Indian Heart Journal 69 (2017) 68–74

Contents lists available at ScienceDirect

Indian Heart Journal

journal homepage: www.elsevier.com/locate/ihj

Original Article

Comparison of PESI, echocardiogram, CTPA, and NT-proBNP as risk stratification tools in patients with acute pulmonary embolism

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ARTICLE INFO

Article history:
Received 30 March 2016
Accepted 16 July 2016
Available online 1 August 2016

Keywords:
Qanadli index
Pulmonary embolism
Echocardiogram
NT-proBNP
Right ventricle

ABSTRACT

Objective: The aim of this study is to prospectively assess the diagnostic accuracy of pulmonary embolism severity index, echocardiogram, computed tomography pulmonary angiogram (CTPA), and N-terminal pro b-type natriuretic peptide (NT-proBNP) for predicting adverse events in acute pulmonary embolism patients.

Methods: Thirty consecutive acute pulmonary embolism patients were included in this study. Combined adverse events consisted of in-hospital death or use of escalation of care including cardiopulmonary resuscitation, mechanical ventilation, vasopressor therapy, or secondary thrombolysis during hospital stay.

Results: The outcomes were met in 30% of patients. Qanadli index (a measure of clot burden on CTPA) and NT-proBNP were significantly higher in patients with adverse events than those without ($p = 0.005$ and $p = 0.009$, respectively). PESI had moderate positive correlation with right ventricular dysfunction (RVD) ($r = 0.449$, $p = 0.013$) but there was no significant difference in PESI between patients with and without adverse events ($p = 0.7$). Receiver operating characteristic analysis indicated that Qanadli index was the best predictor of adverse events with area under the curve (AUC) of 0.807 (95% CI: 0.651–0.963) with a negative predictive value (NPV) of 100% and positive predictive value (PPV) of 47.4% at cut-off value of 19. Right ventricle to left ventricle ratio on CTPA was found to predict RVD with AUC of 0.94 (95% CI: 0.842–1.000), NPV (77.8%), and PPV (95.2%) at cut-off value at 1.15.

Conclusion: Qanadli index is more accurate predictor of adverse events than pulmonary embolism severity index, NT-proBNP, and RVD on echocardiogram and CTPA.

1. Introduction

Acute pulmonary embolism (PE) presents with wide spectrum and variable prognosis. Risk stratification is of paramount importance and is useful not only to select an appropriate treatment strategy but also to potentially reduce costs of management. Currently, bedside echocardiography is the principal risk-stratifying tool by assessing right ventricular overload.[1–3] Subset of patients with right ventricular dysfunction (RVD) who are initially stable detoriate during hospital stay and require escalation of care including thrombolysis. Identifying such patients at admission may help to prioritize them to close monitoring in intensive care unit, which may improve outcomes. Moreover there are no established reference values to further stratify RVD patients into mild, moderate, and severe by echocardiogram.[4]

The prognostic value of echocardiography in hemodynamically stable patients appears moderate and is mostly due to the poor standardization of echocardiographic criteria.[5,6] Many factors besides echocardiography have been shown to have prognostic value in the short-term including biomarkers,[7–11] as well as, computed tomography pulmonary angiogram (CTPA).[12,13] Recent guidelines from both American and European societies recommend risk stratification be an integral part in the evaluation and management of patients with acute PE.[14,15] However, most accurate predictor is controversial. These acute PE practice guidelines emphasize the prognostic utility of clinical risk prediction scores, biomarkers, and imaging studies but they do not indicate which method is the preferred means of risk stratification. Clinical prognostic scores, echocardiography, CTPA,

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http://dx.doi.org/10.1016/j.ihj.2016.07.010

and biomarkers have not been concomitantly studied, previously, in the same patient group. The aim of this study is to assess the relationship and diagnostic accuracy of pulmonary embolism severity index (PESI), echocardiography, CTPA, and N-terminal pro b-type natriuretic peptide (NT-proBNP) with adverse events in acute PE patients and to identify most accurate predictor.

