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Unmet needs in diagnostics of acute pulmonary embolism and their determinants in Polish hospitals

Short title: Unmet needs in diagnostics of acute pulmonary embolism

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WHAT'S NEW?

- Access to imaging studies, essential for diagnosing acute pulmonary embolism, is limited and unevenly distributed across Polish hospitals
- Access to expert pulmonary embolism consultations is restricted owing to the limited availability of Pulmonary Embolism Response Teams (PERT) or due to a lack of awareness about their existence
- The value of multiparametric risk assessment models in acute pulmonary embolism is not adequately recognized

ABSTRACT

Background: Acute pulmonary embolism (APE) represents the third most common acute cardiovascular disease in Poland, posing an increasing burden on healthcare systems.

Aims: This study aimed to assess the availability of diagnostic methods and unmet needs in APE diagnosis in Polish hospitals.

Methods: An online survey prepared using the modified Delphi method was distributed to hospital departments for completion by the physicians. For the purpose of the present analysis we assessed the full sets of responses to questions related to the availability of diagnostic tests and the unmet needs in diagnostics of APE.

Results: We received 204 full sets of responses. A 24-hour access to echocardiography and ultrasonographic compression test, was declared by 119 (58.3%) and 89 (43.6%) respondents, respectively. A group of 171 (83.82%) respondents reported a 24-hour access to computed tomography angiography (angio-CT), however only 13 (6.4%) declared a routine availability to the measurement of the right ventricle to left ventricle ratio in the angio-CT reports. Most respondents did not have (88; 43.1%) access to Pulmonary Embolism Response Team consultations or were unaware of this option (41; 20.1%). The risk of death in APE was most commonly attributed to the diagnosis of a "saddle embolism" (n = 152; 74.5%). Relatively rarely (n = 102; 50%) was high importance attributed to multiparametric risk assessment scores.

Conclusions: Our study indicates a need for improvement in the organization and accessibility of APE diagnostics in Polish hospitals, and for an increasing awareness of current standards in APE diagnosis among physicians.

Key words: acute pulmonary embolism, diagnostic methods, Pulmonary Embolism Response Team, risk assessment scales, healthcare accessibility.

INTRODUCTION

Acute pulmonary embolism (APE) stands as the third most prevalent acute cardiovascular condition following myocardial infarction and stroke [1, 2]. Over recent years, there has been a noticeable increase in the incidence and hospitalization rates due to APE and its complications, imposing a growing burden on healthcare systems worldwide [2]. During the acute phase, the disease is associated with high mortality and is often diagnosed posthumously. Nearly half of APE patients do not achieve full recovery in the subsequent months and endure symptoms of post-pulmonary embolism syndrome, characterized by impaired exercise tolerance and reduced quality of life [3, 4]. In some cases, a rare and severe complication known as chronic thromboembolic pulmonary hypertension (CTEPH) develops [5–7].

The principles of APE diagnosis and treatment have been thoroughly outlined in the guidelines of the European Society of Cardiology [2]. However, it remains unclear whether current practices and access to various diagnostic and therapeutic methods in hospital wards in Poland align with contemporary standards.

This study aimed to assess the availability of diagnostic methods and unmet needs in APE diagnosis in Polish hospitals.

METHODS

Study Population

The study population comprised physicians of various specialties working in hospital wards across three voivodeships: Małopolskie, Świętokrzyskie, and Podkarpackie. Physicians working in pediatric and psychiatric wards were excluded from the study. Additionally, physicians from two hospitals that consult patients with APE and offer interventional treatment in these voivodeships were excluded to mitigate selection bias.

Survey Development

The survey was drafted by two physicians (GK and LW) and then reviewed by a group of three cardiologists and two cardiology residents from the submitting center. Preliminary topics were identified through literature review and consultations within the hospital. The modified Delphi technique, involving two rounds, was employed to achieve final consensus on the survey topics among a group of experts, including the authors (AA, MF, MK, PP). Each question was rated on a scale of 1 to 10, with only questions scoring >7 points retained in the survey. The decision to set the cutoff value at 7 was arbitrarily made by the research team. In the first round, 62 out of 65 questions received a positive rating. The remaining questions were modified based on

expert suggestions and, along with an additional question proposed by one expert, underwent a second round. As a result, 3 out of 4 questions were accepted, resulting in a questionnaire consisting of 65 questions.

