【 ORIGINAL ARTICLE 】

Association of Admission Glucose Level and Improvement in Pulmonary Artery Pressure in Patients with Submassive-type Acute Pulmonary Embolism

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Abstract:

Objective   The admission glucose level is a predictor of mortality even in patients with acute pulmonary embolism (APE). However, whether or not the admission glucose level is associated with the severity of APE itself or the underlying disease of APE is unclear.

Methods   This study was a retrospective observational study. A pulmonary artery (PA) catheter was used to accurately evaluate the severity of APE. The percentage changes in the mean PA pressure (PAPm) upon placement and removal of the inferior vena cava filter (IVCF) were evaluated. We hypothesized that the admission glucose level was associated with the improvement in the PA pressure in patients with APE.

Patients   A total of consecutive 22 patients with submassive APE who underwent temporary or retrievable IVCF insertion on admission and repetitive PA catheter measurements upon placement and removal of IVCFs were enrolled.

Results   There was a significant positive correlation between the admission glucose levels and the percentage changes in the PAPm (r=0.543, p=0.009). A univariate linear regression analysis showed that the admission glucose level was the predictor of the percentage change in PAPm (β coefficient=0.169 per 1 mg/dL; 95% confidence interval, 0.047-0.291; p=0.009). A multivariate linear regression analysis with the forced inclusion model showed that the admission glucose level was the predictor of the percentage change in PAPm independent of diabetes mellitus, PAPm on admission, troponin positivity, and brain natriuretic peptide level (all p<0.05).

Conclusion   The admission glucose level was associated with the improvement in the PAPm in patients with submassive-type APE.

Key words: admission glucose level, pulmonary embolism, inferior vena cava filter

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Introduction

Acute pulmonary embolism (APE) remains a fatal disease in the clinical setting. A previous study reported that the mortality rate of untreated APE is about 30% (1). Even with standard therapy, the in-hospital mortality rate of APE was reported to be 14% in the Japanese registry (2). Severe APE was reported to cause right ventricular (RV) dysfunction (RVD), leading to cardiogenic shock, and the mortality rate of APE with cardiogenic shock was up to 30% (2). Therefore, the accurate classification of the severity of APE is important. APE has been classically defined as having three types according to the hemodynamic status of the patient

and the presence of RVD: massive type, submassive type, and non-massive type (3, 4). Recently, however, APE has been defined as having four types according to the hemodynamic status, presence of RVD, pulmonary embolism (PE) severity index, and cardiac laboratory biomarkers [elevated cardiac troponin (Tn) or brain natriuretic peptide (BNP) level]: high, intermediate-high, intermediate-low, and low (5).

Anticoagulant therapy is the initial therapy in all patients with APE who have no contraindications to anticoagulant therapy. More aggressive therapies, such as the use of a percutaneous cardiopulmonary support device or fibrinolytic therapy, are needed in some patients (6, 7). In addition, insertion of an inferior vena cava filter (IVCF) is an optional therapy to prevent the recurrence of APE. Preventing the recurrence of APE, particularly in the acute phase, is important, as a previous report demonstrated that 90% of deaths resulting from PE were due to the recurrence of APE, which mostly occurred within 1 week (8). Recently, in the PREPIC2 study, IVCF insertion was reported to have no additional benefit in patients with APE who could be treated with anticoagulant therapy (9). However, the mean time between randomization and attempted IVCF insertion was 1.5 days, and the severity classification of APE was mixed, including the non-massive type of APE, in the PREPIC2 study. We believe that the risk of APE recurrence is highest on the day of admission; therefore, IVCF insertion may be more beneficial the sooner it is performed after admission. Earlier IVCF insertion may have some benefits in patients with poor improvement in their pulmonary artery (PA) pressure (PAP) in the acute phase. However, even early IVCF insertion may have no marked benefit in patients with a low-risk status, such those with the non-massive type of APE. Therefore, whether or not patients with APE actually need IVCF insertion remains unclear.

