RESEARCH ARTICLE

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Assessment of Right Ventricular Function by Echocardiography in Patients with Pulmonary Embolism

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Abstract

Background and Aim: Pulmonary embolism (PE) is a cardiovascular disease associated with significant morbidity and mortality. Right ventricular (RV) dysfunction is a major determinant of prognosis in PE, and echocardiography is a key tool for assessing RV function. This study aimed to evaluate RV function by echocardiography in patients with intermediate-high-risk PE, with particular attention to the effect of thrombolytic therapy (TT).

Materials and Methods: This retrospective, observational, comparative cohort study included 36 patients diagnosed with intermediate-high-risk PE between 2017 and 2019. The diagnosis of PE was confirmed by computed tomographic angiography or ventilation-perfusion scintigraphy. Echocardiographic assessment included RV free wall longitudinal strain (RVFWLS), and functional capacity was measured by the 6-minute walk distance (6MWD). Patients were divided into TT and non-TT groups for comparison.

Results: Of 36 patients diagnosed with intermediate-high-risk PE, 58.3% (n=21) received TT, while 41.7% (n=15) did not receive this treatment. The mean RVFWLS was -29.76% in the TT group and -22.8% in the non-TT group ($P = 0.012$). The mean 6MWD was 434 m in the group receiving TT and 357 m in the group not receiving TT. Although 6MWD was higher in the TT group, the difference was not statistically significant ($P = 0.179$).

Conclusion: Echocardiographic evaluation provides valuable insight into RV function in patients with PE. In this cohort of intermediate-high-risk patients, TT was associated with better preservation of RV systolic function, supporting its potential role in selected cases.

Keywords: Embolism, pulmonary, fibrinolytic therapy, right ventricular function speckle tracking echocardiography

INTRODUCTION

Right ventricular (RV) function is a prognostic marker in patients with pulmonary embolism (PE) and plays an instrumental role in guiding treatment decisions. This patient group has been identified as being in the high-risk category for the development of long-term RV dysfunction.[1]

The utilization of thrombolytic therapy (TT) in intermediate-high-risk patients with PE remains a subject of considerable debate. The extant studies have primarily focused on mortality, and there are limited data on the evaluation of the long-term effect of TT on RV function.[2]

The present study investigates the RV function of patients with intermediate-high-risk PE who received TT, aiming to evaluate

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its long-term impact on RV performance. We hypothesized that TT preserves RV systolic function, as measured by RV free wall longitudinal strain (RVFWLS), in this patient population.

METHODS

Patients who were treated in outpatient clinics or admitted to hospital with a diagnosis of submassive (intermediate-high-risk) PE at University of Health Sciences Türkiye, Antalya Training and Research Hospital between January 2017 and June 2019 were included in this retrospective, observational, comparative cohort study.

The patient data were retrieved from the hospital automation system, archives, outpatient clinic examination records, and patient files. The study was approved by the Clinical Research Ethics Committee of University of Health Sciences Türkiye, Antalya Training and Research Hospital (decision no: 18/15, date: 08.08.2019).

The study population was selected in accordance with the 2019 European Society of Cardiology (ESC) PE guidelines.[3] A comprehensive analysis was conducted of the clinical presentations, blood parameters, computed tomography (CT) angiography, and echocardiographic (ECHO) findings of patients diagnosed with PE across the entire hospital system. The criteria for RV systolic dysfunction were defined as a RV wall/left ventricular wall ratio >1 on ECHO or CT and a lateral S' velocity of 14 ng/L, according to the 2019 PE guidelines. Patients who met the criteria for intermediate-high-risk PE, as defined by the 2019 ESC PE guidelines, and had received optimal medical treatment for at least three months after the diagnosis of PE were contacted by telephone. RV function was evaluated by ECHO using a Philips EPIQ 7C device. RVFWLS values were expressed as negative percentages; more negative values (i.e., larger absolute values) indicate better RV systolic function. Subsequently, a 6-minute walk test (6MWD) was performed. Patients aged 18 to 80 years who were diagnosed with intermediate-high-risk PE and had follow-up data for a minimum of six months were included in the study. Patients older than 80 years, younger than 18 years, and those with high-risk (massive), intermediate-low-risk, and low-risk PE were excluded from the study.