The final survey was uploaded to the dedicated internet platform www.webankieta.pl. A function blocking multiple survey completions from the same device was implemented. Unique links and QR codes were generated for the questionnaire.

Survey Distribution

Invitations to participate in the study were prepared as electronic email messages and sent via traditional mail to all hospitals and their departments located in the three voivodeships: Małopolskie, Podkarpackie, and Świętokrzyskie. In total, invitations were extended to 647 heads of departments working in hospital wards. The survey was available for completion from June 20, 2022, to April 30, 2023.

Survey Questions

The 65 questions were categorized into the following sections: (a) 6 questions characterizing the respondent's institution, (b) 12 questions characterizing the respondent (experience, specialization, knowledge about acute pulmonary embolism), (c) 3 questions about the availability of a multidisciplinary acute pulmonary embolism team (PERT), (d) 4 questions about the methods of risk assessment of APE, (e) 19 questions about access to diagnostic tests and therapeutic procedures, (f) 12 questions about hospital care, (g) 8 questions about post-hospital care, and (h) 1 open question about the three most unmet needs in the diagnosis and treatment of acute pulmonary embolism. For the purpose of the present analysis we assessed the full sets of responses to questions related to the availability of diagnostic tests and the unmet needs in diagnostics of APE. The questionnaire is attached as a supplement. For the purposes of the current study, questions no. 1–10, 11, 23, 25, 26, and 29–36, 65 were utilized.

Statistical Analysis

Categorical values were presented as number (percent) and compared between two groups using the chi-squared test. Logistic regression analysis was employed to assess the most important determinants of the availability of different diagnostic tests. In logistic regression analysis, the dependent variable was the availability of a particular procedure in a 24/7 mode, while the independent variables included: city population size, presence of Emergency Department in hospital, presence of department dedicated to acute pulmonary embolism, presence of a formal

procedure, and voivodeship. These are not all variables assessed in the study; however, they were recognized by the study authors as potential factors influencing respondents' answers. The significance level was set at $\alpha = 0.05$. The Bioethical Committee of Jagiellonian University approved the protocol of this study. The statistical calculations were performed using the Statistica 13.1 software.

RESULTS

Study group

We received 204 full sets of responses, primarily from the Małopolskie voivodeship, followed by Podkarpackie and Świętokrzyskie voivodeships. The majority of participants were specialists or specializing in cardiology and internal medicine, followed by anaesthesiology and intensive care, rheumatology, and emergency medicine. A small group ($n = 4$; 2.0%) consisted of pulmonologists. The characteristics of the respondents are presented in Table 1.

The respondents mainly indicated cardiology departments, internal medicine departments, hospital emergency departments, or central admission units as their primary workplaces (Table 1). The vast majority of respondents held a specialist title in the field of medicine, and over half declared professional experience exceeding 15 years.

Regarding their experience in the diagnosis and treatment of APE, respondents most commonly described it as moderate ($n = 102$; 50.0%), followed by high ($n = 51$; 25.0%), low ($n = 44$; 21.6%), and no experience ($n = 7$; 3.4%).

Characteristics of the hospitals

The majority of respondents worked in cities with a population of $>100,000$, typically in hospitals with a 24/7 functioning Central Admission Unit (CAU) or Hospital Emergency Department (ER). In most of these hospitals, patients with APE were treated. The dedicated department for APE treatment was most commonly the cardiology department, followed by internal medicine, anesthesiology and intensive care, lung diseases and angiology departments. Some respondents indicated the absence of a dedicated APE treatment department in the hospital where they worked (Table 1).

Access to Specialized Consultations

Most respondents did not have (88; 43.1%) access to Pulmonary Embolism Response Team (PERT) consultations or were unaware of this option (41; 20.1%). Only 17 (8.3%) respondents declared having a 24-hour access to PERT consultations in their workplace, and 58 (28.4%) in

another hospital. Access to formally approved APE diagnostic and treatment procedures was available to 73 (35.8%) respondents.

Availability of Laboratory Tests

Almost all respondents had 24-hour access to cardiac troponin ($n = 202$; 99.0%) and D-dimer concentration ($n = 201$; 98.5%) measurements. The continuous ability to determine NT-proBNP/BNP level was declared by 187 (91.7%) respondents, and an additional 12 (5.9%) respondents had non-24-hour access. Only, a few respondents (5; 2.5%) did not have access to NT-proBNP/BNP assessment.

