



## Case report

## Redo aortic valve-sparing root replacement for failing autograft after the Ross procedure: A case report



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## ABSTRACT

**Introduction and importance:** Late pulmonary autograft dilatation is observed in 10–20 % of patients after the Ross procedure, more often during the second decade of follow-up. Composite aortic root replacement with a valved conduit is the most common redo procedure. An aortic valve-sparing root replacement does not require lifelong anticoagulation and may significantly decrease the risk of complications, associated with a valve prosthesis.

**Presentation of the case:** We report a case of late pulmonary autograft dilatation developed after the Ross procedure. The annual transthoracic echocardiography after 20 years revealed severe dilatation of the pulmonary autograft, measuring 60 mm in diameter. The patient underwent a successful elective redo valve-sparing aortic root replacement (David I procedure). The aortic cross-clamp time was 144 min, and the CPB time was 181 min. The patient had an uneventful midterm postoperative course.

**Clinical discussion:** Late pulmonary autograft failure after the Ross procedure is a relatively rare condition, leading to repeat operation. Late autograft failure can contribute to aortic regurgitation, heart failure, and death due to ascending aortic dissection and rupture. Several research groups reported good early and midterm results of redo valve-sparing root replacement in such cases. In a reoperative valve-sparing root replacement after the Ross procedure, the portion of the native aorta with the adjacent part of the autograft may complicate the aortic root proper sizing.

**Conclusion:** Redo valve-sparing root replacement (David I procedure) is a viable option in pulmonary autograft dilatation with unaffected valve leaflets.

## 1. Introduction

Ross procedure is a valuable alternative to mechanical or biological aortic valve (AV) replacement, especially in children and young adults. Aortic root replacement with mechanical or biological valved conduit is a relatively easy procedure. However, it is associated with the risk of embolic complication, the need for long-term anticoagulation (in mechanical valves), or the risk of structural valve deterioration (in biological valves). The Ross procedure is free from these negative features. Nevertheless, it is technically much more complex and is associated with a significantly higher risk of perioperative adverse events and late autograft failure. Late pulmonary autograft dilatation is observed in 10–20 % of patients after the Ross procedure, more often during the second decade of follow-up [1]. Typically, the root reimplantation technique does not influence the autograft fate, but preoperative aortic valve annulus >28 mm is associated with increased autograft failure [2]. The

predominant cause of failure of the pulmonary autograft, leading to repeated surgery, is dilatation of the neo-aortic root [3]. Composite aortic root replacement with a mechanical or biological valved conduit is the most common redo procedure [4]. A possible option is aortic valve-sparing root replacement (VSRR) [5]. The purpose of this report is to present a case of redo VSRR due to the failed pulmonary autograft after the Ross procedure. The work has been reported in line with the SCARE 2020 criteria [6].

## 2. Case presentation

This case report involved a 30-year-old male who presented with pulmonary autograft dilatation 21 years after the Ross procedure. The Ross procedure was performed due to the bicuspid AV and severe aortic regurgitation (AR). Although the bicuspid aortic valve is a relative contraindication for Ross surgery, in this situation, the absence of

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distinct asymmetry of the aortic root made it possible to perform an effective operation. After the primary procedure, the early and midterm postoperative course was uneventful; however, annual transthoracic echocardiography (TTE) after 20 years revealed severe dilatation of the pulmonary autograft measuring 60 mm in diameter. We did not reveal any additional risk factors for complications, associated with the aorta and/or aortic valve, like uncontrolled hypertension, signs of connective tissue disorder, family history of aortic disease, or sudden death. The patient remained asymptomatic, without any signs of congestive heart failure, and had no specific drug history. Physical examination revealed only a mild early diastolic murmur at the third intercostal space on the left (the Erb's point). TTE showed moderate AR, normal left ventricular size, and function. Aortic valve leaflets presented unchanged. The hemodynamic performance of the homograft valve was normal. Our patient had preoperative thoracic CT scans (Fig. 1A). Two-dimensional and three-dimensional reconstructions of the scans were made by surgeons using Horos™ v.3.3.6 software (Horos Project). The patient was referred for elective redo aortic root surgery. The EuroSCORE II surgical risk counted at 5.39 %, except valve-sparing surgery – 3.19 %.