The term "healed PE" was defined as the absence of occlusive lesions on follow-up CT pulmonary angiography and the absence of perfusion defects on ventilation-perfusion scintigraphy after a minimum of three months of optimal medical therapy. This study is summarized in the central Figure 1.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY). The descriptive statistics were presented as n (%), mean ± standard deviation, and median (min-max). The associations between categorical variables were analyzed using Pearson's chi-square test and Fisher's exact test. The Shapiro-Wilk test was employed to assess the assumption of normality. When measurement values in the

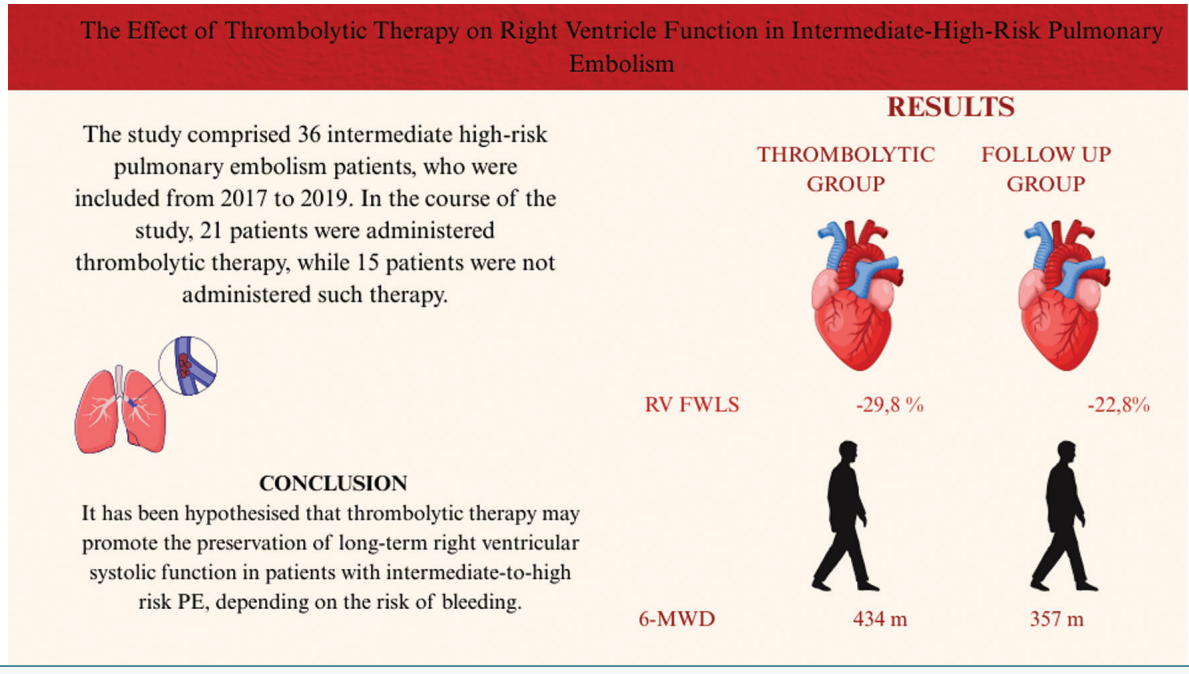

Figure 1. Graphical abstract showing the effect of thrombolytic therapy on right ventricular function in patients with intermediate-high-risk pulmonary embolism.

RVFWLS: Right ventricular free wall longitudinal strain, 6MWD: 6-minute walk distance

two groups were not normally distributed, the Mann-Whitney U test was applied. Conversely, when the data followed a normal distribution, the Student's t-test was used. The Kruskal-Wallis test was used to perform nonparametric comparisons among three or more groups, and the Bonferroni-Dunn test was applied as a post-hoc analysis following significant results. Spearman's correlation test was used to analyze ordinal variables or continuous variables that did not follow a normal distribution. Conversely, Pearson's correlation test was used for continuous variables that were normally distributed. Statistically significant results were defined as those with *P* values less than 0.05.

RESULTS

The study included 36 patients diagnosed with intermediate-high-risk PE. A total of 21 patients (58.3%) received TT, while 15 (41.7%) did not.

