

Determinants of survival in acute pulmonary thromboembolism: real-life data from a 3-level health institution

 Hatice Çetindoğan¹,  Nesrin Öcal²,  Deniz Doğan²,  Cantürk Taşçı²,  Yakup Arslan²,
 Derya Doğan³

¹Department of Chest Diseases, Ankara Yıldırım Beyazıt University Yenimahalle Training and Research Hospital, Ankara, Türkiye

²Department of Chest Diseases, Gülhane Faculty of Medicine, University of Health Sciences, Ankara, Türkiye

³Department of Chest Diseases, Ankara Etlik City Hospital, Ankara, Türkiye

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Corresponding Author: Hatice Çetindoğan, cetindoganh@gmail.com

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ABSTRACT

Aims: Given that pulmonary thromboembolism is a prevalent cause of cardiovascular mortality, identifying quick and accessible diagnostic-prognostic markers for pulmonary thromboembolism may significantly contribute to mortality reduction. In this study, we aimed to determine to what extent diagnosis-prognosis markers of patients are predictive of survival, based on real-life data.

Methods: Data from patients hospitalized with the diagnosis of pulmonary thromboembolism were retrospectively investigated. The demographic, clinical, and radiological findings were analyzed. Probability, severity, and mortality score determinations of patients with acute PE were analyzed using the Charlson Comorbidity Index, Pulmonary Embolism Severity Index, and Simplified Pulmonary Embolism Severity Index scores.

Results: The data of 300 patients were evaluated. The mortality rate was 11%. The mortality group had an elevated mean age compared to the survival group ($p=0.035$). Hospital death was 7.3%, highest in the 9th and 6th decades ($p=0.025$ and $p=0.036$). The mortality rate was 26.6% in patients with thrombus in the pulmonary artery trunk ($p=0.01$). The presence of right heart strain on echocardiography was correlated with mortality. ($p<0.05$). The mean Pulmonary Embolism Severity Index and Simplified Pulmonary Embolism Severity Index scores also showed an important difference between survival groups ($p=0.028$ and $p=0.021$). Although the mean Charlson Comorbidity Index score tended to be higher among the non-survivors, this numerical difference did not achieve statistical significance ($p>0.05$). Mortality was significantly higher in those with a high 30-day early mortality score compared to those in all groupse ($p=0.02$).

Conclusion: Demographic and clinical characteristics are closely related to the survival of patients with pulmonary thromboembolism. An individual approach to patients diagnosed with pulmonary thromboembolism will provide management above all scores.

Keywords: Demographic, risk, Pulmonary Embolism Severity Index, Charlson Comorbidity Index, prognosis

INTRODUCTION

Pulmonary thromboembolism (PE) is a widely prevalent condition morbidity and mortality that affects the pulmonary and cardiovascular systems. Although the acute PE mortality rates have decreased with the widespread clinical use of diagnosis and treatment algorithms in the guidelines published in recent years, the incidence of PE is gradually increasing.¹ PE is still the third most common acute cardiovascular disease globally after myocardial infarction and stroke.² Given that numerous differential diagnoses can mimic the presenting signs and symptoms of PE, maintaining a high index of clinical suspicion is the paramount initial step in the diagnostic process. Possible delays in diagnosis are

among the most important points in terms of mortality. In many post-mortem evaluations, PE findings were found in individuals who were not clinically diagnosed while alive.

A timely diagnosis and a prognosis assessment for determining how the patient should be followed up may be at least as effective on survival as the clinical findings of the patient. Thus, a rapid and easy diagnostic approach will play a key role in reducing mortality.

Individualized patient management based on demographic, clinical, and radiological findings may be an appropriate

approach in this respect. The most logical way to achieve all this is to benefit from real-life data. However, data on this subject are limited.

