

# Brachiocephalic Artery Cannulation in Proximal Aortic Surgery

that Requires Circulatory Arrest

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*The brachiocephalic artery is an alternative cannulation site in the repair of ascending aortic lesions that require circulatory arrest. We evaluate the effectiveness and safety of this technique.*

Proximal aortic surgery was performed in 32 patients from 2006 through 2012 via brachiocephalic artery cannulation and circulatory arrest. Twenty-four (75%) of the patients were men. The mean age was  $48.69 \pm 9.43$  years (range, 30–68 yr). Twelve had type I dissection, 2 had type II dissection, and 18 had true aneurysms of the ascending aorta. All operations were performed through a median sternotomy. The arterial cannula was inserted through an 8-mm vascular graft anastomosed to the brachiocephalic artery in an end-to-side fashion. In dissections, the distal anastomosis was performed without clamping the aorta. The patients were cooled to 24 °C, and circulatory arrest was established. The brachiocephalic and left carotid arteries were clamped, and antegrade cerebral perfusion was started at a rate of 10 mL/kg/min. Cardiopulmonary bypass was resumed after completion of the distal anastomosis and the initiation of rewarming. The proximal anastomosis was then performed.

None of the patients sustained a major neurologic deficit, but 5 patients experienced transient postoperative agitation (<24 hr). There were 2 early deaths (6.25%), on the 3rd and the 11th postoperative days, both unrelated to the cannulation technique.

Brachiocephalic artery cannulation through a graft can be a safe and effective technique in proximal aortic surgical procedures that require circulatory arrest. (**Tex Heart Inst J 2014;41(6):596-600**)

**C**irculatory arrest (CA) is usually necessary for surgical correction of pathologic conditions in which the proximal aorta is grossly involved: this includes the distal ascending aorta and the transverse aortic arch. Despite the development of various surgical and cerebral protection techniques, neurologic injury during CA is still a major cause of death.<sup>1,2</sup> Hypothermia during arrest is the chief element in cerebral protection, but it is not enough by itself. Additional technical measures during CA include antegrade or retrograde cerebral perfusion, external cranial cooling, and medical ischemic cerebral preconditioning. Although none of these techniques for cerebral protection has proved clearly superior to the others, antegrade cerebral perfusion (ACP) in union with hypothermia is the most widely accepted and practiced.<sup>3</sup> In preparation for ACP, the right axillary, the right brachial, or the brachiocephalic (BC) artery is cannulated<sup>3-6</sup>; alternatively, one or both carotid arteries are cannulated, and this is the approach preferred by most surgeons.<sup>2</sup> Brachial or axillary artery cannulation requires a separate incision, whereas direct cannulation of a carotid artery requires extra manipulation and extra instruments within the operative area. Brachiocephalic artery cannulation (via a graft) provides a single access site both for cardiopulmonary bypass (CPB) and for ACP.<sup>3,7-11</sup> Considering these advantages, we have preferred to use the BC artery cannulation technique since 2006. In this retrospective study, we communicate our results in the 32 patients who underwent BC artery cannulation during the period under review.

## Patients and Methods

At the 4 hospitals where we practice, 32 patients underwent BC artery cannulation from 2006 through 2012, in preparation for proximal aortic surgery under CA. Eight

of the 32 patients were women (25%), and the mean age of the overall group was  $48.69 \pm 9.43$  years (range, 30–68 yr). Twelve patients (37.5%) had a DeBakey type I dissection, and 2 (6.25%) had a DeBakey type II. The rest (56.25%) had true aneurysms of the ascending aorta. Two patients (6.25%) had a history of prosthetic aortic valve placement. The baseline characteristics of the patients appear in Table I.

The major criterion for the application of this technique was the presence of a proximal aortic lesion that did not affect the BC artery and would require CA in the course of surgical repair. In patients who had similar aortic lesions (but no need for CA), we cannulated a femoral artery or a healthy segment of the aorta itself.

All patients were evaluated with computed tomography before the operation, in order to obtain an exact diagnosis and determine the extent of the lesion. The BC artery was especially studied for its diameter and integrity as a potential cannulation site. In only one patient was that vessel judged ineligible for cannulation.

The protocol for this retrospective study was approved by the institutional review boards of all 4 institutions.

## Surgical Technique

All patients were monitored via the right radial artery and the jugular vein, and the body temperature was monitored through a nasopharyngeal probe. Median sternotomy was performed with all patients under general anesthesia. The left BC vein was isolated, taped, and retracted to expose the branch vessels. The BC artery was dissected up to the point of its bifurcation and taped. The left carotid and left subclavian arteries were also isolated for clamping. After systemic heparinization, the BC artery was partially clamped and an 8-mm polytetrafluoroethylene or Dacron graft was anastomosed to that vessel in end-to-side fashion (Fig. 1). The right radial artery pressure was maintained above 50 mmHg during this time. A 24F arterial cannula was then inserted through this graft and affixed at several points. Cardiopulmonary bypass was initiated after the insertion of a 2-stage venous cannula into the right atrium. For decompression of the left side of the heart, a vent catheter was inserted through the right superior pulmonary vein.