Availability of Imaging Studies

24-hour access to echocardiography and ultrasonographic compression test, including reporting the examination, was declared by 119 (58.3%) and 89 (43.6%) respondents, respectively. One hundred seventy one (83.8%) respondents reported 24-hour access to computed tomography angiography (angio-CT). In units without 24-hour access to angio-CT, 14 (42.4%) respondents declared the availability of a defined angio-CT procedure in an external center.

Only 13 (6.4%) respondents declared that the description of the left ventricle to right ventricle dimension (LV/RV) was routinely available in the report from the angio-CT examination, 80 (39.2%) obtained periodic descriptions of this parameter, and 111 (54.4%) had no access to the result of this measurement at all (Figure 1.).

In the logistic regression analysis, the availability of 24/7 angio-CT was determined by the presence of CAU/ED in the hospital (OR 6.3, 95% CI 1.6 to 24.3, $P = 0.008$), 24-hour access to echocardiography by the presence of a dedicated APE department (OR 2.1; 95% CI: 1.1 to 3.9, $P = 0.02$), the size of the town where the hospital is located (OR 1.9; 95% CI: 1.1–3.6, $P = 0.02$), and the presence of CAU/ED (OR 5.7; 95% CI: 1.1 to 29.1, $P = 0.03$). Regarding ultrasound (USG), the size of the locality was a determinant (OR 2.8; 95% CI: 1.6–5.1, $P = 0.0006$). Due to the generally very low availability of RV/LV descriptions and widespread availability of NT-proBNP measurements, determinants of access to these examinations were not evaluated in the multifactorial analysis. Furthermore, disparities in access to PERT consultations (most accessible in the Małopolskie voivodeship) and echocardiography (most accessible in the Świętokrzyskie voivodeship) were observed among voivodeships (Table 2); the p values of these statistics are shown in Supplementary table.

Respondents' Awareness of Prognostic Factors in APE

The risk of death in APE was most commonly attributed to the diagnosis of a "saddle embolism" (n = 152; 74.5%). The next most important factors were the degree of symptom severity (n = 149; 73.4%), right ventricular function (n = 147; 72.6%), arterial blood oxygen saturation (n = 144; 70.6%), arterial blood pressure (n = 140; 68.6%), heart rate (n = 127; 62.3%), and central location of clots in angio-CT (n = 125; 61.3%). Rarely was high importance attributed to multiparametric risk assessment scores such as the Pulmonary Embolism Severity Index/simplified Pulmonary Embolism Severity Index (PESI/sPESI) (n = 73; 35.8%) and the Bova scale (29; 14.2%) (Figure 2.).

Unmet Needs Reported by Respondents

The most frequently mentioned problem (n = 31 respondents) was the lack of established procedures in the management of patients with APE, including difficulties in transferring patients to reference centers, challenges in consulting patients within the PERT team, and the absence of integrated and coordinated medical care.

The next most frequently reported unmet need (n = 15) was restricted access to angio-CT, including long distances to the facility performing the examination, lack of clear radiological descriptions, absence of RV to LV size comparisons, and the absence of radiologists on duty in the hospital. Ten respondents reported restricted access to echocardiography and ultrasound. Fifteen respondents reported insufficient post-hospital assessment in the outpatient clinic, including the inability to diagnose cancer and coagulation disorders. Ten respondents reported limited experience and the need for increased training in recognizing APE.

DISCUSSION

Pulmonary embolism (PE) remains one of the leading causes of mortality in Polish hospitals [8]. Accurate diagnosis of this condition, crucial for implementing effective therapeutic algorithms, requires appropriate equipment and human resources [2, 9, 10].

In the present study, for the first time, we identified that the most unmet need among physicians working in various Polish hospitals in the care of APE patients is limited access to highly specialized consultations with Pulmonary Embolism Response Teams (PERT) and the ability to directly transfer patients to higher-reference hospitals. Both factors are crucial as they may enhance patient survival by facilitating the prompt implementation of diverse treatment techniques [11–17]. A significant majority of physicians also indicated a lack of routine availability of RV/LV measurement in the reports of angio-CT, and approximately half reported insufficient access to 24-hour echocardiography and compression ultrasound testing.

