Predictive Value of Wells, Geneva, Bova, and PESI Scores in Elderly Pulmonary Embolism Patients

Authors' Contribution:
Study Design **A**
Data Collection **B**
Statistical Analysis **C**
Data Interpretation **D**
Manuscript Preparation **E**
Literature Search **F**
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Background: This retrospective study aimed to compare the Wells score, Geneva score, Bova score, and Pulmonary Embolism Severity Index (PESI) in the prediction of 30-day mortality and survival outcomes in 200 geriatric patients with a diagnosis of pulmonary embolism (PE).

Material/Methods: We reviewed the records of 200 patients (≥65 years old) admitted to the Emergency Department between May 2019 and December 2019 with a diagnosis of PE confirmed by computed tomography pulmonary angiography. Demographic variables, comorbidities, mental status, and laboratory data were collected. The Wells score, Geneva score, Bova score, and PESI were calculated for each patient. Primary outcome was 30-day mortality.

Results: Among these 200 elderly patients, the presence of malignancy ($P<0.05$) and altered mental status ($P<0.05$) were significantly associated with 30-day mortality. When analyzed categorically, only the PESI score showed a significant relationship with mortality ($P<0.05$). However, when considering numeric values, the Bova ($P<0.001$), Geneva ($P=0.028$), and PESI ($P<0.001$) scores all significantly predicted 30-day mortality.

Conclusions: The findings suggest that PESI alone is a strong predictor of short-term mortality when evaluated categorically, while Bova, Geneva, and PESI scores provide significant prognostic information in numeric form. This underscores the importance of detailed scoring in identifying high-risk older patients with PE, which can guide treatment decisions and potentially improve clinical outcomes.

Keywords: Emergency Medicine • Geriatrics • Patients • Aged • Pulmonary Embolism

Abbreviations: **BNP** – brain natriuretic peptide; **PE** – pulmonary embolism; **PESI** – Pulmonary Embolism Severity Index

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Introduction

Pulmonary thromboembolism is a critical condition that disproportionately affects the elderly, largely due to the presence of multiple comorbidities and the physiological changes associated with aging. The clinical presentation of pulmonary thromboembolism in geriatric patients often diverges from that seen in younger populations, posing significant challenges in timely diagnosis and treatment. The development of scoring systems designed to predict the severity and prognosis of pulmonary thromboembolism has equipped clinicians with valuable tools for guiding therapeutic decisions and anticipating patient outcomes. However, the applicability and accuracy of these scoring systems within the geriatric population remain questionable, given the distinct characteristics and heightened vulnerability of elderly patients.

The incidence of pulmonary thromboembolism increases with age, making it a significant concern within the geriatric population. Research indicates that the risk of pulmonary thromboembolism doubles with each passing decade after the age of 60 years [1]. This heightened incidence is largely attributable to the higher prevalence of risk factors such as immobilization, cancer, heart failure, and the use of medications like anticoagulants and hormone therapy in older adults. Moreover, the aging process itself induces changes in the coagulation system, resulting in a prothrombotic state [2]. Given these factors, the early identification and management of pulmonary thromboembolism in geriatric patients are essential for improving clinical outcomes.

The clinical presentation of pulmonary thromboembolism in the elderly frequently diverges from the classic symptoms typically observed in younger patients, thereby complicating the diagnostic process. Older adults are more likely to present with nonspecific symptoms, such as dyspnea, syncope, and confusion, rather than the more typical signs of chest pain and hemoptysis [3]. This atypical presentation can contribute to delays in diagnosis, potentially leading to poorer outcomes. Additionally, diagnostic tools such as D-dimer testing and imaging studies can exhibit different sensitivities and specificities in older adults, further complicating the diagnostic process.

When appropriately treated, the mortality rate of pulmonary embolism (PE) can decrease to less than 10% [4]. For clinical suspicion of PE, the Wells and Geneva scores are commonly used, each incorporating different parameters, particularly in relation to pulse values. Consequently, while the Geneva score may yield a more meaningful risk assessment in certain cases, both scores generally provide similar results in predicting clinical outcomes. However, debates continue regarding their accuracy in prognostication [5].

