Diagnostic Performance of Unenhanced Electrocardiogram-gated Cardiac CT for Myocardial Edema Using Cardiac T2 Mapping as a Reference Standard

Takafumi Emoto
Kumamoto University: Kumamoto Daigaku
Masafumi Kidoh (masafkidoh@yahoo.co.jp)
Kumamoto University: Kumamoto Daigaku https://orcid.org/0000-0002-9589-7054
Seitaro Oda
Kumamoto University: Kumamoto Daigaku
Daisuke Sakabe
Kumamoto University: Kumamoto Daigaku
Kosuke Morita
Kumamoto University: Kumamoto Daigaku
Masahiro Hatemura
Kumamoto University: Kumamoto Daigaku
Takeshi Nakaura
Kumamoto University: Kumamoto Daigaku
Yasunori Nagayama
Kumamoto University: Kumamoto Daigaku
Akira Sasao
Kumamoto University: Kumamoto Daigaku
Taihei Inoue
Kumamoto University: Kumamoto Daigaku
Yoshinori Funama
Kumamoto University: Kumamoto Daigaku
Seiji Takashio
Kumamoto University: Kumamoto Daigaku
Koichi Kaikita
Kumamoto University: Kumamoto Daigaku
Kenichi Tsujita
Kumamoto University: Kumamoto Daigaku
Toshinori Hirai
Kumamoto University: Kumamoto Daigaku

Research Article

Keywords: Tomography, X-Ray Computed; Heart; Myocardium; Edema, Cardiac

Posted Date: May 11th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-500731/v1

Abstract

Purpose

To assess the diagnostic performance of unenhanced electrocardiogram (ECG)-gated cardiac CT for myocardial edema, using T2 mapping as the reference standard.

Methods

This study included 34 patients (23 men; age 64.7 ± 14.6 years) who underwent cardiac CT and MRI. On the unenhanced ECG-gated cardiac CT images, regions of interest (ROIs) were drawn on the septal myocardium. Using T2 mapping as the reference standard, the diagnostic performance of unenhanced cardiac CT for myocardial edema was evaluated by using the area under the receiver operating characteristic curve (AUC) with sensitivity and specificity.

Results

Mean CT values moderately correlated with mean T2 values (Rho = -0.41; $P < 0.05$). Mean CT values provided a sensitivity of 63.2% and a specificity of 93.3% for detecting myocardial edema, with a cut-off value of ≤ 45.0 HU (AUC = 0.77; $P < 0.01$). Inter-observer reproducibility in measuring mean CT values was excellent (ICC = 0.93; [95% CI: 0.86, 0.96]).

Conclusion

This is the first clinical study to assess the diagnostic performance of unenhanced ECG-gated cardiac CT for myocardial edema, using T2 mapping as the reference standard. Our study suggested that the CT value of myocardium in unenhanced ECG-gated cardiac CT may be an optional parameter in addition to late iodine enhancement and extracellular volume fraction for myocardial tissue characterization, but further prospective, large-scale clinical studies are needed.

Introduction

The assessment of myocardial edema provides useful incremental diagnostic and prognostic information in a variety of cardiac diseases including acute myocarditis, myocardial infarction (MI), cancer therapy-related cardiac dysfunction and light-chain (AL) amyloidosis [1-4]. Currently, T2 mapping cardiovascular magnetic resonance imaging (CMR) technique is widely used for the quantitative assessment of myocardial edema and is considered a noninvasive reference standard [5-8].

From early animal studies on computed tomography (CT) imaging of acute MI, it is known that acute MI may present as areas of reduced CT values on unenhanced CT [9-11]. Theoretically, increased water content should result in a decrease of the CT value when compared with healthy myocardium. But, the evaluation of myocardial edema using unenhanced electrocardiogram (ECG)-gated cardiac CT has not been widely performed in clinical practice, and its usefulness is not fully understood. To the best of our knowledge, there are no clinical studies to evaluate myocardial edema using unenhanced ECG-gated cardiac CT in patients.

In recent years, there has been an increasing number of reports on the usefulness of myocardial tissue characterization using cardiac CT [12, 13]. But there are no parameters other than late iodine enhancement (LIE) and extracellular volume fraction (ECV) unlike CMR, which limits the evaluation of myocardial edema using cardiac CT [14]. We hypothesized that CT values of myocardium on unenhanced CT may be useful in the evaluation of myocardial edema. In addition, using cardiac CT, more detailed myocardial tissue characterization may be possible when combined with LIE and ECV. Thus, in the present study, we assessed the diagnostic performance of unenhanced ECG-gated cardiac CT for myocardial edema, using T2 mapping as the reference standard.

Materials And Methods

This retrospective study protocol was approved by our institutional review board, which waived the requirement for written informed consent.

