Thrombus in the Right Coronary Sinus of Valsalva Originating From the Left Atrial Appendage Causing Embolic Inferior Wall Myocardial Infarction

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Abstract
Acute myocardial infarction (MI) is commonly a result of coronary atherosclerotic plaque rupture and superimposed thrombus formation. Nevertheless, uncommon causes of MI including embolism from aortic root and ascending aorta mural thrombi must be considered when coronary atherosclerotic disease is not evident. We report a case of an 84-year-old woman who presented with an inferior ST-segment elevation MI. Initial attempts to engage the right coronary artery (RCA) were unsuccessful. Aortic angiography revealed evidence of the left coronary artery ostium with absence of the right coronary ostium or RCA. Probing with a coronary wire where the RCA ostium was presumed to be located yielded resolution of the ST-segment elevation. The RCA was then easily engaged using a guide catheter, and angiographic evaluation showed a smooth vessel with no evidence of coronary artery disease except for abrupt termination of the distal PL2 branch. Contrast-enhanced computed tomography revealed an aortic root thrombus extending into the right coronary sinus of Valsalva and a thrombus in the left atrial appendage. The case reveals RCA embolism from an aortic root thrombus likely originating from the left atrial appendage. A conservative approach to treatment with anticoagulation was pursued that resulted in full recovery. A review of the literature revealed that the etiology of aortic root thrombi is proposed to be multifactorial. Prospective randomized studies are needed to demonstrate the best treatment approach, although this appears to be impracticable given the rarity of the disease.

Keywords
aortic root thrombus, left atrial appendage thrombus, embolic myocardial infarction

Introduction
Acute myocardial infarction (MI) is commonly a result of coronary atherosclerotic plaque rupture and superimposed thrombus formation. Nevertheless, uncommon causes of MI including embolism from aortic root and ascending aorta mural thrombi must be considered when coronary atherosclerotic disease is not evident. The mechanism behind aortic root thrombus formation remains unclear and is likely multifactorial incorporating all 3 components of the Virchow’s triad. This report presents a rare case of acute MI secondary to a thrombus in the right coronary sinus of Valsalva possibly originating from the left atrial appendage, successfully treated with anticoagulation. We reviewed the literature for similar cases and discussed the possible etiopathogeneses and different treatment modalities for this rare entity.

Case Presentation
An 84-year-old woman with hypertension presented to the emergency department with epigastric pain, nausea, and dizziness for 3 hours. A 12-lead electrocardiogram showed a junctional rhythm at rate of 40 and 2 mm inferior ST-elevations with lateral ST depressions. High-sensitivity troponin-I level was 0.01 ng/mL. Initial management included aspirin, clopidogrel, and intravenous heparin, and she was subsequently taken emergently to the catheterization laboratory. Attempts to engage the right coronary artery (RCA) were unsuccessful despite using multiple guide catheters. The left coronary system showed no angiographic evidence of coronary artery disease except for abrupt termination of the distal PL2 branch. Contrast injection in the right coronary sinus suggested ostial total occlusion of the RCA (Figure 1A). Probing with a coronary wire near where
the RCA ostium was presumed to be located was associated with an increase in the heart rate with an idioventricular rhythm and resolution of inferior ST-elevation. The RCA was then easily engaged with a guide catheter. Angiographic evaluation of the RCA showed a smooth vessel with no evidence of coronary artery disease except for abrupt termination of the distal PL2 branch (Figure 1B). A computed tomography angiogram was then done to explore the cause of the right ostial occlusion and revealed an aortic root thrombus (21 × 16 mm) with extension into the right coronary sinus, together with near complete obliteration of the left atrial appendage with another large thrombus (Figure 2A and B). Serial electrocardiograms demonstrated paroxysmal atrial fibrillation with complete resolution of inferior ST-segment elevation. Subsequent troponin-I levels peaked at 74 ng/mL. A transthoracic echocardiogram showed inferobasal septal hypokinesis and ejection fraction of 45%. A brain magnetic resonance imaging obtained secondary to mental status changes that occurred a few hours after the procedure showed multiple embolic cerebral infarcts and complete occlusion of the left internal carotid artery. The patient was treated with intravenous heparin and bridged to warfarin therapy. She was discharged home in good condition on hospital day 5. Follow-up 6 months after

Figure 1. Aortic root angiogram showing evidence of the left main coronary artery originating from the left coronary artery ostium (white arrow) with absence of the right coronary ostium or right coronary artery (red arrow; A) and a right anterior oblique view of the right coronary artery showing no angiographic evidence of coronary artery disease with abrupt occlusion of the distal posterolateral branch (PL2, red arrow; B).

