

The Vulnerable Elders Survey-13 scale is superior to the simplified Pulmonary Embolism Score Index in predicting 3-month postdischarge mortality in elderly survivors of acute pulmonary embolism

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KEY WORDS

comprehensive geriatric assessment, pulmonary embolism, simplified Pulmonary Embolism Score Index, Vulnerable Elders Survey-13 scale

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ABSTRACT

INTRODUCTION Acute pulmonary embolism (APE) is the most serious manifestation of venous thromboembolism. The simplified Pulmonary Embolism Severity Index (sPESI) is employed for prediction of 30-day mortality in APE. The Vulnerable Elders Survey (VES-13) is used to identify participants at a risk of health impairment.

OBJECTIVES We aimed to compare the VES-13 and sPESI scales for prediction of 3-month mortality in elderly patients hospitalized for APE.

PATIENTS AND METHODS All patients with APE were managed according to the European Society of Cardiology (ESC) guidelines and followed up for at least 3 months after discharge. Clinical evaluation of all patients involved the Charlson Comorbidity Index (CCI) and biochemical tests. The patients with VES-13 score equal to or above 3 (VES-13 $\geq$ 3) were evaluated with comprehensive geriatric assessment (CGA).

RESULTS A total of 164 patients met the inclusion criteria. There were significantly fewer men in the VES-13 $\geq$ 3 than the VES-13<3 group (34% vs 54.5%; $P < 0.01$). The patients in the VES-13 $\geq$ 3 group had lower median (interquartile range [IQR]) body mass index and higher sPESI score than those in the VES-13<3 group (25.6 [21.8–28.4] kg/m² vs 28 [25.3–31] kg/m²; $P = 0.001$ and 2 [1–2] points vs 1 [0–1] point; $P < 0.001$, respectively). There were no differences in APE severity according to the ESC stratification and CCI. Logistic regression analysis identified the VES-13 score as a significant independent risk factor for 3-month mortality.

CONCLUSIONS The VES-13 score is a better tool than sPESI for predicting 3-month mortality. Geriatric survivors of APE characterized with VES-13 $\geq$ 3 points should be closely monitored after discharge. The Norton Scale Score in a combination with the VES-13 may be useful in predicting 3-month mortality among numerous tests used in the CGA.

INTRODUCTION Acute pulmonary embolism (APE) is the most serious presentation of venous thromboembolism (VTE).¹ VTE is the third most common cause of death worldwide.¹ APE occurs globally in 600 000 to 1 million individuals

each year, with almost a 1-year mortality rate of almost 15%. Elderly individuals constitute a unique population of patients, accounting for approximately 41% of all APE patients aged above 65 years.² Our previous studies indicated that the

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WHAT'S NEW?

Acute pulmonary embolism (APE) is one of the leading causes of death globally. Increasing prevalence of acute disorders, as well as aging of societies constitute the main reasons for elderly people being a dominant group hospitalized in internal medicine departments. Elderly patients form a special population and are characterized by more comorbidities and functional impairments than the general population. Therefore, a comprehensive assessment based not only on disease severity evaluation, but also on psychological, environmental, social, and functional status is needed. The Vulnerable Elders Survey-13 (VES-13) is an easy and compact questionnaire that identifies populations at a higher risk of functional deterioration. Our study is the first to demonstrate that patients older than 60 years with APE, characterized by a higher VES-13 score are at a higher risk of 3-month mortality. The VES-13 may be a better predictive tool than the simplified Pulmonary Embolism Score Index in the elderly population. Moreover, subsequent assessment using the Norton Scale Score improved risk stratification at the 3-month postdischarge mortality prediction.

mean age of patients with APE is 64 years.³ In the Western world, aging is a major problem for public health systems. Based on data obtained from the World Health Organization (WHO), the number of people aged 65 years and older is expected to reach 2 billion by 2050.⁴ According to data from the Statistics Poland, by 2040, individuals aged 80 years and older will constitute almost 36% of all elderly individuals above 65 years of age.⁵ This demographic trend provides a better understanding of the geriatric population and a patient-centered approach that requires social, psychological, environmental, and functional status evaluations.

Elderly individuals are usually characterized by numerous comorbidities and frequently atypical clinical manifestations of acute cardiovascular conditions that require comprehensive diagnostics. Additionally, they present physical disabilities and poor pharmacologic compliance, which may directly contribute to increasing costs of treatment.^{6,7} Hospitalization due to acute cardiovascular events, such as PE, is a severe stressor that may lead to functional impairment during hospitalization and after discharge.^{8,9} Functional status is commonly defined as the ability to perform routine daily activities without excessive effort, safely, and independently. There are several risk factors for functional decline, such as multimorbidity,¹⁰ low level of physical activity and social contacts,¹⁰ reduction in muscle mass and strength,¹¹ abnormal body mass index (BMI), depressive disorders, cognitive impairment,¹² injuries, and falls.¹³ Functional status is a valuable indicator of general health and an important determinant of the quality of life. Precise and validated clinical tools are required to better identify high-risk patients and predict a risk of mortality.