Table 1 presents the patients' general characteristics by treatment group. The mean age was 59.62±15.98 years in the TT group and 57.53±12.86 years in the non-TT group. No statistically significant difference in mean age was observed between patient groups across treatment categories ($P = 0.679$). 38.1% of the patients who received TT were male. An examination of the data revealed no statistically significant differences in gender distribution across the various treatment groups ($P = 0.908$). No significant differences were observed between groups for other parameters ($P > 0.05$).

Imaging and laboratory findings of patients at the time of diagnosis, stratified by TT groups, are compared in Table 2. The mean RV/left ventricular ratio was 1.12±0.07 in the TT group and 1.10±0.10 in the non-TT group; no significant difference was found ($P = 0.674$). Troponin T values were significantly higher in the TT group than in the group without TT ($P = 0.002$). No significant differences were observed between the groups for other ECHO and CT parameters.

The following investigation analyzed the post-treatment RV parameters of the patients according to their TT group (see

Table 1. Baseline demographic and clinical characteristics of patients

Variables	TT (n=21)	No TT (n=15)	*P*-value
Age (years)	59.62±15.98	57.53±12.86	0.679
Gender - Female - Male	 13 (61.9%) 8 (38.1%)	 9 (60%) 6 (40%)	0.908
History of CVD	2 (9.5%)	1 (6.7%)	0.999
Clinical presentation at diagnosis of PE - Acute - Subacute	 20 (95.2%) 1 (4.8%)	 10 (66.7%) 5 (33.3%)	0.063
Type of anticoagulant used - NOAC - OAC - LMWH	8 (38.1%) 10 (47.6%) 3 (14.3%)	 3 (20%) 9 (60%) 3 (20%)	 0.295 0.463 0.463
Temporary risk factors - No - Strong - Moderate - Weak	 14 (66.7%) 3 (14.3%) 1 (4.8%) 3 (14.3%)	9 (60%) 3 (20%) 1 (6.7%) 2 (13.3%)	0.938
Persistent risk factors - No - Genetic - Cancer	 16 (76.2%) 3 (14.3%) 2 (9.5%)	 13 (86.7%) 1 (6.7%) 1 (6.7%)	0.832
Idiopathic	11 (52.4%)	9 (60%)	0.650
s-PESI score	1 (1-3)	1 (1-2)	0.825
Duration of dyspnea (days)	2.5 (1-7)	2 (1-28)	0.657

CVD: Cardiovascular disease, PE: Pulmonary thromboembolism, NOAC: New oral anticoagulant, OAC: Oral anticoagulant, LMWH: Low-molecular-weight heparin, s-PESI: Simplified pulmonary embolism severity index, TT: Patients who received thrombolytic therapy, No TT: Patients who did not receive thrombolytic therapy

Table 3). The analysis yielded a statistically significant result: the mean proximal RV outflow tract diameter of the patients who received TT (28.27±3.21) being smaller compared to that of the patient group not receiving TT (32.07±6.43), as indicated by a *P*-value of 0.032. Despite this, the incidence of RV hypertrophy was lower in the patient cohort that underwent TT (5.3%) compared with the cohort that did not receive this therapy (35.7%). However, this difference was not statistically significant ($P = 0.062$). The mean RV wall thickness was lower in patients who received treatment (3.13±0.55) than in those who did not (3.94±1.25) ($P = 0.038$). The mean right atrial (RA) longitudinal diameter of patients who received treatment (45.46±7.38) was smaller than that of patients who did not receive treatment (52.1±9.14) ($P = 0.038$). The analysis revealed no statistically significant differences in the RA area ($P = 0.313$), RV velocity ($P = 0.240$), estimated RV pressure ($P = 0.314$), baseline RVFWLS ($P = 0.114$), and pulmonary artery pressure ($P = 0.157$) between the treatment groups in the study. A subsequent comparison of the inferior vena cava (IVC) diameter between the treatment groups revealed that the IVC diameter in the treated group (11.75±3.89) was significantly smaller than in the untreated group (15.91±5.01) ($P = 0.009$). A greater percentage of patients in the TT group (90%) exhibited a IVC collapse rate exceeding 50% compared with those in the non-therapy group (53.3%) ($P = 0.022$). Mean apical RVFWLS ($P = 0.008$), mean mid RVFWLS ($P = 0.027$), and overall mean RVFWLS ($P = 0.012$) were elevated in the cohort receiving TT. Although the mean 6MWD was higher in the treated group, the difference was not statistically significant ($P = 0.179$).

