The diagnostic accuracy of 256-row computed tomographic angiography compared with invasive coronary angiography in patients with suspected coronary artery disease

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Aims

To assess the diagnostic accuracy of 256-row computed tomographic angiography (CTA) in patients with suspected coronary artery disease (CAD). Non-invasive imaging of the coronary artery by CTA has increasingly been used in recent years. The accuracy of 256-row CTA has not yet been studied. We sought to assess the accuracy of 256-row CTA compared with invasive coronary angiography (ICA) in the diagnosis and assessment of CAD.

Methods and results

We prospectively evaluated 104 consecutive individuals who accepted CTA and then underwent ICA. The presence of stenosis ≥ 50% was considered obstructive. The diagnostic accuracy of CTA for detecting obstructive stenosis was compared with that of ICA. The area under the receiver-operating-characteristic curve (AUC) was used to evaluate the diagnostic accuracy of CTA relative to ICA. A total of 86 patients had obstructive CAD. The patient-based analysis of CTA for detecting stenosis ≥ 50% according to ICA revealed an AUC of 0.744 [95% confidence interval (CI), 0.572–0.916], with a sensitivity of 98.8%, a specificity of 50%, a positive predictive value (PPV) of 92.4%, and a negative predictive value (NPV) of 87.5%. The segment-based analysis revealed an AUC of 0.915 (95% CI, 0.847–0.982), with a sensitivity of 93.5%, a specificity of 95%, a PPV of 77.6%, and an NPV of 98.7%. The vessel-based analysis revealed an AUC of 0.887 (95% CI, 0.808–0.966), with a sensitivity of 94.3%, a specificity of 87.3%, a PPV of 82.7%, and an NPV of 95.9%.

Conclusion

256-Row CTA is a highly sensitive test of CAD and has a high predictive value. 256-Row CTA may be a potential alternative to detect coronary artery stenosis and rule out CAD in suspected patients.

Keywords

256-Row computed tomography • Computed tomographic angiography • Invasive coronary angiography • Multi-detector computed tomography

Introduction

Despite substantial advances in medical and interventional treatments, coronary artery disease (CAD) remains the leading cause of death worldwide. Accordingly, diagnosis of the presence and severity of CAD is important for determining appropriate clinical management. Traditionally, CAD is evaluated indirectly by identifying abnormal regional wall motion and abnormal myocardial perfusion with stress tests and myocardial perfusion scans.¹ These non-invasive tests focused on functional assessment and aimed primarily at indirect identification of flow-limiting coronary artery stenosis. Invasive coronary angiography (ICA) reveals the extent, location, and severity of obstructive lesions and defines therapeutic options.² Although both non-invasive and invasive tests can predict outcome, ICA provides direct identification of the coronary arteries.

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Multi-detector computed tomographic angiography (CTA) has been used as a non-invasive test to determine the presence and severity of coronary stenosis for years. For diagnosis of obstructive CAD, multi-detector CTA has been able to replace some of the traditional examinations and avoid the risk caused by invasive procedures of ICA. However, there are several limitations for 64-row CTA because of substantial amounts of radiation dose, motion artefacts, irregular heart beats, highly calcified lesions, severe obesity, tachycardia, and routine use of beta-blockers. To decrease the CTA drawbacks, new device such as 256- or 320-row CTA was developed. The 320-row CTA can detect more coronary arterial segments and reduce radiation dose. However, no data is available about the accuracy of 320-CTA in the diagnosis of CAD. Using prospective electrocardiogram (ECG)-gating technique, high diagnostic accuracy of CTA in the reduction of radiation dose could be maintained.

256-Row CTA has advantages of faster gantry rotation times, increased X-ray tube power, and larger detector coverage. When compared with former CT generations, 256-row CTA provides shorter scanning time, better image quality, and lower radiation dose. However, the accuracy of 256-row CTA in the diagnosis of CAD is not known. The aim of this study was to assess the accuracy of 256-row CTA compared with ICA in the diagnosis of CAD.