The 32 patients were cooled to 24 °C before aortic clamping, and then CA was established. The left carotid arteries and the proximal segment of the BC artery were clamped at this stage, in order to start ACP through the arterial cannula at a rate of 10mL/kg/min. An aortotomy was performed, and the lesion was directly inspected. The left carotid artery clamp was removed for a short while, to check the retrograde flow and the efficiency of cerebral perfusion. At this time, the right radial artery pressure was maintained between 30 and 50 mmHg.

**TABLE I.** Baseline Characteristics of the 32 Patients

Variable	Value
Mean age (yr),	48.69 ± 9.43
Range	30–68
Male	24 (75)
Female	8 (25)
Type I dissection	12 (37.5)
Acute	10 (31.25)
Chronic	2 (6.25)
Type II dissection (acute)	2 (6.25)
Annulo-aortic ectasia	8 (25)
Marfan syndrome	2 (6.25)
Aortic valve disease	6 (18.75)
Reoperation (AVR)	2 (6.25)
Mean ascending aortic diameter (cm),	5.82 ± 0.79
Range	4.2–8
Coronary artery disease	5 (15.63)
Smoking	25 (78.13)
Hypertension	32 (100)
Chronic pulmonary disease	18 (56.25)

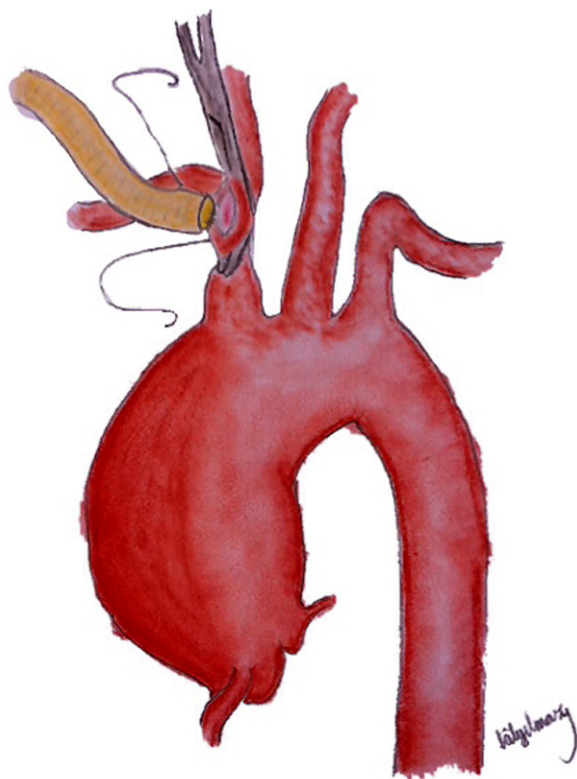
AVR = aortic valve replacement

Data are presented as number (percentage) or as mean ± SD (range).

The distal aortic anastomosis was done first. In 12 patients with acute aortic dissection, this anastomosis was performed at the healthiest aortic wall, as close as possible to the ostium of the BC artery, depending upon the location and direction of the false lumen. In the 2 patients with chronic dissection, the intimal flap was excised partly in a crescent shape, leaving both lumina patent; the anastomosis replaced the hemiarch. The graft was filled with the retrograde blood flow and deaired. The clamps on the BC and left carotid arteries were removed, and the graft itself was clamped. Circulation was resumed, and rewarming was started.

The proximal aortic repair was undertaken at this stage. In 11 of the 14 patients, there was a healthy and durable aortic wall proximal to the intimal tear. Consequently, a supracoronary graft interposition was possible. In 2 patients, the aortic valve and the right coronary artery were also involved, which required a Bentall procedure. In the remaining patient, who had a dissected right coronary ostium and a healthy aortic valve, the graft was tailored to sit on the annulus at the right coronary cusp (excluding the coronary ostium), and to cover the rest of the aortic diameter in a supracoronary position. The right coronary artery was then bypassed with a saphenous vein graft.

