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Does Adding the Pulmonary Infarction and Right Ventricle to Left Ventricle Diameter Ratio to the Qanadli Index (A Combined Qanadli Index) More Accurately, Predict Short-Term Mortality in Patients with Pulmonary Embolism?

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Abstract

Background The Qanadli index can be used to assess the severity of pulmonary arterial involvement in patients with acute pulmonary embolism. However, it seems that considering pulmonary infarction and right ventricle/left ventricle (RV/LV) ratio along with this index (called the combined Qanadli index) can provide a more accurate view of changes in cardiovascular parameters in these patients and help predict mortality in a better manner. In this regard, we evaluated the ability of the combined Qanadli index versus the Qanadli index in predicting short-term mortality in patients with pulmonary embolism.

Methods This retrospective study enrolled 234 patients with acute pulmonary embolism. Patients were divided into two groups: those who expired in 30 days and who survived. Then they were evaluated by computed tomography angiography of pulmonary arteries. The RV/LV diameter ratio and also pulmonary artery obstruction index (PAOI) were calculated. The patient's computed tomography scans were reviewed for pulmonary infarction. By adding the RV/LV ratio and pulmonary infarction to PAOI, a new index called the modified Qanadli score was made. Univariable and multivariable logistic regression was done for finding predictors of mortality.

Results Nine cases (40%) of patients in the mortality group and 42 (20%) of survivors had ischemic heart disease and the difference was significantly meaningful. The mean Qanadli index in the mortality group was 16.8 ± 8.45 and in survivors was 8.3 ± 4.2.

Keywords
- Qanadli index
- embolism
- cardiovascular

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By adding the pulmonary infarction score and PAOI score to RV/LV ratio score, the odds ratio (OR) for predicting mortality increased significantly to 13 and 16, respectively, which were significantly meaningful. Based on our findings, the highest OR for predicting short-term mortality was obtained through a combined Qanadli index (PAOI score + pulmonary infarction score + RV/LV score) that was 17 in univariable and 18 in multivariable logistic regression analysis (p-value = 0.015).

Conclusion The new combined Qanadli index has more ability than the Qanadli index and RV/LV ratio for predicting changes in cardiovascular parameters and short-term mortality in patients with pulmonary embolism.

Introduction

The role of pulmonary angiography by multidetector computed tomography (MDCT) angiography in the diagnosis of acute pulmonary embolism (PE) is well-known. By allowing the evaluation and imaging of pulmonary arteries to the subsegmental level, MDCT is fully accepted as an efficient and accurate method in the evaluation of PE.[1–19] Based on previous studies, an increased right ventricle to left ventricle diameter ratio (RV/LV) on MDCT could indicate the severity of PE and predict short-term mortality in patients with PE.[2,3,10]

Previous attempts had tried to investigate the role of pulmonary artery obstruction index (PAOI) assessed by the Qanadli score in predicting mortality. Several of these studies were able to show the predictive nature of PAOI in the mortality of patients with PE but others could not. But in most of the studies, even the ones which could not find PAOI as a predictor of mortality, a strong correlation was found between PAOI and RV/LV ratio.[2,20,21] Additionally, PE can cause pulmonary infarction in several patients that can aggravate the general health condition of patients with PE and was associated with short-term mortality.

The point is that Qanadli index calculation only includes criteria related to obstruction of pulmonary arterial branches but logically, the condition of the lung parenchyma or existing of an increased RV/LV ratio can be very effective in determining the patient's prognosis.[2,22] Therefore, in our opinion, adding these indicators to the Qanadli index and presenting a new index called the combined Qanadli score would be a more accurate identifier of the condition and prognosis of patients. Therefore, in this study, we aimed to design a new index by adding the "pulmonary infarction and increased RV/LV ratio" to the Qanadli index on pulmonary CT angiography of patients with PE and to assess its role in predicting short-term mortality.

