

UCSF

UC San Francisco Previously Published Works

Title

Assessment of Left Ventricular Enlargement at Multidetector Computed Tomography.

Permalink

<https://escholarship.org/uc/item/5036f4fh>

Journal

Journal of computer assisted tomography, 39(5)

ISSN

0363-8715

Authors

Kathiria, Nazima N
Devcic, Zlatko
Chen, James S
[et al.](#)

Publication Date

2015-09-01

DOI

10.1097/rct.0000000000000279

Peer reviewed

Assessment of Left Ventricular Enlargement at Multidetector Computed Tomography

Nazima N. Kathiria, DO, Zlatko Devcic, MD, James S. Chen, MD, PhD, David M. Naeger, MD, Michael D. Hope, MD, Charles B. Higgins, MD, and Karen G. Ordovas, MD

Purpose: Because left ventricular (LV) enlargement (LVE) is indicative of an array of cardiac pathologies, including cardiomyopathic, ischemic, and valvular heart diseases, it is important to recognize it early in the course of these diseases. The recognition of LVE on nongated contrast-enhanced computed tomography (CT) scans should be facilitated by the availability of a dimensional index. To our knowledge, no CT index of LVE has been proposed. Therefore, the study aimed to define whether the maximum LV diameter (LVd) measured on nongated multidetector computed tomography can identify LVE when referencing echocardiography as the diagnostic standard.

Materials and Methods: The patient population consisted of 438 consecutive patients who had a contrast-enhanced, nongated 16- or 64-detector CT of the chest for evaluation of pulmonary embolism or aortic dissection between January 2006 and March 2008. One hundred fifty-five patients in this group also had an echocardiogram within 2 months of the CT study. The maximum LV cavity size, septal to lateral wall dimension, was measured perpendicularly to the long axis of the left ventricle on the axial CT scans by 2 observers blinded to the echocardiography data.

An receiver operating characteristic analysis was performed to identify a highly specific cutoff for the diagnosis of LVE on CT, using echocardiogram as the standard of reference. Interobserver agreement was assessed using Bland-Altman analysis.

Results: A total of 84 females and 71 males were evaluated (female to male ratio of 1.09). The mean age for the 155 patients was 58 years. Six percent of these patients had a diagnosis of LVE on 2-dimensional echocardiography. The mean (SEM) LV internal diameter at nongated multidetector computed tomography between the group with normal LV and the group with LVE by echocardiography was 4.4 (0.7) cm for the normal LV and 5.9 (1.2) cm for the dilated LVs ($P < 0.0001$). With the use of threshold value of LVd of 5.6 cm, a sensitivity of 78%, specificity of 100%, positive likelihood ratio of 113.5, and negative likelihood ratio of 0.22 were calculated. The LVd measurements had an excellent agreement between observers on the Bland-Altman analysis.

Conclusions: Left ventricular enlargement can be reliably identified on nongated contrast-enhanced multidetector CT when the maximum luminal diameter of the LV is greater than 5.6 cm. Nongated contrast-enhanced CT scan can be used to recognize LVE.

Key Words: left ventricular enlargement, nongated chest CT

(*J Comput Assist Tomogr* 2015;00: 00–00)

Left ventricular (LV) dysfunction is associated with an array of cardiac pathologies. Some of the most frequent maladies include cardiomyopathy, ischemia, and valvular heart disease. These conditions can be clinically silent until late in their progression. Left ventricular volume is a predictor of mortality and morbidity

in heart disease.^{1,2} Indeed, assessment of LV size in patients with coronary artery disease, for example, is important in determining prognosis and in guiding decisions regarding therapy.³

Because of these factors, there are a number of imaging approaches to evaluating the LV size. Basic imaging techniques, such as determining cardiac size by chest x-ray, for example, via cardiothoracic ratio, are limited in sensitivity and specificity.⁴

Two-dimensional echocardiography is now the most frequently used initial imaging study for evaluating LV size and function. Recent studies have explored the use of electrocardiogram (ECG)-gated multidetector computed tomography (MDCT) in assessing cardiac function.⁵ However, ECG-gated multidetector chest computed tomography (CT) is used in a small minority of patients referred for CT compared with the population undergoing nongated contrast-enhanced CT scan of the chest for various clinical indications.

