Section: Cardiothoracic Surgery

Case Series

ISCHEMIC SUB MITRAL ANEURYSMS - A RARE CASE SERIES

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ABSTRACT

Background: Sub-mitral aneurysm (SMA) is a rare left ventricular outpouching traditionally considered a congenital anomaly. Acquired inflammatory, infectious, and ischemic forms have also been described. Ischemic SMA associated with coronary artery disease is particularly uncommon and may present with variable clinical manifestations.

Case Series: We present a case series of three patients with ischemic sub-mitral aneurysms associated with coronary artery disease. Patients presented with chest pain, left ventricular dysfunction, and aneurysmal pathology in the setting of myocardial ischemia. Echocardiography and coronary angiography were used for initial diagnosis and assessment of coronary anatomy, ventricular function, and associated mitral regurgitation. Cardiac magnetic resonance imaging provided detailed anatomical and functional characterization of the aneurysm in one patient. All three patients underwent surgical repair using a polytetrafluoroethylene patch, with concomitant coronary revascularization where indicated. The postoperative course was uneventful in all patients, with improvement in left ventricular systolic function during follow-up.

Conclusion: Ischemic sub-mitral aneurysm is an extremely rare but clinically important entity that should be considered in patients with coronary artery disease presenting with unexplained mitral regurgitation, heart failure, or left ventricular aneurysmal pathology. Multimodality imaging facilitates accurate diagnosis, anatomical assessment, and surgical planning. Early recognition and individualized surgical management may prevent potentially life-threatening complications and result in favorable clinical outcomes.

Keywords: Sub-mitral aneurysm; Ischemic left ventricular aneurysm; Coronary artery disease; Myocardial infarction; Mitral regurgitation; Cardiac magnetic resonance imaging; Multimodality imaging; Surgical repair.

INTRODUCTION

Sub-mitral aneurysm (SMA) of the left ventricle (LV) is a rare cardiac outpouching arising in relation to the posterior mitral annulus. It was initially described predominantly in individuals of African ancestry, but subsequent reports have documented the condition across different ethnic groups, including patients from India. The lesion is traditionally considered congenital and has been attributed to a developmental defect or weakness at the junction between the posterior mitral annulus, fibrous skeleton, and adjacent LV myocardium. However, acquired forms have also been described in association with inflammatory, infectious, rheumatic, and ischemic cardiac disease.[1-6]

The clinical spectrum of SMA is broad, ranging from an incidental or asymptomatic finding to clinically significant mitral regurgitation, left ventricular dysfunction, heart failure, ventricular

arrhythmias, thromboembolic events, myocardial ischemia, and, rarely, ventricular rupture or sudden cardiac death.[7-9] Mitral regurgitation is an important consequence because the aneurysm can distort the posterior mitral annulus and subvalvular apparatus, resulting in impaired leaflet coaptation. Although submitral aneurysms are well recognized in congenital and inflammatory settings, an ischemic origin is distinctly uncommon and may be difficult to distinguish from a conventional post-myocardial-infarction LV aneurysm. Multimodality imaging, including echocardiography, coronary angiography, cardiac computed tomography, and cardiac magnetic resonance, can help define the aneurysm, establish its relationship to the mitral valve and coronary arteries, assess LV function, and support identification of the underlying etiology. In this case series, we describe three patients with ischemic sub-mitral aneurysms associated with coronary artery disease, highlighting their varied clinical presentations, imaging characteristics, and surgical management.[7-9] This follows the overall approach of your example papers, which introduce the rarity, etiological spectrum, clinical manifestations, and diagnostic importance before stating the purpose of the case series.

