Original Article

Pulmonary Embolism and Right Heart Thrombi: A Single-Center Experience

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Abstract

Background: *The right heart thrombus (RHT) embolizes from deep venous thrombi and sits in the right atrium or the right ventricle. We aimed to determine the occurrence and prognosis of the RHT in patients with pulmonary embolism.*

Methods: *We reviewed the cohort data of 622 patients with acute pulmonary embolism obtained from the registry of Tehran Heart Center. Demographic, physiological, clinical, and echocardiographic data, as well as clinical outcomes, were compared between patients with and without the RHT.*

Results: *The study population comprised 622 patients, including 329 men (52.8%). The mean age of the patients was 60.2±17.0 years. Thirty patients (4.8%) had echocardiographically proven RHT. Baseline demographic and clinical characteristics were not different between the 2 groups. Right ventricular dysfunction was more prevalent in the RHT (+) group, and more patients in this group were treated with thrombolysis (P=0.013 and P<0.001, respectively). Overall, 3 out of 21 patients (14.2%) in the RHT (+) group vs 29 out of 306 patients (9.4%) in the RHT (−) group died at 1 month (P=0.445) and 5 out of 21 patients (23.8%) in the RHT (+) group vs 56 out of 307 patients (18.2%) in the RHT (−) group died at 1 year (P=0.562).*

Conclusion: *The RHT is an influential complication in patients with pulmonary emboli, and it seems to increase the mortality rate of patients with acute pulmonary embolism.*

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Keywords: *Right atrium; Right ventricle; Thrombosis; Pulmonary embolism; Survival*

Introduction

The right heart thrombus (RHT) is detected by echocardiography in 4% of patients diagnosed with acute pulmonary embolism (PE), mostly in massive cases.[1, 2] The RHT embolizes from deep venous thrombi.[3] Most RHT cases are found in the right atrium, and those in the right atrium or the right ventricle (RV) have a benign prognosis.[1] The RHT often prolapses into the tricuspid or pulmonary valves during the cardiac cycle. Occasionally, the RHT can cause systemic thromboembolism after passing through a patent foramen ovale or a reopened foramen due to the increased atrial pressure resulting from a prior PE case.[3]

The RHT is associated with chronic heart disease, renal insufficiency, immobilization, and recent major bleeding.[4-6] However, the data on the predictors and survival of

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PE patients with the RHT are limited, with most of the studies having described the prevalence, natural history, and prognostic significance of the RHT.[3, 7-9] We studied the predictors of the occurrence and prognosis of the RHT in patients with PE who presented to our center.

Methods

We studied the data of 622 consecutive patients who were diagnosed with acute pulmonary thromboembolism and admitted to our hospital, a tertiary care teaching hospital, between September 2006 and September 2015. The data were retrieved from the Pulmonary Thromboembolism Data Bank of Tehran Heart Center.[10] Pulmonary thromboembolism diagnosis was confirmed via pulmonary spiral computed tomography angiography (CTA) scanning. Otherwise, the diagnosis was confirmed by a ventilation-perfusion scan. Two-dimensional and Doppler echocardiographic examinations were performed within 48 hours of admission. RV dysfunction was described as an RV diameter of greater than 34 mm, a tricuspid annular plane systolic excursion value of less than 16 mm, or a pulsed Doppler peak velocity at the tricuspid annulus value of less than 10 cm/s or hypokinesia in the RV free wall. The RHT was diagnosed with the use of echocardiography within the right atrial or ventricular cavity. The study protocol was confirmed by the institutional research board and medical ethics committee.

The demographic, physiological, echocardiographic, clinical, and follow-up data of the eligible patients were retrieved. The patients were divided into 2 groups based on admission echocardiographic findings: those with the RHT (RHT [+]) and those without the RHT (RHT [−]). After that, the study variables were compared between these 2 groups.