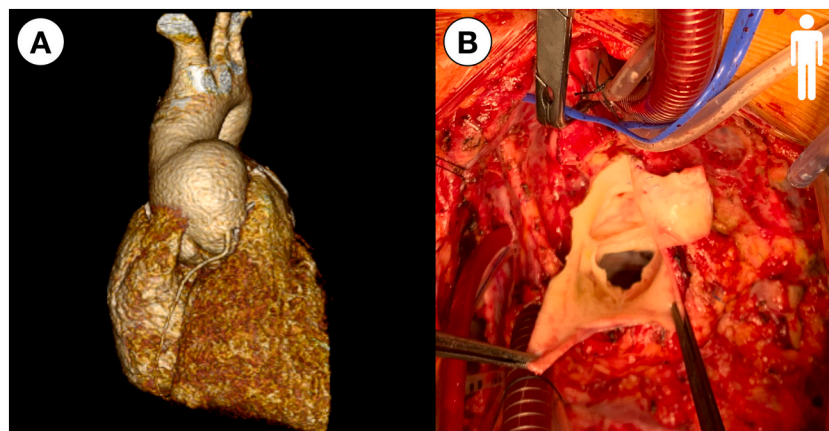
The operation was performed by a highly qualified surgeon with personal experience of >1500 ascending aortic operations, including >120 David I procedures. After full median repeated sternotomy, dissection of adhesions, and central cannulation, the cardiopulmonary bypass (CPB) was established. Antegrade cardioplegia using a one-shot Bretschneider (Custodiol®) solution was applied. The autograft cusps were prolapsing but intact (Fig. 1B). Sinuses of the autograft were excised (Fig. 2A). The coronary ostia were isolated by the button technique. We performed root replacement and aortic valve reimplantation (David I procedure) with a Valsalva graft (Vascutek, Inchinnan, Scotland, UK). Due to the part of the native aortic root distal to the level of the anatomical ventriculo-aortic junction, preserved at the initial Ross procedure, the reimplantation stage turned out to be relatively simple. Despite the presence of adhesions, it was not necessary to dissect the aortic root to the level of the left ventricle outflow tract (like in the conventional primary David I procedure), since we placed 12 U-shaped 2-0 Ethibond sutures with pledgets (Ethicon Inc., Hamburg, Germany) anchoring the aortic root prosthesis at the level of the remaining part of the pulmonary autograft, located 8–10 mm distal to the level of the ventriculo-aortic junction (Fig. 2C). The choice of graft size was made after direct measurements of the aortic ring diameter and the aortic root height, which matches the commissure height between left coronary and non-coronary cusps [7] (Fig. 2B). In our case, the diameter of the aortic ring was 27 mm; the aortic root height was 38 mm, so we used a 30 mm Valsalva graft (Fig. 3A). After the reimplantation stage, we revealed a prolapsed free margin of the left coronary cusp due to its excessive length, which was plicated with a single 5-0 Prolene suture (Ethicon

Inc., Hamburg, Germany), placed in its central portion. The aortic cross-clamp time was 144 min, and the CPB time was 181 min.

