

A modified fistula procedure for control of hemorrhage in repair of acute type A aortic dissection with concomitant coronary artery bypassing graft

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Abstract

Background

Uncontrolled oozing after an open repair of acute type A aortic dissection (ATAAD) may be an undesired and frustrating complication. Cabrol fistula and its modifications is a promising technique to decrease blood loss. However, it remains difficult to performed Cabrol fistula when saphenous veinous graft (SVG) bridging to artificial ascending aorta is required for treating concomitant coronary artery problems. Here we introduce an easier technique to perform Cabrol fistula when concomitant SVG bridging to artificial ascending aorta is required.

Method

Patients who received a repair of acute type A aortic dissection with concomitant SVG bridging to artificial ascending aorta in our center from January 2015 to December 2021 were enrolled in this study. They were randomly divided into two groups: Fistula group, who received modified fistula procedure, and No-fistula group who didn't receive any fistula procedure. In fistula group, the proximal side of the venous graft was anastomosed to the prosthesis graft through a diameter of 4-5mm hole in a pericardium, after the aortic dissection was repaired. The margin of pericardium was sutured to the residual margin of the aortic adventitia using continuous stitching, following by a connection from the pericardium to right atrial appendage cava, or a connection from the right side of the native aortic adventitia to the left side of the superior vena cava. The preoperative characters, perioperative data, and postoperative outcomes were compared between these two groups.

Result

Sixty-two patients were enrolled in this study, 31 cases in each group. Preoperative characters were comparable between two groups. The chest closure time in fistula group was lower than that in no-fistula group (58.5 ± 15.5 vs. 83.7 ± 24.6 min, $P < 0.001$). The drainage volume in 24 hours after the surgery was 300.0 (200.0, 400.0) mL in the fistula group and 424.0 (335.0, 565.0) mL in the no-fistula group ($P = 0.002$). The average volume of blood red cells transfused in fistula group was fewer than that in no-fistula group (2.1 ± 1.6 U vs. 3.5 ± 2.4 U, $P < 0.05$). No patient needed reopening for respectively in the fistula group, whereas 3 patients were reopened in the no-fistula group (0.0% vs 9.7%, $P = 0.076$). The mechanical ventilation support period, duration of intensive care unit stay, and hospital stay were shorter in the fistula group compared with the no-fistula group [44.0 (32.5, 60.5) hours vs 66.0 (48.0, 77.5) hours, $P = 0.006$; 5.6 ± 3.1 days vs 7.3 ± 5.5 days, $P < .0001$, 18.9 ± 9.8 days vs 23.2 ± 8.7 days, $P < 0.001$; respectively]. One year follow-up showed good patency of SVG in both groups ($p = 1.00$).

Conclusion

The modified fistula procedure could be a promising procedure to control devastating bleeding in patients with ATAAD who require ascending aorta replacement with concomitant SVG bridging to artificial ascending aorta.

Introduction

Despite the improvements of surgical techniques and hemostatic agents, uncontrolled bleeding after an open repair of acute type A aortic dissection (ATAAD) remains an undesired and frustrating complication. Oozing from suture lines mainly because the suture line is usually located in the aortic segment involved by the dissection, the blood coagulability is decreased after the dissection process, and the cardiopulmonary bypass (CPB) time is long.(1–3) Oozing can be controlled eventually in the majority of cases, but recovery of complete hemostasis takes a long time in some cases, especially in patients with ATAAD. Blood loss and time consumption is unavoidable, which may affect the postoperative outcome. Furthermore, catastrophic oozing cannot be controlled by conventional methods occasionally arises, and it is usually unpredictable.(1, 4) Cabrol et al.(5) proposed a “perigraft-to-right atrium” shunt for uncontrolled bleeding during graft replacement of ascending aortic and aortic root within the aneurysmal sac, which was called Cabrol shunt or Cabrol fistula. The fistula is constructed between the aneurysm wrap and the right atrial appendage for autotransfusion of the oozing into the circulation.⁸ This technique has been proved to be effective. Thus, it has been applied not only to aortic aneurysmal diseases, but also to ATAAD(4, 6, 7).