The Vulnerable Elders Survey-13 (VES-13) is a simple tool for dynamic screening of community-dwelling populations, which enables identification

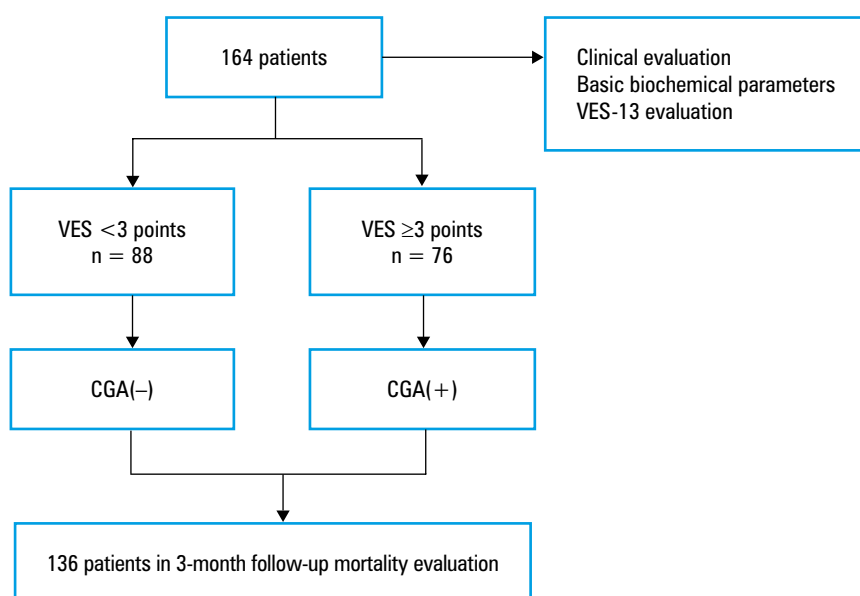
of older persons at a risk of health deterioration.¹⁴ The VES-13 scale is primarily used in outpatient clinics; however, its utility has also been proven in hospital settings.¹⁵ The main advantage of the VES-13 scale is its ability to predict mortality, health service utilization, functional deterioration, and complications for community-dwelling older people.¹⁶ The VES-13 questionnaire includes questions about age, self-related health, physical activity, and activities of daily living. In addition to easy administration by nonphysicians, a considerable benefit of using the VES-13 score is the possibility of applying it in different settings. Scoring 3 or more points on the VES-13 scale is associated with a higher risk of mortality and functional impairment.¹⁷

VES-13 is a tool mostly used for the functional assessment of patients. An important aspect of using VES-13 is to take into consideration the age of the patient and their health self-assessment. To explore the status of older patients, the comprehensive geriatric assessment (CGA) might be used. CGA is a multidimensional battery of validated tests used to evaluate psychological, functional, social, and medical limitations in older populations.¹⁸ The main aim of the CGA is to detect the most vulnerable elderly individuals and plan and coordinate the most suitable interventions.¹⁹ In oncology, CGA is a valuable tool for decision-making processes and cancer treatment.^{20,21} CGA might be useful for mortality prediction in patients with dementia and acute myocardial infarction.²² CGA data represent information that is not routinely acquired during standard clinical judgment. Complex assessment of geriatric patients might facilitate recognition of frailty in this population. Frailty syndrome is a known risk factor of mortality in APE.²³

Among patients with APE, the most popular scale for predicting early 30-day mortality is the simplified Pulmonary Embolism Score Index (sPESI). The sPESI is a clinical scale widely used to assess 1-month mortality risk, which effectively discriminates against patients with a low risk of mortality during APE episodes.²⁴ It is composed of 6 equivalent variables: the presence of cancer, chronic heart failure, chronic pulmonary disease, systolic blood pressure below 100 mm Hg, arterial oxyhemoglobin saturation below 90%, and age over 80 years. However, it can be postulated that the population of patients aged 60–79 years was not sufficiently represented during development of the scale. Moreover, the sPESI does not include motor skills, psychological and social status evaluations, and cognitive function assessment.

The extent of vulnerability in patients with cardiovascular disease (CVD) is poorly characterized. There are limited data regarding mortality prediction in the elderly population with APE. This novel study assessed the utility of the VES-13 scale in predicting 3-month mortality in elderly patients hospitalized for APE, and analyzed which of the

FIGURE 1 Flowchart presenting the study design
Abbreviations: CGA, Comprehensive Geriatric Assessment; VES-13, Vulnerable Elders Survey-13



numerous tests used in CGA is the most powerful in postdischarge mortality prediction.

PATIENTS AND METHODS **Study design and population** This was a single-center analysis of all consecutive patients diagnosed with APE in a reference department. All patients met the following inclusion criteria: first episode of APE with symptom onset not earlier than 14 days before and confirmation of PE (at least at the level of 1 segmental pulmonary artery) on computed tomography pulmonary angiography. The patients were managed according to the current European Society of Cardiology (ESC) guidelines for APE diagnosis and management.¹ Physical examinations, including blood pressure and heart rate monitoring, were performed on hospital admission and repeated every day. Additionally, biochemical tests were performed on admission and repeated within a few days.

All participants were evaluated in a structured manner. A detailed history of major cardiovascular risk factors and characteristics of pharmacologic treatment were obtained. Multimorbidity was quantified using the Charlson Comorbidity Index (CCI).²⁵

The VES-13 score was assessed on the last day of hospital stay before discharge. The VES-13 is a compact questionnaire containing 13 questions regarding self-rated health, age, functional disabilities, and limitations of physical functioning. The questionnaire enables a detailed identification of vulnerability among the elderly individuals. The maximum score is 10 points; the higher the score, the higher the risk of geriatric problem recurrence.^{16,26} In Poland, the National Health Fund (Narodowy Fundusz Zdrowia [NFZ]) finances the CGA in patients with VES-13 score equal to or above 3 points.²⁷ We first decided to compare the patients at a risk of vulnerability (with VES-13 score ≥ 3 points) with those characterized by VES-13 score below 3 points.

