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Myocardial Scar Imaging by Standard Single-Energy and Dual-Energy Late Enhancement Computed Tomography: Comparison to Pathology and Electroanatomical Map in an Experimental Chronic Infarct Porcine Model

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Abstract

Background—Myocardial scar is a substrate for ventricular tachycardia and sudden cardiac death. Late enhancement computed tomography (CT) imaging can detect scar, but it remains unclear whether newer late enhancement dual-energy (LE-DECT) acquisition has benefit over standard single-energy late enhancement (LE-CT).

Objective—We aim to compare late enhancement CT using newer LE-DECT acquisition and single-energy LE-CT acquisitions to pathology and electroanatomical map (EAM) in an experimental chronic myocardial infarction (MI) porcine study.

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Methods—In 8 chronic MI pigs (59±5 kg), we performed dual-source CT, EAM, and pathology. For CT imaging, we performed 3 acquisitions at 10 minutes post-contrast: LE-CT 80 kV, LE-CT 100 kV, and LE-DECT with two post-processing software settings.

Results—Of the sequences, LE-CT 100 kV provided the best contrast-to-noise ratio (all $p < 0.03$) and correlation to pathology for scar ($\rho=0.88$). While LE-DECT overestimated scar (both $p=0.02$), LE-CT images did not (both $p=0.08$). On a segment basis ($n=136$), all CT sequences had high specificity (87–93%) and modest sensitivity (50–67%), with LE-CT 100 kV having the highest specificity of 93% for scar detection compared to pathology and agreement with EAM ($\kappa 0.69$).

Conclusions—Standard single-energy LE-CT, particularly 100kV, matched better to pathology and EAM than dual-energy LE-DECT for scar detection. Larger human trials as well as more technical-based studies that optimize varying different energies with newer hardware and software are warranted.

Keywords

computed tomography; electrophysiology; imaging; myocardial infarction; myocardial scar

INTRODUCTION

Myocardial scar is a substrate for ventricular tachycardia (VT) and sudden cardiac death. Scar-related VT may be due to non-ischemic etiologies, but the most common cause is prior myocardial infarction (MI).¹ Substrate mapping, with electroanatomical mapping (EAM) that combines activation maps with voltage maps, is useful in patients with scar-related VT.² However, point by point mapping with EAM is time-consuming and requires hours of fluoroscopic time, even in the hands of skilled electrophysiologists.

Because iodinated contrast have similar kinetics as gadolinium, late enhancement of iodine with standard single-energy cardiac computed tomography (LE-CT) acquired 10 minutes after contrast administration is an alternative for myocardial scar detection in those with contraindications to magnetic resonance imaging (MRI).^{3, 4} With the advent of dual-source CT, two x-ray tubes and detectors are mounted perpendicular to each other, allowing the newer application of dual-energy CT scanning (DECT). With DECT, each x-ray tube can emit a different tube potential, thus allowing for scanning with two energy levels simultaneously.⁵ As tissues in the body and iodine-based contrast media have unique absorption characteristics when penetrated with different x-ray energy levels, DECT allows for delineation of the iodine content within the myocardium and appears to have a promising role for late enhancement (LE-DECT) myocardial scar imaging.⁶

Since pre-procedural scar imaging with CT may be helpful for electrophysiologists tackling a complex VT ablation case,⁷ both LE-CT and LE-DECT protocols have been reported to yield high accuracy and good correlation to late gadolinium enhancement cardiac MRI (LE-MRI) and histopathology for the detection of myocardial scar in the reperfused chronic MI model.^{3, 4, 6} Thus, we sought to determine whether LE-CT or LE-DECT was optimal for use with EAM in an experimental pig study. In the chronic MI porcine study, we compared standard single-energy LE-CT and dual-energy LE-DECT protocols for assessing

myocardial scar size and its diagnostic accuracy for scar detection as compared to pathology. We also assessed the diagnostic accuracy of EAM to pathology and compared the agreement between these CT protocols and EAM for scar detection.

