Review Article

Surgical management for unruptured sinus of Valsalva aneurysms: a narrative review of the literature

Quynh Nguyen[1], Dominique Vervoort[2], Kevin Phan[3], Jessica G. Y. Luc[4]

[1]Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB, Canada; [2]John Hopkins Bloomberg School of Public Health, Baltimore, MD, USA; [3]NeuroSpine Surgery Research Group, Prince of Wales Private Hospital, Sydney, Australia; [4]Division of Cardiovascular Surgery, Department of Surgery, University of British Columbia, Vancouver, BC, Canada

Contributions: (I) Conception and design: JGY Luc; (II) Administrative support: JGY Luc; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: JGY Luc, Q Nguyen; (V) Data analysis and interpretation: JGY Luc, Q Nguyen; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Jessica G. Y. Luc, MD. Division of Cardiovascular Surgery, University of British Columbia, 1081 Burrard Street, Unit 486, Vancouver, BC, V6Z 1Y6, Canada. Email: jessicagyluc@gmail.com.

Abstract: Unruptured sinus of Valsalva aneurysms (SVAs) are rare cardiac lesions that arise due to congenital or acquired etiologies. They could be asymptomatic or cause various clinical manifestations as a consequence of their mass effect on the coronary arteries, heart valves, and other adjacent structures. While the factors predicting SVA rupture are not fully understood, ruptured SVAs carry a high complication and mortality rate, highlighting the need for early recognition and management of unruptured SVAs. Imaging modalities such as echocardiography, computed tomography (CT), angiography, and magnetic resonance imaging (MRI) are essential in identifying and characterizing the aneurysm as well as associated cardiac anomalies. However, there are no specific guidelines for the diagnosis and management of SVAs. Herein, we performed a contemporary systematic review to examine the presentation, diagnostic tests and findings, as well as outcomes for surgical intervention of unruptured SVAs. We demonstrate that surgical repair remains the preferred method of treatment in order to prevent complications such as rupture or thrombus formation. Surgery should be prompted in patients with symptomatic, large, or rapidly expanding unruptured SVAs, as well as those unruptured SVAs that contain intraluminal thrombi, have a mass effect on surrounding structures, or are recurrent. Surgical outcomes are generally good with favourable prognosis and minimal recurrence.

Keywords: Unruptured sinus of Valsalva aneurysms; sinus of Valsalva aneurysms (SVAs); surgical management

Submitted Aug 18, 2020. Accepted for publication Jan 08, 2021.
doi: 10.21037/jtd-20-2682
View this article at: http://dx.doi.org/10.21037/jtd-20-2682

Introduction

Sinus of Valsalva (SV) aneurysm (SVA) is an enlargement of the aortic root area between the aortic valve annulus and the sinotubular junction. While the factors predicting SVA rupture are not fully understood, ruptured SVAs carry a high complication and mortality rate, highlighting the need for early recognition and management of unruptured SVAs (1).

SVAs can be congenital or acquired, with the former being more prevalent (2). The true prevalence of SVAs is unknown; the estimated rate is approximately 0.09% of the general population and 0.1% to 3.5% of all congenital cardiac defects (2). Multiple SVAs are even rarer with very few cases reported in the literature (3-5). SVAs most often affect one of the SVs, and originate predominantly from the right SV (RSV) (2,6-9). Patients with unruptured SVAs could be asymptomatic or present with non-specific symptoms such as dyspnea, chest pain, palpitation and syncope (5,10-19). Unruptured SVAs may cause valvular regurgitation, annular dilation or deformity, as well as compression of the coronary arteries, cardiac chambers and outflow tracts (20-26). A comprehensive state-of-the-art imaging review of SVAs has been reported, including various imaging modalities such as echocardiography, computed tomography (CT), angiography, and magnetic resonance imaging (MRI) that can be used for the diagnosis of SVAs (24-31). SVAs may rupture into cardiac chambers or extracardiac locations, and the type of complications depends on the locations into which the rupture occurs (31). The incidence of ruptured SVAs is unknown with only a single centre review of 53 SVA cases that reported ruptured SVAs in 64% of the cases (1). While size is one criterion which may be associated with rupture, the factors predicting SVA rupture are not fully understood. Ruptured SVAs carry a high mortality rate, with a mean survival period of 3.9 years if left untreated (1).

There are no specific guidelines for the diagnosis and management of SVAs, with medical and surgical options reported (32-38). While ruptured SOVAs require urgent surgical intervention, the management of unruptured SVAs remains controversial. Unruptured SVAs that do not require surgical intervention are managed conservatively using serial follow-up surveillance imaging (31). These imaging studies provide temporal data on the size and growth of the SVA, the relationship of SVA with the surrounding structures, and potential complications. The assessment and conservative management of unruptured SVAs using multimodality cardiovascular imaging have been thoroughly discussed in a recent review and will not be reviewed in this paper (31). On the other hand, the decision to intervene on unruptured SVA is complex and multifactorial, depending on the aneurysmal sizes, the growth trends on surveillance imaging, as well as patient clinical characteristics (2). Our study focuses on the surgical management of unruptured SVAs, which is an area subject to greater controversy.

The present systematic review aims to describe the contemporary clinical presentation, diagnostic tests and findings, as well as outcomes for surgical intervention of unruptured SVAs in patients with no associated congenital heart defects, underlying connective tissue disorders or other concomitant cardiac conditions. We present the following article in accordance with the Narrative Review reporting checklist (available at http://dx.doi.org/10.21037/jtd-20-2682).

Methods

Literature search strategy

Studies examining surgical outcomes of unruptured SVAs in adult patients were identified through electronic searches performed in June 2020 using Ovid Medline, Embase, Cochrane Database of Systematic Reviews, and Scopus. To achieve the maximum sensitivity of the search strategy, we combined the terms: "aneurysm", "aneurysms", "sinus of Valsalva", "unruptured", as well as "sinus of Valsalva aneurysms" as either keywords or MeSH terms. The reference lists of all retrieved articles were reviewed and assessed for further identification of potentially relevant studies using the inclusion and exclusion criteria. After removal of duplicates, 175 articles were screened in abstract and full-text, with 52 articles included in the final analysis (*Figure 1*).

Selection criteria

Eligibility of studies for the present systematic review was determined prior to commencement of data collection. These included all studies that were contemporary as defined as published after the year 2000, with described surgical management for the unruptured SVA in adult patients with no previous cardiac surgery or concomitant cardiac pathologies and no familial connective tissue diseases. All publications were limited to those involving human subjects and in the English language.

Articles were excluded if they were review articles, case reports/series on pediatric patients or published before the year 2000. Articles with insufficient information on management, those with conservative management, as well as those that described patients with familial lesions, systemic conditions, previous cardiac surgery or concomitant cardiac problems were also excluded. Papers without accessible full-texts online were also not included in our study.

Data extraction

All data was extracted from article texts, tables, and figures and discrepancies were resolved by group discussion and consensus.

Statistical analysis

Descriptive statistics were used. Non-parametric continuous variables are expressed as medians with the interquartile range (IQR). Categorical data were expressed as counts and percentages. Statistical analyses were performed using GraphPad Prism version 8.4.3, GraphPad Software, La Jolla California USA.

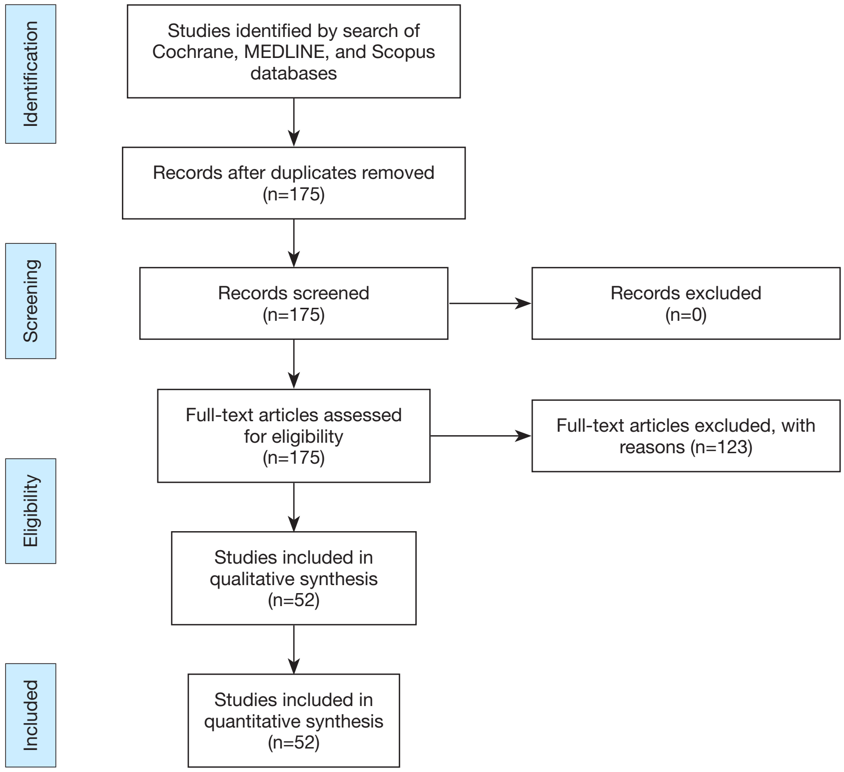

Figure 1 PRISMA schematic of the search strategy. PRISMA, Preferred reporting items for systematic reviews and meta-analyses.

