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Left atrio-vertebral ratio: A new computed-tomography measurement to identify left atrial dilation

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ABSTRACT

Background: Left cardiac chambers dilation, interstitial lung changes and pleural effusions are the characteristics of cardiogenic pulmonary oedema on computed tomography (CT) of the chest but mensuration of the left atrial size is not routinely performed. Cardiac chambers normal dimensions are known to be proportional to the patient's build and anthropomorphic data but adjustment of chambers dimensions to available elements seen on the axial CT images has never been evaluated before.
Objectives: Our objective was to use data easily available on axial images to directly scale the left atrium. We chose to divide the left atrial diameter by the thoracic vertebral diameter, using the latter as a body-mass indicator. As a preliminary study, we aimed to evaluate the range of values of this left atrio-vertebral ratio (LAVR) by comparing patients suffering from cardiogenic pulmonary oedema with patients free of cardiac disease. We hypothesized that if the difference of values in these two populations of patients was significant enough, this ratio would be relevant and could be used as a quick criterion in different clinical situations.
Method: Two radiologists reviewed CT scans of 32 of patients free of cardiac disease and 40 patients in acute cardiac failure. The maximum diameter of the left atrium at the level of the right inferior pulmonary vein was divided by the vertebral transverse diameter to generate a left atrio-vertebral ratio. Receiver operating characteristic curves identified the threshold associated with pulmonary oedema.
Measurements and main results: The mean LAVR was 1.85 ± 0.27 in asymptomatic patients and 2.48 ± 0.35 in patients with pulmonary oedema. A LAVR of 2.1 yielded 85% sensitivity and 88% specificity for the diagnosis of cardiogenic pulmonary oedema.
Conclusions: LAVR is a simple new measure directly scaling the left atrial diameter to the anthropomorphic characteristics of the patient. In our series, a ratio above 2.1 is strongly associated with cardiogenic pulmonary oedema indirectly suggesting left atrial dilation. The results were significantly different between the two populations of patients (no heart condition versus cardiogenic pulmonary oedema) suggesting a high potential for clinical application.

1. Introduction

Respiratory failure in intensive care unit is frequently secondary to a combination of factors involving lung parenchymal and cardiovascular events. Although computed tomography is the method of choice to demonstrate both lung and mediastinal changes, to our knowledge, there is no CT measure scaling LA size to the patient's specific body habitus, in order to identify a left atrial dilatation on axial images. This could prove very useful in raising the possibility of left cardiac failure in the context of acute dyspnoea and interstitial lung changes [1].

Normal left atrial (LA) volume is difficult to evaluate, not only because of its shape and motion, but also because its absolute

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value is not relevant. LA volume has been proven to be proportional to a patient's physical characteristics, calculated from height and weight [2]. Consequently, accurate gold-standard measures are provided by ECG-gated, contrast-enhanced CT or MRI images after time-consuming post-processing 3-D reformatting in different planes, reproducing echocardiographic images [3–7]. Chamber outlines are traced, and dimensions indexed to the body mass index or to the body surface area of the patient, calculated from height and weight data [8,9]. Such measurements are therefore never used in routine practice.

LA enlargement has generated considerable attention recently, not only because of the significant development of techniques such as radiofrequency ablation of atrial fibrillation [10,11] but also because it is an extremely common condition and it reflects the burden of cardiovascular diseases in the general population [11,12]. It has been proven to increase the risk of developing atrial fibrillation [13], it is an individual risk factor for stroke, an independent predictor factor of chronic heart disease [14], a strong predictor of overall mortality and more specifically after acute myocardial infarction [15]. Furthermore, LA size is a marker of the severity and chronicity of diastolic dysfunction [16] and it has been shown that a simple measure of LA dilation could identify individuals who may warrant further cardiac investigation and risk factor modification [17].

CT scans of the chest are performed frequently for various indications, to assess mediastinal, cardio-vascular or parenchymal lung diseases. Recent literature has focused exhaustively on the necessity to examine the heart and vascular structures on every thoracic CT scan performed regardless of the indication [18–20]. It can indeed prove an essential screening tool when unsuspected findings such as coronary calcifications in middle-aged patients are discovered, influencing their clinical management with possible public health consequences [20].

Despite those numerous examples, LA enlargement is not yet routinely diagnosed on chest CT scan, and is only rarely mentioned on reports.