Study population

From December 2017 to February 2019, 257 patients in whom the cardiac disease was clinically suspected were referred for T2 mapping CMR imaging. Of the 257 patients, 35 patients underwent unenhanced ECG-gated cardiac CT for coronary artery calcium scoring and the evaluation of myocardium within 3 months from T2 mapping CMR imaging. One patient was excluded from the study because of poor CT image quality. Finally, 34 patients (23 men and 11 women; age 64.7 ± 14.6 years) comprised our study group. The median time interval between cardiac CT and CMR was 11 [1 – 30] days. Patient characteristics are summarized in Table 1. To evaluate the diagnostic performance of unenhanced cardiac CT for various degrees of myocardial edema including diffuse myocardial edema that cannot be assessed by conventional T2-weighted imaging but can be assessed by T2 mapping, this study included patients with various cardiac diseases [hypertrophic cardiomyopathy (n = 8), dilated cardiomyopathy (n = 5), old myocardial infarction (n = 4), atrial fibrillation-mediated cardiomyopathy (n = 4), valvular heart disease (n = 2), cardiac amyloidosis (n = 2), cardiac shunt (n = 2), myocarditis (n = 1), cardiac sarcoidosis (n = 1), takotsubo cardiomyopathy (n = 1), arrhythmogenic right ventricular cardiomyopathy (n = 1), and undiagnosed diseases (n = 3)].

Cardiac CT and CMR image acquisition

Patients underwent unenhanced ECG-gated cardiac CT with an axial scan using a third-generation, 320 × 0.5 mm detector-row CT unit (Aquilion One Genesis edition; Canon Medical Systems). We administered oral metoprolol tartrate (20 mg; Lopressor; Novartis Pharma) 60 minutes before scanning. Unenhanced

ECG-gated cardiac CT was obtained at 120 kVp in mid-diastole at low heart rates and in end-systole at high heart rates (>70 beats per minute). The tube current value was determined via automatic exposure control (SURE Exposure3D; Canon Medical Systems) using x-ray attenuations on anteroposterior and lateral scout images. For the evaluation of myocardium, full-scan reconstruction was performed using a hybrid iterative reconstruction algorithm (adaptive iterative dose reduction 3D or AIDR3D; Canon Medical Systems) with the noise reduction strength set to "standard" and a soft tissue kernel (FC01). Image reconstruction was performed for an 18.0-cm display field-of-view. We recorded the scanner-generated volume CT dose index (mGy) and the dose–length product (DLP) for each examination. The effective radiation dose to the chest was estimated using the following formula: DLP × 0.014 (conversion factor) [15]. Each original data set of 0.5-mm axial images was processed for multiplanar reformation in the short-axis plane with a section thickness of 8.0 mm. Parameters for unenhanced cardiac CT imaging are summarized in Table 2.

Patients underwent CMR using a 3T MRI scanner (Ingenia CX, R5.4; Philips Medical Systems). T2 mapping was performed in a single midventricular short-axis section (section thickness: 8.0 mm). A navigator gated black blood prepared gradient spin-echo sequence (GraSE) was used and 9 images were acquired. The imaging parameters were: TR = 1 heartbeat, 9 echos TE1 = 9.7ms, ΔTE = 9.7ms, FA = 90°, EPI factor: 7, resolution of 1.88 × 1.91 mm and SENSE factor = 2.

Quantitative analysis of myocardium

All measurements for cardiac CT and MRI were performed together by two board certified radiologists with 8 (T.I.) and 12 (M.K.) years of experience in cardiovascular imaging with no prior knowledge of the patient's clinical information using a postprocessing workstation (Ziostation 2; Ziosoft).

On the unenhanced ECG-gated cardiac CT images, freehand regions of interest (ROIs) were manually drawn on the septal mid-ventricular wall. In this study, we compared the CT values (cardiac CT) and T2 values (CMR) of the mid-septum rather than the other segments because a guideline for CMR mapping recommended that for accurate assessment in patients with diffuse myocardial disease, a single ROI should be drawn in the septum on mid-cavity short-axis maps to avoid the veins, lungs, and liver as sources of susceptibility artifacts [5]. Care was taken to avoid inclusion of the left ventricular blood pool using narrow window width (and therefore high-contrast) CT review settings. Visually detectable myocardial calcification and fat were excluded in the measurements. We recorded the mean CT values of the septal mid-ventricular wall on unenhanced cardiac CT images. For the evaluation of interobserver reliability, the cardiovascular radiologist (S.O. with 16 years of experience) with no prior knowledge of the patient's clinical information manually drew ROIs on the septal segments of the midleft ventricle using a postprocessing workstation (Ziostation 2; Ziosoft).

As a reference standard, using T2 maps, mean T2 values were measured on the septal mid-ventricular wall in accordance with CT ROIs. We identified myocardial edema with the T2 cut-off value [present (> 47 milliseconds) or absent (47 milliseconds)] defined locally at our institution in accordance with previous reports [5].