Results and discussion

Clinical presentation

Unruptured SVAs can present at various ages, ranging from 21 to 84 years old (*Table 1*). The median age at presentation was 59 years old. Unruptured SVAs were more commonly reported in males (58%, 30/52 cases—patient's sex was unspecified in one case) than in females (42%, 22/52 cases). Patients with SVAs can be asymptomatic (9%, 5/53 cases) or present with non-specific symptoms such as dyspnea (43%, 23/53 cases), chest pain/pressure/tightness/discomfort (34%, 18/53 cases), palpitations (15%, 8/53 cases), and syncope/presyncope (9%, 5/53 cases). Other less common initial presentations reported include tonic clonic seizure (2%, 1/53 cases), chronic cough (2%, 1/53 cases), exertional intolerance (2%, 1/53 cases), fever (2%, 1/53 cases), dizziness (2%, 1/53 cases), orthopnea (2%, 1/53 cases), and peripheral edema (2%, 1/53 cases). More severe cases of unruptured SVAs can present with myocardial ischemia and infarction (9%, 5/53 cases), heart failure (9%, 5/53 cases), as well as cardiogenic shock (4%, 2/53 cases). Among the patients who presented with signs and symptoms of heart failure, 4% were classified as New York Heart Association (NYHA) class II (2/53 cases), and 6% were classified as NYHA class III/IV (3/53 cases).

Murmur is a common finding (43%, 23/53 cases) on physical examination of patients with unruptured SVAs. Among these described murmurs, a diastolic murmur was appreciated in 43% of the cases (10/23 cases). A systolic murmur was also appreciated in 43% of the cases (10/23 cases), with the majority of them being described as systolic ejection murmur (30%, 7/23 cases). The majority of the reported murmurs were heard over the left sternal region (48%, 11/23 cases). Other areas such as aortic (13%, 3/23 cases), pulmonic (9%, 2/23 cases), base (4%, 1/23 cases), or mitral (4%, 1/23 cases) have also been described. Most murmurs were grade 2 or 3 (26%, 6/23 cases). Grades 1, 4, and 5 murmurs were each reported once among patients (4%, 1/23 cases). Information on the characteristics of these murmurs was scarce: 9% (2/23 cases) were described as blowing, 4% (1/23 cases) was described as soft and 4% (1/23 cases) was described as regurgitant murmur.

Table 1 Demographic and clinical presentation of previously described cases of sinus of Valsalva aneurysms

Patient No	Reference	Year	Age	Sex	Clinical presentation								Others	NYHA Class	Murmur (timing/grade/quality/location)	Comorbidities
					Asymptomatic	Dyspnea	Chest pain	Palpitation	Syncope	Arrhythmia	Conduction defect	MI				
1	Pólos *et al*. (8)	2020	68	M	–	Y	–	–	–	–	–	–	–	III–IV	–	Smoker
2	Serban *et al*. (9)	2019	49	M	–	–	Y	–	–	–	–	–	–	–	–	–
3	Wang *et al*. (10)	2019	46	M	–	Y	–	–	–	–	–	–	–	–	Systolic/–/–/mitral; Diastolic/–/–/ aortic	–
4	Umeda *et al*. (11)	2018	69	F	–	Y	–	–	–	–	–	–	–	–	–	–
5	Khanna *et al*. (13)	2017	55	M	–	–	Y	–	–	–	–	–	–	–	–	–
6	Ponti *et al*. (14)	2017	71	M	–	Y	Y	–	–	–	–	–	Myocardial ischemia	–	–	–
7	Luo *et al*. 4	2017	48	M	–	Y	–	–	–	–	–	–	–	–	–	–
8	Guner *et al*. (16)	2017	45	M	–	Y	Y	–	–	–	–	–	–	–	Early diastolic/2/blowing/L sternal border	–
9	Chigurupati *et al*. (5)	2017	39	F	–	Y	Y	Y	Y	–	AV block	–	–	–	Diastolic/4/–/aortic	HTN
10	Giambruno *et al*. (17)	2016	61	F	Y	–	–	–	–	–	–	–	–	–	Y	–
11	Prifti *et al*. (18)	2016	52	F	–	Y	–	–	–	ST	–	–	–	III	–	–
12	Sato *et al*. (19)	2016	75	M	–	–	–	Y	–	AF	–	–	–	–	–	HTN
13	Qian *et al*. (12)	2016	60	F	–	Y	–	–	–	–	–	–	Chest tightness	–	Early diastolic/–/soft/–	–
14	Karvounaris *et al*. (20)	2015	63	F	–	Y	–	–	–	ST	LBBB	–	Cardiogenic shock	–	Systolic/3/–/–	–
15	Gong *et al*. (21)	2015	45	M	–	Y	–	–	–	–	–	–	–	–	Diastolic/–/–/L 2nd–3rd intercostal space	–
16	Chikkabasavaiah *et al*. (22)	2014	21	M	–	–	–	–	–	–	–	–	Tonic clonic seizure	–	Early diastolic/–/–/L upper parasternal	–
17	Ogiwara *et al*. (23)	2013	61	F	–	–	–	–	–	–	–	Y	–	–	–	–
		9y f/u	70	–	–	Y	–	–	–	–	–	–	–	–	–	–
18	Schönrath *et al*. (24)	2013	67	M	–	Y	Y	–	–	–	–	–	–	–	–	–
19	Minagawa *et al*. (25)	2013	70	M	–	–	–	–	–	–	RBBB	–	–	–	Systolic ejection/–/–/L upper parasternal	HTN
20	Lu *et al*. (26)	2013	52	M	–	–	–	–	–	AF	–	–	Chest discomfort	–	Diastolic/3/regurgitant/L sternal border	HTN, smoker
21	Hu *et al*. (27)	2013	66	F	–	–	–	Y	–	–	–	–	–	–	–	–
22	Jouni *et al*. (28)	2012	78	M	–	Y	Y	–	–	–	–	–	–	–	Diastolic/–/–/–/	HTN, dyslipidemia, OSA
23	Yagoub *et al*. (29)	2012	56	M	Y	–	–	–	–	–	–	–	–	–	Y	–
24	Saritas *et al*. (30)	2012	75	M	–	–	–	–	Y	–	–	–	–	–	–	–
25	Altarabsheh *et al*. (32)	2011	50	F	–	–	–	–	–	–	–	–	Chronic cough	–	–	–
26	Gupta *et al*. (33)	2010	56	F	–	Y	–	–	–	–	–	–	–	–	–	–
27	Sohal *et al*. (34)	2010	84	M	–	–	–	–	Y	–	–	–	–	–	–	–
28	Rosu *et al*. (35)	2010	72	M	–	Y	–	–	–	–	–	–	–	–	–	–
29	Gunay *et al*. (36)	2010	36	M	–	–	–	–	–	–	–	–	Signs of TS	–	–	–
30	Tang and Liu (37)	2010	56	-	–	–	–	–	–	–	–	–	–	–	–	–
31	Bhat *et al*. (38)	2009	35	F	–	–	Y	–	–	–	–	–	–	II	–	–
32	Matteucci *et al*. (39)	2009	54	F	–	–	–	–	Y	–	–	–	–	II	–	HTN

Table 1 (*continued*)

Table 1 (*continued*)