METHODS

In 13 swine (Yorkshire or Yorkshire mix, 77% male, 30–50 kg), we used a closed-chest coronary artery occlusion-reperfusion technique to induce a ST-elevation MI. Procedure-related death occurred in two animals following acute infarction due to ventricular arrhythmias. After 4–6 weeks post-reperfusion, 11 animals survived and underwent CT imaging and EAM prior to sacrifice. For this study, we included data from 8 pigs, where we had all 4 modalities available for analysis: LECT, DECT, EAM, and pathology. All pig procedures were performed under general anesthesia. This animal study protocol was approved by the Hospital Subcommittee on Research Animal Care (SRAC) which conforms to the USDA Animal Welfare Act, PHS Policy on Humane Care and Use of Laboratory Animals, the “ILAR Guide for the Care and Use of Laboratory Animals” and other applicable laws and regulations.

Chronic Myocardial Infarction Protocol

In a closed-chest ischemia-reperfusion porcine model, we used standard cardiac catheterization technique to create a ST-elevation myocardial infarction with balloon occlusion and transcatheter intracoronary injection of ethyl alcohol of a left coronary vessel, either left anterior descending (LAD) or left circumflex (LCx) artery.⁸ Selective coronary angiogram of the left coronary system was performed prior to balloon angioplasty (Boston Scientific Maple Grove, MN) of the mid-distal LAD or diagonal branch (n=7) or LCx (n=1). In all 8 animals, coronary artery occlusion was achieved via balloon inflation at 6–10 atmospheres for a mean duration of 53±40 minutes. In 7 animals, supplemental transcatheter intracoronary injection of 70% ethyl alcohol (Owens & Minor Mechanicsville, VA, mean volume of 0.6±0.1 ml) was given to further induce myocardial necrosis. Acute MI was documented by the presence of new ST elevations in contiguous leads during continuous surface electrocardiographic (ECG) monitoring and reperfusion of the occluded vessel was confirmed by repeat coronary angiography. The animals were then housed for 4–6 weeks to allow the infarction to mature.^{3, 6, 9}

Late Enhancement CT Scans

Image Acquisition and Reconstructions—At a mean of 33±9 days following induction of MI, the pigs underwent ECG-gated cardiac CT with a 128-slice dual-source CT scanner (Definition FLASH, Siemens Healthcare, Forchheim, Germany). All CT images were acquired at end-expiration and retrospectively-gated. After baseline noncontrast CT scan, test bolus, and contrast-enhanced CT images were acquired with a total of 145±35 mL of intravenous iodinated contrast (Iopamidol 370, Iovue, Bracco Diagnostics Inc., Princeton, NJ, USA) given, we performed 3 sequential delayed CT scan acquisitions at 10 minutes after contrast administration: LE-CT at 80 kV, LE-CT at 100 kV, and LE-DECT. Both LE-CT 80 kV and 100 kV acquisitions were acquired with the following scanning parameters: 2×128×0.6 mm slice collimation, gantry rotation time of 280ms, temporal

resolution 75 ms, effective tube current of 370 mAs, and automated pitch adaptation. For LE-CT 80 kV or 100 kV, reconstructions were made using a soft-convoluted kernel B10f with 0.75 mm and 0.4 mm increment, during the best systolic phase since the myocardial thickness was most comparable to the pathology thickness. LE-DECT scan was acquired with the following parameters: one tube with 165 mAs/rot at 100kV and the second tube with 140mAs/rot at 140kV, 64×0.6 mm slice collimation, gantry rotation time of 280ms, temporal resolution 140 ms, and automated pitch adaptation. For LE-DECT, reconstructions were made using a dedicated dual-energy convolution kernel D30f with 1.5 mm and 1.0 increment, as previously described,⁶ during best systole.

Image Interpretation—All images were transferred to an offline commercially available workstation (Syngo MMWP, Siemens, Forchheim, Germany) for analysis. For all measurements with LE-CT and LE-DECT, we used a slice thickness of 5 mm. For LE-CT (80 kV and 100 kV), we used a minimum intensity projection (MiniP) with a narrow window width of ~100 Hounsfield unit (HU) and center of ~100 HU to enhance the brightness of the infarcted myocardium from normal myocardium. For LE-DECT, we used two dual energy software settings (Heart perfusion blood volume [PBV] and General Viewing [GV]). The PBV software uses a 3-material-decomposition algorithm based on typical attenuation of iodine, fat, and soft tissue at 2 different energy levels: 140kV and 100kV. The weighted fused images with 60% contribution from the 140kV scan and 40% from the 100kV scan are then loaded simultaneously into the software application, with the 60% myocardial iodine map “Hot Body 16 bit” overlay superimposed onto gray scale multi-planar reformat (MPR) images. Similar method with 60% overlay was used for the GV tool, where the images are merged from the high (70%) and low (30%) tube voltage.