The patients with VES-13 ≥ 3 points were evaluated with the CGA. The interpretation of the VES-13 scale is as follows: 0–5 points means that a patient does not require any geriatric care, whereas 6 points indicate that the patient needs specialist geriatric support. We used a standard of 3 points as an indication for CGA, as per the NFZ guidelines.^{19,28}

Thus, the patients with VES-13 ≥ 3 points underwent a detailed assessment, including the Mini-Mental State Examination (MMSE), the Clock Drawing Test (CDT), the Activities of Daily Living (ADL) test, the instrumental Activities of Daily Living (iADL) test, the Barthel scale, the Geriatric Depression Scale (GDS), and the Norton Scale Score (NSS). Each test was performed by a geriatrician and validated by another independent geriatrician to limit intra- and interobserver variability.

A detailed questionnaire was used to obtain the medical history, current health, socioeconomic, and demographic status, and lifestyle habits of all the study participants. The study flowchart for all evaluated patients is presented in **FIGURE 1**.

The exclusion criteria included dementia, a MMSE score below 21 points, total deafness and/or blindness, chronic thromboembolic pulmonary hypertension, and a lack of consent to participate in the study. According to the POL-SENIOR study,²⁹ we excluded participants with MMSE score below 21 points to reduce the percentage of patients who could not fully comprehend the content of the GDS questionnaire, and to avoid inclusion of participants with a reduced ability to give informed consent to participate in the study. The clinical and primary end point of the study was defined as mortality at 3 months after hospital discharge. All procedures were performed in accordance with the ethical standards of the Institutional Research Committee (KB 88/2008) and the 1964 Declaration of Helsinki.

Comprehensive geriatric assessment Cognitive function

Cognitive function was assessed using the MMSE, which is commonly used in daily clinical practice to evaluate orientation, immediate memory, attention and calculation, delayed verbal recall, language, and constructional praxis. The maximum score is 30 points, and the score below 24 is considered indicative of dementia.³⁰ CDT was performed in a comfortable and quiet room without distractors. The task of the test is to draw a clock indicating 10 minutes to 2 o'clock. It is assessed with the Shulman 5-point scale, where 5 points indicate a perfect clock, 4 points are given for minor visuospatial errors, 3 points for inaccurate representation of 10 minutes to 2 o'clock when the visuospatial organization is well done, 2 points for moderate visuospatial disorganization of numbers so that accurate denotation of 10 minutes to 2 o'clock is impossible, 1 point for severe visuospatial disorganization, and 0 points for inability to create any reasonable representation of a clock.³¹ The cut-off score for considering a drawing as abnormal according to the Shulman system was any score below 4 points.

Functional assessment The ADL test is a tool used to determine self-reported dependence/independence and skills crucial for basic living activities, with questions regarding dressing, bathing, transfer, feeding, toileting, and continence.³² The maximum possible score is 6 points. A score of 5–6 points means full functionality, 3–4 points indicate moderate functional impairment, and 0–2 points severe functional impairment.^{19,28} Cutoff values below 5 points were considered abnormal.

The iADL test measures the ability to live independently in a community and estimates dependence and independence on housekeeping, laundry, shopping, using a telephone, transportation, meal preparation, managing medication, and managing finances.³³ The maximum score is 8 points, with lower values denoting dependency.

The Barthel scale was used to assess the ability to perform daily activities. The maximum score is 100 points; the higher the score, the more skillful a patient is at completing daily living activities. Normal values range between 95 and 100 points, moderate functional impairment is diagnosed at a score of 75–95 points, serious functional impairment at 25–45 points, and severe functional impairment at 0–20 points.³⁴ In Poland, 40 points are a cutoff for the NFZ to provide nursing and care services.

Assessment of emotions and mood Emotions and mood were assessed using the GDS. This study used a 15-item version of the test. The GDS is a useful depression screening tool for determining the intensity of depressive symptoms, characterized by high sensitivity and specificity in different populations of elderly people. A score equal to or

above 6 points was regarded as probable development of depressive symptoms and a need for a more detailed diagnosis.²⁹

Norton Scale Score NSS calculates the bedside risk of developing pressure ulcers. The NSS is a compact scoring system that evaluates the mental status, activity levels, physical condition, incontinence, and mobility. For each domain, a minimum of 1 and a maximum of 4 points can be given, with a final score ranging from 5 to 20 points.³⁵ A score equal to or below 14 points indicates a higher risk of pressure ulcer development.

Statistical analysis Normality of the variable distribution was evaluated using the Shapiro–Willk test. Continuous variables with normal distribution are shown as means and SD. Parameters with non-normal distribution are expressed as medians and interquartile ranges (IQRs). Continuous variables with normal distribution were compared with the *t* test for independent variables (assuming equality of variances). Continuous variables with non-normal distribution were analyzed using the Mann–Whitney test. Categorical variables were compared using the χ^2 test. To determine the cutoff values for the VES-13 and sPESI tests for predicting 3-month mortality, a receiver operating characteristic (ROC) curve was constructed. The cutoff value was determined as the point with the highest sum of specificity and sensitivity. We used a stepwise backward logistic regression model to assess the independent risk factors for 3-month mortality, with selected variables that were significant in the univariable analysis included in the regression model. Classification and Regression Trees (CARTs) were used to determine the cutoff value for the NSS test for predicting 3-month mortality. The level of significance was defined as *P* value below 0.05. All analyses were performed using STATISTICA package version 11 (StatSoft Inc., Tulsa, Oklahoma, United States).

