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Adventitial Inversion Technique without the Aid of Biologic Glue or Teflon Buttress for Acute Type A Aortic Dissection

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Abstract

Background. In the surgical treatment of acute type A aortic dissection, the dissected aortic layer is usually reinforced by Teflon felt and/or biologic glues. However, the use of Teflon felt necessitates the use of large needles which can make a new intimal tear and the use of biologic glues can cause redissection or pseudoaneurysm formation in the chronic stage.

Methods. From March 2001 to November 2004, 18 patients underwent emergent surgery for acute type A aortic dissection. Graft replacement of the ascending aorta was performed in 1 patient, of the hemiarch in 12 patients, and of the total arch in 5 patients. The adventitial inversion technique was used for both proximal and distal stump construction of the dissected aortic wall without the aid of Teflon felt or biologic glue. Aortic regurgitation was treated with resuspension of the aortic commissures.

Results. There were 2 hospital deaths and the overall hospital mortality rate was 11.1%. Postoperative computed tomography showed closure of the false lumen in aortic root, aortic arch, and proximal descending thoracic aorta in all of the patients. Postoperative echocardiography demonstrated no aortic regurgitation in any of the patients. In the surviving 16 patients, there were no findings of computed tomography suggestive of redissection or pseudoaneurysm formation during the follow-up period of 1 to 44 months (mean 18±14 months).

Conclusions. The adventitial inversion technique provides an excellent mid-term result in the treatment for acute type A aortic dissection by facilitating thrombotic closure of the proximal and distal false lumen.

Word count: 248

Introduction

It is universally accepted that emergent surgery should be performed for acute type A aortic dissection to prevent fatal complications during the acute stage. The dissection process originates from a primary intimal tear which often extends retrogradely into the aortic root or antegradely to the distal aorta. This pathologic process destroys the integrity of the aortic root resulting in its rupture, aortic regurgitation, or compromise of the coronary circulation. In contrast, the same pathologic process can cause compression of the distal true lumen by the formation of a pressurized false lumen leading to malperfusion of vital organs and extremities, or enlargement of the aorta to form an aneurysm in the chronic stage. Therefore, it is essential to restore the integrity of the aortic wall and eliminate blood flow in the false lumen as much as possible.

Conventionally, the aortic wall is reconstructed by reapproximation of the dissected aortic layers with Teflon felt reinforcements (1). Biologic glues, such as gelatin-resorcinol-formaldehyde (GRF) glue (Cardial, Technopole, Sainte-Etienne, France) and more recently, BioGlue (Cryolife International, Inc, Kennesaw,GA) have also been used to secure graft anastomoses in an aorta that has become fragile as a result of the dissection process (2,3). However, the use of Teflon felt strips for reinforcement results in increased thickness, which requires the use of large needles and heavy sutures, leading to a new intimal tear at the anastomotic site (4,5). In contrast, there have been several reports concerning the incidence of redissection and pseudoaneurysm formation originating from the site of anastomosis after the use of biologic glues (6-10). Postoperative patency of the residual false lumen is also an important factor that compromises the long-term prognosis after surgical repair of aortic dissection because of the risk of aneurysmal enlargement and rupture in the chronic stage (11-14).

The adventitial inversion technique was first reported in 1995 by Floten et al. as a safe technique for the treatment of acute dissecting aneurysms, which facilitates surgery and solves the problem of intraoperative and postoperative bleeding due to tissue friability (4,5). However, the mid-term results of this procedure have not been reported. The purpose of this study was to present our clinical experience with the adventitial inversion technique for emergent surgery for acute type A aortic dissection.