Figure 2. Contrast-enhanced computed tomography revealed the presence of an aortic root mass 21 × 16 mm suggestive of a thrombus, extending into the right coronary sinus of Valsalva (red arrow; A) with near complete obliteration of the left atrial appendage with another large thrombus (red arrow; B).
the index hospitalization revealed no symptoms or signs of disease recurrence.

Discussion

Although atherosclerotic coronary artery disease is the major cause of acute coronary syndrome, thromboembolism remains a well-recognized etiology for MI. Mural thrombosis of the aorta is well described in patients with clinical evidence of thromboembolic disease and also in asymptomatic patients. The majority of these cases are associated with aneurysmal disease with nonaneurysmal mural thrombosis of the ascending aorta being an exceedingly rare entity. A large postmortem study evaluating 10671 autopsy specimens showed a 0.4% incidence of nonaneurysmal thoracoabdominal aortic mural thrombosis, with only 0.1% of cases involving the ascending aorta. While systemic embolism seems to be the main determinant of morbidity and mortality in this uncommon disease, data on coronary artery occlusion secondary to aortic thrombi is limited to case reports and case series. We report a rare case of nonaneurysmal aortic root thrombus originating from the left atrial appendage extending into the right coronary sinus of Valsalva causing complete ostial occlusion of the RCA presenting with acute MI. A PubMed search identified 16 similar cases of aortic root thrombi causing RCA embolic MI (Table 1).

The etiology of thrombus formation in the aorta remains unclear and is likely multifactorial, incorporating all 3 arms of the Virchow’s triad (blood stasis, hypercoagulable state, and endothelial injury). First, the aorta is a site of high blood flow velocity that precludes blood stasis and thrombus formation. Nevertheless, the aortic sinuses instigate the development of eddy currents that function in holding the aortic valve leaflets away from the aortic wall aiding in their closure during systole. These currents create blood stasis and turbulence increasing the likelihood of thrombus formation in the aortic sinuses. Furthermore, endothelial injury is also a likely culprit. In 7 of the 16 previously described cases, aortic wall abnormalities were noted. Bertrand et al described a ruptured atherosclerotic plaque while the remaining 6 cases identified superficial erosive lesions. Although the current paradigm states that plaque rupture is a prerequisite to thrombus formation, it was shown that superficial endothelial erosions with an intact nonruptured fibrous cap may lead to superimposed thrombus formation. This observation was found to be more common in women with prothrombotic risk factors including smoking, diabetes, and hyperlipidemia, which were evident in the majority (5/6) of our reviewed cases with aortic plaque erosions. The last arm of the Virchow’s triad—hypercoagulable state—also plays a role and was evident in 9 of the reported cases.

Risk factors reported included prosthetic aortic valves, heparin-induced thrombocytopenia, protein S deficiency, and estrogen and progesterone hormonal therapy. Ennezat et al and Eguchi et al reported multiple thrombi attached to different sites of the ascending aorta and aortic arch, which favors the hypercoagulable state as a contributor to thrombus formation rather than local aortic wall atherosclerotic disease. In the cases by Decker et al and Shahin et al, no risk factors for hypercoagulable state or aortic wall disease were identified. The authors proposed retrograde thrombus migration from the RCA to the aorta. The only reported case that reported atrial thrombosis as the source of aortic root thrombosis was that by Mizuguchi et al. Similarly, we suspect that the source of aortic thrombus in our patient is likely the left atrial appendage. However, we feel that other factors including aortic wall endothelial injury cannot be excluded as contributors on the basis of noninvasive diagnostic studies.

Appropriate treatment of thrombi in the ascending aorta remains unclear and multiple modalities of treatment have been described including anticoagulation, thrombolysis, catheter thromboembolectomy, and surgical thromboembolectomy. Most reported cases of RCA occlusion secondary to aortic root thrombus were treated with surgical thromboembolectomy. The rationale underlying an invasive approach lies behind the risk of recurrent embolism associated with conservative treatment with anticoagulation. In a study by Laperche et al, 15 patients with thrombi in the aortic arch were treated with long-term anticoagulation and 22% suffered recurrent embolism. In a meta-analysis of case reports and case series conducted by Fayad et al, surgical intervention was found to be associated with better outcomes when compared with anticoagulation therapy for nonaneurysmal, nonatherosclerotic mural thrombi. Due to our patient’s elderly age and the considerable risk of mortality associated with cardiac surgery following acute MI, we decided to pursue medical management. Our case is one of a few that demonstrated success of conservative medical management with anticoagulation in patients with RCA occlusion secondary to aortic thrombi.