Patient No	Reference	Year	Age	Sex	Clinical presentation								Others	NYHA Class	Murmur (timing/grade/quality/location)	Comorbidities
					Asymptomatic	Dyspnea	Chest pain	Palpitation	Syncope	Arrhythmia	Conduction defect	MI				
33	Michiels *et al*. (40)	2009	75	M	–	Y	–	Y	–	–	–	–	–	–	–	–
34	Ravindranath *et al*. (41)	2009	35	F	–	Y	Y	Y	–	–	–	–	–	–	–	–
35	Darabian *et al*. (42)	2009	32	F	–	Y	–	–	–	–	–	–	–	–	/–/–/blowing/L upper sternal edge	–
36	Sasaki *et al*. (43)	2009	56	M	–	–	–	–	–	–	–	–	–	–	–	–
37	Yang *et al*. (44)	2008	69	M	Y	–	–	–	–	PAC, PVC	AV block	–	–	–	Systolic ejection/2/–/L sternal border, 2nd and 3rd intercostal space	HTN
38	Fukui *et al*. (45)	2008	38	F	Y	–	–	–	–	–	–	–	–	–	Diastolic/–/–/–/	–
39	Klein *et al*. (46)	2008	58	F	–	–	–	–	–	–	–	–	Chest pressure	–	–	–
40	Zannis *et al*. (47)	2007	24	M	–	–	Y	Y	–	–	AV block, RBBB, LBBB	–	Exertional intolerance	–	–	–
41	Vermeulen *et al*. (48)	2006	81	F	–	–	Y	–	–	–	–	–	Fever	–	–	HTN, DM
42	Yilik *et al*. (49)	2006	29	M	–	Y	–	–	–	AF	–	–	–	–	–	Smoker
43	Joshi *et al*. (50)	2006	78	M	–	–	Y	–	–	AF	–	–	Dizziness	–	Systolic ejection/–/–/pulmonic	–
44	Joshi *et al*. (50)	2006	65	M	–	–	–	–	–	–	–	–	–	–	Y	–
45	Shin *et al*. (51)	2005	35	F	–	–	Y	–	–	–	–	Y	Cardiogenic shock	–	–	–
46	Mookadam *et al*. (52)	2005	76	M	–	Y	–	–	Y	SB	–	–	Orthopnea, peripheral edema	–	Systolic ejection/1/–/base	HTN
47	Akashi *et al*. (53)	2005	62	F	Y	–	–	–	–	–	AV block	–	–	–	Systolic ejection/–/–/L parasternal	–
48	Sharda *et al*. (54)	2004	38	F	–	–	Y	Y	–	–	–	Y	–	–	Systolic ejection/3/–/L 3rd intercostal space	–
49	Mohanakrishnan *et al*. (55)	2003	23	M	–	Y	–	–	–	EB (6–7/min)	–	–	–	III	Systolic ejection/–/–/L parasternal	–
50	Banerjee and Jagasia (56)	2002	75	M	–	–	–	–	–	–	–	–	–	–	Diastolic/2/–/R upper sternal border	–
51	Lijoi *et al*. (57)	2002	75	F	–	–	Y	–	–	–	–	–	Myocardial ischemia	–	–	HTN, smoker
52	Rhew *et al*. (58)	2001	61	M	–	–	–	–	–	PAC	AV block, RBBB	–	–	–	Systolic/5/–/L sternal border and pulmonic	–
53	Tsukui *et al*. (59)	2000	63	F	–	Y	–	Y	–	AF	–	–	–	–	–	–

AF, atrial fibrillation; AV, atrioventricular; DM, diabetes mellitus; EB, ectopic beats; F, female; f/u, follow up; HTN, hypertension; LBBB, left bundle branch block; M, male; MI, myocardial infarction; N, no; NYHA, New York Heart Association; OSA, obstructive sleep apnea; PAC, premature atrial contractions; PVC, premature ventricular contractions; RBBB, right bundle branch block; SB, sinus bradycardia; ST, sinus tachycardia; TS, tricuspid stenosis; y, year; Y, yes.

Arrhythmias (21%, 11/53 cases) and conduction abnormalities (13%, 7/53 cases) were commonly reported in patients with unruptured SVAs. The most common arrhythmia observed was atrial fibrillation (9%, 5/53 cases). Other arrhythmias described include sinus tachycardia (4%, 2/53 cases), sinus bradycardia (2%, 1/53 cases), premature atrial contractions (4%, 2/53 cases), premature ventricular contractions (2%, 1/53 cases), and the presence of ectopic beats (2%, 1/53 cases). In terms of conduction issues, first-degree atrioventricular block was reported in 9% of patients (5/53 cases), followed by right bundle branch block (6%, 3/53 cases) and left bundle branch block (4%, 2/53 cases).

Comorbidities were mentioned in 23% of patients (12/53 cases). These include hypertension (19%, 10/53 cases), obstructive sleep apnea (2%, 1/53 cases), smoking (8%, 4/53 cases), dyslipidemia (2%, 1/53 cases), and type II diabetes (2%, 1/53 cases).

Diagnosis

Imaging modalities

Echocardiography (92%, 49/53 cases), CT (60%, 32/53 cases), and angiography (60%, 32/53 cases) were the most frequently used imaging modalities for the diagnosis of unruptured SVAs (*Table 2*). Transthoracic echocardiography (TTE) (83%, 44/53 cases) offered a non-invasive initial assessment of morphology, location, and origin of an SVA. Transesophageal echocardiography (42%, 22/53 cases) was performed in cases of diagnostic uncertainty, or if involvement of the surrounding structures was not well delineated on TTE. Three-dimensional echocardiography allowed for the reconstruction of SVAs and associated lesions with excellent resolution (2%, 1/53 cases). Cardiac catheterization confirmed the diagnosis, the hemodynamic significance of the lesion, and associated cardiac abnormalities. Coronary angiography (30%, 16/53 cases), CT angiography (CTA) (25%, 13/53 cases), aortic angiography (23%, 12/53 cases), ventricular angiography (6%, 3/53 cases), and aortic CTA (2%, 1/53 cases) have all been used previously as well. CT and MRI (11%, 6/53 cases) have been used as supplemental or confirmatory tests. In some cases, the diagnosis of unruptured SVA is made intra-operatively (2%, 1/53 cases).

Aneurysm characteristics from imaging studies

The majority of unruptured SVA cases involved one SV (83%, 44/53 cases), although there have been cases that involved two or all three SV's (17%, 9/53 cases) (*Table 2*). SVAs originated predominantly from the RSV (64%, 34/53 cases), followed by the non-coronary SV (NSV) (36%, 19/53 cases) and the left SV (LSV) (28%, 15/53 cases). A thrombus was present in 34% of the cases (18/53 cases). Eight percent (4/53 cases) of the reported unruptured SVAs were described as being calcified.

Unruptured SVAs may cause structural and functional anomalies of surrounding cardiac structures. Associated aortic problems such as dilation of the annulus (6%, 3/53 cases) and ascending aorta (4%, 2/53 cases) have both been described in the context of unruptured SVAs. Large unruptured SVAs can have a mass effect on adjacent cardiac chambers, outflow tracts and great vessels, thereby distorting, obstructing or compressing them (58%, 31/53 cases). The right ventricle (RV) (36%, 19/53 cases), RV outflow tract (30%, 16/53 cases), and right atrium (19%, 10/53 cases) were most commonly affected, consistent with the observation that the majority of unruptured SVAs arise from the RSV. Although less common, compression of left sided structures such as the left atrium (9%, 5/53 cases), left ventricle (LV) (6%, 3/53 cases), and LV outflow tract (2%, 1/53 cases) was also reported in the presence of unruptured SVAs, with aortic root compression and pulmonary artery constriction uncommonly reported (2%, 1/53 cases).

Valvular issues were described in 60% of the cases (32/53 cases), with aortic regurgitation being the most common (49%, 26/53 cases). Mitral regurgitation (15%, 8/53 cases), tricuspid regurgitation (8%, 4/53 cases) and tricuspid annular deformity (2%, 1/53 cases) comprise the rest of the valvular complications. Unruptured SVAs can affect the coronary arteries by displacing, compressing, obstructing or stretching them (34%, 18/53 cases). The right coronary artery (19%, 10/53 cases) and left main coronary artery (15%, 8/53 cases) were predominantly affected. Complications involving other coronary arteries such as the posterior descending artery (2%, 1/53 cases), posterior left ventricular artery (2%, 1/53 cases), left anterior descending (4%, 2/53 cases), and left circumflex artery (2%, 1/53 cases) have also been described.

Histopathology

Histopathological information was available in 18 case reports. Of these cases, inflammatory causes, which manifested as either inflammatory cell infiltration or non-specific chronic inflammatory changes, were reported in 33% of patients (6/18 cases). Degenerative changes in the tunica media of the aneurysm wall were found in 44% of

Table 2 Diagnostic findings in previously described cases of sinus of Valsalva aneurysms.