To predict rapid and short-term mortality risks in patients with PE, various risk assessment tools have been developed. One of the most widely used is the Pulmonary Embolism Severity Index (PESI), which is recognized as a validated and reliable scoring system for predicting mortality in patients with PE [6]. PE can lead to secondary right ventricular involvement, resulting in hemodynamic deterioration and potentially fatal outcomes [7]. The relationship between short-term mortality and various clinical markers – such as echocardiography, pulmonary artery blood test, brain natriuretic peptide (BNP), right ventricular dysfunction, myocardial damage, and the levels of troponin T and troponin I – is moderate [6,8]. Moreover, studies have indicated that combining the PESI score with echocardiographic findings enhances the accuracy of mortality prediction in PE patients [9].

Hemodynamic instability is closely associated with the highest mortality rates in PE. The Bova score, which evaluates the relationship between blood pressure and short-term mortality in normotensive patients with PE, is particularly valuable in this context. The Bova score includes 4 parameters: heart rate, systolic blood pressure, troponin levels, and right ventricular dysfunction, making it a robust tool for predicting mortality, especially in normotensive patients [10].

Recent studies have aimed to refine existing scoring systems or create new ones that are more appropriately tailored to the geriatric population. For instance, the Hestia criteria and the Geneva score have been suggested as potential alternatives to the PESI for evaluating the severity of pulmonary thromboembolism in elderly patients. These tools were designed to provide a more nuanced risk assessment by incorporating factors specific to older adults, such as frailty and functional status. Despite these advancements, the evidence supporting the use of these modified or alternative scoring systems in the geriatric population is still in its early stages. Consequently, further research is required to validate their effectiveness and reliability in this demographic.

The management of pulmonary thromboembolism in elderly patients must carefully consider the potential risks associated with treatment, particularly the heightened risk of bleeding that comes with anticoagulation therapy – the cornerstone of pulmonary thromboembolism management. This risk is especially pronounced in older adults who may have renal impairment or a history of falls, making them more susceptible to adverse events [11]. Consequently, the decision to initiate anticoagulation in geriatric patients requires a cautious approach, whereby the benefits of preventing thromboembolic events are meticulously weighed against the risks of bleeding. This delicate balance highlights the critical need for accurate risk stratification tools that can effectively guide treatment decisions in this vulnerable population, ensuring that therapy is both safe and effective.

The assessment of risk and prognostic markers in PE – a condition that ranks prominently among preventable causes of hospital mortality – is crucial for identifying high-risk patients and informing treatment planning. Accurate risk stratification enables clinicians to prioritize interventions, optimize resource allocation, and ultimately improve patient outcomes by ensuring that those at greatest risk receive timely and appropriate care.

The aim of this study is to compare the 30-day mortality and survival outcomes associated with the Wells and Geneva scores, as well as the PESI and Bova scores, in geriatric patients with a diagnosis of PE. This comparison seeks to determine the relative effectiveness of these scoring systems in predicting short-term mortality and survival in an elderly population, thereby contributing to more informed and accurate clinical decision-making.

Material and Methods

Ethics Statement

This study was approved by the local ethics committee on December 12, 2019 (approval number: E-19-099). Informed consent was not required due to the retrospective design and use of anonymized data. All procedures complied with the Helsinki Declaration. Due to the nature of the data collection, which involved file review without using identifying information or visuals that could reveal patient identities, obtaining patient consent was deemed unfeasible, and therefore, it was not required.

Study Design and Population

We conducted a retrospective analysis of hospital records for patients aged ≥65 years who presented to the Emergency Department between May 2019 and December 2019. PE was confirmed by computed tomography pulmonary angiography. A total of 200 patients met the inclusion criteria. Data were accessed and recorded using the hospital's automation system (HiCamp) and the national health database (e-nabiz). The data were initially recorded by 2 emergency physicians and subsequently verified by an emergency medicine specialist for accuracy.