Physicians working in hospitals with 24-hour CAU or ED, dedicated departments for PE treatment, and in larger cities more frequently had access to imaging studies. The study also revealed that physicians often attributed little importance to multidimensional risk assessment scales (PESI/sPESI, Bova) in making therapeutic decisions.

Although the survey was distributed to departments of various specialties, cardiologists constituted the main group of respondents, followed by internal medicine and anesthesiology physicians. Unexpectedly, lung diseases physicians showed limited interest in the survey, possibly reflecting the fact that, as mentioned by participating physicians, cardiology departments usually handle PE patients in Polish hospitals.

Angio-CT of the pulmonary arteries plays a crucial role in diagnosing APE, and it should be performed to confirm or exclude the disease [2]. Besides APE diagnosis, this examination allows for the assessment of clot location, essential for planning interventional treatment, and the measurement of heart chamber size, including the RV/LV ratio used in risk stratification. Echocardiography and ultrasound of lower limb veins also play a significant role in differential diagnosis, risk assessment, and patient monitoring. In situations where angio-CT cannot be performed in hemodynamically unstable patients, a typical echocardiographic pattern of right ventricular overload consistent with clinical presentation of APE enables the use of fibrinolytic treatment. In our study, 97.1% of respondents indicated that their facility treated APE patients, and 95% reported having CAU or ED working on 24/7 basis, yet only 83.4% declared 24-hour access to angio-CT. Only about half of the respondents had the capability for 24-hour echocardiography, and an even smaller number had access to compression ultrasound testing. Importantly, physicians rarely had access to RV/LV parameter descriptions in angio-CT reports, which should be a standard in APE patient evaluations [10]. It is noteworthy that hospitals without 24-hour access to angio-CT often lack established procedures for referring patients to external centers for this examination. The availability of 24-hour imaging studies was associated with the presence of CAU/ED, size of the locality and the presence of dedicated department for APE in a given hospital.

In recent years, multidisciplinary teams called PERT have played an increasingly significant role in decision-making for APE patients. This is partly because the availability of PERT teams improves patient prognosis. In one study, the 30-day mortality of APE patients decreased from 8.5% to 4.7% after introducing the option of consulting with PERT [18]. These teams conduct real-time patient consultations, make clinical decisions, develop action plans for immediate implementation and offer a spectrum of therapeutic methods [4]. In Poland, two documents outlining the principles of PERT team operation have been created [9, 10]. Their establishment

is also recommended by ESC [2], although, as indicated by our study, access to PERT consultations is limited.

The study draws attention to the low value assigned by physicians to multidimensional parameters such as the PESI/sPEI or Bova scales, despite their important role in APE risk stratification. According to these scales, patients are classified into low or intermediate risk groups, guiding decisions on further monitoring and treatment modalities [2]. The survey results reflect similar findings from an international survey conducted among Emergency Medicine physicians and experts in thromboembolic diseases. In that study, only 29.5% of respondents used prognostic models in APE patient risk assessment, with clinical judgment being the most commonly employed method. Respondents cited lack of familiarity with these models (52.3%) and their impracticality (34.2%) as the most common reasons for not using them [19].

Our study indicates a tendency to attribute little prognostic value to multifactorial parameters such as the "saddle embolus" pattern, which occurs rarely (2.6%–5.4%) and is currently not considered a single prognostic factor in the studied population [20–22]. However, some reports suggest the need for special monitoring of this patient group, especially with a high clot burden in central pulmonary arteries [23].

An interesting finding in our study is that despite the majority of respondents being medical specialists with over 15 years of experience, most assessed their experience in APE treatment as moderate. Considering the high in-hospital mortality of APE patients, ranging from 21.9% to 16% between 2006 and 2014 [8], intensive education in the diagnosis of APE patients is necessary, including postgraduate training.

Our study has several strengths. Firstly, it is the first analysis of the opinions of Polish physicians working in hospitals regarding unmet needs in the diagnostic process of APE patients. Secondly, our survey was prepared by a group of experts in the field of APE. Thirdly, the survey was distributed to all hospital departments, and respondents were recruited from a large region of Poland inhabited by almost 7 million people.