The admission glucose level is a predictor of mortality in various diseases (10-15). Recently, some reports have shown the admission glucose level to be a predictor of mortality, even in patients with APE (16-18). However, whether or not the admission glucose level is associated with the severity of APE itself or the underlying disease of APE is unclear. Furthermore, while a PA catheter can accurately evaluate the severity of APE, no study has investigated the association between the admission glucose level and the PAP as determined by using a PA catheter.

The aim of the present study was to examine whether or not the admission glucose level was associated with the improvement in the PAP in patients with APE by investigating the association between the admission glucose level and the percentage change in the mean PAP (PAPm) determined using a PA catheter.

Materials and Methods

Patients

The present study was a retrospective observational study in patients with APE treated at Saiseikai Yokohamashi Nanbu Hospital from March 2010 through March 2016. We used temporary IVCFs (Neuhause Protect; Toray Medical, Tokyo, Japan) or retrievable IVCFs (Günther Tulip; Cook Japan, Tokyo, Japan) aggressively in patients with massive- or submassive-type APE as soon as possible on admission to prevent the recurrence of APE and performed PA catheter (Swan-Ganz thermodilution catheter; Edwards Lifesciences, Irvine, USA) measurements repeatedly upon insertion and removal of IVCFs. Consecutive patients with submassive-type APE who underwent temporary or retrievable IVCF insertion were screened for eligibility. As which patients need IVCF insertion among those with submassive APE in the clinical setting remains unclear, and it is important to exclude the potential confounding factors influencing the severity of APE. We therefore limited the included patients to those with submassive-type APE. All patients were given intravenous unfractionated heparin (intravenous bolus dose of 5,000 international units, then a continuous intravenous infusion) adjusted according to the activated partial thromboplastin time (aPTT) so that the ratio of the patient's value to the control value remained between 1.5 and 2.5 (19). The target ratio was reached within the first day in all patients.

APE was defined as the acute onset of symptoms suspicious of PE on the basis of the European Society of Cardiology guideline (5). Computed tomographic pulmonary angiography, pulmonary angiography, or lung scintigraphy was used to confirm PE. Massive, submassive, and non-massive types were defined as follows: massive type was APE with sustained hypotension (systolic blood pressure <90 mm Hg for at least 15 min or requirement for inotropic support not due to reasons other than PE, such as arrhythmia, hypovolemia, sepsis, or left ventricular dysfunction), pulselessness, or persistent profound bradycardia (heart rate <40 beats per minute with signs or symptoms of shock); submassive type was APE without systemic hypotension (systolic blood pressure <90 mm Hg) but with RVD; and non-massive type was APE without systemic hypotension (systolic blood pressure <90 mm Hg) and RVD (4).

We also excluded patients with any of the following characteristics: (i) contraindications of the initial anticoagulant therapy; (ii) lack of repetitive PA catheter measurements; (iii) mechanical ventilation; and (iv) hemodialysis.

A total of consecutive 22 patients with submassive-type APE who underwent temporary or retrievable IVCF insertion met the eligibility criteria and were enrolled. A PA catheter was used to accurately evaluate the severity of APE. The percentage changes in PAPm upon placement and removal of IVCFs were evaluated, and we divided the patients into two groups according to the percentage change in

PAPm: a good improvement group, comprising 11 patients with percentage change in PAPm <-28.8%; and a poor improvement group, comprising 11 patients with percentage change in PAPm ≥-28.8%. Some previous reports demonstrated that the percentage changes in PAP with treatments by recombinant tissue-type plasminogen activator, nitric oxide, and pulmonary embolectomy were -27.3% (31±7 mmHg to 22±6 mmHg), -11.9% (32.9±1.3 mmHg to 29.0±1.4 mmHg), and -22.3% (44.9±5.7 mmHg to 34.9±7.1 mmHg), respectively (20-22). Therefore, our cutoff value of the percentage change in PAPm <-28.8% had clinical significance. The present study protocol was approved by the Saiseikai Yokohamashi Nanbu Hospital Institutional Review Board and complied with the provisions of the Declaration of Helsinki.