However, in some cases, a saphenous veinous graft (SVG) from ascending aorta to coronary artery is required, which may increase the difficulty to build a perigraft patch around the ascending aorta. Herein we proposed a novel modification of fistula procedure when concomitant SVG bridging to ascending aorta was required.

Methods and patients

From January 2015 to December 2021, 80 patients who suffered from ATAAD concomitant with coronary artery involvement or primary coronary disease received ascending aortic replacement (AAR) with concomitant coronary artery bypassing graft (CABG) in our center. Preoperative diagnosis was also based on echocardiography, computed tomography angiography (CTA), including coronary artery CTA. Exclusive criteria were chronic aortic dissection, aortic aneurysm, retrograde type B aortic dissection without ascending aorta involvement and preoperative acute myocardial infarction. Patients without saphenous venous grafts or proximal graft anastomosis to the prosthesis of ascending aorta was excluded from the study. All patients received surgery immediately after ATAAD diagnose was confirmed. Cases were randomly divided into two groups: Fistula group, who received modified fistula procedure, and No-fistula group who didn't receive any fistula procedure. The present research protocol was reviewed and approved by the institutional review board of Union Hospital of Fujian Medical University in Fuzhou, China (No. 2015083).

Surgical Procedure

After general anesthesia and median sternotomy, arterious cannulation was performed via femoral artery, or combined with right axillary artery cannulation if selected cerebral perfusion (SCP) was required. The venous cannulation was performed via the superior and inferior vena cava. Then Cardiopulmonary bypass (CPB) was established. When the nasopharyngeal temperature reached 32°C, the ascending aorta was cross clamped, and cold blood cardioplegia (4°C) was antegrade perfused via coronary artery ostia. Once the coronary artery was severely involved and repair was judged unavailable, retrograde cardioplegia perfusion was performed via coronary venous sinus. SVG was harvested for CABG. Anastomose between distal graft and target coronary artery was performed, follow with cardioplegia perfusion via graft. After that, aortic root procedure was performed if necessary, followed with AAR. Circulatory arrest was started once the hemi-arch or total arch repair was required. After the anastomoses of distal ascending aorta was finished, systemic perfusion was resumed, and the patient was rewarmed. A suitable size of autologous or bovine pericardium was harvested. After the partial ascending aortic graft was clamp, a hole with a size of about 4–5 mm was made on the prothesis graft and the pericardium at a certain position. After that, the proximal side of venous graft was anastomosed to the prothesis graft, through the hole of the pericardium (Fig. 1A, B). All clamps were removed after the anastomoses was finished. During warming, active hemorrhage was carefully stopped by sutures, and then the margin of pericardium was sutured to the residual margin of the aortic adventitia by continuous stitch (Fig. 2A, B). Before the perigraft cavity was totally closed (4 cm stitching margin was leave for drainage of the oozing of the blood), a 6–8 mm incision on the pericardium was made, followed with a connection to the right atrial appendage, and then the totally close of the leaved stitching margin (Fig. 3). Another method was connecting the right side of native aortic adventitia to the left side of the superior vena cava (SVC), followed with totally closed of the pericardium. After the weaning of CPB, protamine was used to reverse the heparinization. Sternum was closed after totally hemostasis.

Patient received dual antiplatelet therapy and statins after discharge. One-year SVG patency were calculated by coronary artery CTA. According to the Fitzgibbon classification (Fitzgibbon GM, Kafka HP, Leach AJ, Keon WJ, Hooper D, Burton JR. Coronary bypass graft fate and patient outcome: angiographic follow-up of 5,065 grafts related to survival and reoperation in 1,388 patients during 25 years. J Am Coll Cardiol. 1996;28:616 – 26.), grade A was defined as excellent graft with unimpaired runoff ; grade B was defined as stenosis reducing caliber of proximal or distal anastomoses or trunk to < 50% of the graft coronary artery; grade O was defined as complete graft occlusion.