For scar quantification, the epicardial, endocardial, and myocardial scar areas were measured on contiguous LV short axis stacks at 6 mm increments from base to apex (Figure 1). Myocardial scar was delineated as regions with increased signal intensity, representing increased iodine content and seen as hyperenhancement on late enhancement CT images, compared to normal myocardium. We measured the CT signal intensity of the hyperenhanced myocardium and remote myocardium to derive the contrast-to-noise ratio (CNR), which is defined as the difference in attenuation of scar and remote myocardium, divided by the standard deviation of the remote myocardium.¹⁰ Myocardial and scar volumes were calculated by using Simpson’s summation of disc. Percentage myocardial scar is defined as the scar volume divided by the LV myocardial volume. For measurement reproducibility of 2 independent readers in a random sample of 10 datasets (5 pigs with 5 datasets of single-energy and 5 datasets of dual-energy). One CT reader, who was blinded from the EAM and pathology, performed all the CT scar quantification.

For the qualitative assessment of myocardial scar, two CT readers blinded to the EAM and pathology evaluated in consensus for the presence of scar, which is defined as regions of hyperenhancement, according to the 17-segment American Heart Association (AHA) model.¹¹

Electroanatomical Maps

After CT imaging, we performed detailed high density EAM mapping with >300 points of the endocardial surfaces of the myocardium using bipolar voltage maps (CARTO XP, Biosense-Webster, Inc., Diamond Bar, CA) to map the site of myocardial scar. Standard voltage settings of >1.5 mV represented normal myocardium and <1.5 mV represented scarred myocardium. Location of scar was evaluated based on the 17-segment American Heart Association (AHA) model¹¹ with consensus read by two electrophysiologists, who were blinded to the CT and pathology results.

Pathology

After the EAM, the animals were sacrificed. Median thoracotomy was performed and the excised heart was immediately placed in a buffered formalin solution. Short-axis 8 mm slices of the heart aligned along the LV long axis were obtained with a large-blade knife. All pathology slices were photographed on both the apical and basal surfaces. For LV myocardium and scar volumetric quantification, we performed consensus reading with two readers who were blinded to the CT data and measured the epicardial, endocardial, and myocardial scar areas using ImageJ 1.46 (National Institutes of Health, Bethesda, MD) and corresponding volumes were calculated by using Simpson's summation of disc. Location of myocardial scar was assessed based on the 17-segment AHA model of the LV.¹¹

Statistical Analysis—Descriptive statistics were expressed as mean $\pm$ standard deviation (SD) or median with interquartile range [IQR] for continuous variables and as frequency and percentages for nominal variables. We used intraclass correlation coefficient to determine the measurement reproducibility between 2 independent readers. We used Student t-test to compare the differences between CNR of 100 kV LE-CT to the other CT sequences. Spearman's correlation was used to compare percentage scar between late enhancement CT protocols and pathology. We used Wilcoxon signed rank test to compare the difference in percentage scar by CT protocols with pathology. We calculated the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy for scar detection between CT images and EAM as compared to pathology on a per segment basis. We compared the difference in specificities between 100 kV LE-CT and the other CT protocols using McNemar's test. For comparison between CT and EAM, we reported exact agreement and used Cohen κ statistics to determine the degree of agreement between the 2 modalities. A two-tailed p-value of <0.05 was considered statistically significant. Statistical analyses were performed using SAS (Version 9.2, SAS Institute Inc., Cary, NC, USA).

RESULTS

Of the 8 pigs included in the analysis, 75% were male and weighed 59 ± 5 kg by the time of CT scan acquisition. Following induction of the ischemia-reperfusion model, the mean duration until CT was 34 ± 9 days, and until EAM was 38 ± 9 days. The mean duration between the CT and EAM was 5 ± 2 days. Figure 2 depicts an example of one of the chronic infarct pigs.

Quantitative Assessment of Scar

The interobserver intraclass correlation coefficient of myocardial volume was 0.86 and percentage scar was 0.85, both $p < 0.005$.