Blood sampling

Blood samples were obtained on admission for the measurement of D-dimers, white blood cell count, hemoglobin, Tn, BNP, blood glucose, hemoglobin A1c (HbA1c), low-density lipoprotein cholesterol, high-density lipoprotein (HDL) cholesterol, triglycerides, estimated glomerular filtration rate (eGFR), and high-sensitivity C-reactive protein (hs-CRP). Tn was defined as positive when the admission cardiac-specific troponin T or I level increased to above the 99th percentile of a normal reference population. aPTT was measured on admission (baseline aPTT) and during the administration of intravenous unfractionated heparin. We also evaluated the daily average of each aPTT ratio calculated as the ratio of aPTT divided by baseline aPTT to confirm the effect of anticoagulant therapy during the acute phase. In addition, as previous studies showed that a shortened aPTT was associated with a hypercoagulable status (23-25), aPTT levels were used as the marker of coagulable status in the present study.

Two-dimensional echocardiography protocol

All patients underwent two-dimensional echocardiography (2DE) repetitively on admission and at the time of IVCF removal, according to standard techniques. All analyses were independently interpreted by expert sonographers blinded to the clinical data. Ultrasonography was performed with a 3-MHz phased array probe. The left ventricular ejection fraction (LVEF) and tricuspid regurgitation peak gradient were measured. RVD was defined as RV dilation (apical four-chamber RV diameter divided by left ventricular diameter >0.9) or RV systolic dysfunction on echocardiography (4, 26).

Lower-limb venous ultrasonography protocol

All patients underwent bilateral lower-limb venous ultrasonography on admission to evaluate the presence of deep vein thrombosis (DVT), according to standardized techniques. All analyses were independently interpreted by expert sonographers blinded to the clinical data. Ultrasonography was performed with a 10-MHz linear probe and a 3.5-MHz convex probe. All patients were evaluated using compression ultrasound testing and Doppler ultrasonography of the entire leg. Iliac veins were visualized with direct imaging and Doppler flow tests. All venous segments over the entire length of the leg were examined in both the transverse and longitudinal axes. DVT was ruled out on the basis of negative results of the compression ultrasonography test and the absence of a visualized thrombus. DVT was diagnosed on the basis of a lack of compressibility of a deep vein, direct visualization of a thrombus, or the absence of Doppler flow according to a previous report (27). Proximal DVT was defined as occurring in the popliteal vein or above, and distal DVT was defined as occurring below the popliteal vein.

Statistical analysis

Continuous variables are expressed as the mean±standard deviation for parameters with a normal distribution and as medians (25th to 75th percentiles) for parameters with a skewed distribution. Differences between two groups were assessed using Student's t-test for variables with a normal distribution, the Mann-Whitney U test for variables with a skewed distribution (HDL cholesterol, the admission glucose level, HbA1c, D-dimers, hs-CRP, and BNP), and the chi-squared or Fisher's exact test, as appropriate, for categorical variables. The correlation between the admission glucose level and the percentage change in the PAPm or aPTT level was determined using Pearson's correlation coefficient. Univariate linear regression analyses and a multivariate linear regression analysis with forced inclusion variables (the admission glucose level, diabetes mellitus, PAPm on admission, Tn positivity, BNP level) for the prediction of the percentage change in PAPm were performed. All statistical tests were two-tailed, and p<0.05 was considered to indicate statistical significance. All statistical analyses were conducted with the SPSS software program, version 18.0 (Statistical Package for Social Sciences, Japan, Tokyo, Japan).