Materials and Methods

Patients

From March 2001 to November 2004, 18 patients underwent emergent surgical treatment for acute type A aortic dissection. Seven patients (38.9%) were male, and the average age was 69.7±10.9 years (range: 48 to 85 years). Table 1 summarizes the type of aortic dissection and the preoperative characteristics of the patients. There were 5 patients who were accompanied by organ malperfusion; 2 had impairment of cerebral blood flow, 2 had acute myocardial infarction, and 1 had leg ischemia. Nine patients had cardiac tamponade, 3 had shock, and 1 had cardiac arrest requiring cardiopulmonary resuscitation preoperatively. All patients underwent computed tomographic (CT) scan and echocardiographic examination soon after the onset of acute aortic dissection, and all underwent emergent surgery within 24 hours after onset. Mild to moderate aortic regurgitation was present in 9 of 14 patients (64%) who were diagnosed by preoperative echocardiography. Based on the preoperative contrast CT scan, together with observation during operation, a primary intimal tear was detected at the ascending aorta in 2 patients (11.1%), at the aortic arch in 10 patients (56.6%), and at the proximal descending aorta in 5 patients (27.7%). Intimal tear was not identified in 1 patietnt. The dissection extended proximally to the aortic root in all patients, and extended distally to the aortic arch in 5 patients, to the descending thoracic aorta in 6 patients, to the abdominal aorta in 2 patients, and to the common iliac artery in 5 patients.

Surgical Techniques

The surgical technique used in this series principally consisted of resection of the aorta containing the primary intimal tear whenever feasible and obliteration of the false lumen. Figure 1 (A and B and C) demonstrates the basic procedure employed for construction of the aortic stump. The adventitial inversion technique was used for both proximal and distal stump construction of the dissected aortic wall in all patients. No Teflon felt strips or biologic glue were used for the reinforcement of aortic layers and obliteration of the false lumen. Extracorporeal circulation was instituted, with the arterial cannula placed in the femoral or right axillary artery, a single two-stage venous cannula placed in the right atrium, and a left ventricular venting cannula placed via the right superior pulmonary vein. The ascending aorta was cross-clamped just proximal to the innominate artery. During the retrograde infusion of blood cardioplegia, the aorta was transected and antegrade cardioplegia was administered selectively. The proximal repair was performed during the period of cooling by extracorporeal circulation. Aortic regurgitation caused by commissural detachment during the dissection process was initially repaired with resuspension of the aortic commissures using mainly 4-0 polypropylene (Prolene, Ethicon, Somerville, NJ) sutures with Teflon pledgets placed on both the inner and outer side of the aorta. The intima was separated proximally from the adventitia and the intima then was transected 7 to 8 mm distal to the level of sinotubular junction. The adventitia was trimmed 1.0 cm longer than the level of intimal edge. The redundant adventitia was then inverted into the aortic lumen and tacked to the luminal surface of the intima by horizontal 6-0 polypropylene mattress sutures at the level of sinotubular junction. The resection margin was then sandwiched between two layers of adventitia. This fine horizontal mattress sutures was helpful in isolating the false lumen present in the aortic root from the suture line with the graft. The proximal anastomosis was constructed between the reinforced aorta and the gelatin-coated woven Dacron graft (Gelweave, Vascutek, TERUMO Co., Scotland, U.K.) just above the level of the previous horizontal mattress suture line using continuous 4-0 RB-1 polypropylene sutures without Teflon buttresses or biologic glues (Figs. 1B and C and 2).

When the patient was cooled down to a pharyngeal temperature of 20℃, systemic circulation was arrested. The aortic clamp was removed to allow inspection of the inside of the aortic arch. For the distal aortic reconstruction, the procedure was tailored to resect the aorta containing the primary intimal tear. For ascending aorta or hemiarch replacement, the open distal method was employed under deep hypothermic circulatory arrest without cerebral perfusion. These procedures were generally completed within 30 minutes. During resection of the diseased ascending aorta or inner curve of the arch, the margin of the intima was trimmed back 1.5 cm distal to the adventitial resection line. The redundant adventitia was then inverted inside over the intima and tacked with 5-0 polypropylene over-and-over sutures. The distal anastomosis is constructed between the graft and the reinforced aorta proximal to the previous suture line using continuous 4-0 RB-1 polypropylene over-and-over sutures without Teflon buttress or biologic glues (Figs.1B and C and 3).