Statistical Analysis

The normality of distributions was tested using the Shapiro-Wilk test. Normal variables are expressed as means ± SD, whereas non-normal data are expressed as medians and interquartile ranges.

Correlations between mean CT values on unenhanced cardiac CT and various parameters (including mean T2 values) were evaluated via Spearman's rank correlation analysis.

Sensitivity and specificity for the identification of myocardial edema were measured by using T2 mapping as the reference standard. Receiver operating characteristic analysis was performed; Youden's index was used to find an optimal sensitivity-specificity cut-off point.

Interobserver reliability was evaluated using intraclass correlation coefficients (ICCs) for CT value measurements. The value of ICC lies between 0 and 1, with ICC = 0 indicating no reproducibility between observers and ICC = 1 perfect reproducibility.

A P value of < 0.05 was considered statistically significant; all reported P-values are 2-tailed. Statistical analyses were performed using Bell Curve for Excel (version 2.15; SSRI) and MedCalc version 11.2 (MedCalc Software).

Results

Mean CT values moderately correlated with mean T2 values (Rho = -0.41; [95% confidence interval [CI]: -0.66, -0.09]; $P < 0.05$) (Fig. 1).

Using T2 mapping, we identified myocardial edema in 19 patients. Mean CT values provided a sensitivity of 63.2% (95% CI: 38.4%, 83.7%) and a specificity of 93.3% (95% CI: 68.1%, 99.8%) for detecting myocardial edema, with a cut-off value of 45.0 Hounsfield unit (HU) (AUC = 0.77; [95% CI: 0.59, 0.89]; $P < 0.01$) (Fig. 2 and Table 3).

Inter-observer reproducibility in measuring mean CT values was excellent (ICC = 0.93; [95% CI: 0.86, 0.96]). Correlations between CT value and clinical parameters in all patients are shown in Table 4. Representative cases are shown in Fig. 3.

Discussion

We assessed the diagnostic performance of unenhanced ECG-gated cardiac CT for myocardial edema, using T2 mapping as the reference standard. Mean CT values showed a moderate negative correlation with mean T2 values (Rho = -0.41; $P < 0.05$). Mean CT values provided a sensitivity of 63.2% and a specificity of 93.3% for detecting myocardial edema (CT cut-off value = 45 HU). Because of high specificity and modest sensitivity, myocardial edema can be ruled in but not ruled out through the use of unenhanced cardiac CT. The intrinsically limited contrast resolution due to small difference in x-ray attenuation between different tissues and coexistence of myocardial edema and various substances deposition (such as collagen, iron, fat, and calcification, etc.) may have reduced the sensitivity [16, 17], although visually detectable myocardial calcification and fat were not included in the measurements.

Evaluations of myocardial edema using unenhanced CT have been performed only in animal experiments. In 1976, Ter-Pogossian et.al [9] performed unenhanced non ECG-gated CT scans of the chest of a series of dead dogs and reported that acute MI (acute myocardial edema) were imaged as regions of lower x-ray attenuation. In 1981, Skiöldebrand et.al [10] explored the capability of unenhanced non ECG-gated CT to detect acute MI in living dogs. They reported that areas of lower x-ray attenuation were detected without contrast medium enhancement in large transmural infarctions. In 2009, Mahnken et.al [11] analyzed whether unenhanced ECG-gated dual-source cardiac CT permits the assessment of myocardial edema in acute MI comparing with CMR in living pigs. They found a substantial agreement between unenhanced cardiac CT and T2-weighted CMR for assessing the size of edema and concluded that unenhanced ECG-gated dual-source cardiac CT permits the detection of myocardial edema in acute MI. All previous animal studies have focused on evaluating focal myocardial edema in acute MI [9-11]. To our knowledge, this is the first clinical study to quantitatively evaluate myocardial edema including focal and diffuse edema using unenhanced ECG-gated cardiac CT.

ECV allows us to detect extracellular edema because increased ECV reflects the expansion of extracellular space [18]. On the other hand, T2 mapping is useful for the detection of extracellular and intracellular edema [19, 20]. Thus, combining T2 mapping with ECV allows us to define the spatial location of increased myocardial water. That is, T2 mapping prolongation in the absence of ECV changes is highly suggestive of intracellular edema formation [3]. Cardiac CT allows us to quantify ECV and assess LIE similar to CMR [12, 13], but no other parameters are available unlike CMR, which is a limitation for myocardial evaluation in cardiac CT [14]. Theoretically, CT value on the unenhanced cardiac CT image has the potential to reflect intracellular edema (in addition to extracellular edema) similar to T2 mapping, which cannot be quantified using ECV. It may contribute to a more accurate characterization of myocardial tissue by combining CT-derived ECV and LIE in cardiac CT.

