Aortic extension of catheter-induced coronary artery dissection: diagnosis, grading and follow-up with MDCT

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Dissection of a coronary artery is a well-known complication of cardiac catheterization and percutaneous coronary intervention. Retrograde extension of the dissection to the ascending aorta, however, is reported as an infrequent and serious complication (1,2).

Aortocoronary dissection is generally suspected at the time of coronary catheterization. Immediate percutaneous coronary stenting will usually be performed to in order to seal the entry point of the dissection. In most cases, urgent cross-sectional imaging is thereafter required for confirmation of the residual iatrogenic aortic dissection, evaluation of its extent, and later for non invasive follow-up, although there is currently no consensus as to which imaging technique should be used.

In this study, we have retrospectively reviewed eight cases of catheter-induced aortocoronary dissection that were referred for multidetector computed tomography (MDCT) evaluation of the aortic extent of the dissection. The objectives of the present study are 1) to describe the findings in MDCT evaluation of retrograde aortic extension of catheter-induced coronary artery dissection, 2) to present a MDCT grading classification of aortocoronary dissection, and 3) to discuss the use of MDCT in the follow-up of this complication.
Methods and Materials

MATERIAL AND METHODS

Patients

The cases of iatrogenic aortocoronary dissection that were referred to our two centers for MDCT evaluation between February 2004 to September 2009 were retrospectively reviewed and included in this study. This study was approved by the institutional review board of our two centers, and the requirement for informed consent was waived.

Eight patients (5 males, 3 females), with a mean age of 71 years (56 to 80 years) were referred for evaluation of aortocoronary dissection during this period.

Three patients were admitted for acute myocardial infarction, three patients had unstable angina, and the remaining two had stable angina. All patients underwent cardiac catheterization. The access site for catheterization was the right radial artery in six patients and the right femoral artery in one patient. One patient was catheterized first through the right radial artery and then through the right femoral artery. One patient had no significant (# 50 % luminal narrowing) coronary artery stenosis, two patients had one coronary artery disease, and five patients had double vessel disease (Table 1).

Imaging

MDCT evaluation was performed either on a 16-slice CT (Lightspeed 16, General Electric Healthcare), a 64-slice CT (Lightspeed VCT, General Electric Healthcare), or a 256-slice CT (iCT, Philips Healthcare). For CT angiography, collimation varied from 0.6 - 1.2 mm, and gantry rotation from 500 to 270 msec. ECG-gating (retrospective or prospective) was usually used when heart rate was < 80 bpm. No ECG-gating was used when heart rate was > 80 bpm. Non ionic contrast medium (iopamidol-370 (Isovue® -370, Bracco Imaging, Milan, Italy) and iodixanol-320 (Visipaque™ -320; GE Healthcare, Princeton, NJ), 100 ml) was injected at a rate of 5 mL/s through an 18-gauge needle into right antecubital vein.

Diagnostic catheter coronary angiograms were performed using a standard protocol, and interventional strategy and choice of device were decided by the attending physician.

The MDCT angiographic examinations and catheter coronary angiograms were all reviewed retrospectively, by a radiologist with 12-year experience in chest CT and
catheter coronary artery angiography interpretation (CCL), and correlated with the initial reports of these examinations.

MDCT angiography was used to confirm the retrograde aortic extension of the aortocoronary dissection. Aortic involvement was graded based on the Dunning (3) criteria for classification of aortocoronary dissection developed for conventional angiography. The level of the most superior extent of the intimal flap was used to localize the highest level of aortic extension. We defined a grade 1 aortic extent of the dissection when the dissection flap involved the ipsilateral Valsalva sinus only; a grade 2 dissection when the sinus of Valsalva and the tubular portion of the ascending aorta were involved, for a length of 40 mm or less; and a grade 3 dissection when the dissection flap extended into the ascending aorta for more than 40 mm in length (Figure 1). We define the ascending aorta as the aortic root component (aortic valve annulus, sinuses of Valsalva, sinotubular junction) and the tubular portion, up to the origin of the right subclavian artery.
Aortic involvement was graded based on the Dunning (3) criteria for classification of aortocoronary dissection. The level of the most superior extent of the intimal flap is used to localize the highest level of retrograde aortic extension of the dissection. The aortic extent and grading is illustrated in gray shading. Grade 1 aortic extent of the dissection: the dissection flap involves the ipsilateral Valsalva sinus only; Grade 2 dissection: the sinus of Valsalva and the tubular portion of the ascending aorta are involved, for a length of 40 mm or less; Grade 3 dissection: the dissection flap extends into the ascending aorta for more than 40 mm in length. Chartrand-Lefebvre et al., University of Montreal Medical Center, Montreal Heart Institute