RESULTS As the CGA is only performed in patients with VES-13 $\geq$ 3, we decided to first analyze the differences between the patients with VES-13 $\geq$ 3 and VES-13 $<$ 3 scores.

In this study, a total of 164 patients with APE were enrolled; 76 patients with VES-13 $\geq$ 3 points and 88 individuals with VES-13 $<$ 3 points. The median (IQR) age in the VES-13 $\geq$ 3 group was higher than that of the VES-13 $<$ 3 group (83 [74–87] vs 73 [66–74] years; *P* < 0.001). There was a lower percentage of men in the VES-13 $\geq$ 3 vs the VES-13 $<$ 3 group (34% vs 54.5%; *P* = 0.009). The VES-13 $\geq$ 3 group included also more patients with numerous comorbidities and higher median (IQR) scores of the CCI (3 [2–5] vs 2.5 [1.5–4]; *P* = 0.35); however, there was no significant difference in the comorbidity rate (TABLE 1).

There was no significant difference between the groups in APE clinical severity and course according to the ESC guidelines (TABLE 1); however, the patients in the VES-13 $\geq$ 3 group were

TABLE 1 Characteristics of patients with Vulnerable Elders Survey-13 score equal to or above 3 and below 3 points

Parameters	VES-13 ≥ 3 (n = 76)	VES-13 < 3 (n = 88)	P value
Age, y	83 (74–87)	70 (66–74)	< 0.001
Men, n (%)	26 (34.2)	48 (54.5)	0.009
BMI, kg/m ²	25.6 (21.8–28.4)	28 (25.3–31)	0.001
CCI, points	3 (2–5)	2.5 (1.5–4)	0.35
Clinical course of APE			
Low risk of APE, n (%)	12 (15.8)	21 (23.9)	0.2
Intermediate-low risk of APE, n (%)	27 (35.5)	28 (31.8)	0.62
Intermediate-high risk of APE, n (%)	36 (47.4)	33 (37.5)	0.2
High risk of APE, n (%)	2 (2.6)	7 (7.95)	0.14
RV/LV ratio > 1 , n (%)	28 (36.8)	26 (29.5)	0.32
sPESI, points	2 (1–2)	1 (0–1)	< 0.001
Biochemical parameters			
Sodium, mmol/l	140 (137–143)	139 (137.5–142)	0.57
Potassium, mmol/l	4.3 (0.5)	4.3 (0.4)	0.7
Urea, mg/dl	45.9 (33.6–70.3)	33.1 (26.5–39.7)	< 0.001
GFR, ml/min/1.73 m ²	69.5 (49.8–85.4)	86.9 (69.2–95)	< 0.001
Characteristics of cardiovascular risk			
Total cholesterol, mmol/l	154.3 (44.8)	163.8 (44.4)	0.23
NT-proBNP, pg/ml	1403 (390–4085)	609 (201–2096)	0.01
Troponin, ng/l	32 (15–60)	29 (12–73)	0.53
D-Dimer, $\mu\text{g/l}$	4051 (1658–14 311)	5331 (2385–14 485)	0.11
Inflammatory markers and platelets			
WBC, $\times 10^3/\mu\text{l}$	9.3 (6.3–12)	7.7 (6.4–9.6)	0.07
CRP, mg/l	11.9 (2.3–41)	15.5 (4.7–50.1)	0.34
Procalcitonin, ng/ml	0.13 (0.1–0.3)	0.08 (0.06–0.14)	< 0.001
NLR	5.9 (3–8.2)	3 (2.1–5.5)	< 0.001
Medications			
ACEI, n (%)	37 (48.7)	37 (42)	0.39
ARB, n (%)	7 (9.2)	16 (18.2)	0.09
β -Blockers, n (%)	50 (65.8)	52 (59)	0.38
MR blockers, n (%)	8 (10.5)	3 (3.4)	0.07
Calcium channel blockers, n (%)	19 (25)	14 (15.9)	0.15
Diuretics, n (%)	47 (61.8)	34 (38.6)	0.003
Statins, n (%)	37 (48.7)	38 (43.2)	0.48
Low-molecular-weight heparin, n (%)	19 (25)	23 (26.1)	0.87
Vitamin K antagonist, n (%)	3 (3.9)	2 (2.3)	0.53
NOAC, n (%)	53 (69.7)	65 (73.9)	0.56

Continuous variables are shown as mean (SD) or median (interquartile range).

SI conversion factors: to convert urea to mmol/l, divide by 6; NT-proBNP to ng/l, multiply by 1; troponin to $\mu\text{g/l}$, multiply by 0.001; procalcitonin to $\mu\text{g/l}$, multiply by 1.

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; APE, acute pulmonary embolism; ARB, angiotensin II receptor blocker; BMI, body mass index; CCI, Charlson Comorbidity Index; CRP, C-reactive protein; GFR, glomerular filtration rate; LV, left ventricle; MR, mineralocorticoid receptor; NOAC, non-vitamin K antagonist; NLR, neutrophil-to-lymphocyte ratio; NT-proBNP, N-terminal pro-B-type natriuretic peptide; RV, right ventricle; sPESI, simplified Pulmonary Embolism Score Index; WBC, white blood cells; others, see [FIGURE 1](#)

characterized by higher median (IQR) sPESI score than those in the VES-13 < 3 group (2 [1–2] vs 1 [0–1]; $P < 0.001$). We observed no significant differences in the pharmacologic treatment except for loop diuretic prescription, which was significantly more common in the VES-13 ≥ 3 than in the VES-13 < 3 group ([TABLE 1](#)).