2. Material and methods

2.1. Patients

We prospectively studied all consecutive patients with confirmed acute PE on CTPA and admitted in Sri Venkateswara Institute of Medical Sciences (SVIMS), Tirupati between May 2013 and December 2014. Patients with renal impairment (serum creatinine >1.5 mg/dl), preexisting left ventricular dysfunction (LVEF < 50%) and preexisting chronic lung disorders which can increase the after load to right ventricle were excluded. On admission, patients were assessed for (1) detailed medical history including clinical presentation and risk factors; (2) vital data including respiratory rate, blood pressure, pulse rate, and pulse oximetry oxygen saturation; (3) laboratory data including serum creatinine, urea, sodium, potassium, and NT-proBNP; (4) echocardiogram and lower limb venous ultrasound; (5) electrocardiogram. Adverse events were defined as in-hospital death or use of escalation of care, which included cardiopulmonary resuscitation, mechanical ventilation, vasopressor therapy, or secondary thrombolysis during hospital stay. Thrombolysis at admission was considered as primary thrombolysis and thrombolysis in patients detoriated during hospital stay was considered as secondary thrombolysis. Patients were stratified into five risk classes according to PESI described by Aujesky et al.,[16] which identified 11 features from demographic, history, and clinical findings. PESI class I and II were considered as low-risk group and PESI class III, IV, V were categorized as high-risk group.

2.2. Echocardiogram

Soon after the diagnosis of acute PE, Transthoracic echocardiogram was performed using a Philips IE-33 machine, Netherlands with a 5–1 MHz frequency range transducer. Echocardiographic RVD was defined as presence of right ventricular dilation (right ventricular end diastolic diameter [RVEDD] at the base >42 mm or right ventricle to left ventricle end diastolic diameter ratio [RV/LV] >1) or paradoxical ventricular septal motion or hypokinesia of right ventricular free wall or tricuspid regurgitation jet velocity (TRJV) > 2.8 m/s.[4] RVEDD was defined as maximal short-axis dimension in the basal one third seen on right ventricle focused apical four chamber view.[4] Paradoxical ventricular septal motion was visually assessed for ventricular septal curvature, looking for a D shaped pattern in systole and diastole. TRJV was measured using continuous-wave Doppler across tricuspid valve. All the echocardiograms were performed by a single qualified operator who was blinded to clinical diagnosis, NT-proBNP and CTPA of the patients.

2.3. Computed tomography pulmonary angiography

CTPA was obtained from SIEMENS SOMATOM Definition AS, a single source 128 slice CT scanner. Right ventricle diameter was measured from inner wall to inner wall in the widest point, usually seen in basal third of right ventricle, on transverse section of reconstructed four chamber image showing the tricuspid valve at its widest.[17] So also left ventricular diameter measured when mitral valve was at its widest.[17] The RV/LV diameter ratio was calculated. Ventricular septal bowing was subjectively judged as being present or absent.

2.4. Qanadli index

Extent of pulmonary vascular obstruction was graded using Qanadli index, a CTPA clot burden score, described by Qanadli et al.[18] A thrombus was considered non-occlusive if contrast material was seen in the vessel adjacent to the filling defect. If there was complete endoluminal filling of the vessel with thrombus, non-perfusion of the distal vessel and attenuation of distal segmental, and subsegmental branches in the occluded vascular territory, it was considered as completely occlusive. Following data was assessed, (1) location and number of filling defects, (2) occlusive or non-occlusive nature of the filling defect. Each lung was regarded as having 10 segmental arteries. Subsegmental emboli were scored as a partial obstruction of the segmental artery. PE involving a lobar or larger artery received a score equal to number of segmental arteries supplied. Non-occlusive PE was given a weight of 1 and occlusive PE was given a weight of 2. The maximum obstruction score for each patient was 40 (20 for each lung).

All the CTPA were assessed by a single qualified radiologist who was blinded to clinical data, echocardiogram and NT-proBNP levels of the patient.

