Surgical treatment of thoracic aortic pseudoaneurysm: a systematic review of the literature

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Introduction: Thoracic aortic false aneurysm is a rare complication of cardiac surgery or procedures on the thoracic aorta. We present the results of a systematic review of the literature. Our aim was to determine the best treatment options and surgical techniques.
Methods: We performed a literature search regarding thoracic aortic pseudoaneurysm and its surgical treatment in English, limited by the dates 1st January 1979 to 31st December 2022. We searched the PubMed and EMBASE databases for the following medical terms: thoracic aortic false aneurysm, pseudoaneurysm, and surgical treatment.
Results: Our search screened 4,046 articles. Only nine articles were eligible. The other articles were single case reports or small series of case reports with fewer than nine patients. All the studies were retrospective. Ninety percent of the cases underwent prior aortic or cardiac surgery. The surgical treatment strategies were chosen according to the location of the pseudoaneurysm and were overall inconclusive.
Conclusion: According to the current literature, there are no clear guidelines or recommendations; therefore, the operation should be tailored to each patient individually. Regular checkups involving imaging techniques after cardiac surgeries are recommended. Despite significant advancements in endovascular treatment, it is often not suitable, making open surgery the treatment of choice.

Key words: thoracic aortic false aneurysm, aortic pseudoaneurysm, a systematic review.

Chirurgická léčba pseudoaneuryzmatu hrudní aorty: systematický přehled literatury

Úvod: Falešné aneuryzma hrudní aorty je vzácnou komplikací kardiochirurgických výkonů nebo výkonů na hrudní aortě. Uvádíme výsledky systematického přehledu literatury. Naším cílem bylo stanovit nejlepší možnosti léčby a operační postupy.
Metody: Provedli jsme rešerši literatury zabývající se pseudoaneuryzmatem hrudní aorty a jeho chirurgickou léčbou v angličtině, která byla vymezena daty 1. leden 1979 až 31. prosinec 2022. V databázích PubMed a EMBASE jsme vyhledávali následující medicínské termíny: falešné aneuryzma hrudní aorty, pseudoaneuryzma a chirurgická léčba.
Výsledky: Naše vyhledávání prověřilo celkem 4 046 článků. Pouze devět z nich splňovalo kritéria způsobilosti. Ostatní články byly samostatné kazuistiky nebo malé série kazuistik s méně než devíti pacienty. Všechny studie byly retrospektivní. Devadesát

DECLARATIONS:

Declaration of originality:
The manuscript is original and has not been published or submitted elsewhere.

Ethical principles compliance:
The authors attest that their study was approved by the local Ethical Committee and is in compliance with human studies and animal welfare regulations of the authors' institutions as well as with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects adopted by the 18th WMA General Assembly in Helsinki, Finland, in June 1964, with subsequent amendments, as well as with the ICMJE Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals, updated in December 2018, including patient consent where appropriate.

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procent případů už dříve podstoupilo operaci aorty nebo srdce. Strategie chirurgické léčby byly zvoleny podle umístění pseudoaneuryzmatu a byly celkově nejednoznačné.

Závěr: Podle současné literatury neexistují jednoznačné pokyny či doporučení, operace by tedy měla být přizpůsobena individuálně danému pacientovi. Po kardiochirurgických výkonech se doporučují pravidelné kontroly, které obnášejí i vyšetření zobrazovacími metodami. I navzdory výraznému pokroku v endovaskulární léčbě není tato metoda vždy vhodná, a pak je léčbou volby otevřená operace.

Klíčová slova: falešné aneuryzma hrudní aorty, pseudoaneuryzma aorty, systematický přehled.

Introduction

Aortic false aneurysm, also referred to as aortic pseudoaneurysm, occurs when the aortic wall is disrupted, causing it to expand and be contained only by the periaortic connective tissue (1). This condition is commonly seen in thoracic aortic false aneurysms (TAFAs) where the blood leakage is constrained by the surrounding mediastinal structures. On one hand, it is often an infrequent complication of cardiac surgery (2); on the other hand, it can also develop through traumatic (3), inflammatory, or infectious (4) events. Patients are usually asymptomatic, which can lead to delayed diagnostic processes. This factor, combined with an unpredictable progression, makes it a hazardous situation. TAFAs can manifest through gradual expansion and compress or invade the surrounding structures (1, 5, 6). Thanks to rapid development and significant advancements in vascular interventional radiology, endovascular management might become the preferred choice of treatment, if technically feasible, to avoid complications associated with reoperation (7). However, endovascular treatment of TAFA is often not suitable and still faces limitations, which makes open surgery the treatment of choice. Regarding these facts, we present an overview of surgical approaches in the treatment of TAFAs.