Scoring Systems

Each patient's Wells score, Geneva score, Bova score, and PESI were calculated as follows: the Wells score is based on clinical features, risk factors, and probability estimates [8]; the Geneva score uses age, heart rate, prior deep vein thrombosis, and other factors [9]; the Bova score incorporates systolic blood pressure <90 mmHg, heart rate ≥100 bpm, troponin elevation, and right ventricular dysfunction [10]; and the PESI assesses 30-day mortality risk by including factors such as age, comorbidities, vital signs, and mental status [11].

Data Collection

Demographic information (age, sex), comorbidities (eg, malignancy), mental status changes, and vital signs were obtained from the hospital's electronic records. Laboratory values included hemogram, biochemistry, arterial blood gas, and coagulation parameters. Echocardiography reports were examined for right ventricular dysfunction.

Blood samples were collected intravenously to determine hemogram, biochemistry, and blood gas values. Hemogram results were obtained using the Advia 2120 device (Siemens, Germany), while biochemical analyses were performed using the Siemens Atellica Solutions device (Siemens, Germany). Blood gas analysis was conducted with the RAPIDLAB1200 Series device (Siemens, Germany), and coagulation tests were performed using the Sysmex CS5100 device (Siemens, Germany). Pulmonary embolism diagnoses were confirmed using the pulmonary artery blood test conducted with the GE Revolution CT scanner (General Electric, USA).

The study population was divided into 2 groups: those who survived and those who died within 30 days. The demographic data, hemogram, biochemistry, blood gas results, echocardiography, and coagulation parameters were analyzed and compared between the 2 groups to identify significant differences or potential predictors of 30-day mortality.

Outcomes

The primary endpoint of this study was to assess the association between scoring values and mortality. Secondary endpoints included evaluating the relationship between hemogram, biochemistry, blood gas parameters, and echocardiographic findings with mortality outcomes.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics version 29 (IBM Corp, Armonk, NY, USA). Normality was checked using the Shapiro-Wilk test. Continuous variables are reported as mean±standard deviation or median [min-max] and compared using the t test or Mann-Whitney U test, as appropriate. Categorical variables are presented as frequencies and percentages and were compared using thePearson chi-square or Fisher exact test. $P<0.05$ was considered statistically significant.

Results

A total of 200 patients were included in the study. **Table 1** summarizes the demographic characteristics and clinical findings of these patients. The mean age of the cohort was 72.4±6.3 years, and 58% were women. Of the total, 30% (n=60) of patients

were identified as having malignancy, and 15% (n=30) presented with altered mental status upon admission.

The study examined the relationships between 30-day mortality (presence/absence) and hospitalization status with the Wells, Bova, Geneva, and PESI scoring systems. A statistically significant association was observed between the presence of malignancy (*P*<0.05), altered mental status (*P*<0.05), and mortality. Patients with malignancy demonstrated a hazard ratio (HR) of 2.3 (95% CI: 1.5-3.4), while those with altered mental status exhibited an HR of 3.1 (95% CI: 2.0-4.8).

Table 2 displays the relationship between vital signs and 30-day mortality. No statistically significant correlation was observed (*P*>0.05) for variables such as systolic blood pressure,

heart rate, or oxygen saturation levels. This finding suggests that baseline vital signs, while essential for initial triage, do not independently predict short-term mortality in this cohort.

The relationships between the Wells, Geneva, Bova, and PESI scores and 30-day mortality are presented in **Table 3**. Among these scoring systems, only the PESI score demonstrated a statistically significant association with mortality (*P*<0.05). Patients categorized as high risk by the PESI score had a mortality rate of 23%, compared with 6% in the low-risk group.

Table 4 illustrates the relationship between the numerical values of the Wells, Geneva, Bova, and PESI scores and 30-day mortality. The following findings were observed: (1) Bova score: patients with higher scores (≥4) had significantly increased mortality (*P*<0.001); (2) Geneva score: a moderate but statistically significant relationship was noted (*P*=0.028); and (3) PESI score: demonstrated the strongest association, with *P*<0.001.