Our study had some limitations. First, the number of patients was relatively small and the study was performed in a retrospective manner at a single center. Second, the radiation doses of unenhanced cardiac CT for the evaluation of myocardium in this study were higher than those of coronary calcium scans in previous studies [21, 22]. But, for the accurate and reproducible quantifications, we believe that an adequate radiation dose is necessary because the previous study reported that the reduction of image noise and beam hardening artifact improved quantitative accuracy for the myocardial tissue characterization in cardiac CT [23].

In conclusion, this is the first clinical study to assess the diagnostic performance of unenhanced ECG-gated cardiac CT for myocardial edema, using T2 mapping as the reference standard. Mean CT values moderately correlated with mean T2 values. Mean CT values provided a sensitivity of 63.2% and a specificity of 93.3% for detecting myocardial edema, with a cut-off value of $\leq$ 45.0 HU. Our study suggested that the CT value of myocardium in unenhanced ECG-gated cardiac CT may be an optional parameter in addition to LIE and ECV for myocardial tissue characterization, but further prospective, large-scale clinical studies are needed.

Abbreviations

myocardial infarction (MI)

cardiovascular magnetic resonance imaging (CMR)

computed tomography (CT)

electrocardiogram (ECG)

dose–length product (DLP)

regions of interest (ROIs)

intraclass correlation coefficients (ICCs)

late iodine enhancement (LIE)

extracellular volume fraction (ECV)

Declarations

COI statement:

The authors declare no conflicts of interest associated with this manuscript.

Disclosures: None

Declarations: Not applicable

References

1. Friedrich MG, Marcotte F (2013) Cardiac magnetic resonance assessment of myocarditis. Circ Cardiovasc Imaging 6(5):833-839
2. Walls MC, Verhaert D, Min JK et al (2011) Myocardial edema imaging in acute coronary syndromes. J Magn Reson Imaging 34(6):1243-1250
3. Galan-Arriola C, Lobo M, Vilchez-Tschischke JP et al (2019) Serial Magnetic Resonance Imaging to Identify Early Stages of Anthracycline-Induced Cardiotoxicity. J Am Coll Cardiol 73(7):779-791
4. Kotecha T, Martinez-Naharro A, Treibel TA et al (2018) Myocardial Edema and Prognosis in Amyloidosis. J Am Coll Cardiol 71(25):2919-2931

5. Messroghli DR, Moon JC, Ferreira VM et al (2017) Clinical recommendations for cardiovascular magnetic resonance mapping of T1, T2, T2* and extracellular volume: A consensus statement by the Society for Cardiovascular Magnetic Resonance (SCMR) endorsed by the European Association for Cardiovascular Imaging (EACVI). J Cardiovasc Magn Reson 19(1):75
6. Kim PK, Hong YJ, Im DJ et al (2017) Myocardial T1 and T2 Mapping: Techniques and Clinical Applications. Korean J Radiol 18(1):113-131
7. Patel AR, Kramer CM (2017) Role of Cardiac Magnetic Resonance in the Diagnosis and Prognosis of Nonischemic Cardiomyopathy. JACC Cardiovasc Imaging 10(10 Pt A):1180-1193
8. Lota AS, Gatehouse PD, Mohiaddin RH (2017) T2 mapping and T2* imaging in heart failure. Heart Fail Rev 22(4):431-440
9. Ter-Pogossian MM, Weiss ES, Coleman RE et al (1976) Computed tomography of the heart. AJR Am J Roentgenol 127(1):79-90
10. Skioldebrand CG, Lipton MJ, Redington RW et al (1981) Myocardial infarction in dogs, demonstrated by non-enhanced computed tomography. Acta Radiol Diagn (Stockh) 22(1):1-8
11. Mahnken AH, Bruners P, Bornikoel CM et al (2009) Assessment of myocardial edema by computed tomography in myocardial infarction. JACC Cardiovasc Imaging 2(10):1167-1174
12. Oda S, Kidoh M, Takashio S et al (2020) Quantification of Myocardial Extracellular Volume With Planning Computed Tomography for Transcatheter Aortic Valve Replacement to Identify Occult Cardiac Amyloidosis in Patients With Severe Aortic Stenosis. Circ Cardiovasc Imaging 13(5):e010358
13. Chang S, Han K, Youn JC et al (2018) Utility of Dual-Energy CT-based Monochromatic Imaging in the Assessment of Myocardial Delayed Enhancement in Patients with Cardiomyopathy. Radiology 287(2):442-451
14. Agricola E, Beneduce A, Esposito A et al (2020) Heart and Lung Multimodality Imaging in COVID-19. JACC Cardiovasc Imaging 13(8):1792-1808
15. Jessen KA, Shrimpton PC, Geleijns J et al (1999) Dosimetry for optimisation of patient protection in computed tomography. Appl Radiat Isot 50(1):165-172
16. Kumar V, Harfi TT, He X et al (2019) Estimation of myocardial fibrosis in humans with dual energy CT. J Cardiovasc Comput Tomogr 13(6):315-318
17. Kumar V, McElhanon KE, Min JK et al (2018) Non-contrast estimation of diffuse myocardial fibrosis with dual energy CT: A phantom study. J Cardiovasc Comput Tomogr 12(1):74-80
18. Robinson AA, Chow K, Salerno M (2019) Myocardial T1 and ECV Measurement: Underlying Concepts and Technical Considerations. JACC Cardiovasc Imaging 12(11 Pt 2):2332-2344
19. Mavrogeni S, Papavasiliou A, Giannakopoulou K et al (2017) Oedema-fibrosis in Duchenne Muscular Dystrophy: Role of cardiovascular magnetic resonance imaging. Eur J Clin Invest 47(12)
20. Kidoh M, Oda S, Nakaura T, et al. Myocardial Tissue Characterization by Combining Extracellular Volume Fraction and T2 Mapping. JACC Cardiovasc Imaging. 2021 in press.