Data Collection

Postoperative drainage in the first 24 hours, amount of red blood cell transfusion, incidence of reopening for hemostasis, ventilation support period, intensive care unit stay duration, and 30-day mortality were collected. Data were analyzed using SPSS 22.0. Continuous variables were presented as mean $\pm$ SD or

medium (Q25, Q75) and categorical variables were presented as numbers (%). Inter-group differences were evaluated using the t test or Mann-Whitney U for continuous variables, and using the chi-squared test for categorical variables. Calculated p values of less than 0.05 were considered significant.

Results

Patient Characteristics

Sixty-two patients (31 cases in each group) were enrolled in this study. The mean age of patients in fistula group was 56.1 ± 8.8 years, while that in no-fistula group was 55.3 ± 9.6 years. No significant differences of the gender, body mass index, preoperative comorbidities (including hypertension, Marfan syndrome, diabetes mellitus, chronic or acute renal dysfunction, cardiac operation history, shock, and history or new onset of cerebral events), degree of aortic valve regurgitation, and ejection fraction between the two groups were found. CABG was required for the result of dissection involved (28 cases in fistula group vs. 30 cases in no-fistula group), or primary coronary artery disease (3 cases in fistula group vs. 1 case in no-fistula group). The average interval between the onset of symptoms to the operation was 16.8 ± 6.1 hours in fistula group, and 14.3 ± 5.6 hours in no-fistula group, respectively. The preoperative patient data are shown in Table 1.

Table 1
Demographic Characteristics of the Subject Cohort.

Variables	Results		P value
	Fistula group (n = 31)	No-fistula group (n = 31)	
Age (years)	56.1 ± 8.8	55.3 ± 9.6	0.74
Male gender (n, %)	18, (58.1)	21, (67.7)	0.43
BMI (kg/m ²)	26.3 ± 2.8	27.1 ± 1.6	0.88
Hypertension (n, %)	21, (67.7)	25, (80.6)	0.25
Marfan syndrome (n, %)	2, (6.5)	3, (9.7)	0.64
Diabetes mellitus (n, %)	2, (6.5)	2, (6.5)	1.00
Chronic renal failure (n, %)	2, (6.5)	2, (6.5)	1.00
Acute renal failure (n, %)	3, (9.7)	3, (9.7)	1.00
Cardiac operation history (n, %)	2, (6.5)	3, (9.7)	0.64
Shock (n, %)	3, (9.7)	3, (9.7)	1.00
History of cerebral event (n, %)	1, (3.2)	1, (3.2)	1.00
New onset of cerebral event (n, %)	3, (9.7)	3, (9.7)	1.00
Moderate-to-severe regurgitation (n, %)	17, (54.8)	18, (58.1)	0.80
Ejection fraction (%)	63.5 ± 5.6	61.6 ± 7.3	0.86
Coronary artery disease			
Dissection involved	28, (90.3)	30, (96.8)	0.30
Neri type A (n, %)	12	14	0.75
Neri type B (n, %)	15	11	0.16
Continuous variables were presented as mean ± SD or medium (Q25, Q75); categorical data are given as the counts (percentage). BMI: body mass index.			

Surgical Data

Surgical data were shown in Table 2. Aortic root and arch procedure in two groups were similar between the two groups, as well as the graft number and location. There were no significant differences in the mean duration of CPB, aortic cross-clamping, and SCP between the two groups. However, the chest closure time in fistula group was lower than that in no-fistula group (58.5 ± 15.5 vs. 83.7 ± 24.6 min, $P <$

0.001). The intraoperative RBC infusions in the fistula group was 1.7 ± 0.9 U, which was comparable to that in non-fistula group (2.1 ± 1.2). However, the P value was closed to 0.05 ($p = 0.06$).

Table 2
Surgical data of the Study Subjects.