Table 4 presents the mean values of RVFWLS according to patients' general characteristics and imaging findings at the time of diagnosis. The median RVFWLS values were 27 (20-48) and 17.5 (11-26) in acute and subacute patients, respectively. The mean RVFWLS of acute patients was significantly higher than that of subacute patients ($P = 0.014$). Mean RVFWLS values among patients with thrombus on control CT (21.82±7.08) were lower than among those without it (30.11±7.55) ($P = 0.007$). The mean RVFWLS was lower in patients with chronic thromboembolic pulmonary hypertension than in patients with healed PE ($P = 0.010$). No significant differences were observed between the groups for other parameters.

Table 5 presents the results of the correlation analysis between mean RVFWLS and other variables across all patients and treatment groups. In all patients, a moderate, statistically significant negative correlation was identified between the RA diameter at diagnosis and the mean RVFWLS after treatment (r=-0.557, $P = 0.031$). The patients who received TTwere found to have a statistically significantly strong negative correlation between D-dimer at diagnosis and the mean post-treatment RVFWLS (r=-0.745, $P = 0.008$). In contrast, those patients who did not receive TT had a statistically significantly negative moderate correlation between dyspnea duration at diagnosis and the mean post-treatment RVFWLS (r=-0.580, $P = 0.023$).

Table 2. Comparison of echocardiographic, CT, and laboratory findings between treatment groups

Variables	TT (n=21)	No TT (n=15)	*P*-value
RV/LV ratio	1.12±0.07	1.10±0.10	0.674
Location of thrombus on CT - Main pulmonary artery - Lobar	 19 (95%) 1 (5%)	 12 (100%) 0 (0%)	0.999
D-dimer (ng/mL)	3149.5 (1410-62145)	2478.5 (1032-16447)	0.713
Troponin T (pg/mL)	229 (15-348)	43 (16-197)	**0.002**
Venous Doppler findings	4 (57.1%)	1 (10%)	0.101
LVEF (%)	60 (60-65)	60 (45-65)	0.211
RV diameter (mm)	48 (42-52)	49 (41-51)	0.815
RA diameter (mm)	55 (44-58)	56.5 (48-64)	0.232
TR rating	2.5 (1-3)	3 (2-4)	0.228
SPAP (mmHg)	61 (1-74)	62.5 (37-85)	0.740
Evidence of RV overload	18 (100%)	15 (100%)	-
D-shape	9 (90%)	5 (62.5%)	0.275
Presence of thrombus on control CT	5 (25%)	7 (53.8%)	0.142

RV/LV: Right ventricular to left ventricular diameter, CT: Computed tomography, LVEF: Left ventricular ejection fraction, RV: Right ventricular, RA: Right atrium, TR: Tricuspid regurgitation, SPAP: Systolic pulmonary artery pressure, TT: Patients who received thrombolytic therapy, No TT: Patients who did not receive thrombolytic therapy

Table 3. Comparison of right ventricular echocardiographic parameters and functional measures between treatment groups

Variables	TT (n=21)	No TT (n=15)	*P*-value
Apical A4C RV basal diameter (mm)	34.44±6.73	37.63±8.51	0.224
Apical A4C RV mid diameter (mm)	26.62±5.02	30.84±9.00	0.117
Apical A4C RV long diameter (mm)	47.20±8.98	49.50±8.22	0.442
Proximal RVOT diameter_psla (mm)	28.27±3.21	32.07±6.43	**0.032**
Distal RVOT diameter_pssa (mm)	21.64±4.09	23.99±4.00	0.107
RV/LV diameter A4C baseline	0.84±0.14	0.90±0.20	0.288
RV wall thickness (mm)	3.13±0.55	3.94±1.25	**0.038**
TAPSE (mm) - Normal - Pathological	20.47±4.57 18 (85.7%) 3 (14.3%)	18.15±4.27 11 (73.3%) 4 (26.7%)	0.132 0.418
Tricuspid S velocity (cm/s)	18.83±4.68	16.59±2.94	0.122
RV FAC (%)	50.83±8.71	50.46±12.33	0.924
RA longitudinal diameter (mm)	45.46±7.38	52.10±9.14	**0.031**
IVC diameter (mm)	11.75±3.89	15.91±5.01	**0.009**
IVC collapse ratio - <50% - >50%	 2 (10%) 18 (90%)	 7 (46.7%) 8 (53.3%)	**0.022**
RVFWLS apical (%)	27.76±8.70	19.73±7.16	**0.008**
RVFWLS mid (%)	33.06±8.74	25.27±10.28	**0.027**
RVFWLS basal (%)	27 (17-48)	25 (9-32)	0.114
RVFWLS average (%)	29.76±7.69	22.80±6.96	**0.012**
6MWD (meters)	434.33±137.97	357.27±143.10	0.179
PAP (mmHg)	27 (18-50)	31 (16-90)	0.157