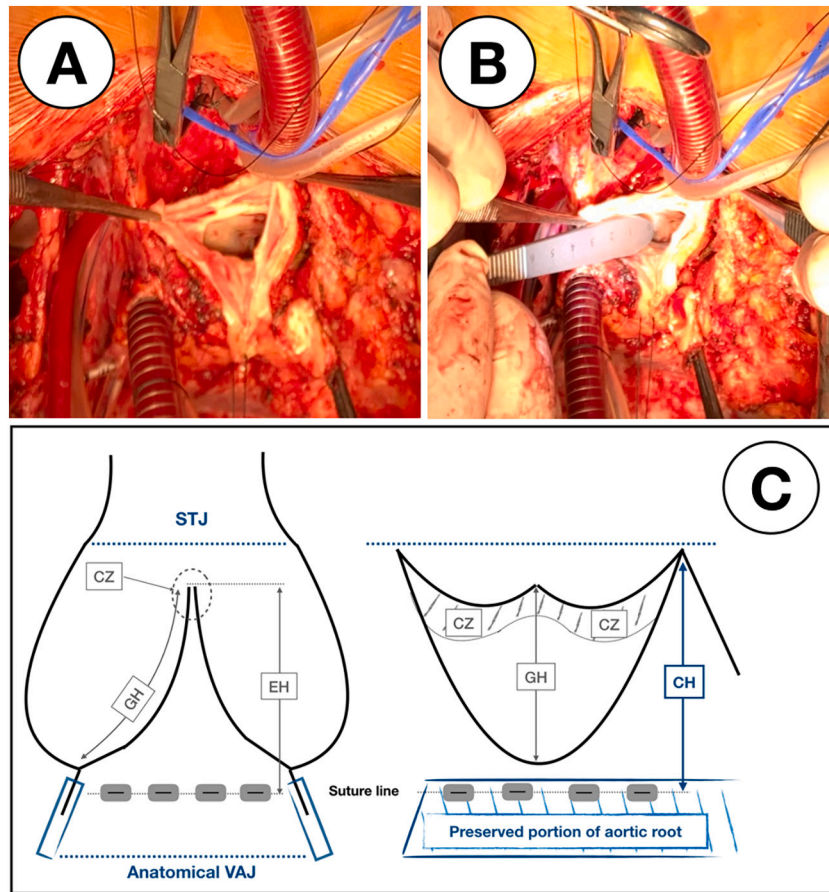
Transesophageal echocardiography was performed after weaning from the CPB to a satisfactory heart rate and left ventricular filling. It revealed normal aortic leaflet motion without prolapse and trivial AR (Fig. 3B). The operation was then completed conventionally (Fig. 3C). TTE was performed on postoperative day 7 and showed a trace AR and AV peak gradient of 13.7 mmHg and a maximum AV velocity of 1.8 m/s. The patient had an uneventful postoperative course and was discharged on postoperative day 18. The computed tomography performed before discharge showed the absence of prolapse of the aortic valve leaflets (Fig. 4A) and did not reveal any adverse signs, like para-aortic hematoma, false aneurysm, or coronary ostia stenosis (Fig. 4B). The follow-up TTE performed on postoperative month 12, showed mild AR. During 1-year follow-up, the patient is doing well.