Patient No	Reference	Year	Diagnostic methods	Aneurysm characteristics				Associated findings				
				Sinus of origin	Size (mm)	Thrombus [presence/size (mm)/location]	Calcification	Aortic annulus (mm)	Ascending aorta (mm)	Valvular complications	Coronary artery complications	Others
1	Polos *et al*. (8)	2020	TTE, CTA	RCSRSV	50×51×64	–	–	35	–	AR (severe, RCC prolapse)	–	RV protrusion
2	Serban *et al*. (9)	2019	TTE, TEE, CT	RCSRSV	53×51	Y/–/along aneurysm's wall	–	–	–	AR (trivial)	RCA obstruction	RV protrusion, RVOT distortion
3	Wang *et al*. (10)	2019	TTE	NCSNSV	36×47×51	Y	–	–	54	MR (moderate), AR (severe)	–	–
4	Umeda *et al*. (11)	2018	TTE, CA	RCSRSV	20×13	Y/20/near RCC–LCC commissure	–	–	–	MR (severe, P3 prolapse)	–	–
5	Khanna *et al*. (13)	2017	CA, CT	NCSNSV	–	–	–	–	–	–	–	–
		2y f/u	TTE, CT	NCSNSV	28×29	Y/18×20/ protruding into RA	–	–	–	AR (mild)	–	–
6	Ponti *et al*. (14)	2017	CA, TTE, CTA	LCSLSV	–	–	–	–	–	AR (mild)	LM compression	–
7	Luo *et al*. (15)	2017	TTE, TEE, 3DE, CT	NCSNSV	98x62×76	–	–	–	–	MR (mild/ moderate)	–	LA, RA compression
8	Guner *et al*. (16)	2017	TTE, CT	LCSLSV, RSV, NSV	70	–	–	–	–	AR (mild)	–	–
9	Chigurupati *et al*. (5)	2017	CTA, TTE	RCSRSV, NSV	41×36 (R), 60x57 (N)	–	–	22	23	AR (severe), MR (trivial)	–	–
10	Giambruno *et al*. (17)	2016	TTE, CT, CTA	RCSRSV	59×56	–	–	–	–	AR (moderate)	RCA ran across SVA's surface	–
11	Prifti *et al*. (18)	2016	TTE, TEE, CT	NCSNSV	74×60	–	–	–	–	–	–	RA compression
12	Sato *et al*. (19)	2016	TTE, CT	RCSRSV	20	–	–	–	–	AR (mild)	–	–
13	Qian *et al*. (12)	2016	TEE, CTA	LCSLSV	87	–	–	–	–	–	–	LV compression
14	Karvounaris *et al*. (20)	2015	TTE, TEE	LCSLSV	59×92	Y	–	–	–	MR (moderate), TR (moderate)	LM over–stretched	PA constriction, LA protrusion
15	Gong *et al*. (21)	2015	TTE, CT, CTA, TEE	LCSLSV, RSV	57, 57	–	–	–	–	AR (moderate/ severe)	–	–

Table 2 (*continued*)

Table 2 (*continued*)

Patient No	Reference	Year	Diagnostic methods	Aneurysm characteristics: Sinus of origin	Size (mm)	Thrombus (presence/size (mm)/location)	Calcification	Aortic annulus (mm)	Associated findings: Ascending aorta (mm)	Valvular complications	Coronary artery complications	Others
16	Chikkabasavaiah *et al*. (22)	2014	TTE, TEE, CT, MRI, AA	LCSLSV	100×32×60	–	Y	–	–	AR (moderate)	–	Dissection into IVS and LV
17	Ogiwara *et al*. (23)	2013	AA, TTE	LCSLSV	–	–	–	–	–	–	RCA aneurysm, LAD aneurysm, LM stretched	–
		9y f/u	TTE, CT	RCSRSV, NSV	41×25 (R), 55×47 (N)	Y	–	–	–	AR (severe)	–	Aortic root compression, RA, LA protrusion
18	Schonrath *et al*. (24)	2013	CT, TEE, MRI, CA	LCSLSV	75	Y	–	–	–	–	LM occlusion	–
19	Minagawa *et al*. (25)	2013	TTE, 3D CT, CT	RCSRSV	33	–	–	–	–	–	–	RVOT compression
20	Lu *et al*. (26)	2013	TTE, TEE, ACTA, CTA	RCSRSV	50×33	–	–	–	–	AR (moderate)	–	–
21	Hu *et al*. (27)	2013	TTE, CT	RCSRSV	75×60	–	–	–	–	–	RCA compression	RVOT compression
22	Jouni *et al*. (28)	2012	TTE, CTA, TEE	RCSRSV	51	–	–	–	–	AR (moderate/severe)	–	RVOT protrusion
23	Yagoub *et al*. (29)	2012	TTE, CT, CA	RCSRSV	35×37×42	–	–	–	–	–	–	RVOT compression
24	Saritas *et al*. (30)	2012	TTE, CT	NCSNSV	48×40	Y/28/inside aneurysm sac	–	–	–	–	–	RA compression
25	*Altarabsheh et al. (32)*	2011	CT, TTE, CA, AA, CTA	LCSLSV, RSV, NSV	84×70 (L), 35×32 (N)	Y	–	–	–	AR (trivial)	LM compression	–
26	Gupta *et al*. (33)	2010	TTE, CT, CTA, CA	NCSNSV	–	Y	Y	–	–	–	–	–
27	Sohal *et al*. (34)	2010	TTE, CA, AA	RCSRSV	62×51	–	–	–	–	TR	–	RVOT obstruction
28	Rosu *et al*. (35)	2010	CT	RCSRSV	–	–	–	–	–	–	–	RVOT compression
29	Gunay *et al*. (36)	2010	CT, TEE	NCSNSV	–	–	–	–	–	–	–	RA protrusion
30	Tang and Liu (37)	2010	CA, CT, CTA	RCSRSV	–	–	–	–	–	–	RCA compression	–

Table 2 (*continued*)

Table 2 (*continued*)

Patient No	Reference	Year	Diagnostic methods	Aneurysm characteristics				Associated findings				
				Sinus of origin	Size (mm)	Thrombus (presence/size (mm)/location)	Calcification	Aortic annulus (mm)	Ascending aorta (mm)	Valvular complications	Coronary artery complications	Others
31	Bhat *et al*. (38)	2009	TTE, LVA, AA	LCSLSV, RSV, NSV	100×60 (L), 30 (R), 30 (N)	Y	–	–	–	–	LM compression	RVOT compression
32	Matteucci *et al*. (39)	2009	TEE, CT	NCSNSV	67	–	–	–	–	–	RCA displaced	RA compression
33	Michiels *et al*. (40)	2009	TTE, CTA, CA	RCSRSV	67×48	–	–	–	–	–	–	RV protrusion
34	Ravindranath *et al*. (41)	2009	TTE, AA	LCSLSV, RSV, NSV	62×35 (L)	Y	–	–	–	MR (mild)	–	–
35	Darabian *et al*. (42)	2009	TTE, CTA	NCSNSV	75×58	–	–	–	–	AR (moderate)	–	LA, RA protrusion; LVOT, RVOT obstruction
36	Sasaki *et al*. (43)	2009	Intra–operative	NCSNSV	30×32×36	Y	Y	–	–	TV annular deformity	–	RA protrusion
37	Yang *et al*. (44)	2008	CT, TTE	RCSRSV	–	Y	–	–	–	MR (mild), TR (mild)	–	RVOT obstruction
38	Fukui *et al*. (45)	2008	TTE, CT	RCSRSV	52	–	–	–	–	AR (severe)	RCA compression	–
39	Klein *et al*. (46)	2008	CT, TTE, AA	RCSRSV	80×60	–	–	–	–	AR (moderate)	–	–
40	Zannis *et al*. (47)	2007	TTE, TEE, CT	LCSLSV, RSV	–	–	–	–	–	–	–	–
41	Vermeulen *et al*. (48)	2006	TTE, CA, MRI	RCSRSV	50	Y	–	–	–	–	RCA obstruction	RV protrusion
42	Yilik *et al*. (49)	2006	CT, TTE, TEE, CA	NCSNSV	97×80	–	–	–	–	–	–	–
43	Joshi *et al*. (50)	2006	TTE, TEE, MRI, CA	RCSRSV	42×35	–	–	–	–	–	RCA displaced	RVOT obstruction
44	Joshi *et al*. (50)	2006	TTE, TEE, CT	RCSRSV	59×49	–	–	–	–	AR (severe)	RCA involved in SVA	RVOT compression
45	Shin *et al*. (51)	2005	TTE, TEE, CT	LCSLSV	30	–	–	–	–	AR (moderate/ severe)	LM compression	–
46	Mookadam *et al*. (52)	2005	TTE, TEE	RCSRSV	57	–	–	Dilated	Dilated	AR (moderate)	–	RVOT obstruction
47	Akashi *et al*. (53)	2005	TTE, TEE, AA	LCSLSV, RSV, NSV	42×40 (L), 16×20 (R), 60×60 (N)	–	–	–	–	AR (trivial), MR (trivial), TR (moderate)	–	LA, RA compression

