Annular Subvalvular Left Ventricular Aneurysms: A Comprehensive Review

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Abstract

Introduction: Subaortic and submural aneurysms have been collectively referred as subvalvular aneurysms (SVA), which are relatively rare cardiac malformation commonly, reported in young adult African ancestry.

Methods: Herein is provided a comprehensive review of all relevant English-language articles published from 1962 to December 2018, regarding to etiology, clinical presentation, diagnosis, complications and treatment of the SVA.

Results: A total of 150 patients with SVA were identified, of these, 83 (55.3%) were male, with median age 24-year-old. Submural aneurysms were reported in 140 patients and only 10 subaortic aneurysms were found. Congenital SVA accounted for 83% (125) of the cases. The most frequent presentation was dyspnea and heart failure (64%) followed by chest pain (7%). Palpitations, supra-ventricular tachycardia and ventricular tachycardia accounted for 3%, 2% and 4%, respectively. Asymptomatic individuals account for 7%. Two-dimensional transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) were available in 119 patients (79.3%), and in 38 patients (25.3%), respectively. Contrast left ventriculography was performed in 60 patients. Three-dimensional TTE was performed in 17 (11.3%) patients and three-dimensional TEE in five (3.3%). Computed tomography and magnetic resonance imaging was performed in 16 (10.7%) patients each. Non-death was reported for patients with subaortic aneurysms, on the other hand, the surgical mortality was 11% (15) for submural aneurysms.

Conclusion: Majority of SVA is congenital presenting with myriad of symptoms ranging from asymptomatic to cardiogenic shock. Surgery is safe and effective treatment with acceptable mortality. Despite the limitations, TTE remains the first-line diagnostic method. Another imaging modality is recommended when TTE is not conclusive.

Keywords: Subvalvular Aneurysm; Echocardiography; Computed Tomography; Magnetic Resonance Imaging

Introduction

Among left ventricular aneurysms, the subvalvular types are the least commons. Subaortic and submural aneurysms have been collectively referred to as subvalvular aneurysms (SVA) and are relatively rare cardiac malformation commonly, reported in young adult African ancestry. They occur in two constant anatomic positions. Subaortic aneurysms occur under the intermediate portion of the left cusp of the aortic valve and submural aneurysms under the posterior leaflet of the mitral valve. Submural aneurysms are more common than subaortic aneurysms [1]. With the advancement of cardiac imaging techniques and the wide availability of echocardiography worldwide, the number of reported clinical cases has increased in recent years, although, the number of patients in any series is quite small. Furthermore, SVA is not mentioned in textbooks. The aim of the present study is to make an exhaustive review of these aneurysms, as well as to describe our experience, that has been published over the last few years, regarding to etiology, clinical presentation, diagnosis, complications and treatment of these aneurysms [2-5].

Methods

It was identified relevant English-language articles published from 1962 to December 2018 searching by the keywords “annular subvalvular left ventricular aneurysm”, “subvalvular aneurysm”, “Submitral aneurysm”, “aortic subvalvular aneurysm” and “subaortic aneurysm” using the PubMed database. A total of 772 abstracts and full-length articles were screened. A manual search was performed from the citations in primary articles to identify any other reports not identified in PubMed. Cases diagnosed at autopsy and, autopsy series are not included. A total of 84 full-text articles were accessed accounting for 150 patients between children to adults [2-85].

Results

Eighteen case series with two or more patients, and 66 clinical cases of SVA were identified from reports published between 1962 and 2018. The largest series included 12 patients [22]. Overall, 150 patients with SVA were indentified. There were 83 male (55.3%) and 67 female (44.7%) (male:female ratio 1.2:1). Information regarding the age was available in 141 patients; age and sex distribution of these patients are illustrated in figure 1. The SVA developed in all age groups with youngest patient being 6-month-old (26). The median age was 24-year-old. Of the 150 patients, 140 (93.3%) had submitral aneurysms and only 10 (6.7%) had subaortic aneurysms.

![Figure 1: Distribution of the population according to the age and gender.](image)

Etiology

SVA was considered acquired in 26 patients (17%). In these patients the main associated causative factor was tuberculosis in 15 patients [6,20,22,51,82,83] followed by myocardial infarction in five [17,35,36,46,62] and aortitis in three patients [10,44,47]. Rheumatic carditis was reported in two patients [22] and hypersensitive or eosinophilic myocarditis [9] in one. Congenital SVA accounted for 83% of the patients.

Clinical presentation: Information of clinical presentation was available in 140 patients (Figure 2). The most frequent presentation was dyspnea and heart failure (64%) followed by chest pain (7%). Asymptomatic individuals account for 7% [11,13,22,29,35,53,64,81].