We are also aware of the limitations of our study. The voluntary nature of our survey might have introduced self-selection bias, as only the most engaged physicians from the most active hospitals in APE treatment may have completed the survey. Therefore, the level of unmet needs in the diagnosis of APE may be underestimated in our study. Our study was conducted based on physicians working in a selected Polish region; therefore, it may not be generalizable to the entire Polish population. However, the healthcare system in Poland is unified, reducing the likelihood of significantly different results from other Polish regions. As the survey completion process was unsupervised, respondents might have filled out the survey multiple times.

However, we consider this unlikely as the survey was time-consuming, anonymous, and there were no incentives for providing favorable responses. Additionally, the survey could only be submitted once from a specific computer IP address. The study authors acknowledge the possibility of survey completion by physicians from the same hospital or department, however this does not diminish the value of the study because even within one facility, individuals may have different experiences and express their opinions independently.

CONCLUSIONS

Limited continuous access to imaging studies, multidisciplinary consultations, and procedures for transferring patients to higher-tier centers, along with limited awareness of patient risk assessment principles, are the main unmet needs in the diagnosis of patients with APE in Polish hospitals. These factors may potentially hinder physicians from conducting comprehensive diagnostic evaluations, leading to underdiagnosis or overdiagnosis. Therefore, there is a need to improve accessibility to imaging studies in hospitals on a 24/7 basis, develop procedures to coordinate the flow of patients with suspected APE, including PERT consultations, and educate physicians on APE management in both pregraduate and postgraduate settings.

Article information

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1. Characteristics of respondents and hospitals where they work

Variable	Characteristics	n (%)
Characteristics of hospital		
Voivodeships	Małopolskie	99 (48.5%)
	Podkarpackie	61 (29.9%)
	Świętokrzyskie	23 (11.3%)
	others	21 (10.3%)
City population size	<50 000	54 (26.5%)
	50 000–100 000	35 (17.2%)
	100 000–500 000	49 (24.0%)
	>500 000	66 (32.3%)
Presence of ED in hospital	Yes	194 (95.1%)
	No	10 (4.9%)
Treatment of APE at the facility	Yes	198 (97.1%)
	No	6 (2.9%)
Characteristics of respondents		
Specialist Title	Yes	153 (75.0%)
	No	51 (25.0%)
Professional experience	<5 years	31 (15.2%)
	5–14 years	67 (32.8%)
	>15 years	106 (52.0%)
Specialization	Cardiology	65 (31.9%)
	Internal medicine	41 (20.1%)
	Anaesthesiology	20 (9.8%)
	Rheumatology	11(5.4%)
	Emergency medicine	10 (4.9%)
	Other*	57 (27.9%)
Department of work	Cardiology	64 (31.4%)
	Internal medicine	29 (14.2%)
	24 hour ED/CAU	24 (11.8%)
	Other	87 (42.6%)
Presence of department dedicated to APE	Yes	136 (66.7%)
	No	68 (33.3%)

Department dedicated to APE	Cardiology	93 (45.6%)
	Internal medicine	22 (10.8%)
	Anaesthesiology	14 (6.9%)
	Pulmonology	5 (2.5%)
	Angiology	2 (1.0%)

*orthopedics, neurology, surgery, pulmonology, gynecology, rehabilitation, allergology, radiology, radiotherapy, urology, cardiosurgery, nephrology, angiology, vascular surgery, geriatrics, immunology, family medicine, oncology, otolaryngology, paediatrics, psychiatry, urology

Abbreviations: APE for acute pulmonary embolism; ED for emergency department; CAU for central admission room

Table 2. Presents the declared availability of diagnostic tests and their results depending on the hospital's characteristics

