Which method to measure RV/LV diameter ratio is the best predictor of mortality in patients with acute PE?

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Aims and objectives

Acute pulmonary embolism (PE) is a potentially fatal disease [1]. It has however a wide clinical spectrum, from asymptomatic event, to life threatening condition due to cardiogenic shock.

Right ventricular (RV) failure is the primary cause of death in patients with acute PE [2]. Normally, the RV faces low resistance as it empties into a low-pressure system of the pulmonary vasculature. In acute PE, both mechanical obstruction and hypoxic vasoconstriction increase pulmonary vascular resistance, and initiating a series of hemodynamic derangements leading to RV dysfunction [3].

Risk stratification helps optimizing the selection of those patients who need close monitoring for possible expedited initiation of more aggressive therapy, such as thrombolysis or embolectomy, in addition to anticoagulation [4].

Echocardiographic findings indicating RV dysfunction have been identified as independent predictors of adverse outcome [5], but are heterogeneous and are difficult to standardize [6]. In addition it is usually performed as additional test for risk stratification following PE diagnosis with CT.

CT pulmonary angiography (CTPA) which is currently the leading modality for PE diagnosis [4], allows also the visualization and measurements of the cardiac chambers and thus has the potential to be an alternative to echocardiography to assess RV dysfunction by calculating the ratio between the diameters of the RV and the left ventricle (RV:LV dR).

Recent meta-analysis reports that RV dilation at CTPA is associated with an increased risk of death at 30 days in patients with acute PE [7].

Various methods to assess RV:LV dR were suggested in the literature with inconsistent results regarding the capability to predict adverse prognosis.

The aim of this study is to determine which method of measuring the RV:LV dR is the best predictor of higher pulmonary arterial obstruction and mortality in patients with acute PE.
Methods and materials

Patients:

After institutional board review approval, we retrospectively analyzed all consecutive patients with acute PE on CTPA which were scanned between 01/2007-12/2009.

CT scans:

CTPA studies were performed with either a 64-section (Philips Brilliance 64) or a 16-section (Philips Brilliance 16) multidetector CT scanner, by using a standard CTPA protocol with the following parameters: section thickness 1mm, 120 kVp, 240 mAs, detector width 64X0.625 or 16X0.75 mm (depending on the scanner).

The studies were done with a bolus tracker technique after intravenous administration of 70-100 mL iodine at a rate of 3-4 mL/sec.

CT analysis:

Studies were initially identified by means of procedure codes to identify CTPA, then radiology reports were used to identify cases with acute PE. Positive cases were transferred from the PACS system to a dedicated work station (Comprehensive Cardiac Analysis, Extended Brilliance Workspace, Research Version Philips Healthcare, Cleveland, OH).

The RV:LV dR was calculated using three different measurements methods:

1. Largest RV and largest LV diameter as measured on the original axial images. These measurements were measured not necessarily on the same slice. (ax- figs. 1-2).

2. Largest RV and largest LV diameter on four chamber view which was reconstructed manually using two oblique reconstructions [8] (4man- figs. 3-6).

3. Largest RV and largest LV diameter on completely automatic 4 chamber reformations (4func- figs. 7-8) provided by the dedicated analysis software.
All measurements were performed in consensus by two radiologists (Y.A., E.S.). While performing the measurements, the readers were blinded to the clinical data and patients outcome.

The various RV:LV dR were correlated with the pulmonary arterial obstruction index using the Qanadli scoring system [9] and the 30 days mortality data derived from the ministry of internal affairs office.

**Statistical Analysis:**

All data were displayed as mean and standard deviation (SD) for continuous variables with normal distribution and as median and interquartile range for continuous variables without normal distribution (like PAOI). Categorical variables were displayed as the number and percent on each group.

All correlations were done using the Pearson's correlation analysis.

Survival analysis was done using the Cox proportional hazard model with mortality at 30 days as the outcome measure and PAOI as the independent variable. Age, gender and other baseline variables were considered in the models as potential confounders.

All analyses were two-sided, and P<0.05 was considered statistically significant. All analyses were done using the SPSS statistical software.
Fig. 1: RV Diameter measurement on axial view

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Fig. 2: LV Diameter measurement on axial view

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Fig. 3: Manual 4 chamber view reconstructed using two oblique views - step 1

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**Fig. 4:** Manual 4 chamber view reconstructed using two oblique views - atep 2

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Fig. 5: Manual 4 chamber view reconstructed using two oblique views - final view

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Fig. 6: Diameter measurements on manually reconstructed 4 chamber view

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Fig. 7: Automatic 4 chamber view reconstruction

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Fig. 8: Diameter measurements on automatically reconstructed 4 chamber view

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Results

Our cohort consisted of 465 patients; 270 women and 195 men with a mean age of 66 ± 17.

One hundred fifty three (33%) had active malignancy.

The median pulmonary arterial obstruction index PAOI was 7 (IQR 2-18) representing 17.5% of obstruction (IQR 5%-45%).

Fourty-nine patients (10.5%) died within 30 days of the PE diagnosis, 14 of them (1.5%) did not have active malignancy.

Cox regression analysis revealed that RV:LV dR based on 4man and 4func were significantly associated with increased mortality. The univariate analysis showed that age, active malignancy and both RV:LV dR based on 4man and 4func were significant predictors of mortality. Following adjustment to age and the presence of active malignancy RV:LV dR based on 4man and 4func were capable to predict increased mortality (p=0.014 , p=0.003, respectively), while axial measurements could not.
Conclusion

Our study shows that in patients with acute PE on CTPA, measurements of the diameter ratio between the RV and LV which are performed on manually or automatically reconstructed four chamber views can help predicting mortality, while measurements on the axial images are not useful.

Although the axial method is the easiest and most rapid way to assess RV dysfunction at MDCT, since the heart is oriented in multiple oblique angels within the chest, this method is less accurate.

We suggest using an automated analysis software which allows 4 chamber measurements with no need for time consuming manual reconstructions.
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