Materials and Methods

The local ethics committee approved our retrospective cohort study. The patients' data were reviewed from September 2020 to December 2022. The inclusion criteria were positive PE on CT angiography study and at least 30 days of postdiagnosis follow-up. The exclusion criteria were chronic PE, cardiogenic shock, and poor-quality CT images. In total, 248 patients with PE were identified. We excluded eight patients because of the poor quality of images and six patients because of cardiogenic shock; a total of 234 patients were entered into the study. Patients were divided into two groups: those who expired in 30 days and those who survived. After evaluating the patients' demographic information and clinical records, CT angiography of pulmonary arteries was performed for them. All of the CT scans were performed by MDCT scanner (Brilliance 64; Philips Medical System, Cleveland, Ohio, United States). The slice thickness was 1 mm and the increment was 0.5 mm. For CT angiography 50 mL iodinated contrast material (Visipaque 320mm iodine/mL) was injected via a peripheral vein and scans were taken at the end of inspiration during a single breath hold. The images were evaluated on a workstation (extended brilliance workspace, Philips Medical System; Nederland B. V). A radiologist with 12 years of experience in reading thoracic CT scans reported the images, who was blinded to the clinical history of patients.

On CT pulmonary angiography, the RV/LV ratio was calculated, by measuring the maximum diameter of the RV and LV just below the mitral and tricuspid valve, respectively, perpendicular to the interventricular septum on a true four-chambered heart view. The RV/LV ratio greater than one is considered the criterion for RV dysfunction. We calculated the pulmonary artery obstructive index (Qanadli index) based on the degree of involvement of pulmonary arterial branches. If the PAOI of the patient was less than 16, it was scored 1, and if PAOI was more than 16, it was scored 2.[19]

In calculating the new index, we added two new parameters to the previous index: 1) pulmonary infarction, which scored 1 if it was unifocal, and 2 if there were more focus of infarction (multifocal) and it was scored 0 if there was not any pulmonary infarction on imaging (►**Fig. 1**).

The pulmonary infarction was defined as below:

Peripheral wedge-shaped pulmonary consolidations are a classic manifestation of pulmonary infarct, particularly in the setting of a PE.

Other recognized features include:

- Wedge-shaped (less often rounded) juxta pleural opacification (Hampton hump) without air bronchograms
- Consolidation with internal air lucencies, "bubbly consolidation"

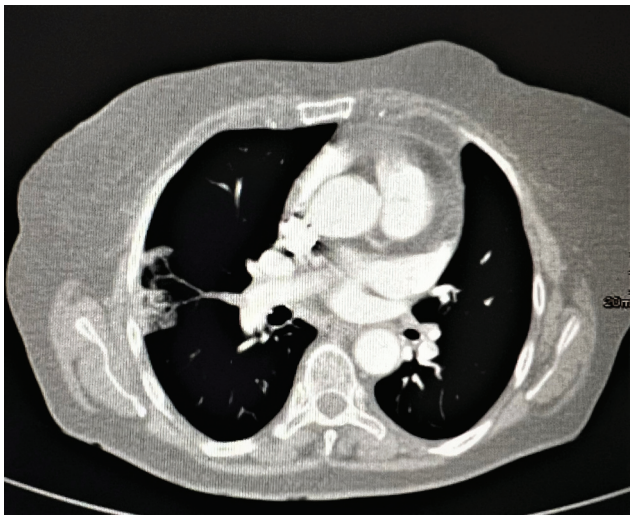

Fig. 1 Unifocal pulmonary infarction in the right middle lobe in a patient with pulmonary embolism that was scored 1.

- Represents noninfarcted aerated lung parenchyma co-existing side-by-side with infarcted lung in the same lobule[9]

- Convex borders with a halo sign
  - Secondary to adjacent hemorrhage
- Decreased in normal lung enhancement
  - May be scattered areas of low attenuation within the lesion (necrosis)
  - Sometimes appears as hyperenhancement of the infarct perimeter
- Cavitation: may be seen in septic embolism and infection of a bland infarct (cavitary)

2) The increased RV/LV ratio, which scored as 10 if it exists, and 0 if was not, based on the odd ratio (OR) of this measurement on predicting short-term mortality in previous studies. The cutoff point value for the increased RV/LV ratio was considered 1 according to the previous research[2] (►**Fig. 2**). Therefore, in the most severe condition, the combined Qanadli index would be as follows:

PAOI (2) +pulmonary infarction score (2) + increased RV/LV ratio (10) = 14.

Finally, the prognostic value of both the Qanadli index and the new index for predicting mortality in 30 days was assessed.

For statistical analysis, results were presented as mean ± standard deviation for quantitative variables and were summarized by frequency (percentage) for categorical variables. Continuous variables were compared using the *t*-test or Mann–Whitney U test whenever the data did not appear to have normal distribution or when the assumption of equal variances was violated across the study groups. Categorical variables were compared using the chi-square test. Multiple logistic regression analyses were used to identify the predictors of adverse outcomes by using variables *p*-value less than 0.05 in univariate analysis. For the statistical analysis, the statistical software SPSS version 24 (SPSS Inc., Chicago, Illinois, United States) was used.