2.5. NT-proBNP

Within three hours of diagnosis of PE, NT-proBNP levels were measured by using Roche CARDIAC proBNP test kit (code 04659449190, Roche Diagnostics Ltd., Germany) and Cobas h 232 POC (Point of Care) system.

The study design was observational and did not interfere with therapeutic decisions. The protocol of this study was approved by the Institutional ethics Committee. All participating patients gave their informed consent.

3. Statistical analysis

Descriptive statistics including mean and standard deviation (SD) for continuous variables and proportions for categorical data were calculated. The differences observed were tested for statistical significance by unpaired student's *t*-test, chi-square test (parametric) and Mann–Whitney *U* test (non-parametric). Correlations between continuous and categorical variables were ascertained by using Pearson's correlation tests respectively. A *p*-value <0.05 was considered as statistically significant. Receiver operating characteristic (ROC) analysis was performed to find out sensitivity and specificity of the tests. All the statistical analysis was performed on Microsoft-excel spread sheets and Statistical Package for Social Sciences software (SPSS) for Microsoft Windows, version 20.0, (IBM Corp., Armonk, NY, USA).

4. Results

A total of fifty-six patients were screened for acute PE and thirty-six were diagnosed to have acute PE. Six patients were excluded as 4 patients had renal dysfunction, 1 had left ventricular dysfunction and 1 had lung fibrosis secondary to pulmonary tuberculosis. Baseline characteristics of the study population are displayed in Table 1. The patient's age ranged from 21 to 76 years with mean age of 41.20 ± 12.98 years. Twenty four (80%) patients were males and 6 (20%) were females. Dyspnea (100%) was the most common symptom followed by chest pain (33.3%). Risk factors were dyslipidemia (43.3%), smoking (30%), immobilization due to recent trauma or surgery (26.7%), cancer (6.7%), hypertension (13.3%), diabetes (10%), stroke (3.3.%), and coronary artery disease (6.7%). Twenty-six patients (86.66%) had tachycardia. Two patients had systemic hypotension at presentation. Fourteen patients (46.6%) had

Table 1
Baseline characteristics of study population.

Characteristic	Total cohort ($n=30$)	With AEs ($n=9$)	Without AEs ($n=21$)	p-value
Demographics				
Age (years)	41.20 ± 12.98	34.56 ± 6.56	44.05 ± 14.09	0.06
Male	24 (80%)	8 (88.9%)	16 (76.2%)	
Female	6 (20%)	1 (11.1%)	5 (23.8%)	0.64
Chest pain	10 (33.3%)	1 (11.1%)	9 (42.9%)	0.20
Dyspnea				
NYHA Class-1	1 (3.3%)	0	1 (4.8%)	
NYHA Class-2	7 (23.3%)	0	7 (33.3%)	
NYHA Class-3	13 (43.3%)	3 (33.3%)	10 (47.6%)	
NYHA Class-4	9 (30.0%)	6 (66.7%)	3 (14.3%)	0.004*
Hemoptysis	05 (16.7%)	1 (11.1%)	4 (19%)	0.99
Syncope	6 (20%)	0	6 (28.6%)	NA
Altered Sensorium	1 (3.3%)	1 (11.1%)	0	NA
Recent Surgery/trauma	8 (26.7%)	1 (11.1%)	7 (33.3%)	0.42
Cancer	2 (6.7%)	0	2 (9.5%)	NA
Stroke	1 (3.3%)	0	1 (4.8%)	NA
CAD	2 (6.7%)	0	2 (9.5%)	NA
Dyslipidemia	13 (43.3%)	3 (33.3%)	10 (47.6%)	0.75
Smoking	9 (30%)	5 (55.6%)	4 (19%)	0.12
Hypertension	4 (13.3%)	0	4 (19%)	NA
Diabetes	3 (10%)	0	3 (14.28%)	NA
HR, bpm	118.50 ± 15.65	121.0 ± 13.49	117.19 ± 16.62	0.55
SBP, mm of Hg	114.33 ± 16.63	115.56 ± 10.14	113.81 ± 18.95	0.79
DBP, mm of Hg	73.20 ± 9.30	73.33 ± 5.0	73.14 ± 10.74	0.96
Respiratory rate	29.33 ± 5.91	31.22 ± 4.24	28.52 ± 6.42	0.26
Sr. Creatinine, mg/dl	1.08 ± 0.24	1.16 ± 0.21	1.05 ± 0.24	0.24
Sr. Sodium, mg/dl	136.33 ± 4.52	137.44 ± 4.67	135.86 ± 4.49	0.39
Sr. Potassium, mg/dl	4.07 ± 0.71	3.82 ± 0.76	4.17 ± 0.67	0.22
ICU Stay, days	2.89 ± 2.22	4.44 ± 2.19	2.16 ± 1.86	0.006*