Biochemical characteristics and inflammatory markers After comparing the VES-13 scores, we analyzed the patients from both groups in terms of biochemical parameters. The patients with VES-13 ≥ 3 score were characterized by higher plasma levels of N-terminal pro-B-type natriuretic peptide (NT-proBNP) and urea and lower

TABLE 2 Comprehensive geriatric assessment (CGA) in patients with Vulnerable Elders Survey-13 score equal to or above 3 points evaluated with CGA depending on their survival after 3 months

Clinical test	VES-13≥3 subgroup (n = 76)	3-month follow-up		P value
		Died (n = 16)	Survived (n = 41)	
MMSE				
Median	27 (24–28)	24.5 (23–27)	27 (25–28)	0.002
<24 points, n (%)	10 (13.2)	6 (37.5)	1 (2.4)	
≥24 points, n (%)	66 (86.8)	10 (62.5)	40 (97.6)	
CDT				
Median	4 (1.5–5)	4 (1–5)	4 (3–5)	0.22
4–5 points, n (%)	40 (52.6)	9 (56.3)	26 (63.4)	
<4 points, n (%)	36 (47.4)	7 (43.7)	15 (36.6)	
ADL				
Median	5 (1–6)	1 (0–6)	6 (0–6)	<0.001
5–6 points, n (%)	40 (52.6)	2 (12.5)	29 (70.7)	
<5 points, n (%)	36 (47.4)	14 (87.5)	12 (29.3)	
iADL				
Median	3 (1–6)	1 (1–2.5)	4 (2–8)	<0.001
8 points, n (%)	16 (21)	1 (6.25)	11 (26.8)	
<8 points, n (%)	60 (78.9)	15 (93.75)	30 (73.2)	
NSS				
Median	17 (12.5–19)	12.5 (9–15)	17 (16–19)	<0.001
>14 points, n (%)	49 (64.5)	4 (25)	35 (85.4)	
≤14 points, n (%)	27 (35.5)	12 (75)	6 (14.6)	
Barthel scale				
Median	75 (27.5–92.5)	35 (17.5–55)	90 (70–95)	<0.001
≤40 points, n (%)	24 (31.6)	10 (62.5)	7 (17.1)	
>40 points, n (%)	52 (68.4)	6 (37.5)	34 (82.9)	
GDS				
Median	4 (2–7)	4 (2–7.5)	3 (2–5)	0.38
0–5 points, n (%)	51 (67.1)	10 (62.5)	31 (75.6)	
6–15 points, n (%)	25 (32.9)	6 (37.5)	10 (24.4)	

Abbreviations: ADL, activities of daily living; CDT, clock drawing test; iADL, instrumental activities of daily living; GDS, geriatric depression scale; MMSE, Mini-Mental State Examination; NSS, Norton Scale Score; others, see [TABLE 1](#)

glomerular filtration rate (GFR) calculated using the Chronic Kidney Disease Epidemiology Collaboration formula ([TABLE 1](#)). There were no significant differences between the groups in terms of sodium, potassium, total cholesterol, high-sensitivity troponin T (hs-TnT), and D-dimer levels ([TABLE 1](#)). Even though we did not observe any significant differences in C-reactive protein (CRP) and white blood cell count (WBC), we showed that the patients with VES-13≥3 score had higher median procalcitonin level and neutrophil-to-lymphocyte ratio (NLR) (0.13 [0.1–0.3] ng/ml vs 0.08 [0.06–0.14] ng/ml; $P < 0.001$ and 5.9 [3–8.2] vs 3 [2.1–5.5]; $P < 0.001$, respectively) than the patients with VES-13<3 score.

Comprehensive geriatric assessment Among the patients above 60 years of age with a minimum 3 points on the VES-13 scale a detailed CGA was

performed ([TABLE 2](#)). The patients who died within the 3-month period had lower median MMSE score than the survivors (24.5 [23–27] vs 27 [25–28] points; $P = 0.002$) ([TABLE 2](#)). Despite a close association between the MMSE and CDT tests described in the literature, we did not observe any differences in the CDT scores. However, the subgroup of patients who died after 3-months presented with functional impairment measured by the ADL and iADL scales ([TABLE 3](#)). Furthermore, the APE geriatric subpopulation at a higher risk of death within 3 months after hospital discharge was characterized by a higher median risk of pressure sore development, evaluated using the NSS, as compared with the survivors (12.5 [9–15] vs 17 [16–19]; $P < 0.001$). As the Barthel scale is widely used to assess the ability to perform daily activities, we evaluated it in the patients with VES-13≥3 points. Almost 32% of them scored 40 or less than 40 points on the Barthel scale, which indicated a need for nursing and care services funded by the NFZ. There were no significant differences in terms of emotion and mood assessment measured by the GDS ([TABLE 3](#)).

Receiver operating characteristic curve for 3-month mortality ROC curves for predicting 3-month mortality were constructed using the VES-13 and sPESI scales ([FIGURE 2A](#) and [2B](#)). The cutoff value for predicting 3-month mortality with the VES-13 scale was set at 8 points, with an area under the curve (AUC) of 0.88 (95% CI, 0.789–0.971; $P < 0.001$), 77.8% sensitivity, and 90.2% specificity ([FIGURE 2A](#)). For sPESI, the cutoff value was set at 2 points, with an AUC of 0.81 (95% CI, 0.728–0.885; $P < 0.001$), 88.9% sensitivity, and 70.5% specificity ([FIGURE 2B](#)).