MATERIALS AND METHODS

Case 1

A 48-year-old man presented to the outpatient department with complaints of chest pain and shortness of breath. His initial evaluation revealed significant comorbidities, including poorly controlled type 2 diabetes mellitus (HbA1c, 11%), acute kidney injury (serum creatinine, 3.02 mg/dL), and moderate anemia (hemoglobin, 9.0 g/dL). Transthoracic echocardiography demonstrated regional wall-motion abnormalities, a dilated left ventricle with moderate systolic dysfunction, and a left ventricular ejection fraction (LVEF) of 35%. Mild mitral regurgitation was noted. Coronary angiography revealed extensive multivessel coronary artery disease, with critical stenoses involving the ostioproximal left circumflex (LCx), ostioproximal left anterior descending (LAD), proximal right coronary artery (RCA), and distal RCA. In view of the extensive coronary artery disease and associated LV aneurysmal pathology, the patient was scheduled for coronary artery bypass grafting (CABG) with surgical aneurysm repair. Intraoperatively, a large 6 × 5 cm aneurysm was identified in the sub-mitral region of the left ventricle, containing organized thrombus. The aneurysm was therefore characterized as a sub-mitral LV aneurysm in association with significant coronary artery disease. CABG was performed using great saphenous vein grafts to the mid-LAD, distal RCA, and major obtuse marginal branch (OM1). The aneurysm was repaired using a polytetrafluoroethylene (PTFE) patch, followed by two-layer approximation of the aneurysmal sac. The procedure was completed with appropriate myocardial protection using intermittent fibrillatory and cardioplegic arrest. The postoperative course was uneventful, with stable hemodynamics and no reported major postoperative complications. The patient was discharged in stable condition. Follow-up echocardiography demonstrated improvement in LV systolic function, with the LVEF increasing from 35% to 38%.

Case 2

A 46-year-old man with a history of type 2 diabetes mellitus, hypertension, chronic smoking, and alcohol use was initially evaluated at an outside hospital for chest pain and was diagnosed with coronary artery disease. On day one he underwent percutaneous transluminal coronary angioplasty (PTCA) with implantation of two drug-eluting stents (DES) in the RCA. Ten days later he developed stent thrombosis and underwent repeat PTCA of the RCA.

The patient subsequently presented to our emergency department with chest pain of 2 days' duration. Electrocardiography showed sinus rhythm with Q waves in leads II, III, and aVF and T-wave inversions in V5–V6, while troponin I was negative. Transthoracic echocardiography revealed a large inferoseptal LV aneurysm measuring 8 × 5.1 cm, associated with inferior and posterior wall hypokinesia. LV systolic function was moderately reduced, with an LVEF of 37%. Mild-to-moderate mitral regurgitation, moderate tricuspid regurgitation, and grade I diastolic dysfunction were also noted. A loculated posterior pericardial effusion was present, raising the possibility of a sealed-off ventricular perforation. Repeat coronary angiography demonstrated mild proximal LAD disease with otherwise normal LAD and LCx vessels. The RCA was dominant and showed diffuse in-stent restenosis involving the proximal, mid, and distal segments. The overall angiographic impression was single-vessel coronary artery disease involving the RCA with extensive in-stent restenosis.

After cardiothoracic surgical evaluation, the patient was planned for CABG with LV aneurysmectomy and PTFE patch repair, with management of the associated pericardial collection. Initial medical therapy included intravenous anticoagulation, dual antiplatelet therapy, statin therapy, and beta-blockade. The patient subsequently underwent CABG using saphenous vein grafts to the LAD and RCA, excision of the LV aneurysmal sac, open drainage of the pericardial collection, and repair with a PTFE patch. The procedure was performed through a median sternotomy under cardiopulmonary bypass with intra-aortic balloon pump (IABP) support. Intraoperatively, the pericardium was markedly thickened and densely adherent to the heart. RCA endarterectomy was performed and the previously implanted stent was removed, and a large LV aneurysmal sac was

identified. Postoperatively, the patient required IABP and inotropic support, which were gradually weaned. His subsequent recovery was uneventful. Follow-up echocardiography demonstrated significant improvement in LV systolic function, with LVEF improving from 37% preoperatively to 48% postoperatively.

Case 3

A 62-year-old man with a history of type 2 diabetes mellitus presented for a second opinion regarding management of coronary artery disease, following an ST-segment elevation myocardial infarction 6 weeks earlier. His initial presentation had been delayed, with approximately 1 week of malaise, fatigue, and exertional dyspnea. Electrocardiography demonstrated Q waves with persistent ST-segment elevation.

Emergency coronary angiography at the referring institution demonstrated mild disease in the distal RCA with non-obstructive flow and moderate disease involving the LAD and LCx. The distal LCx was considered the likely culprit vessel, and primary percutaneous coronary intervention was performed with placement of a drug-eluting stent extending from the proximal LCx into the obtuse marginal branch (OM1).

