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Partial Clamping of the Brachiocephalic Trunk for Total Ascending Aorta Replacement without Circulatory Arrest: Early and Midterm Results

Antonio Maria Calafiore, MD,[1] Michele Di Mauro, MD,[2] Carlos-A. Mestres, MD,[3] Gabriele Di Giammarco, MD,[2] Giovanni Teodori, MD,[1] José L. Pomar, MD,[3] Luca Weltert, MD,[1] Antonio Bivona, MD,[2] Massimo Gagliardi, MD,[2] Angela Lorena Iacò, MD[2]

[1]Division of Cardiac Surgery, University Hospital, Torino, Italy; [2]Department of Cardiology and Cardiac Surgery, "G. D'Annunzio" University, Chieti, Italy; [3]Department of Cardiovascular Surgery, Hospital Clínico, Institut d'Investigacions Biomediques August Pi i Sunyer (IDIBAPS), University of Barcelona, Barcelona, Spain

ABSTRACT

Background: The aim of this study was to evaluate in elective patients the early and midterm results of partial clamping of the brachiocephalic trunk (BCT) for total ascending aorta replacement (TAAR) without circulatory arrest. Contraindications to the procedure were BCT/aortic arch calcifications and chronic aortic dissection.

Methods: The right radial artery was cannulated to monitor the systemic pressure after the BCT was partially clamped. A specially designed clamp was applied obliquely to occlude approximately 50% of the BCT and part of the aortic arch. The distal tip of the clamp was positioned in front of the left subclavian artery. From January 2002 to October 2003, 92 patients underwent TAAR. In 62 patients (67.4%), partial clamping of the BCT was used. Twenty of these patients underwent isolated TAAR, 27 underwent aortic valve replacement and TAAR, 11 had a Bentall operation, and 2 had a Cabrol operation. The aortic valve was spared in the remaining 2 patients. The mean (± SD) aortic cross-clamping and cardiopulmonary bypass times were 96 ± 31 minutes and 116 ± 43 minutes, respectively.

Results: Early mortality was 1.6% (1 patient). No cerebrovascular accidents occurred, demonstrating the safety of the technique. The major complications were acute respiratory insufficiency in 2 cases and acute renal failure in 5. The mean follow-up time was 9.0 ± 6.5 months. The mean 18-month and event-free survival rate was 96.6% ± 0.9%.

Conclusion: Partial clamping of the BCT for TAAR without circulatory arrest provides good early and midterm clinical results. Aortic arch clamping is not associated with cerebrovascular accidents.

INTRODUCTION

Total ascending aorta replacement (TAAR) in elective patients is generally performed during circulatory arrest with deep hypothermia and with or without cerebral perfusion. To avoid circulatory arrest and its potentially negative effects [Svensson 1993, Ergin 1994, Gottlieb 1994, Westaby 1997, Langley 2000, Griepp 2001], Scorsin et al [2003] introduced in selected cases the clamping of the aortic arch between the brachiocephalic trunk (BCT) and the left common carotid artery along with total clamping of the BCT itself. In the same period, our group described a simple TAAR technique without circulatory arrest that consists of partial clamping of the BCT [Calafiore 2003].

The aim of this study was to analyze early and midterm results of partial clamping of the BCT for TAAR.

MATERIALS AND METHODS

Patient Selection

Candidates for this technique are patients who need elective TAAR. Contraindications to the procedure are (*a*) preoperative or perioperative evidence of calcification of the aortic arch or the BCT and (*b*) chronic dissection of the ascending aorta and/or aortic arch.

Surgical Technique

Patients are monitored as usual, but the right radial artery is cannulated. Femoral cannulation for arterial inflow is preferred, but the distal arch can be cannulated in selected cases. The aortic arch, as well as the BCT and the left common carotid artery, is isolated and immobilized. A specially designed clamp is used for the procedure (Figure 1). Cardiopulmonary bypass is stopped for a few seconds, and 50%

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Address correspondence and reprint requests to: Antonio Maria Calafiore, MD, Division of Cardiac Surgery, "S. Giovanni Battista" Hospital, c.so Bramante 86, Torino, Italy; 39-011-6335514; fax: 39-011-6336130 (e-mail: calafiore@unich.it).