### 3. Discussion

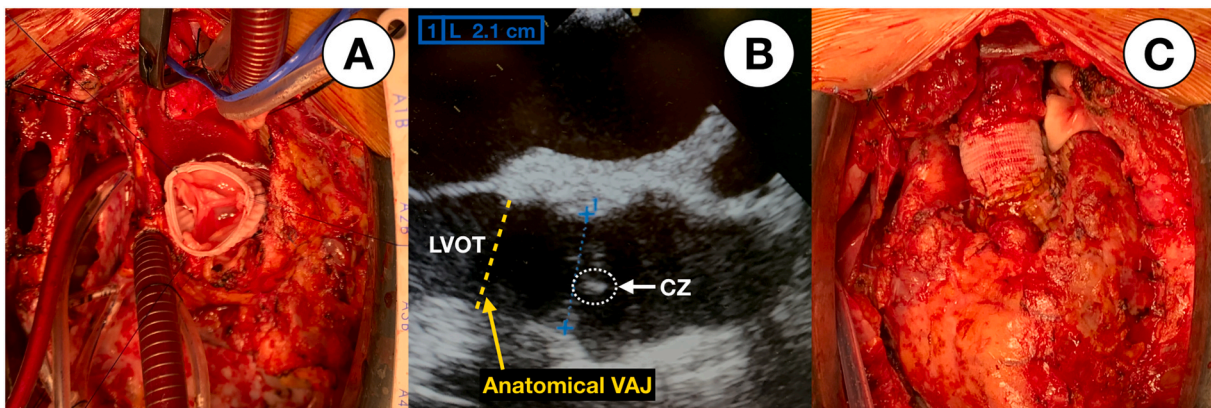
Dilation of the pulmonary autograft is one of the most frequent causes of repeated operation after the Ross procedure [8]. Late autograft failure can contribute to AR, heart failure, and death due to ascending aortic dissection and rupture. According to Schneider et al., the cumulative incidence of reoperations at 15 and 20 years after the Ross procedure is 35.2 % and 45.3 %, respectively [9]. David et al. reported excellent results of the Ross procedure: freedom from reoperation on the pulmonary autograft for any reason of 81.8 % at 20 years. They did not reveal the association between the risk of reoperation and the technique of implantation of the autograft [7]. AV reimplantation, invented by David and Feindel in 1992, has been generally acknowledged to be one of the standard procedures for aortic root aneurysm in patients with tricuspid AV and unchanged cusps. However, VSRR requires deep dissection of the aortic root, displacement of the commissures, and, often, additional cusps procedures. Several types of VSRR procedures were invented, and the David I procedure (root replacement with the AV reimplantation) currently appears as one of the most popular. Other than the David operation, another option is the Yacoub (remodeling) procedure [9]. Our group does not have a lot of experience with this method. Yacoub procedure looks more straightforward, but it carries the risk of late aortic ring dilatation, which may lead to recurrent AR. Some authors recommend the reimplantation technique over the remodeling technique, to prevent future dilatation of the aortic annulus and recurrent late AR. In redo cases, VSRR becomes more challenging. One of the relevant issues is to choose an optimal aortic graft size, which may affect the function of the reimplanted AV. During the AV assessment in all VSRR procedures, we perform direct measurements of the aortic ring diameter and the aortic root height. It is known, that in Valsalva graft,



**Fig. 1.** Failed pulmonary autograft after the Ross procedure: three-dimensional reconstruction of the CT scan showing severe aortic root dilatation (A) and intraoperative view of the dissected autograft showing intact cusps (B).



**Fig. 2.** Intraoperative view showing pulmonary autograft leaflets after excision of sinuses, prepared for the reimplantation (A), direct measurement of the commissure height between left coronary and non-coronary cusps (B), and schematic drawing of the aortic root (C) with labeled parts (VAJ – ventriculo-aortic junction, STJ – sinotubular junction) and parameters affecting aortic valve function (CH – coaptation height, CZ – coaptation zone, EH – effective height, GH – geometric height).

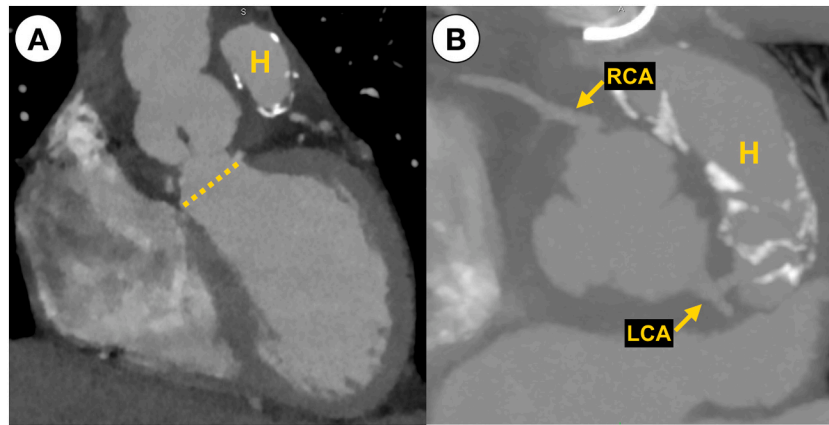


**Fig. 3.** Intraoperative view showing water test after aortic valve reimplantation (A), transesophageal echocardiography (B) showing coaptation zone (CZ) and coaptation line (blue dotted line) far from the left ventricle outflow tract (LVOT, orange dotted line) and anatomical ventriculo-aortic junction (VAJ), and final view (C).

