COMPARISON BETWEEN ECHOCARDIOGRAPHIC AND NON ECG-GATED COMPUTED TOMOGRAPHIC MEASUREMENTS IN DOGS

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**Key words: computed tomography, echocardiography, cardiac measurements, dog.**

**Running Head:** non ECG-gated cardiac CT measurements

ABSTRACT

The aim of this study was to compare echocardiographic measurements with non ECG-gated contrast enhanced cardiac computed tomographic (CT) measurements in dogs. Fifty-seven dogs were included in the study. The following echocardiographic parameters were measured: M-mode interventricular septum in diastole and systole, left ventricular internal diameter in diastole and systole, left ventricular free wall in diastole and systole, 2D left atrial maximal diameter, 2D left atrium to aorta ratio in diastole, 2D aortic annulus in systole, 2D pulmonary annulus in diastole and systole. Computed tomographic measurements were obtained from multiplanar reconstruction (MPR) images, replicating the imaging planes used for 2D measurements on echocardiography. It was not possible to discriminate between systole and diastole. The results showed moderate Lin’s concordance correlation coefficients between the left ventricular internal diameter in systole (0.77), the aortic annuli (0.84), and the pulmonary annuli in diastole (0.78) and in systole (0.80). Low coefficients were obtained between the other parameters. Bland-Altman plots for the parameters with highest concordance correlation coefficients were calculated. They suggested equivalence between the measurements of the aortic annuli. Equivalence was not seen between the remaining echocardiographic and CT measurements. Therefore, non ECG-gated CT is not a reliable way of quantitatively assessing cardiac size.

INTRODUCTION

Computed tomographic (CT) examination of the thoracic boundaries, mediastinum, pleura, lungs and bronchi is performed routinely in small animal veterinary medicine ([Armbrust and others 2012](#_ENREF_1); [Drees and others 2011a](#_ENREF_6); [Drees and others 2011b](#_ENREF_7); [Habing and others 2011](#_ENREF_11); [Henjes and others 2011](#_ENREF_14); [Kirberger and others 2013](#_ENREF_16); [Mai 2011](#_ENREF_19); [Marolf and others 2011](#_ENREF_20); [Mesquita and others 2014](#_ENREF_22); [Petite and Kirberger 2011](#_ENREF_25); [Reetz and others 2012](#_ENREF_26); [Saulnier 2012](#_ENREF_28); [Saunders and others 2011](#_ENREF_29); [Schwarz and Johnson 2011](#_ENREF_31)), but comparatively little information has been published on the assessment of the cardiac structures ([Drees and others 2013](#_ENREF_8); [Henjes and others 2012](#_ENREF_13); [Lee and others 2013](#_ENREF_17); [O'Brien and others 2013](#_ENREF_23); [Park and others 2012](#_ENREF_24); [Sieslack and others 2013](#_ENREF_32)). CT examination of the heart has often been hampered by image degradation due to motion artefacts. However, improvements in CT technology, especially the development of multidetector CT (MDCT), with higher temporal and spatial resolution, have shortened scan times. Images of the heart are consequently less degraded by motion artefacts, and CT is gaining importance as a method of cardiovascular imaging in veterinary medicine. In cardiac CT, ECG-gated studies are ideally used to obtain cardiac images synchronised to a specific phase of the cardiac cycle and to prevent motion artefacts. ECG-gating requires specialised hardware and software which is not currently widely available in veterinary practices.

In human medicine, ECG-gated CT studies have stimulated interest around the evaluation of the heart and coronary arteries ([Marten and others 2005](#_ENREF_21)). Non ECG-gated CT angiography (CTA) is routinely used for evaluation of suspected pulmonary embolism ([Schoepf and others 2004](#_ENREF_30)) and acute aortic syndrome ([Blanke and others 2012](#_ENREF_3)) in people. There is only one recently published study in human medicine evaluating the use of non ECG-gated CTA for left-sided cardiac measurements ([Huckleberry and others 2012](#_ENREF_15)). In that study, thresholds for the left atrial and left ventricular diameter were chosen on axial CT images; the results show that, using these thresholds, left-sided cardiac enlargement was detected with high specificity, but low sensitivity.

