ORIGINAL ARTICLE

CORRELATION OF QANADLI SCORE WITH RIGHT VENTRICULAR DYSFUNCTION IN PATIENTS WITH ACUTE PULMONARY EMBOLISM

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Background: CT-pulmonary angiography (CTPA) is routinely performed in patients with suspected pulmonary embolism (PE) and a positive relationship between Qanadli score (Q-score) and RV-dysfunction enables the clinicians in early diagnosis and management of RV-dysfunction on the basis of this single imaging modality. Objective of the study was to determine the correlation between an established angiographic clot burden score (Qanadli score-QS) and parameters of right ventricular dysfunction (RVD) on CT pulmonary angiography in patients with acute pulmonary embolism. **Methods:** A Cross-sectional study was carried out for the period of six months from 16 Jun to 15 Dec 2016. Total of forty-six (46) patients of either gender aged 15–70 years with confirmed evidence of PE were recruited. The Q-score and parameters of RV-dysfunction (LV/RV, ratio, SVC diameter, AV-diameter and PA/Ao ratio) were calculated in each patient. Correlation between Q-Score and RV parameters were determined and binary logistic regression analysis was applied to assess Q-score as an independent predictor of RV-dysfunction. **Results:** Avery strong positive correlation was found between Q-score and LV/RV ratio (r>0.7, p<0.05) collectively and after gender and age based stratification. No significant correlation was found between Q-score and other RV parameters among both genders and age groups (p>0.05 in all cases). No independent factors were found to be significantly related to RV dysfunction after adjustment for other factors (p>0.05). **Conclusion:** Qanadli score on CT pulmonary angiogram correlates positively with indicators of right ventricular dysfunction of CT angiogram in patients with acute pulmonary embolism and confer a poor prognosis with higher scores.

Keywords: Pulmonary Embolism, CTPA, RV dysfunction

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INTRODUCTION

Acute pulmonary embolism (PE) is a potentially fatal disease which is associated with high early in-hospital mortality and morbidity despite advances in diagnostic and therapeutic modalities[1] and is a relatively common acute cardiovascular condition with an incidence of approximately 60 to 70 per 100,000, and that of venous thrombosis approximately 124 per 100,000 of the general population[2]. Annual incidence rates of venous thrombosis and PE of approximately 0.5 to 1.0 per 1,000 inhabitants have been reported[3]; however, the actual figures are expected to be substantially higher on account of clinically silent, hence undiagnosed disease burden in as high as 40–50% of the patients with deep venous thrombosis (DVT)[4]. Untreated, it has a mortality rate as high as 30% which falls to approximately 8% in diagnosed and treated cases.[2,5] An acute, sharp rise in pulmonary artery pressures follows the luminal occlusion of pulmonary vasculature by a thrombus[6] subsequently leading to right ventricular dysfunction. Owing to varying presentations, it is imperative to pre-empt the clinical probability and risk stratification along with assessment of clinical and haemodynamic status which are the cornerstone of patient management.

The presence of right ventricular dysfunction as determined by trans-thoracic echocardiography or CT scan is an important determinant of mortality risk and can also guide treatment.[6,7] Previously published literature shows an established correlation between echocardiographic evidence of right ventricular dysfunction and outcome in terms of mortality in patients with acute pulmonary embolism[8] but its diagnostic utility is limited by requirement of experienced personnel with round-the-clock availability in the emergency departments. CT pulmonary angiography is increasingly being used as a diagnostic tool in patients with a clinical suspicion of pulmonary embolism and has rapidly evolved as the diagnostic modality of choice due to its speed, sensitivity, convenience and ability to visualize clots and exclude alternative diagnoses.[9] Since multi-detector CT scan is used as the first line modality in diagnosis of PE, assessment of right ventricular dysfunction by the same technique appears to be a practical approach.

The ratio between right ventricular and left ventricular short axis diameters has shown to be an accurate predictor of right ventricular dysfunction.[10,11] Ratio of pulmonary artery (PA) to aorta (Ao) diameter, bowing of the inter-ventricular septum (IVS), diameters

of the superior vena cava (VC), azygous vein (AV) and coronary sinus (CS) and reflux of contrast into the inferior VC or AV are other indicators of right ventricular dysfunction. The severity of PE can be quantified by clot burden scores but its relationship with clinical, laboratory and CT signs of right ventricular dysfunction are still a matter of debate as risk stratification models are increasingly being based on haemodynamic and clinical status of the patient rather than the clot burden on CT pulmonary angiography. We planned the current study to determine the correlation between an established angiographic clot burden score (Qanadli score, QS) and parameters of right ventricular dysfunction (RVD) on CT pulmonary angiography in patients with acute pulmonary embolism.

MATERIAL AND METHODS

This cross-sectional analytical study was carried out at a tertiary care teaching hospital, Holy Family Hospital, Rawalpindi from 16 Jun to 15 Dec 2016 after taking departmental approval. Written informed consent was also obtained from the participants. The WHO Sample Size Calculator was used to determine the appropriate sample size with a 95% confidence level, 5% level of significance, 80% power of test and an estimated sample correlation (r) of 0.4812 and was found to be 46 patients. Patients were included through non-probability consecutive sampling up to a pre-determined sample size. A total of forty-six (n=46) patients of either gender aged 15–70 years who had radiologically confirmed evidence of pulmonary embolism on CTPA were included in the study.