In the event that total arch replacement was necessary, both the innominate artery and the left common carotid artery were cannulated from inside the aortic arch. Selective cerebral perfusion (SCP) was then started at a rate of 8 to 10 mL/kg/min for cerebral protection. The left subclavian artery (LSA) was clamped during SCP. The descending aorta distal to the origin of the LSA was transected completely. The adventitial inversion technique was also applied to make a reinforced aortic cuff. The inverted adventitia was tacked with 5-0 polypropylene over-and-over sutures. An elephant trunk procedure was used for the construction of the anastomosis with the descending thoracic aorta. A piece of woven Dacron graft, 7 to 10 cm in length, was invaginated inward over itself and placed into the true lumen of the descending thoracic aorta to close the false lumen. The graft was attached to the reinforced aortic cuff using 4-0 RB-1 polypropylene over-and-over suture. Subsequently, the invaginated graft was pulled out and anastomosed to the branched arch graft and its third limb was anastomosed to the LSA. Antegrade systemic circulation was restarted through the fourth limb of the arch graft and the patient was rewarmed. Subsequently, the proximal anastomosis and individual reconstruction of the other cervical vessels were accomplished. If the dissection extended into the cervical vessels, the adventitial inversion technique was also employed for these vessels by inverting the redundant adventitia inward, which was tacked by several interrupted 6-0 polypropylene stitches to secure the anastomosis with the graft limbs.

Follow-up.

The patients were followed up until January 2005 at our outpatient clinic. The follow-up was completed in al of the patients. The mean follow-up period was 23±14 months, and the longest period was 46 months. The residual false lumen and residual AR was evaluated by contrast CT scan and echocardiography, respectively, before discharge in all of the patients. During the follow-up period, contrast CT scan and echocardiography were performed generally every 6 to 12 months for most of the patients.

Results

Surgical procedures and results are shown in Table 2. The mean extracorporeal circulation time was 215±73 minutes, the mean cardiac ischemic time was 136±52 minutes, the mean SCP time was

60.6±67.0 minutes, and the mean cerebral ischemic time 21.9±7.1 minutes. There were 2 hospital deaths and the overall hospital mortality rate was 11.1%. One patient died of perioperative myocardial infarction due to severe coronary artery disease, which was proven by autopsy. Another patient, who was transferred to the operating room while receiving cardiopulmonary resuscitation, did not survive the operation. The mean postoperative blood loss was 635±214 ml and no reexploration was required in any patients. There were 2 major central nervous system injury and transient postoperative delirium was observed in 1 patients. Nine patients were extubated within 24 hours. Prolonged mechanical ventilation (>5 days) was required in 2 patients and 1 patient required a tracheostomy. There was 2 late death from unknown causes 3 and 12 months, respectively, after surgery. The remaining 14 patients are doing well during the follow-up period of 23±14 months (range: 3 to 46 months). None of the patients who survived underwent a second-stage operation for aortic root or distal aortic lesions.

The status of the false lumen evaluated by the latest CT scan are summarized in Table 3. The interval between the operation and the latest CT scan was 1 to 44 months (mean: 18±14 months). Contrast CT scan showed thrombotic closure of the aortic root in all of the patients. The distal aorta below the distal anastomosis was completely closed in 12 of 16 (75%) patients. There was only 4 patient who had a patent false lumen in the descending thoracic aorta or abdominal aorta (4 of 16, 25%). Three of these are the patients who had total arch replacement because the primary intimal tear was present distal to the left subclavian artery. Even in these patient, the false lumen in the proximal portion of descending thoracic aorta was closed by thrombi. In the 16 patients who were followed up by CT scan for 1 to 44 months after surgery, aneurysmal enlargement, redissection, or pseudoaneurysm formation was found in neither the aortic root nor in the distal aorta. Postoperative echocardiography demonstrated no AR in 9 patients who had mild to moderate AR preoperatively. In these patients, no AR was found by echocardiography during the follow-up period.