21. Vonder M, van der Werf NR, Leiner T et al (2018) The impact of dose reduction on the quantification of coronary artery calcifications and risk categorization: A systematic review. J Cardiovasc Comput Tomogr 12(5):352-363
22. van Velzen SGM, Lessmann N, Velthuis BK et al (2020) Deep Learning for Automatic Calcium Scoring in CT: Validation Using Multiple Cardiac CT and Chest CT Protocols. Radiology 295(1):66-79
23. Emoto T, Kidoh M, Oda S et al (2020) Myocardial extracellular volume quantification in cardiac CT: comparison of the effects of two different iterative reconstruction algorithms with MRI as a reference standard. Eur Radiol 30(2):691-701

Tables

Table 1: Patient characteristics

Characteristic	All	Myocardial edema (+) on T2 mapping	Myocardial edema (-) on T2 mapping	P value
No. of patients	34	19	15	
Sex	Woman 11 Man 23	Woman 6 Man 13	Woman 5 Man 10	1.00
Age (y)	64.7 ± 14.6	66.5 ± 16.6	62.4 ± 11.7	0.42
Body weight (kg)	58.2 ± 14.4	57.4 ± 17.1	59.1 ± 10.5	0.75
Body mass index (kg/m^2)	22.1 ± 3.6	21.8 ± 4.4	22.4 ± 2.4	0.62
Mean heart rates during CT scan (beats per minute)	62.1 ± 13.0	63.1 ± 13.1	60.9 ± 13.3	0.64
Total calcium score (Agatston units)	0 (0 – 73.0)	25.0 (0 – 234.5)	0 (0 – 37.5)	0.21
Estimated glomerular filtration rate (eGFR) (mL/min/1.73 m^2)	69.2 ± 15.8	65.5 ± 15.9	73.9 ± 15.0	0.13
Brain natriuretic peptide (BNP) (pg/mL)	104.0 (36.7 – 273.2)	117.0 (76.8 – 484.6)	62.9 (17.8 – 114.0)	< 0.05
Diabetes	12 (35)	6 (31.6)	6 (40.0)	0.72
Hypertension	18 (53)	7 (46.7)	11 (57.9)	0.73
Hyperlipidemia	11 (32)	5 (26.3)	6 (40.0)	0.47
Heart failure	10 (29)	7 (36.8)	3 (20.0)	0.45
Smoking	3 (9)	3 (15.8)	0 (0)	0.24

Note: Normal variables are expressed as means ± standard deviation, whereas non-normal data are expressed as medians and interquartile ranges, with percentages in parentheses.

Table 2: Parameters for unenhanced cardiac CT

Parameter	Value
Detector collimation (mm)	0.5
Peak tube voltage (kVp)	120
Rotation time (sec)	0.275
Tube current (mA)	571.8 ± 191.9
Volume CT dose index (mGy)	8.8 ± 3.0
Dose-length product (mGy▯cm)	141.5 ± 47.7
Effective radiation dose (mSv)	2.0 ± 0.7
Section thickness (mm)	0.5

Note: Data were obtained with prospective electrocardiogram gating. Unless otherwise specified, data are presented as the mean ± standard deviation.

Table 3: Diagnostic performance of unenhanced cardiac CT for myocardial edema.

Parameter	
Sensitivity (%)	63.2 (12/19) [38.4, 83.7]
Specificity (%)	93.3 (14/15) [68.1, 99.8]
PPV (%)	92.3 (12/13) [63.7, 98.8]
NPV (%)	66.7 (14/21) [52.2, 78.5]
Accuracy (%)	76.5 (26/34) [58.8, 89.3]
AUC	0.77 [0.59, 0.89]
Significance (P value)	P < 0.01

Note: Numbers in parentheses are raw data, and numbers in brackets are 95% confidence intervals. AUC = area under the receiver operating characteristic curve, NPV = negative predictive value, PPV = positive predictive value.