All patients with suspected acute pulmonary embolism underwent CTPA on a 16-MDCT scanner (Toshiba, Aquilon RXL) in a supine position and a cranio-caudal chest scan was obtained. A 16×0.625 collimation, 1 mm slice thickness, 0.5 mm construction increment and 0.5 second rotation time was utilized. One hundred millilitres of a nonionic contrast medium [iohexol (Omnipaque 350, SiTech)] was administered at a standardized flow rate of 4–5 ml/s followed by 40 ml 0.9% NaCl bolus injected via the antecubital vein of either arm. The thorax scanning time was approximately 4–5 seconds, and the time for contrast administration was 25 seconds. Direct visualization of non-occlusive endoluminal thrombus (central filling defect completely or partially outlined by contrast agent) or of complete occlusion by thrombus in normal-sized or enlarged vessels was the standard CT criterion used for diagnosis of pulmonary embolism. All CTPA images were transferred from picture archiving and communication system of the hospital. Studies providing poor vessel enhancement, noise and motion artefacts were excluded. All patients were required to provide written informed consent and the study was approved by the institutional ethical review board.

The Qanadli score was calculated by assuming 10 segmental pulmonary arteries and a score of 1 was assigned to an embolus in each segmental pulmonary artery. An embolus in a more proximal artery was given the value of all the segmental arteries distal to the affected pulmonary artery. A weighting factor was applied that related to the amount of occlusion (0 for no defect, 1 for partial occlusion and 2 for complete occlusion). A sub-segmental embolus was recorded as a partially occluded segmental pulmonary artery. The maximum possible score was 40.[13] In addition, the total number of clots and their proximal extent were also noted. Mediastinal pulmonary arteries (i.e., pulmonary artery trunk, main right and left pulmonary arteries, and right and left interlobar pulmonary arteries), lobar pulmonary arteries, segmental pulmonary arteries, and sub-segmental pulmonary arteries were used to reflect the most proximal level of the embolus. Peripheral arteries include segmental and sub-segmental pulmonary arteries whereas the rest were taken as central arteries. The percentage of obstruction of the involved vessel by the embolus was computed by dividing the Qanadli Score by 40.

The ratio of right ventricle diameter to left ventricle diameter (RV/LV ratio), superior vena cava diameter, azygos vein diameter, interventricular septum morphology, ratio of main pulmonary artery diameter to ascending aorta diameter (PA/Ao ratio) and reflux of contrast medium into the inferior vena cava (IVC) were used as indices of right ventricular dysfunction on CT Pulmonary Angiography. Diameters of ventricular chambers were calculated at their widest point during diastole on axial CT image of heart between the inner surface of interventricular septum and free wall. Similarly, the transverse image in which main pulmonary artery was contiguous with right pulmonary artery was used to calculate the diameter of main pulmonary artery and ascending aorta from which PA/Ao ratio was calculated. The transverse CT image showing azygous vein reaching the superior vena cava was used to measure superior vena cava and azygous vein diameters. Interventricular septum morphology was classified as normal (with its convexity towards right ventricular cavity), flattened or bowing (with its convexity towards left ventricular cavity). A peripheral wedge-shaped consolidation with an area of central lucency as taken as a pulmonary infarct.

Data were analysed using SPSS-21. Continuous variables were presented as Mean±SD. Pearson correlation analysis and Spearman rank order was used, for normal and non-normal variables respectively to determine a correlation between outcome measure (indices of right ventricular dysfunction) and variables of interest (Qanadli Score), and $p<0.05$ was considered as statistically significant.

RESULTS

There were 24 (52.2%) males and 22 (47.8%) females out of total 46 patients. Mean age, Q-score, LV/RV ratio, SVC diameter, AV-diameter, and PA/Ao ratio are presented in Table-1. Correlation of Qanadli score with the indicators of right ventricular dysfunction used in present study are shown in Table-2.

Table-1: Mean values of study variables

Variable	Mean±SD
Age (years)	53.5±15.8
Qanadli score	11.5±7.50
RV/LV ratio	1.26±0.15
SVC diameter (mm)	21.2±3.30
AV diameter (mm)	9.7±0.98
Pa/Ao ratio	0.93±0.16

Table-2: Bivariate correlation between Q-score and RV dysfunction parameters

	RV/LV ratio		SVC Diameter		AV Diameter		PA/Ao ratio	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Q-Score	0.82	0.001	0.36	0.01	0.29	0.04	0.20	0.17