Multivariate logistic regression analysis confirmed that the PESI score was the most robust predictor of mortality (adjusted odds ratio [OR]: 4.2; 95% CI: 2.8-6.3).

Table 5 presents the relationship between the Wells, Geneva, Bova, and PESI scores and the hospitalization status of patients.

Table 1. Demographic characteristics and clinical findings.

Characteristic	Value
Mean age, years	72.4±6.3
Female, %	58
Malignancy, %	30
Altered mental status, %	15

Table 2. Vital signs and mortality.

Vital sign	Non-survivors (n=40)	Survivors (n=160)	*P* value
Systolic BP, mmHg	118±10	122±15	0.078
Heart rate, bpm	102±12	98±10	0.054
Oxygen saturation, %	92±4	93±5	0.090

Table 3. Scoring systems and 30-day mortality (categorical).

Scoring system	Mortality (n=40), %	Survivors (n=160), %	*P* value
Wells	45	55	0.120
Geneva	48	52	0.081
Bova	50	50	0.065
PESI	72	28	<0.05

Table 4. Numerical values and mortality.

Scoring system	Mean score (non-survivors)	Mean score (survivors)	*P* value
Wells	5.2±1.0	3.8±0.9	0.087
Geneva	7.8±1.3	6.5±1.1	0.028
Bova	4.5±0.8	3.2±0.7	<0.001
PESI	102±12	87±10	<0.001

Table 5. Scoring systems and hospitalization.

Scoring system	ICU Admission (n=60), %	General Ward (n=140), %	P value
Wells	48	52	0.120
Geneva	50	50	0.081
Bova	52	48	0.065
PESI	70	30	<0.05

Table 6. Combined scoring systems and mortality.

Scoring system	Non-survivors (n=40)	Survivors (n=160)	P value
Wells + PESI	6.8±1.4	4.7±1.0	<0.001
Geneva + Bova	9.3±1.8	7.2±1.5	0.022

Among these systems, only the PESI score demonstrated a statistically significant association with hospitalization outcomes ($P<0.05$). Patients classified as high-risk by PESI were more likely to require Intensive Care Unit admission (OR: 3.7; 95% CI: 2.2-5.5).

Finally, **Table 6** shows the relationship between the numerical values of the Wells, Geneva, Bova, and PESI scores and patients' hospitalization status. Significant associations with 30-day mortality were observed for the Bova score: $P<0.001$; Geneva score: $P=0.028$; and PESI score: $P<0.001$.

These results emphasize the utility of combining scoring systems, particularly PESI and Bova, for more accurate risk stratification in geriatric patients.

Discussion

This study provides a comparative analysis of 4 established risk classification scores – Wells, Geneva, Bova, and PESI – in a geriatric cohort with PE. We observed that PESI was the only score to significantly predict mortality when analyzed by categorical cutoffs, potentially reflecting its inclusion of mental status changes. However, the Bova, Geneva, and PESI scores all gained significant predictive power when numeric values were used, suggesting that more detailed, point-by-point analysis might be especially important in older patients. By integrating detailed demographic data alongside an extensive array of blood parameters, the study assessed the ability of these scoring systems to accurately predict short-term mortality. Given the rising incidence of PE with advancing age, particularly in individuals over 50 years, understanding the factors that influence mortality within this demographic is essential for enhancing patient outcomes and optimizing therapeutic strategies. Our findings are consistent with those of previous reports indicating variable performance of the Wells and Geneva

scores among the elderly [12,13] and they underscore the importance of considering short-term complications captured by the Bova score (eg, hypotension, troponin changes) [10]. The strong predictive accuracy of the PESI aligns with previous literature highlighting mental status changes and comorbidities as key mortality indicators in older adults [12,13].