To the authors’ knowledge, there are no published studies comparing cardiac measurements obtained by echocardiography and non ECG-gated CT in dogs. A thorough evaluation of the cardiovascular system is part of the complete thoracic CT examination, but is usually limited to a subjective assessment. There are no guidelines or data for assessment of the heart on non-gated thoracic CT in dogs. Studies are therefore required to determine the accuracy of the cardiac measurements obtained from CT examination in comparison to those obtained during echocardiographic assessment (currently considered the preferred method for cardiac measurements in veterinary medicine).

The aim of this study was to compare standard morphologic echocardiographic measurements with measurements acquired during non ECG-gated contrast enhanced cardiac CT of dogs. It was hypothesised that the CT measurements would be intermediate between systolic and diastolic echocardiographic measurements or closer to diastolic measurements (representing the longest phase of the cardiac cycle). A better understanding of the correlation between echocardiography and CT may make it possible to determine reference values which could be used as an aid to interpretation of non ECG-gated CT.

MATERIALS AND METHODS

Study population

The clinical records database of the Small Animal Teaching Hospital of the University of Liverpool was searched retrospectively for dogs that had undergone both ECG-gated echocardiography and non ECG-gated contrast enhanced CT of the thorax within 28 days of each other. Studies performed between November 2008 and February 2013 were included.

Equipment and technique

All echocardiograms were conducted using an echocardiographic system Vivid 7 (General Electric Medical System, Wisconsin, USA) with non-sedated patients positioned in right lateral recumbency. Right parasternal views were obtained through the dependent thoracic wall. Offline analyses of recommended standard views and measurements ([Sahn and others 1978](#_ENREF_27); [Thomas and others 1993](#_ENREF_33)) were performed using a dedicated echocardiography workstation (EchoPac, General Electric Medical System). Each patient’s echocardiographic report was reviewed electronically by one observer (XNC). Any missing measurements were obtained by the same observer from the recorded DICOM images. The pre-existing echo measurements and reports had been performed by up to six cardiologists, who were either ECVIM-CA (Cardiology) diplomates or their cardiology residents, working under direct diplomate supervision.

Thoracic CT studies were acquired with a 4-slice CT scanner (Siemens SOMATOM, Siemens Healthcare Diagnostics, Illinois, USA). All dogs were positioned in sternal recumbency and were examined under general inhalational anaesthesia during a hyperventilation-induced apnoea. The most commonly used general anaesthesia protocol included premedication with medetomidine (0.002mg/kg, intravenously) and butorphanol (0.2mg/kg, intravenously), induction with propofol (dose to effect, intravenously) and volatile maintenance on isoflurane (1.5–2%) in oxygen via an appropriate breathing system. However, this protocol was varied slightly depending upon individual patient requirements.

Intravenous iodinated contrast medium (Omnipaque, iohexol, 300mg I/mL, GE Healthcare AS, Nycoveie 1-2, NO-0401 Oslo, Norway) at a dose of 600 mg I/kg body weight was used in all dogs. Post-contrast studies were obtained immediately following manual or pressure intravenous injection. Scanning parameters differed for individual patients. The most common protocol used consisted of a helical volumetric acquisition using 1.5mm collimation, pitch 1, 0.5s rotation time, 120 kVp, and 150 mAs. The reconstruction field of view depended on patient body size (varying between 180-250mm). Reconstructions were most commonly generated with a 3mm slice thickness using a standard (soft tissue) kernel and 1.5-2mm slice thickness with a sharp (lung) kernel. Reconstructions with soft tissue algorithms of post-contrast studies were used for CT measurements. Studies were viewed on a computer workstation using proprietary DICOM software (OsiriX Pixmeo, Geneva, Switzerland (version 4.1.1 64-bit) in standard soft-tissue display windows with adjustment of the window level as required. CT measurements were performed after a training period by one observer (PLV) blinded to the echocardiographic results. Multiplanar reconstruction (MPR) images were created simulating the planes used on echocardiographic studies. In cases in which the margins of the left atrial or left ventricular walls appeared duplicated because of cardiac motion artefacts, the outermost wall excursion was chosen for measurements, generating the maximal diameter (Figure 1A).Three measurements for each parameter were made and a mean of these measurements was calculated and used in the analyses.

