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Original Article *Özgün Araştırma*

RELATIONSHIP BETWEEN BLOOD PRESSURE INDEX AND RIGHT VENTRICULAR DYSFUNCTION AND MORTALITY IN PATIENTS WITH PULMONARY EMBOLISM

Pulmoner Emboli Hastalarında Kan Basıncı İndeksinin Sağ Ventrikül Disfonksiyonu ve Mortalite ile Olan İlişkisi

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ABSTRACT

Objective: Pulmonary embolism is a cardiopulmonary emergency commonly encountered in emergency departments with a high mortality rate. In cases of pulmonary embolism, the prompt and effortless implementation of echocardiography in the emergency department for the identification of right ventricular dysfunction, a significant predictor of mortality, is not always feasible. The aim of this study is to demonstrate the role of the readily available blood pressure index in determining right ventricular dysfunction and mortality in patients with pulmonary embolism.

Material and Methods: A total of 180 patients (90 females and 90 males) who were diagnosed with pulmonary embolism based on computed tomography pulmonary angiography in the emergency department between 2013 and 2019 and subsequently underwent echocardiography were included in the study. The blood pressure index was obtained by dividing the systolic blood pressure by the diastolic blood pressure.

Results: The average blood pressure index of the patients was calculated as 1.7±0.2. There was no statistically significant difference in terms of BPI between the two groups, one with right ventricular dysfunction and the other without right ventricular dysfunction, based on echocardiography (p=0.529). A total of 22.2% of the patients experienced 30-day mortality. There was no significant difference in terms of blood pressure index between the group with observed mortality and the group without observed mortality (p=0.438).

Conclusion: No significant relationship was identified between blood pressure index and right ventricular dysfunction or mortality in patients with pulmonary embolism. However, considering the ease of accessibility and applicability of blood pressure index in emergency departments, we believe it can be considered as a useful parameter. We anticipate that blood pressure index would yield more accurate results in determining right ventricular dysfunction and mortality, especially in patients with pulmonary embolism who have reduced systolic blood pressure.

Keywords: *Pulmonary embolism, blood pressure index, mortality*

ÖZ

Amaç: Pulmoner emboli, acil servislerde sıkça karşılaşılan ve mortalitesi yüksek kardiyopulmoner bir acildir. Pulmoner emboli, hastalarında mortaliteyi gösteren, sağ ventrikül disfonksiyonunun saptanmasında; Ekokardiyografinin (EKO) yapılması acil serviste her zaman hızlı ve kolay olmamaktadır. Bu çalışmadaki amaç; daha kolay elde edilebilen kan basıncı indeksinin, pulmoner emboli hastalarında sağ ventrikül disfonksiyonunun ve mortaliteyi belirlemedeki rolünü göstermektir.

Gereç ve Yöntemler: Çalışmaya 2013- 2019 tarihleri arasında acil serviste bilgisayarlı tomografi pulmoner anjiografi sonucunda pulmoner emboli tanısı alan ve sonrasında EKO'su yapılan 180 hasta (90 kadın ve 90 erkek) çalışmaya dahil edildi. Kan basıncı indeksini; sistolik kan basıncının diyastolik kan basıncına bölünmesi ile elde edildi.

Bulgular: Hastaların ortalama kan basıncı indeksini 1.7±0.2 olarak hesaplandı. EKO'da sağ ventrikül disfonksiyonu olan ve olmayan iki grup arasında kan basıncı indeksi yönünden istatistiksel olarak anlamlı farklılık saptanmadı (p=0.529). Hastaların %22.2'sinde 30 günlük mortalite gözlendi. Mortalite gözlenen ve gözlenmeyen grup arasında kan basıncı indeksi yönünden anlamlı fark yoktu (p=0.438).

Sonuç: Pulmoner embolide kan basıncı indeksi ile sağ ventrikül disfonksiyonu ve mortalite arasında anlamlı bir ilişki tespit edilmedi. Ancak kan basıncı indeksi acil servislerde kolay ulaşılabilen ve uygulanabilen bir yöntem olması nedeniyle kullanılabilir bir parametre olduğunu düşünmekteyiz. Kan basıncı indeksi; özellikle sistolik kan basıncını düşüren pulmoner emboli hastalarında sağ ventrikül disfonksiyonunu ve mortaliteyi belirlemede daha doğru sonuçlar ortaya koyacağını tahmin etmekteyiz.