Results

Baseline characteristics

Table 1 summarizes the baseline characteristics of the two groups of patients according to the percentage change in PAPm. There were no significant differences between the two groups in baseline characteristics, including age, sex, coronary risk factors, methods of therapy, biomarkers, and medications (Table 1). Of the 22 patients, only 3 were administered not only intravenous unfractionated heparin but also oral warfarin, a vitamin K antagonist, before the IVCF removal. No patients were administered direct oral anticoagulant before the time of IVCF removal. Two patients were administered oral warfarin from day 2, and one patient was administered oral warfarin from day 4; the international normalized ratio of prothrombin time (PT-INR) of the 2 patients treated on day 2 were 1.91 and 1.31, respectively, and that of the 1 treated on day 4 was 1.60 at the time of IVCF

Table 1. Baseline Clinical Findings.

Variables	Good improvement group (n=11)	Poor improvement group (n=11)	p value
Age, years	65±9	66±12	0.77
Male, n (%)	4 (36)	3 (27)	0.50
Body mass index, kg/m²	24±4	24±5	0.99
Current smoker, n (%)	3 (27)	1 (9)	0.29
Hypertension, n (%)	4 (36)	6 (55)	0.39
Dyslipidemia, n (%)	7 (64)	5 (45)	0.39
LDL cholesterol, mg/dL	128±20	112±29	0.17
HDL cholesterol, mg/dL	49 (38-56)	54 (42-79)	0.29
Triglycerides, mg/dL	123±42	107±61	0.47
Diabetes mellitus, n (%)	1 (9)	1 (9)	0.76
Admission glucose, mg/dL	133 (103-146)	143 (112-246)	0.09
Hemoglobin A1c, %	5.8 (5.6-6.2)	5.7 (5.6-6.2)	0.54
Use of fibrolytic therapy, n (%)	2 (18)	1 (9)	0.50
Use of temporary IVCF, n (%)	10 (91)	11 (100)	0.50
Use of retrievable IVCF, n (%)	1 (9)	0 (0)	0.50
Duration of IVCF use, days	5.6±3.2	4.6±0.9	0.34
Admission systolic blood pressure, mm Hg	132±18	120±19	0.15
Admission heart rate, bpm	97±19	106±16	0.25
White blood cell count, /μL	8,245±2,382	8,727±2,714	0.66
Hemoblobin, g/dL	14.3±1.8	13.3±2.6	0.34
D-dimer, μg/mL	10.6 (6.8-14.1)	10.1 (7.2-28.2)	0.87
Average APTT ratio	2.4±0.5	2.7±0.8	0.38
hs-CRP, mg/dL	1.09 (0.32-2.19)	1.01 (0.36-1.52)	0.92
eGFR, mL·min⁻¹·1.73 m⁻²	58±11	52±19	0.42
Troponin positivity, n (%)	5 (45)	7 (64)	0.25
BNP, pg/mL	221.4 (143.3-599.5)	209.7 (136.9-412.9)	0.97
Medication on admission, n (%)			
Aspirin	2 (18)	1 (9)	0.50
Thienopyridine	0 (0)	0 (0)	1.00
Anticoagulant	0 (0)	0 (0)	1.00
Beta-blocker	0 (0)	2 (18)	0.24
ACE-I or ARB	1 (9)	2 (18)	0.50
Statin	2 (18)	1 (9)	0.50

Data are shown as the mean±standard deviation or number (percentage) or median (range).

Good improvement group: percentage change in PAPm <-28.8%. Poor improvement group: percentage change in PAPm ≥-28.8%

PAPm: mean pulmonary artery pressure, LDL: low-density lipoprotein, HDL: high-density lipoprotein, IVCF: inferior vena cava filter, aPTT: activated partial thromboplastin time, hs-CRP: high-sensitivity C-reactive protein, eGFR: estimated glomerular filtration rate, BNP: brain natriuretic peptide, ACE-I: angiotensin-converting enzyme-inhibitors, ARB: angiotensin II receptor blockers

removal. However, there was no significant difference between the two groups in the daily average of each aPTT ratio to confirm the effect of anticoagulant therapy during the acute phase (p=0.38). Only the admission glucose level tended to be higher in patients in the poor improvement group than in the good improvement group [143 (112-246) mg/dL vs. 133 (103-146) mg/dL, p=0.09]. The HbA1c level did not differ markedly between the two groups [5.7% (5.6-6.2) vs. 5.8% (5.6-6.2%), p=0.54].