LV angiography performed during the initial evaluation demonstrated a large sub-mitral aneurysm arising from the inferior wall of the LV, with associated mild apical hypokinesia. Subsequent echocardiography confirmed a large sub-mitral aneurysm with moderately impaired LV systolic function. The patient was treated with aspirin, ticagrelor, carvedilol, lisinopril, and rosuvastatin. Because of the unusual location and large size of the aneurysm, cardiac magnetic resonance (CMR) was performed 6 weeks after revascularization to further characterize the aneurysm and reassess LV function. CMR demonstrated severe global LV hypokinesia and dyskinesia involving the aneurysmal segment, with an LVEF of 40%. The LV was markedly dilated, with an end-diastolic volume of 407 mL and an indexed end-diastolic volume of 205 mL/m². Right ventricular size and systolic function were preserved, with an RVEF of 46%, and there were no significant valvular abnormalities.

CMR demonstrated a wide-based true aneurysm with a 55-mm neck, measuring 105 × 75 × 53 mm, arising from the inferior wall in the sub-mitral region. A small amount of laminar thrombus was present. The aneurysm accounted for approximately 200 mL, or 45%, of the total LV volume during diastole. Of the measured LV stroke volume of 82 mL, approximately 50 mL entered the aneurysmal cavity, leaving only 32 mL of forward flow into the aorta, demonstrating the substantial hemodynamic impact of the aneurysm. Given the large aneurysm, severe LV remodeling, and significant reduction in effective forward stroke volume, the patient was referred for surgical management. Excision of the aneurysmal sac and PTFE patch repair were performed. The postoperative course was uneventful, and the patient was discharged with stable hemodynamics. Follow-up echocardiography demonstrated improvement in LV systolic function, with LVEF increasing to 48%.

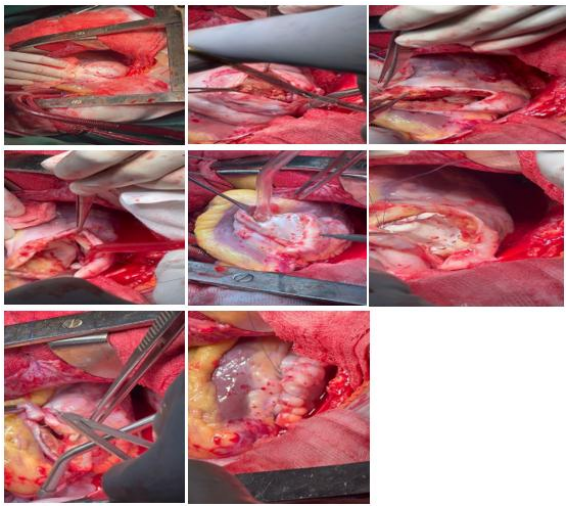
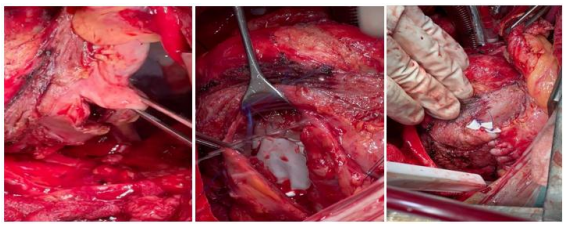
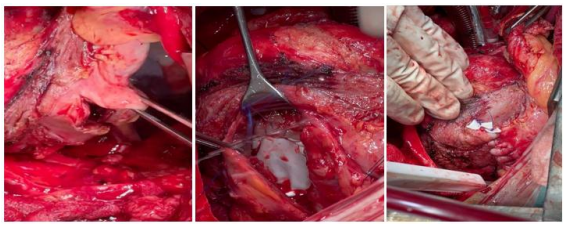


Figure 1: INTRA-OP PICS OF CASES

Intraoperative photograph demonstrating the large sub-mitral left ventricular aneurysm measuring approximately 6 × 5 cm, with organized thrombus within the aneurysmal sac.



Large inferoseptal aneurysm, pericardial adhesions/loculated collection, RCA disease and operative repair



Large inferior-wall sub-mitral aneurysm

DISCUSSION

Sub-mitral aneurysm (SMA) is an uncommon form of left ventricular aneurysmal pathology, classically described in individuals of African ancestry, although subsequent reports have documented its occurrence in Asian, Caucasian, and other populations. Du Toit et al,[1] described sub-valvar mitral aneurysms as a rare entity occurring in relation to the posterior mitral annulus, while Sharma et al,[3] reported a series of submitral aneurysms in Indian patients, demonstrating that the

condition is not restricted to the African population. Our three cases further demonstrate the occurrence of this uncommon lesion in an Indian population, with the distinctive feature of its association with coronary artery disease and an ischemic clinical setting.