Possibly, because of misconceptions regarding the utility of non-ECG-gated MDCT evaluation of the heart, no index of LV size has been defined or tested for evaluating LV size for this imaging modality. A practical parameter for detection of LV enlargement (LVE) in patients undergoing CT studies for reasons other than cardiac dysfunction is highly desirable.

The aim of the study was to determine whether LV diameter (LVd) measured on nongated MDCT can detect LVE, using echocardiography as the standard imaging method, in patients referred for chest CT for evaluation of pulmonary embolism and/or aortic dissection.

MATERIALS AND METHODS

This retrospective study was approved by the institutional committee on human research. Four hundred thirty-eight consecutive patients underwent nongated contrast-enhanced MDCT studies between January 2006 and March 2008. Of these patients, 155 had received 2-dimensional echocardiography within 2 months of the CT scan.

All MDCT scans were acquired using a 16-MDCT (LightSpeed LX/i; GE Healthcare) or 64-MDCT (LightSpeed GE VCT). The nongated MDCT studies were obtained through the chest only or included the chest, abdomen, and pelvis for the diagnosis or exclusion of pulmonary embolism or aortic dissection after administration of 150 mL of iohexol (Omnipaque 350; Nycomed Amersham) delivered at a rate of 3 to 4 mL/s. The chest was imaged from the apices to the dome of the diaphragms with scanning delays optimized for the appropriate vasculature bed. The 2-dimensional echocardiography studies were performed at the same institution within 3 months of the computed tomography angiography study date, in accordance with the specifications of the American Society of Echocardiography.⁶

Computed Tomography Image Analysis

One experienced observer blinded to the echocardiographic data independently reviewed all axial images from the contrast-enhanced nongated MDCT studies on a picture archiving and communication system workstation (AGFA, Mortsel) and determined

From the UCSF Department of Radiology and Biomedical Imaging, San Francisco, CA.

Received for publication January 1, 2015; accepted April 23, 2015.

Correspondence to: Nazima N. Kathiria, DO, University of California, San Francisco, Department of Radiology, Cardiac and Pulmonary Imaging, 505 Parnassus Avenue, San Francisco, CA 94143-0628 (e-mail: nnkathiria@yahoo.com).

The authors declare no conflict of interest.

Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.

DOI: 10.1097/RCT.0000000000000279

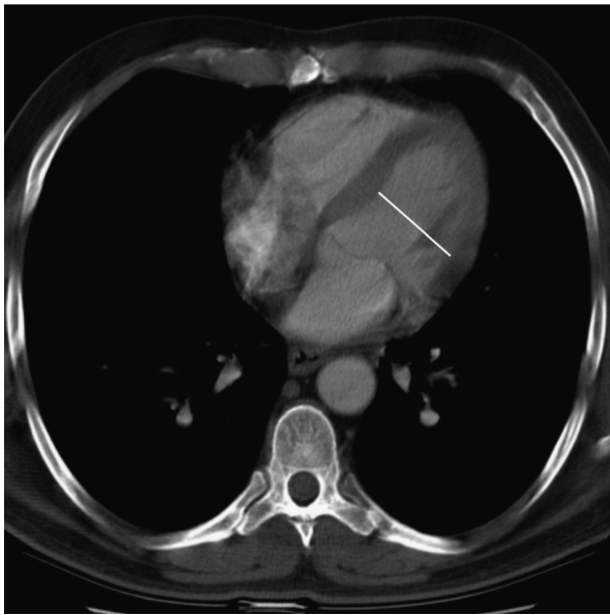


FIGURE 1. Left ventricular diameter measurement. Example of LVd measured in the axial plane, from inner margin of the septum to the inner margin of the lateral wall.

the maximum dimension of the contrast-opacified LV lumen, defined as the maximum dimension measured perpendicularly to its long axis at an equatorial CT level. This maximum dimension was measured between the midventricular septal wall to the midposterolateral LV wall (Fig. 1). In addition, a second observer obtained the maximum LV transverse dimension in 46 patients for the purpose of interobserver agreement analysis. Echocardiography reports from the electronic medical record were reviewed to determine LV size. Patients were divided into 2 groups, normal left ventricle and LVE, based on echocardiography measurements.