Table 2 (*continued*)

Table 2 (*continued*)

Patient No	Reference	Year	Diagnostic methods	Aneurysm characteristics				Associated findings				
				Sinus of origin	Size (mm)	Thrombus (presence/size (mm)/location)	Calcification	Aortic annulus (mm)	Ascending aorta (mm)	Valvular complications	Coronary artery complications	Others
48	Sharda *et al*. (54)	2004	TTE, CA, LVA, RVA	RCSRSV	–	–	–	–	–	–	PDA, PLV occlusion (due to thrombi)	RVOT obstruction
49	Mohanakrishnan *et al*. (55)	2003	TTE, MRI, CT	RCSRSV	120×30	Y	–	–	–	–	–	RVOT compression
50	Banerjee and Jagasia (56)	2002	TTE, TEE, CT, CA, AA	RCSRSV	70	Y	–	–	–	AR (mild)	–	RA compression
51	Lijoi *et al*. (57)	2002	LVA, AA, CA, TEE	LCSLSV	20×70	Y	–	–	–	–	LM, LAD, LCx displaced; 1st Diag, 2nd Diag stretched/ elongated causing stenosis	–
52	Rhew *et al.* (58)	2001	TTE, CT, TEE, AA	RCSRSV	100×100	–	Y	–	–	AR (mild)	–	RVOT compression
53	Tsukui *et al.* (59)	2000	CT, AA, MRI	NCSNSV	70	–	–	Dilated	–	AR (moderate/ severe)	–	–

3DE, 3D echocardiography; AA, aortic angiography; ACTA, aortic computed tomography angiography; AR, aortic regurgitation; CA, coronary angiography; CT, computed tomography; CTA, computed tomography angiography; Diag, diagonal branch of LAD; f/u, follow up; IVS, interventricular septum; L, left; LA, left atrium; LAD, left anterior descending; LCC, left coronary cusp; LSV, left sinus of Valsalva; LCx, left circumflex; LM, left main; LV, left ventricle; LVA, left ventricle angiography; LVOT, left ventricle outflow tract; MR, mitral regurgitation; MRI, magnetic resonance imaging; N, no; NSV, non-coronary sinus of Valsalva; PA, pulmonary artery; PDA, posterior descending artery; PLV, posterior left ventricular; R, right; RA, right atrium; RCA, right coronary artery; RCC, right coronary cusp; RSV, right sinus of Valsalva; RV, right ventricle; RVA, right ventricle angiography; RVOT, right ventricle outflow tract; STJ, sinotubular junction; SVA, sinus of Valsalva aneurysm; TEE, transesophageal echocardiography; TR, tricuspid regurgitation; TTE, transthoracic echocardiography; TV, tricuspid valve; y, year; Y, yes.

cases (8/18 cases), with mucoid deposits noted in 39% of them (7/18 cases). Damage, deficiency or absence of elastic fibers was present in 28% of the reported cases (5/18 cases). Atherosclerotic degeneration was also noted in 6% of patients (1/18 cases).

Surgical management and outcomes

All 53 cases (100%) of unruptured SVAs were managed surgically (*Table 3*). One patient was initially managed conservatively with medical follow-up and TTE every 6 months. However, at the two-year follow-up, the unruptured SVA was shown to increase in size, with thrombus formation and mass effect on surrounding structures, necessitating surgical intervention.

Indications for treatment

The rationale behind surgical treatment of unruptured SVAs was mentioned in 21 cases (*Table 3*). Among these cases, the majority of unruptured SVAs were surgically managed to as a preventative measure to avoid complications such as aneurysm rupture or thrombus formation (38%, 8/21 cases with information on treatment indication). Aneurysm size, either large or rapidly increasing size, was an indication for surgical treatment in 29% of patients (6/21 cases). Other indications included symptomatic clinical presentation (14%, 3/21 cases), presence of a thrombus (14%, 3/21 cases), observation of a mass effect on adjacent structures (14%, 3/21 cases), and recurrent aneurysm after surgical resection (5%, 1/21 cases).

Surgical approaches

Surgical approaches for the management of unruptured SVAs were mainly dependent on aneurysm size and the presence of associated lesions (*Table 3*). Small aneurysms can be repaired by direct closure of the aneurysmal orifice (4%, 2/53 cases). For larger aneurysms, patch repair was preferred as direct closure may distort the anatomy of the aortic root (66%, 35/53 cases). The presence of valvular issues generally requires valve replacement/repair or annular repair. Aortic valve (AV) replacement/repair was performed in 36% of patients (19/53 cases), AV annuloplasty in 6% (3/53 cases), mitral valve (MV) replacement/repair in 8% (4/53 cases), MV annulus reconstruction in 2% (1/53 cases), and tricuspid valve repair in 2% of patients (1/53 cases). If the involvement of the unruptured SVA was extensive and the aortic root appeared distorted, full aortic root replacement (23%, 12/53 cases) or ascending aorta replacement (4%, 2/53 cases) may be necessary. Coronary artery bypass grafting was performed in cases where one or more coronary arteries were compromised due to mass effect of the aneurysms (17%, 9/53 cases).

Operative outcomes

The majority of operations for unruptured SVAs were uneventful (96%, 51/53 cases) *(Table 3*). In-hospital mortality was reported in two patients (4% of cases), one intra-operative and the other within 48 hours post-operation due to multi-organ failure. Patients spent 4 to 21 days in hospital after surgical management of unruptured SVAs.

Prognosis

Follow-up, ranging from five days to nine years in duration, was reported in 31 cases (*Table 3*). The majority of these cases were asymptomatic and showed obliteration of the aneurysm as well as restoration of aortic root anatomy and valvular function (94%, 29/31). One patient needed percutaneous intervention at follow-up due to a detected leak, and the aneurysm only showed partial thrombosis after surgical repair (14). At the two-month follow-up post percutaneous intervention, CTA showed almost complete thrombosis of the aneurysm lumen. One patient was reported to have recurrence of SVA at nine-years of follow-up, which required surgical intervention (23).

Limitations

Our study is subject to a number of limitations. Given that our review article only includes published articles, it may be subject to publication bias. In addition, in our efforts to provide a contemporary review by limiting the inclusion criteria to articles published after the year 2000, we may have excluded other less contemporary, but relevant studies. Heterogeneity in study populations is evident. We cannot account for centre-specific practices, threshold for intervention, and postoperative management that may affect the therapeutic strategies and patient outcomes of unruptured SVAs.

Conclusions

Unruptured SVAs are rare entities that can cause significant morbidity and devastating consequences if ruptured. Advances in cardiac imaging have made early recognition and diagnosis of unruptured SVAs possible in a less invasive manner in recent years. Regardless, the diagnosis of

