Experiences of cabrol root replacement in management of type A aortic dissection postprint

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Abstract

Objective The Cabrol procedure was introduced by Professor Cabrol C in 1981; however, limited information exists regarding outcomes of the Cabrol technique in aortic dissection (AD). This study investigated 7-year outcomes of aortic root replacement employing this procedure in type A aortic dissection.

Methods From January 2009 to December 2016, 47 patients with type A aortic dissection underwent the Cabrol procedure at our institution. All patients received preoperative echocardiography and CT scan of the whole aorta. The Cabrol procedure was performed for aortic root repair. Concomitant replacement of the right hemiarch or total aortic arch with stented elephant trunk implantation was performed based on the extent of arch dissection. A retrospective analysis was conducted to evaluate the effectiveness of this procedure in type A aortic dissection.

Results A total of 47 patients were enrolled, including 6 cases of isolated Cabrol procedure, 13 cases with concomitant right hemiarch replacement, and 28 cases with concomitant total arch replacement and frozen elephant trunk technique. The 30-day mortality was 10.6% (5/47). Acute renal failure occurred in 25.5% (12/47) of patients, with 12.8% (6/47) requiring continuous renal replacement therapy (CRRT) during hospitalization. The median hospital stay was 25.5 days (range, 15–128 days). The follow-up period ranged from 6 to 36 months.

Conclusion The Cabrol procedure is feasible and safe for patients with type A aortic dissection, with patent prosthetic vascular grafts.

Full Text

Preamble

Clinical Research Experiences of Cabrol Root Replacement in Management of Type A Aortic Dissection

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Abstract: **Objective** The Cabrol procedure was introduced by Professor Cabrol C in 1981, but limited information exists regarding outcomes of the Cabrol technique in aortic dissection (AD). This study explored the 7-year results of aortic root replacements in type A aortic dissection employing this procedure. **Methods** From January 2009 to December 2016, 47 patients with type A aortic dissection underwent Cabrol procedure in our hospital. All patients received echocardiography and CT scan of the whole aorta before operation. The Cabrol procedure was performed to repair the aortic root. Replacement of the right hemi aortic arch or total aortic arch with stented frozen elephant trunk implantation was performed based on the extent of dissection in the aortic arch. A retrospective analysis was performed to evaluate the effectiveness of this procedure in type A aortic dissection. **Results** Forty-seven cases were admitted, including 6 cases of simple Cabrol procedure, 13 cases with concomitant replacement of right hemi aortic arch, and 28 cases with concomitant total aortic arch replacement and frozen elephant trunk technique. The 30-day mortality was 10.6% (5/47). Acute renal failure developed in 25.5% (12/47) of patients, and 12.8% (6/47) required continuous renal replacement therapy (CRRT) during hospitalization. The median hospital stay was 25.5 days, ranging from 15 to 128 days. Follow-up ranged from 6 to 36 months. **Conclusion** The Cabrol procedure is feasible and safe for patients with type A aortic dissection. The artificial blood vessels remain unobstructed.

Keywords: aortic dissection; surgical procedure; Cabrol procedure

Introduction

Aortic dissection (AD) is a life-threatening disease caused by a tear in the intimal layer of the aorta or bleeding within the aortic wall, resulting in separation of the aortic wall layers. The aortic root can be impaired by AD, leading to root dilation and aortic valve insufficiency. Aortic root replacement is indicated for these patients. However, direct anastomosis of the coronary artery to the ascending aorta in the usual fashion may result in coronary ostial stenosis and unmanageable bleeding. The Cabrol procedure can reduce the incidence of these complications. In this study, we reviewed the clinical data of 47 patients diagnosed with type A AD who underwent Cabrol procedure in our hospital from January 2009 to December 2016 to evaluate the effectiveness of Cabrol procedure in type A aortic dissection.

Methods

Patients' Characteristics

This study included 47 patients (40 males and 7 females) with a mean age of 48.2 ± 10.6 years (range 21 to 66). Basic patient information is shown in Table 1 . Several staging systems exist for aortic dissection [1, 2]. We adopted the following method to classify AD into three stages: acute phase (within 14 days), sub-acute phase (14–60 days), and chronic phase (>60 days) [3]. In this study, 17 patients were in the acute phase (36.2%), 20 in the sub-acute phase (42.6%), and 10 in the chronic phase (21.3%). All patients underwent echocardiography, CT scan of the entire aorta, and ECG-gated coronary CT scan preoperatively [4]. Based on clinical condition at admission, 11 patients received emergency operation within 6 hours after admission. The median interval between disease onset and surgery was 3.8 days (range 0.6 to 120). One patient had left heart failure and another suffered cardiac tamponade.