Figure 1. A specially designed clamp is used for the procedure.

of the BCT is cross-clamped obliquely. The distal portion of the clamp is directed toward the distal arch (Figure 2). Care must be taken that the pressure in the right radial artery remains the same after cardiopulmonary bypass is resumed so that if the clamp is correctly applied, partial clamping of the BCT does not cause any drop in the right radial artery pressure. Thus, the entire ascending aorta can be resected and replaced during a conventional normothermic cardiopulmonary bypass (Figure 3). The aortic arch can be partially replaced if necessary (video 1).

Clinical Experience

From January 2002 to October 2003, 264 patients underwent ascending aorta and/or aortic arch surgery (155 at the University of Chieti during the period of this study, 63 at the University of Torino from March 2003 to October 2003, and 46 at the University of Barcelona from September 2002 to October 2003). Elective ascending aorta and aortic arch replacement was performed in 212 patients (80.3%). Aortic arch replacement was added in 14 patients. Of the remaining 198 cases, 92 patients (46.5%) underwent TAAR. In 30 cases (32.6%), circulatory arrest was mandatory because of aortic arch calcification in 28 patients (detected by preoperative computed tomography [CT] scan in 16 cases and by perioperative finger palpation in 12) or chronic dissection (2 cases). Sixty-two patients (67.4%) who underwent TAAR using partial clamping of the BCT without circulatory arrest were included in this study. The preoperative data are summarized in Table 1.

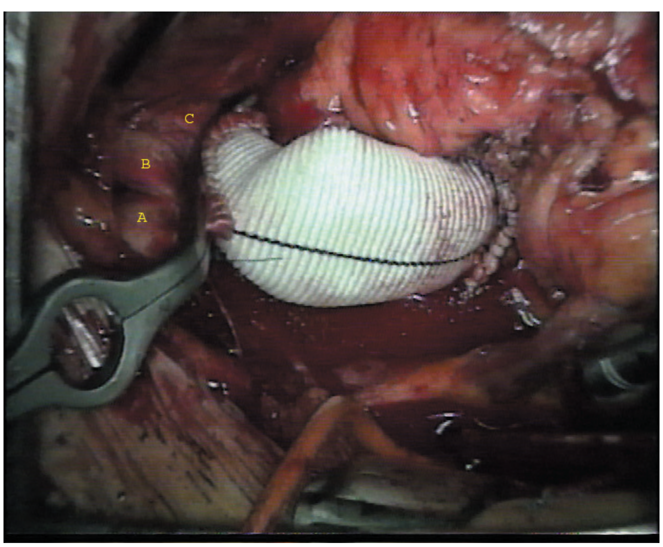

Figure 2. Fifty percent of the brachiocephalic trunk (A) is cross-clamped obliquely. The distal portion of the clamp is directed toward the distal arch. B, left common carotid artery; C, subclavian artery.

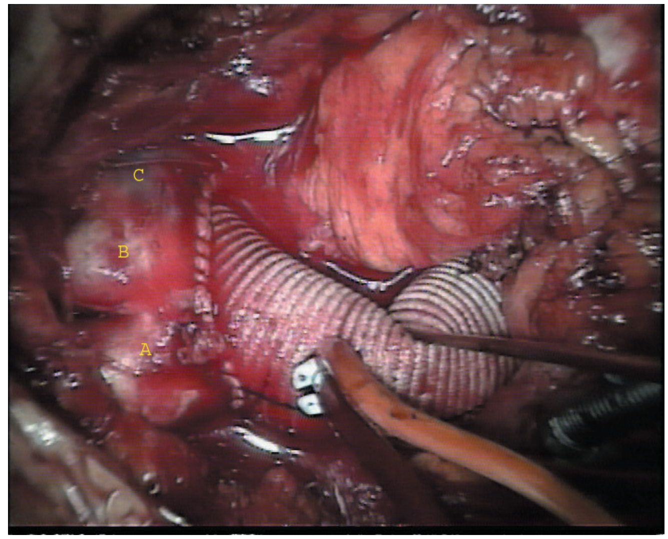

Figure 3. The entire ascending aorta can be resected and replaced. A, brachiocephalic trunk; B, left common carotid artery; C, subclavian artery.