Methods

Study population

From December 2008 to June 2009, 1447 individuals underwent CTA in our institute. Three hundred and seventy-seven (26%) of these subjects had significant CAD by CTA. People who hesitated or refused ICA were not enrolled. One hundred and twelve patients consented to participate in this study and were transferred to ICA. Eligible patients were at least 30 years of age and had suspected symptomatic CAD. Patients were not eligible if they had history of allergy to iodinated contrast medium or contrast-induced nephropathy, elevated serum creatinine level (>1.5 mg/dL). To avoid complication and prevent bias, patients with malignancy with life expectancy less than 1 year, organ transplantation, or percutaneous coronary intervention (PCI) within the past 6 months were excluded. Patients with arrhythmias including atrial fibrillation, heart rates >70/min, obesity, and higher Agatston calcium scores were all enrolled. The influence of calcification on the diagnostic accuracy of 256-row CTA was assessed by dividing the patients into three groups according to different Agatston calcium score (<400, 400–999, ≥1000). Patients were followed for any adverse events at 7 and 30 days after ICA. The study protocol was approved by local institutional review board. All patients gave written informed consent.

Acquisition and analysis of data from computed tomographic angiography

All patients underwent two CT tests (calcium scoring and angiography) using a 256-row CT system (Brilliance iCT, Philips, Eindhoven, The Netherlands). Pre-contrast scanning for calcium scoring was performed by using a standard, prospective ECG gating (40–80% of R-R interval) protocol with 3-mm section thickness and collimation, 300-ms gantry rotation, 120-kVp tube voltage, 925-mA tube current–time product. The scan parameters of CTA were 270-ms gantry rotation, 120-kVp tube voltage, 925-mA tube current–time product with prospective ECG gating when heart rate was <70/min, and 592-mA tube current–time product with retrospective ECG gating when heart rate was >70/min. The tube current–time product was adjusted based on body stature. According to our early experiences, beta-blocker with propranolol (40 mg) was prescribed orally to patient with heart rate >90/min prior to CTA. Non-ionic contrast medium (average 60 mL) (Optiray 350, Taco Healthcare, Montreal, Quebec, Canada) was continuously injected into the antecubital vein at a rate of 4 mL/s when body weight <60 kg or 5 mL/s when body weight >60 kg, followed by a 15–20 mL bolus of saline at a rate of 4 mL/s using a dual-head injector (OptiVantage, Mallinckrodt, Taco Healthcare, Montreal, Quebec, Canada).

Cross-sectional images were reconstructed with a section thickness of 0.9 mm at 0.45 mm interval. If prospective ECG gating was used, the transverse images were reconstructed at 75% of the cardiac cycle; if retrospective gating was used, the transverse images were reconstructed at 40 and 75% of the cardiac cycle. Additional windows were reconstructed after examination of the data sets if motion artefacts were present. The reconstruction interval with the fewest motion artefacts was chosen and used for further analysis. All images were interpreted by two independent radiologists both had more than 5-year cardiac CT experience. All coronary arteries were divided into 14 segments and all coronary segments ≥1.5 mm in diameter were analysed visually. The presence of stenosis ≥50% was considered obstructive. Inter-reader visual differences exceeding 50% were resolved by a third observer. Vessel-based data sets were conducted to create the patient-based data sets used in the primary analysis. Segments that could not be evaluated by any of the three observers were rated as false-positive and were included in the final data sets.

The effective dose to the patients was calculated by the equation:

dose (mSv) = volume CT dose index (CTDIvol in mGy) × scan length (cm) × conversion factor (mSv × mGy⁻¹ × cm⁻¹) = dose-length product (DLP in mGy cm) × conversion factor. The CTDIvol was provided by the CT scanner. The conversion factor is 0.017.

Acquisition and analysis of data from invasive coronary angiography

Invasive coronary angiography was performed using standard techniques for quantitative coronary angiography (QCA). The angiograms were interpreted by two cardiologists who both had over 10-year experience of cardiac catheterization. These two cardiologists were blind to the results of CTA. All coronary artery segments ≥1.5 mm in diameter were analysed visually and quantitatively and condensed to 14 segments for comparison with data from CTA. Quantitative coronary angiography of the most severe stenosis was performed in all segments.

Segment- and vessel-based analysis

In segment-based analysis, all coronary arteries were divided into 14 segments. These 14 segments were (i) proximal right coronary artery (RCA), (ii) middle RCA, (iii) distal RCA, (iv) posterior descending branch, (v) posterolateral branch, (vi) left main coronary artery (LMCA), (vii) proximal left anterior descending artery (LAD), (viii) middle LAD, (ix) distal LAD, (x) all diagonal branches, (xi) proximal left circumflex artery (LCX), (xii) middle LCX, (xiii) distal LCX, and (xiv) all obtuse marginal branches. Intermediate arteries and stents were classified as additional segments. In vessel-based analysis, the coronary arteries were divided into RCA, LMCA, LAD, and LCX. Intermediate arteries were classified as additional vessels.
The native vessels of the patients who accepted coronary artery bypass graft surgery were not included in the final data sets. Only internal mammary arteries and vein grafts were evaluated.