Palpitations [4,5,6,67,78] supra-ventricular tachycardia [5,65,85] and ventricular tachycardia [25,37-39,45,62] accounted for 3%, 2% and 4%, respectively. Other atypical presentations were atrial fibrillation [30], pre-syncope [61], pericardial effusion [83], myocardial infarction [48] and stroke [23] with only one patient each. Information regarding mitral regurgitation (MR) was available in 113 patients: severe in 61%, moderate in 19.5% and mild in 11.5% (Figure 3). Nine patients had no data regarding severity of MR. Aortic regurgitation was presented in only nine patients [2,15,18,22,59,60,66,78,82]. Fifty-six patients were in NYHA class III and IV.
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Associated congenital heart disease

The association of SVA and aneurysm of sinus of Valsalva was found in six patients [2,11,15,18,51]. The SVA was associated with left ventricular non-compaction and with mitral valve prolapsed in different patients [2,8].

Diagnostic investigations: Information regarding the use of two-dimensional transthoracic echocardiography (TTE) was available in 119 patients (79%). Diagnoses were made in 104 (87.4%), missed in 9 (7.6%), and suspected but not definitive in 6 (5.0%). Of the 38 patients (25%) who had information on TEE, the diagnosis was made in all cases. Contrast left ventriculography was the diagnostic technique in 60 patients. Three-dimensional TTE was performed in 17 patients [2-5,34,40,64,65] and three-dimensional TEE in five [2,6,65] with excellent visualization of the aneurysm. Multidetector computed tomography (MDCT) [4,6,9,10,14,36,40,43,48,60,61,65,76,77,84] and magnetic resonance imaging (MRI) [3,5,6,12,34,35,41,45,55,56,63,68,80] was performed in 16 patients.

Complications: Subvalvular aneurysm was found complicating as fistulous communication to left atrium in 13 patients [2,8,11,24,32,43,58,64,74,75,77] and compressing one or more coronary arteries in 15 patients [15,25,26,52,57,60,63-66,68,73,79,82]: circumflex coronary artery in 13, right coronary in three, left anterior descending artery in two and left main in one. Intra-aneurysmal clots were described in 17 patients [4,6,7,11,13,24,27,31,37,48,49,56,68,81,85].

Surgical management and outcomes: One hundred and two patients were proposed for surgical treatment. Of these, three patients refused surgery [6,15,74] and one died suddenly while awaiting surgery [47]. Ninety-eight patients underwent surgical treatment: 92 with submitral aneurysms and six with subaortic aneurysms. Of the 92 patients with submitral aneurysm undergoing surgery, the information regarding the surgical approach was available for 88 patients (89.8%). The combined approach was performed in 10 patients, and the transatrial approach in 31 patients. In the remaining 47 patients the transaneurysmal approach was the surgical option taken. Mitral annuloplasty was performed in 12 patients [22,23,51,59,64,69,79]. Preservation of MV was not possible in 30 patients, [4,5,17,22,27,40,46,50,41,55,67,68,70,75,77,85] thus mitral valve replacement was performed. In the group of patients with submitral aneurysm the surgical mortality was 11%. The most frequent causes of death were low cardiac output/cardiogenic shock [3,9,38,67,73], sudden death [51] and myocarditis [51]. Of the six patients with subaortic aneurysm undergoing surgery, the information regarding the surgical approach was available in five patients. Transaneurysmal approach was performed in one patient [51] and transvalvular aortic approach in four [5,41,60,82] without surgical mortality. No one needed aortic valve replacement.

Discussion

The SVA was firstly described by Abrahams., et al. in 1962 [86], is a rare entity that occurs predominantly in young blacks almost exclusively from poor socio-economic groups in sub-Saharan Africa and south India, but, has also been reported from Europe, North America, Japan and Australia [2-85]. These aneurysms are usually left ventricular ones, situated below the mitral and aortic valves and extending into the substance of the fibrous ring from which the valves arise [1]. Other terms used in the literature to describe SVA are submitral, subaortic, annular subvalvular, non-ischaemic subannular, Bantu aneurysm and supernumerary chambers of the left ventricle [87].

Etiology: The etiology of SVA is not completely understood and there is ongoing debate around this topic. The etiology of subvalvular aneurysms is mostly thought to be a congenital weakness of the fibrous annulus of the valve, which is further supported by the predominant single race group involved, as well as the anatomy and embryology of the affected area [22]. It account for 83% of the cases in present review. However, there are, isolated case reports of submitral aneurysms in patients with, underlying infectious and/or inflammatory conditions, suggesting that a second insult will lead to manifestation of disease in predisposed individuals [6]. In present review we found that tuberculosis was the cause of SVA in 15 patients, however, there are few histologically proven cases [20,22,51,82]. Some investigators hypothesize that there is a simple coexistence of these two pathologies taking into account the high prevalence of tuber-
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culosis in countries where most of the aneurysms have been diagnosed [22]. Myocardial infarction was the second cause of submitral aneurysms. Ischemic aneurysms are usually localized in the apex of left ventricle, and result from anterior wall myocardial infarction, ischemic subvalvular aneurysms are rare. Rheumatic carditis, aortitis, and myocarditis have also been described as cause of SVA, but they are extremely rare.