Variables	Results		P value
	Fistula group (n = 31)	No-fistula group (n = 31)	
Intraoperative time			
CPB time (min)	139.0 ± 31.7	130.7 ± 44.6	0.58
Aortic Clamp time (min)	47.5 ± 18.6	48.3 ± 15.8	0.77
SCP time (min)	10.7 ± 3.2	10.5 ± 4.2	0.94
Chest closure time (min)	58.5 ± 15.5	83.7 ± 24.6	< 0.001
Intraoperative RBC infusion (U)	1.7 ± 0.9	2.1 ± 1.2	0.06
Aortic root procedure			
Aortic valve-sparing (n, %)	26, (83.9)	25, (80.6)	
Bentall (n, %)	4, (12.9)	3, (9.7)	0.69
Aortic valve replacement (n, %)	1, (3.2)	3, (9.7)	0.3
Aortic arch procedure (n, %)			
None	4, (12.9)	1, (3.2)	0.16
Hemi-arch replacement	9, (29.0)	8, (25.8)	0.78
Total arch replacement	18, (58.1)	22, (70.1)	0.29
Mitral valve repair	2, (6.5)	1, (3.2)	0.55
Location of SVG distal end (n, %)			
RCA	26, (83.9)	28, (90.3)	0.45
LCA	3, (9.7)	2, (6.5)	0.64
RCA + LCA	2, (6.5)	1, (3.2)	0.55
SVG number of the case (n)			
1	27, (87.1)	29, (93.5)	0.39
2	4, (12.9)	1, (3.2)	0.16
3	0, (0.0)	1, (3.2)	0.31
Continuous variables were presented as mean ± SD or medium (Q25, Q75); categorical data are given as the counts (percentage). CPB: cardiopulmonary bypass; SCP: selective cerebral perfusion; RBC: red blood cells; SVG, saphenous veinous graft; RCA: right coronary artery; LCA, left coronary artery.			

The postoperative data are shown in Table 3. The average pericardial drainage volume in 24 hours after the surgery was 300.0 (200.0, 400.0) mL in the fistula group and 424.0 (335.0, 565.0) mL in the no-fistula group ($P = 0.002$). The average volume of blood red cells transfused in the fistula group and the no-fistula group was transfused in the fistula group and the no-fistula group was 2.1 ± 1.6 U and 3.5 ± 2.4 U, respectively ($P < 0.05$). No patient needed reopening for respectively in the fistula group, whereas 3 patients were reopened in the no-fistula group (0.0% vs 9.7%, $P = 0.076$). The mechanical ventilation support period, duration of intensive care unit stay, and hospital stay were shorter in the fistula group compared with the no-fistula group [44.0 (32.5, 60.5) hours vs 66.0 (48.0, 77.5) hours, $P = 0.006$; 5.6 ± 3.1 days vs 7.3 ± 5.5 days, $P < 0.0001$, 18.9 ± 9.8 days vs 23.2 ± 8.7 days, $P < 0.001$; respectively].

Table 3
Postoperative complication and morbidity data of the Study Subjects.

Variables	Results		P value
	Fistula group (n = 31)	No-fistula group (n = 31)	
Pericardial drainage volume in 24h after surgery (mL)	300.0 (200.0, 400.0)	424.0 (335.0, 565.0)	0.002
RBC infusion (U)	2.1 ± 1.6	3.5 ± 2.4	0.023
Re-operation for hemaostasis (n, %)	0, (0.0)	3, (9.7)	0.076
Mechanical ventilation (h)	44.0 (32.5, 60.5)	66.0 (48.0, 77.5)	0.006
Intensive care in ICU (d)	5.6 ± 3.1	7.3 ± 5.5	0.013
Hospitalization time (d)	18.9 ± 9.8	23.2 ± 8.7	< 0.001
30-d death (n, %)	2, (6.5)	4, (12.9)	0.39
Low cardiac output syndrome (n, %)	1, (3.2)	2, (6.5)	0.55
Dialysis (n, %)	4, (12.9)	7, (22.6)	0.32
Gastrointestinal hemorrhage (n, %)	2, (6.5)	3, (9.7)	0.64
Sepsis (n, %)	1, (3.2)	2, (6.5)	0.55
Temporary neurological dysfunction (n, %)	4, (12.9)	3, (9.7)	0.69
Continuous variables were presented as mean $\pm$ SD or medium (Q25, Q75); categorical data are given as the counts (percentage). RBC: red blood cells; ICU: intensive care unit.			