More real-life data are needed to demonstrate the principles of the individualized approach.^{2,3} Clinical guidelines offer us some scoring systems in terms of PE probability and prognosis, such as Well's probability scoring, Pulmonary Embolism Severity Index (PESI) and simplified PESI (sPESI) scores, and 30-day early mortality risk groups determined according to the ESC/ERS pulmonary embolism guideline. PESI is a clinical risk score used to assess the 30-day mortality risk in patients with acute pulmonary embolism (PE). sPESI is an easier and faster version of PESI (Table 1, 2).^{4,5}

Table 1. Pulmonary Embolism Severity Indexes (PESI, sPESI) ^{1,4,5}		
Parameter	PESI score	sPESI score
Age	Age/year	>80 age is one point
Malignancy	30	1
Male gender	10	-
Chronic pulmonary disease	10	1
Chronic cardiac disease	10	1
Systolic blood pressure <100 mmHg	30	1
Pulse ≥110/min	20	1
Respiratory rate ≥30/min	20	-
Respiratory rate ≥30/min	20	-
Arterial O ₂ saturation <90%	20	1
Change in mental status	30	1
	Low risk Class I: ≤65 Class II: 66-85 High risk Class III: 86-105 Class IV: 106-125 Class V: >125	Low risk: 0 High risk: ≥1

However, it may not be correct to evaluate the data obtained from these scorings in the same way for every patient. Patient characteristics, especially demographic findings and comorbidities, weaken the validation of these scorings.

The Charlson Comorbidity Index (CCI) is a validated prognostic scoring system used to measure a patient's comorbidity burden, assigning a specific weight (point) to each comorbid diagnosis. As the total CCI score increases, so does the patient's risk of mortality and rehospitalization. CCI measures disease burden and evaluates more than 17 comorbidities, including cardiovascular disease,

malignancies, chronic lung and neurological diseases, and connective tissue diseases (Table 3).⁶

Table 3. Charlson Comorbidity Index ⁶	
Score	Comorbidity
1	Coronary artery disease
1	Congestive heart failure
1	Chronic pulmonary disease
1	Peptic ulcer
1	Peripheral vascular disease
1	Mild liver failure
1	Cerebrovascular disease
1	Connective tissue disease
1	Diabetes mellitus
2	Hemiplegia
2	Moderate or severe renal failure
2	Diabetes mellitus causing end-organ failure
2	Any tumor diagnosed 5 years ago
2	Leukemia
2	Lymphoma
3	Moderate or severe liver failure
6	Metastatic solid tumor
6	AIDS (not just HIV+)

The central purpose of this analysis is to examine the clinical utility of probability and risk scoring systems and to determine to what extent diagnosis-prognosis markers of patients are predictive of survival, based on real-life data.

METHODS

Ethics

The study was carried out with the permission of the Health Sciences University Gülhane Training and Research Hospital Scientific Researches Evaluation and Ethics Committee (Date: 05.11.2020, Decision No: 2020-430). All processes involving human subjects were executed in strict conformity with the principles outlined in the Declaration of Helsinki and prevailing ethical guidelines.

Methodological Blueprint and Participants

The files and data of adult patients diagnosed with acute PE in the chest diseases clinic between October 1, 2016, and October 1, 2020, were subjected to retrospective review. Patients with a definite diagnosis of PE and whose data could be accessed

Table 2. PE severity and early (in-hospital or 30-day) mortality risk stratification ^{1,4,5}				
Early mortality risk group		Risk parameters and scores		
		Shock or hypotension	Clinical parameters PESI 3, 4, 5 sPESI ≥1	Cardiac troponin(>0.04 ng/ml) elevation
High		+	+	+
Intermediate	High	-	+	+
	Low	-	+	One (+) or both (-)
Low		-	-	No evaluation is required, if requested it should be negative

PE: Pulmonary embolism, PESI: Pulmonary Embolism Severity Index, sPESI: Simplified PESI, ECHO: Echocardiography, CTA: Computed tomography-angiography

reliably were included. Patient files were analyzed in terms of clinical, laboratory, and radiological findings.

Patients were Categorized as Follows as PE Diagnosis Methods

Computed tomography-angiography (CTA), ventilation/perfusion scintigraphy (V/Q), and/or clinical+echocardiography (ECHO)±Doppler ultrasonography (USG) findings. The Well's scores (which evaluate the likelihood of pulmonary embolism) and PESI and sPESI scores (which evaluate the risk of early mortality after diagnosis) of the patients at the time of diagnosis were recalculated in light of the data obtained from the file scan. CCI scores were also calculated by examining comorbidities from patient files and medical histories in electronic records. The survival and mortality of the patients during the diagnosis and treatment of PE were recorded. Findings were compared and analyzed between survival and mortality groups. These examinations were also discussed in terms of age groups, comorbidity groups, and clinical and radiological findings.