Clinical presentation: These aneurysms may produce serious hemodynamic disturbance in several ways: 1) Aortic and mitral incompetence results from distortion of the cusps and fibrous annulus of these valves and leads to left ventricle failure; 2) The larger aneurysms of the subvalvular type may accommodate a large regurgitant flow during systole which is returned to the ventricle in diastole and places a serious load on this chamber; 3) Coronary artery compression further impairs the function of the left ventricle and contributes to the heart failure [88]. Patient with SVA presents with myriad of symptoms ranging from asymptomatic, shortness of breath, reduced exercise tolerance to chest pain. Patients may also present with arrhythmia, thromboembolic event or myocardial ischemia secondary to compression of the coronary artery [1].

In the present review, the most common form of clinical presentation of SVA was dyspnea/congestive heart failure, followed by chest pain. Other forms of clinical presentation were supra-ventricular and ventricular arrhythmias. In some cases, it presents as myocardial ischemia due to compression of the coronary arteries by the aneurysm. Although the presence of thrombus within the aneurysm was found in 11% of the patients, ischemic stroke is a rare form of clinical presentation. Myocardial infarction, cardiogenic shock, atrial fibrillation, pre-syncope, and pericardial effusion as the first clinical manifestation of SVA is also extremely rare.

Associated congenital heart disease: The association of SVA with other congenital heart disease has been described [2,8,11,15,18,31]. The present review revealed that the most frequent association is association of SVA with sinus of Valsalva aneurysm.

Diagnostic Investigations: The questions that should be answered with the available imaging modalities for diagnosis of SVA concern the exact localization, and size of aneurysm, size of basic wall defect, spatial relationship and potential involvement of the mitral or aortic annulus, morphological features of the aneurysm in the proper sense of true or pseudoaneurysm, assessment of global LV function, mitral or aortic regurgitation and potential adverse hemodynamic effects of the aneurysm.

Until the advent of echocardiography and computerized tomography, cardiac catheterization and angiography were necessary to confirm the diagnosis, locate the origin of the aneurysm, and assessment the severity of hemodynamic disturbances. Coronary angiography was necessary when there were suspicions of coronary disease or extrinsic compression of the coronary arteries by the aneurysm.

Since first case using two-dimensional echocardiography in diagnosis of submitral aneurysm reported by Davies., et al. in 1982 [19] the TTE became the first-line investigation for diagnosis of SVA. In the cases of submitral aneurysm TTE reveal, in most cases, an aneurysmal dilatation behind to the posterior leaflet of the mitral valve, communicating with the left ventricular cavity through one (Figure 4) or more necks (Figure 5). However in few cases the submitral aneurysm may be located next to the anterior mitral valve leaflet and may be confused with a subaortic aneurysm [24]. The subaortic aneurysms are located under the intermediate portion of the left cusp of the aortic valve.

Figure 4: Transthoracic echocardiography A - Parasternal longitudinal view B - apical four-chamber view C - Parasternal short axis view at mitral valve level, D - Subcostal view showing submitral aneurysm (asterisk), Ao: Aorta; LA: Left Atrium; LV: Left Ventricle; MV: Mitral Valve; RA: Right atrium; RV: Right Ventricle.

Misdiagnosis or doubt in diagnosis of SMA by TTE is not so rare. In the present review, of the 119 patients who underwent transthoracic echocardiography, diagnoses were missed in nine (8%) patients and suspected but not definitive in six (5%). In the nine patients in whom the diagnosis was missed, the main diagnoses were mitral regurgitation in two patients [27] followed by pericardial effusion [33], mitral valve aneurysm [4], normal TTE [38], suspected cavity in the left atria [30], mild dilated cardiomyopathy [39] in one patient each. In case reported by Fitchett., et al. [25], echocardiography showed extensive calcification in the area of the mitral annulus and aneurysmal structure could not be recognized on cross sectional echocardiogram. To avoid these mistakes it is essential that recordings are made from multiple sites using apical, parasternal and subcostal windows (Figure 4).

In the six patients in whom the diagnosis was suspected but not definitive the greatest diagnostic difficulty was related to the fact that TTE was unable to show the origin and location of the neck of the aneurysm in two patients with SMA located next to the anterior mitral valve leaflet [24] and in one patient with subaortic aneurysm [41]. On the other hand, transesophageal echocardiography performed in 34 patients was diagnostic in all cases, including in five cases in which the diagnosis in TTE was suspected but not definitive showing to be superior to the TTE in the diagnosis of this cardiac pathology [24,41,44,54].

