoms to surgery[6,23].

Shock, a key factor in both Boey and PULP scoring systems, proved its significance in our study. We only had two patients who were classified as 'shock' according to Boey and not according to PULP. In our analysis of the data, we used the definition of PULP for calculating the significance of shock. We did that as the definition of shock in Boey is not specific[15,16].

Finally, regarding the scoring systems prediction values concerning mortality, the PULP score was found to be the best predictive score for mortality, with an AUC of 93.5% at a cutoff point of greater than or equal to 8., which showed AUC for PULP score of 93.1%[6] and 92.9%[23] and even better than the original PULP study's AUC of 83%[14]. Anbalakan *et al*. showed a lower AUC of 75% but still ranked as the best scoring system in their study[22].

The Boey score had lower AUC values in all studies compared with PULP[6,14,22] consistent with our results (86.6% vs. 93.5% AUC for Boey and PULP, respectively). However, PULP was found to be tougher due to extensive patient data collection, factors not matching all demographic populations, and the weak ASA scoring system. However, the Boey scoring system has limitations such as not including age, a weak shock definition, and not including many comorbidities that could significantly affect the outcome, such as history of heart disease or active diseases.

The ASA score is the only nonspecific scoring system that we included in our comparison. We did that because it is already an integral part of the PULP scoring system. It is considered a good option for PPU patients, with a weak AUC (84.5%) but high specificity (97.7%). Indeed, some studies have even shown that it was stronger than the Boey system[14,22,23]. However, we cannot support the use of ASA score as it is nonspecific, subjective, lacks clear definition, and does not consider age as an independent factor.

The PULP scoring system is a valuable tool for determining risks associated with PPU and implementing additional perioperative care to reduce mortality rates. This is especially important in areas with limited resources and high patient flow. Prognostic scoring systems are often more reliable than clinical practice and sense, as they provide more accurate predictions, especially in subjective clinical situations.

This study has limitations. We did not examine other potential biomarkers (e.g., albumin and BUN) for predicting morbidity and mortality in PPU patients. Also, the sample size included in this study is relatively small. A larger sample size might have revealed associations not seen in this study; however, most of the results are in line with most of the large cohorts published, and as a result this prospective cross-sectional analytic study should have a wide validity.

Table 8: Cutoff and diagnostic accuracy indices of scoring systems for predicting mortality after perforated peptic ulcer repair across various studies

Study	n (%)	Score	Cutoff	Sensitivity %	Specificity %	AUC%
Current study 2021 Egypt (*n*=52)	9 (17.3)	ASA	≥4	66.7	97.7	84.5
		Boey	≥2	77.8	76.7	86.6
		PULP	≥8	77.8	93	93.5
Møller *et al.*, Denmark (*n*=2668)	16 (10.5)	ASA	≥3	–	–	78
		Boey	≥1	–	–	70
		PULP	≥7	73	79	83
Lohsiriwat *et al.*, 2009 Thailand (*n*=152)	13 (8.55)	ASA	–	–	–	91
		Boey	–	–	–	86
Thorson *et al.*, 2014 Norway (*n*=172)	28 (16)	ASA	≥3	85.7	66.0	79
		Boey	≥1	64.3	94.4	75
		PULP	≥6	92.9	58.3	79
Buck *et al.*, 2011 Denmark (*n*=117)	20 (17)	ASA	≥3	–	–	73
		Boey	≥2	–	–	63
Menekse *et al.*, 2015 Turkey (*n*=227)	23 (10.1)	ASA	--	–	–	91.4
		Boey	--	–	–	92.0
		PULP	--	–	–	95.5
Anbalakan *et al.*, 2015 Singapore (*n*=332)	24 (7.2)	ASA	≥3	83.3	98.1	75
		Boey	≥2	58.3	86.3	72
		PULP	≥8	62.5	87.3	75

n, number of patients; -- not reported.

CONCLUSION

The study highlights the importance of using scoring systems for predicting morbidity and mortality post-PPU repair. These systems can be used preoperatively at hospital admission, assisting in quick and effective triage. The PULP scoring system is recommended for patients suspected of having a PPU. The Boey scoring system, being less accurate but simpler, is recommended for hemodynamically unstable cases or those unfamiliar with other scoring systems. These systems help reallocate resources and reduce mortality by determining patients requiring ICU admission. Prioritizing old age patients can help guide management decisions.

CONTRIBUTORS' LIST

The manuscript has been read and approved by all the authors; the requirements for authorship as stated earlier in this document have been met, and each author believes that the manuscript represents honest work.

CONFLICT OF INTEREST

There are no conflicts of interest.

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