RESULTS

Isolated TAAR was performed in 20 patients. In the remaining 42 cases, aortic valve surgery was added because of coexisting aortic valve disease (stenosis in 13 cases and regurgitation in 31). The aortic valve was spared in 2 patients with mild-to-moderate aortic valve regurgitation (1 David procedure and 1 Yacoub procedure) and was replaced in the remaining patients (Table 2). Partial BCT clamping was performed in 43 cases on the basis of a preoperative CT scan. All

Table 1. Preoperative Characteristics

Age, y*	63.4 ± 10.0
Female sex, n	24 (38.7%)
Hypertension, n	31 (50.0%)
Aortic valve stenosis, n	13 (21.0%)
Aortic valve regurgitation, n	31 (50.0%)
Coronary disease, n	16 (25.8%)

*Data presented as the mean ± SD.

Table 2. Operative Data*

Isolated AAR, n	20 (32.2%)
AAR and AOV replacement, n	27 (43.5%)
Bentall procedure, n	11 (18.0%)
Cabrol procedure, n	2 (3.2%)
David procedure, n	1 (1.6%)
Yacoub procedure, n	1 (1.6%)
Coronary artery bypass grafting, n	16 (25.8%)
Mitral valve repair, n	3 (4.8%)
Triscuspid valve repair, n	1 (1.6%)
Aortic cross-clamping time, min	96 ± 36
Cardiopulmonary bypass time, min	118 ± 48

*AAR indicates ascending aorta replacement; AOV, aortic valve.

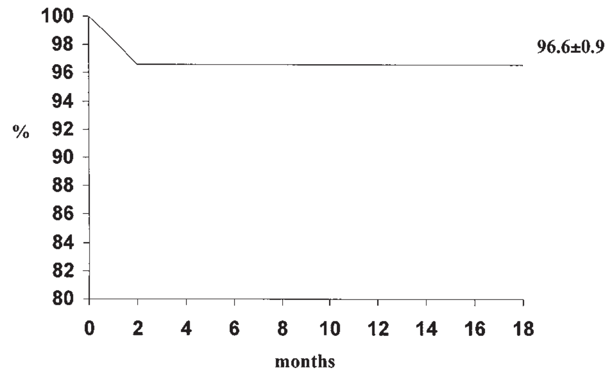

Figure 4. Eighteen-month survival and event-free survival.

of the patients had perioperative finger palpation of the arch, which was the only method in 19 patients to confirm or exclude the use of arch clamping.

One patient (1.6%) died during the first month after the operation, and no patient experienced any cerebral complications. The mean (± SD) awaking time was 8 ± 10 hours. Seven patients (11.3%) needed a chest revision because of excessive bleeding. Major postoperative complications occurred in 5 patients (8.1%) (Table 3).

Follow-up times ranged from 1 to 22 months (mean, 9.0 ± 6.5 months). One patient with a preoperative history of chronic obstructive pulmonary disease died 2 months after the operation due to the sequelae of respiratory failure that started during the postoperative period. The mean 18-month survival and event-free survival rate was 96.6% ± 0.9% (Figure 4).

DISCUSSION

Although recent studies have confirmed that deep hypothermia produces a reduction in oxygen metabolism [McCullough 1999, Langley 2000], Svensson et al [1993] reported different incidences of stroke, depending on the times of circulatory arrest (7-29 minutes, 12/298 [4%]; 30-44 minutes, 15/201 [7.5%]; 45-59 minutes, 9/84 [10.7%]; 60-120 minutes, 7/48 [14.6%]). In the same study, a multivariate analysis confirmed that a circulatory arrest time longer than 45 minutes was associated with an increased risk of stroke and that an arrest time longer than 65 minutes was associated with a higher risk of mortality as well [Svensson 1993]. Other investigators have fixed a period of 25 to 30 minutes as the upper limit for a safe deep-hypothermic circulatory arrest [Ergin 1994, Griepp 2001] to achieve adequate protection of all organs, especially with regard to the neurologic system.