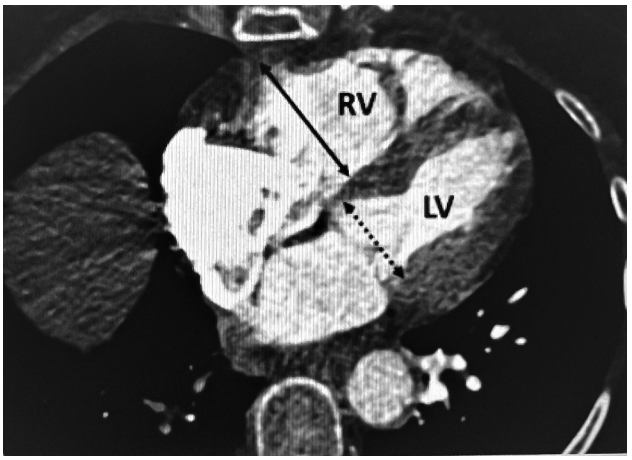

Fig. 2 Measurement of right ventricle (RV) and left ventricle (LV) diameter on axial computed tomography pulmonary angiography image. The RV/LV ratio was calculated, by measuring the maximum diameter of the right ventricle (black arrow) and left ventricle (black dotted arrow) just below the mitral.[34]

Results

In this study, a total of 234 patients with acute PEs were studied. The mean age of patients was 68.88 ± 17.01 years in the range of 23 to 83 years. One-hundred seventeen cases (55.2%) were male. The baseline characteristics of patients are summarized in ►**Table 1**. Nine cases (40%) of patients in the mortality group, and 42 (20%) of survivors had ischemic heart disease and the differences were significantly meaningful (p-value < 0.05).

Table 1 Comparisons of quantitative and qualitative characteristics of patients with pulmonary embolism between subgroups of mortality and survivors

	Death < 3 0 days $n = 22$	Survivors $n = 212$	*p*-Value
Mean age, year	68.88 ± 17.01	54.34 ± 18.12	0.34
Male gender,	12 (58.4%)	117(55.2%)	0.42
Ischemic heart disease	9(40%)	42 (20%)	0.03
Congestive heart failure	7 (30%)	32 (15%)	0.02
Myocardial infarction	5(21%)	19 (9%)	0.04
Chronic obstructive pulmonary disease	1 (3%)	4(2%)	0.24
Diabetes mellitus	6 (28%)	34(16%)	0.21
Hypertension	14(63%)	95(45%)	0.65
Malignancy	2(11%)	15 (7%)	0.01
Coagulopathy	2 (10%)	6 (3%)	0.56

Table 2 Comparison of chest CT findings between subgroups of mortality and survivors in patients with pulmonary embolism

	Death < 3 0 days $n = 22$	Survivors $n = 212$	*p*-Value
PAOI	16.8 ± 8.45	8.3 ± 4.2	0.34
Pulmonary infarction	13 (63.3%)	72(33.9%)	0.42
RV/LV ratio > 1	19(86%)	38 (18%)	0.03

Abbreviations: PAOI, pulmonary artery obstruction index; RV/LV, right ventricle/left ventricle.

The mean Qanadli index in the mortality group and survivor group was 16.8 ± 8.45 and 8.3 ± 4.2, respectively, which was not significantly meaningful. Regarding cardiovascular findings, there was a significant difference in RV/LV ratio between subgroups. Eighty-six percent of patients who died in 30 days and 18% of survivors had an RV/LV ratio of more than 1 (p-Value = 0.03; ►**Table 2**).

Multivariable logistic regression analysis indicated that PAOI score, and pulmonary infarction score alone nor together could predict mortality in patients with PE, but the RV/LV ratio score with an OR of 10 in Univariable analysis and 12.34 in multivariable can be a strong predictor of mortality in 30 days. By adding the pulmonary infarction score and PAOI score to RV/LV ratio score, the OR for predicting mortality increases significantly to 13 and 16, respectively, which is significantly meaningful. Based on our findings, the higher OR for predicting short-term mortality was obtained through a combined Qanadli index (PAOI score + pulmonary infarction score + RV/LV score) that was 17 in univariable and 18 in multivariable logistic regression analysis that was considered significant (p-Value = 0.015; ►**Table 3**).