RV: Right ventricular, RA: Right atrium, RVOT: Right ventricular outflow tract, A4C: Apical four-chamber view, TAPSE: Tricuspid annular plane systolic excursion, FAC: Fractional area change, IVC: Inferior vena cava, FWLS: Free wall longitudinal strain, 6MWD: 6-minute walk distance, PAP: Pulmonary artery pressure, TT: Patients who received thrombolytic therapy, No TT: Patients who did not receive thrombolytic therapy

Table 4. Comparison of post-treatment RVFWLS according to patient characteristics

Variables	n	Mean ± SD / median (min-max)	*P*-value
Gender			
- Female	22	28.2±9.27	0.074
- Male	14	23.67±4.52	
Clinical picture at PE diagnosis			**0.014**
- Acute	30	27 (20-48)	
- Subacute	6	17.5 (11-26)	
Anticoagulation therapy			
- NOAC	11	26.9±8.23	0.853
- OAC	19	26.59±6.39	0.949
- LMWH	6	23 (11-48)	0.310
Risk factors			
- Temporary	36	26 (11-48)	0.733
- Persistent	36	25.5 (11-48)	0.278
D-shape during PE			0.611
- Yes	14	25 (11-37)	
- No	4	28 (26-30)	

Table 4. Continued

Variables	n	Mean ± SD / median (min-max)	*P*-value
Development of recurrent VTE			0.952
- Yes	3	25 (21-37)	
- No	33	26 (11-48)	
Presence of thrombus on control CT			**0.007**
- Yes	12	21.82±7.08	
- No	21	30.11±7.55	
Result after treatment			**0.010**
- Improved PE	19	29 (21-48)	
- CTEPH	5	13 (11-23)	
- CTEPD	10	26 (22-32)	

Notes: Data are presented as mean ± standard deviation for normally distributed continuous variables, median (min-max) for non-normally distributed continuous variables, and n (%) for categorical variables

PE: Pulmonary thromboembolism, NOAC: New oral anticoagulant, OAC: Oral anticoagulant, LMWH: Low-molecular-weight heparin, VTE: Venous thromboembolism, CTEPH: Chronic thromboembolic pulmonary hypertension, CTEPD: Chronic thromboembolic pulmonary disease, RVFWLS: RV free wall longitudinal strain, SD: Standard deviation, CT: Computed tomography

Table 5. Post-treatment RVFWLS correlation with patient characteristics and laboratory parameters

	Total		TT		No TT	
Variables	**r**	***P*-value**	**r**	***P*-value**	**r**	***P*-value**
Age	-0.041	0.824[1]	-0.09	0.732[1]	-0.127	0.651[1]
s-PESI	0.066	0.721[2]	0.099	0.705[2]	0.002	0.999[2]
RV/LV ratio at the time of PE diagnosis	0.290	0.179[1]	0.548	0.081[1]	-0.012	0.969[2]
D-dimer during PE	-0.174	0.427[2]	-0.745	**0.008[2]**	0.452	0.141[2]
Troponin T during PE	0.295	0.172[1]	0.044	0.887[1]	0.578	0.080[2]
LVEF during PE	0.17	0.450[2]	-0.344	0.330[2]	0.213	0.506[2]
RV diameter during PE	-0.276	0.284[1]	-0.178	0.673[1]	-0.376	0.319[1]
RA diameter during PE	-0.557	**0.031[1]**	-0.397	0.378[1]	-0.571	0.139[1]
TR degree during PE	-0.112	0.619[2]	0.134	0.711[2]	-0.146	0.651[2]
Estimated SPAP during PE	0.089	0.694[2]	0.025	0.946[2]	0.134	0.678[2]
Dyspnea duration	-0.252	0.171[2]	0.131	0.628[2]	-0.580	**0.023[2]**