Table 3. Thirty-Day Clinical Results*

Deaths, n	1 (1.6%)
Cerebrovascular accident, n	0
Acute renal failure, n	5 (8.0%)
Acute respiratory failure, n	2 (3.2%)
Reoperation for bleeding, n	7 (11.3%)
Awaking time, h	8 ± 10
Ventilation time, h	12 ± 10
Time to extubation, h	15 ± 13
Bleeding, mL/12 h	781 ± 555
Intensive care unit stay, h	19 ± 12
Hospital stay, d	8 ± 7

*Data are presented as the mean ± SD where appropriate.

Even if direct cerebral perfusion techniques are able to reduce the incidence of cerebral complications [Kazui 1994, Dossche 1999, Hagl 2001, Di Eusanio 2002], deep hypothermia and circulatory arrest are associated with a systemic inflammatory response due to ischemia/reperfusion. Increased numbers of neutrophils produce oxygen-derived free radicals, cytokines, proteases, and lipid-derived mediators, such as arachidonic acid and leukotrienes, that contribute to cerebral injury and renal failure [Langley 2000].

Neutrophils and their products cause injuries to the endothelium as well. Consequently, there is an impaired vasorelaxation of the micro- and macrocirculation because of impairment of the endothelial response to the basal and agonist-stimulated release of autacoids (nitric oxide). Therefore, the clinical results of this response may be acute myocardial infarction and multiorgan hypoperfusion [Langley 2000]. Multiorgan failure is also related to apoptosis (genetically programmed cell death) triggered by inflammatory mediators [Gottlieb 1994]. In addition, hypothermia produces alterations in platelet morphology, depressed enzyme functions, sequestration in the hepatic sinusoids, and decreased platelet aggregability, all of which expose the patient to a higher risk of excessive bleeding [Westaby 1997].

Therefore, alternative clamping techniques were designed for TAAR to avoid circulatory arrest and its potential complications. Scorsin et al [2003] proposed clamping the aortic arch between the BCT and the left common carotid artery along with total clamping of the BCT itself. This technique can be applied only in selected patients with the following characteristics: (*a*) a preoperative transcranial Doppler echocardiogram that demonstrates Willis polygon patency; (*b*) a preoperative CT scan that shows no aortic arch or BCT calcification; (*c*) preoperative or intraoperative evidence of the separate origins of the BCT and the left common carotid artery; and (*d*) preoperative or perioperative evidence of extensive atheroma in the aortic arch wall.

Partial clamping of the BCT, as previously reported [Calafiore 2003], can be indicated in all elective patients who do not present arch calcifications or chronic dissection, with a change only in cannulation from the left to the right radial artery in the standard monitoring of the patient. This technique can be applied without any preoperative CT scan evaluation, if necessary, because an intraoperative palpation of the aortic arch is sufficient to avoid any cerebral or vascular complications.

During the period of this study, 67.4% of patients scheduled for TAAR underwent partial clamping of the BCT, avoiding circulatory arrest. One patient died 19 days after the operation from a coagulopathy. Of special note is that there were no postoperative cerebrovascular accidents. This finding is crucial for demonstrating the safety of the procedure. Even if the patient in the operating theater did not undergo a perioperative aortic arch echocardiographic scanning, a preoperative CT scan and/or a perioperative digital palpation of the wall were sufficient to confirm the possibility of safely clamping the aortic arch. During the follow-up period, no patient showed any cerebral or vascular complications related to aortic arch clamping.

In conclusion, it is possible in selected cases to replace the entire ascending aorta while avoiding circulatory arrest. On the basis of preoperative or perioperative evaluation, partial BCT clamping can be used in approximately two thirds of patients. In the mid term, the technique is not associated with major complications.

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