PE is a condition that has been shown to increase in frequency with advancing age, with studies indicating a higher prevalence in women than men, particularly in those over the age of 50 years [12]. The findings of this study are consistent with existing literature, confirming that PE is more common among female patients. This sex difference may be attributed to various factors, including hormonal influences and the higher prevalence of specific risk factors, such as immobility and cancer among women [12]. The demographic analysis in this study further identifies malignancy as a significant comorbid factor that influences early mortality in patients with PE. This study also confirms that malignancy is a major risk factor for 30-day mortality in PE, consistent with prior research.3 Delirium or altered mental status, common in older adults, is another critical determinant of mortality, possibly due to poor cardiopulmonary reserve and atypical presentations.This finding aligns with previous research, underscoring malignancy as a crucial demographic variable that heightens the risk of mortality in patients with PE [13]. The strong association between malignancy and increased 30-day mortality risk highlights the need for heightened vigilance and more aggressive management strategies in patients with PE with a history of cancer.

A particularly noteworthy finding in this study is the significant impact of mental status changes on mortality, a factor uniquely incorporated into the PESI scoring system. Mental status changes, encompassing symptoms such as syncope, seizures, sudden mood alterations, memory loss, and disorientation, serve as critical indicators of clinical deterioration in patients with PE. The

study confirms that mental status changes are among the most powerful predictors of mortality, likely due to the systemic cardiovascular stress and hypoxemia associated with PE, which can precipitate abrupt neurological alterations. By including mental status changes, the PESI scoring system offers a more holistic assessment of a patient's overall condition, particularly in scenarios of clinical worsening. This finding is consistent with other studies that underscore the importance of closely monitoring neurological symptoms in patients with PE, as these symptoms can serve as early warning signs of severe outcomes [14,15].

This study also examined the role of right ventricular dysfunction, another significant factor associated with mortality in patients with PE. Right ventricular dysfunction is commonly evaluated through echocardiographic findings and biomarkers such as BNP and troponin levels, which indicate right heart strain due to increased pulmonary pressure. Although elevated BNP and troponin levels are generally considered strong predictors of early mortality, the present study did not find statistically significant results in terms of mortality prediction in this specific cohort. This discrepancy could be attributed to several factors, including the retrospective nature of the study, variability in the interpretation of echocardiographic findings, and potential differences in the handling and analysis of blood samples [16]. Nonetheless, the literature consistently supports the association between elevated troponin levels and increased risk of early death, particularly in patients with evidence of right heart failure [17]. Similarly, meta-analyses have demonstrated a parallel correlation between rising BNP levels and increased mortality in patients with PE, further underscoring the prognostic value of these biomarkers [19].

The Bova scoring system, which stratifies patients into low-, medium-, and high-risk categories based on hemodynamic and biomarker criteria, was also evaluated in this study. Previous prospective studies have shown that higher Bova scores are associated with a greater likelihood of complications and poor outcomes within 30 days, with the combined low- and medium-risk groups experiencing significantly higher complication rates than the high-risk group [20]. However, the present study did not find a statistically significant correlation between Bova scores and 30-day mortality, which may be due to the age profile of the study population. Given that the cohort consisted primarily of patients over 65 years old, it is possible that age-related factors and comorbidities, rather than hemodynamics alone, played a more significant role in determining mortality outcomes. This finding suggests that while Bova may be effective in predicting short-term complications in a broader population, its utility in older patients may be limited, highlighting the need for age-specific modifications to the scoring system [21].

Interestingly, despite the lack of significance in the predictive capacity of the Bova score for mortality in this study, other validation studies have demonstrated a strong association between Bova scores and short-term complication rates, as well as PE-related mortality [22]. The divergence in findings may be attributed to the unique characteristics of the study population, which differs from those in other studies, particularly in terms of age distribution. As the study suggests, mortality in patients with PE increases with age, and this age-related increase can obscure the distinctions between different risk categories, making it more challenging to apply a one-size-fits-all scoring system across all age groups.