This does not however mean that LA size is not subjectively assessed: experienced radiologists know by experience and visual appreciation when LA appears too large proportionally to the patient's chest dimensions. CT scan, unlike echocardiography, provides accurate visual information on a patient's body habitus [21,22] that could be directly used to quantitatively index LA size. To our knowledge, this has never been exploited.

We hypothesized that the radiologist's experienced eye could be translated into a mathematical model, providing a range of normal LA ratios. We aimed to identify a quick measure, easily identified on axial native images or on picture archiving systems (PACs) in hospital wards. We first worked on a left atrio-thoracic ratio (personal oral communication, European Society of Thoracic Imaging meeting, Amsterdam, June 2014, "Left atrio-thoracic ratio: a new possible indicator of left atrial dilation on thoracic MDCT") by indexing left atrial diameter to the thoracic transverse diameter at the same level. This measure, although interesting, was subjected to many biases, in particular difficulties for breathless patient to perform reproducible full inspiration. We therefore worked on a different ratio using the thoracic vertebral body as a fixed element representative of the patient's corpulence [21,22]. We used it to index the left atrial diameter, generating the left atrio-vertebral ratio.

In the current study, our objective was to evaluate the clinical relevance of the LAVR by comparing the values found in patients suffering from cardiogenic pulmonary oedema with patients free of cardiac disease. We hypothesised that if the variations between these two populations of patients were significant enough, this ratio, which can be quickly and easily measured, would prove applicable and useful in routine practice.

2. Material and method

2.1. Subject selection

We retrospectively collected from the database of our institution (Pasteur University Hospital, Nice, France) the names of patients hospitalized between January and December 2013 who had undergone both a chest CT scan and a transthoracic echocardiography within the same hospital stay (quotation T2A).

From them, we selected two populations of patients: a cohort of patients free of cardiac disease (asymptomatic population) and a cohort of patients suffering from cardiogenic pulmonary oedema at the time of the CT scan (symptomatic population).

The selection criteria included:

2.1.1. Asymptomatic population: no heart disease

1. Negative medical history of cardiac disease or hypertension.
2. No cardio-vascular treatment.
3. No clinical evidence of cardiac insufficiency.
4. Normal transthoracic echocardiography.
5. No CT evidence of cardiac disease or pulmonary oedema (including ground glass attenuation areas, interlobular septal lines thickening and pleural effusions).

2.1.2. Symptomatic population: cardiogenic pulmonary oedema

1. Clinical examination suggesting left cardiac failure: dyspnoea, tachypnea, tachycardia, crepitant rales on auscultation and prompt amelioration under appropriate treatment.
2. Increased brain natriuretic peptide on blood tests.
3. Transthoracic echocardiography indicating left cardiac failure and left atrial dilatation.
4. CT scan lung changes consistent with cardiogenic pulmonary oedema (including ground glass attenuation areas, interlobular septal lines thickening and pleural effusions).

2.1.3. Patients excluded of the study

Patients with severe thoracic scoliosis, pericardial effusion (>5 mm) or significant hiatal hernia were excluded as we anticipated that the changes in the heart shape or orientation could modify the results.

2.2. CT examination

All patients underwent CT scans using a 64 multi-detector CT (light speed GE). Scanning parameters varied between patients and contrast injection was performed or not, depending on clinical indications. Reconstructed images with 1.25 mm slice thickness were available for all patients. None of the CT scans were ECG-gated. All images were recorded on the hospital picture archiving system (PACS Agfa).

Two independent radiologists studied the images: a senior thoracic radiologist (15 years experience) and junior radiologist (2 years experience) blinded to the clinical diagnosis. The two radiologists independently chose the level at which to take the measurements on mediastinal windows (W400-L40) and worked separately on an Advantage Windows station. Lung changes were analysed on parenchymal windows (W1600 L 600) and described accordingly to the Fleischner Society Glossary of terms [23]. Cardiogenic pulmonary oedema was suggested in reference to the literature on the subject [24].

It was agreed that the maximal LA diameter was to be traced manually on an image showing the right inferior pulmonary vein insertion (thus avoiding the left auricle), in a plane parallel to the posterior vertebral wall. The thoracic vertebral diameter was measured at the same level, excluding osteophytes and coastal bulges (the closest pedicular level could be observed for reference). The