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Results

Retrograde aortic extension of coronary artery dissection occurred in the catheterization laboratory in all 8 cases, either during the diagnostic portion of the conventional coronary angiogram (5 patients), or during percutaneous coronary intervention (PCI) (3 patients). The aortocoronary dissection involved the right coronary artery in seven patients (88%), and the left coronary artery in one patient. In two cases, the dissection involved a normal coronary artery (patients 5 and 7).

The dissection of the coronary artery was visible with conventional coronary artery angiography in all cases. Persistent dye staining extending to the aorta during conventional coronary artery angiography made the index of suspicion for retrograde aortic dissection high and prompted the request for MDCT evaluation.

MDCT evaluation allowed confirmation and grading of the retrograde aortic dissection in all cases, according to the classification shown in Figure 2 (Table). There were three cases of grade 1 aortic extent of dissection (Figure 3), three cases of grade 2 (Figures 4, 5) and two cases of grade 3 (Figures 6-8). In all 8 cases of retrograde aortic dissection, only the ascending aorta was involved. In general, superior image quality was obtained when ECG-gating was performed.

Immediate coronary stenting by the interventional cardiologist was successfully performed in two cases of grade 1 dissection, two cases of grade 2 dissection, and one case of grade 3 dissection, with no adverse patient event. In one patient (patient no 7), despite successful stenting, the temporary obstruction of the right coronary artery was associated with a periprocedural inferior left ventricular myocardial infarction. Coronary stenting failed in a case of grade 3 dissection involving the right coronary artery (patient no 8). This patient went to surgery, where massive right ventricular infarction was found. Surgical replacement of the ascending aorta, as well as aortocoronary bypass of the right and left coronary arteries was successfully performed. However, the patient died several hours later. Conservative management was chosen for one case of grade 1 dissection, and one case of grade 2, without any other adverse events.

Timing of MDCT examinations was decided by the referring clinician, after consultation with the radiologist (Figure 2). In 7 out of 8 patients, the first MDCT was done less than one hour after the end of the catheterization procedure. Six patients underwent a second MDCT, one day later in most cases (5 out of 6 cases). Three patients underwent a repeat MDCT one week after occurrence of the dissection. The longest CT follow-
up was performed at 45 days, for a grade 3 patient (patient no 1, Figure 7)). Available imaging follow-up of the aortic extent of the dissection with MDCT demonstrated a gradual decrease in the length and diameter of the dissection in all patients (Figure 7). There was no case of progression of the dissection on imaging follow-up.
**Fig. 0:** Aortic involvement was graded based on the Dunning (3) criteria for classification of aortocoronary dissection. The level of the most superior extent of the intimal flap is used to localize the highest level of retrograde aortic extension of the dissection. The aortic extent and grading is illustrated in gray shading. Grade 1 aortic extent of the dissection: the dissection flap involves the ipsilateral Valsalva sinus only; Grade 2 dissection: the sinus of Valsalva and the tubular portion of the ascending aorta are involved, for a length of 40 mm or less; Grade 3 dissection: the dissection flap extends into the ascending aorta for more than 40 mm in length. Chartrand-Lefebvre et al., University of Montreal Medical Center, Montreal Heart Institute

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**Fig. 0:** Table 1 - Characteristics of patients with aortocoronary dissection