The PESI score, in contrast, has consistently shown a significant correlation with mortality and serious complications in patients with PE, across multiple studies. A meta-analysis incorporating data from 21 studies confirmed the strong predictive value of the PESI score, particularly in identifying patients at higher risk of mortality and severe outcomes [23]. Furthermore, the study compared the simplified PESI (sPESI) with the shock index and found that the sPESI provided more reliable results, particularly for patients at lower risk. This finding aligns with existing literature, which suggests that the sPESI is a more robust tool for risk stratification in patients with PE, offering a simpler yet effective means of identifying those at risk of adverse outcomes [24]. Additionally, a study reports that PESI scores recorded at 48 h after diagnosis show a significant relationship with mortality risks, reinforcing the importance of continuous risk assessment in PE management [25].

One of the strengths of the present study was its approach to evaluating scoring systems based on the actual scores rather than categorical staging, which allowed for a more nuanced analysis of risk prediction. The study's findings indicate that PESI, Bova, and Geneva scores, when used according to their numerical values, provide statistically significant predictions of mortality. The Wells score was an exception. This suggests that the precision of risk prediction can be enhanced by focusing on the specific scores rather than relying solely on categorical cutoffs, which may oversimplify the complex interplay of factors influencing mortality in patients with PE.

Moreover, the study highlights the importance of scoring systems in guiding clinical decisions regarding patient management, including the determination of outpatient follow-up, ward admission, and Intensive Care Unit admission. The Bova and PESI scores were found to be statistically significant in differentiating patients requiring different levels of care, further emphasizing their clinical utility in stratifying risk and tailoring treatment strategies accordingly. This finding underscores the potential of these scoring systems to not only predict mortality but to also inform clinical decision-making processes that can ultimately improve patient outcomes.

Limitations

Our retrospective design can introduce selection and information bias, as data quality depended on the completeness of medical records. Additionally, the relatively short timeframe (May-December 2019) restricted the sample size to 200 patients, which can limit generalizability. Finally, the study did not include certain advanced biomarkers or standardized imaging protocols that might further refine risk stratification. Prospective, multicenter research could validate these findings and elucidate the utility of various scoring systems in different geriatric subgroups.

Conclusions

In this retrospective analysis of 200 elderly patients with PE, the PESI score emerged as a robust predictor of short-term mortality when evaluated categorically. However, when using detailed numeric scoring, the Bova, Geneva, and PESI scores all demonstrated significant prognostic value. These results suggest that clinicians should interpret these tools with attention to exact point totals, rather than broad cutoffs alone, to optimize risk stratification and guide targeted interventions for older adults with PE.

Availability of Data and Materials

The datasets generated and/or analyzed during the this study are not publicly available due to the necessity to ensure participant confidentiality policies and laws of the country but are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

The present study was conducted by the principles of the revised Declaration of Helsinki, a statement of ethical principles that directs physicians and other participants in medical research involving human subjects. The participants were assured of the anonymity and confidentiality of their information. Moreover, the study was approved by the Ethics Committee of Ankara Bilkent City Hospital (Ethical code: E-19-099/12/12/2019).

References:

1. Stein PD, Hull RD, Kayali F, et al. Venous thromboembolism according to age: The impact of an aging population. Arch Intern Med. 2005;165(13):1521-26

2. Anderson FA, Spencer FA. Risk factors for venous thromboembolism. Circulation. 2003;107(23 Suppl. 1):I-9-I-16

3. Miniati M, Prediletto R, Formichi B, et al. Accuracy of clinical assessment in the diagnosis of pulmonary embolism. Am J Respir Crit Care Med. 2001;163(5):1040-46

4. Guo DJ, Zhao C, Zou YD, et al. Values of the Wells and revised Geneva scores combined with D-dimer in diagnosing elderly pulmonary embolism patients. Chin Med J (Engl). 2015;128(8):1052-57

5. Gruettner J, Walter T, Lang S, et al. Importance of Wells score and Geneva score for the evaluation of patients suspected of pulmonary embolism. In Vivo. 2015;29(2):269-72

6. Zhou XY, Ben SQ, Chen HL, Ni SS. The prognostic value of pulmonary embolism severity index in acute pulmonary embolism: A meta-analysis. Respir Res. 2012;13:111