Table 1 details the CT signal intensity, CNR, LV myocardial volume, scar volume, and percent scar of the LV myocardium on standard LE-CT, dual-energy LE-DECT, and pathology. LE-CT 100 kV had the best CNR compared to the other CT sequences (all $p < 0.03$). The percentage scar ranged from 5.7% to 9.4% with the LE-CT and LE-DECT protocols as compared to 4.4% with pathology. Table 2 shows the correlation and difference in percentage scar between LE-CT, LE-DECT, and pathology. The LE-DECT images overestimated the percentage of scar (both $p=0.02$), while LE-CT sequences did not (both $p=0.08$). LE-CT 100 kV correlated best to pathology for percentage scar ($\rho=0.88$, $p=0.002$).

Qualitative Assessment of Scar

Table 3 outlines the diagnostic accuracy of the LE-CT, LE-DECT, and EAM scans as compared to the gold standard of pathology for detecting presence of myocardial scar on a per segment basis using the 17-segment American Heart Association (AHA) model.¹¹ While all the CT sequences had modest sensitivity for detection of scar (50–67%), they were highly specific for scar detection and ranged from 87–93%, with the LE-CT 100kV having the highest specificity of 93% as compared to pathology. When compared to LE-CT 100 kV, there was a significant difference in specificity between the LE-DECT GV sequence ($p=0.03$), though no differences in specificity between CT sequences (all $p=NS$).

EAM was highly specific for scar detection at 94% when compared to pathology. Importantly, there was no significant difference in specificity between the LE-CT 100 kV with EAM ($p=0.65$). Table 4 shows the agreement between the various CT sequences versus EAM for scar, with the best agreement (91%) seen between LE-CT 100kV and EAM (κ 0.69, 95% CI 0.52–0.86).

DISCUSSION

In a chronic myocardial infarction porcine model, both LE-CT and LE-DECT are able to visualize dense myocardial scar and have excellent correlation and specificity to pathology for scar quantification. However, despite CT technological advances with dual-energy capabilities, we found that LE-DECT overestimated the amount of scar more than LE-CT acquisitions. As compared to the other CT sequences, standard single-energy LE-CT at 100kV had the greatest CNR, best correlation to pathology scar size, and the highest specificity compared to pathology and agreement as compared to EAM.

To facilitate VT mapping and ablation, pre-procedural imaging is widely utilized in clinical practice to identify the presence, location, and severity of the underlying heart disease that likely contains the VT substrate.¹ LE-MRI is an established modality and preferably used to identify regions of myocardial scar.^{12–14} Defining myocardial scar and border zone using LE-MRI have been shown to facilitate substrate-guided ventricular tachycardia ablation.¹⁵ However, its utility remains limited for patients with claustrophobia, inability to lie supine

for prolonged periods or perform long breath holds, and generally contraindicated for patients with cardiac devices despite feasibility reports of its safety in such patients.^{15, 16}

As an alternative to MRI, cardiac CT is a non-invasive imaging modality, which has been shown to provide information on non-viable myocardium and scar burden and characteristics using single energy LE-CT acquisition, with varying protocols using either 80kV or 100kV.^{3, 4, 17} Initial feasibility study showed good diagnostic accuracy with LE-DECT imaging for the detection of myocardial scar by pathology, but no difference in diagnostic accuracy when compared to 100kV grayscale LE images or LE-MRI.⁶ However, a limitation of that study was that the 100kV grayscale LE-CT was derived from the LE-DECT image acquisition. Our porcine study of chronic ischemic reperfusion model differs in that we performed three separate sequential image acquisitions within one suspended breathhold (LE-CT 80kV, LE-CT 100kV, and LE-DECT), our infarct size is small (average 4% scar of myocardium) and we compared the CT sequences to detailed EAM voltage maps.

In our selection of which dual energy settings to compare to the single energy 80kV or 100kV settings, we opted to compare two DECT settings with different linear blending settings (PVB and GV) since linear blending have been shown to improve image quality and provides more precise estimation to scar volume over the non-blended monochromatic high and low energies alone.¹⁸ Interestingly, despite the conceptual advantage of using two-energy CT sources for image acquisition,⁵ we found that the standard grayscale 100 kV single-energy LE-CT images correlated best to pathology, with a slight over-estimation but no significant difference in percent scar compared to pathology, the highest specificity (93%) for infarct detection, and best agreement to EAM (κ 0.69).