Anahtar Kelimeler: *Pulmoner emboli, kan basıncı indeksi, mortalite*

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INTRODUCTION

Pulmonary embolism (PE) is a frequently encountered cardiopulmonary emergency characterized by the occlusion of the pulmonary arterial bed, leading to potentially life-threatening consequences (1). Owing to its diverse symptomatology, the diagnosis of PE can be challenging, often resulting in underdiagnosis. Nonetheless, early and accurate diagnosis, followed by prompt initiation of appropriate treatment, holds paramount importance for optimizing patient outcomes (2).

The obstruction of the pulmonary arterial bed by a venous thrombus can precipitate acute yet reversible right ventricular failure (1). Right ventricular dysfunction (RVD) serves as a significant prognostic factor in the clinical course of patients with PE. Echocardiographic assessment (ECHO) revealing RVD is indicative of an unfavorable prognosis, necessitating the implementation of more aggressive therapeutic interventions, including early administration of thrombolytic therapy (2).

Right ventricular dysfunction may be attributed to insufficient compensatory mechanisms or impaired myocardial perfusion due to increased oxygen demand. Both circumstances contribute to compromised nourishment and functional impairment of the right ventricle, thereby potentially leading to fatal consequences (3-5).

Due to the unavailability of echocardiography (ECHO) as a readily accessible procedure, researchers have explored alternative modalities (6). Ates et al. conducted a study in which they proposed a metric called the blood pressure index (BPI). This index is calculated by dividing systolic blood pressure by diastolic blood pressure. Their investigation demonstrated that a BPI cut-off value of <1.4 exhibited a high degree of specificity and sensitivity in predicting mortality and identifying RVD in the context of pulmonary embolism (6).

In this study, our objective was to assess the diagnostic utility of BPI in determining RVD and mortality in patients diagnosed with PE in the emergency department. Additionally, we aimed to evaluate the relationship between BPI and arterial blood gas parameters.

MATERIALS AND METHODS

This study was planned as a retrospective file review. Ethical approval was obtained from the Etlik City Hospital Ethics Committee (date: 03/05/2023; number: AESH-EK1-2023-130) After obtaining ethical approval, the study was conducted in accordance with the Helsinki Declaration. The study data were recorded by two emergency specialists, and one emergency specialist reviewed the records.

In this study, patients diagnosed with PE in the emergency department of our secondary level healthcare facility between January 2013 and December 2019 were screened. Patients who were diagnosed with PE based on computed tomography pulmonary angiography (CTPA) and had an echocardiography (ECHO) performed during the diagnostic phase were included in the study. Demographic characteristics of the patients, systolic and diastolic blood pressure values at admission, blood gas analysis results, CTPA and ECHO results, were obtained from the hospital information management system and patient records archive. Data on the 30-day mortality of the patients were collected through the death reporting system.

Patients under the age of 18, those who had previously experienced PE, patients diagnosed with heart failure, individuals with acute renal failure, and those with acute liver failure were not included in the study.

This study aimed to compare the hemodynamic parameters between the group diagnosed with PE and detected RVD on ECHO and the group diagnosed with PE but without RVD on ECHO. Additionally, in this study, the association between vital signs, blood gas analysis, and mortality was analyzed between the group diagnosed with PE and detected with RVD on ECHO and the group diagnosed with PE but without RVD on ECHO.

The Blood Pressure Index (BPI) is calculated by dividing the systolic blood pressure by the diastolic

KÜ Tıp Fak Derg 2023;25(2):279-284
Doi: 10.24938/kutfd.1313498

blood pressure (BPI=Systolic BP/Diastolic BP). The relationship between BPI and mortality, as well as blood gas levels, was investigated

Statistical Analysis

The data analysis was performed using IBM SPSS 25.0 statistical software package. Descriptive statistical methods, such as frequency, percentage, mean, standard deviation, median, and minimum-maximum values, were employed to evaluate the study data. In addition, for the comparison of categorical variables, Pearson, Yates, or Fisher's chi-square ($\chi 2$) tests were utilized. The normality of the data was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests, revealing that the data did not follow a normal distribution. For group comparisons, the Mann-Whitney U test was employed. Logistic regression (binary logistic regression) analysis was conducted to determine the risk ratios for mortality. The relationships between variables were examined using the Spearman's rank correlation test. Values with a probability (P) less than or equal to 0.05 were considered statistically significant, indicating a significant difference between groups, while values greater than 0.05 were deemed statistically insignificant, indicating no difference between groups.

RESULTS

During our study period, we identified a total of 180 patients who were diagnosed with PE in the emergency department. The average age of the cases was 67.1±14.6, with 90 of them (50%) being female. The average age of the deceased patients was 73, while the surviving patients had an average age of 68.5. Although there was a difference in age between the groups, the p-value did not reach statistical significance (p=0.091).