Independent risk factors for 3-month mortality in logistic regression analysis The multivariable logistic regression model including variables that were significant in the univariable analysis (continuous variables, such as VES-13, BMI, GFR, NT-proBNP, hs-TnT, procalcitonin and sPESI, and a categorical variable of sex) indicated that the VES-13 score (and not sPESI) was an independent risk factor for the 3-month mortality ([TABLE 3](#)). An increase by 1 point on the VES-13 score was associated with an approximately 2.5-fold elevated risk of 3-month all-cause mortality among patients aged 60 years or older, with the first episode of APE ([TABLE 3](#)).

Comprehensive geriatric assessment and its value in 3-month mortality prediction In the next step, we analyzed whether the CGA improves 3-month mortality prediction in the VES-13≥3 group. In the logistic regression model (with continuous variables including VES-13 score, MMSE, ADL, iADL, NSS, and the Barthel scale), VES-13 and NSS were independent risk factors for postdischarge mortality ([TABLE 3](#)). We noted that an increase by 1 point in the VES-13 score was related to a 59% higher risk of 3-month mortality, and

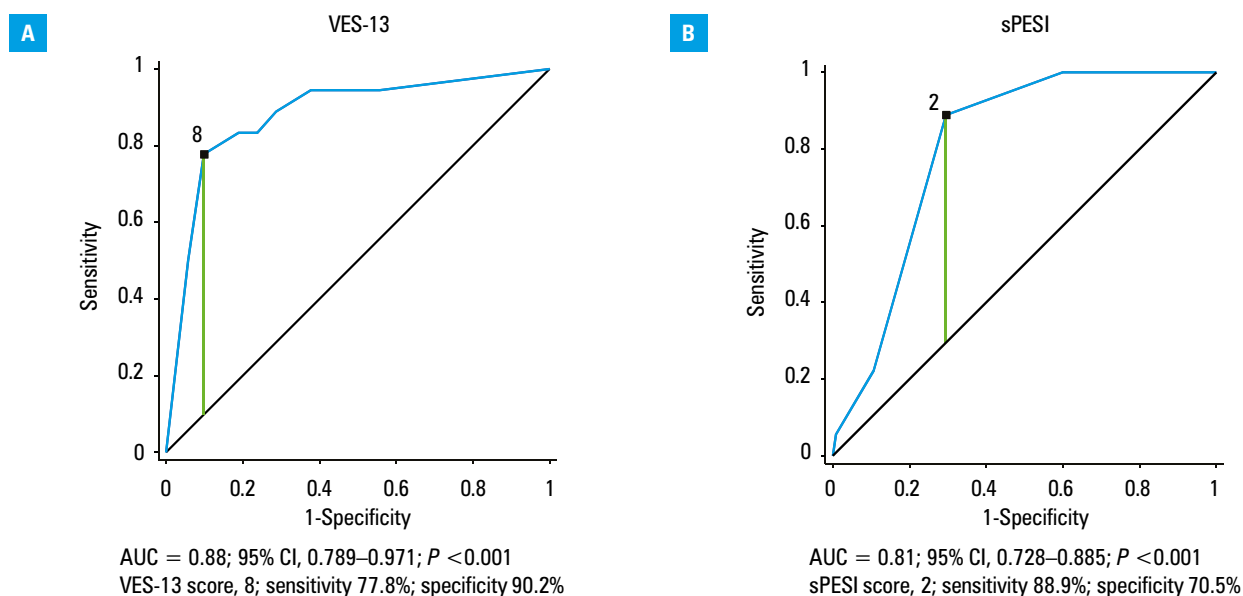


FIGURE 2 **A** – receiver operating characteristic (ROC) curve of the Vulnerable Elders Survey-13 (VES-13) for predicting 3-month mortality among patients with acute pulmonary embolism (APE); **B** – ROC curve of the simplified Pulmonary Embolism Severity Index (sPESI) for predicting 3-month mortality among patients with APE

Abbreviations: AUC, area under the curve; others, see [FIGURE 1](#)

TABLE 3 Independent risk factors for 3-month mortality in logistic regression model

Variable	Odds ratio for mortality (95% CI)	P value
3-month mortality in total population ^a		
VES-13 score	2.67 (1.05–6.75)	0.04
BMI, kg/m ²	1.54 (0.97–2.46)	0.07
3-month mortality in VES-13 $\geq$ 3 points subgroup ^b		
VES-13 score	1.59 (1.02–2.49)	0.04
NSS	0.74 (0.59–0.93)	0.009

a Logistic regression model built with the following continuous variables: VES-13, BMI, GFR, NT-proBNP, high-sensitivity troponin T, procalcitonin and sPESI, and a categorical variable of sex

b Logistic regression model built only for the population of patients with VES-13 $\geq$ 3 points and performed CGA, and including continuous variables such as VES-13 score, MMSE, ADL, iADL, NSS, and Barthel scale

Abbreviations: see [FIGURE 1](#), [TABLES 1](#) and [2](#)