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Sex/ Age</th>
<th>Previous cardiac interventions</th>
<th>Indication for CCA ± PCI</th>
<th>Arteries with significant stenosis</th>
<th>Side of dissection</th>
<th>Dissection occurred during</th>
<th>Dunning grade dissection</th>
<th>No of stents deployed</th>
<th>No. of CT scans</th>
<th>Evolutio of dissection based on CT scans</th>
<th>Timing of CT scans (from catheterization laboratory)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F / 80</td>
<td>none</td>
<td>Acute MI</td>
<td>LAD, RCA</td>
<td>R</td>
<td>CCA</td>
<td>3</td>
<td>1</td>
<td>5 (NG)</td>
<td>↓</td>
<td>&lt;1h, 36h, 5d, 9d, 6w</td>
</tr>
<tr>
<td>2</td>
<td>M / 58</td>
<td>CABG</td>
<td>Unstable angina</td>
<td>LAD, Cx, RCA</td>
<td>R</td>
<td>CCA</td>
<td>2</td>
<td>0</td>
<td>2 (G)</td>
<td>↓</td>
<td>&lt;1h, 48h</td>
</tr>
<tr>
<td>3</td>
<td>M / 79</td>
<td>none</td>
<td>Acute MI</td>
<td>LMCA, LAD</td>
<td>R</td>
<td>CCA</td>
<td>2</td>
<td>4</td>
<td>2 (G)</td>
<td>↓</td>
<td>13h, 6d</td>
</tr>
<tr>
<td>4</td>
<td>M / 56</td>
<td>CCA</td>
<td>Stable angina</td>
<td>RCA</td>
<td>R</td>
<td>PCI</td>
<td>1</td>
<td>3</td>
<td>2 (G)</td>
<td>↓</td>
<td>&lt;1h, 31h</td>
</tr>
<tr>
<td>5</td>
<td>F / 78</td>
<td>CCA + PCI</td>
<td>Unstable angina</td>
<td>RCA, Cx (LMA)</td>
<td>PCI</td>
<td>0</td>
<td>3 (NG)</td>
<td>↓</td>
<td></td>
<td>&lt;1h, 24h, 7d</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>M / 74</td>
<td>none</td>
<td>Acute MI</td>
<td>RCA</td>
<td>R</td>
<td>PCI</td>
<td>1</td>
<td>5</td>
<td>1 (G)</td>
<td>—</td>
<td>&lt;1h</td>
</tr>
<tr>
<td>7</td>
<td>F / 70</td>
<td>CCA</td>
<td>Atypical angina</td>
<td>none</td>
<td>R</td>
<td>CCA</td>
<td>2</td>
<td>4</td>
<td>2 (G)</td>
<td>↓</td>
<td>&lt;1h, 48h</td>
</tr>
<tr>
<td>8</td>
<td>M / 73</td>
<td>none</td>
<td>Unstable angina</td>
<td>LAD, RCA</td>
<td>R</td>
<td>CCA</td>
<td>3</td>
<td>failure</td>
<td>1 (G)</td>
<td>—</td>
<td>&lt;1h</td>
</tr>
</tbody>
</table>

Note: CABG: coronary artery bypass surgery, CCA: conventional coronary angiography, PCI: percutaneous coronary intervention, MI: myocardial infarction, LAD: left anterior descending artery, RCA: right coronary artery, Cx: Circumflex artery, LMCA: left main coronary artery, #: regression of the aortic extent of the dissection on follow-up, h: hours, d: days, w: weeks, G: ECG-gated scan, NG: non ECG-gated scan

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Fig. 0: Grade 1 aortocoronary dissection in a 56-year-old male, initially evaluated for stable angina. A, Conventional right coronary artery angiography shows a long dissection of the right coronary artery, with a small retrograde extension to the ipsilateral sinus of Valsalva (arrow). Right coronary artery stenting was done in the same session. B,C,D,E, ECG-gated 16-slice MDCT angiography, axial view, done immediately after catheterization laboratory. An intimal flap (arrows) is seen in the right sinus of Valsalva, with a tiny circulating false lumen. The dissection is adjacent to the right coronary ostium. The proximal part of a patent right coronary artery stent is visible. Chartrand-Lefebvre et al., University of Montreal Medical Center, Montreal Heart Institute

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**Fig. 0:** Grade 2 aortocoronary dissection in a 70-year-old female, presenting initially with atypical chest pain. The left conventional diagnostic coronary angiogram and the first and second sequences of the right angiogram demonstrated no significant coronary artery stenosis (not shown). A, The third sequence of the right coronary angiogram showed the appearance of a long dissection of the right coronary artery. B, A later sequence showed the appearance of a grade 2 retrograde aortic dissection (arrows). C, Final result after immediate right coronary artery stenting shows a patent coronary artery, with aortic persistent dye staining. Chartrand-Lefebvre et al., University of Montreal Medical Center, Montreal Heart Institute