Table 3 Treatment approaches and outcomes of sinus of Valsalva aneurysms

Patient No	Reference	Year	Approach	Indication for treatment	Method of repair	Complications	Pathology/histology	Hospital stay (d)	Follow-up time	Follow-up findings
1	Polos *et al.* (8)	2020	Surgery	Clinical presentation	Direct closure of the opening of aneurysm, AV repair, AV annuloplasty, aortic root replacement	–	–	–	1 m	TTE—competent AV, no AR
2	Serban *et al.* (9)	2019	Surgery	Aneurysm size	Resection and patch repair of aneurysm, CABGx1 (SVG to RCA)	–	Elastic fibers deficiency, mucoid deposits	11	1 m	Asymptomatic; TTE, TEE, CT—normal AV, aortic root and ascending aorta
3	Wang *et al.* (10)	2019	Surgery	Aneurysm size, involvement of adjacent structures	Resection of aneurysm, MVR, MV annulus reconstruction, AVR, ascending aorta replacement	–	Mucoid degeneration, abscess formation, inflammatory cells infiltration	–	–	TTE—functioning AV and MV; CTA—restoration of normal aortic root anatomy
4	Umeda *et al.* (11)	2018	Surgery	Prevent systemic embolization	Patch repair of aneurysm, MV repair	–	Fresh thrombus with fibrin, red blood cells, white blood cells, platelets	–	–	–
5	Khanna *et al.* (13)	2017	Medical f/u, TTE q6m	–	–	–	–	–	2 y	TTE, CT—enlarged SVA originated from NSV (28x29mm), with thrombus (18x20mm), protruding into RA; mild AR
		2y f/u	Surgery	Prevent systemic embolization	Resection and patch repair of aneurysm	–	–	–	–	–
6	Ponti *et al.* (14)	2017	Surgery	–	Patch repair of aneurysm, CABGx3 (LIMA to LAD, SVG to LCx, SVG to ramus)	–	–	–	–	TTE, CTA—leak at anterior border of the patch used to close the aneurysm, only partial thrombosis of aneurysm; readmitted for percutaneous procedure
		f/u	Percutaneous	Leak detected and only partial thrombosis of aneurysm post surgical repair	Selective catheterization through the residual neck, implantation of Amplazer septal occluder	–	–	–	2 m	CTA—almost complete thrombosis of aneurysm lumen
7	Luo *et al.* (15)	2017	Surgery	–	Bentall procedure, MVR	–	–	7	–	–
8	Guner *et al.* (16)	2017	Surgery	–	Cabrol procedure	–	–	–	–	–
9	Chigurupati *et al.* (5)	2017	Surgery	–	Modified Bentall procedure	–	–	–	–	–
10	Giambruno *et al.* (17)	2016	Surgery	Aneurysm size	Resection and patch repair of aneurysm, AVR, CABGx1 (SVG to RCA)	–	No specific pathologic conditions/ infective processes	5	1 y	Asymptomatic; TTE—functioning AV and good biventricular function
11	Prifti *et al.* (18)	2016	Surgery	Prevent rupture	Resection and patch repair of aneurysm	–	Mucoid deposits, loss of elastic fibers, eosinophilic infiltration	–	1 m, 1 y	1m: CTA—complete thrombosed cavity of the previous aneurysm; 1y: TTE—mild AR
12	Sato *et al.* (19)	2016	Surgery	Aneurysm size	Patch repair of aneurysm	–	–	–	1w, 3 m, 1 y	1w: CT—no leakage of contrast medium into the isolated aneurysm; 3m: TTE, CT—aneurysm size reduction, heterogeneous echogenicity, blood flow in the aneurysm, thrombus formation, a recurrent fistula, partial recanalization between the patched aneurysm and the R SOV; 1y: TTE—significant aneurysm size reduction, no shunt flow
13	Qian *et al.* (12)	2016	Surgery	Prevent thrombus formation and rupture	Resection of aneurysm, reconstruction of coronary arteries	–	Breakage of the intimal elastic fiber, lymphocytic infiltration, fibroplastic proliferation, calcification foci and hyaline degeneration with cystic degeneration of the tunica media	–	–	–
14	Karvounaris *et al.* (20)	2015	Surgery	Clinical presentation	Bentall procedure	Dead	–	–	–	–
15	Gong *et al.* (21)	2015	Surgery	–	AV annuloplasty, aortic sinus repair, coronary artery ostia graft	–	–	–	–	–

Table 3 (*continued*)

Table 3 (*continued*)

Patient No	Reference	Year	Approach	Indication for treatment	Method of repair	Complications	Pathology/histology	Hospital stay (d)	Follow-up time	Follow-up findings
16	Chikkabasavaiah *et al.* (22)	2014	Surgery	–	A sandwich device fabricated with Gortex and Teflon felt was used to close the aneurysm (Trusler's repair), gel foam was injected to facilitate clot formation in the aneurysm, AV subcommissural annuloplasty	–	–	–	1 m	Asymptomatic; TTE—clot formation within aneurysm, minimal AR
17	Ogiwara *et al.* (23)	2013	Surgery	–	Resection and patch repair of aneurysm, LM reimplanted using button technique, CABGx2 (SVG to LAD, SVG to RCA—IMA's were too small for bypass grafting)	–	Mild atherosclerotic degeneration	–	9 y	TTE, CT—recurrent SVA's originated from RSV and NSV; severe AR; aortic root, RA and LA compression
		9y f/u	Surgery	Recurrent aneurysms	AVR, aortic root replacement	Unsuccessful separation from bypass, cardiac output was not maintained, dead within 48h post–operative	–	–	–	–
18	Schonrath *et al.* (24)	2013	Surgery	–	Resection of aneurysm, aortic root replacement, CABGx2 (LIMA to LAD, RIMA to LCx)	–	–	–	–	–
19	Minagawa *et al.* (25)	2013	Surgery	Prevent rupture	Patch repair of aneurysm	–	–	21	2w, 4 m	2w: TTE—RVOT flow 3.1m/s; 4m: TTE, CT—further improved RVOT flow, no AR, no leakages to SVA sac, size reduction of the SVA sac, improvement of RVOT obstruction, RVOT flow 0.6m/s
20	Lu *et al.* (26)	2013	Surgery	–	Bentall procedure, modified Maze III procedure (for AF)	–	Diffuse mucin deposits in the media of the aneurysm, absence of medial elastic fibers	–	2.5 m	Unremarkable
21	Hu *et al.* (27)	2013	Surgery	–	Aneurysm repaired with scalloped patch of wider diameter than the distance between the sinotubular ridge superiorly and the bases of aortic annulus inferiorly, creating a pseudosinus. An aortic flap was tailored around the ostium of the RCA and sewn to the patch (the flap base was the normal aortic wall, it's free edge was corresponding to the remnant edge of the patch)	–	Mucoid degeneration in the wall of the aneurysm	–	–	CTA, TTE—functioning AV, no AR, preserved aortic geometry
22	Jouni *et al.* (28)	2012	Surgery	–	Patch repair of aneurysm, AVR	–	–	–	–	–
23	Yagoub *et al.* (29)	2012	Surgery	–	Valve–sparing repair of aneurysm	–	–	–	–	TTE—obliteration of SVA, functioning AV
24	Saritas *et al.* (30)	2012	Surgery	–	Patch repair of aneurysm, AVR, CABGx3	–	–	–	–	–
25	Altarabsheh *et al.* (32)	2011	Surgery	–	AVR, aortic root replacement, reimplantation of coronary buttons	–	–	–	–	–
26	Gupta *et al.* (33)	2010	Surgery	–	Resection of aneurysm, ascending aorta replacement, reimplantation of R coronary button	–	–	–	–	–
27	Sohal *et al.* (34)	2010	Surgery	–	Resection and patch repair of aneurysm	–	–	–	–	–
28	Rosu *et al.* (35)	2010	Surgery	–	Patch repair of aneurysm, reimplantation of R coronary button	–	–	–	–	–
29	Gunay *et al.* (36)	2010	Surgery	–	Resection and patch repair of aneurysm	–	–	–	–	–
30	Tang and Liu (37)	2010	Surgery	–	Patch repair of aneurysm, AVR, CABGx1 (SVG to RCA)	–	–	9	–	–
31	Bhat *et al.* (38)	2009	Surgery	–	Patch repair of aneurysm	–	Nonspecific chronic inflammation	–	9 m	Asymptomatic; TTE—near normal dimensions of 3 sinuses, normal biventricular function
32	Matteucci *et al.* (39)	2009	Surgery	Aneurysm size	Resection and patch repair of aneurysm	–	Eosinophilic infiltration of aneurysmal wall	–	1 m	Asymptomatic; no LVOT obstruction

Table 3 (*continued*)

Table 3 (*continued*)