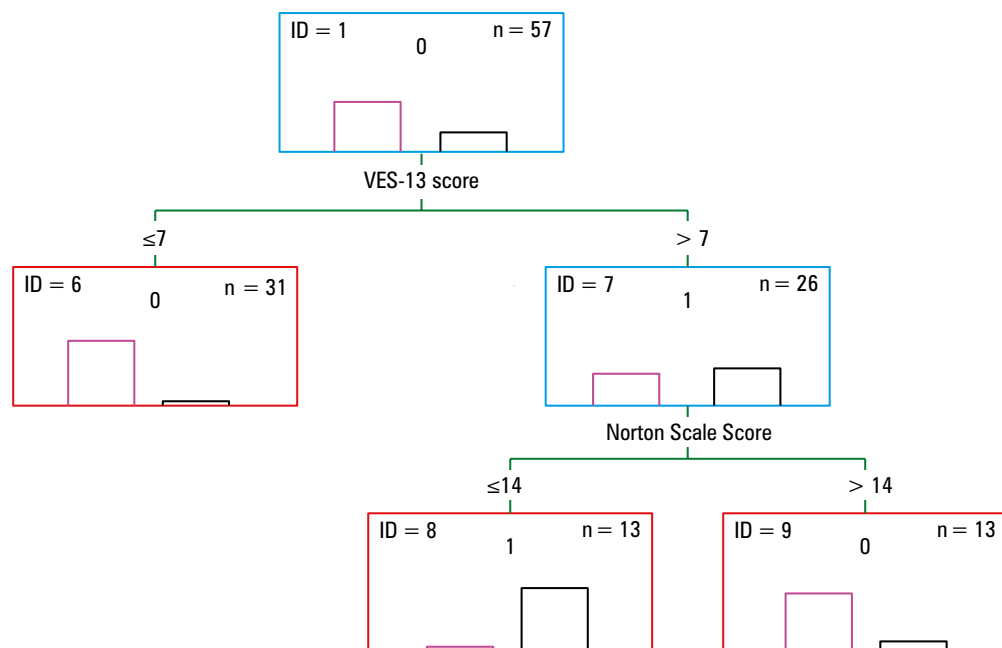
a 1-point decrease in the NSS was related to by 35% higher odds of death ([TABLE 3](#)). We employed the CART algorithm to identify the cutoff values for the VES-13 and NSS tests ([FIGURE 3](#)).

In a subgroup of patients with VES-13 score above 7 points, the percentage of 3-month mortality was 53.9%, and in a subgroup of patients with VES-13 score above 7 points and NSS score equal to or below 14 points, the percentage of 3-month mortality reached 92.3% (data not shown).

DISCUSSION The main finding of our study is the observation that the VES-13 score may be useful in predicting 3-month postdischarge mortality in patients after the first episode of APE aged 60 years or older. According to the ESC APE guidelines,¹ there are several parameters for early (in-hospital and 30-day) mortality prediction, such as hemodynamic instability, right-to-left ventricular ratio above 1, sPESI score, hs-TnT plasma

concentration, rarely used creatinine level, and hyponatremia.¹ We observed no significant differences between the VES-13 $\geq$ 3 group and the VES-13<3 group in terms of APE severity according to the ESC risk stratification, plasma hs-TnT concentration, and frequency of right ventricular failure. However, the VES-13 $\geq$ 3 group had a higher sPESI score than the VES-13<3 group. sPESI is widely used in daily clinical practice due to its simplicity and appropriate validation in large cohorts. There is a lack of data in the literature showing the potential for using any other scales (validated in clinical trials) dedicated to the elderly population diagnosed with APE. Very elderly populations aged 80 years and more are under-represented in most studies, and the sPESI scale does not distinguish between elderly (>60 years old) and very elderly (>80 years old) patients. In contrary, the VES-13 scale considers the exact age of patients in relation to their functional status. Taking these factors into account, we compared

FIGURE 3 Classification and regression tree showing the cutoff value for Norton Scale Score to predict 3-month mortality among patients with acute pulmonary embolism (APE). The pink line denotes APE survivors, and the black line denotes patients who died within 3 months after hospital discharge. Abbreviations: ID, identifier



the sPESI with the VES-13 score for 3-month mortality prediction. Our study is the first to demonstrate that the VES-13 score is a better tool than the sPESI to predict 3-month mortality among elderly APE patients. According to the European Statistical Office data, approximately 20.3% of the European Union population were aged 65 years or more in 2019. To the best of our knowledge, there are no data in the literature describing the use of the VES-13 among patients with APE. Continuous physical impairment, as measured with the VES-13 questionnaire, is a well-known condition that results in a higher demand for nursing, medical, and care services. Moreover, it increases health care system expenses and leads to lower quality of life. Progressive loss of independence in performing daily activities is related to an increased risk of frailty syndrome and higher mortality.³⁶ The use of the VES-13 score in patients with CVDs is limited.

The patients with higher VES-13 score (≥ 3 points) were characterized by a higher risk of 3-month mortality. The VES-13 scale is strongly associated not only with age but also with functional status. Bell et al⁹ discovered that vulnerability measured with the VES-13 scale was common in older patients hospitalized for CVDs, and it was associated with greater use of health care services. In this study, a multivariable logistic analysis indicated that a 1-point increase in VES-13 score was independently related to low social support, depression, female sex, and heart failure (HF).⁹ In a study conducted by Le Courvoisier et al³⁷ in 555 patients aged 75 years or older and diagnosed with HF exacerbation, the functional decline correlated with the worst short-term prognosis. We observed that the VES-13 score above 8 was associated with greater 3-month mortality in the total APE population. The same relationship was confirmed for VES-13 score above 7 points in the VES-13 ≥ 3 group.