Variables		CTA	RV/LV	ECHO	USG	PERT	NT-proBNP
City population size	<100 000 (n = 89)	70 (78.7%)	2 (2.2%)	44 (49.4%)	27 (30.3%)	27 (30.3%)	84 (94.4%)
	>100 000 (n = 115)	101 (87.8%)	11 (9.6%)	75 (65.2%)	62 (53.9%)	48 (41.7%)	103 (89.6%)
	<i>P</i> -value	0.078	0.034	0.023	0.001	0.094	0.217
Presence of ED in hospital	Yes (n = 194)	166 (85.6%)	11 (5.7%)	117 (60.3%)	87 (44.8%)	72 (37.1%)	180 (92.8%)
	No (n = 10)	5 (50.0%)	2 (20.0%)	2 (20.0%)	2 (20.0%)	3 (30.0%)	7 (70.0%)
	<i>P</i> -value	0.003	0.070	0.012	0.122	0.649	0.011
Presence of department dedicated to APE	Yes (n = 136)	116 (85.3%)	9 (6.6%)	88 (64.7%)	55 (40.4%)	49 (36.0%)	126 (92.6%)
	No (n = 68)	55 (80.9%)	4 (5.9%)	31 (45.6%)	34 (50.0%)	26 (38.2%)	61 (89.7%)
	<i>P</i> -value	0.420	0.839	0.009	0.194	0.758	0.474
Presence of a formal procedure	Yes (n = 73)	61 (83.6%)	10 (13.7%)	44 (60.3%)	32 (43.8%)	30 (41.1%)	70 (95.9%)
	No (n = 131)	110 (84.0%)	3 (2.3%)	75 (57.3%)	57 (43.5%)	45 (34.4%)	117 (89.3%)
	<i>P</i> -value	0.940	0.001	0.675	0.964	0.338	0.103
Voivodeship	Małopolskie (n = 99)	84 (84.8%)	6 (6.1%)	54 (54.5%)	44 (44.4%)	58 (58.6%)	93 (93.9%)
	Podkarpackie (n = 61)	48 (78.7%)	4 (6.6%)	35 (57.4%)	24 (39.3%)	11 (18.0%)	57 (93.4%)
	Świętokrzyskie (n = 23)	23 (100%)	0 (0%)	19 (82.6%)	10 (43.5%)	4 (17.4%)	19 (82.6%)
	<i>P</i> -value	0.144	0.178	0.046	0.815	0.000	0.170

Supplementary Table presenting the obtained *P*-values (in Table 2)

	CTA	RV / LV	Echo	USG	PERT	NT- proBNP
City population size	0.078	0.034	0.023	0.001	0.094	0.217
Presence of ED in hospital	0.003	0.070	0.012	0.122	0.649	0.011
Presence of department dedicated to APE	0.420	0.839	0.009	0.194	0.758	0.474
Presence of a formal procedure	0.940	0.001	0.675	0.964	0.338	0.103
Voivodeship	0.144	0.178	0.046	0.815	0.000	0.170