The etiopathogenesis of SMA remains incompletely understood. The traditionally accepted mechanism is a congenital developmental abnormality involving the fibrous portion of the posterior mitral annulus. Nayak and Victor,[9] subsequently proposed a potential anatomical basis related to the sub-mitral membranous curtain. These observations support the concept that a structurally vulnerable sub-mitral region may predispose to aneurysm formation.

However, SMA is not exclusively congenital. Acquired forms have been described in association with infective and inflammatory conditions, including infective endocarditis, rheumatic carditis, tuberculosis, HIV infection, Chagas disease, and Takayasu arteritis. Barnawi et al,[10] in their report of a patient with rheumatic heart disease, highlighted the possibility of an acquired inflammatory mechanism and emphasized that the diagnosis may be missed when the clinical presentation is attributed to the underlying valvular disease. In our series, there was no history provided to suggest an infectious or inflammatory etiology; instead, all three patients had significant coronary artery disease or a recent ischemic event, supporting an ischemic association in this series.

Ischemic sub-mitral aneurysm

Ischemic SMA is particularly unusual. Conventional post-myocardial-infarction LV aneurysms most commonly involve the anterior or apical LV, whereas the sub-mitral location represents an atypical site for an ischemic aneurysm. Lorusso et al,[11] reviewed post-myocardial-infarction ventricular aneurysms and emphasized their relationship to myocardial infarction and adverse LV remodeling. The presence of an aneurysmal lesion specifically in the sub-mitral region therefore raises an important diagnostic consideration when evaluating patients with coronary artery disease and LV aneurysmal pathology.

The three patients in our series demonstrate different clinical settings in which an ischemic sub-mitral aneurysm may be encountered. Case 1 had extensive multivessel coronary artery disease involving the LAD, LCx, and RCA, together with regional wall-motion abnormalities, LV dilatation, and moderate LV systolic dysfunction. A large 6 × 5 cm sub-mitral aneurysm containing organized thrombus was identified intraoperatively. Case 2 had a history of RCA intervention complicated by stent thrombosis and subsequently diffuse in-stent restenosis; echocardiography demonstrated an 8 × 5.1 cm inferoseptal LV aneurysm with regional wall-motion abnormalities and reduced LV systolic function. Case 3 was evaluated following an ST-segment elevation myocardial infarction and underwent LCx/OM1 revascularization; LV angiography and subsequent CMR demonstrated a very large sub-mitral aneurysm arising from the inferior LV wall.

Thus, although the clinical circumstances differed, the common finding across our series was the coexistence of coronary artery disease/ischemic myocardial injury and an aneurysm in the sub-mitral region. This association is important because an aneurysm in this location may otherwise be presumed to represent the more commonly recognized congenital or inflammatory form of SMA.

Clinical manifestations and hemodynamic consequences

The clinical presentation of SMA is highly variable. Kumar et al,[8] reported four patients with different presentations, including heart failure due to severe mitral regurgitation and ventricular tachycardia associated with the aneurysm. They emphasized that patients may remain asymptomatic for prolonged periods or present with heart failure, systemic thromboembolism, ventricular arrhythmias, myocardial ischemia, or sudden cardiac death.

Mitral regurgitation is an important consequence of SMA. Du Toit et al,[1] and subsequent reports have described distortion of the posterior mitral annulus and adjacent subvalvular apparatus, resulting in impaired mitral leaflet coaptation. In our series, mitral regurgitation was present in all three patients, although its severity varied from mild in Case 1 to mild-to-moderate in Case 2; Case 3 had no significant valvular abnormality on CMR. This variation reinforces the fact that SMA does not invariably present with severe mitral regurgitation.

The size of the aneurysm may also have important hemodynamic consequences. This was particularly evident in Case 3, in whom CMR demonstrated a wide-based aneurysm measuring 105 × 75 × 53 mm with a 55-mm neck. The aneurysmal cavity accounted for approximately 200 mL, or 45%, of the total LV diastolic volume. Of the measured LV stroke volume of 82 mL, approximately 50 mL entered the aneurysmal cavity, leaving only 32 mL of antegrade flow into the aorta. These findings provide objective evidence of the substantial contribution of a large sub-mitral aneurysm to LV remodeling and ineffective forward stroke volume.