The spatial extent of these aneurysms can be challenging to delineate, thus resulting in surgical failure, which is often attributable to either failure to identify additional aneurysm necks (50% of failures) or inadequate closure of the aneurysm [22]. Preoperative assessment has previously been done using TTE, 2-dimensional TEE, and invasive angiography [65]. The addition of 3D TTE [2,40,64,65] and 3D TEE [2,64,65] allows accurate identification of the SMA neck, improves assessment of the SMA's spatial extent (Figure 6A and B) and provides necessary information regarding mitral valve anatomy and the mechanism of mitral regurgitation. In addition, three-dimen-
sional transesophageal echocardiography proved to be unparalleled in the diagnosis of the rupture of the submitral aneurysm into the left atrium (Figure 6C and 6D). The computed tomography [40,43,65] (Figure 7 and 8) and the cardiac MRI studies [3,12] have greatly improved the detailed description of SVA and detection of associated calcifications, thrombus formation and coronary artery compress- 

Figure 6: Real time three-dimensional transthoracic echocardiography zoom mode from the ventricular view in diastole (A) and systole (B) showing bilobed submitral aneurysm (asterisk). Real time three-dimensional transesophageal echocardiography zoom mode in face view in diastole (a) and in systole (B) showing rupture of submitral aneurysm (blue arrow). AV: Aortic Valve; MV: Mitral Valve (modified from the reference 2 with permission).

Figure 7: Contrast Enhanced Computed Tomography of a 33 years old female, frontal projection (A,B) and axial projection (C,D) showing two subvalvular aneurysms one in subaortic position (An1) and other in submitral position (An2) With thrombus inside of the aneurysms. These findings were confirmed at surgery. Ao: Aorta; An: Aneurysm; LA: Left Atrium; LV: Left Ventricle.
Complications: Besides the arrhythmic complications, three major complications of SVA have been reported: first, is rupture of SVA into left atrium. It should be suspected whenever the transthoracic echocardiogram noted a paraavalvular jet of mitral regurgitation. Is transesophageal echocardiography superior to TTE in the diagnosis of this complication [2]. Thus, given the suspicion of rupture of the aneurysm into the left atrium we strongly recommend performing TEE whenever possible. Multidetector cardiac CT may also be useful in this context [43]. Second, is compression of coronary arteries that lead to coronary insufficiency. Third, is thrombus formation inside the aneurysm with risk of thromboembolism. Although thrombi were present in 11% of the reviewed cases, thromboembolic complications are rare.

Management and outcomes: Surgical repair is the definitive treatment preserving or not the valve. Two techniques are described to repair the submtrial aneurysms: First, is the transaneurysmal approach described in 1963, by Shire and Barnard [89]. This technique has the disadvantage of inadequate exposure of the mitral annulus, residual mitral regurgitation, and in some cases it is technically difficult due to adhesions. Second, is the transatrial approach described by Antunes, in 1987 [90]. The transatrial approach has the advantage of good exposure of the mitral annulus, and the MV can be assessed and tested for competence following repair of the SMA. In the presence of a large aneurysmal neck, SMA is difficult to repair through the transatrial approach. In these cases, the transaneurysmal approach is also difficult. So, the combined approach is a good option [4]. Regarding the surgical approach to repair subaortic aneurysms, the surgical approach can be by transaneurysmal [51] or transvalvular aortic technique [5,41,60,82].

The review presented herein showed an acceptable surgical mortality of submtrial aneurysms. The surgical techniques used took into account the experience of the surgical team. In most cases, was used the combined approach, transaneurysmal and transatrial technique. All authors point out that whenever possible the mitral valve should be preserved. Mitral valve replacement should be done only in cases where mitral repair cannot be performed, which happened in 34% of the reviewed cases revealing the difficulty in mitral valve repair in submtrial aneurysms. We would like to emphasize that the surgical mortality in subaortic aneurysms was zero.
Conclusion

Patient with SVA presents with myriad of symptoms ranging from asymptomatic, shortness of breath, reduced exercise tolerance to chest pain. Patients may also present with arrhythmia, thromboembolic event or myocardial ischemia. There are several modalities available for the evaluation of patients presenting with SVA. These include: 1. Echocardiography that is the first-line method for the diagnosis of SVA. It also allows assessment of cardiac morphology and function but it is operator dependent exam and may be limited by patient-related factors such as body habitus. 2. CT angiography provides detailed information of the coronary arteries, assessment of cardiac lesions as well as the rest of the aorta. However, this modality requires cardiac gating or heart rate control. 3. Cardiac MRI assessment allows accurate assessment of morphology of the SVA, tissue characteristics, presence of thrombus, flow and systolic function. Surgery is the unique curative treatment with acceptable surgical mortality, bearing in mind that many of the patients present late in functional classes of NYHA III and IV.

Bibliography


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