AE, adverse events; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; SPO_2, pulse oxymetry oxygen saturation; Sr., serum; TLT, thrombolytic therapy; IQR, intra quartile range.
* Significant p-value ($p < 0.05$).

arterial saturation less than 90%. Twenty-two patients had RVD – 21 patients were diagnosed based on RV/LV ratio >1 (5 patients had LVEDD < 42 mm and 16 had LVEDD > 42 mm) and 1 patient based on right ventricle free wall hypokinesia and TRJV > 2.8 m/s. Seven patients had hyponatremia (23.33%) and five patients had hypokalemia (16.66%). There was no statistically significant difference in serum urea, sodium, and potassium among patients with and without adverse events as well as among patients with and without RVD. Nine patients (30%) had deep vein thrombosis.

Ten patients (33.3%) were thrombolysed with streptokinase of whom two patients were thrombolysed (primary thrombolysis) at admission due to systemic hypotension. All patients were treated with heparin. Nine patients had complicated in hospital course of whom 2 patients (6.7%) died (Table 2). Eight patients (26.7%) were thrombolysed (secondary thrombolysis) after deterioration during hospital stay. There was need for mechanical ventilation in 2 patients (6.7%) and inotropic support in 2 patients (6.7%). All these 9 patients had RVD.

Prognostic parameters of patients with and without adverse events are displayed in Table 3.

4.1. Clinical prognostic scoring (PESI)

Patients in PESI class I, II, III, IV and V were 13.3%, 40%, 26.7%, 10%, and 10%, respectively. Fourteen patients were categorized as high risk according to PESI. Four patients in low-risk group (25%) and 5 patients in high-risk group (39.28%) had adverse events during hospital stay. Two patients, who were categorized at admission as low risk, expired during hospital stay. There is no significant difference in PESI score between patients with and without adverse events ($p = 0.77$).

Table 2
Combined adverse events in study population.

Combined adverse events	Total cohort ($n=30$)
Secondary thrombolysis	8 (26.7%)
Mechanical ventilator	2 (6.7%)
Inotropes	2 (6.7%)
In-hospital deaths	2 (6.7%)

4.2. Echocardiography

There was no statistically significant difference of RV/LV ratio, RVEDD, and TRJV, measured at admission, among patients with and without adverse events ($p = 0.38$, $p = 0.27$, and $p = 0.36$, respectively). There was no adverse event in patients without RVD. ROC analysis of RVEDD and RV/LV ratio on echocardiography in predicting adverse events is displayed in Table 4.

4.3. CTPA based parameters

Mean Qanadli index of whole cohort was 19.37 ± 7.55. There was a significant difference in Qanadli index among patients with and without adverse events ($p = 0.005$) as well as patients with and without RVD ($p = 0.001$). There was no significant difference in CTPA RV/LV ratio among patients with and without adverse events ($p = 0.27$) while there was statistically significant difference in CTPA RV/LV ratio among patients with and without RVD ($p = 0.0001$). Qanadli index with a cut-off value of >19 discriminates patients with adverse events with AUC of 0.807 (specificity: 52.38% and sensitivity: 100%).

4.4. NT-proBNP

Median NT-proBNP of patients was 2032 pg/ml. Patients with adverse events had higher NT-proBNP levels than those without ($p = 0.0094$). None of the patients with lower NT-proBNP (<729 pg/ml) had adverse events. The ROC analysis (Fig. 1 and Table 4)

Table 3
Prognostic variables in patients with and without adverse events.