Discussion

The goals of surgery for acute type A aortic dissection is establishing a competent aortic valve, replacing the aortic segments in which the primary intimal tear has occurred, preventing antegrade flow into the false lumen, and having the patient survive the operation (15). Furthermore, it is desirable that the procedure decreases late aortic or aortic valve complications, including aneurysmal enlargement in the proximal or distal aorta, redissection or pseudoaneurysm formation at the site of anastomosis, and reappearance of aortic regurgitation (12,13,15,16). It is well recognized that the prognosis of patients with a patent distal false lumen is inferior to that of those patients with a thrombosed false lumen (12,13).

Conventionally, the aortic wall is reconstructed by reapproximation of the dissected aortic layers with Teflon felt reinforcement (1). Biologic glues, such as GRF glue, and more recently, BioGlue, have been used to obliterate the false lumen and to secure graft anastomoses in an aorta that has become fragile as a result of the dissection process (2,10). These techniques have assured safe and secure anastomosis and hemostasis of the suture site, which leads to improvement in the immediate surgical outcome. However, redissection or pseudoaneurysm formation originating from the anastomotic site, as well as postoperative patency of the residual false lumen, are ominous findings that lead to a decrease in long-term survival (11-14).

The use of Teflon felt strips for reinforcement results in increased thickness, which requires the use of large needles and heavy sutures that can cause a new intimal tear at the anastomotic site with blood flow leaking into the false lumen, which will remain patent postoperatively (4,5). Biologic glues have been reported to cause tissue necrosis leading to redissection or pseudoaneurysm formation by the toxicity of formaldehyde or formalin contained in these glues (6-10). The adventitial inversion technique enables us to perform accurate and smooth suturing of the graft to the dissected aorta with 4-0 polypropylene on an RB needle. In the present study, all 16 woven Dacron-aorta anastomoses held sutures well and did not bleed intraoperatively. Bleeding from the operative site did not exceed 800 ml in 24 hours. Most importantly, there was no evidence of redissection or pseudoaneurysm formation at the anastomotic site during the follow-up period in any of the patients.

The false lumen, identified preoperatively in the aortic root, aortic arch, and proximal descending thoracic aorta was completely closed at the time of discharge in all surviving patients. Follow-up CT scan identified 4 patients in whom a residual patent false lumen continued to be present below the distal descending aorta because of the preoperative anatomy. Ergin et al. found a 56% patency rate for the distal false lumen in sutured anastomoses and concluded that the anastomotic technique is an important factor related to complications of the distal false lumen (17).

We hypothesize that the reason for our excellent results of this technique are as follows. First, because the adventitia is very pliable tissue, it can fill in the tiny gap along the suture line, providing a leakproof anastomosis between the aortic cuff and graft. Therefore, it is not necessary to use biologic glue for anastomotic site reinforcement, which bears a potential risk of tissue toxicity caused by formaldehyde or glutaraldehyde. Secondly, by avoiding the use of felt strips, it is not necessary to use large needles and heavy sutures, which markedly decreases the risk of new intimal tears at the anastomotic site. Finally, the suture line between the graft and the aorta is isolated from the false lumen by fine 6-0 or 5-0 polypropylene stitches, which would help obliterate the false lumen.

In order to decrease late aortic complications and the reoperation rate, some suggest that extended operative procedures, such as routine aortic arch replacement and total aortic root replacement, should be performed (13,18). In our experience, if the primary intimal tear is resected, there was no patent false lumen left postoperatively in either the aortic root or aortic arch in any of our patients using our technique of adventitial inversion. Therefore, if the aortic valve and sinuses are structurally normal, only aortic valve reconstruction at the level of the sinotubular junction and supracoronary ascending aortic graft replacement are required. Likewise, hemiarch replacement is usually the treatment of choice when the intimal tear extends into, or originates, in the arch. Total aortic arch replacement is employed only for cases in which the intimal tear is present distal to the aortic arch or in which the arch vessels are compromised.

In conclusion, we performed the adventitial inversion technique for the treatment of acute type A aortic dissection in 18 patients. This technique provided accurate and smooth anastomoses of the dissected aorta to the graft and held sutures well without bleeding intraoperatively. Postoperative CT scan showed thrombotic closure of the proximal and distal false lumen in most of the patients. This technique has great advantages in preventing blood leakage into the false lumen at the anastomosis site, which reinforces this area and induces thrombotic closure of the proximal and distal false lumen postoperatively.