Notes: One refers to Pearson correlation test and 2 refers to Spearman correlation test; r: Correlation coefficient

s-PESI: Simplified pulmonary embolism severity index, RV/LV: Right ventricular/left ventricular, PE: Pulmonary thromboembolism, LVEF: Left ventricular ejection fraction, RV: Right ventricular, RA: Right atrium, TR: Tricuspid regurgitation, SPAP: Systolic pulmonary artery pressure, TT: Patients who received thrombolytic therapy, No TT: Patients who did not receive thrombolytic therapy

DISCUSSION

The findings of this study demonstrated that the long-term RVFWLS was superior in the TT group compared with the anticoagulant-only treatment group [-(29.76±7.69%) and -(22.8±6.96%), respectively, $P = 0.012$]. Furthermore, the 6MWD was 434.33±137.97 m in the group receiving TT, and 357.27±143.10 m in the group not receiving TT.

In the correlation analysis, a significant negative correlation was observed between D-dimer levels and RVFWLS in the TT group (r=-0.745, $P = 0.008$). This finding suggests that patients with a higher initial thrombotic burden or higher inflammatory activity demonstrated a more pronounced improvement in RV systolic function following TT. This relationship may reflect the enhanced efficacy of TT in patients with a substantial clot load, in whom the rapid restoration of pulmonary perfusion contributes to improved RV recovery. Therefore, D-dimer may serve not only as a diagnostic and prognostic biomarker but also as a potential indicator of treatment responsiveness in selected PE patients.

In intermediate-high-risk patients with PE, RV dysfunction is associated with increased mortality and morbidity.[4] The development of RV dysfunction may cause organ congestion,

leading to hepatic failure and cardiorenal syndrome. It may also increase hospitalization rates.[5-8] Therefore, RV function is critically important in intermediate-high-risk PE patients.

The intricate geometry of the RV, in conjunction with the predominance of parameters suggesting displacement of the RV basal segment, limits assessment of RV dysfunction. A recently developed ECHO parameter, strain, facilitates the evaluation of the systolic and diastolic function of the RV. Moreover, it enables the early detection of alterations of the ventricular by quantifying changes in myocardial length.[9]

In previous studies, low-dose TT did not increase bleeding complications and concomitantly improved hemodynamic parameters.[10-12] In intermediate-high-risk patients with PE, low-dose TT may help preserve RV function without increasing bleeding events.

The pulmonary embolism thrombolysis (PEITHO) study provided guidance on the efficacy of TT in patients with intermediate-high-risk PE. The PEITHO study focused on early mortality and hemodynamic deterioration.[2] Early hemodynamic deterioration was observed less frequently in the TT group. In contrast, major hemorrhages and strokes occurred more frequently in the TT group. According to the most recent guidelines, TT is not advised for patients with intermediate-high-risk PE because of the increased risk of bleeding complications.[3] A notable feature of the PEITHO study was the use of tenecteplase rather than tissue plasminogen activator, which diverges from standard clinical protocols. This potential difference might have influenced the outcomes observed.

A meta-analysis published in 2023 found similar risks of mortality and major bleeding between systemic TT and anticoagulation therapy in intermediate-risk PE. Intracranial bleeding was found to be more prevalent in the thrombolysis group; however, the results were not conclusive due to the wide confidence interval.[13]

Elderly patients, who represent a particularly vulnerable group with respect to bleeding risk, have recently become the focus of attention for the use of low-dose thrombolytic protocols because of their more favorable safety profile. In the study by Yilmaz and Uzun[14] conducted in submassive PE patients with a mean age of 69 years, the administration of half-dose rt-PA significantly reduced the incidence of death or hemodynamic decompensation without increasing the rates of major or minor bleeding; no intracranial hemorrhage was reported. These findings indicate that, in elderly individuals, low-dose TT may maintain efficacy while keeping the bleeding risk within an acceptable range.[14]

A comprehensive evaluation of the long-term outcomes revealed no statistically significant differences between the study groups in RV function, as determined by conventional evaluation methods. This finding was reported in the PEITHO study published in 2017.[15] In the present study, similar results were obtained for RV function when evaluated by conventional methods. However, the implementation of RVFWLS, a novel parameter of RV function was associated with favorable changes in RV strain values over an extended period in patients undergoing TT.