Some notable observations from our study are worthy of discussion. Our findings that both LE-CT and LE-DECT overestimate scar as compared to pathology are consistent with human study that showed LE-DECT to overestimate scar size as compared LE-MRI.¹⁹ The systematic overestimation of CT delayed enhancement imaging over pathology and LE-MRI is not surprising and is a reflection of the increased noise, and thus resultant poorer spatial resolution. Thicker slabs are required to reduce the noise in order to visualize the scar and results in a trade-off with overestimation of scar due to volume averaging of voxels over 5-mm slice thickness. We also found that LE-DECT overestimated infarct size more than LE-CT despite theoretical advantages of DECT. Potential explanations may be the effect on image quality due to overlapping beam energies as well as the differences in temporal resolution, whereby the single energy LE-CT has the advantage of 75 ms and the LE-DECT has a poorer 140 ms temporal resolution. Moreover, the reduced noise and greater CNR can explain why single-energy LE-CT with 100kV outperformed 80kV imaging.

Our disappointing results with DECT highlight the need for more basic DECT research, particularly with multi-vendors and different dual energy modes. Reassuring is that late enhancement CT, irrespective of single or dual energy, has high specificity for scar detection and has a role for patients with contraindications to MRI. Other added benefits of our finding that single-energy 100kV LE-CT was best for scar detection are the easy

postprocessing requirement, widespread availability, and the lower radiation dose as compared to dual-energy scanning, making it a favourable for human studies.

Limitations

There are several notable limitations to our study. Our sample size is small but show the feasibility of late enhancement CT image acquisition for myocardial scar detection. We used a high contrast dose for the pig experiments, thus translation to human studies will be limited to those with normal renal function. Our results are limited to the single CT vendor with a second-generation dual-source scanner and linear blending settings, and may not be applicable to newer hardware and software configuration or to other CT vendors with dual-energy capabilities. Studies varying combination of different energies, virtual monochromatic energies or using spectral CT imaging may further optimize late enhancement CT. Additionally, larger human studies designed to prospectively examine the role of pre-procedural planning for VT ablations using LE-CT for myocardial scar detection are needed to determine its clinical utility and effectiveness.

CONCLUSIONS

Late enhancement CT acquisitions have high specificity for scar detection compared to pathology, with standard single-energy LE-CT using 100kV having the best CNR, correlation to scar quantification, and assessment of location by pathology and EAM. Larger human trials as well as more technical-based studies that optimize varying different energies with newer hardware and software are warranted.

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Highlights

- In a chronic infarct model study, we compared late enhancement dual-energy CT (LE-DECT) versus standard single-energy (LE-CT) 80 and 100 kV acquisitions to detect myocardial scar.
- There is a systematic overestimation of CT delayed enhancement imaging using single-energy LE-CT and dual-energy LE-DECT over as compared to pathology.
- LE-DECT overestimated infarct size more than LE-CT.
- Single-energy LE-CT with 100kV outperformed single-energy LE-CT with 80kV imaging for scar quantification.
- Single-energy 100 kV LE-CT had best contrast-to-noise ratio and matched best to pathology and electroanatomical mapping (EAM).
- Larger human trials as well as more technical-based studies that optimize varying different energies with newer hardware and software are warranted.

Figure 1. Schematic of myocardial scar measurement

Four-chamber view (B) and two-chamber view (B) are aligned orthogonally with the apex for short-axis (C) measurements of systolic image per 6 mm increments. The epicardial boundary is outlined in red, the endocardial boundary is outlined in orange, and the myocardial scar area is outlined in turquoise (C, D). Summation of the areas using Simpson's summation of disc provides the myocardial and scar volumes.

Figure 2. Pig with a chronic left anterior descending artery infarction

Short-axis CT images at the level of the mid left ventricle with noncontrast (A), contrast-enhanced (B), standard LE-CT at 80 kV (C) and 100 kV (D), LE-DECT using perfusion blood volume (E) and general viewing (F) reconstructions. Corresponding electroanatomical mapping (G) and pathology (H) demonstrate scar in the mid anterior and anteroseptal segments. Note thinning of the mid anterior and anteroseptal segments of the left ventricular myocardium on the contrast-enhanced CT (B) and matching regions of myocardial scar on LE-CT (white arrows [C, D, E, F]) and pathology (black arrow [H]).