Characteristic	Total cohort ($n=30$)	With AEs ($n=9$)	Without AEs ($n=21$)	p-value
PESI score	90.03 ± 25.44	87.89 ± 18.20	90.95 ± 28.34	0.77
Echocardiographic parameters				
Echo RV/LV ratio	1.05 ± 0.16	1.07 ± 0.09	1.02 ± 0.16	0.38
RVEDD, mm	42.53 ± 7.96	45.0 ± 5.54	41.48 ± 8.7	0.27
TR JV, m/s	2.77 ± 1.07	3.08 ± 0.87	2.73 ± 0.98	0.36
Echo RV dysfunction				
Yes	22 (73.3%)	09 (100%)	13 (61.9%)	–
No	08 (26.7%)	00 (0%)	08 (38.1%)	
Qanadli index	19.37 ± 7.55	25.0 ± 4.33	16.95 ± 7.39	0.005*
CT RV/LV ratio	1.44 ± 0.44	1.57 ± 0.35	1.38 ± 0.45	0.27
IVS bowing				
Yes	17 (56.7%)	8 (88.9%)	9 (42.9%)	
No	13 (43.3%)	1 (11.1%)	12 (57.1%)	0.04*
Median NTproBNP, pg/ml	2032.50	3451.0	1392.5	0.0094*
(IQR)	(550.0–4082.0)	(2425.0–6784.0)	(315.0–2506.0)	

AE, adverse events; echo, echocardiography; RVD, right ventricular dysfunction; TRJV, tricuspid regurgitation jet velocity; PAOI, pulmonary vascular obstruction index; RV, right ventricle; LV, left ventricle.
* Significant p-value ($p < 0.05$).

Table 4
ROC analysis of various prognostic tools in predicting adverse events.

Variable	Cut-off	AUC	95% CI	p-value	Sensitivity (%)	Specificity (%)	PPV	NPV
Qanadli index	>19	.807	0.651–0.963	0.009	100	52.38	47.4	100
NT-proBNP	>729	.772	0.593–0.952	0.020	100	38.10	40.91	100
RV/LV ratio on echocardiogram	>0.95	.709	0.525–0.893	0.074	100	42.86	42.9	100
CT RV/LV ratio	>1.15	.646	0.446–0.845	0.213	100	42.9	42.9	100
RVEDD	>47	.675	0.463–0.886	0.135	55.56	85.7	62.5	81.8

AUC, area under curve; PPV, positive predictive value; NPV, negative predictive value; NT-proBNP, N-terminal pro-brain natriuretic peptide; RV, right ventricle; LV, left ventricle; CT, computed tomography; RVEDD, right ventricular end diastolic diameter.

illustrates the sensitivity and specificity of NT-proBNP measurements in discriminating patients with and without adverse events. The AUC was 0.772, which indicates good discriminative power. A NT-proBNP value > 729 pg/ml had a specificity rate of 38.1% and positive predictive value of 40.91% for detecting adverse events.

4.5. Right ventricular dysfunction

At admission, between patients with RVD and without RVD, there was significant difference in systolic blood pressure, diastolic blood pressure, and arterial saturation but there was no significant