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Fig. 0: Grade 2 aortocoronary dissection in a 70-year-old female (same patient as in Figure 4). A, Non-contrast ECG-gated 64-slice MDCT performed immediately after catheterization laboratory demonstrates persistent highly dense contrast staining in the anterior aortic wall (arrow). B,C,D, ECG-gated 64-slice MDCT angiography (same session as A). The grade 2 aortic extent of the dissection is seen (B, D), involving the root and the tubular portion of the ascending aorta. The false lumen has a circulating inferior part (D, black arrow), at the level of the right sinus of Valsalva, with the superior part containing dense contrast agent (D, white arrow) from the previous conventional angiogram. The stented right coronary artery is patent (B, C). Chartrand-Lefebvre et al., University of Montreal Medical Center, Montreal Heart Institute

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Fig. 0: Grade 3 aortocoronary dissection in a 80-year-old female, presenting initially with chest pain. Conventional coronary artery angiography A, The first sequence of the right angiogram shows an occluded right coronary artery (arrow). B, Appearance of right coronary artery dissection, with grade 3 retrograde extent to the ascending aorta (arrows); a guidewire is in the coronary artery. C, Direct stenting of the coronary artery ostium at the suspected entry site. D, Final result in the catheterization laboratory shows a patent coronary artery, with aortic persistent dye staining. Chartrand-Lefebvre et al., University of Montreal Medical Center, Montreal Heart Institute

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Fig. 0: Grade 3 aortocoronary dissection in a 80-year-old female (same patient as in Figure 6). A, Conventional aortography, done in the catheterization laboratory, shows a dissection flap (arrow) in the ascending aorta, separating the true lumen from the circulating false lumen. B-C-D, Non-gated 16-slice MDCT angiography. The aortic dissection in oblique MPR (B) and axial view (C) is well seen, less than 2 hours after the percutaneous coronary artery intervention, adjacent to the ostium of the right coronary artery. The false lumen is mostly non circulating. Partial regression of the dissection is noted after 2 two days (D), and complete regression after 6 weeks (E). Chartrand-Lefebvre et al., University of Montreal Medical Center, Montreal Heart Institute

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Fig. 0: Grade 3 aortocoronary dissection in a 73-year-old male with instable angina. A,C, Non-contrast ECG-gated 64-slice MDCT performed immediately after catheterization laboratory demonstrates persistent highly dense contrast staining in the anterolateral aortic wall (arrows). B,D,E, ECG-gated 64-slice MDCT angiography (same session as A,C). The grade 3 aortic extent of the dissection is seen, involving the root and the tubular portion of the ascending aorta. F, Intraoperative ultrasound shows a partially thrombosed false lumen of the ascending aorta. Chartrand-Lefebvre et al., University of Montreal Medical Center, Montreal Heart Institute

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DISCUSSION AND CONCLUSION

Catheter-induced coronary artery dissection with retrograde extension to the ascending aorta is reported as a rare event (4, 5), and to our knowledge has never been described in the radiology literature. However, interventional cardiologists increasingly are treating more complex lesions percutaneously, and the true incidence of this entity is unknown and may be underestimated. Eight patients with iatrogenic aortocoronary dissection referred to our institution in the last five years were retrospectively reviewed to assess for the extent of retrograde aortic dissection. This is one of the largest series of patients with catheter-induced aortocoronary dissection, and the largest series of CT imaging of this pathology. While most of these cases were managed successfully with coronary artery stenting in the catheterization laboratory, there was one death in our series. Practicing radiologists should be aware of this urgent and serious entity, as well as of the benefits of MDCT for confirming the diagnosis of retrograde aortic extension of the dissection, grading its extent, and follow-up of its evolution in time.