In addition, there were no significant differences between the two groups in the findings of 2DE or lower-limb venous ultrasonography (Table 2). The LVEF and the location of remaining DVT did not differ markedly between the two groups.

However, although there were no significant differences between the two groups in the baseline PA catheter findings, the PAPm at the time of IVCF removal was higher in patients in the poor improvement group than in those in the good improvement group (26±8 mmHg vs. 20±6 mmHg, p= 0.04) (Table 3).

Association between the admission glucose level and the percentage change in PAPm

We then investigated the association between the admission glucose level and the percentage change in the PAPm. There was a significant positive correlation between the ad-

Table 2. Ultrasonography Findings.

Variables	Good improvement group (n=11)	Poor improvement group (n=11)	p value
2D-echocardiography on admission			
LVEF, %	62±4	60±9	0.50
TRPG, mm Hg	59±18	53±18	0.43
RVD/LVD	1.2±0.2	1.3±0.3	0.42
2D-echocardiography at the time of IVCF removal			
LVEF, %	63±5	61±7	0.57
TRPG, mm Hg	21±12	27±23	0.52
RVD/LVD	0.9±0.2	1.0±0.2	0.30
Lower-limb venous ultrasonography			
Proximal DVT, n (%)	6 (55)	4 (36)	0.41
Only distal DVT, n (%)	4 (36)	6 (55)	0.39
No DVT, n (%)	1 (9)	1 (9)	0.76

Data are presented as the mean±standard deviation.

Good improvement group: percentage change in PAPm <-28.8%. Poor improvement group: percentage change in PAPm ≥-28.8%

PAPm: mean pulmonary artery pressure, LVEF: left ventricular ejection fraction, TRPG: tricuspid regurgitation peak gradient, RVD/LCD: right ventricular diameter divided by left ventricular diameter, IVCF: inferior vena cava filter, DVT: deep vein thrombosis

Table 3. PA Catheter Findings.

Variables	Good improvement group (n=11)	Poor improvement group (n=11)	p value
PA catheter on admission			
PAPs, mmHg	57±14	54±15	0.59
PAPd, mmHg	18±7	17±5	0.87
PAPm, mmHg	33±8	31±7	0.72
CVP, mmHg	5±5	7±5	0.35
CI, L·min^{-1}·m^{-2}	2.1±0.3	1.9±0.5	0.36
PA catheter at the time of IVCF removal			
PAPs, mmHg	35±10	45±14	0.07
PAPd, mmHg	11±5	16±5	0.03
PAPm, mmHg	20±6	26±8	0.04
CVP, mmHg	4±3	7±4	0.03
CI, L·min^{-1}·m^{-2}	2.7±0.3	2.6±0.5	0.64

Data are presented as the mean±standard deviation.

Good improvement group: percentage change in PAPm <-28.8%. Poor improvement group: percentage change in PAPm ≥-28.8%.

PA: pulmonary artery, IVCF: inferior vena cava filter, PAPs: systolic pulmonary artery pressure, PAPd: diastolic pulmonary artery pressure, PAPm: mean pulmonary artery pressure, CVP: mean central venous pressure, CI: cardiac index

mission glucose level and the percentage change in PAPm (r =0.543, p=0.009) (Fig. 1), which means that a high admission glucose level was associated with a poor improvement in the PAPm.
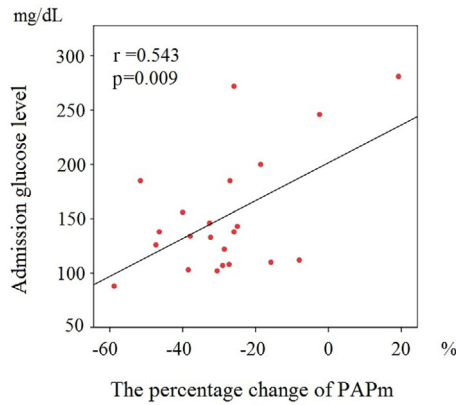
Association between the admission glucose level and admission aPTT level