Categorical variables were shown as frequencies (percentages) and were compared between the 2 groups using the χ^2 test. Continuous variables were portrayed as the median for abnormally distributed variables and the mean±the standard deviation (SD) for normally distributed ones using the Kolmogorov–Smirnov and Shapiro–Wilk tests to assess normality and were compared between the groups using the Student t test or the Mann–Whitney U test based on the normality of the data. Additionally, binary logistic regression was performed to determine the factors associated with the RHT. Variables with a P value of less than 0.2 in the univariate analysis were selected for the logistic regression analysis. All the statistical analyses were performed using SPSS, version 24.0 (IBM, NY, USA). A P value of less than 0.05 was considered statistically significant.

Results

From 622 patients with PE who presented to our center and who were assessed by echocardiography, 30 patients (4.8%) had the RHT. Age, the prevalence of dyspnea, heart rate, and systolic blood pressure were similar in both groups. The majority of the patients in both groups were men. The frequency of malignancy in the RHT (+) group was twice that in the RHT (−) group. The RHT (+) group had a longer interval between the onset of symptoms and admission (median = 7 vs 3 d), although not statistically significant. The details of the baseline characteristics of the patients and their comparison between the study groups are presented in Table 1.

RV dysfunction was more prevalent in the RHT (+) patients (P=0.013). Meanwhile, thrombolysis was used as the treatment of choice more frequently in the RHT (+) patients (P<0.001). The mortality rates, both at 1 month and 1 year, were higher in the RHT (+) group: 3 out of 21 patients in the RHT (+) group vs 29 out of 306 patients in the RHT (−) group at 1 month and 5 out of 21 in the RHT (+) group vs 56 out of 307 in the RHT (−) group at 1 year. The difference, however, failed to constitute statistical significance (Table 2).

Sex and smoking were 2 eligible variables for binary logistic regression, but neither could predict the occurrence of the RHT (Table 3).

Discussion

In the present study, the RHT had a prevalence rate of 4.8% in our patients with PE. The RHT (+) group had a higher percentage of RV dysfunction and a higher rate of thrombolytic use than the RHT (−) group. The mortality rate was higher in the RHT (+) group, although this difference was not statistically significant due to the low number of the RHT (+) patients compared with the RHT (−) patients.

In a study by Barrios et al,[11] RHT (+) patients had more risk factors for venous thromboembolism, particularly immobilization exceeding 4 days. Another study also reported advanced age, a history of trauma, recent surgery, prolonged immobility, obesity, hormone replacement therapy, childbirth, and smoking as the common risk factors for deep vein thrombosis.[12] However, we did not observe such an association.

As was shown by the International Cooperative Pulmonary Embolism Registry (ICOPER), a local stasis in a dilated RV due to prior congestive heart failure or acute pulmonary thromboembolism increases the chance of observing thrombi in echocardiography.[7] The authors considered stasis to be a cause of the RHT in the absence of other predisposing factors for local thromboses such as central catheters, electrode wires, and individually related extraneous determinants such as age, malignancy, and chronic obstructive pulmonary disease (COPD). Still, we did not observe any association between these factors and the RHT, which might be due to

Table 1. Baseline characteristics of the study population and their comparison between the patients with and without the RHT*