The groups differed in terms of risk factors such as age, sex, NT-proBNP concentration, and proinflammatory parameters. Sex-specific differences should not be discarded in the APE population. According to WHO,³⁸ average lifespan of women in Poland in 2020 was 7.7 years longer than that of men. Keller et al³⁹ reported cardiac troponin concentration, sPESI and Bova score, and right ventricular dysfunction as factors predicting adverse outcome in normotensive female patients only, while tachycardia, hypoxia, and NT-proBNP levels could be used to predict the adverse outcome in both sexes. However, there were no differences in 30-day survival between sexes.

In a Mendelian randomization study, genetically predicted BMI was positively associated with APE and most cardiovascular conditions.⁴⁰ On the other hand, it can be postulated that patients with higher mortality rate are characterized with lower BMI, which might indicate the presence of cardiovascular obesity paradox.⁴¹ BMI above 30 kg/m² is a risk factor for development of CVDs. However, the optimal BMI for patients already suffering from a cardiovascular condition (such as APE) remains to be established.⁴¹ It is well-known that vulnerability is associated with cardiometabolic disorders.⁴² Kravchenko et al⁴² demonstrated that VES-13 score, being a frailty marker, is associated with HF, development of pressure ulcers, and urinary incontinence. In our study, the patients with VES-13 ≥ 3 points were characterized by higher NT-proBNP concentration.

Proinflammatory markers, such as CRP, are a part of routine assessment in APE patients. In our study, the patients with higher VES-13 score were characterized by higher procalcitonin levels and higher NLR. It is hypothesized that “inflammaging,” defined as immunosenescence and age-related increase in circulating proinflammatory cytokines, plays a crucial role in the frailty syndrome development.⁴³ Peripheral NLR was proposed as

a better indicator of inflammation than WBC. According to the literature, the balance between neutrophils and lymphocytes is considered an index of systemic inflammation. Increased NLR has been shown to be related to coronary plaque disruption in acute coronary syndromes (ACSs), and higher in-hospital mortality and neutrophil levels seem to modulate inflammatory response in inflammatory processes.⁴⁴

In a retrospective study, Kayrak et al⁴⁵ for the first time confirmed that NLR is an independent predictor of 30-day mortality, irrespectively of systolic blood pressure, creatine kinase myocardial band, age, and type 2 diabetes mellitus among patients with APE. Previously, the prognostic value of NLR was confirmed in HF and ACSs.⁴⁶ It seems that cytokines released from neutrophils might be responsible for vascular injury.

We demonstrated that the participants with VES-13 greater than 7 points and the NSS equal to or below 14 points were at a higher risk of 3-month mortality. The NSS was primarily developed to assess geriatric nursing issues and the risk of pressure ulcers. This simple tool evaluates clinical frailty and predicts patient outcomes. Lower NSS values were shown to predict mortality and morbidity in patients with HF, and those after transcatheter aortic valve replacement and myocardial infarction.⁴⁷ This is the first study to demonstrate the combined use of the VES-13 and NSS tests for risk stratification in the patients with APE.

The sPESI scale has been validated and is of great importance in clinical practice; however, it may be less precise for mortality prediction. This is because it does not include the parameters evaluated in the VES-13 tool. Hence, the VES-13 score may be a complementary clinical tool to the sPESI scale to better predict the 3-month mortality. CGA is the gold standard for identifying and managing health conditions among geriatric patients, not only with neoplastic but also with CVD.⁴⁸ CGA mediated by the initial VES-13 evaluation may be a useful strategy for health care system physicians. As the geriatric assessment is time-consuming and comprises many tests, we propose a compact approach consisting of the VES-13 in the first step and NSS that may be useful in daily clinical practice to identify patients at a higher risk of 3-month mortality.

Our study had several limitations. It included a relatively small number of participants; however, patients with dementia were excluded. Owing to the self-reported nature of the VES-13, we excluded the most ill patients with communication, vision, and hearing disorders. The VES-13 score was assessed on the last day of hospitalization. Therefore, we could not evaluate its potential value for predicting in-hospital mortality. We decided to exclude the patients with dementia from our study. Dementia (developed in the course of Alzheimer's disease or for numerous other causes) strongly influences prognosis in elderly patients with chronic diseases.⁴⁹ Additional

studies are needed to validate the usefulness of VES-13 scale in assessing the prognosis in elderly APE patients with dementia.⁵⁰

In conclusion, there is no standardized tool for evaluating the vulnerable functional status during hospitalization. Vulnerability and functional impairment, assessed with the VES-13 scale, are prevalent among elderly patients hospitalized in cardiology departments for their first episode of APE. It may be postulated that the VES-13 scale is a better tool for predicting the 3-month mortality than the widely used sPESI scale. The VES-13, supplemented by the NSS test, are useful screening tools for identifying patients at a higher risk of postdischarge death. However, the CGA indicates the need for further screening and prioritization of postdischarge care. Better understanding of the social, psychological, and mental status of our patients may enable direct implementation of more effective treatment strategies, more intense age-related prophylaxis, and inspiration for lifestyle changes.

ARTICLE INFORMATION

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CONTRIBUTION STATEMENT PP and AMI designed the study protocol; EK-S, MS, and KW evaluated the geriatric assessment; OD-D, MM, and AO-P collected the data; AZ-L, AP, IB, and KN prepared the database; AMI and PP analyzed the results and wrote the manuscript.

CONFLICT OF INTEREST None declared.

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