We also investigated the association between the admission glucose level and the admission aPTT level. There was a significant negative correlation between the admission glu-
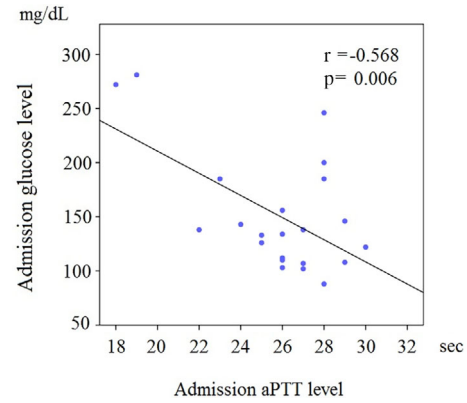
cose level and the admission aPTT level (r=-0.568, p=0.006) (Fig. 2).

Univariate and multivariate linear regression analyses for the prediction of the percentage change in PAPm

We hypothesized that the admission glucose level was associated with the improvement of the PAP in patients with APE. To test this hypothesis, we conducted univariate linear regression analyses and a multivariate linear regression

Figure 1. Association between the admission glucose level and the percentage change in the PAPm. There was a significant positive correlation between the admission glucose level and the percentage change in the PAPm (r=0.543, p=0.009). PAPm: mean pulmonary artery pressure

Figure 2. Association between the admission glucose level and admission aPTT level. There was a significant negative correlation between the admission glucose level and the admission aPTT level (r=-0.568, p=0.006). aPTT: activated partial thromboplastin time

analysis with the forced inclusion model to predict the percentage change in the PAPm (Table 4). A univariate linear regression analysis showed that the admission glucose level was indeed a predictor of the percentage change in PAPm (β coefficient=0.169 per 1 mg/dL; 95% confidence interval, 0.047-0.291; p=0.009). Diabetes mellitus, PAPm on admission, Tn positivity, and BNP level were not predictors of the percentage change in PAPm (all p>0.1). A multivariate linear regression analysis with the forced inclusion model showed that the admission glucose level was a predictor of the percentage change in PAPm independent of diabetes mellitus, PAPm on admission, Tn positivity, and BNP level (all p<0.05).

Discussion

The present study showed that the admission glucose level had a significant positive correlation with the percentage change in the PAPm. Furthermore, the admission glucose level was a predictor of the percentage change in the PAPm independent of diabetes mellitus, PAPm on admission, Tn positivity, and BNP level. To our knowledge, this is the first study to demonstrate that the admission glucose level is associated with the improvement in the PAP in patients with APE.

Preventing the recurrence of APE is important. IVCF, which is an optional therapy aimed at preventing the recurrence of APE, is being increasingly used; however, there is no benefit to using IVCF routinely in patients with APE (5, 28, 29). Nevertheless, IVCF is effective in some patients (30, 31). It is therefore important to distinguish high-risk patients with APE who may need IVCF from low-risk patients with APE who may not need it. Although previous studies have shown that Tn and pro-BNP were useful for predicting the clinical outcome in patients with APE (32, 33), the present study showed that the admission glucose level was associated with the percentage change in

the PAPm independent of diabetes mellitus, PAPm on admission, Tn positivity, and BNP level. Our results revealed that patients with high admission glucose levels might be at a risk of a poor improvement in the PAP.