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Figure legends

Fig. 1. Surgical procedure for the repair of acute type A aortic dissection

(A) In this case, the primary intimal tear is present in the aortic arch and the dissection extends proximally to the aortic root and distally to the descending thoracic aorta.

(B) The ascending aorta is transected and the dissected aorta containing the intimal tear is excised. After the adventitia is separated, the intima and media is trimmed and the adventitia is left for subsequent inversion into the aortic lumen.

(C) The intima is transected proximally 7 to 8 mm distal to the level of the sinotubular junction and the adventitia is trimmed 1.0 cm longer than intimal edge. The redundant adventitia is inverted into the aortic lumen and tacked to the luminal surface of the intima using horizontal 6-0 polypropylene mattress sutures at the level of sinotubular junction. Distally, the intima is separated from the adventitia and tailored at the level of the intimal tear. The redundant adventitia is trimmed 1.5 to 2.0 cm longer than the intima and inverted over the intima and tacked with 5-0 polypropylene over-and-over sutures.

Fig. 2. Reconstruction of the proximal anastomosis. Aortic regurgitation is repaired with resuspension of the aortic commissures using 4-0 RB-1 polypropylene sutures with Teflon pledgets placed on both the inner and outer sides of the aorta. The proximal anastomosis is constructed between the reinforced aorta and the woven Dacron graft just above the level of the previous horizontal mattress suture line using continuous 4-0 RB-1 polypropylene sutures without Teflon buttress or biologic glues.

Fig. 3. Reconstruction of the distal anastomosis.

The distal anastomosis is constructed between the graft and the reinforced aorta proximal to the previous suture line using continuous 4-0 RB-1 polypropylene over-and-over sutures.

Table 1. Preoperative Patient Characteristics

			Preoperative extension of dissection					
Case No.	age/sex	Location of Intimal Tear	Proximal	Distal	Malperfusion	Cardiac tamponade	Shock	AR
1	65/F	Ascending	Aortic root	Aortic arch	Brain	yes	no	mild
2	72/F	Descending	Aortic root	Descending aorta	no	no	no	moderate
3	67/M	Descending	Aortic root	Abdominal aorta	no	no	no	moderate
4	48/M	Descending	Aortic root	Iliac artery	no	no	no	mild
5	73/M	Arch	Aortic root	Descending aorta	no	no	no	unknown
6	59/M	Arch	Aortic root	Aortic arch	Coronary	no	no	mild
7	55/M	Arch	Aortic root	Aortic arch	no	no	no	moderate
8	72/F	unknown.	Aortic root	Aortic arch	no	yes	no	unknown
9	74/M	Descending	Aortic root	Iliac artery	Coronary	no	no	no
10	69/F	Arch	Aortic root	Descending aorta	no	yes	no	no
11	48/F	Descending	Aortic root	Iliac artery	Rt.leg	yes	no	no
12	74/F	Arch	Aortic root	Abdominal aorta	no	yes	no	no

13	80/F	Arch	Aortic root	Aortic arch	no	yes	yes	unknown
14	81/F	Arch	Aortic root	Iliac artery	Brain	yes	yes	unknown
15	80/F	Arch	Aortic root	Iliac artery	no	no	no	mild
16	77/M	Arch	Aortic root	Descending aorta	no	yes	yes	mild
17	85/F	Arch	Aortic root	Descending aorta	no	yes	no	mild
18	76/F	Ascending	Aortic root	Descending aorta	no	no	no	no