Conclusion

Acute MI with absence of coronary atherosclerotic disease should warrant the consideration of embolic disease complicating aortic root thrombosis. This carries great importance, as treatment may be substantially different than that of conventional atherosclerotic coronary artery occlusion. Prospective randomized studies are needed to demonstrate the best treatment approach, although this appears to be impracticable given the rarity of the disease.
Table 1. Reported Cases of Aortic Root Thrombi Causing Right Coronary Artery (RCA) Occlusion.

| Author/Year | Age/Gender | Risk Factors | Thrombus Size/Location | Method of Diagnosis | Clinical Presentation | Non-Coronary Embolization | Aortic Wall Pathology | Treatment | Outcome |
|-------------|------------|--------------|------------------------|---------------------|-----------------------|--------------------------|------------------------|-----------|---------|
| Ennezat et al\(^3\) (2006) | 60/Male | Prosthetic aortic valve | Non–coronary sinus of Valsalva | TEE | Inferolateral MI | Cerebral embolism | Not reported | Aspirin, heparin | Uneventful survival |
| 69/Male | Prosthetic aortic valve | Right coronary sinus of Valsalva | TEE | Inferolateral MI | Cerebral embolism | Not reported | Aspirin, warfarin | Uneventful survival |
| Knoess et al\(^4\) (2007) | 30/Female | Smoking | 8 × 20 cm | Autopsy | Absent | Absent | Absent | Absent | Death |
| | | DM | | | | | | | |
| | | Pregnancy | | | | | | | |
| | | AF | | | | | | | |
| | | Protein C and S deficiency | | | | | | | |
| Mizuguchi et al\(^5\) (1994) | 78/Female | Absent | 40 × 30 mm | Contrast-enhanced CT | Absent | Absent | Absent | Surgical thrombectomy | Uneventful survival |
| | | Right coronary sinus of Valsalva | | | | | | | |
| Nakamori et al\(^6\) (2009) | 78/Female | Absent | 1 cm above the RCA ostium | Autopsy | Absent | Absent | Absent | Catheter thrombus aspiration | Uneventful survival |
| | | Right coronary sinus of Valsalva | | | | | | | |
| Tamura et al\(^7\) (2011) | 59/Male | Smoker | Right coronary sinus of Valsalva | TEE | Inferolateral MI | Absent | Absent | Aortic wall erosion | Surgical thrombectomy | Uneventful survival |
| | | | | | | | | | |

(continued)
| Author/Year | Age/Gender | Risk Factors | Thrombus Size/Location | Method of Diagnosis | Clinical Presentation | Non–Coronary Embolization | Aortic Wall Pathology | Treatment | Outcome |
|------------|------------|--------------|------------------------|---------------------|-----------------------|--------------------------|------------------------|-----------|---------|
| Nishizaki et al10 (2003) | 49/Female Smoking | Ascending aorta | CT | Inferior MI | Renal artery | Erosion of atheromatous plaque | Surgical thrombectomy | Uneventful survival |
| Bertrand et al11 (2009) | 61/Male Not reported | Ascending aorta above the RCA ostium | Left anterior oblique ventriculography | Inferior MI | Absent | Ulcerated atheromatous plaque | Surgical thrombectomy | Uneventful survival |
| Eguchi et al12 (2004) | 56/Male Smoking | 18 × 4 mm | TEE | Inferolateral MI Absent | Aortic wall erosion | Surgical thrombectomy | Uneventful survival |
| Shahin et al13 (2002) | 37/Female Smoking | RCA with extension to the aorta from the RCA ostium | TEE | Inferior MI | Absent | Not reported | Surgical thrombectomy | Uneventful survival |
| Kristiansen et al14 (1996) | 41/Male HTN | 10 mm | TEE | Inferior MI | Limb ischemia | Absent | Surgical thrombectomy | Uneventful survival |
| Decker et al15 (1995) | Female (age not reported) | Not reported | Ascending aorta | TEE | MI (anatomy not specified) | Absent | Absent | Heparin | Uneventful survival |
| Dik et al16 (1993) | 46/Female Smoking Progesterone therapy | Ascending aorta near the RCA ostium | TEE | Inferior MI | Absent | Aortic wall erosions | Surgical thrombectomy | Uneventful survival |

Abbreviations: AF, atrial fibrillation; CECT, contrast-enhanced computed tomography; COCPs, combined oral contraceptive pills; CT, computed tomography; DM, diabetes mellitus; HIT, heparin-induced thrombocytopenia; HLD, high-density lipoprotein; HTN, hypertension; MDCT, multidetector computed tomography; MDMA, methylenedioxymethamphetamine; MI, myocardial infarction; TEE, transesophageal echocardiography.
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