Discussion

Because acute PE can be fatal, estimating its severity and progression is critical.[23–28] Therefore, the role of pulmonary imaging based on pulmonary CT angiography in determining the extent and severity of pulmonary involvement associated with PE is well understood.[29] Previous studies have found a close relationship between the severity of acute pulmonary arterial embolism and changes in physiological and cardiovascular parameters, especially changes in RV diameters. In this regard, it is expected that the clinical outcome of acute PE is quite consistent with the severity of cardiovascular involvement. The Qanadli index is commonly used to assess the severity of pulmonary arterial involvement in such patients but its role in predicting mortality is under debate. However, it seems that the RV/LV ratio of more than 1 has been accepted as one of the strong predictors of short-term mortality.[2]

Considering pulmonary infarction and the RV/LV ratio along with PAOI called the combined Qanadli index can provide a more accurate view of changes in cardiovascular parameters in these patients. Therefore, this study was designed and performed to evaluate the ability of the new index versus PAOI based on Qanadli score in predicting mortality in 30 days in patients with PE. What we found in this study was that, although RV/LV ratio was able to predict short-term mortality, this feature was more robust for the new index that was a combination of RV/LV ratio, PAOI, and pulmonary infarction. In fact, the correlation between the new index and mortality seems to be much stronger with the RV/LV ratio alone. In general, it can be concluded that the new combined index compared with Qanadli or RV/LV ratio has a higher diagnostic capability in predicting cardiovascular pathological changes, whether mortality.

This study is the first study comparing the predicting value of combined CT indices, namely the combined Qanadli index and Qanadli index in predicting short-term mortality in patients with PE. Other studies have also been successful in confirming the relationship between the Qanadli index and cardiovascular changes, and their findings are consistent with our results. In the El-Menyar et al[21] study, there was a significant correlation between the Qanadli value and RV/LV index, so based on the receiver operating characteristic curve, Qanadli above 17.5 was able to detect RV dysfunction and mortality. Although their finding was consistent with ours, the cutoff point from the ROC curve in his study was slightly

Table 3 Predictors of mortality in 30 days of 234 patients with acute pulmonary embolism

	Univariable analysis OR (95% CI)	*p*-Value	Multivariable analysis OR (95% CI)	*p*-Value
Calculated parameters				
PAOI score	1.09 (0.774–1.25)	0.062	–	–
PAOI score+ pulmonary infarction score	2.06 (0.513–9.42)	0.07	–	–
PAOI score + pulmonary infarction score + RV/LV score (new index)	17.03 (2.39–121.34)	0.025	18.01 (2.42–134.34)	0.015
PAOI score + RV/LV score	14.01 (2.27–118.34)	0.022	16.01 (2.89–119.34)	0.034
Pulmonary infarction score + RV/LV score	11.53 (1.12–111.25)	0.036	13.24 (1.28–115.34)	0.021
RV/LV score	10 (1.38–61.04)	0.023	12.34 (1.78–112.34)	0.028
Pulmonary infarction score	1.06 (0.635–1.65)	0.068	–	–

Abbreviations: CI, confidence interval; OR, odds ratio; PAOI, pulmonary artery obstruction index; RV/LV, right ventricle/left ventricle.

different from our mean obstruction index in the mortality group. In the study of Furlan et al, there was a strong correlation between the RV/LV ratio with both Qanadli and Mastora indices.[30] In the study of Çildag et al, there was a significantly strong correlation between the decrease in the Qanadli index and RV diameter.[31] In the study of Zhou et al, the RV/LV index in CT had a strong correlation with the pulmonary artery obstruction index based on the Qanadli score. Accordingly, the value of the Qanadli index in patients with RV/LV more than 1 and RV/LV less than1 showed a significant difference.[32,33] Therefore, in various studies, the high diagnostic value of the Qanadli score and RV/LV ratio in patients with PE was confirmed, but according to our findings, this value for the combined Qanadli index was much higher than the Qanadli index. Further investigation with larger samples is necessary for confirming results and also for determining the cutoff point of the new combined Qanadli index in predicting short-term mortality in patients with PE.

Conclusion

In conclusion, the new combined Qanadli index has more ability than the Qanadli index and RV/LV ratio for predicting changes in cardiovascular parameters and short-term mortality in patients with PE.

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None.

Conflict of Interest
None declared.

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