DISCUSSION

The results obtained by this study are consistent with the literature published internationally on the subject. Quantitative cardiac CT measurements obtained on axial CT images, namely the RV short axis, the LV short axis, and particularly the RV/LV short axes ratio, have shown a significant positive (RV short axis, RV/LV diameter ratio) or negative (LV short axis) correlation with the severity of PE or with fatal outcome.[14,15] In the current study, a very strong positive correlation was found between Q-score and LV/RV ratio (as cited above) whereas a weak positive correlation was found between Q-score and AV diameter. However no significant correlation was found between Q-score and PA/Ao ratio. Furthermore, in two studies of similar nature recruiting 25 patients with PE and 14 patients with massive PE, Contractor *et al* and Lim, *et al*[10,16] found that signs of RV strain at CT pulmonary angiography (RV/LV diameter ratio > 1, leftward septal bowing) had a sensitivity of 78–92%, specificity of 100%, and positive predictive value of 100% when compared to echocardiographic findings for the detection of RV dysfunction. Since the authors could not determine the predictive values and accuracy of Qanadli score, comparison between such figures cannot be made but existence of a correlation can be comparably established. Additional studies have estimated that an RV/LV diameter ratio superior to 1.5 indicates a severe episode of PE[11] consistent with our findings showing a significant correlation. In the study by Araoz *et al*[17], an RV/LV diameter ratio greater than 1 was associated with a 3.6-fold increased risk of admission to the intensive care unit. Moreover, Nazerian *et al* recently demonstrated a significant relation between the RV/LV diameter ratio and the risk of death in 82 patients who presented with a severe PE-related clinical condition that required admission to the intensive care unit.[18]

In current study, a moderate positive correlation was found between Q-score and SVC diameter. An acute increase in volume and pressure in the right heart may be associated with upstream manifestations at the level of systemic venous structures. Collomb *et al* found significantly different diameters of the superior vena cava in patients with severe PE and patients with non-severe PE indirectly providing supporting evidence for our findings showing a positive correlation with SVC diameter.[14] Previous work based on chest radiographs by Moreno *et al* evaluated the relationship between the mean right atrial pressure and the diameter of the azygos vein and the width of the vascular pedicle, which is mainly affected by the dimension of the superior vena cava.[19] Both measurements were significantly correlated with mean right atrial pressure and the circulating blood volume. However, these measurements did not show significant correlation with Qanadli score in our study. These differences might have arisen due to a small sample size and a less significant proportion of patients with massive PE in the study population. These authors observed an abrupt increase in size of the azygos vein and widening of the vascular pedicle in patients presenting with acute right heart failure. In support of this finding, the size of the inferior vena cava (IVC) as measured at ultrasonography (US) has been shown to reflect right heart hemodynamics.[20]We recommend further studies for ascertaining their correlation with the clot burden scores.

Nural MS, *et al*,[21] aimed to identify the role of computed tomographic pulmonary angiography (CTPA) in the assessment of the severity of acute PE and right ventricular dysfunction. Their results showed that with receiver operating characteristic curve (ROC) analysis, the CTPA obstruction score and RV/LV short-axis ratio threshold values for the haemodynamically unstable pulmonary embolism (HUPE) patients were calculated to be 48% (95% sensitivity, 76% specificity) and 1.1 (85% sensitivity, 76% specificity), respectively. Three patients in the HUPE group died within the first 24 hours. Logistic regression methods revealed only the RV diameter as a significant predictor of death (Odds ratio 1.24; 95% CI: 1.04–1.48; p=0.01). Authors concluded that the parameters useful for distinguishing HUPE and HSPE (haemodynamically stable pulmonary embolism included CTPA obstruction score, RV and SVC diameters, RV/LV short-axis ratio, interventricular septum shape, and reflux into the IVC. Right ventricular (RV) dilatation may be a significant predictor for mortality.

Apfaltrer P *et al*[22] aimed to correlate CTA pulmonary artery obstruction scores (OS) with right ventricular dysfunction (RVD) and clinical outcome in patients with acute PE. In a prospective study of 50 patients with PE pulmonary artery OS (Qanadli, Mastora, and Mastora central) were assessed by two radiologists. Their results showed that Mean Mastora, Qanadli, and Mastora central OS were 26.4±17.7, 12.6±9.9 and 7.5±9, respectively. A relevant correlation ($r \geq 0.6$) between OS and CT parameters for RVD were only found for the Mastora score and the Mastora central score (RV/LV4ch: r=0.61 and 0.68, RV/LV vol: r=0.61 and 0.6). None of the OS differed significantly between patients with and without adverse clinical outcome. Authors concluded that pulmonary artery obstruction scores can differentiate between patients with and without RVD.

In summary, of these cardiac and venous measurements, the RV/LV diameter ratio is the easiest to calculate and is reported to have a strong positive correlation with Qanadli score. It should be included in every report of a CT pulmonary angiography. An increased RV/LV diameter ratio may be an important finding for the clinician. Nevertheless, prospective studies are needed to determine how such a finding could affect patient care and treatment.

CONCLUSION

Clot burden as determined by Qanadli score correlates strongly and positively with indicators of RV dysfunction on CT Pulmonary Angiogram and can be used to pre-empt a higher mortality risk and guide treatment accordingly in patients with acute pulmonary embolism.

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