**Statistical analysis**

All data were analysed by SPSS statistical software (SPSS 16.0 version for windows, SPSS, Inc., Chicago, IL, USA). The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of detecting coronary stenosis ≥50% by CTA were compared with ICA by using a 2 × 2 cross-tabulation model. The area under the receiver-operating-characteristic curve (AUC) was used to evaluate the diagnostic accuracy of CTA relative to that of ICA. Confidence intervals (CI) were calculated according to the percentile method. Generalized estimating equation (GEE) method was applied for stenosis evaluation to account for clustering of coronary artery segments within patients.

The statistic power of the subgroup was analysed by GPower software (version 3.0) with χ² test. All tests were two-sided, and a value of \( P < 0.05 \) was considered statistically significant.

**Results**

From December 2008 to June 2009, 112 patients who were eligible for analysis were enrolled. Eight patients were excluded because of long duration from CTA to ICA. Thus, 104 patients were included in the analysis (Figure 1). The baseline characteristics of the patients are shown in Table 1. Most of the ICA was performed within 1 month after CTA examination. The median duration from CTA to ICA was 13.5 days (interquartile range, 7–24 days). None of the patients had serious adverse events 30 days after ICA.
Accuracy of 256-row CT angiography

Table 1  Baseline characteristics of the 104 patients

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex, n (%)</td>
<td>80 (76.9)</td>
</tr>
<tr>
<td>Age (years) Median (range)</td>
<td>61.5 (35–88)</td>
</tr>
<tr>
<td>Body mass index (kg/m²) Median</td>
<td>27.1</td>
</tr>
<tr>
<td>&lt;19, n (%)</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td>19–30, n (%)</td>
<td>89 (85.6)</td>
</tr>
<tr>
<td>&gt;30, n (%)</td>
<td>14 (13.5)</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>37 (35.6)</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>76 (73.1)</td>
</tr>
<tr>
<td>Dyslipidemia, n (%)</td>
<td>71 (68.3)</td>
</tr>
<tr>
<td>Smoking, n (%)</td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>60 (57.7)</td>
</tr>
<tr>
<td>Past</td>
<td>20 (19.2)</td>
</tr>
<tr>
<td>Current</td>
<td>24 (23.1)</td>
</tr>
<tr>
<td>Previous myocardial infarction, n (%)</td>
<td>6 (5.8)</td>
</tr>
<tr>
<td>Prior percutaneous coronary intervention, n (%)</td>
<td>33 (31.7)</td>
</tr>
<tr>
<td>Prior coronary artery bypass graft surgery, n (%)</td>
<td>4 (3.8)</td>
</tr>
<tr>
<td>Previous congestive heart failure, n (%)</td>
<td>2 (1.9)</td>
</tr>
<tr>
<td>Family history of CAD, n (%)</td>
<td>14 (13.5)</td>
</tr>
<tr>
<td>Beta-blocker required before CTA, n (%)</td>
<td>4 (3.8)</td>
</tr>
<tr>
<td>Baseline rhythm on CTA, n (%)</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>101 (97.1)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>3 (2.9)</td>
</tr>
<tr>
<td>Heart rate on CTA Median (range)</td>
<td>45 (45–103)</td>
</tr>
<tr>
<td>&gt;70/min, n (%)</td>
<td>31 (29.8)</td>
</tr>
<tr>
<td>Agatston calcium score, n (%)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>6 (5.8)</td>
</tr>
<tr>
<td>1–99</td>
<td>27 (25.9)</td>
</tr>
<tr>
<td>100–399</td>
<td>42 (40.4)</td>
</tr>
<tr>
<td>400–999</td>
<td>15 (14.4)</td>
</tr>
<tr>
<td>≥1000</td>
<td>14 (13.5)</td>
</tr>
<tr>
<td>Time from CTA to ICA Median (range)</td>
<td>13.5 (0–52)</td>
</tr>
<tr>
<td>&lt;10 days, n (%)</td>
<td>36 (34.6)</td>
</tr>
<tr>
<td>10–29 days, n (%)</td>
<td>50 (48.1)</td>
</tr>
<tr>
<td>30–60 days, n (%)</td>
<td>18 (17.3)</td>
</tr>
</tbody>
</table>

A total of 43 segments had motion artefacts on CTA. Majority of these motion artefacts were very mild and did not interfere interpretation by readers. Only one segment of native vessel was excluded due to motion artefact because of difficult evaluation. The image quality of each segment was evaluable (complete absence of motion artefacts or sufficient to rule out ≥50% stenosis except one segment). Twenty patients and 54 segments required a third reader because of inter-reader visual difference exceeding 50%. The inter-reader variability for stenosis detection by segment in CTA was 3.6%.