Characteristic	All Patients (N=622)	RHT (+) (n=30)	RHT (−) (n=592)	P
Age (y)	60.2±17.0	56.6±17.9	60.5±17.0	0.228
BMI, kg/m^2	29.6±6.1	29.1±5.7	29.6±6.1	0.556
Male gender	329 (52.8)	21 (70.0)	308 (52.0)	0.064
Malignancy	37 (5.9)	3 (10)	34 (5.0)	0.413
COPD	25 (4.0)	0 (0)	25 (4.2)	0.626
Previous DVT/PE	85 (13.6)	5 (16.6)	80 (13.5)	0.587
Immobilization	172 (27.6)	7 (23.3)	165 (27.9)	0.588
Recent surgery	79 (12.7)	5 (16.7)	74 (12.5)	0.57
Diabetes mellitus	113 (18.1)	3 (10.0)	110 (18.6)	0.332
Hypertension	252 (40.5)	9 (30.0)	242 (40.9)	0.236
Smoking	127 (20.4)	9 (30.0)	118 (19.9)	0.182
Heart failure	39 (6.2)	3 (10.0)	36 (6.1)	0.425
Presenting Symptom				
Dyspnea	554 (89.0)	27 (90.0)	527 (89.0)	0.934
Chest pain	303 (48.7)	13 (43.3)	290 (48.9)	0.492
Syncope	59 (9.4)	2 (6.7)	57 (9.6)	0.999
Diagnosed DVT**	181/405 (44.7)	7/20 (35.0)	174 /385 (45.2)	0.371
Heart rate, beat/min	101.0±19.8	101.0±19.7	100.5±20.7	0.73
Systolic blood pressure, mm Hg	129.7±21.7	125.5±18.7	130.0±21.8	0.269
Respiratory rate, 1/min	22.0 [18.0, 28.0]	25.0 [18.0, 30.0]	22.0 [18.0, 30.0]	0.783
Interval of symptom onset to admission, d	3.0 [1.0, 7.0]	7.0 [2.7, 11.0]	3.0 [1.0, 7.0]	0.246
Atrial fibrillation	30 (4.8)	0 (0)	30 (5.1)	0.395
Right bundle branch block	82 (13.1)	5 (16.6)	77 (13.0)	0.823
Pleural effusion	96 (15.4)	6 (20.0)	90 (15.2)	0.442

*Data are presented as n (%) or mean±SD.
**Percentage calculated after omitting missing values
COPD, Chronic obstructive pulmonary disease; DVT, Deep vein thrombosis; PE, Pulmonary embolism; RHT: Right heart thrombus

Table 2. Echocardiographic, treatment, and outcome characteristics of the study population and their comparison between the patients with and without the RHT*

Characteristic	All Patients (N=622)	RHT (+) (n=30)	RHT (−) (n=592)	P
Transthoracic echocardiography				
RV diameter, mm	39.2±8.2	42.5±9.0	39.1±8.1	0.255
RV dysfunction	430 (69.1)	27 (90.0)	403 (68.1)	0.013
High risk in the simplified pulmonary embolism severity index	374 (60.1)	19 (63.3)	355 (60.0)	0.74
Thrombolysis	111 (17.8)	20 (66.7)	91 (15.4)	<0.001
Hospital stay, d	9.0 [7.0, 11.0]	9.0 [5.7, 14.2]	9.0 [7.0, 11.0]	0.800
Mortality at 1 month**	32/327 (9.7)	3/21 (14.3)	29/306 (9.5)	0.445

*Data are presented as n (%) or mean±SD.
**Percentage calculated after omitting missing values.
RHT, Right heart thrombus; RV, Right ventricle

Table 3. Determinants of the right heart thrombus analyzed by multivariable binary logistic regression

Characteristic	Odds Ratio	95% Confidence Interval	P
Male sex	0.522	0.224–1.21	0.132
Smoking	1.339	0.569–3.151	0.504

P<0.05 was considered significant.

the small number of our RHT (+) patients compared with our RHT (−) patients.

We found that the frequency percentage of malignancy was twofold among our RHT (+) patients. Similar to our results, the prevalence of malignancy among RHT (+) patients was higher in another study (22.5% of the RHT [+] group vs 17% of the RHT [−] group).[8] Nonetheless, there is a discrepancy between studies insofar as a study reported that cancer was not more frequent among RHT (+) patients than among RHT (−) patients.