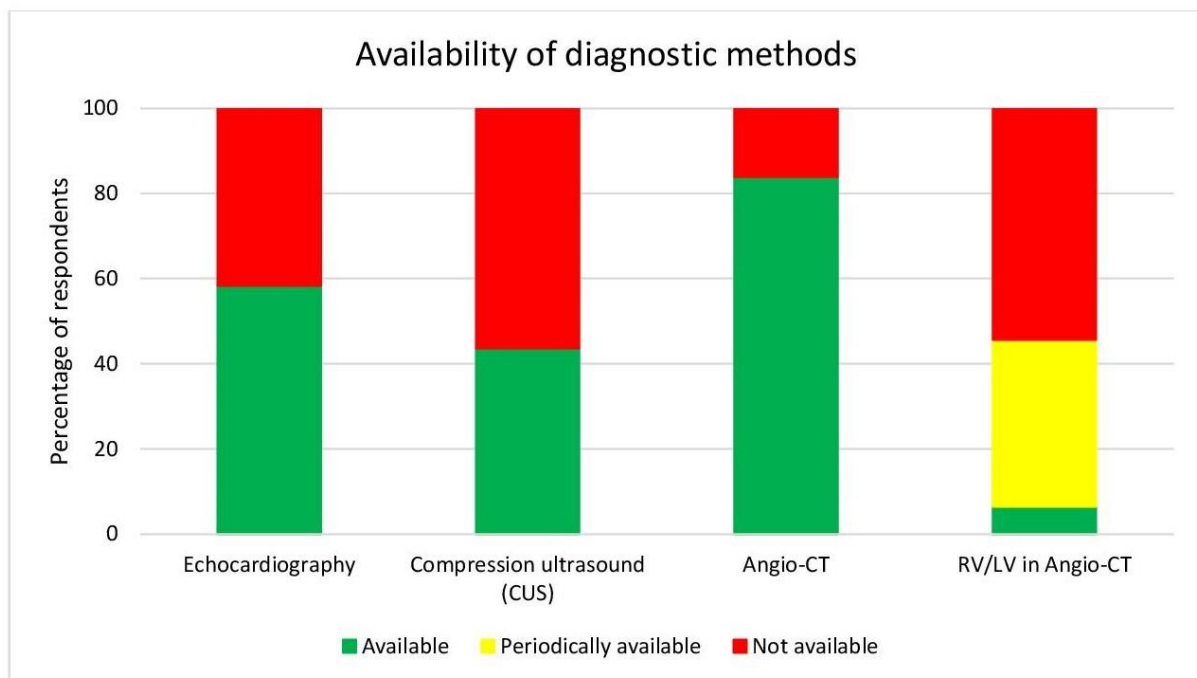


Figure 1. The proportion of respondents indicating the availability of diagnostic tests and their results on 24/7 basis

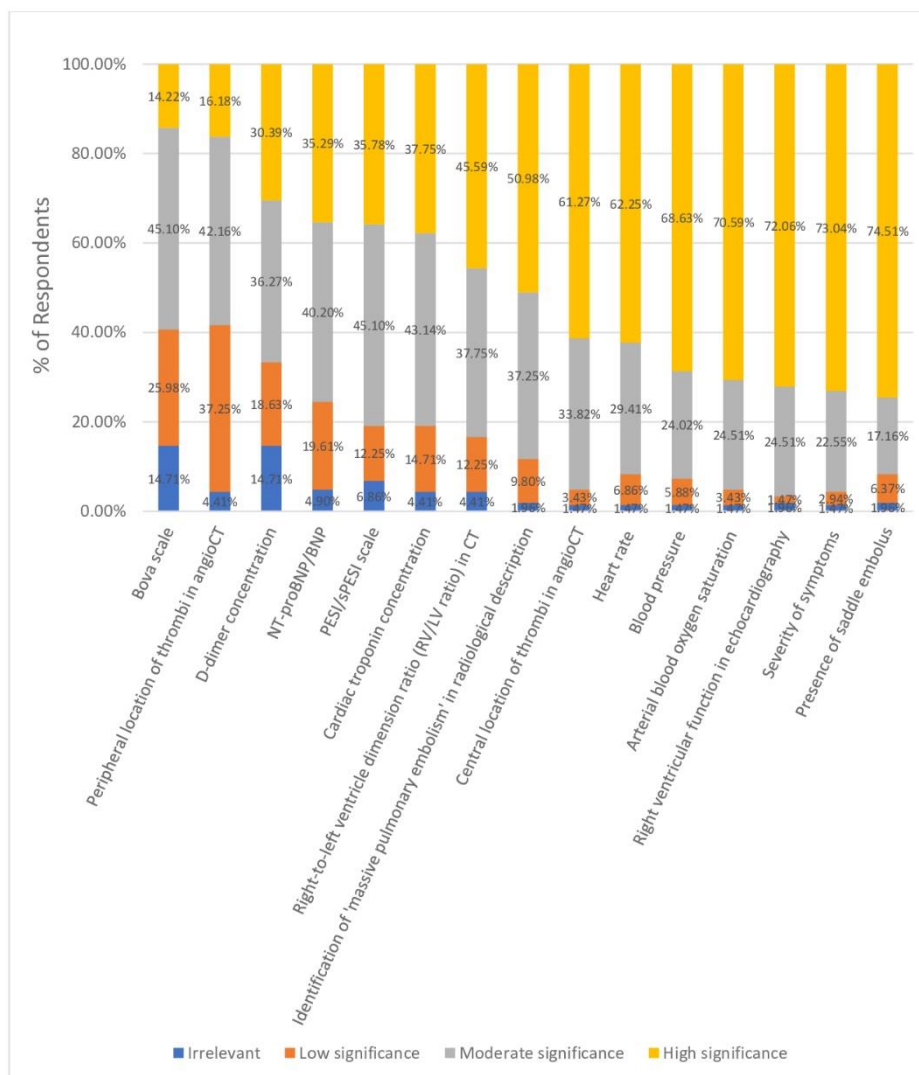


Figure 2. Importance of various prognostic parameters in acute pulmonary embolism according to respondents' assessments