Table 4: Correlations between CT value and clinical parameters in all patients

Clinical parameter	Rho	95 % CI	P value
Sex	0.07	-0.28, 0.40	0.71
Age (y)	0.13	-0.22, 0.45	0.45
Body weight (kg)	0.01	-0.34, 0.34	0.98
Body mass index (kg/m^2)	-0.08	-0.40, 0.27	0.67
Mean heart rates during CT scan (beats per minute)	-0.29	-0.57, 0.05	0.10
Total calcium score (Agatston units)	-0.18	-0.49, 0.16	0.30
eGFR (mL/min/1.73 m^2)	-0.11	-0.44, 0.23	0.52
BNP (pg/mL)	0.08	-0.27, 0.41	0.66
Diabetes	-0.03	-0.37, 0.31	0.86
Hypertension	-0.01	-0.34, 0.33	0.97
Hyperlipidemia	-0.08	-0.41, 0.27	0.65
Heart failure	-0.01	-0.34, 0.33	0.97
Smoking	-0.12	-0.44, 0.23	0.49
T2 value (milliseconds)	-0.41	-0.66, -0.09	< 0.05

eGFR = Estimated glomerular filtration rate, BNP = Brain natriuretic peptide

Figures

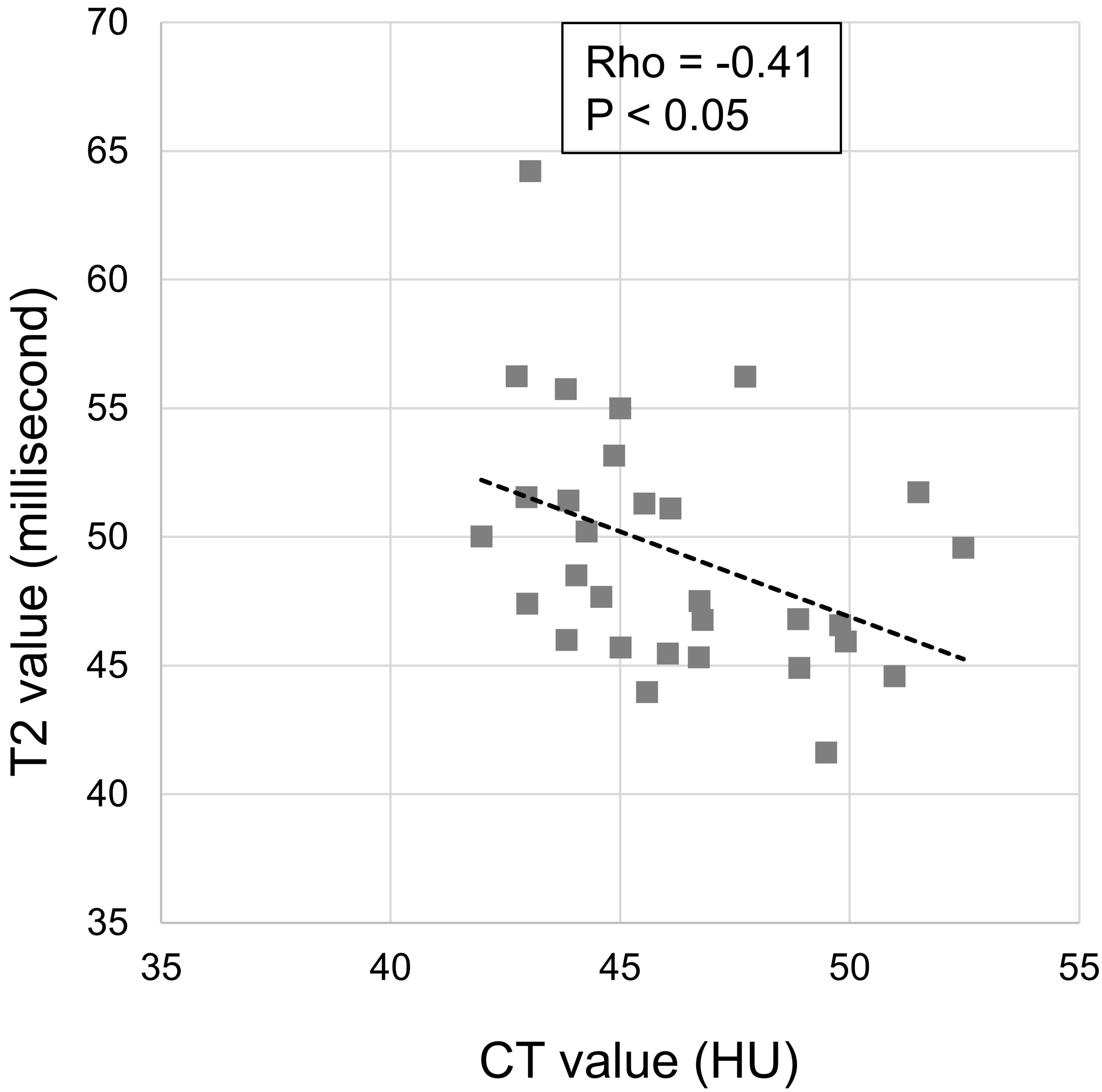

Figure 1

Scatterplots showing results of correlation between mean CT values and mean T2 value. Mean CT values moderately correlated with mean T2 values (Rho = -0.41; [95% CI: -0.66, -0.09]; P < 0.05).

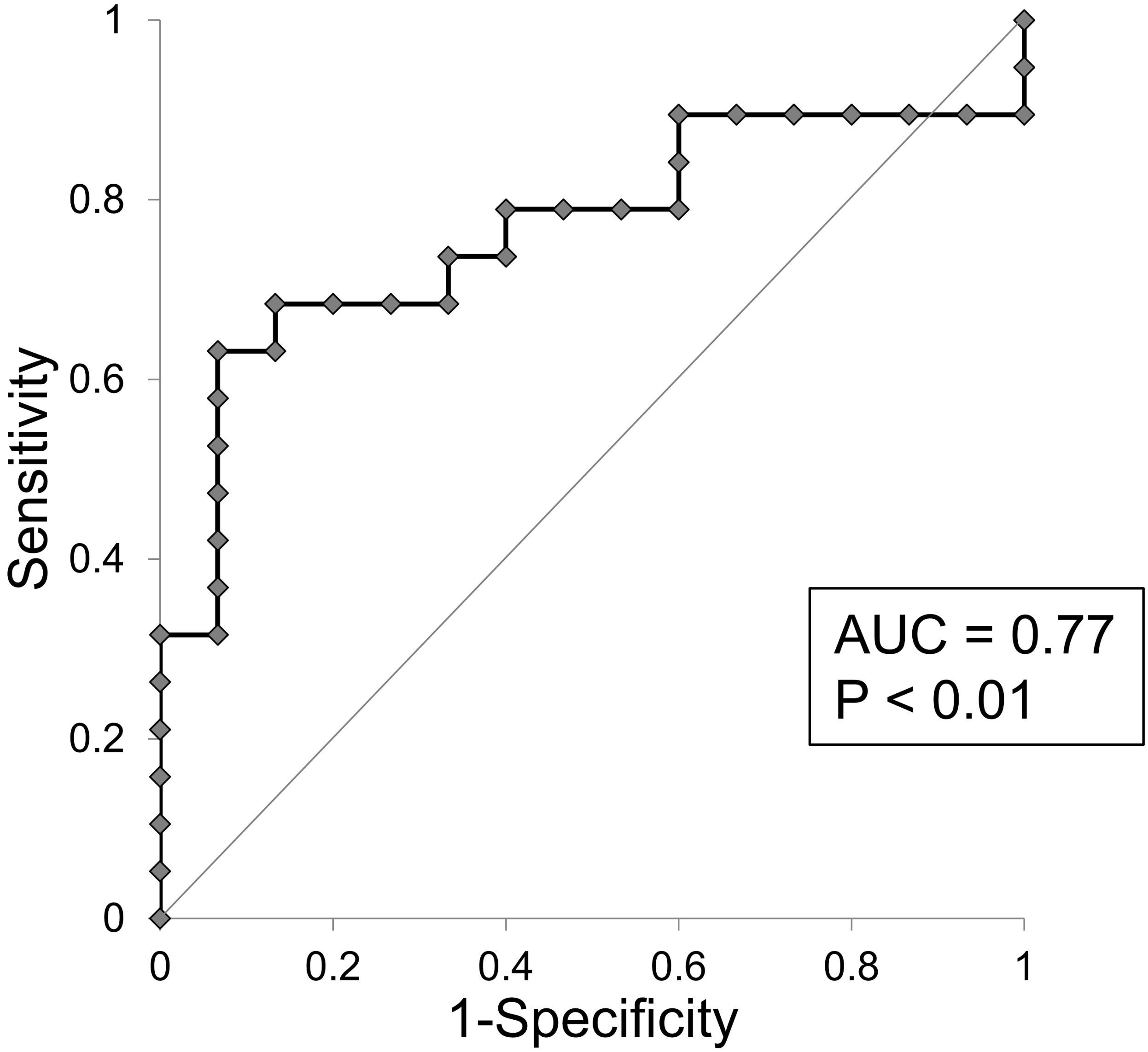

Figure 2

Receiver operating characteristic analysis. Sensitivity and specificity for the identification of myocardial edema were measured by using T2 mapping as the reference standard. Mean CT value provided a sensitivity of 63.2% (95% CI: 38.4%, 83.7%) and a specificity of 93.3% (95% CI: 68.1%, 99.8%) for detecting myocardial edema, with a cut-off value of ≤ 45.0 Hounsfield unit (HU) (AUC = 0.77; [95% CI: 0.59 to 0.89]; P < 0.01).