The incidence of postoperative low cardiac output syndrome, new onset of dialysis, gastrointestinal hemorrhage, sepsis, and temporary neurological dysfunction in the fistula group was comparable with the no-fistula group. No permanent neurologic dysfunction, paraplegia, or paralysis occurred in both groups. The 30-day mortality in the fistula group was comparable to that in the no-fistula group. In the fistula group, echocardiography and CTA indicated that all fistulas were closed spontaneously with

thrombus accumulation inside the perigraft compartments in a few days postoperative. The complications from the thrombus accumulation, such as pulmonary embolism, compression of the graft, right atrium, and SVC, were not observed. No heart failure caused by left to right shunt was found in the fistula group. One year follow-up showed good patency of SVG in both groups (96.6% in fistula group vs. 100% in no-fistula group, $p = 1.00$) (Table 4).

Table 4
One-year SVG patency Fitzgibbon classification of the Study Subjects

One-year SVG patency Fitzgibbon classification	Results (n, %)		P value
	Fistula group (n = 29)	No-fistula group (n = 27)	
Grade A (n, %)	28,(96.6)	27,(100)	1.00
Grade B (n, %)	1, (3.4)	0	1.00
Grade O (n, %)	0	0	N/A
SVG, saphenous veinous graft.			

Comment

It is catastrophic when uncontrollable bleeding occurs in the process of the open aortic repair for treating ATAAD. Unfortunately, we cannot predict which patients will bleed after surgical repair. The perigraft-to-right atrium shunt which was proposed by Cabrol et al., was making a wrap around the ascending aorta, followed with making a shut to the right atrium(5). This procedure was proved to be a good technique to decrease time consumption for achieving a good coagulation, as well as to decrease blood loss. The point of this technique was to create an entire cavity to collect all the bleeding around the graft, and drainage to the right heart system. However, it remained difficult to make a whole warp when a SVG anastomoses on the ascending aorta was required.

There are some techniques to settle this problem. One of the methods is connecting the proximal end of SVG bridge to a non-aorta vessel, including left subclavian artery, left common carotid artery, and right brachiocephalic artery. However, Wang M and his colleagues(8) compared the outcomes of the cases whose SVG bridge to artificial ascending aorta with those SVG bridge to non-aorta vessel. They reported that no differences in early outcomes between these two groups were detected, but SVG bridge to artificial ascending aorta may have higher mid-term patency. Therefore, it is better to connect the proximal end of SVG bridge to artificial ascending aorta. Another method was modified the Cabrol shunt technique. Lin and his colleague(9) used “Mantle-style” technique with a promising outcome. Their technique was to use a 15×15-cm glutaraldehyde-treated bovine pericardial patch, with a circular shape at the central part. The diameter of the circle was equal to the size of the aortic graft, to allow the patch “wear” around the aortic graft. The inner border of the patch was suture to the graft, proximal to the graft-to-saphenous vein anastomosis site. The outer border was sutured to the surrounding great

vessels and cardiac structures, including the right pulmonary artery superoposteriorly, SVC and right atrium right laterally, main pulmonary trunk and right ventricular infundibulum left laterally, and right ventricular free wall inferoanteriorly. It could drainage the oozing from the root to the right atrium. However, it could not drainage the oozing from the distal aortic anastomoses. Besides, the suture on the back of the graft still carries difficulties. And a big pericardial patch was required.

The present fistula technique was to make a small hole on the patch, which size was suit for the SVG. The patch around the proximal venous graft anastomosis acting as pledgets could further reduce the oozing from the anastomosis. And the perigraft wrapping could be easily performed without disruption by the SVG. Moreover, it could cover almost all the stitch of the anastomosis.

In all cases of this study, very little bleeding could be found after the fistula procedure was done. Blood loss was small during the formation of coagulation. Time consumption for hemostasis could also be reduced. Further congestive heart failure due to the left to right shut was reported in some literatures (10, 11). Fortunately, it didn't occur in our study, and the fistula was spontaneously closed because of the thrombus formation around the graft. We guess the point was that active bleeding should be totally settled before the closure of the pericardial patch, and the diameter of the shunt should not be too large. The key point of the present procedure is the size of the hole on the aortic graft and pericardium should suit to the SVG. And the size of the pericardium should be accurately assessed before suturing.