Patient-based analysis

The AUC for CTA was 0.744 (95% CI, 0.572–0.916, P = 0.003) for the diagnosis of a patient with at least one coronary stenosis ≥50% as assessed by ICA (Figure 2). The sensitivity of patient-based analysis was 98.8% and the specificity was 50%. The PPV and NPV were 92.4 and 87.5%, respectively. Overall disease prevalence was 86%.

Segment-based analysis

There were a total of 1475 segments in these patients. Two hundred and seventy-seven obstructive segments were detected by CTA and 230 obstructive segments were detected by ICA (Table 2). The AUC for CTA was 0.915 (95% CI, 0.847–0.982, P < 0.001) for the diagnosis of a patient with coronary stenosis ≥50% as assessed by ICA (Figure 2). The sensitivity of segment-based analysis was 93.5% and the specificity was 95%. The PPV and NPV were 77.6 and 98.7%, respectively. Overall disease prevalence was 15.6%. According to GEE method, the odds ratio for segment-based analysis was 273.5 (95% CI, 150.8–496.0). This statistical analysis means that no interdependence problem was observed. Figure 3A shows a critical stenosis in the middle portion of LAD. 3D reconstruction, CTA, and ICA correlated well with each other.

Vessel-based analysis

There were a total of 401 vessels in these patients. One hundred and seventy-nine obstructive segments were detected by CTA and 157 obstructive vessels were detected by ICA (Table 2). The AUC for CTA was 0.887 (95% CI, 0.808–0.966, P < 0.001) for the diagnosis of a patient with coronary stenosis ≥50% as assessed by ICA (Figure 2). The sensitivity of vessel-based analysis was 94.3% and the specificity was 87.3%. The PPV and NPV were 82.7 and 95.9%, respectively. Overall disease prevalence was 39.2%.

Segment-based analysis in patients with different Agatston calcium scores

All patients were divided into three groups by calcium score: <400, 400–999, and ≥1000 (Table 2). In patients with a calcium score <400, the sensitivity, specificity, PPV, and NPV for the diagnosis of coronary stenosis ≥50% were 90.4, 96.3, 79, and 98.5%, respectively. In patients with a calcium score of 400–999, the sensitivity, specificity, PPV, and NPV were 97.1, 94.6, 77.3, and 99.4%, respectively. In patients with a calcium score ≥1000, the sensitivity, specificity, PPV, and NPV were 100, 86.4, 74.2, and 100%, respectively. The low PPV indicates that CTA tends to over-estimate the severity of the heavily calcified lesions.

Analysis of intra-stent stenosis

Thirty-three patients had undergone PCI, and there were 78 stents in total (Table 2). Nine stents were excluded because of small diameter. The sensitivity, specificity, PPV, and NPV for the diagnosis of in-stent stenosis ≥50% were 54.5, 85.1, 37.5, and 91.9, respectively.
Analysis of bypass grafts
Four patients had undergone coronary artery bypass graft surgery, and there were 13 bypass grafts in total (Table 2). The sensitivity, specificity, PPV, and NPV for the diagnosis of bypass graft stenosis ≥50% were 100, 100, 100, and 100%, respectively. Figure 3B reveals an occluded vein graft in a patient with triple vessel disease.

Segment-based analysis in patients with heart rate greater than 70/min
Thirty patients had a heart rate greater than 70/min on CTA, and three patients had atrial fibrillation (Table 1). The sensitivity, specificity, PPV, and NPV for the diagnosis of coronary artery stenosis ≥50% in this group of patients were 95.5, 92.7, 70.3, and 99.1%, respectively. Figure 3C reveals a CTA image from a 71-year-old patient with atrial fibrillation. His heart rate on CTA was 103/min. The quality of the images is still excellent under the situation of tachyarrhythmia.