Statistical Analysis

The data analysis was performed on the entire dataset using the dedicated IBM SPSS Statistics platform (Version 22.0; Armonk, NY, USA, 2013). The compatibility of continuous variables with normal distribution was evaluated by the Kolmogorov-Smirnov test. The Mann-Whitney U test or Student's t-test was used depending on whether the groups were normally distributed or not. The correlations of the obtained numerical parameters were analyzed. A value of $p < 0.05$ was evaluated as sympathetically important.

RESULTS

A total of 600 patients with a preliminary diagnosis of PE were hospitalized in the chest diseases clinic between October 1, 2016, and October 1, 2020. It was determined that the data of 445 of them could be accessed and 300 of them could be included in the study. Exclusion criteria: Inability to access the patient file or incomplete/insufficient clinical data. Pregnancy (due to different clinical evaluation processes). Hospitalization with a preliminary diagnosis of PE, but an alternative diagnosis has been confirmed (e.g., pneumonia, aortic dissection, malignant embolism, chronic thromboembolic disease). Patients hospitalized due to the development of acute complications during the treatment process with a diagnosis of PE. In case of duplicate records of the same patient during the study period (Figure 1).

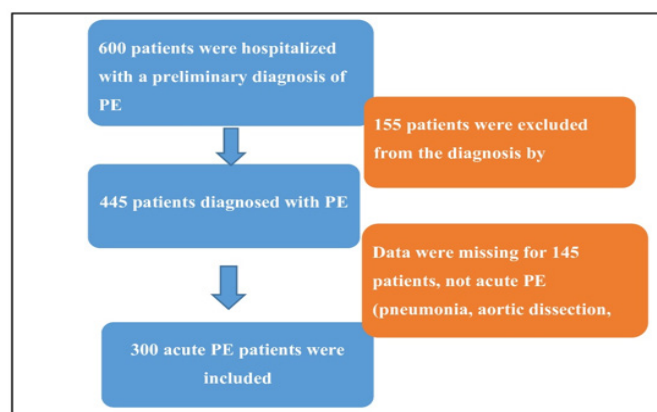


Figure 1. Patients' inclusion-exclusion scheme

Baseline characteristics of patients: The mean age of the patients was 66.1 ± 17.6 years (20-96). When the gender distributions were examined, it was observed that 51.3% ($n=154$) of all patients were female, 48.7% ($n=146$) were male, and the mean age in women was significantly higher (69.3 ± 16.2 and 62.6 ± 18.4 years, respectively; $p=0.001$). Out of 300 patients, 278 (89%) resulted in survival, while 22 (11%) resulted in mortality. The mean age was significantly different between the mortality and survival groups (70.1 ± 17.6 vs. 65.7 ± 17.6 years, $p=0.035$).

When patients were examined in terms of survival according to decades of age, it was observed that the highest mortality rates were observed in patients in the 9th and 6th decades ($p=0.025$ and $p=0.036$, respectively) (Figure 2).

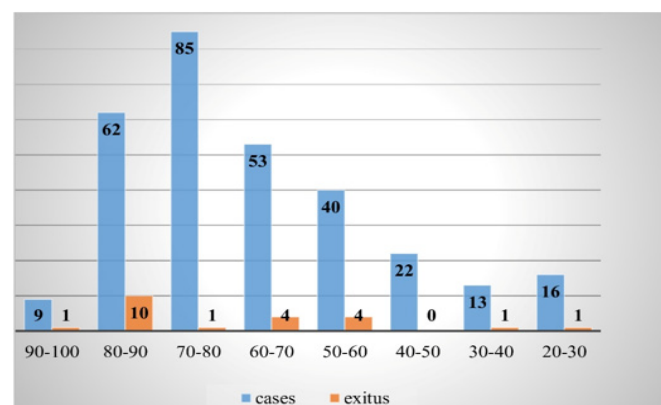


Figure 2. Mortality rates according to age decades

When patients were examined in terms of survival according to decades of age, it was observed that the highest mortality rates were observed in patients in the 9th and 6th decades (comorbidities were investigated both for all patients and for the mortality group).

The distribution of comorbidities in order of frequency was as follows: diabetes mellitus (DM) in 23.7%, malignancy (active or in remission) in 22.7%, chronic obstructive pulmonary disease (COPD) in 12.3%, chronic kidney disease (CKD) in 11%, atrial fibrillation (AF) in 7.7%, and cerebrovascular event in 7% ($p=0.025$ and $p=0.036$, respectively).