Conclusion

Although some surgeons don't like to utilize Cabrol shunt in the AAR procedure with or without concomitant CABG, we still believe our modified fistula procedure could be an alternative technique salvage procedure to control devastating bleeding in patients with ATAAD when AAR with concomitant SVG bridging to artificial ascending aorta is required.

Declarations

Ethics approval and consent to participate

This study was complied with the principles of the Declaration of Helsinki and the research protocol was reviewed and approved by the Institutional Review Board of Union Hospital of Fujian Medical University, Fuzhou, China (No. 2015083). Informed consent was waived in accordance with institutional policy for retrospective studies. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no conflict of interest.

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Data Availability Statement

The data is provided in the supplementary information document. The data used and/or analyzed in the current study should be provided upon the reasonable request of the corresponding author.

Clinical trial number

Not applicable.

Authors' contributions

Qianzhen Li and Liangwan Chen designed the study and submitted the manuscript. Chunfeng Wu and Xin Luo prepared the first draft of the manuscript and made the literature review. Chunfeng Wu and Xin Luo are contributed equally to this study and share first authorship. Weiye Xu collected and analyzed data together. All authors read and approved the final manuscript.

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Figures

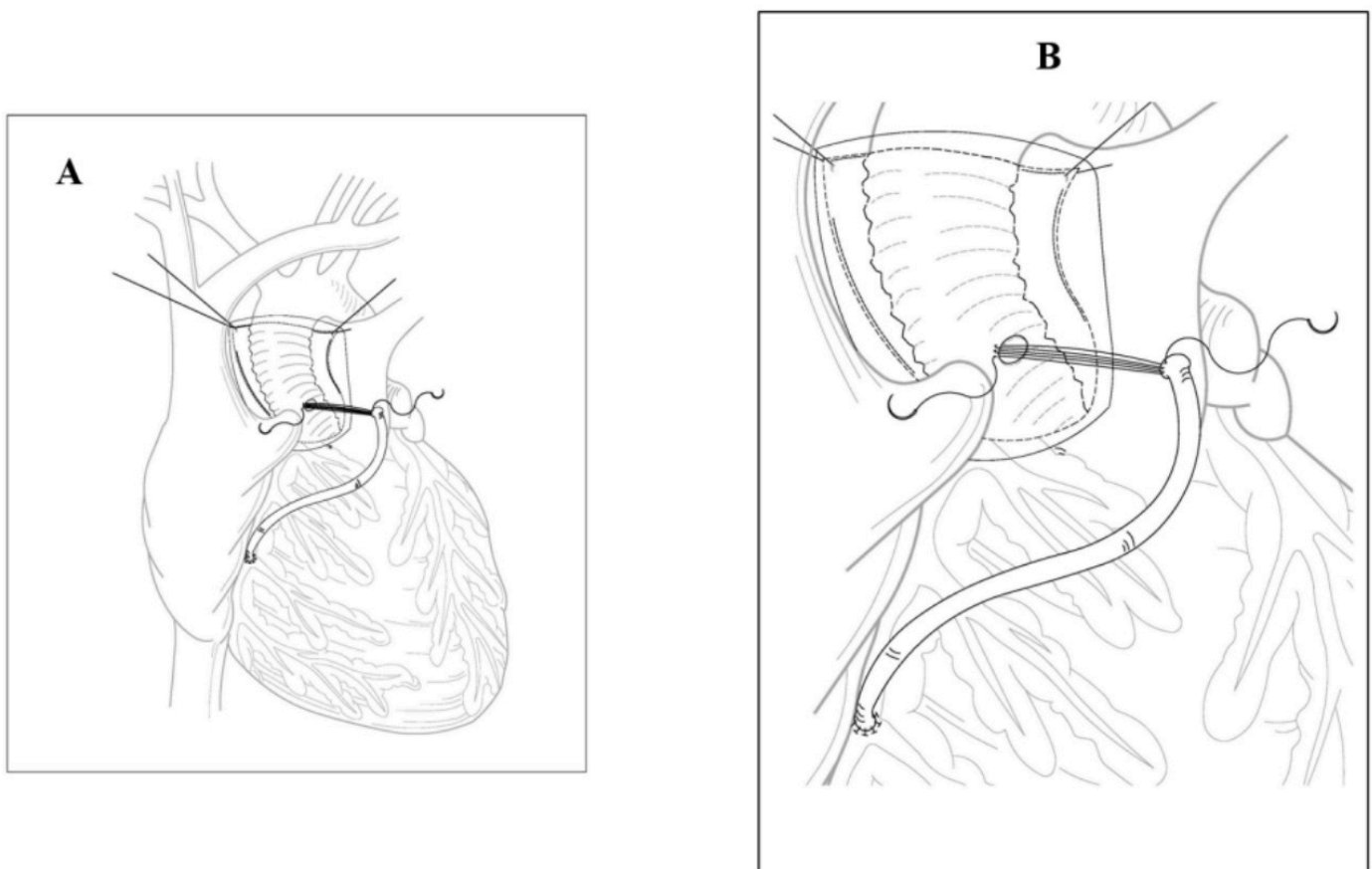


Figure 1

A. After the partial ascending aortic graft was clamp, a hole with a size of about 4 - 5 mm was made on the prothesis graft and the pericardium at a certain position. After that, the proximal side of venous graft

was anastomosed to the prothesis graft, through the hole of the pericardium. B. B is the enlargement of A.

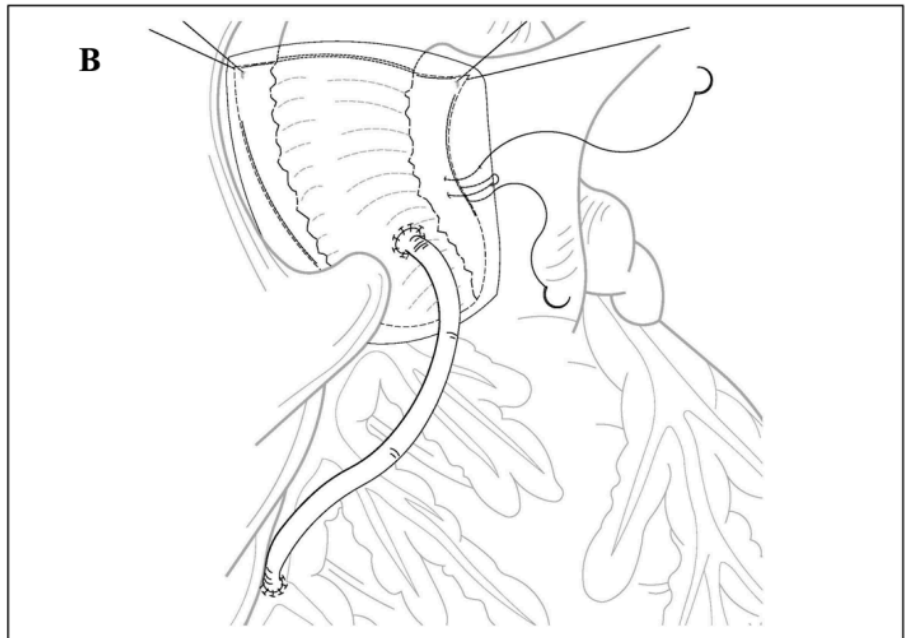
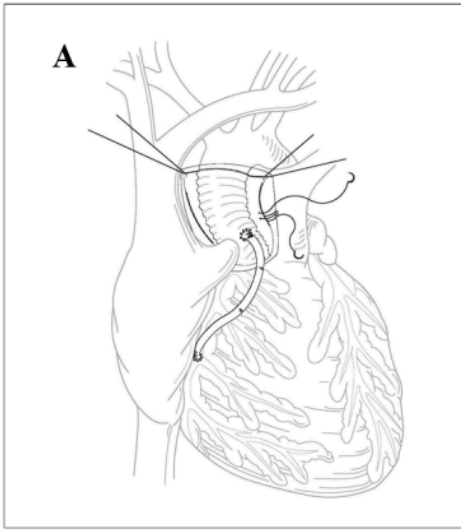


Figure 2

A. The margin of pericardium was sutured to the residual margin of the aortic adventitia by continuous stitch. B is the enlargement of A.