The RVFWLS enables the evaluation of three segments of the RV. This feature plays a pivotal role in determining whether the contraction of the basal segment of the RV is active or passive. It provides objective data in cases where traditional parameters are inadequate.

In a study by Vitarelli et al.[16] intermediate-risk PE patients (with ECHO evidence of RV dysfunction) were compared with healthy subjects. A comparative analysis revealed that the global RVLS and RVFWLS values were lower in the PE group than in the healthy group. Research findings demonstrate that RVFWLS can predict mortality, the need for cardiopulmonary resuscitation, and recurrent PE.[16]

In the present study, RVFWLS values, which facilitated assessment of subclinical RV dysfunction, differed significantly in patients undergoing TT. Furthermore, the 6MWD, a well-established metric for predicting annual mortality in patients with pulmonary hypertension, was higher in patients receiving thrombolytics. The small number of patients in our study may explain why the 6MWD did not reach statistical significance.

There is no consensus on the standardization of the 6MWD as a prognostic indicator following PE. However, it is a significant prognostic indicator in patients with pulmonary arterial hypertension (PAH).[17] According to the 2022 ESC PAH guideline, the annual mortality rate is reported to be less than 5% for individuals with a 6MWD greater than 440 meters, 5% for those with a 6MWD ranging from 165 to 440 meters, and 10% for individuals with a 6MWD shorter than 165 meters.[18] In the present study, the mean distance was 434 meters in the cohort receiving TT and 357 meters in the cohort not receiving TT. The cohort receiving TT walked a distance close to the 440-meter threshold, which suggests an annual mortality rate of less than 5%, as reported in the ESC PAH guideline. The lack of statistical significance is likely attributable to an inadequate number of patients in the study. However, the observed difference in 6MWD, although not statistically significant, is clinically meaningful and suggests a positive trend toward improved functional capacity with TT.

Study Limitations

This study has several limitations. First, its retrospective, nonrandomized design introduces potential selection bias. A significant baseline difference in troponin T levels (higher in the TT group; $P = 0.002$) further reinforces this bias. Although sicker patients received TT and showed better long-term RV function, suggesting a possible therapeutic benefit, this imbalance limits the validity of direct comparisons between the groups. Second, the small sample size (n=36) reduced statistical power and likely explained why the clinically meaningful difference in 6MWD did not reach statistical significance. Third, the multivariate analysis may carry a risk of overfitting, and residual confounding cannot be entirely excluded. Furthermore, the definition of "healed PE" relied on imaging findings (absence of occlusive lesions on CT and absence of perfusion defects on scintigraphy), while ECHO parameters of RV remodeling were not systematically evaluated. Finally, because this was a single-center study, the generalizability of these findings is limited. Larger, multicenter prospective studies are needed to confirm and expand these results.

CONCLUSION

In conclusion, our findings indicate that TT is associated with better long-term RV systolic performance, as reflected by RVFWLS values, in intermediate-high-risk PE patients. The clinically meaningful, though non-significant, improvement observed in 6MWD further supports a potential functional benefit of TT. However, given the small sample size, non-randomized design, and baseline differences between groups, these findings should be interpreted with caution and validated through larger, prospective multicenter studies. Therefore, TT may be considered for intermediate-high-risk PE patients with significant RV dysfunction and a low bleeding risk.

Ethics

Ethics Committee Approval: The study was approved by the Clinical Research Ethics Committee of University of Health Sciences Türkiye, Antalya Training and Research Hospital (decision no: 18/15, date: 08.08.2019).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Concept: R.A., N.B., Z.E., M.R.E., B.T., F.H.K., E.C.Ö., G.K., Ş.A., Design: R.A., N.B., Z.E., M.R.E., B.T., F.H.K., E.C.Ö., G.K., Ş.A., Data Collection or Processing: R.A., N.B., M.R.E., E.C.Ö., Analysis or Interpretation: R.A., N.B., Z.E., Ş.A., Literature Search: R.A., N.B., Writing: R.A.

Conflict of Interest: No conflict of interest was declared by the authors.

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