Among the comorbidities in the mortality group, 17.3% had AF, 15.1% had CKD, 10.8% had COPD, 10.2% had malignancy, and 7.1% had DM. AF and CKD were significantly more common in the mortality group ($p=0.02$).

Among all patients, immobility was the most common risk factor, with a rate of 42.7%. This was followed by cancer and surgery in the last 4 weeks (17.7% and 10%, respectively). The distribution of predisposing factors in the general population and mortality group is summarized in Table 4.

Conditions that make up the "other" risk factors included COVID-19 infection, minor surgery, antiphospholipid antibody syndrome, Osler-Weber-Rendu syndrome, heavy smoking, and secondary polycythemia (Table 4).

We observed that 63 (21%) of the patients diagnosed with PE were screened for genetic thrombophilia according to their indications (non-provocable/idiopathic PE, recurrent PE,

Table 4. Mortality rates for each risk factor

Risk factor	n (%)	Mortality, n (%)*
Atrial fibrillation	17 (5.7)	1 (5.8)
Pregnancy	3 (1)	0
Surgery in the last 4 weeks	30 (10)	0
Active cancer	53 (17.7)	6 (11.3)
Malignancy in remission	13 (4.3)	0
Immobility	128 (42.7)	14 (10.9)
Bone fracture	21 (7)	2 (9.5)
Short trip	6 (2)	0
Other **	10 (3.3)	2 (20)

*Death rates are calculated based on the number of patients in each risk factor group
 **Other: COVID-19, minor surgery, antiphospholipid disease, Osler Weber Rendu, smoker and secondary polycythemia

young age, etc.). Among the 18 patients with homozygous mutations, the FV-Leiden mutation was the first, with a rate of 46.2%.

Findings related to PE: The most common symptoms were dyspnea (87.1%) and chest pain (54.6%). While the mortality rate was significantly lower in patients presenting with chest pain, it was significantly higher in those presenting with syncope ($p=0.025$ and $p<0.001$ respectively).

The diagnostic methods of the patients were determined. 227 (75.7%) patients were diagnosed with CTA, 63 (21.0%) patients were diagnosed with V/Q scintigraphy, and 21 (7.0%) patients were diagnosed with clinical+ECHO±Doppler USG findings. 101 (33.7%) of the patients diagnosed with PE had concurrent acute DVT. The percentages represent the frequency of use of diagnostic modalities. Some patients, particularly in cases of diagnostic uncertainty, were evaluated with more than one method (e.g., CTA+ECHO or CTA+V/Q scintigraphy). Therefore, the distribution of patients by diagnostic method exceeds 100% overall. Percentages reflect the relative rates of use of the diagnostic methods used, not mutually exclusive patient groups. We found that the thrombus localization in our PE cases was associated with mortality. The mortality rate was high in those with thrombus in the pulmonary artery trunk (26.6%) ($p=0.01$).

ECHO was performed on 217 of 300 patients in the study population. Patients who underwent echocardiography may be more clinically stable, have more comorbidities, or be more suitable for evaluation. Reasons for patients not undergoing echocardiography: Clinical instability/hemodynamic disturbance, inadequate image quality (obesity, chest wall deformity, mechanical ventilation), referral to rapid CT pulmonary angiography and postponement of echocardiography during the diagnostic process, early discharge or transfer of the patient, limited device/operator access. Right heart dilatation was reported in 6.3% of the patients who underwent ECHO, tricuspid regurgitation in 69.1%, and global hypokinesia in 12.0%. In 148 patients whose sPAP could be measured with ECHO, the mean sPAP was 46.4 ± 21.4 mmHg. Patients with normal Pab values were not recorded. Patients with Pab values above 30 were included in the study. Patients with increased right heart load were included in the measurements. Of course, considering that sPAP is calculated indirectly from the tricuspid velocity, it is reasonable to think that most patients in whom sPAP cannot

be measured do not have high pressures. In this respect, this rate may not reflect the full patient population. Systolic pulmonary artery pressure (sPAP), right heart dilatation, and global hypokinesia findings indicating right heart strain showed significant differences in terms of survival. sPAP was higher in the mortality group.