Surgical Techniques

Surgery was performed through a standard median sternotomy under cardiopulmonary bypass (CPB) with or without selective cerebral perfusion via the right axillary artery, depending on the extent of aortic dissection. General anesthesia was induced first, with blood pressure monitored in the left radial artery and left femoral artery. The right axillary artery was the preferred inflow site for CPB, as it can provide adequate perfusion for both brain hemispheres via the circle of Willis in most cases; the iliac artery was used when the axillary artery was unavailable.

After heparin administration, arterial cannulation was performed through the right axillary artery or iliac artery, followed by venous cannulation through the superior and inferior vena cava or right atrium. Left ventricular drainage was established via cannulation in the right inferior pulmonary vein. The patient was then cooled. When nasopharyngeal temperature reached 34 °C, the ascending aorta was clamped. During the cooling phase (target temperature 28 °C), a longitudinal incision was made in the ascending aorta and cardioplegic solution was perfused through the left and right coronary arteries. After cardiac arrest, ice was placed around the heart to maintain hypothermia. The aortic wall was examined, thrombus in the aortic dissection was cleared, and the aortic valve, aortic sinus, and coronary arteries were inspected. If the aortic sinus and aortic valve were severely damaged, either Cabrol procedure (only for those whose coronary artery could not be easily sutured to the ascending aorta prosthesis directly) or Bentall procedure (for most patients) was performed.

An appropriate composite valved vascular prosthesis was selected and sutured to the aortic valve annulus using interrupted vertical mattress sutures. An 8-mm artificial blood vessel was then sutured to the left and right coronary arteries in end-to-end anastomosis. A hole was created in both the 8-mm vessel and the artificial ascending aorta at an appropriate location, and they were connected

by side-to-side anastomosis, ensuring the coronary arteries were not twisted or under tension. For patients with dissection involving the coronary artery, concomitant coronary artery bypass grafting (CABG) was necessary.

For patients with extensive aortic dissections involving the aortic arch and descending aorta, the aortic arch was also replaced with an artificial blood vessel. Based on the range of aortic dissection, patients might require aortic arch replacement [5]. In this study, 13 patients underwent replacement of the right hemi aortic arch (one of whom also underwent tricuspid valve repair), and 28 patients underwent replacement of the total arch and stented frozen elephant trunk implantation (Sun' s procedure) [6]. Surgeries concomitant with arch replacement were all performed under deep hypothermia (21–27 °C) with circulatory arrest and cerebral cardiopulmonary bypass perfusion through the right axillary artery [7]. Two patients received right hemi arch replacement without circulatory arrest because they were diagnosed with ascending aorta dissection without arch involvement.

The sternum was closed in the usual fashion. In 21 patients, bleeding from anastomotic stomas of the ascending aorta and coronary artery was difficult to control. In this situation, we used the dissected aortic wall together with preserved bovine pericardium or a patch of autologous pericardium to create a perigraft-to-right-atrial shunt (Cabrol Shunt) to divert blood into the right atrium [8].

Results

All surgeries were completed successfully. The mean cardiopulmonary bypass time was 270.6 ± 83.2 minutes (range 145 to 538 minutes). The mean aortic clamping time was 140.6 ± 42.4 minutes (range 80 to 259 minutes). Thirty-nine patients underwent selective cerebral perfusion, with a mean cerebral perfusion time of 27.3 ± 9.3 minutes (range 11 to 54 minutes). Two patients (4.3%) required reoperation for bleeding. Postoperative complications included endoleak of stent (one case managed conservatively), neurological complications (6 cases), and acute renal failure (12 cases). Peri-operative mortality was 10.6% (5/47). Data on early deaths are shown in Table 2 . A total of 42 patients recovered from the operation and were discharged successfully. The median hospital stay was 25.5 days (range 15 to 128 days).

Table 2. Data of early deaths (within 30 days) in hospital

Preoperative complication	Interval time* (day)	Emergency surgery	Procedures	Cause of death
Hypertension	0.6	Yes	Cabrol + TAR* + FET* + CABG	LCOS*
Hypertension	0.8	Yes	Cabrol + TAR + FET + CABG	MODS*
Hypertension	120	No	Cabrol + TAR + FET	MODS and bleeding
Hypertension	3	No	Cabrol + TAR + FET	Rupture of abdominal aorta
Hypertension	7	No	Cabrol + TAR + FET	Bleeding

*Interval time means time between disease onset and surgery; TAR means total arch replacement; FET means frozen elephant trunk; LCOS means low cardiac output syndrome; MODS means multiple organ dysfunction syndrome.