Our results also revealed that COPD was more prevalent in RHT (−) patients. In contrast, Torbicki et al[7] found no association between COPD and the RHT. They reported that their RHT (+) patients were more hemodynamically compromised at the time of diagnosis than their RHT (−) patients, as shown by a lower systemic arterial pressure, a higher prevalence of hypotension, a higher heart rate, and frequent RV hypokinesia in echocardiography, with the latter chiming in with our findings. A previous investigation reported a higher frequency of RV hypokinesia in RHT (+) patients.[13] Due to lower blood pressure levels, higher heart rates, and more recurring events of hypoxemia and syncope, the RHT (+) patients in that study were considered more hemodynamically compromised. This issue does not tally with our findings since we had a lower syncope frequency among our RHT (+) patients. Nevertheless, in our study, blood pressure and heart rate were similar in both groups, and RV dysfunction was more prevalent in the RHT (+) patients. A larger number of RHT (+) patients could have resulted in a different finding regarding our patients' hemodynamics.

The prognostication of RHT (+) patients is essential to the selection of the best therapeutic option. We drew upon thrombolytics more commonly in the RHT (+) group. However, in the last European Society of Cardiology (ESC) guideline of PE, there is no indication to use thrombolytics based on the presence of the RHT.[14]

We found a higher rate of 1-month and 1-year mortality in our RHT (+) patients. Similarly, in the study by Torbicki et al,[7] the 14-day and 3-month outcomes were worse in RHT (+) patients. Additionally, in an investigation by Barrios et al,[8] PE-related and all-cause-related mortality were more frequent among RHT (+) patients. One explanation for this finding based on our results may be that the interval between the symptom onset and hospital admission was longer among the RHT (+) patients. However, this interval was shorter in another study, where the in-hospital mortality of RHT (+) patients was 18.7%, and the presence of shock at the time of admission and systemic thrombolysis were the independent predictors for mortality.[15] In another study by Barrios et al,[16] the short-term mortality rate of RHT (+) patients was 16.7%, while the mortality rate in PE patients without the RHT was 4.4%. The authors concluded that in patients with a PE diagnosis, concomitant diagnosis of the RHT dramatically increased the risk of death.

According to the ICOPER database analysis, the RHT cannot independently be the causative risk factor for a higher mortality rate because of the limited number of patients. Consequently, the confirmative value of the RHT on mortality fails, rendering us unable to determine whether it results from the direct cause of a poor prognosis.[8] In a pooled analysis of 316 patients with the RHT and PE, the presence of shock reduced the odds of survival, but age, RV dysfunction, and clot mobility did not affect mortality.[15] An adjusted analysis for shock showed that treatment modality and clot location alone, as well as systemic thrombolysis, increased the odds of survival compared with systemic anticoagulation. We believe that conducting an updated meta-analysis on this issue could help to explore the effect of the RHT on the mortality of PE patients.

The small number of RHT (+) patients (n=30) in our study precluded us from reaching a high statistical analysis power. Another weakness of note is that we enrolled patients with PE from only a tertiary referral center. Therefore, the generalizability of our findings should be done cautiously.

Conclusion

Based on Tehran Heart Center's Pulmonary Thromboembolism Registry, the RHT occurred in about 5% of patients with PE and increased the risk of mortality. However, extensive studies are required to determine the predictors and prognosis of RHT (+) patients with pulmonary thromboembolism.

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References

1. Dalen JE. Free-Floating Right Heart Thrombi. Am J Med 2017;130:501.
2. Dzudovic B, Obradovic S, Rusovic S, Gligic B, Rafajlovski S, Romanovic R, Ratkovic N, Dincic D. Therapeutic approach in patients with a floating thrombus in the right heart. J Emerg Med 2013;44:e199-205.
3. Nkoke C, Faucher O, Camus L, Flork L. Free Floating Right Heart Thrombus Associated with Acute Pulmonary Embolism: An Unsettled Therapeutic Difficulty. Case Rep Cardiol 2015;2015:364780.
4. López-Jiménez L, Montero M, González-Fajardo JA, Arcelus JI, Suárez C, Lobo JL, Monreal M; RIETE Investigators. Venous thromboembolism in very elderly patients: findings from a prospective registry (RIETE). Haematologica 2006;91:1046-1051.
5. Muriel A, Jiménez D, Aujesky D, Bertoletti L, Decousus H, Laporte S, Mismetti P, Muñoz FJ, Yusen R, Monreal M; RIETE Investigators. Survival effects of inferior vena cava filter in