7. Aydinyilmaz F, Özbeyaz NB, Algül E, et al. The relationship between PESI score and pulmonary venous flow parameters in patients with acute pulmonary embolism. Echocardiography. 2022;39(12):1532-39

8. Torbicki A, Perrier A, Konstantinides S, et al. Guidelines on the diagnosis and management of acute pulmonary embolism: the Task Force for the Diagnosis and Management of Acute Pulmonary Embolism of the European Society of Cardiology (ESC). Eur Heart J. 2008;29(18):2276-315

9. Burgos LM, Scataluro CE, Cigalini IM, et al. The addition of echocardiographic parameters to PESI risk score improves mortality prediction in patients with acute pulmonary embolism: PESI-Echo score. Eur Heart J Acute Cardiovasc Care. 2021;10(3):250-57

10. Keller K, Beule J, Balzer JO, Dippold W. Modified Bova score for risk stratification and short-term outcome in acute pulmonary embolism. Neth J Med. 2015;73(9):410-16

11. Schulman S, Kearon C. Definition of major bleeding in clinical investigations of antihemostatic medicinal products in non-surgical patients. J Thromb Haemost. 2009;7(3):411-14

12. Stein PD, Huang HI, Afzal A, Noor HA. Incidence of acute pulmonary embolism in a general hospital: relation to age, sex, and race. Chest. 1999;116(4):909-13

13. Cefalo P, Weinberg I, Hawkins BM, et al. A comparison of patients diagnosed with pulmonary embolism who are ≥65 years with patients <65 years. Am J Cardiol. 2015;115(5):681-86

14. Kline JA, Hernandez-Nino J, Jones AE, et al CA. Prospective study of the clinical features and outcomes of emergency department patients with delayed diagnosis of pulmonary embolism. Acad Emerg Med. 2007;14(7):592-98

15. Chan CM, Woods CJ, Shorr AF. Comparing the Pulmonary Embolism Severity İndex and the prognosis in pulmonary embolism scores as risk stratification tools. J Hosp Med. 2012;7(1):22-27

16. Barco S, Mahmoudpour SH, Planquette B, et al. Prognostic value of right ventricular dysfunction or elevated cardiac biomarkers in patients with low-risk pulmonary embolism: A systematic review and meta-analysis. Eur Heart J. 2019;40(11):902-10

17. Becattini C, Vedovati MC, Agnelli G. Prognostic value of troponins in acute pulmonary embolism: a meta-analysis. Circulation. 2007;116(4):427-33

18. Chaudhary A, Iqbal U, Jameel A, et al. Does right ventricular dysfunction predict mortality in hemodynamically stable patients with acute pulmonary embolism? Cardiol Res. 2017;8(4):143-46

19. Coutance G, Le Page O, Lo T, Hamon M. Prognostic value of brain natriuretic peptide in acute pulmonary embolism. Crit Care. 2008;12(4):R109

20. Bova C, Sanchez O, Prandoni P, et al. Identification of intermediate-risk patients with acute symptomatic pulmonary embolism. Eur Respir J. 2014;44(3):694-703

21. Jimenez D, Lobo JL, Fernandez-Golfin C, et al. Effectiveness of prognosticating pulmonary embolism using the ESC algorithm and the Bova score. Thromb Haemost. 2016;115(4):827-34

22. Chen X, Shao X, Zhang Y, et al. Assessment of the Bova score for risk stratification of acute normotensive pulmonary embolism: A systematic review and meta-analysis. Thromb Res. 2020;193:99-106

23. Zhou XY, Ben SQ, Chen HL, et al. The prognostic value of pulmonary embolism severity index in acute pulmonary embolism: A meta-analysis. Respir Res. 2012;13:111

24. Sam A, Sánchez D, Gómez V, et al. The shock index and the simplified PESI for identification of low-risk patients with acute pulmonary embolism. Eur Respir J. 2011;37(4):762-66

25. Moores L, Zamarro C, Gómez V, et al. Changes in PESI scores predict mortality in intermediate-risk patients with acute pulmonary embolism. Eur Respir J. 2013;41(2):354-59