Patient No	Reference	Year	Approach	Indication for treatment	Method of repair	Complications	Pathology/histology	Hospital stay (d)	Follow-up time	Follow-up findings
33	Michiels *et al.* (40)	2009	Surgery	–	Patch repair of aneurysm, reimplantation of R coronary button	–	–	–	–	–
34	Ravindranath *et al.* (41)	2009	Surgery	–	Patch repair of aneurysm	–	Nonspecific chronic inflammation	–	–	TTE—near normal dimensions of all 3 sinuses, normal biventricular function, no regional wall motion abnormalities
35	Darabian *et al.* (42)	2009	Surgery	–	Resection and patch repair of aneurysm, AVR, MVR	–	–	–	3 m	Unremarkable
36	Sasaki *et al.* (43)	2009	Surgery	–	Patch repair of aneurysm, TV repair	–	Aneurysmal sac filled with a highly laminated and calcified agglutinative thrombus, the surface of the aneurysm contained only a layer of elastic fibers	–	1 y	Unremarkable
37	Yang *et al.* (44)	2008	Surgery	Presence of intraluminal thrombus	Patch repair of aneurysm	–	–	–	–	TTE—normal aortic root, no AR
38	Fukui *et al.* (45)	2008	Surgery	–	Resection and patch repair of aneurysm, AVR, reimplantation of R coronary button, reconstruction of RCA	–	Diffusely necrotized aortic media, severely destroyed elastic fiber of the media	21	–	–
39	Klein *et al.* (46)	2008	Surgery	–	Aortic root replacement, reimplantation of L coronary button, CABGx1 (SVG to RCA)	–	–	4	–	–
40	Zannis *et al.* (47)	2007	Surgery	Aneurysm size, aneurysm extracardiac extension	Patch repair of aneurysm	–	–	8	11 m	Unremarkable
41	Vermeulen *et al.* (48)	2006	Surgery	–	Patch repair of aneurysm, CABGx1 (SVG to RCA)	–	Thrombus material in the organisation phase suggesting that the origin of the aneurysm was a degenerative dissection of the right coronary sinus	7	–	TTE—unremarkable
42	Yilik *et al.* (49)	2006	Surgery	–	Resection and patch repair of aneurysm	–	Mucoid degenaration of the tunica media, no inflammatory change	–	5d, 3 m	TTE—normal aortic root, no AR
43	Joshi *et al.* (50)	2006	Surgery	Prevent rupture	Patch repair of aneurysm	–	–	5	1 y	TTE—competent AV, no RVOT gradient
44	Joshi *et al.* (50)	2006	Surgery	Prevent rupture	AVR, hemiroot replacement, reimplantation of R coronary button	–	Cystic medial necrosis of the aortic wall with myxoid changes in the valve tissue	7	1 y	Asymptomatic; TTE—functioning AV, no AR, root diameter 35mm, no residual aortic aneurysm
45	Shin *et al.* (51)	2005	Surgery	–	Patch repair of aneurysm, AVR	–	–	–	–	TTE—normal LV wall motion, functioning AV; Multislice spiral CT—good coronary flow, no compression
46	Mookadam *et al.* (52)	2005	Surgery	–	Repair of aneurysm, AV repair, resection of ventricular aneurysm	–	–	–	6 y	Unremarkable
47	Akashi *et al.* (53)	2005	Surgery	Prevent complications	Valve-sparing aortic root remodeling using Yacoub procedure	–	–	–	–	AA—no AR
48	Sharda *et al.* (54)	2004	Surgery	–	Patch repair of aneurysm	–	–	–	–	TTE—unremarkable
49	Mohanakrishnan *et al.* (55)	2003	Surgery	Clinical presentation	Resection and patch repair of aneurysm, RVOT reconstruction using pericardial patch	–	–	8	–	–
50	Banerjee and Jagasia (56)	2002	Surgery	–	Resection and patch repair of aneurysm	–	–	–	–	–

Table 3 (*continued*)

Table 3 (*continued*)

Patient No	Reference	Year	Approach	Indication for treatment	Method of repair	Complications	Pathology/histology	Hospital stay (d)	Follow-up time	Follow-up findings
51	Lijoi *et al.* (57)	2002	Surgery	–	Direct closure of the opening of aneurysm	–	–	–	6 m	Asymptomatic; TTE—normal aortic root, no AR, normal LV function; Thallium scintigraphy, exercise stress test—no residual ischemia
52	Rhew *et al.* (58)	2001	Surgery	Prevent rupture, relieve outflow tract obstruction	Patch repair of aneurysm	–	–	–	–	–
53	Tsukui *et al.* (59)	2000	Surgery	Prevent rupture	Resection and patch repair of aneurysm, AVR	–	Mucoid degeneration of the tunica media without inflammatory changes	–	10 m	Unremarkable

AA, aortic angiography; AR, aortic regurgitation; AV, aortic valve; AVR, aortic valve replacement; BBB, bundle branch block; CABG, coronary bypass grafting; CT, computed tomography; CTA, computed tomography angiography; d, day; f/u, follow up; IMA, internal mammary artery; L, left; LAD, left anterior descending; LSV, left sinus of Valsalva; LCx, left circumflex; LIMA, left internal mammary artery; LM, left main; LV, left ventricle; LVOT, left ventricular outflow tract; m, month; MV, mitral valve; MVR, mitral valve replacement; NSV, non-coronary sinus of Valsalva; q, every; R, right; RA, right atrium; RCA, right coronary artery; RSV, right sinus of Valsalva; RIMA, right internal mammary artery; RVOT, right ventricular outflow tract; SVA, sinus of Valsalva aneurysm; SVG, saphenous vein graft; TEE, transesophageal echocardiography; TTE, transthoracic echocardiography; TV, tricuspid valve; TVR, tricuspid valve replacement; w, week; y, year.

unruptured SVAs still requires a high index of suspicion, as patients can be asymptomatic or present with non-specific symptoms. Surgical repair remains the preferred method of treatment in order to prevent complications such as rupture or thrombus formation. Surgery should be prompted in patients with symptomatic, large, or rapidly expanding unruptured SVAs, as well as those unruptured SVAs that contain intraluminal thrombi, have a mass effect on surrounding structures, or are recurrent. Surgical outcomes are generally good with favourable prognosis and minimal recurrence.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at http://dx.doi.org/10.21037/jtd-20-2682

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jtd-20-2682). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Vural KM, Sener E, Taşdemir O, et al. Approach to sinus of Valsalva aneurysms: A review of 53 cases. Eur J Cardiothorac Surg 2001;20:71-6.
2. Weinreich M, Yu PJ, Trost B. Sinus of Valsalva Aneurysms: Review of the Literature and an Update on Management. Clin Cardiol 2015;38:185-9.
3. Omeh DJ, Makaryus AN. Unruptured Multiple Sinus of Valsalva Aneurysms. Case Rep Radiol 2020;2020:5046095.
4. Vijay BA, Vijan V, Mathew N. Surviving All Odds: A Unique Case of Multiple Congenital Unruptured Sinus of Valsalva Aneurysms Involving Both Left and Right Coronary Sinuses with Biventricular Dysfunction and Heart Block. Case Rep Cardiol 2016;2016:4654031.
5. Chigurupati K, Kumaresan B, Gadhinglajkar S, et al. Multiple unruptured aortic sinus of Valsalva aneurysms: A rare presentation. Echocardiography 2017;34:317-9.
6. Yan F, Abudureheman M, Huo Q, et al. Surgery for sinus of Valsalva aneurysm: 33-year of a single center experience. Chin Med J (Engl) 2014;127:4066-70.
7. Choudhary SK, Bhan A, Sharma R, et al. Sinus of Valsalva aneurysms: 20 years' experience. J Card Surg 1997;12:300-8.
8. Pólos M, Șulea CM, Benke K, et al. Giant unruptured sinus of Valsalva aneurysm successfully managed with valve-sparing procedure - a case report. J Cardiothorac Surg 2020;15:6.
9. Serban AM, Bătrâna N, Cocoi M, et al. The role of echocardiography in the diagnosis and management of a giant unruptured sinus of Valsalva aneurysm. Med Ultrason 2019;21:194-6.
10. Wang B, Ma D, Qu L, et al. Sinus of Valsalva aneurysm protruding into the mitral anterior leaflet causing dyspnea: A CARE-compliant case report. Medicine (Baltimore) 2019;98:e18169.
11. Umeda H, Isotani A, Arita T, et al. Rapid growth of thrombus formation in the unruptured sinus of Valsalva aneurysm following coronary angiography. J Echocardiogr 2018;16:182-4.
12. Qian H, Ouyang Q, Li Y, et al. Compression of left ventricle by a rare giant unruptured sinus of Valsalva aneurysm. Anatol J Cardiol 2016;16:E1-2.
13. Khanna R, Shah P, Dey M, et al. Unruptured sinus of Valsalva aneurysm mimicking as right atrial tumor. Echocardiography 2017;34:1107-9.
14. Ponti A, Qanadli SD, Kirsch M, et al. Left sinus of Valsalva aneurysm as a cause of chronic stable angina. Interact Cardiovasc Thorac Surg 2017;24:967-8.
15. Luo Y, Fang Z, Meng W. A giant aneurysm of noncoronary sinus of Valsalva concomitant with aortic regurgitation and mitral regurgitation. Echocardiography 2017;34:796-8.
16. Guner A, Celik M, Kahyaoglu M, et al. Multiple aneurysmatic involvement of sinus of Valsalva. Echocardiography 2017;34:627-8.