patients with acute symptomatic venous thromboembolism and a significant bleeding risk. J Am Coll Cardiol 2014;63:1675-1683.
6. Riera-Mestre A, Jiménez D, Muriel A, Lobo JL, Moores L, Yusen RD, Casado I, Nauffal D, Oribe M, Monreal M; RIETE investigators. Thrombolytic therapy and outcome of patients with an acute symptomatic pulmonary embolism. J Thromb Haemost 2012;10:751-759.
7. Torbicki A, Galié N, Covezzoli A, Rossi E, De Rosa M, Goldhaber SZ; ICOPER Study Group. Right heart thrombi in pulmonary embolism: results from the International Cooperative Pulmonary Embolism Registry. J Am Coll Cardiol 2003;41:2245-2251.
8. Cameron J, Pohlner PG, Stafford EG, O'Brien MF, Bett JH, Murphy AL. Right heart thrombus: recognition, diagnosis and management. J Am Coll Cardiol 1985;5:1239-1243.
9. Kajamohideen N, Swaminathan N, Palanisamy G, Gnanavelu G, Sangareddi V. Morphology of right heart thrombi in pulmonary embolism: A case series and analysis. JIAE 2017;1:24-26.
10. Jenab Y, Lotfi-Tokaldany M, Alemzadeh-Ansari MJ, Seyyedi SR, Shirani S, Soudaee M, Ghaffari-Marandi N. Correlates of syncope in patients with acute pulmonary thromboembolism. Clin Appl Thromb Hemost 2015;21:772-776.
11. Barrios D, Rosa-Salazar V, Jiménez D, Morillo R, Muriel A, Del Toro J, López-Jiménez L, Farge-Bancel D, Yusen R, Monreal M; RIETE investigators. Right heart thrombi in pulmonary embolism. Eur Respir J 2016;48:1377-1385.
12. Haji Zeinali AM, Jenab Y, Ariannejad H, Kassaian SE, Alidoosti M, Aghajani H, Zafarghandi MR. Catheter-Directed Thrombolysis in Acute Iliofemoral Deep Vein Thrombosis with or without Stenting: A Case Series. J Teh Univ Heart Ctr 2018;13:186-190.
13. The European Cooperative Study on the clinical significance of right heart thrombi. European Working Group on Echocardiography. Eur Heart J 1989;10:1046-1059.
14. Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, Huisman MV, Humbert M, Jennings CS, Jiménez D, Kucher N, Lang IM, Lankeit M, Lorusso R, Mazzolai L, Meneveau N, Áinle FN, Prandoni P, Pruszczyk P, Righini M, Torbicki A, Van Belle E, Zamorano JL; The Task Force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology (ESC). 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS): The Task Force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology (ESC). Eur Respir J 2019;54:1901647.
15. Islam M, Nesheim D, Acquah S, Kory P, Kourouni I, Ramesh N, Ehrlich M, Bajpayee G, Steiger D, Filopei J. Right Heart Thrombi: Patient Outcomes by Treatment Modality and Predictors of Mortality: A Pooled Analysis. J Intensive Care Med 2019;34:930-937.
16. Barrios D, Rosa-Salazar V, Morillo R, Nieto R, Fernández S, Zamorano JL, Monreal M, Torbicki A, Yusen RD, Jiménez D. Prognostic Significance of Right Heart Thrombi in Patients With Acute Symptomatic Pulmonary Embolism: Systematic Review and Meta-analysis. Chest 2017;151:409-416.