Follow-up ranged from 6 to 36 months. All patients underwent echocardiography and CT scan of the whole aorta at discharge, 3 months and 9 months after discharge, and then annually. Cardiac function was satisfactory in all patients. Two patients (6.1%) died at home during follow-up from causes including aneurysm rupture and neurological complications. The remaining surviving patients had no endoleak or stenosis at coronary artery anastomotic stomas. Regarding patients who received Cabrol shunt, most shunts had disappeared by follow-up, with no pseudoaneurysm or compression on coronary arteries. Only one patient had persistent shunt from the left coronary artery anastomosis to the right atrium 6 months after surgery, though this patient remained asymptomatic with no changes observed during 2 years of follow-up.

Discussion

Aortic dissection is a catastrophic cardiovascular disease with extremely high mortality without reasonable and appropriate treatment. Surgical mortality for patients with type A AD is 26%, compared to 58% for those not receiving surgery [9]. Currently, open surgical repair is most commonly used for dissections involving the aortic root, ascending aorta, and aortic arch. Management

of the aortic root represents one of the key surgical challenges.

For patients with genetic connective tissue disorders such as Marfan syndrome or Loeys-Dietz syndrome [10, 11], the pathology involves dilation of the aortic sinus. Most of these patients have hypoplastic aortic valves with aortic valve insufficiency, and their coronary arteries typically originate from the sinotubular junction of the aorta or even higher. The most appropriate technique for these patients is the Bentall procedure [12-14]. However, for AD patients without aortic sinus dilation caused by hypertension or bicuspid aortic valve, aortic valve insufficiency may occur due to avulsion of the aortic valvular commissure. The aortic sinus size may be normal, and the coronary artery origin may be very close to the annulus. For these patients, performing Bentall procedure may create high tension at the anastomotic stoma between the artificial ascending aorta and coronary artery ostium, potentially causing bleeding that could result in myocardial ischemia and surgical failure.

The Cabrol procedure, introduced by Professor Cabrol C in 1981 [15], has demonstrated good long-term results after many years of follow-up. In this technique, coronary arteries are reconstructed using artificial blood vessel bypass grafting, reducing or avoiding high tension at coronary artery anastomotic stomas. In our hospital, we use the Cabrol procedure to treat type A aortic dissection involving the aortic root and valves with satisfactory early and late results. Several key points should not be neglected.

First, patient selection requires caution. In this study, all patients were diagnosed with type A aortic dissection involving the aortic valve, with or without aortic sinus dilation. Based on our experience, if the distance between the coronary ostium and aortic valve annulus is less than 10 mm, performing Bentall procedure would likely result in bleeding at the coronary artery anastomotic stoma, suggesting Cabrol procedure as the better option. One important consideration is that we cannot definitively determine whether to choose Bentall or Cabrol procedure preoperatively, as echocardiography or CT scan cannot provide the exact diameter of the true aortic sinus or the precise distance between the coronary ostium and aortic valve annulus. These measurements are typically made directly during operation. In our experience, if the distance between coronary ostium and aortic valve annulus is insufficient, especially when stitches in the aortic valvular annulus are placed from outside to inside, reconstruction of the coronary artery without high tension at the anastomotic stoma becomes very difficult after prosthetic valve fixation. Therefore, Cabrol procedure is preferable for these patients.

Second, careful attention must be paid to coronary artery reconstruction. During surgery, we need to determine whether coronary artery dissection is present [17]. Professor Neri and colleagues described three main types of coronary lesions due to proximal dissection: type A, ostial dissection; type B, dissection with a coronary false channel; and type C, circumferential detachment with inner cylinder intussusception [18]. Neri type A and B are common, while type C is rare (likely because most type C patients die before admission). The tech-

nique of coronary artery repair becomes much more difficult and depends on the type and extent of the lesion and which coronary artery is involved. In Neri type A and B patients, there is dissection between intima and adventitia without intimal rupture. We can repair the coronary ostium dissection using continuous suture with 6-0 prolene, then reconstruct the coronary artery without high tension at the anastomotic stoma. For Neri type C patients, both Cabrol and Bentall procedures result in high mortality and poor prognosis. We recommend closing the dissected coronary ostium and performing aortocoronary bypass with saphenous vein (CABG). In this study, 2 patients with Neri type C coronary lesions who underwent Cabrol procedure, Sun's procedure, and CABG died postoperatively from low cardiac output. Other research has indicated that type C patients have higher mortality than others [19].