While the mean sPAP was 41.8 ± 22.4 mmHg in survivors, it was 51.3 ± 31.1 mmHg in the mortality group ($p=0.037$). The mortality rates in those with and without right heart dilatation were 11.8% and 1.6%, respectively ($p=0.021$); and the mortality rates in those with and without global hypokinesia were 25.0% and 5.8%, respectively ($p=0.007$).

PESI and sPESI scores were significantly different between survival and mortality groups ($p=0.028$ and $p=0.021$, respectively). There was a higher mortality rate in those with higher CCI and age-adjusted CCI scores, but the difference was not significant ($p>0.05$). The prognosis of patients according to the early mortality risk groups was also analyzed (Table 2). The frequency of death was significantly higher in the high-risk group than in all groups ($p=0.02$).

The relationship between the laboratory test results of the patients at the time they were diagnosed with PE and survival was also analyzed. Among the parameters, only high D-dimer was associated with mortality. Pro-BNP and cardiac enzymes were also higher in the mortality group, but the difference was not statistically significant.

The correlations between the obtained data were also analyzed. Accordingly; significant correlations were found between sPAP and age ($r=0.185$ and $p=0.006$), sPAP and PESI score ($r=0.156$ and $p=0.022$), D-dimer and age ($r=0.117$ and $p=0.034$), D-dimer and PESI score ($r=0.141$ and $p=0.034$), age and PESI score ($r=0.579$ and $p<0.001$), PESI and WELLS score ($r=0.265$ and $p<0.001$), and PESI and length of hospital stay ($r=0.136$ and $p=0.019$).

DISCUSSION

The real-life data obtained in this study show that advanced age, presenting with syncope, high D-dimer level, central location of thrombus, detection of right heart strain findings on echocardiography, presence of comorbidities, high PESI and sPESI scores, and being in a high early mortality risk group are significantly associated with mortality in patients with acute PE. Based on these results, an individualized approach and close follow-up in patients with these risk factors may provide positive gains in prognosis. When the studies in the literature are examined, meticulous and successful PE management has a significant effect on the patient's prognosis.

While a mortality rate of up to 30% is observed in untreated acute PE, the mortality rate in PE diagnosed and treated in a timely manner has been reported as 8%.⁸ In a study conducted in Germany, the in-hospital mortality rate of patients hospitalized with a diagnosis of acute PE between 2005 and 2015 was reported as 16.6%.⁹ In our study, this rate was 7.3%, and it is seen that we have made positive progress in survival with the developments in PE diagnosis and treatment modalities.

In recent studies, old age is considered a risk factor for both the risk of developing PE and PE-related mortality.^{10,11} This claim was largely confirmed in our study.

While patients aged 60 years and over constituted 75.0% of all cases, elderly patients constituted 72.7% of cases resulting in mortality. On the other hand, no significant difference was found when we examined the mortality rates of the elderly and young patient groups separately (7.1% vs. 8.0%).

It has been reported in the literature that many comorbidities are frequently seen in this patient group.^{12,13} Studies are showing that COPD exacerbation and AF may be risk factors for PE frequency and mortality. On the other hand, the cause-and-effect relationship between PE and AF is complex.^{14,15} While thrombus formation can be triggered by AF, acute PE itself can also trigger the development of AF. The hypothesis that PE can cause AF has a pathophysiological basis. A sudden increase in pulmonary vascular resistance can cause loading of the right ventricle and thus an increase in right atrial pressure. This can lead to atrial arrhythmias such as AF.¹⁵ It has been reported that the risk of VTE is increased in patients with active cancer.^{16,17} Similar to the literature, malignancy and AF were frequently detected in our study. When we performed subgroup analysis for the mortality group, the order of comorbidity frequency was AF, chronic kidney disease, chronic obstructive pulmonary disease and malignancy.

Many risk factors that increase the incidence of PE have been identified. Depending on the presence of these risk factors, patients are classified as unprovoked and provoked PE.¹ Whether the risk factor is permanent or transient is also important. Recent history of lower extremity fracture, history of hospitalization for heart failure or AF in the last 3 months, hip or knee prosthesis, major trauma, myocardial infarction in the last 3 months, and spinal cord injury have been identified as the strongest risk factors.^{1,17} The fact that our study population was predisposed to immobility, advanced age, and multiple comorbidities was also found to be consistent with the literature.