The average systolic blood pressure at the time of admission for the patients was 130.1±24.6 mmHg, and the average diastolic blood pressure was 77.1±13.2 mmHg. The mean Blood Pressure Index (BPI) for the patients was calculated as 1.7±0.2. The average respiratory rate was 20.9, and the average pulse rate was 102.2. Table 1 provides a summary of the other vital signs and blood gas measurements.

Table 1: Vital signs of the patients

Vital Signs	Average±SD (min-max)
Systolic blood pressure (mmHg)	130.1±24.6 (80-200)
Diastolic blood pressure (mmHg)	77.1±13.2 (42-120)
BPI	1.7±0.2 (1-3)
Pulse rate (bpm)	102.2±21.4 (10-150)
Body temperature (°C)	36.9±0.6 (36-40)
Respiratory rate (breaths/min)	20.9±3.5 (7-37)
Oxygen saturation (%)	90.4±7.8 (60-99)
pH	7.4±0.1 (7-7.8)
pO_2	61.6±26.1 (11-205)
pCO_2	34.1±9.6 (13-77)
HCO_3	21.8±3.7 (10-35)
BE	-1.3±3.7 (-21--9)

BPI: Blood pressure index, pO_2: Partial pressure of oxygen, pCO_2: Partial pressure of carbon dioxide, HCO3: Bicarbonate, BE: Base excess

When the ECHO's of the patients were examined, it was found that 43.3% (n=78) of the patients had RVD. The systolic pulmonary artery pressure (sPAP) ranged from a maximum of 110 mm/Hg to a minimum of 20 mm/Hg, with a mean of 44.0±18.4. Other echocardiographic findings are presented in Table 2.

In ECHO, we did not find a statistically significant difference in terms of BPI length of stay (p=0.529) between the group with existing RVD and the group without RVD (Table 3). 30-day mortality was observed in 22.2% of the patients (n=40). There was no significant difference in terms of ICU length of stay between the group with observed mortality and the group without observed mortality (p=0.438) (Table 3).

KÜ Tıp Fak Derg 2023;25(2):279-284
Doi: 10.24938/kutfd.1313498

Tablo 2: Echocardiographic findings of the patients

ECHO findings	Number of patients n (%)
Right ventricle size is normal	102 (56.7)
Right ventricle size is increased	78 (43.3)
Systolic function is decreased	148 (82.2)
Systolic function is decreased	32 (17.8)
Pulmonary artery pressure is normal.	83 (46.1)
Pulmonary artery pressure is increased	97 (53.9)
Tricuspid regurgitation is present	79 (43.9)
No tricuspid regurgitation	101 (56.1)

Table 3: Comparison of blood pressure ındex in terms of right ventricular dysfunction and mortality

RVD	RVD absent (102)	RVD present (78)	p-value
BPI	1.78 (0.36)	1.68 (0.46)	0.529 [b]
Mortality	**Deceased (40)**	**Survived (140)**	
BPI	1.69 (1.33-2.25)	1.67 (1.25-2.67)	0.438 [a]

BPI: Blood pressure index RVD: Right ventricular dysfunction
a: * Mann Whitney-U test b: * Spearman's rho correlations test

Table 4: Correlation between Blood Pressure Index and Blood Gas Parameters

	p	R
BPI -Oxygen Saturation	0.727	-0.026
BPI -pH	0.43	-0.059
BPI -pO_2	0.798	-0.19
BPI -pCO_2	0.144	0.109
BPI -HCO_3	0.594	-0.01
BPI -BE	0.801	-0.06

BPI: Blood pressure index, pO_2: Partial pressure of oxygen, pCO_2: Partial pressure of carbon dioxide, HCO3: Bicarbonate, BE: Base excess
The Spearman's Rho correlation test yielded a statistically significant result with $p<0.05$.

A statistically significant correlation between BPI and blood gas parameters was not detected (Table 4).

We did not observe a statistically significant difference in terms of mortality between the two groups, one with RVD and the other without RVD (p=0.763). Additionally, when comparing the vital signs and blood gas results of patients with and without right ventricular dilation, no statistically significant difference was found ($p>0.05$) (Table 5).