Table 1
CT signal intensities and LV myocardial scar measures by LE-CT, LE-DECT, and pathology in the porcine study.

CT signal intensity	LE-CT 80 kV	LE-CT 100 kV	LE-DECT PBV	LE-DECT GV	Pathology
Hyperenhanced myocardium (HU)	147.6±16.4	119.6±14.6	63.9±9.2	76.6±7.1	N/A
Remote myocardium (HU)	96.4±9.4	75.8±10.2	30.6±6.5	59.6±3.0	N/A
SD of remote myocardium (HU)	18.6±2.5	12.9±3.1	17.9±1.8	19.7±0.7	N/A
Contrast-to-noise ratio (CNR)	2.7±0.4	3.5±0.8	1.9±0.4	0.9±0.3	N/A
LV myocardial and Scar Measures					
LV myocardial Volume (cm ³), mean± SD [25th, 50th, 75th percentiles]	87.3±8.9 91.1 [79.7, 93.4]	83.5±11.2 81.3 [74.0, 92.4]	88.2±6.8 86.1 [83.9, 89.6]	86.6±5.9 87.5 [84.4, 91.0]	89.7±6.8 92.3 [86.3, 94.8]
Scar volume (cm ³), mean± SD [25th, 50th, 75th percentiles]	7.6±10.5 4.1 [3.3, 4.9]	4.6±4.1 3.1 [2.5, 4.8]	8.5±6.7 7.4 [4.5, 9.4]	6.1±5.8 3.9 [3.1, 5.6]	3.8±3.1 2.5 [1.6, 5.7]
% scar, mean± SD	8.6±11.5%	5.7±5.5%	9.4±6.4%	6.8±6.2%	4.4±4.0%

LV denotes left ventricular; LE-CT, late enhancement computed tomography; LE-DECT, late enhancement dual-energy computed tomography; PBV, perfusion blood volume; GV, general viewing; HU, Hounsfield unit; SD, standard deviation; N/A, not applicable.

Table 2

Correlation and % scar between LE-CT, LE-DECT and pathology for the measurement of percentage myocardial scar in the porcine model.

	Correlation with Pathology	p-value	% scar with pathology	p-value
LE-CT 80 kV	0.76	0.03	4.1±8.2%	0.08
LE-CT 100 kV	0.88	0.002	1.3±2.0%	0.08
LE-DECT PBV	0.76	0.03	4.9±3.6%	0.02
LE-DECT GV	0.74	0.03	2.4±3.0%	0.02

Abbreviations as in Table 1.

Table 3
Diagnostic accuracy as compared to pathology for detection of myocardial scar on a per segment basis.

	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
LE-CT 80 kV	14/24, 58% (37–78)	101/112, 90% (83–95)	14/25, 56% (35–76)	101/111, 91% (84–96)	115/136, 85% (77–90)
LE-CT 100 kV	16/24, 67% (45–84)	104/112, 93% (86–97)	16/24, 67% (45–84)	104/112, 93% (86–97)	120/136, 88% (82–93)
LE-DECT PBV	12/24, 50% (29–71)	100/112, 89% (82–94)	12/24, 50% (29–71)	100/112, 89% (82–94)	112/136, 82% (74–88)
LE-DECT GV	13/24, 54% (33–74)	97/108, 87% (79–92)	13/28, 46% (28–66)	97/112, 90% (83–95)	110/136, 81% (73–87)
EAM	15/24, 63% (41–81)	105/112, 94% (88–97)	15/22, 68% (45–86)	105/114, 92% (86–96)	120/136, 88% (82–93)

Abbreviations as in Table 1.
PPV denotes positive predictive value; NPV, negative predictive value; EAM, electroanatomical map.

Table 4

Agreement of presence or absence of myocardial scar between various CT sequences vs EAM in the porcine study.

	Concordance		Discordance		Exact Agreement
	CT+/EAM+	CT-/EAM-	CT+/EAM-	CT-/EAM+	
LE-CT 80 kV	16	105	9	6	89% (121/136)
LE-CT 100 kV	17	107	7	5	91% (124/136)
LE-DECT PBV	13	103	11	9	85% (116/136)
LE-DECT GV	15	101	13	7	85% (116/136)

Abbreviations as in Tables 1 and 3.