Variables

The following echocardiographic variables were measured (Table 1): M-mode diastolic dimensions were made at the start of the QRS complex on a simultaneously acquired ECG, and systolic dimensions were defined as the nadir of septal motion. At least three cardiac cycles were made for each variable to derive the mean. M-mode interventricular septum in diastole (E\_IVSd), interventricular septum in systole (E\_IVSs), left ventricular internal diameter in diastole (E\_LVIDd), left ventricular internal diameter in systole (E\_LVIDs), left ventricular free wall in diastole (E\_LVPWd), left ventricular free wall in systole (E\_LVPWs), 2D left atrial maximal diameter (E\_LAMAX) from right parasternal (RPS) 4 chamber view, measuring LA diameter during end-ventricular systole, 2D short-axis left atrium to aorta ratio in diastole (E\_LA/AO) ([Hansson and others 2002](#_ENREF_12)), 2D aortic annulus in systole from RPS 5 chamber view, between open aortic valve leaflets (E\_AOANNs), 2D pulmonary annulus in diastole (E\_PAANNd) and pulmonary annulus in systole (E\_PAANNs) at the level of the pulmonic valves. The CT variables measured were the same as for the echocardiographic study but discrimination was not possible between systolic and diastolic phases, and therefore only one measurement for each variable was recorded. The measurements of the left ventricle were made at the level of the tips of the papillary muscles from short axis views (Figure 1A). The following CT variables were measured (Table 1): CT\_IVS, CT\_LVID, CT\_LVPW, CT\_LAMAX, CT\_LA/AO, CT\_AOANN and CT\_PAANN.

Statistical analyses

All statistical analyses were conducted with commercially available software (SPSS 16.0 for Windows, SPSS Inc., Chicago, IL) by PLV and TWM. The estimated Lin’s concordance correlation coefficients and their confidence intervals ([Lin 1989](#_ENREF_18)) were estimated between parameters measured by CT and by echocardiography. The Lin’s concordance correlation coefficient evaluates agreement between two measurements by integrating assessment of precision (via the Pearson correlation coefficient) and accuracy (by determining deviation of a line of best fit from the 45 degree line through the origin). Lin’s concordance correlation coefficients were graded into three categories: high (>90), moderate (75-90) and poor (< 75) ([Lin 1989](#_ENREF_18)). For the variables with highest concordance correlation coefficients, equivalence was tested with Bland-Altman plots. The difference of each pair of observations was plotted against the mean of each pair of observations ([Bland and Altman 1986](#_ENREF_2)). The 95% limits of agreement were calculated as the mean of the difference +/- 1.96 SD (SD: standard deviation). Assuming echocardiography as the gold standard, a difference between the CT and the echocardiographic mean of more than 10% of the echocardiographic mean was subjectively considered to be a clinically important difference. Differences of less than 10% and limits of agreement including less than 25% of the variability of the echocardiographic mean were considered to indicate reasonable equivalence. Two macros written for SPSS[[1]](#footnote-1) were used to calculate the Lin’s concordance correlation coefficients and generate the Bland-Altman plots.

RESULTS

A total of 65 dogs fulfilled the inclusion criteria. From those, 57 were used in the analyses. The remaining 8 dogs (12%) had to be excluded due to inadequate depiction of cardiac structures on CT examination. Any pair of measurements that had a missing component (either echocardiographic or CT) was discarded from the analysis of that particular measurement.

Dogs of 32 breeds were included: 6 boxers, 5 Labradors retrievers, 4 West Highland white terriers, 3 golden retrievers, 2 bullmastiffs, 2 German shepherd dogs, 2 Border terriers, 2 Cavalier King Charles spaniels, 2 cocker spaniels, 2 Border collie cross-breeds, 2 English bull terriers, 2 Weimaraners, 2 crossbreeds and 1 each of another 21 breeds. The dogs included 5 intact females, 11 intact males, 20 neutered females and 21 neutered males, with a median age of 7.0 years (range 1-16 years) and a median weight of 23.0 kg (range 2.4-54.0 kg). Median interval between the echocardiography and the CT was 1.0 day (range 0-27). All dogs with an interval of more than 2 days between exams had either a mild condition or a normal CT and echocardiography.