Table 5: Comparisons by RV diameter [median (min-max)]- [n (%)]

	RV Diameter Increased (n=78)	RV Diameter Normal (n=102)	p
Age	72 (35–90)	67.5 (30–90)	0.060 [a]
Gender-Male	37 (47.4%)	53 (52.0%)	0.547 [b]
Gender Female	41 (52.6%)	49 (48.0%)	
SAP	130 (80–200)	124 (90–190)	0.736 [a]
DAP	80 (42–120)	80 (50–111)	0.342 [a]
MAP	97 (61–143)	93 (63–130)	0.415 [a]
Pulse Rate	102 (10–150)	100 (54–150)	0.156 [a]
Respiratory Rate	20 (14–32)	20 (7–37)	0.384 [a]
Fever	36.7 (36.0–38.8)	36.9 (35.8–39.7)	0.140 [a]
pH	7.43 (6.96–7.68)	7.43 (7.17–7.57)	0.362 [a]
O_2Sat	91.75 (65.2–99)	94 (60–99)	0.051 [a]
PO_2	57 (11–125)	63 (14–205)	0.097 [a]
PCO_2	33 (15–74)	33 (13–77)	0.963 [a]
HCO_3	22 (10–32)	22 (12–35)	0.872 [a]
BE	-1 (-21–7)	-1 (-12–9)	0.519 [a]
Mortality	16 (%0.089)	24 (%0.133)	0.763 [b]
BPI	1.67 (1.33-2.67)	1.67 (1.25-2.57)	0.461 [a]

RV: Right Ventricular, SAP: Systolic Arterial Pressure, DAP: Diastolic Arterial Pressure, MAP: Mean Arterial Pressure, BPI: Blood Pressure Index, O2Sat: Oxygen Saturation, pO2: Partial Pressure of Oxygen, pCO2: Partial Pressure of Carbon Dioxide, HCO3: Bicarbonate, BE: Base Excessa: Mann Whitney-U Test, b: Chi-Square Test

DISCUSSION

Pulmonary embolism is a common cardiovascular emergency encountered in the emergency department, with high mortality and morbidity rates. The mortality rate for PE is approximately 10-15% in the first three months following diagnosis (7,8). This study aimed to investigate the relationship between the BPI, RVD, and mortality in patients diagnosed with PE. The findings revealed that there was no association between BPI, RVD, and mortality among the surviving and deceased patients.

The presence of right ventricular dysfunction detected by echocardiography in patients with acute PE is an indicator of poor prognosis and increased risk of

KÜ Tıp Fak Derg 2023;25(2):279-284
Doi: 10.24938/kutfd.1313498

mortality (9). RVD not only reflects the course of the disease but also determines treatment strategies. Risk analysis in normotensive PE cases is commonly performed using echocardiography (10,11). RVD can develop in slightly more than half of PE patients, which increases the risk of sudden cardiac death (12). In a meta-analysis, it was found that patients with RVD detected by echocardiography have twice the risk of mortality associated with pulmonary embolism (13). In cases where access to echocardiography is not possible, ongoing studies are exploring new parameters that can provide insights into right ventricular function. Ates et al. stated that the BPI has high specificity and sensitivity in detecting RVD (6). In this study, no relationship was found between the BPI and RVD. This may be due to the smaller sample size compared to other studies. Additionally, we believe that our patients being normotensive may have contributed to this lack of association. It has been shown that as BPI decreases, statistically significant values are obtained for RVD in PE (6). The presence of hypotension or shock remains the most important prognostic factor in PE (14).

In the study conducted by Hirsh et al., PE is recognized as a significant cause of mortality and morbidity, with approximately six hundred thousand new cases and around sixty thousand deaths occurring each year (15). In our study, the thirty-day mortality rate was determined to be 22.2%. This suggests that despite advancements in the diagnosis and treatment of acute PE, the mortality rate remains high. Previous studies have also shown mortality rates above 15%, further highlighting the significant impact of acute PE on patient outcomes (12). Our mortality rate is parallel to the literature. In patients with RVD, both mortality and morbidity risks have increased. According to the study conducted by Barco et al., mortality was observed to be higher in the group with RVD (6,16). In this study, mortality was observed in nearly half of the patients with RVD. However, unlike the literature, we did not find a significant difference between mortality and RVD in this study. This may be related to the early ECHO examinations and initiation of diagnosis and treatment before the development of RVD in our patients. Additionally, the rate of massive emboli in our study group was very low. In the study by Ateş et al., a significant relationship between RVD and KBI variable was identified, and a significant number of patients were found to have massive PE (6).

In conclusion, no significant relationship was found between BPI and RVD or mortality in PE. However, we believe that BPI can be a useful parameter due to its easy accessibility and applicability in emergency departments. We anticipate that BPI, which reflects the decrease in systolic blood pressure in PE patients, may provide more accurate results in determining RVD and mortality.

Conflict of Interest: No conflict interest. The author alone was responsible for the content and writing of the paper. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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KÜ Tıp Fak Derg 2023;25(2):279-284
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