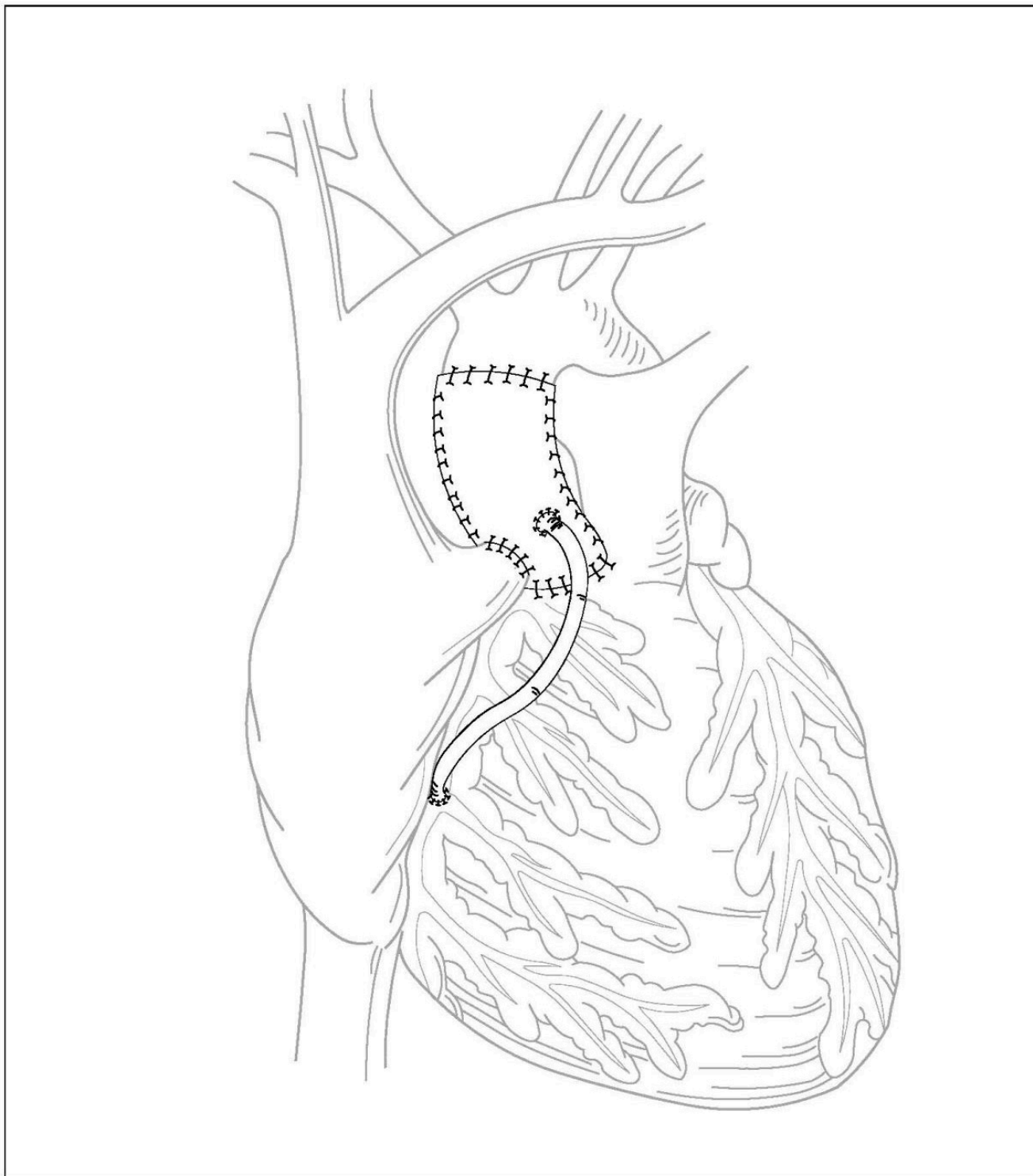


Figure 3

A 6-8 mm incision on the pericardium was made, followed with a connection to the right atrial appendage cava, and then the totally close of the leaved stitching margin.