Effective radiation dose of 256-row computed tomographic angiography
The average radiation dose was 5.1 mSv (range, 2.7–11.1) with the use of prospective ECG gating and 14.8 mSv (range, 7.7–29.3) with the use of retrospective ECG gating.
Evaluation of intra-stent stenosis is difficult and is influenced by stent length, diameter, thickness, and stent design.\textsuperscript{13,14} The angle between stent and X-ray beam also influences the accuracy of stent assessment. Superior visualization can be gained when the stent is oriented parallel to the X-ray beam.\textsuperscript{15} In our study, 37 patients had undergone PCI before and there were 84 stents in total. This number of stents is too small to yield significant statistic results. To confirm the ability of 256-row CTA in detecting intra-stent stenosis, further trials and larger numbers of patients are needed.

It has been well documented that CTA in highly calcified vessels has been difficult and has limited accuracy because of artefacts caused by high-density calcification.\textsuperscript{3,4} Accordingly, patients with high Agatston calcium scores were generally excluded from previous studies of 64-row CTA. We tried to assess the diagnostic accuracy of 256-row CTA in this group of patients. 256-Row CTA can decrease the problem of calcium blooming artefact because of faster gantry rotation times, Z-direction focal-spot sampling, spherical design of the detectors, and a 2D anti-scatter grid placed in front of the detectors. Although the results are acceptable in our study, detecting stenosis in heavily calcified vessels remains challenging in the future. The diagnostic accuracy is influenced by the size, location, and the density of the calcified plaques.\textsuperscript{3,4} Lower PPV (74.2\%) and higher false-positive rates (9.8\%) were found in this study. In our experience, CTA tends to over-estimate the severity of the heavily calcified lesions.

Multi-detector CTA has a role in detecting obstructive graft disease. Computed tomographic angiography and 3D reconstruction can expose the anatomy and location of bypass grafts precisely. Previous studies of 64-row CTA have revealed good correlation with ICA in assessing bypass grafts\textsuperscript{15,16}. However, the presence of stents and calcification may also influence the diagnostic accuracy. In addition, it is also difficult to assess distal runoff arteries.\textsuperscript{15,16} Despite the small number of samples (4 patients and 13 grafts) in our study, the diagnostic accuracy was excellent. 256-Row CTA may become a good tool to provide precise assessment of graft occlusion and patency. More patients and further studies are required to establish the accuracy of 256-row CTA in detecting stenotic bypass grafts.

Tachycardia and arrhythmias are the other limitations of previous multi-detector CTA.\textsuperscript{3,4} In our study, 35 patients (31.3\%) had a heart rate $>$70/min and three patients had atrial fibrillation. Only four patients were prescribed with beta-blockers prior to CT scanning. The low PPV (74.2\%) and high false-positive rate (9.8\%) are attributed to the impact of the highly calcified lesions. By excluding patients with high calcium scores, the results could be better. In the situation of higher heart rates and arrhythmias, 256-row CT still provides favourable diagnostic ability and high image quality. When compared with 64-row CT, 256-row CT can be applied to patients with higher heart rates without the need of beta-blockers to slow heart rate.

Exposure to radiation is a major concern of multi-detector CTA.\textsuperscript{3,4,17} With the use of the prospective ECG-gating technique, the radiation exposure can reduce substantially without decreasing diagnostic image quality.\textsuperscript{6,7} Previous studies reported that 256-row CT is associated with a significant radiation dose reduction.\textsuperscript{8,18} Weigold et al. reported a reduction in radiation dose of more than 50\% by using prospective ECG-gated CTA.\textsuperscript{8} They also...
reported a new radiation dose saving technique by using dynamic z-collimation for retrospectively ECG-gated scans and adaptive z-collimation for prospectively ECG-triggered scans. Both techniques can further reduce the radiation dose of 256-row CT significantly. Another meta-analysis study of 64-row CTA reported a sensitivity of 90%, a specificity of 97%, a PPV of 76%, and an NPV of 96.5% by segment-based analysis. Another meta-analysis study of 64-row CTA reported a sensitivity of 90%, a specificity of 97%, a PPV of 76%, and an NPV of 99%. When using prospective gating, the radiation dose can be reduced to 2.1 mSv by 64-row CTA without measurement of calcium score. However, when using retrospective gating, the radiation dose can be up to 15–25 mSv by 64-row CTA. In our study, the mean radiation dose was 5.1 mSv with the use of prospective gating and 14.8 mSv with the use of retrospective ECG gating. As sinus rhythm and heart rate control are crucial for prospective ECG triggering, rate control to facilitate the use of prospective gating most of the time is very important to reduce radiation dose. When compared with studies of 64-row CTA, our results were not inferior with enrollment of the patients who were usually excluded. The image quality of 256-row CTA is also comparable to that of dual-source CTA. The newest 320-row CTA can acquire images with a single rotation in a single heartbeat. The 320-row CTA can detect 99% coronary arterial segments and reduce radiation dose without significant motion artefact. However, the study patient number is small and the diagnostic accuracy of this newest generation is not known.