The dogs presented for multiple reasons; most presented for pathology unrelated to a cardiac disease; many echocardiographic examinations were performed after detection of a heart murmur during physical examination; some animals were evaluated before commencing chemotherapy with potentially cardiotoxic agents.

Seven of 57 dogs (12%) had normal echocardiography and an unremarkable CT. Based on the results of echocardiographic examination, 20 dogs were diagnosed with myxomatous mitral valve degeneration, which was graded as mild in 19 cases and as moderate in one case. Only in two cases was there evidence of mild left atrial and left ventricular dilation and moderate pulmonary hypertension; however, the pulmonary hypertension was not attributed to high left-sided filling pressures in any of the cases. Other valvular anomalies were mitral dysplasia (2), tricuspid dysplasia (1), tricuspid endocarditis (1), mitral and tricuspid regurgitation (1) and sub-/ aortic stenosis (6). Other findings were dilated cardiomyopathy (1), pulmonary hypertension (7), a systemic to pulmonary anomalous vessel (1), pericardial effusion (8), pleural effusion (7), small cardiac or pericardial masses (2), mediastinal masses (6) and lung masses (1).

Table 2 shows the means, standard deviations, minimum and maximum for the parameters measured on images acquired by echocardiography and CT. The CT measurements were intermediate between the echocardiographic systolic and diastolic measurements. In the case of the left atrial maximal diameter, the CT measurements for individual animals were never higher than their echocardiographic measurements (data not shown).

Lin’s concordance correlation coefficients between the parameters measured on images acquired by echocardiography and by CT are shown in Table 3 and Figure 2. The concordance correlation coefficients were positive for all pairs of measurements. Moderate concordance correlation coefficients were found between E\_LVIDs and CT\_LVID (0.77), between E\_AOANN and CT\_AOANN (0.84), between E-PAANNs and CT\_PAANN (0.80) and between E-PAANNd and CT\_PAANN (0.78). The correlation between the other parameters was poor, ranging from 0.37 to 0.70.

Figure 3 B, C, D and E represent the Bland-Altman plots corresponding to the parameters with a moderate concordance correlation coefficient (E\_LVIDs and CT\_LVID, E\_AOANN and CT\_AOANN, E-PAANNs and CT\_PAANN, E-PAANNd and CT\_PAANN). An example of a plot corresponding to a pair of measurements with poor concordance correlation coefficient (E\_LVIDd and CT\_LVID) (0.62) has been included for comparison (Figure 3A). The distribution of the data points in the Bland-Altman plots was essentially uniform in nature over the range of measurements, with no evidence of any systematic variation in the difference related to the magnitude of the variable. The line of zero difference represents the line where both measurements would be equivalent. There was a varying degree of bias between the various echocardiographic and CT measurements. There was a difference between the echocardiographic and the CT means for the parameters E\_LVIDd and CT\_LVID of 7.2 mm (Figure 3A), 20% of the echocardiographic mean (36.8 mm, Table 2) and the limits of agreement were wide (31% of the echocardiographic mean). This high variation indicated that the measurements were not equivalent. The mean difference between E\_LVIDs and CT\_LVID was -2.9 mm, which represented a variation of 11% of the echocardiographic mean (26.3 mm, Table 2). The limits of agreement ranged from -14.1 to 8.2 mm. This means that 95% of the CT measurements were up to approximately 11 mm lower or 11 mm higher than the echocardiographic measurements. These values represented a variation of approximately 41% of the echocardiographic mean, indicating that they were not equivalent. Figure C represents the Bland-Altman plot for the parameters E\_AOANN and CT\_AOANN. The mean of the difference between these parameters was 0.6 mm, which represented a variation of 3.3% of the mean of the echocardiographic measurement (18.1 mm, Table 2). The limits of agreement varied from -3.9 to 5.1 mm. This implied that 95% of the CT measurements were approximately 4.5 mm (24%) lower or 4.5 mm (24%) higher than the echocardiographic measurements. These measurements were considered equivalent. In Figure D, there was a mean difference of 0.2 mm between the mean measurements of E\_PAANNs and CT\_PAANN (1.1% of the mean of the echocardiographic measurement). The limits of agreement varied from -5.0 to 5.5 mm, which means that the CT measurements were approximately up to 29% higher or lower than the echocardiographic measurements. No equivalence could be assumed. A difference of -0.8 mm (5% of the mean of the echocardiographic measurement) was found between measurements of E\_PAANNd and CT\_PAANN (Figure 3E). The limits of agreement varied from -5.9 to 4.3 mm, representing a variation of 29% of the echocardiographic mean. As in the previous case, no equivalence could be assumed.