17. Giambruno V, Cucchietti C, Pisano C, et al. Alternative Surgical Approach to Repairing a Giant Sinus of Valsalva Aneurysm. Tex Heart Inst J 2016;43:43-4.
18. Prifti E, Ademaj F, Baboci A, et al. Surgical treatment of a giant unruptured aneurysm of the noncoronary sinus of Valsalva: a case report. J Med Case Rep 2016;10:252.
19. Sato Y, Kawasaki T, Yamano M, et al. Unusual clinical course after surgical repair of unruptured aneurysm of sinus of Valsalva. J Med Ultrason (2001) 2016;43:523-6.
20. Karvounaris S, Michas G, Karampetsos V, et al. Giant Unruptured Left Sinus of Valsalva Aneurysm as an Unusual Cause of Ischemic Heart Failure. Hellenic J Cardiol 2015;56:441-3.
21. Gong W, Ye X, Wang Z, et al. Two balls around aortic root: Multiple huge unruptured aneurysms of the Valsalva sinus. Eur Heart J Cardiovasc Imaging 2015;16:827.
22. Chikkabasavaiah NA, Patra S, Basavappa R, et al. Large unruptured sinus of valsalva aneurysm dissecting into interventricular septum and presenting as a complex myocardial cystic mass. Echocardiography 2014;31:E207-11.
23. Ogiwara M, Ozaki M, Iwazaki M, et al. Multiple recurrent sinus of valsalva aneurysms. J Card Surg 2013;28:677-9.
24. Schönrath F, Alkadhi H, Landmesser U, et al. Giant unruptured sinus valsalva aneurysm: An unusual cause of typical angina. Eur Heart J 2013;34:1608.
25. Minagawa T, Watanabe S, Kanda K, et al. Surgical treatment for an asymptomatic and unruptured sinus of Valsalva aneurysm: Report of a case. Surg Today 2013;43:1199-201.
26. Lu S, Sun X, Wang C, et al. Surgical correction of giant extracardiac unruptured aneurysm of the right coronary sinus of Valsalva: Case report and review of the literature. Gen Thorac Cardiovasc Surg 2013;61:143-6.
27. Hu Y, Chen J, Zhong Q. Modified repair for huge unruptured aneurysm of the right sinus of valsalva. Thorac Cardiovasc Surg 2013;61:323-6.
28. Jouni H, Driver SL, Wright RS, et al. Danger above: a classic case of an unruptured right sinus of Valsalva aneurysm. BMJ Case Rep 2012;2012:bcr2012007437.
29. Yagoub H, Srinivas BP, McCarthy J, et al. Gigantic unruptured sinus of Valsalva aneurysm presenting as an incidental murmur. BMJ Case Rep 2012;2012:bcr2012006824.
30. Saritas A, Unal EU, Caliskan A, et al. Unruptured sinus of valsalva aneurysm displacing the right atrium. Eur J Cardiothorac Surg 2012;42:745.
31. Xu B, Kocyigit D, Betancor J, et al. Sinus of Valsalva Aneurysms: A State-of-the-Art Imaging Review. J Am Soc Echocardiogr 2020;33:295-312.
32. Altarabsheh SEI, Araoz PA, Deo SV, et al. Unruptured sinus of valsalva aneurysm involving all three sinuses. Ann Thorac Surg 2011;91:e26-7.
33. Gupta M, Haseen MA, Shrivastav A, et al. Giant Unruptured Calcified Aneurysm of Non-coronary Sinus of Valsalva. Heart Lung Circ 2010;19:629.
34. Sohal M, Rajani R, De Belder A. Sinus of Valsalva aneurysm - An unusual cause of syncope. Echocardiography 2010;27:E60-1.
35. Rosu C, Basile F, Prieto I, et al. Unusual presentation of an isolated unruptured aneurysm of the right sinus of Valsalva causing compression of the right ventricular outflow tract. Eur J Cardiothorac Surg 2010;38:504.
36. Gunay R, Sensoz Y, Kayacioglu I. Giant unruptured non-coronary sinus of Valsalva aneurysm presenting as tricuspid stenosis. Eur J Cardiothorac Surg 2010;37:1471.
37. Tang G, Liu Y. 64-Row MDCT demonstration of an unruptured aneurysm of the sinus of Valsalva. J Card Surg 2010;25:70-1.
38. Bhat PS, Babu M, Gehlot R, et al. Aneurysm of all 3 sinuses of Valsalva causing coronary insufficiency. Asian Cardiovasc Thorac Ann 2009;17:637-9.
39. Matteucci MLS, Rescigno G, Capestro F, et al. Syncope triggered by a giant unruptured sinus of Valsalva aneurysm. Interact Cardiovasc Thorac Surg 2009;9:1047-8.
40. Michiels V, Salgado R, Vrints C, et al. Sinus of Valsalva Aneurysm. J Am Coll Cardiol 2009;54:876.
41. Ravindranath KS, Bhat S, Subramanyam KS, et al. Rare presentation of unruptured sinus of valsalva aneurysm involving all three sinuses. Indian Heart J 2009;61:121-2.
42. Darabian S, Ahmadi SH, Abbasi K, et al. Giant unruptured noncoronary sinus of valsalva aneurysm. J Card Surg 2009;24:351-3.
43. Sasaki S, Asano M, Fukuda K, et al. Unruptured Sinus of Valsalva Aneurysm Suspected to Be a Cardiac Tumor. Ann Thorac Surg 2009;87:1619.
44. Yang Y, Zhou Y, Ma L, et al. Unruptured aneurysm of the sinus of valsalva presenting with thrombosis and right ventricular outflow obstruction. J Card Surg 2008;23:782-4.
45. Fukui S, Mitsuno M, Yamamura M, et al. Successful Repair of Unruptured Aneurysm of the Right Sinus of Valsalva. Ann Thorac Surg 2008;86:640-3.
46. Klein LW, Chavez JR, Montoya A. Giant Unruptured Sinus of Valsalva Aneurysm. J Invasive Cardiol 2008;20:258.
47. Zannis K, Tzvetkov B, Deux JF, et al. Unruptured

congenital aneurisms of the right and left sinuses of Valsalva. Eur Heart J 2007;28:1565.
48. Vermeulen T, Claeys M, Vrints C. Unruptured sinus of Valsalva aneurysm presenting as acute coronary syndrome. Acta Cardiol 2006;61:665-7.
49. Yilik L, Lafci B, Özsöyler I, et al. Giant extracardiac unruptured sinus of Valsalva aneurysm in a patient with left ventricular dysfunction. Heart Vessels 2006;21:328-30.
50. Joshi P, Garlick B, Dunning J. Modified Root Reconstruction Methods to Treat Unruptured Aneurysm of Sinus of Valsalva (UASOV) - Two Case Reports. Heart Lung Circ 2006;15:389-92.
51. Shin JK, Jung JP, Park CR, et al. Acute myocardial infarction due to unruptured aneurysm of left sinus of valsalva with aortic valve regurgitation. J Card Surg 2005;20:545-8.
52. Mookadam F, Haley J, Mendrick E. Rare cause of right heart failure: Contained rupture of a sinus of Valsalva aneurysm associated intraventricular septal aneurysm. Eur J Echocardiogr 2005;6:221-4.
53. Akashi H, Tayama E, Tayama K, et al. Remodeling operation for unruptured aneurysms of three sinuses of Valsalva. J Thorac Cardiovasc Surg 2005;129:951-2.
54. Sharda A, Yadava OP, Dubey S, et al. Unruptured sinus of Valsalva aneurysm presenting as acute coronary syndrome. Indian Heart J 2004;56:155-7.
55. Mohanakrishnan L, Vijayakumar K, Sukumaran P, et al. Unruptured sinus of valsalva aneurysm with right ventricular outflow obstruction. Asian Cardiovasc Thorac Ann 2003;11:74-6.
56. Banerjee S, Jagasia DH. Unruptured sinus of Valsalva aneurysm in an asymptomatic patient. J Am Soc Echocardiogr 2002;15:668-70.
57. Lijoi A, Parodi E, Passerone GC, et al. Unruptured aneurysm of the left sinus of Valsalva causing coronary insufficiency: Case report and review of the literature. Tex Heart Inst J 2002;29:40-4.
58. Rhew JY, Jeong MH, Kang KT, et al. Huge calcified aneurysm of the sinus of Valsalva. Jpn Circ J 2001;65:239-41.
59. Tsukui H, Hoshino S, Saito N, et al. Giant extracardiac unruptured aneurysm of the sinus of Valsalva: A case report. Heart Vessels 2000;15:289-90.

Cite this article as: Nguyen Q, Vervoort D, Phan K, Luc JGY. Surgical management for unruptured sinus of Valsalva aneurysms: a narrative review of the literature. J Thorac Dis 2021;13(3):1833-1850. doi: 10.21037/jtd-20-2682