Several previous studies showed that the admission glucose level was a predictor of the prognosis in patients with APE (16-18). The findings of these previous studies were consistent with our results; however, the reasons underlying the prognosis in patients with APE might be multifactorial, including cancer death (34). Although we believe that a poor improvement in the PAP itself leads to a poor prognosis in patients with high admission glucose levels, no previous studies have determined the precise hemodynamics using a PA catheter, as was done in the present study. To our knowledge, this is the first study to assess the precise hemodynamics repeatedly using a PA catheter to elucidate the predictors of improvement in the PAP in patients with APE. The present study did not have a large impact, but only a small impact on the clinical setting in terms of investigating the mechanism underlying the association between the admission glucose level and outcomes.

The admission glucose level is a predictor of mortality in various diseases (10-15). A high glucose level at admission reflects stress hyperglycemia caused by sympathetic nervous activity, which can trigger a hypercoagulable state and exacerbate the risk of overt thrombosis in some patients (35). In addition, hyperglycemia itself can induce thrombin activation, potentially inducing oxidative stress (36). The present study also demonstrated a negative correlation between the admission glucose level and the admission aPTT level, indicating that patients with a high admission glucose level were in a hypercoagulable status, as previously reported (23-25). Furthermore, hyperglycemia following hypoglycemia may activate thrombosis through oxidative stress production (37). These mechanisms might have caused a vicious cycle, leading to a poor improvement in PAP in patients with a high admission glucose level in the present study, although there

Table 4. **Univariate and Multivariate Linear Regression Analyses for Predicting the Percentage Change in PAPm.**

Variables	Univariate			Multivariate (model 1)			Multivariate (model 2)		
	β	95% CI for β	p value	β	95% CI for β	p value	β	95% CI for β	p value
Admission glucose level, per 1 mg/dL	0.169	0.047-0.291	0.009	0.150	0.015-0.284	0.031	0.170	0.043-0.296	0.011
Diabetes mellitus	20.10	-5.362-45.57	0.115	9.078	-16.08-34.23	0.459		Not selected	
PAPm on admission, per 1 mm Hg	0.090	-0.984-1.165	0.862		Not selected		-0.048	-0.983-0.888	0.916
Troponin positivity	7.604	-8.599-23.81	0.338		Not selected			Not selected	
BNP level, per 1 pg/mL	0.004	-0.025-0.032	0.795		Not selected			Not selected	

Variables	Multivariate (model 3)			Multivariate (model 4)		
	β	95% CI for β	p value	β	95% CI for β	p value
Admission glucose level, per 1 mg/dL	0.171	0.045-0.297	0.010	0.186	0.060-0.312	0.006
Diabetes mellitus		Not selected			Not selected	
PAPm on admission, per 1 mm Hg		Not selected			Not selected	
Troponin positivity	7.504	-6.350-21.36	0.270		Not selected	
BNP level, per 1 pg/mL		Not selected		0.013	-0.012-0.038	0.289

All forced inclusion variables are shown in univariate analyses.

CI: confidence interval, PAPm: mean pulmonary artery pressure, BNP: brain natriuretic peptide

were no significant differences between the two groups in the severity of APE or PAP on admission.

Study limitations

Our study has several limitations. First, the present study included a small number of patients enrolled at a single center. Therefore, further studies are needed to draw definite conclusions. Second, we limited the present study patients to only those with submassive-type APE; however, which patients need IVCF insertion remains unclear, especially among those with submassive APE in the clinical setting. We therefore believe that our results have clinical significance. Third, we excluded patients on mechanical ventilation and hemodialysis; therefore, our results might not be applicable to those patients. However, it is difficult to precisely evaluate the data of PA catheterization in such patients.

Conclusions

The admission glucose level has a significant positive correlation with the percentage change in the PAPm. Furthermore, the admission glucose level is a predictor of the percentage change in the PAPm independent of diabetes mellitus, PAPm on admission, Tn positivity, and BNP level. The admission glucose level is associated with the improvement in the PAPm in patients with submassive-type APE.

The authors state that they have no Conflict of Interest (COI).

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