DISCUSSION

To the authors’ knowledge, there are no previous studies comparing cardiac morphologic measurements obtained by echocardiography and non-ECG gated CT in dogs. The only similar study was performed in human medicine, where non-ECG gated CT was found to have low sensitivity but high sentivity for demonstrating left-sided chamber enlargement. It was concluded in that study that non-ECG gated CT may still be more reliable and reproducible than chest radiography for the assessment of left-sided chamber enlargement ([Huckleberry and others 2012](#_ENREF_15)). In dogs, there is a study comparing cardiac morphologic measurements using echocardiography and ECG-gated CT ([Park and others 2012](#_ENREF_24)). In this study, no statistically significant differences are reported for most of the parameters measured, except for IVSd and LVPWd. The authors suggest that these differences are due to the reduced reproducibility and accuracy of echocardiography.

In the present study, the fundamental reason for the lack of concordance between most of the echocardiographic and CT measurements is likely the inability of the technique to distinguish between the systolic and diastolic phases in the CT. The CT measurements were hypothesised to be intermediate between the echocardiographic systolic and diastolic measurements, or closer to the diastolic ones. Intermediate measurements were obtained, but the hypothesis that they would be closer to the diastolic measurements could not be accepted.

The results of this study showed moderate Lin´s concordance correlation coefficients between E\_LVIDs and CT\_LVID, E\_AOANN and CT\_AOANN, E\_PAANNs and CT\_PAANN and between E\_PAANNd and CT\_PAANN. It is notable that the echocardiographic- and CT-derived measurements of the aortic and pulmonary annuli had higher coefficients than most of the other measurements. This can be explained through a reduced variation in the size of the annuli in comparison with the size of the internal diameters and walls between the diastolic and the systolic phase, likely reducing one source of error during measurement of the annuli on images from CT examination. Although the aortic valve leaflets were not always visible on the CT images, the well-defined sinus of Valsalva was satisfactorily used as a landmark to measure the aortic annulus. The lack of clear visualization of the pulmonary valves in most of the cases on the CT images prevented accurate measurements (Figure 1D).

It is remarkable that for the variable left atrial maximal diameter, CT measurements were never higher than echocardiographic measurements. Consequently, it seems unlikely that CT measurement would overestimate left atrial diameter. Therefore, the authors suggest that a subjectively enlarged left atrial diameter on CT images might be genuine and indicative of left atrial dilation.

In individual CT scan images, poor visualization of the limits of the internal diameters due to cardiac motion artefacts is an additional reason for the poor concordance correlation coefficient for most of the measurements. In the present study, the CT examinations were performed for reasons other than the specific examination of the heart, reflecting the typical general thoracic CT acquisition performed in veterinary medicine with low slice number CT scanners and without ECG-gating. Future studies with MDCT scanners with ≥16 slices with an increased spatial resolution and reduced motion artefacts would improve the visualisation of the boundaries of the cardiac chambers and the annuli. More accurate determination of cardiac dimensions can also be obtained with ECG-gating and volumetric measurements ([Henjes and others 2012](#_ENREF_13); [Lee and others 2013](#_ENREF_17); [Park and others 2012](#_ENREF_24); [Sieslack and others 2013](#_ENREF_32)). Even so, it is unlikely that ECG-gating will be routinely used on patients without prior evidence of cardiac disease and so veterinary radiologists will still be required to perform assessment of the heart in thoracic CT studies obtained without ECG-gating.