Ethical approval

The literature search was exempt from ethical approval as the research involved already published data.

A systematic review of the literature

Methods

Search strategy

Two databases – PubMed and EMBASE – were searched with language limitation to English. The search was limited to the time frame between 1st January 1979 and 31st December 2022. The following MeSH terms were used: "thoracic aortic false aneurysm", "pseudoaneurysm", and "surgical treatment". No other criteria were applied during the search.

Selection criteria

As the first step, titles and abstracts were screened to determine eligibility. Studies presenting ten or more patients with surgical treatment of TAFA were included. Case reports, editorials, commentaries, articles without abstracts, articles in language other than English, and abstracts from congresses were excluded. As the second step, full-text articles were thoroughly reviewed and evaluated. Additionally, we searched the reference lists of the selected articles from the second phase to identify any relevant studies that had not been found in our initial search.

Data extraction

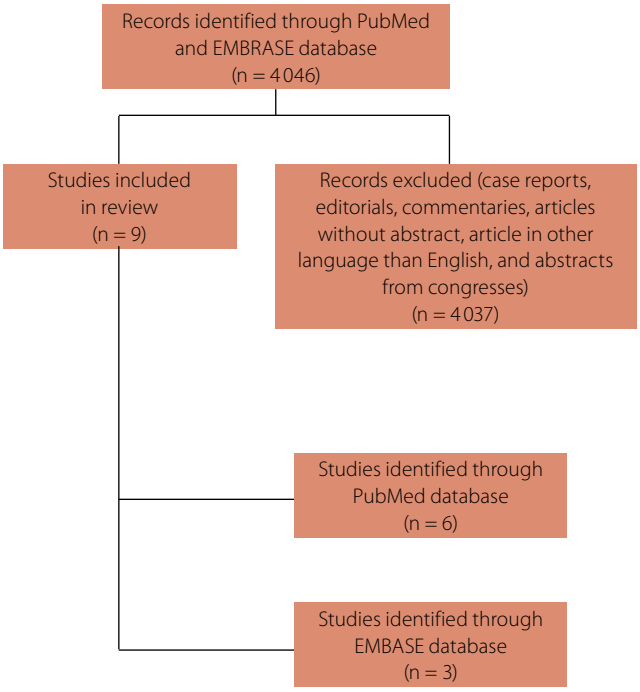
We have utilized the following information: the number of patients, their demographics (sex, age), any comorbidities they may have including connective tissue disorder, chronic obstructive pulmonary disease, hypertension, chronic renal failure, or NYHA, their prior surgical history, details regarding their TAFA (including location and symptoms), details regarding their TAFA surgical repair (such as the type of surgical intervention, the duration of cardiopulmonary bypass, and the duration of aortic clamping), and their in-hospital mortality and survival rates.

Results

Search results

In our literature search, we reviewed a total of 4,046 articles. Of these, only nine studies were case series, with the remainder being single case reports or small series of case reports that had fewer than nine patients. After

Fig. 1. *Flow chart*



careful consideration, we selected nine articles for a thorough review and analysis. No extra articles were found in the reference lists (Fig. 1).

Study and patient characteristics

All of the studies reviewed were retrospective, with a total of 280 patients undergoing open surgical repair for TAFA (2, 5, 6, 8–13). Comprehensive patient data were presented only in two articles (8, 13). All studies reported basic demographic details (sex and age). The majority of patients were male, ranging from 52 % to 80 %. The mean age varied between 30 and 79 years old. However, there were discrepancies in the reporting of comorbidities, with only six studies providing descriptions of comorbidities to varying extents (5, 6, 8, 10). Patient and study characteristics are summarized in Table 1.