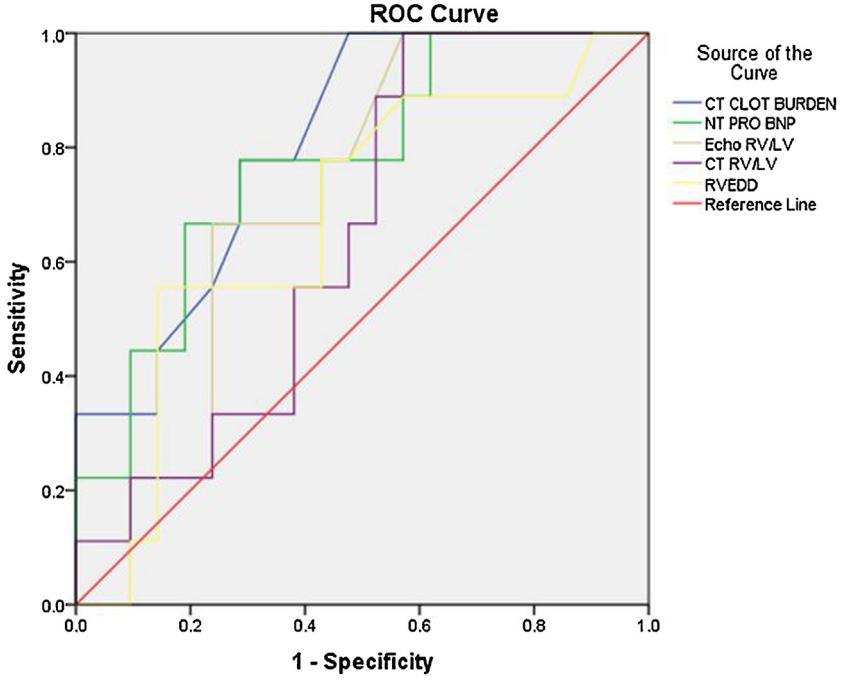

Fig. 1. Receiver operating characteristics of prognostic parameters in predicting adverse events.

Table 5
Relationship between right ventricular dysfunction and other prognostic parameters.

Echocardiographic RVD vs.	Correlation coefficient	*p*-value
SBP	−0.412	0.024*
PESI score	0.449	0.013*
Qanadli index	0.694	<0.0001*
NT-proBNP	0.767	<0.0001*
CT RV/LV ratio	0.675	<0.0001*

SBP, systolic blood pressure; PESI, pulmonary embolism severity index; NT-proBNP, N-terminal pro-brain natriuretic peptide; CT, computed tomography; RV, right ventricle; LV, left ventricle.
* Significant *p*-value ($p < 0.05$).

difference in pulse rate and respiratory rate. Patients with RVD had higher serum creatinine levels than those without (1.15 ± 0.23 mg/dl vs. 0.089 ± 0.13 mg/dl; $p < 0.007$). Nine patients in low-risk PESI group (56.25%) and 13 patients in high-risk PESI group (92.85%) had RVD. Majority of patients with RVD were in class II and III (16 patients, 72.8%). Majority of patients without RVD were in class I and II (7 patients, 87.5%). There was significant difference in PESI score in patients with and without RVD (96.45 ± 24.57 vs. 72.38 ± 19.62; $p = 0.02$). There is moderate positive correlation of PESI with RVD ($r = 0.449$, $p = 0.013$). Correlation of prognostic parameters with RVD is displayed in Table 5. On ROC analysis CTPA RV/LV ratio predicted RVD with AUC of 0.94 (95% CI: 0.842–1.000) at cut-off value of >1.15 (sensitivity: 90%; specificity: 87.5%; negative predictive value: 77.8%; positive predictive value: 95.2%). Qanadli index and CT RV/LV ratio had good positive correlation with RVD ($r = 0.694$, $p < 0.0001$ and $r = 0.675$, $p < 0.0001$, respectively). There was significant difference in median NT-pro BNP levels among patients with and without RVD (2664.50 pg/ml vs. 300 pg/ml; $p < 0.0001$).

4.6. Intensive care unit stay

Mean intensive care unit (ICU) stay was 2.89 ± 2.22 days. Patients with RVD had significantly prolonged ICU stay than those without (mean ICU stay in days; 3.70 ± 0.78 vs. 0.71 ± 0.75, $p = 0.001$). Patients with adverse events had significantly prolonged ICU stay than those without (mean ICU stay in days; 4.44 ± 2.19 vs. 2.16 ± 1.86, $p = 0.006$). Qanadli index, RVD, NT-proBNP and RV/LV ratio on echocardiogram significantly correlated with ICU stay ($r = 0.426$, $p = 0.024$; $r = 0.674$, $p < 0.0001$; $r = 0.615$, $p < 0.0001$ and $r = 0.567$, $p = 0.002$ respectively). RV/LV ratio on echocardiogram correlated with ICU stay ($r = 0.567$ and $p = 0.002$) but RV/LV ratio on CTPA did not correlate with ICU stay ($r = 0.242$, $p = 0.215$).