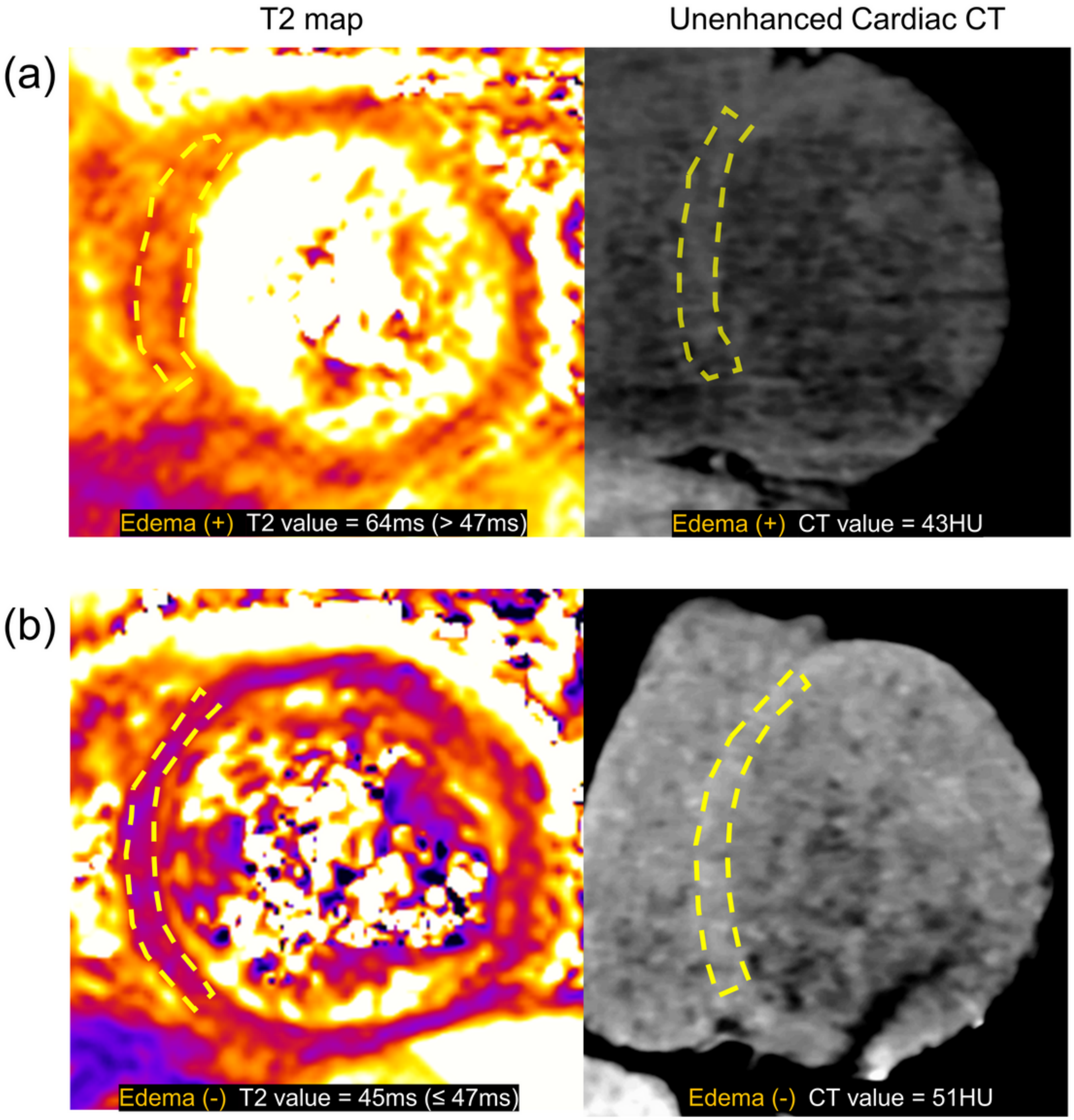

Figure 3

Representative cases. (a) A 69-year-old man with acute myocarditis. T2 mapping revealed diffuse myocardial edema (> 47 milliseconds [ms]). Unenhanced ECG-gated cardiac CT revealed low attenuation (43HU). (b) A 71-year-old man with mitral regurgitation. T2 mapping and unenhanced ECG-gated cardiac CT showed no obvious diffuse myocardial edema.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- TICConflictofInterestDisclosureForm.pdf