Tab. 1. *Study and patient characteristics*

	N	Male (%)	Age (years ± SD)	NYHA III–IV (%)	Connective tissue disorder (%)	Hyper-tension (%)	COPD (%)	Chronic renal failure (%)
Atik et al. (8)	60	70	53 ± 15	25	3	63	33	12
Dumont et al. (9)	11	52	52a	N/A	N/A	N/A	N/A	N/A
Katsumata et al. (6)	10	80	56 ± 13	N/A	1	N/A	N/A	N/A
Malvindi et al. (10)	27	71	64 ± 15	N/A	7	N/A	N/A	N/A
Malvindi et al. (5)	43	77	60 ± 12	23	7	N/A	14	2
Mohammadi et al. (11)	28	64	30 – 74a	N/A	N/A	N/A	N/A	N/A
Razzouk et al. (12)	13	54	51 ± 16	N/A	15	N/A	N/A	N/A
Sullivan et al. (2)	31	77	40 ± 20	N/A	N/A	N/A	N/A	N/A
Villavicencio et al. (13)	57	75	57 ± 18	34	9	47	7	14

[a] – *additional details were not provided*

Symptoms of thoracic aortic pseudoaneurysm

Patients with TAFA typically experience dyspnea at a rate of 22 %, followed by chest pain (18 %) and fever or sepsis (17 %). Stroke, dysphonia, heart failure, or a combination of symptoms are rare occurrences. It is unclear how many patients with TAFA are asymptomatic, as some studies fail to report on asymptomatic cases. However, some authors suggest that a majority of patients with TAFA experience no symptoms (5, 10–12).

The details regarding prior surgeries, TAFA's location, and symptoms are summarized in Table 2.

Causes of thoracic aortic pseudoaneurysm

Prior surgery

In 90 % of the cases, patients had undergone prior aortic or cardiac surgery. Aortic root procedure, specifically Bentall, was the most frequently associated procedure which accounted for 24 % of cases. The remaining procedures included aortic replacement, valve replacement or repair, coronary bypass graft, or heart transplant. Infection was responsible for 24 % of TAFA cases in the group of patients with prior cardiac surgery.

Other causes

Among patients without a history of prior cardiac surgery, 2 % had cardiac issues with no known triggering risk factors, 1.4 % were linked to complications from blunt chest trauma, and the rest were caused by factors

Tab. 2. *Previous surgery, TAFA characteristics, and symptoms*

	Prior surgery (%)	Location of TAFA (%)	Symptoms (%)
Atik et al. (8)	RR 28 AVR/MVR 16 SC/AV/ArchR 16 CABG/AVR 6 RADR 6 Other 6	Proximal composite valve graft anastomosis 32 Distal aortic anastomosis 28 Coronary button reimplantation or vein graft anastomosis 17 Aortic isthmus 8 Proximal supracoronary ascending aorta 8 Aortic cannulation site 3 Proximal aortic arch 2 Aortotomy 2	Ascending aorta Heart failure 36 Chest pain 21 Sepsis 19 Incidental finding 7 Bleeding or drainage from wound 5 Superior vena cave syndrome 5 Pulsatile suprasternal mass 5 Stroke 2 Ascending aorta and arch Sepsis 44 Chest pain 44 Stroke 12 Arch Tracheal compression 33 Chest pain 33 Pulsatile suprasternal mass 33 Descending aorta History of trauma 100 Left main bronchus compression 33 Incidental finding 33 Hemoptysis 17 Chest pain 17
Dumont et al. (9)	CABG/AVR 36 Bentall 18 Coarctation 18 OHT 18	Ascending aorta 3 Aortic suture line 3 Proximal bypass 2 Descending aorta 3 Descending aorta 3	N/A