Limitations

This is a single-centre study of short-term experience of 256-row CTA. The patient number is not large. Interpretation and reconstruction of the images is operator dependant. Although most of the ICA was performed within 1 month after CTA in our study, the delay of ICA may influence the accuracy of CTA. It is surprising to note that even in the early phase of our learning curve, 256-row CTA produced favourable results. In the hands of more experienced operators, the results might be even better. There is substantial referral bias in our study design. However, in segment or vessel analysis, there are normal segments and stenotic segments and different segments are analysed individually. Therefore, the bias may be reduced. To prevent bias for the interpretation of 256-row CTA and to establish the true diagnostic accuracy of 256-row CTA, studies where patients undergo CTA and ICA successively before the results of the CTA are known are needed. There is substantial selection bias in our study design. More than 70% of patients with suspected CAD on CTA did not accept ICA and were not included in this study. There is another selection bias because those subjects without suspected CAD on CTA did not have ICA.

Conclusion

256-Row CTA accurately identifies the presence and severity of CAD. The AUC of 0.915 by segment-based analysis and 0.887 by vessel-based analysis indicates that 256-row CTA has a powerful diagnostic ability and correlates well with ICA in detecting coronary artery stenosis ≥50%. Our study indicates that 256-row CTA is a high sensitive diagnostic tool and has a high NPV. Therefore, 256-row CTA may be a potential alternative to detect coronary artery stenosis and rule out CAD in suspected patients.

Conflict of interest: none declared.

References

Ventricular septal crypt in hypertrophic cardiomyopathy

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Hypertrophic cardiomyopathy (HCM) is characterized by diverse patterns of left ventricular (LV) hypertrophy. Recently, unusual structural convolutions of the LV wall have been reported, including non-compaction in the distal chamber, and ‘clefts’, ‘crypts’, and ‘crevices’ in portions of the LV free wall. With cardiovascular magnetic resonance (CMR), we have recently identified a striking and unusual configuration of the basal ventricular septum that does not resemble in appearance or location any of the aforementioned patterns. Notably, this particularly deep crypt in the septum differs considerably in appearance from the relatively shallow indentations reported in the posterior (inferior) free wall of HCM gene carriers without LV hypertrophy (suggested as premonitory to the appearance of wall thickening). The clinical significance of this novel morphology, identified only by CMR, is uncertain at this time, although its clinical relevance may emerge as investigators image increasing numbers of HCM patients with CMR.

(Panel A) CMR horizontal long-axis diastolic cross-sectional image from a 25-year-old asymptomatic woman with non-obstructive HCM and maximal LV thickness situated in anterior free wall (23 mm). The particularly deep myocardial crypt in the basal ventricular septum (VS) penetrates the myocardium to a depth of 12 mm leaving only 2 mm of residual septal wall (arrow). Wall thickness in the adjacent area of septum is 15 mm. (Panel B) CMR short-axis image with a linear blood containing area in the posterior (inferior) portion of VS (arrows) identifies the location of the crypt in this plane. (Panel C) Post-contrast image showing delayed enhancement that is confined to anterior free wall (arrows). (Panel D) Post-contrast short-axis image corresponding to Panel B showed no evidence of delayed enhancement. LV, left ventricle; RV, right ventricle; VS, ventricular septum.

This patient had a normal global ejection fraction (75%), absence of regional wall motion abnormalities, and mild systolic anterior motion of the mitral valve without obstruction to LV outflow; coronary arteries were normally positioned at their origins from the aorta. The myocardial crypt was not visualized in standard echocardiographic cross-sectional planes. ECG showed narrow deep Q-waves in II, III, AVF, V3–V6, and delayed progression of precordial R-waves, with diminished or absent R-wave in V1–V3, a not uncommon pattern in HCM. Commercial genetic testing was negative for nine sarcomere genes known to be disease-causing for HCM, as well as LAMP2, PRKAG2, and Fabry disease, a result that occurs in ~50% of patients with clinically diagnosed HCM.

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