Other methods to overcome the effect of cardiac motion on image quality include intentional anaesthetic induction of bradycardia with beta-blockers or calcium channel blockers ([Drees and others 2014](#_ENREF_5)) and the performance of multiple sequential scans through the patient ([Saulnier 2012](#_ENREF_28)). In this study, anaesthesia was induced using conventional techniques aimed at reducing respiratory motion without pharmacological induction of bradycardia, and taking into account individual patient requirements in each particular case.

The measurements in this study (Table 2, Figure 3) should not be interpreted as reference values due to the heterogeneous nature of the study population in terms of signalment and disease. In this clinical population, echocardiography was performed on animals suspected of having cardiac disease and therefore few animals with normal echocardiographic results were included. The fact that each animal had paired measurements (so that an individual animal’s echocardiographic and CT derived measurements were compared to one other) limited the problems that could have been caused by the diverse population. Additionally, this study population reflects the group of animals that the results of this study are applicable to.

Limitations of the present study include the use of echocardiography as the method for comparison. In human medicine, cardiac MRI is superior to other imaging modalities for assessment of cardiac structure and function ([Constantine and others 2004](#_ENREF_4)) and could be considered as a gold standard for comparison of different modalities. It is non-invasive, has high spatial resolution and does not use ionising radiation. However, the method most widely used to evaluate the heart in both human and veterinary medicine is echocardiography, due to its wide availability, no requirement for general anaesthesia, ease of use and cost of performance ([Gilbert and others 2010](#_ENREF_10)). Some of the most important limitations of the use of echocardiography are technical factors associated with the examination of non-sedated animals and problems of reproducibility and repeatability of 2-D measurements ([Dukes-McEwan and others 2002](#_ENREF_9)). Taking into account the retrospective nature of this study, the interoperator variability could have been a source of variation in echocardiographic measurements when the images were acquired.

Other limitations of the current study include the position of the animal in sternal recumbency during the CT scan, in comparison with the lateral recumbency that is used for echocardiography and radiography; this will result in a different position of the heart, potentially influencing the measurements obtained ([Thrall 2013](#_ENREF_34)). The effect of patient positioning should theoretically be overcome by using multiplanar reconstructions of the CT data to allow images of the heart in any plane. However, in the study by Huckleberry and others (2012), the use of multiplanar reconstructions for measurement of the left ventricular diameter did not result in improved accuracy compared to native axial images. This was thought to be due to interobserver variability introduced when performing the multiplanar reconstructions. Due to differences in thoracic anatomy between humans and dogs, the use of the axial plane for assessment of heart size in dogs cannot be assumed to be valid or as useful as in people. The orientation of the human heart within the thoracic cavity means that axial CT images give a short axis image of the heart. By contrast, in dogs positioned in sternal recumbency on a CT table, the heart lies approximately perpendicular to the table so that axial images result in an oblique long axis view of the heart.

In conclusion, low slice number non-ECG gate thoracic CT examination is not a reliable modality to quantitatively assess cardiac size in comparison with echocardiography. The present data suggest equivalence only between echocardiographic and the non ECG-gated CT measurements of the aortic annulus. Although there was a small difference between mean echocardiographic and the CT measurements of the pulmonary annulus in the systole and diastole, equivalence could not be concluded. The remaining CT and echocardiographic measurements were not equivalent. Therefore, with low slice number CT, the cardiovascular system should be evaluated only qualitatively. In case of suspicion of a cardiovascular abnormality, other appropriate modalities such as echocardiography or, for some indications, cardiac MRI should be performed.