Some patients had concomitant coronary artery disease, and coronary angiography was very dangerous for them. Moreover, coronary angiography would delay surgery and increase mortality [20]. In our hospital, these patients undergo CT scan of the whole aorta and ECG-gated coronary CT scan simultaneously to evaluate coronary artery lesions. If coronary artery stenosis of 70% or more is present, CABG is recommended.

Third, Cabrol procedure involves more anastomotic stomas than Bentall procedure. In acute and sub-acute type A AD patients, the aorta is fragile and prone to bleeding from needle holes. If bleeding occurs at the coronary artery anastomotic stoma or aortic valve annulus, hemostasis is very difficult because these areas are too deep to be exposed. In this situation, we recommend creating a Cabrol shunt for hemorrhage control [21]. We use the dissected aortic wall together with preserved bovine pericardium or an autologous pericardial patch to create a perigraft-to-right-atrial shunt (Cabrol Shunt) to divert blood into the right atrium. This simple technique is very useful for managing the catastrophic complication of postoperative hemorrhage [22, 23]. However, it is essential to ensure there is no projectile hemorrhage at any anastomotic stoma. If projectile bleeding exists, the Cabrol shunt cannot close after surgery, which may result in left heart failure. Additionally, the pericardial patch should be large enough to avoid high tension when wrapping the artificial blood vessel. If necessary, a bovine pericardial patch can be used to ensure adequate space between the adventitia and artificial blood vessel [23]. In this study, 21 patients underwent Cabrol shunt (15 acute phase, 6 sub-acute phase), with successful intraoperative bleeding control. During follow-up, the space between adventitia and artificial blood vessel was filled with thrombus and the Cabrol shunt was closed in 20 patients, with no aneurysm formation or coronary artery compression. Only one patient had persistent shunt from the left coronary artery anastomosis to the right atrium 6 months after surgery, though this patient remained asymptomatic with no changes during 2 years of follow-up.

Potential Study Limitations

The sample size in this study is limited and follow-up time does not exceed 36 months. There may be patient selection bias, and the patients in this study may not adequately represent the general population. Further studies are necessary to enlarge the patient cohort and extend follow-up duration.

Conclusion

For type A aortic dissection involving the aortic root, mortality is relatively high without surgery. Management of the aortic root is a key point of the operation. If the distance between the coronary ostium and aortic valve annulus is less than 10 mm, the Cabrol technique is feasible and safe based on our experience. The Cabrol shunt is very helpful for controlling hemorrhage, though the shunt may remain patent for a long time after surgery.

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Original Chinese Title and Abstract

Application of Cabrol Surgery for Aortic Root Lesions in Acute Type A Aortic Dissection

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dong General Hospital, Guangdong Academy of Medical Sciences, Guangzhou 510080, China

Abstract: Objective The Cabrol procedure was first introduced by Professor Cabrol C in 1981, but few reports exist on its application for type A aortic dissection. This study summarizes our center' s experience using the Cabrol technique to treat aortic root lesions in acute type A aortic dissection over the past 7 years. **Methods** From January 2009 to December 2016, 47 patients with acute type A aortic dissection underwent Cabrol surgery in our center. All cases were confirmed preoperatively by echocardiography and contrast-enhanced CT of the aorta. Aortic root lesions were managed using Cabrol technique, while arch lesions were treated with hemiarch or total arch replacement. A retrospective analysis was performed on all relevant data. **Results** A total of 47 patients were included, comprising 6 cases of simple Cabrol procedure, 13 cases of Cabrol + right hemiarch replacement, and 28 cases of Cabrol + Sun' s procedure. The overall 30-day mortality was 10.6% (5/47). The incidence of acute renal failure during hospitalization was 25.5% (12/47), with 12.8% (6/47) of patients requiring continuous renal replacement therapy. Median hospital stay was 25.5 days (range 15–128 days), with follow-up of 6–36 months. **Conclusion** Cabrol procedure is safe and effective for managing the aortic root in patients with acute type A aortic dissection. Certain technical details require attention during surgery.

Keywords: Cabrol procedure; aortic dissection; aortic root

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Note: Figure translations are in progress. See original paper for figures.