Katsumata et al. (6)	Dissection repair 70 Aortitis 10 No prior surgery 10 Root abscess 10	Proximal anastomosis 6 Distal anastomosis 3 Annular site 1	Persistent febrile illness 60 Stroke 10 Sepsis 20
Malvindi et al. (10)	Bentall 37 Others 33 AAR 15 AVR 15	Aortic suture line 6 Proximal composite-valve-graft 9 suture line Proximal and distal composite- 1 valve-graft suture lines Aortotomy suture line 3 Left and right coronary ostia 1 Left coronary ostium 1 Right coronary ostium 4 Right coronary ostium and distal 1 ascending aorta suture line Cannulation site 1	Asymptomatic 40 Symptomatic 60 Dyspnea alone 11 Dyspnea with thoracic pain 4 Dyspnea with fever 7 Thoracic pain alone 11 Thoracic pain with fever 4 Fever and systemic signs of inflammation 15 Septic shock and mediastinitis 4 Hemoptysis 4
Malvindi et al. (5)	Bentall/MVR/CABG 55 AVR/AA/CABG 20 Other 6 Arch/TAAAR 4 David + AAR + Arch/ET 4 MVR/TAFA repair 4 MVR + AAR + ET 2	Aortic suture line 17 Proximal composite valve graft suture 5 Aortotomy suture 4 Cerebrovascular vessels suture 2 Left coronary ostium 9 Right coronary ostium 4 Cannulation site 1 Aortic patch suture 1	Asymptomatic 53 Symptomatic 47
Mohammadi et al. (11)	Composite valve graft 50 SC tube/AVR 50	Proximal anastomosis 55 Distal anastomosis 28 Both 14 Right coronary ostia 3	Symptomatic 93 Dyspnea 76 Chest pain 44 Fever 10 Hepatomegaly 10 SVC syndrome 10 AR diastolic murmur 3 Continuous murmur 3 Dysphonia 3 Hemolytic anemia 3 Hemoptysis 3 Transient ischemic attack 3 Asymptomatic 7
Razzouk et al. (12)	CABG 46 AVR/AAR 39 AVR/MVR 15	Aortotomy 23 Bypass graft site 23 Distal site 38 Aortic cannulation 15	Chest pain 38 Dyspnea 31 Hemoptysis 8 Drainage from sternotomy 15 Asymptomatic 8
Sullivan et al. (2)	CABG/AVR /MVR 87 Congenital 13	Aortic suture line 3 Ascending aorta 3 Aortic vent site 1 Needle puncture site 2 Aortic valvulotomy site 5 Aortic cannulation site 10 Bypass graft site 6 Left sinus of Valsalva 1	N/A
Villavicencio et al. (13)	Root/AAR 23 AVR 14 DAR 11 AVR / AAR 10 CABG 4 Arch vessel bypass 2 AA patch 2	Proximal site 18 Distal site 21 Coronary reimplantation site 5 Multiple 5	Dyspnea 44 Chest pain 39 Fever 32

such as autoimmune disease, mycotic pseudoaneurysms, tuberculosis, and foreign bodies in the digestive tract leading to a fistula (2, 8, 9, 13).

Diagnosis and location of thoracic aortic pseudoaneurysm

The diagnosis of TAFA was established using an echocardiogram and computed tomography scan either during routine examinations or after the patient presented with symptomatology. Aortic false aneurysms were found to be connected to either proximal or distal aortic anastomosis (30%), coronary reimplantation sites (8%), cannulation of the vessel (4%), or other issues within the layers of the aortic wall that impeded proper healing. They are life-threatening conditions because of their progressive expansion. They can lead to compression or erosion of the surrounding structures, rupture, bleeding, or fistula development, or they can become a source of persistent infection or embolism. Due to the potentially fatal consequences of TAFAs and the possibility of a silent clinical presentation, it is highly advised to conduct regular checkups on patients who have had cardiac and aortic surgeries.

Tab. 3. *Peri- and post-procedural details*

	Intervention (%)	Mean CPB time (min)	Mean aortic clamping time (min)	IHM (%)	Survival rate 1y (%)	Survival rate 5y (%)	Survival rate 10y (%)
Atik et al. (8)	Tube graft 77 Repair/patch 23	173 ± 74	112 ± 50	6	94	74	60
Dumont et al. (9)	Dacron graft 45 Bovine pericardial patch 36 Homograft 9 Primary closure 9	178 ± 51	38 ± 18	18	N/A	N/A	N/A
Katsumata et al. (6)	Direct suture repair 50 Root/AA homograft 40 Root/AA Dacron graft 10	N/A	N/A	20	80	N/A	N/A
Malvindi et al. (10)	Direct suture 63 Bentall 21 AAR 12 ArchR 4	152 ± 75	96 ± 58	16	83	62	N/A
Malvindi et al. (5)	Bentall/CABG/ Arch/ET 37 Direct suture 32 AA / proximal ArchR 16 Arch / TAAAR 7 AVR + AA + ArchR 2 Debranching + endoprosthesis 2 TAAAR 2	188 ± 69	102 ± 52	6	94	79	68
Mohammadi et al. (11)	Complete revision 75) Direct suture repair 25 Other 1	103a	85a	17	N/A	N/A	N/A
Razzouk et al. (12)	Interposition tube grafts 70 Patch aortoplasty or primary repair 30	N/A	N/A	41	N/A	N/A	N/A
Sullivan et al. (2)	Repaira	N/A	N/A	29	N/A	N/A	N/A
Villavicencio et al. (13)	Graft replacement 47 Composite root 18 Direct suture 18 Patch repair 18	145 ± 72	85 ± 45	7	N/A	77	63

TAFA treatment

Every surgical intervention must be thoroughly planned to avoid TAFA rupture during resternotomy or periprocedural bleeding during the release of adhesions between the heart and the sternum. The surgical treatment options for TAFA mostly included repair with a Dacron graft, pericardial patch, or direct suture repairs. The different types of surgeries are detailed in Table 3 and vary depending on the size and location of the TAFA. The average cardiopulmonary bypass time was 104 minutes, and the average aortic clamping time was 57 minutes.