Statistical Analysis

The means of the LV chamber size in diastole by MDCT were compared between the patients with and without LVE as determined by echocardiography, using the Student *t* test. A *P* value of <0.05 was considered to be statistically significant. Results are expressed as mean (SEM). Sensitivity and specificity of nongated MDCT for detection of LVE were generated through receiver operating characteristic (ROC) analysis. The authors aimed to

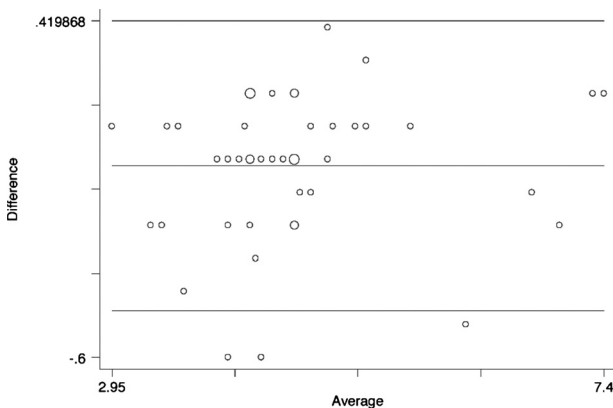


FIGURE 2. Bland-Altman analysis for interobserver agreement of maximum LV diameter measurement.

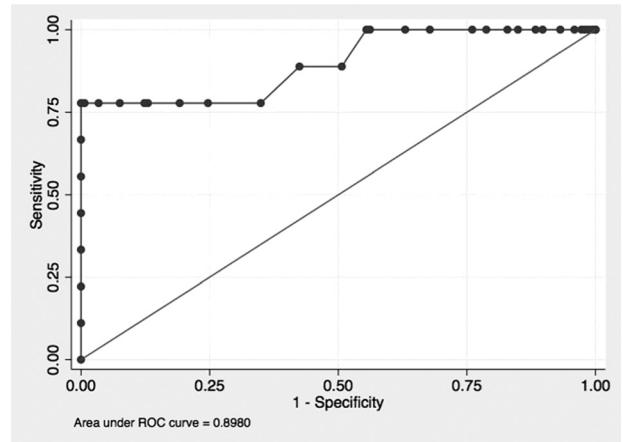


FIGURE 3. The ROC analysis. With the use of a threshold value of 5.6 cm, a sensitivity of 78%, specificity of 100%, positive predictive value of 80%, and negative predictive value of 93% were calculated.

identify a cutoff with very high specificity, so LVE would only be mentioned on a CT report when the abnormality is almost certainly present, to avoid further unnecessary work-up. Statistical analysis was performed using the Stata software package (StataCorp), including descriptive statistics such as means, range, and percentages. The agreement between observers was assessed using Bland-Altman analysis and Pitman test of variance.

RESULTS

The patient population (N = 155) consisted of 74 males and 81 females with a mean age of 58 years (range, 14–96 years). Echocardiographic measurements indicated normal LV size in 94% of the patients and LVE in 6% of the patients. The mean (SEM) LV internal diameter at nongated MDCT between the group with normal LV and the group with LVE by echocardiography was 4.4 (0.7) cm for the normal LV and 5.9(1.2) cm for the dilated LVs (*P* < 0.0001).

Bland-Altman analysis of the agreement between transverse diameter demonstrated a high agreement between the 2 observers, with a mean difference of –0.020 cm (confidence interval, 0.085–0.046) and a Pitman test with a *P* value of 0.39 (Fig. 2).

With the use of ROC analysis, MDCT measurements that provided the optimal test characteristics for identifying LVE by echocardiography as the reference standard were determined (Fig. 3). The authors prioritize a highly specific cutoff so patients would only be referred for additional clinical and echocardiographic evaluation when LVE was certainly present. Using a threshold value of LVd of 5.6 cm, a sensitivity of 78%, specificity 100%, positive likelihood ratio of 113.5, and negative likelihood ratio of 0.22 were calculated.