Ascending=ascending aorta; Descending= descending aorta; Arch= aortic arch,

Table 2. Surgical Procedures and Outcome

Case No.	Operation	Adjunct	Postoperative complications	Surgical outcome
1	A/V suspension, AAR	DHCA	Brain infarction, Respiratory failure	Survive
2	A/V suspension, TAR + elephant trunk	SCP	None	Survive
3	A/V suspension, TAR + elephant trunk, CABG	SCP	AMI	Death
4	A/V suspension, TAR + elephant trunk	SCP	None	Survive
5	A/V suspension, HAR	SCP	None	Survive
6	A/V suspension, HAR, Coronary stent	DHCA	None	Survive
7	A/V suspension, HAR	DHCA	None	Survive
8	A/V suspension, HAR	DHCA	None	Survive
9	TAR + elephant trunk	SCP	LOS, Respiratory failure	Survive
10	HAR	DHCA	None	Survive
11	TAR + elephant trunk	SCP	MNMS	Survive
12	HAR	DHCA	None	Survive
13	A/V suspension, HAR, CABG	DHCA	LOS	Death
14	A/V suspension, HAR	DHCA	None	Survive

15	A/V suspension, HAR	DHCA	None	Survive
16	A/V suspension, HAR	DHCA	None	Survive
17	A/V suspension, HAR	DHCA	Brain infarction	Survive
18	HAR, CABG	DHCA	None	Survive

A/V=aortic valve; AAR=ascending aorta replacement; TAR=total arch replacement; CABG=coronary artery bypass grafting; HAR=hemiarch replacement; DHCA=deep hypothermic circulatory arrest; SCP=selective cerebral perfusion; AMI=acute myocardial infarction; LOS=low output syndrome; MNMS=myonephropathic-metabolic syndrome;

Table 3. Status of False Lumen evaluated by Follow-up CT scan

Case No.	Grafted segments	CT follow up period (months)	Status of Postoperative False Lumen				
			Aortic root	Aortic arch	Proximal Descending aorta	Distal Descending aorta	Abdominal aorta
1	AA	44	Closed	Closed	※	※	※
2	AA + TA	37	Closed	Grafted	Closed	Closed	※
3[a]	AA + TA	—	—	—	—	—	—
4	AA + TA	26	Closed	Grafted	Closed	Patent	Patent
5	AA + HA	34	Closed	Closed	Closed	Closed	Closed
6	AA + HA	33	Closed	Closed	※	※	※
7	AA + HA	27	Closed	Closed	※	※	※
8	AA + HA	17	Closed	Closed	※	※	※
9	AA + TA	6	Closed	Grafted	Closed	Patent	Patent
10	AA + HA	12	Closed	Closed	Closed	Closed	※
11	AA + TA	13	Closed	Grafted	Closed	Patent	Patent

12	AA + HA	10	Closed	Closed	Closed	Closed	Closed
13[a]	AA + HA	———					
14	AA + HA	10	Closed	Closed	Closed	Closed	Closed
15	AA + HA	7	Closed	Closed	Closed	Patent	Closed
16	AA + HA	4	Closed	Closed	Closed	Closed	※
17	AA + HA	1	Closed	Closed	Closed	Closed	※
18	AA + HA	1	Closed	Closed	Closed	Closed	※

a Postoperative CT scan was not performed in case 3 and 13.
※=No dissection was found in this segment preoperatively.
AA=ascending aorta; TA=total arch; HA=hemiarch;