Patients with an anteriorly located TAFA close to the sternum are considered to be high-risk patients for repeated sternotomy, which entails the risk of TAFA rupture or cerebral embolism. To prevent this situation, the authors agree on different techniques such as extramediastinal cardiopulmonary bypass followed by deep hypothermic circulatory arrest, left ventricular venting, inflation of an endoclamp aortic catheter followed by retrograde cardioplegia, or approach to opening the chest (partial sternotomy, thoracotomy, clamshell incision) (5, 6, 8, 9, 11–13).

The choice of the technique also greatly depends on the surgeon's experience. If any bleeding occurs while adhesions are being released, the overall recommendation is to insert a Foley catheter inside the TAFA and inflate it to help control the bleeding (15).

It is not possible to choose one type of surgery which should be performed uniformly on every patient. The authors agree that TAFA repair or aortic replacement depends on the size of the aortic pseudoaneurysm lumen and the overall quality of the remaining aorta. If the aorta shows fragility and has a tendency to tear, a Dacron tube graft replacement should be performed. However, if the aortic tissue is healthy, patch repair with Dacron or bovine pericardium is recommended. For small TAFA lumens, primary repair is a viable solution. Despite a thorough preparation before and during surgery, in-hospital mortality is as much as 41 %.

Conservative treatment is used for patients with a small, stable TAFA, for those who are unsuitable for reoperation or endovascular repair, or those who refuse surgery. However, most studies do not report the number of patients treated conservatively (2, 5, 8–13).

All authors came to the conclusion that each patient must be discussed by a cardiac interdisciplinary team of experts and each treatment must be tailored individually (2, 5, 6, 8–13).

In-hospital mortality and survival

In-hospital mortality of surgical TAFA repair ranged between 6 % and 41 %, and survival rates after surgery reached 94 %, 79 %, and 68 % at 1, 5, and 10 years, respectively.

Factors predicting complications and mortality

The main predictors for complications of the surgical approach were established as follows: active infective endocarditis, New York Heart Association (NYHA) class III–IV, urgent

surgery, TAFA > 55 mm in diameter, age > 65 years, and the duration of cardiopulmonary bypass. The main predictors for perioperative mortality were established as follows: severe systolic dysfunction (LVEF < 35 %) and obesity (body mass index > 30 kg/m^2). In addition, according to the data we obtained, a recurrence rate of up to 12 % at 10 years has been observed, but no specific risk factors have been associated with recurrence (15).

Thoracic aortic pseudoaneurysms are uncommon and unfavorable complications that can arise from cardiac and aortic surgeries (2, 10, 12, 14). Although known as being rare, they form a thoroughly heterogeneous group in all their aspects. They arise from a large variety of causes, which is reflected in various clinical presentations and diverse anatomical findings. TAFAs are associated with a wide spectrum of different surgical techniques used for their repair. These techniques are frequently used despite impressive progress in endovascular methods in recent years. The anatomical variations of the heart, aortic arch, and related arteries present challenges for endovascular repair, limiting the treatment options for many patients.

Conclusion

In conclusion, thoracic aortic false aneurysms are uncommon and unfavorable pathological conditions that can arise from cardiac and aortic surgeries (2, 10, 12, 14). Although known as being rare, they form a thoroughly heterogeneous group in all their aspects. They arise from a large variety of causes, which is reflected in various clinical presentations and diverse anatomical findings. TAFA development and growth can be asymptomatic, and routine follow-up should be recommended in all patients who have undergone aortic surgery. A wide spectrum of anatomical variations of TAFAs leads to surgical treatments that also differ widely. Despite impressive progress in endovascular methods in recent years, this treatment of TAFA is often not suitable and faces limitations, which makes open surgery the treatment of choice in a substantial proportion of affected patients.