The treatment of choice of aortocoronary dissection usually involves an immediate stenting limited to the coronary artery and its ostium, in order to seal the entry point of the dissection, without intervention on the aortic extent of the dissection (4,5). In some cases, localized aortocoronary dissections that appear stable throughout the procedure can probably be managed conservatively (1). Surgical intervention on the aorta, either with aortic replacement or glue aortoplasty (6,7), along with aortocoronary bypass, may be considered depending on the result of immediate coronary stenting (4), aortic extent (3) or progression (8) of the dissection, and clinical condition of the patient. In our series, immediate coronary stenting was performed in five patients and conservative management in two patients, with a favourable outcome. One patient required emergent surgery after right coronary artery stent failure and massive right ventricular infarction, and died shortly after surgery.

In our patients, aortocoronary dissection was the complication of a catheter-induced dissection of the right coronary artery in seven out of eight patients (88 %), and of the left coronary artery and corresponding sinus of Valsalva in one patient. These findings are consistent with the literature: 89% of aortocoronary dissections involve the right side, while 11% involve the left side (9).

Invasive and non invasive imaging methods have been employed to visualize and follow aortocoronary dissection induced in the catheterization laboratory. Trans-oesophageal echocardiography provides an accurate definition of the aortic dissection, enables an
evaluation of the aortic valve function and can be performed in the catheterization laboratory (1,4,9). However this technique is limited by its 2-dimenstional character, and is operator-dependant. In the catheterization laboratory, catheter coronary angiography and aortography are used for immediate diagnosis of the coronary artery dissection and its aortic extent. Intravascular ultrasound has also been used in order to identify the entry point of the dissection (10). However, these invasive imaging methods are seldom employed during follow-up (11,12,13). Finally, intensive surveillance and monitoring is needed in most patients with aortocoronary dissection, which is a potential drawback for the use of magnetic resonance for baseline confirmation of the aortic dissection. It has been be used for follow-up of the aortic extent of the dissection in some cases (14).

In our opinion, MDCT is the non-invasive imaging modality of choice for precise diagnosis and follow-up of the aortic extent of a coronary artery dissection induced in the catheterization laboratory. It can provide 3-dimensional images with a high spatial resolution and detailed information on the anatomy of the aortic root, and the relationship of the coronary leaflets and the ostia of the coronary artery (15). Moreover, ECG-gating eliminates pulsation motion artifacts in the ascending aorta, the aortic valve and the sinuses of Valsalva (15,16), and should be used when available. It is easily performed in intensive care unit patients, and offers high reliability during follow-up.

Non-contrast MDCT performed immediately after catheterization laboratory in patients with aortocoronary dissection can demonstrate persistent highly dense contrast staining in the aortic wall (Figures 4, 7) (17). Contrast-enhanced MDCT can show a circulating or thrombosed aortic false lumen (Figures 2,4,6,7), as well as extra-aortic complications that could occur in aortic dissection in general. Using a grading classification of the aortocoronary dissection according to the superior aortic extension (Figure 1), we were able to grade the dissection in our eight cases. Grading of the aortic extension of the dissection may influence the choice of treatment. Dunning et al. (3) has recommended emergent surgery for patients with an aortic involvemnet of more than 40 mm (grade 3). One of our two patients with grade 3 dissection was treated with immediate coronary stenting without surgery, with an excellent outcome (Figures 5, 6). Follow-up MDCT in this patient showed regression of the aortic dissection after 6 weeks (Figure 6). In the literature, other patients with stable grade 3 aortic extent were also treated without surgery (9,18,19). On the other hand, Hunt et al. (8) reported two patients with grade 3 aortic extent who needed surgical intervention following rapid progression of the dissection over 24 h. Nomura et al. reported a patient who went to surgery because of an asymptomatic delayed progression of a retrograde aortic dissection, occurring 20 days after catheter-induced coronary dissection (20). The outcome of our other patient with grade 3 aortic extent of the dissection seems to be related to the occluded right coronary artery, whose dissection could not be reopened percutaneously, rather than to the high grade of the aortic extension. This patient suffered a massive right ventricular infarction and died.
In conclusion, coronary artery dissection with retrograde extension to the ascending aorta can occur as a complication of cardiac catheterization, with potentially fatal consequences. Interventional cardiologists now attempt to treat more and more complex lesions percutaneously, and the true incidence of this complication could be higher than previously reported. Aortocoronary dissection is usually managed with immediate coronary artery stenting of the entry point. Subsequent non invasive imaging of the residual retrograde aortic extension of the dissection for further evaluation, grading and close monitoring can be done with MDCT.
References


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