Role of multimodality imaging

Accurate anatomical characterization is essential because the location, size, neck, relationship to the mitral valve, and relationship to the coronary arteries influence both diagnosis and surgical planning. Echocardiography remains an important initial modality, while CT and CMR provide additional anatomical and functional information.

Purushotham et al,[12] emphasized the importance of defining the relationship between the submitral aneurysm and the circumflex coronary artery because this relationship may influence the surgical approach. In their series, the location of the circumflex artery relative to the aneurysmal neck had a major bearing on whether a left atrial or external approach could be safely undertaken.

This is particularly relevant to ischemic SMA because coronary anatomy itself forms part of the diagnostic and surgical assessment. In our patients, coronary angiography was essential in demonstrating the underlying CAD, while echocardiography identified the aneurysmal pathology and assessed LV function. Case 3 additionally demonstrates the value of CMR, which provided precise measurements of the aneurysm, its neck, LV volumes, systolic function, and associated thrombus.

Morphological classification

Du Toit et al,[1] classified submitral aneurysms according to their anatomical involvement into three types: Type I, a single localized neck; Type II, multiple necks; and Type III, involvement of the entire posterior mitral annulus. This classification provides a useful framework for describing the anatomical extent of the lesion and may have implications for surgical repair.

In our series, the available imaging and operative information demonstrates considerable variation in aneurysm size and morphology. Case 3 had a particularly broad-based lesion with a 55-mm neck, whereas Cases 1 and 2 were characterized primarily by large aneurysmal sacs identified at surgery or echocardiography. A formal anatomical classification should ideally be assigned only when the number and precise configuration of aneurysmal necks have been adequately demonstrated on imaging or during surgery.

Surgical management

Surgical treatment remains the principal definitive treatment for symptomatic or large SMA, particularly when associated with LV dysfunction, significant mitral regurgitation, thrombus, or other complications. The surgical approach can be broadly categorized into extracardiac and intracardiac/transatrial repair.

The surgical management of SMA was historically described by Shrire and Barnard,[13] who reported surgical treatment of a cardiac aneurysm of uncertain origin. Subsequently, Antunes,[14] described a transatrial approach for correction of submitral LV aneurysms.

Purushotham et al,[12] demonstrated that the choice of surgical approach depends significantly on aneurysmal anatomy and its relationship with the circumflex coronary artery. Their experience showed that an apparently straightforward left atrial approach may provide inadequate access when the aneurysm extends posteriorly or inferiorly and may place the circumflex coronary artery at risk.

Our series demonstrates the role of aneurysmectomy/excision and PTFE patch repair in large ischemic sub-mitral aneurysms. In Case 1, CABG was combined with repair of the 6 × 5 cm aneurysm containing organized thrombus using a PTFE patch and two-layer sac approximation. Case 2 required a more complex procedure comprising CABG, aneurysmal sac excision, pericardial drainage, PTFE patch repair, and RCA endarterectomy, with removal of the previously implanted stent. Case 3 underwent aneurysmal sac excision and PTFE patch repair following detailed CMR characterization.

An important advantage of an intracardiac/transatrial approach is the ability to directly assess the mitral valve and evaluate its competence during the procedure. However, Pektok et al[15] highlighted potential limitations, including incomplete closure, residual mitral regurgitation, and recurrence when additional aneurysmal necks are not identified. The choice of technique therefore needs to be individualized according to the aneurysm, mitral valve, annulus, and surrounding coronary anatomy.

Outcomes in our series

Despite substantial differences in clinical presentation and coronary anatomy, all three patients underwent surgical repair with PTFE patch reinforcement, with concomitant coronary revascularization where indicated. Importantly, all three had an uncomplicated postoperative recovery, and LV systolic function improved on follow-up echocardiography: from 35% to 38% in Case 1, 37% to 48% in Case 2, and 40% to 48% in Case 3.

These observations suggest that recognition of the aneurysmal pathology and appropriate surgical correction, together with treatment of the underlying coronary disease, may be associated with improvement in LV systolic function. However, given the small number of patients and the limited duration of available follow-up, these findings should be regarded as observational rather than definitive evidence of treatment efficacy.

CONCLUSION

Ischemic sub-mitral aneurysm is an extremely rare entity that should be considered in patients with coronary artery disease who present with unexplained mitral regurgitation, heart failure, or left ventricular aneurysmal pathology. Early recognition with appropriate multimodality imaging and timely surgical intervention are essential to prevent potentially life-threatening complications and to achieve favorable clinical outcomes.

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