Abbreviations

AA – ascending aorta
AAR – ascending aorta replacement/repair
ArchR – aortic arch replacement/repair
AV – aortic valve
AVR – aortic valve replacement
CABG – coronary artery bypass graft
CPB – cardiopulmonary bypass
COPD – chronic obstructive pulmonary disease
DAR – descending aorta replacement/repair
ET – elephant trunk
IHM – in-hospital mortality
MVR – mitral valve replacement
N/A – not available
OHT – orthotopic heart transplant
RADR – root / ascending / descending aortic replacement / repair
RR – root replacement
SC – supracoronary ascending aorta replacement
TAAAR – thoracoabdominal aortic aneurysm replacement/repair
TAFA – thoracic aortic false aneurysm

LITERATURE

1. Erbel R, Aboyans V, Boileau C, et al; ESC Committee for Practice Guidelines. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases: Document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC). Eur Heart J. 2014 Nov 1;35(41):2873-926. doi: 10.1093/eurheartj/ehu281. Epub 2014 Aug 29. Erratum in: Eur Heart J. 2015 Nov 1;36(41):2779. PMID: 25173340.

2. Sullivan KL, Steiner RM, Smullens SN, et al. Pseudoaneurysm of the ascending aorta following cardiac surgery. Chest. 1988 Jan;93(1):138-43. doi: 10.1378/chest.93.1.138. PMID: 3257182.

3. Langanay T, Verhoye JP, Corbineau H, et al. Surgical treatment of acute traumatic rupture of the thoracic aorta a timing reappraisal? Eur J Cardiothorac Surg. 2002 Feb;21(2):282-7. doi: 10.1016/s1010-7940(01)01133-2. PMID: 11825736.

4. Aebert H, Birnbaum DE. Tuberculous pseudoaneurysms of the aortic arch. J Thorac Cardiovasc Surg. 2003 Feb;125(2):411-2. doi: 10.1067/mtc.2003.130. PMID: 12579114.

5. Malvindi PG, van Putte BP, Heijmen RH, et al. Reoperations for aortic false aneurysms after cardiac surgery. Ann Thorac Surg. 2010 Nov;90(5):1437-43. doi: 10.1016/j.athoracsur.2010.06.103. PMID: 20971235.

6. Katsumata T, Moorjani N, Vaccari G, et al. Mediastinal false aneurysm after thoracic aortic surgery. Ann Thorac Surg. 2000 Aug;70(2):547-52. doi: 10.1016/s0003-4975(00)01300-x. PMID: 10969678.

7. Huang LJ, Yu FC, Sun LZ, et al. Treatment of aortic pseudoaneurysm with interventional procedure. Chin Med J (Engl). 2006 Apr 5;119(7):612-6. PMID: 16620706.

8. Atik FA, Navia JL, Svensson LG, et al. Surgical treatment of pseudoaneurysm of the thoracic aorta. J Thorac Cardiovasc Surg. 2006 Aug;132(2):379-85. doi: 10.1016/j.jtcvs.2006.03.052. PMID: 16872966.

9. Dumont E, Carrier M, Cartier R, et al. Repair of aortic false aneurysm using deep hypothermia and circulatory arrest. Ann Thorac Surg. 2004 Jul;78(1):117-20; discussion 120-1. doi: 10.1016/j.athoracsur.2004.01.028. PMID: 15223414.

10. Malvindi PG, Cappai A, Raffa GM, et al. Analysis of post-surgical aortic false aneurysm in 27 patients. Tex Heart Inst J. 2013;40(3):274-80. PMID: 23914017; PMCID: PMC3709213.

11. Mohammadi S, Bonnet N, Leprince P, et al. Reoperation for false aneurysm of the ascending aorta after its prosthetic replacement: surgical strategy. Ann Thorac Surg. 2005 Jan;79(1):147-52; discussion 152. doi: 10.1016/j.athoracsur.2004.06.032. PMID: 15620933.

12. Razzouk A, Gundry S, Wang N, et al. Pseudoaneurysms of the aorta after cardiac surgery or chest trauma. Am Surg. 1993 Dec;59(12):818-23. PMID: 8256935.

13. Villavicencio MA, Orszulak TA, Sundt TM 3rd, et al. Thoracic aorta false aneurysm: what surgical strategy should be recommended? Ann Thorac Surg. 2006 Jul;82(1):81-9; discussion 89. doi: 10.1016/j.athoracsur.2006.02.081. PMID: 16798195.

14. Dougenis D, Daily BB, Kouchoukos NT. Reoperations on the aortic root and ascending aorta. Ann Thorac Surg. 1997 Oct;64(4):986-92. doi: 10.1016/s0003-4975(97)00626-7. PMID: 9354515.

15. Quevedo HC, Santiago-Trinidad R, Castellanos J, et al. Systematic review of interventions to repair ascending aortic pseudoaneurysms. Ochsner J. 2014 Winter;14(4):576-85. PMID: 25598723; PMCID: PMC4295735.