the height of the sinus portion (skirt) is equal to its diameter (collar). In primary cases, we usually take the Valsalva graft, whose diameter (and height) approximately corresponds to the diameter of the aortic ring and the height of the aortic root. In a reoperative case after the Ross procedure, the portion of the native aorta with the distally located adjacent part of the autograft may complicate the aortic root proper sizing. Based on this fact, in our patients, we chose the optimal diameter of the Valsalva graft based on the aortic root height [7]. In our cases, repeated

valve-sparing operations required prolonged CPB time and aortic cross-clamp time. Other authors report smaller values of these parameters: mean aortic cross-clamp time 87 min; mean CPB time 120 min. However, they do not specify aortic valve-sparing operations, which compile a small section in a wide spectrum of redo procedures [3]. Ruzmetov et al. in a series of 14 redo VSRRs after the Ross procedure performed 3 David and 11 Yacoub procedures. During follow-up, 10 patients (2 after David procedures) were alive without reoperation; others underwent





**Fig. 4.** Computed tomography after the David procedure shows the absence of the leaflet prolapse (A, note the distance between the leaflet coaptation level and position of the anatomical aortoventricular junction (orange dotted line), and position of the anatomical aortoventricular junction (orange dotted line), and moderately calcified homograft (H)), and normal appearance of proximal zones of the right (RCA) and left (LCA) coronary arteries.

redo aortic valve replacement throughout 1–4 years [10]. The authors did not specify additional cusp repair procedures. In our case, we performed a cusp repair due to residual prolapse of the free margin. According to a multicenter study performed by Mookhoek A et al., which included a total of 86 patients from 6 European centers, reoperation was performed a median of 9.1 years after the Ross procedure. Freedom from reintervention after valve-sparing reoperation was 76 % at 8 years [11]. Ratschiller T et al. reported a reintervention rate of 22.9 % at a mean follow-up of  $11.1 \pm 4.6$  years after the Ross procedure. Reoperations included 10 David and 17 Yacoub procedures, with no early mortality and 2 cases of re-redo aortic valve replacement 2 years after a Yacoub procedure [12]. According to our experience as well as from others, in VSRRs additional cups repair does not significantly affect the risk of late AR. As for our patient, we believe he has good prospects for future life and a low risk of reoperation and complications, associated with the aorta and/or aortic valve. The patient is compliant and is under close follow-up. The possible limitation of this surgery is the expertise and the volume of the given center.

#### 4. Conclusion

Late pulmonary autograft dilatation after the Ross procedure is a rare condition, which may lead to AR, heart failure, aortic dissection, rupture, and death. In a reoperative valve-sparing root replacement after the Ross procedure, the portion of the native aorta with the adjacent part of the autograft may complicate the aortic root proper sizing. Redo valve-sparing root replacement (David I procedure) is a viable option in pulmonary autograft dilatation with unaffected valve leaflets.

#### Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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#### Guarantor

Vladimir Uspenskiy, MD, PhD.

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N/a.

#### CRediT authorship contribution statement

VU: contributed to the surgery; analyzed and interpreted the data; wrote the paper; AF: analyzed and interpreted the data; AM: analyzed and interpreted the data; wrote the paper; VS and OI: analyzed and interpreted the data; MG: contributed the surgery; analyzed and interpreted the data; wrote the paper. The procedure was performed by MG and VU.

#### Declaration of competing interest

The authors declare that they have no conflict of interest.

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