Fig.1

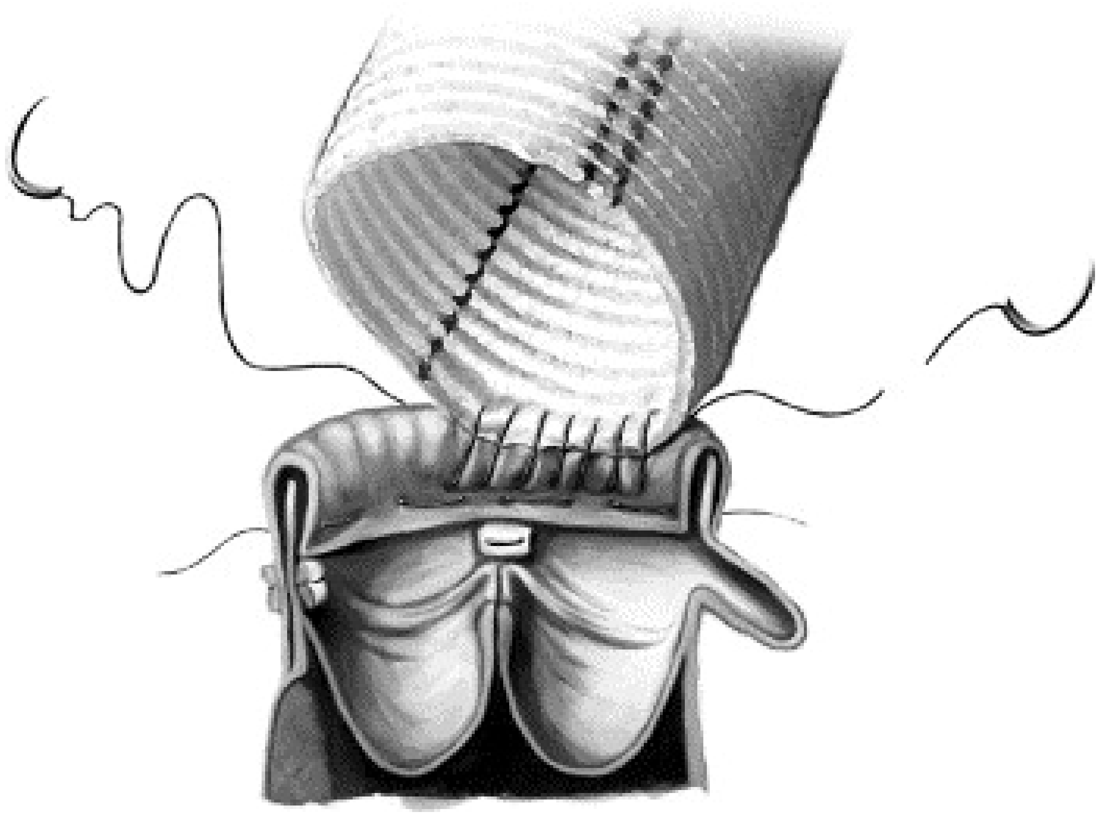


Fig.2

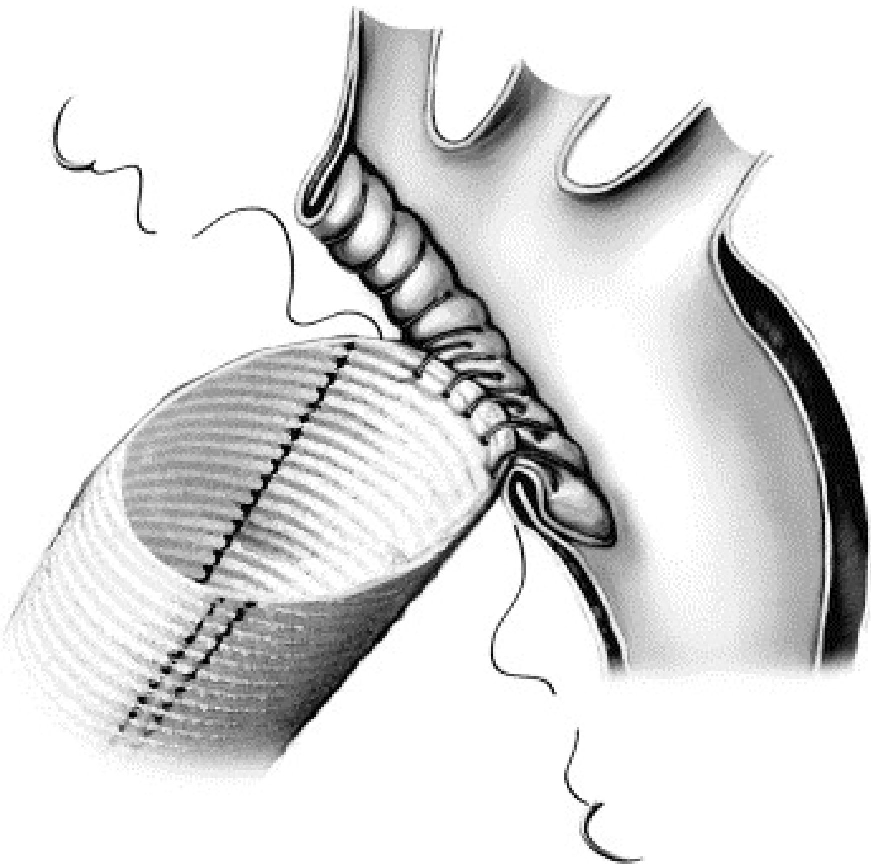