Genetic thrombophilia is one of the well-known PE risk factors. However, the literature on this subject is very limited. Until the early 2000s, only a weak gene locus had been definitively identified as being associated with VTE. Most of these variants involved strong genetic risk factors such as antithrombin or protein C deficiencies, which increase the risk of VTE by almost 10% in heterozygous carriers. However, since these genotypes are found in less than 1% of the population, this type of thrombophilia represented a very small group of patients. Since PE usually occurs as a complication of DVT, hereditary risk factors are generally thought to be common to these two entities. However, the prevalence and risk associated with many risk factors such as Factor V Leiden or activated protein C resistance differ between DVT and PE. The Factor V Leiden paradox suggests that the rs6025 polymorphism increases the risk of DVT more than the risk of PE.^{18,19} These results emphasize the need to consider DVT and PE as different phenotypes in VTE genetic studies. In our study results, the FV-Leiden mutation ranked first among patients with homozygous mutation. DVT was

present in 12 of our 18 patients with the FV-Leiden mutation. This situation was considered consistent with the literature. Considering these data, it seems appropriate to investigate genetic thrombophilia in patients with unprovoked PE in the presence of DVT.

In patients with suspected PE diagnosis, laboratory tests and PE probability scores should be evaluated first. In this respect, D-dimer, a fibrin degradation product, is considered quite guiding in hemodynamically stable patients. In the diagnostic approach to PE, d-dimer is a test with high specificity in exclusion.^{20,21} However, the relationship between D-dimer elevation and prognosis is not clear. According to our results, D-dimer levels were above the expected values according to age in patients diagnosed with PE. We also detected significantly higher D-dimer levels in the mortality group compared to the survivors. These results indicate that D-dimer may have not only a diagnostic but also a prognostic role.

Mortality risk scoring is recommended as a guide in treatment planning in PE patients.²² PESI, sPESI, and early mortality risk scores recommended in current guidelines are still used in clinical practice. In our study, these scores and additional CCI scores of the patients were examined. The mean PESI and sPESI scores showed a significant difference between survival and mortality groups. There are several studies on whether the CCI score can be used to predict acute and long-term outcomes in patients with acute PE.^{6,7} Although the CCI was higher in the mortality group in our study, this difference was not statistically significant.

Hemodynamic status is the most important determinant of PE prognosis. The instability of the patients at the time of presentation is also related to this situation. Right ventricular dysfunction, which is the basic mechanism of hemodynamic collapse in patients with PE, is one of the early mortality indicators in patients with acute PE. Cardiac arrhythmias and conduction disorders due to right ventricular overload have been identified as possible causes of syncope in PE.²³ It has been reported that detection of thrombus in the main pulmonary artery is more common in patients with PE presenting with syncope.²⁴⁻²⁶ In our study, the mortality rate was found to be the highest in patients presenting with syncope and was evaluated in accordance with the literature. ECHO is also quite insignificant in the assessment of the risk of hemodynamic deterioration. In this respect, it is a very important part of the diagnosis and treatment algorithms of patients with PE. Our study results also showed that ECHO findings are closely related to mortality and clearly support this idea.

Limitations

Our study is retrospective and single-center. This limits the number of patients. Collecting data from patient records increases the risk of missing, inconsistent, or incorrect data. This may result in some important variables (e.g., sPAP, which cannot be measured in all patients, or some laboratory tests) being excluded from the analysis. Nevertheless, the goal of presenting real-world data is important and instructive for such studies.

CONCLUSION

The real-life data presented in this study validated the usefulness of the scores recommended by current guidelines in determining the probability, severity, and mortality risk of PE. However, it was also concluded that an individual approach that includes the patients' own baseline characteristics, localization of thrombus, and echocardiographic findings of PE is a better guide. The most important limitation of our study is that it was designed retrospectively. Multicenter, prospective studies with a larger number of cases may clarify this issue more clearly.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Health Sciences University Gülhane Training and Research Hospital Scientific Researches Evaluation and Ethics Committee (Date: 05.11.2020, Decision No: 2020-430).

Informed Consent

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

The authors received no financial support for the conduct or publication of this research.

Author Contributions

All authors contributed significantly to the study's conception, design, data acquisition, analysis, and interpretation. All authors reviewed and approved the final version of the manuscript.

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