5. Discussion

In this prospective study we assessed the prognostic values of Qanadli index, NT-pro BNP, PESI, and right ventricular dilation parameters like RVEDD, RV/LV ratio on CTPA, and echocardiogram in predicting adverse events. We found that in acute PE: (1) NT-proBNP and Qanadli index have good discriminative power for the detection of adverse events; (2) CTPA RV/LV ratio predicts RVD but not adverse events; (3) there is no relationship between PESI and adverse events; (4) Qanadli index is the most accurate predictor of adverse events than NT-proBNP, PESI, RVEDD, and RV/LV ratio.

Acute pressure overload and failure of right ventricle is a critical event in pathophysiology of acute PE. The diagnosis of RVD in acute PE is of utmost importance because RVD is associated with mortality.[1,2,19,20] In our study all adverse events occurred in patients with RVD and secondary thrombolysis was required only in patients with RVD.[1,2] All the patients without RVD had uncomplicated hospital course similar to other studies.[5,6] Unfortunately, there is heterogeneity in definition of right ventricular dilation by echocardiography in different studies as the criteria was not well established.[1,2,21,22] Therefore, we have taken reference values from Guidelines for the echocardiographic assessment of the right heart in adults by American Society of Echocardiography.[4] Following these standard guidelines in future studies may help to maintain uniformity and may make analysis easier. Echocardiography has several limitations like operator dependence and limited acoustic window in obese and pulmonary disease patients. Moreover, there are no standardized echocardiographic reference values for further stratification of RVD into mild, moderate, and severe, signifying the need for other prognostic indicators with incremental prognostic value for precise stratification. NT-proBNP, PESI, CTPA RV/LV ratio, and Qanadli index correlated well with RVD and hence can be useful as prognostic indicators for RVD. However, NT-proBNP and Qanadli index provide indirect evidence of right ventricular dilation. Like echocardiography, CTPA RV/LV ratio provides direct evidence of right ventricular dilation.

On ROC analysis NT-proBNP had good sensitivity and negative predictive value for patients without adverse events (100% and 100%) and modest specificity and positive predictive value for those with adverse events (38.1% and 40.9% respectively). NT-proBNP is an effective tool to identify those without adverse events than those with adverse events. Our results corroborate with those of other published studies that have demonstrated a lower rate of in-hospital complications and better short-term prognosis in PE patients with low NT-proBNP levels.[21,23,11] In patients with low NT-proBNP levels echocardiography will have no incremental prognostic value because of good negative predictive value of NT-proBNP for adverse events. Though various studies[23,11,24] had proposed different cut-off values for adverse events, all studies have found that NT-proBNP had low specificity and high sensitivity for adverse events. Discrepancies in cut-off value may be due to differences in the characteristics of the patients included, measurement at different stages of presentation and analysis of different endpoints.

CTPA is the best imaging modality for diagnosis of acute PE and its prognostic ability is less defined. According to several reports,[12,13,25,26] CTPA RV/LV ratio is a strong predictor of mortality while few[27] reported that there is no association between the RV/LV ratio and death. We found that CTPA RV/LV ratio does not has the ability to predict occurrence of adverse events ($p = 0.213$). Some reported that CTPA RV/LV ratio had good sensitivity and specificity for detecting RVD.[28–30] Few studies have assessed RVD qualitatively on CTPA[11,30] while Mansencal et al.[28] quantified RVD by CTPA RV/LV ratio and compared with echocardiography. In this study we found that CTPA RV/LV ratio has good correlation with RVD ($r = 0.675$) and is able to predict RVD with good discriminative power (AUC = 0.94).