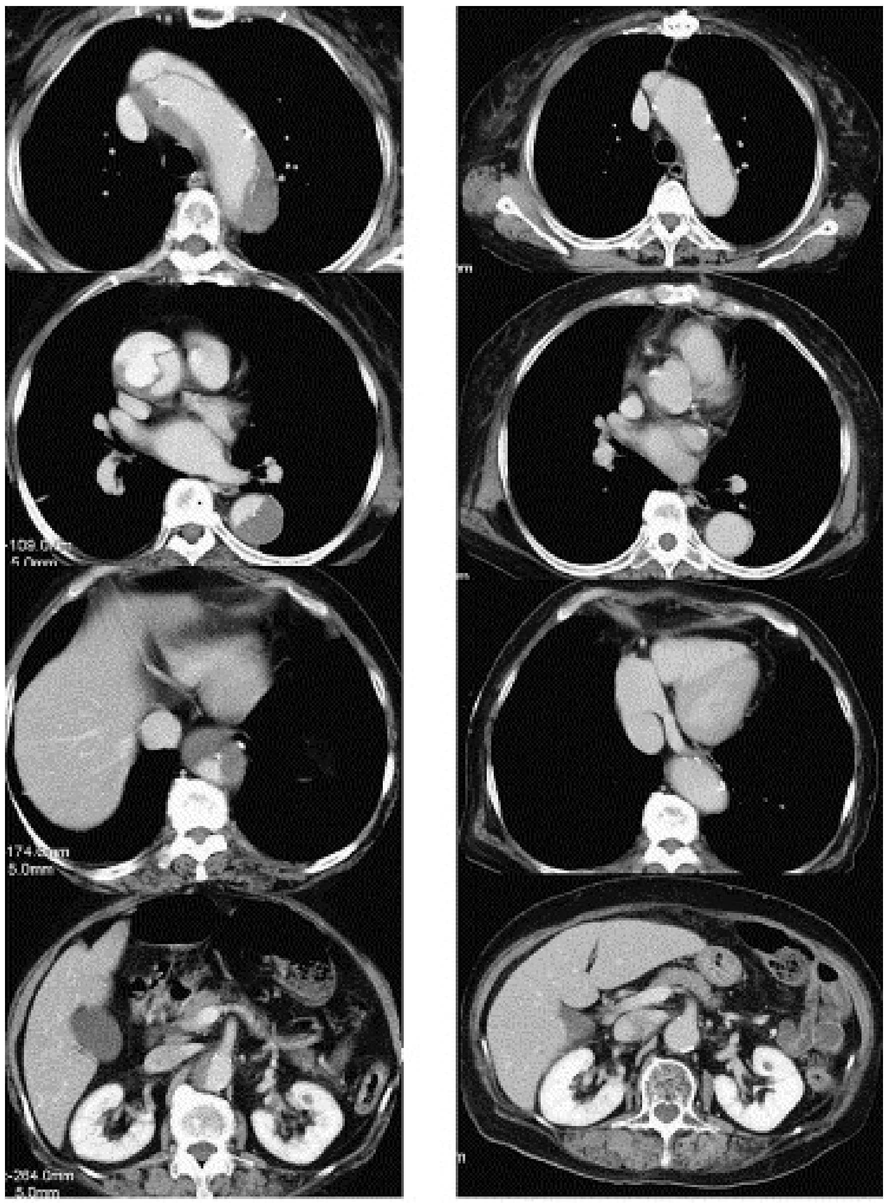


Fig.3



preoperative postoperative