DISCUSSION

Our data shows that LVd measured on nongated MDCT can reliably identify LVE determined by echocardiography. Using a cutoff of 5.6 cm for maximum transverse LV dimension, CT can predict LVE on echocardiography with a sensitivity of 78% and a specificity of 100%. In addition, despite the nongated nature of the MDCT studies in our series, we have shown that LV cavity size can dependably be assessed in this population of patients, as demonstrated by the excellent interobserver agreement/concordance.

Patients frequently receive nongated CT imaging of the chest while undergoing evaluation for diseases such as pulmonary embolism and aortic dissection in the emergency department. The yield from these studies can be enhanced by the additional information available regarding LV size. Left ventricular size is an important diagnostic and prognostic indicator, particularly in patients with heart failure. Incidental finding of an enlarged LV on CT should prompt clinical cardiac evaluation.

Our study included a group of patients with very low prevalence of LVE. Our population was composed of patients with acute symptoms presenting to the emergency department with suspected pulmonary embolism and aortic dissection; therefore, they presented without symptoms to suggest cardiac disease. Consequently, the use of the described transverse diameter threshold would have the best performance if applied to a population with similar disease prevalence. However, with the use of the providing positive and negative likelihood ratios, it is possible to assess the posttest likelihood of disease for populations with different prevalence of disease (pretest probability of disease), as long as the prevalence of disease is known or can be estimated from the literature. Calculating the posttest probability of disease can be performed using the Bayes nomogram, which is a very useful aid on interpretation of diagnostic test results.⁷

The intrinsic limitation of non-ECG-gated MDCT as a technique for assessing LV cavity size is that the images are obtained in a transaxial plane and are susceptible to cardiac motion artifact, with imaging acquired randomly during the cardiac cycle, not necessarily at end diastole. It is likely that there is an underestimation of true LV chamber size, given that the images were not likely acquired during end diastole. However, this is not a significant limitation because temporal and spatial resolution have improved with new generation CT scanners. Also, cardiac physiology dictates that the LV cavity size will not be overestimated if imaging is not obtained in end diastole.

The use of a single measurement to determine LVE in all patients can also be a limitation. However, the intent of this study

was to simplify the recognition of LVE on routine contrast enhanced CT of the chest performed for reasons other than cardiac evaluation; therefore, a straightforward single measurement has the potential to be very useful in practice.

In conclusion, LVE can be reliably determined on nongated MDCT. Because of the high specificity of nongated MDCT imaging for detection of LV dilation, we suggest that LVE should be reported on patients with a maximum LVd of greater than 5.6 cm. When this criterion is met, further clinical or imaging cardiac characterization should be recommended.

REFERENCES

1. Hammermeister KE. Survival in patients with coronary disease. *Circulation*. 1979;60:1427.
2. Hammermeister KE, DeRouen TA, Dodge HT. Variables predictive of survival in patients with coronary disease. Selection by univariate and multivariate analyses from the clinical, electrocardiographic, exercise, arteriographic, and quantitative angiographic evaluations. *Circulation*. 1979;59:421–430.
3. Pfeffer MA, Braunwald E. Ventricular remodeling after myocardial infarction. Experimental observations and clinical implications. *Circulation*. 1990;81:1161–1172.
4. Hammermeister KE, Chikos PM, Fisher L, et al. Relationship of cardiothoracic ratio and plain film heart volume to late survival. *Circulation*. 1979;59:89–95.
5. Sarwar A, Shapiro MD, Nasir K, et al. Evaluating global and regional left ventricular function in patients with reperfused acute myocardial infarction by 64-slice multidetector CT: a comparison to magnetic resonance imaging. *J Cardiovasc Comput Tomogr*. 2009;3:170–177.
6. Lang RM, Bierig M, Devereux RB, et al. Recommendations for chamber quantification. *Eur J Echocardiogr*. 2006;7:79–108.
7. Page J, Attia J. Using Bayes' nomogram to help interpret odds ratios. *ACP J Club*. 2003;139:A11–A12.