Qanadli index on CTPA provides objective, reproducible and quantifiable assessment of pulmonary arterial obstruction.[18,31] Its role in risk stratification in these patients is debated. We found that Qanadli index is greater in patients with adverse events and RVD. Qanadli index predicts patients at low risk of adverse events with good negative predictive value but positive predictive value for adverse events is modest. Contrary to our findings some studies[29,30,32,33] did not find any significant association between the pulmonary artery embolic burden assessed with the Qanadli index and short-term death due to PE. Apfaltrer et al.[34] evaluated 50 patients and reported that pulmonary artery obstruction scores can differentiate between patients with and without RVD but not correlated with adverse clinical outcome. Our study results are consistent with some other studies,[12,35,36] which reported that Qanadli index is a significant predictor of short-term outcomes. Few other studies[37] used Mastora score for assessing pulmonary artery embolic burden and found that it will predict adverse events.

Mean Qanadli scores were 12.6 and 10 in the reports by Apfaltrer et al.[34] and Araoz et al.[17] respectively while in our study it was 19.37. Mean age was around 60 years in studies by Ghaye et al.[26] and Araoz et al.[17] while in our study it was 41.20 ± 12.08 years. These differences in age and severity of pulmonary obstruction reflect differences in the patient characteristics among various studies. Moreover we have not addressed inter and intra observer variability. The outcomes studied in various reports were different. Most of the studies did not exclude pulmonary co-morbidities which can influence outcomes. In patients with associated pulmonary disease, less pulmonary vascular obstruction is required to achieve a similar degree of physiologic impairment.[38] Discordance among studies regarding embolic burden may be due to difference in patient's characteristics and definition of outcomes. Analysis of the accuracy of CTPA parameters in detecting adverse events is limited by heterogeneity across studies. This highlights the need for large prospective multicentre study to evaluate the prognostic role of CTPA parameters.

We found that Qanadli index is better predictor of adverse events than NT-proBNP and RVEDD, RV/LV ratio on echocardiogram and CTPA as indicated by greater AUC. Qanadli index has more specificity and positive predictive value than NT-proBNP in identifying adverse events but not sufficient high enough to be used alone. Qanadli index and NT-proBNP have good sensitivity and negative predictive value but have poor specificity and positive predictive values. Hence, both tests identify patients with benign in-hospital course who may require abbreviated hospital stay. The lack of consistent findings from various studies currently limits the ability to assess prognosis by CTPA measurements alone in those with acute PE. Biomarkers like NT-proBNP because of their wide availability irrespective of location or time of the day and non-invasive nature seems to be appropriate to be used along with CTPA for risk assessment.

The results of this study may have important clinical implications. Qanadli index and NT-proBNP are better predictors of adverse events than echocardiography. A simple and rapid bedside measurement of NT-pro-BNP might facilitate triage of acute PE patients. As CT is best diagnostic imaging modality and simultaneous assessment of the cardiac chambers is a quick and practical means of evaluating for right heart dysfunction. CTPA can be useful as both diagnostic and prognostic tool in patients. Qanadli index and NT-proBNP will help to identify subset of acute PE patients with RV dysfunction, who are hemodynamically stable at admission, worsens during hospital stay even after initiation of anticoagulation. Identification of this sub group shall help in early recognition, close monitoring, and lower threshold for intensive therapy, which may improve outcomes.

6. Limitations

The main limitation of the study is small sample size. This study was conducted at single centre without follow up of the patients after discharge. The role of prognostic tools in prediction of long-term complications and quality of life needs to be evaluated. We used non-ECG gated computed tomography which has limitations in accurately measuring ventricular chamber size. Inter- and intra-observer variability in assessing computed tomography parameters were not studied. The prognostic value of combined prognostic parameters was not assessed which needs to be considered in future research.

7. Conclusion

Qanadli index is a better prognostic indicator than NT-proBNP, PESI, RVEDD, and RV/LV ratio on CTPA and echocardiogram in acute pulmonary embolism patients. RV/LV ratio on CTPA is adequate for predicting right ventricular dysfunction.

Funding

None.

Conflicts of interest

The authors have none to declare.

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