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Table 1. Abbreviations used for echocardiographic and computed tomographic measurements.

|  |  |  |
| --- | --- | --- |
| Echocardiography | E\_IVSd, E\_IVSsE\_LVIDd, E\_LVIDsE\_LVPWd, E\_LVPWsE\_LAMAXE\_LA/AO | interventricular septum in diastole and in systole left ventricular internal diameter in diastole and in systole left ventricular free wall in diastole and in systole left atrial maximal diameter left atrium to aorta ratio in diastole |
| E\_AOANN | aortic annulus in systole |
| E\_PAANNd, E\_PAANNs | pulmonary annulus in diastole and in systole  |
| Non-gated computed tomography | CT\_IVS | interventricular septum |
| CT\_LVID | left ventricular internal diameter |
| CT\_LVPW | left ventricular free wall |
| CT\_LAMAX | left atrial maximal diameter |
| CT\_LA/AO | left atrium to aorta ratio |
| CT\_AOANN | aortic annulus |
| CT\_PAANN | pulmonary annulus |

 Discrimination between systolic and diastolic phases is not possible in non-gated computed tomography.

Table 2. Raw means, standard deviations, minimum and maximum for the parameters measured by echocardiography and by computed tomography (measured in mm).

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | n | Mean | sd | Min | Max | Parameter | n | Mean | sd | Min | Max |
| E\_IVSd | 57 | 9.7 | 2.3 | 4.1 | 15.2 | CT\_IVS | 57 | 11.5 | 2.8 | 4.6 | 18.3 |
| E\_IVSs | 57 | 12.3 | 2.5 | 5.2 | 17.3 |
| E\_LVIDd | 57 | 36.8 | 9.5 | 14.9 | 63.8 | CT\_LVID | 57 | 29.2 | 9.7 | 11.3 | 55.1 |
| E\_LVIDs | 57 | 26.3 | 8.5 | 9.4 | 51.4 |
| E\_LVPWd | 57 | 10.3 | 3.0 | 4.4 | 19.1 | CT\_LVPW | 57 | 10.9 | 2.9 | 4.0 | 16.3 |
| E\_LVPWs | 57 | 13.8 | 3.6 | 6.2 | 24.7 |
| E\_LAMAX | 55 | 35.4 | 9.4 | 19.4 | 61.3 | CT\_LAMAX | 55 | 28.5 | 8.5 | 14.1 | 51.6 |
| E\_LA/AO | 51 | 1.3 | 0.25 | 0.9 | 2.0 | CT\_LA/AO | 51 | 1.3 | 0.2 | 0.9 | 1.8 |
| E\_AOANN | 54 | 18.1 | 4.2 | 9.4 | 25.2 | CT\_AOANN | 54 | 17.4 | 4.3 | 9.4 | 25.4 |
| E\_PAANNd | 50 | 17.3 | 4.2 | 8.3 | 26.5 | CT\_PAANN | 52 | 17.9 | 4.3 | 8.3 | 25.9 |
| E\_PAANNs | 51 | 18.2 | 4.4 | 8.9 | 27.6 |

For description of variables see Table 1.

Table 3. Estimated Lin’s concordance correlation coefficients (rc) and their confidence intervals (95%) between the parameters measured by echocardiography and by computed tomography.

|  |  |  |
| --- | --- | --- |
| Parameters | rc | Confidence Intervals (95%) |
| E\_IVSd | CT\_IVS | 0.37 | 0.18, 0.54 |
| E\_LVIDd | CT\_LVID | 0.62 | 0.49, 0.73 |
| E\_LVPWd | CT\_LVPW | 0.70 | 0.55, 0.81 |
| E\_IVSs | CT\_IVS | 0.58 | 0.39, 0.72 |
| E\_LVIDs | CT\_LVID | 0.77 | 0.65, 0.85 |
| E\_LVPWs | CT\_LVPW | 0.46 | 0.31, 0.60 |
| E\_LAMAX | CT\_LAMAX | 0.65 | 0.52, 0.75 |
| E\_LA/AO | CT\_LA/AO | 0.39 | 0.14, 0.60 |
| E\_AOANN | CT\_AOANN | 0.84 | 0.75, 0.91 |
| E\_PAANNd | CT\_PAANN | 0.78 | 0.65, 0.87 |
| E\_PAANNs | CT\_PAANN | 0.80 | 0.68, 0.88 |

For description of variables see Table 1.

1. García-Granero 2009, <http://gjyp.nl/marta> [↑](#footnote-ref-1)