In the other 18 patients, with no dissection, the aorta was clamped and the proximal repair was performed during the cooling period. The Bentall procedure was



**Fig. 1** Anastomosis of the vascular graft to the brachiocephalic (BC) artery for cannulation. The BC artery is isolated and taped, and an 8-mm Dacron graft is anastomosed in an end-to-side fashion. The aortic cannula is then inserted into the graft and fixed at several points. Through this graft, the surgeon can easily initiate cardiopulmonary bypass and provide antegrade cerebral perfusion during circulatory arrest merely by clamping the proximal BC and left carotid arteries.

performed in 10 of these patients, a valve-sparing graft interposition in 4, and a supracoronary graft interposition in the other 4. Coronary artery bypass grafting was necessary in 5 of these patients. Circulatory arrest was established at the end of the proximal repair, as described above. The distal anastomosis was at the level of the ostium of the BC artery, excluding the clamped aortic tissue in 14 patients. Hemiarch replacement was performed in 3 patients and total arch replacement in one.

In all patients, cardiac arrest was established via retrograde and coronary ostial antegrade administration of blood cardioplegic solution. When all repair was done and CPB was terminated, the graft on the BC artery was cut close to the anastomosis, and the stump was closed with a continuous suture. Operative techniques are summarized in Table II.

## Results

Postoperatively, none of the 32 patients had a major neurologic deficit. Five displayed early postoperative

agitation, which resolved within the first 24 hours. No sequela related to BC artery cannulation—such as bleeding or brachial ischemia—was observed. There were 2 in-hospital deaths (6.25%). One was that of a 68-year-old man who had severe aortic stenosis and aneurysm of the ascending aorta, left ventricular hypertrophy, coronary artery disease, and chronic obstructive pulmonary disease. He died on the 11th postoperative day because of low cardiac output, prolonged ventilatory support, and sepsis. The other patient, who had an acute type I aortic dissection, died of postoperative renal failure and hemodialysis sequelae on the 3rd postoperative day.

The mean follow-up period was  $9.43 \pm 12.46$  months (range, 1–44 mo). All clinical results are summarized in Table III.

## Discussion

When surgical repair of the proximal aorta under circulatory arrest is considered, there are several choices of access for arterial cannulation. Femoral arteries have for years been the most widely used sites, but the retrograde flow within the aorta carries risks of malperfusion and atheroembolization. Therefore, other access sites are sought. The brachial artery,<sup>4,6</sup> the axillary artery,<sup>5</sup> and the BC artery<sup>3,7-11</sup> have been used for this purpose. All 3 of these sites have the advantage of providing a more central and physiologic flow, and they enable antegrade cerebral perfusion during circulatory arrest.

Cerebral protection is achieved through the combination of such techniques as hypothermia, cerebral perfusion, external cranial cooling, and medical ischemic cerebral preconditioning. Hypothermia is the principal and most effective of these for use during CA.<sup>12</sup> Several techniques have been described for cerebral perfusion and in affirmation of its effectiveness. Most investigators have agreed upon the superiority of antegrade

**TABLE II.** Operative Techniques in the 32 Patients

Variable	No.
Distal anastomosis	
Ascending aorta	26
Hemiarch replacement	5
Total arch replacement	1
Proximal anastomosis	
Supracoronary anastomosis	15
Bentall procedure	12
Valve-sparing graft implantation	5
Coronary artery bypass grafting	6

**TABLE III.** Results of Surgery in the 32 Patients

Variable	Value
Deaths	2 (6.25)
Major neurologic complications	0
Minor neurologic complications	2 (6.25)
Gastrointestinal complications	0
Peripheral ischemia	0
Renal complications	5 (15.63)
Revision for bleeding	5 (15.63)
Mean aortic cross-clamp time (min), Range	85.03 ± 16.17 45–125
Mean cardiopulmonary bypass time (min), Range	161.56 ± 26.25 80–210
Mean hypothermic circulatory arrest (min), Range	27.28 ± 6.5 15–40
Mean mechanical ventilation time (hr), Range	26.47 ± 23.25 12–120
Hospital stay (d), Range	7.91 ± 1.63 3–12

Data are presented as number (percentage) or as mean ± SD (range).

over retrograde cerebral perfusion, in combination with hypothermia. Various instruments can measure the effectiveness of such perfusion, but the simplest method is to confirm a good connection between the 2 sides of the cerebral circulation. After the onset of CA, brief release of the clamp on the left carotid artery enables retrograde flow to be checked and its rate evaluated visually. In all our patients, the left carotid blood flow was judged to be sufficient.

When femoral artery cannulation is used, additional cannulas and routes become necessary for ACP. In treating patients with aortic dissection, another disadvantage of femoral cannulation is the need to change arterial flow from the femoral artery to the aortic graft after the distal aortic anastomosis has been completed.

In consideration of these facts, we advocate proximal arterial cannulation for proximal aortic surgery when circulatory arrest is necessary. Brachiocephalic artery cannulation, as one of the choices, does not necessitate an additional incision, does provide more central flow, and can be applied to most patients. This technique, in our judgment, is easier and more practical than the alternative of axillary or brachial artery access.

In regard to the degree of hypothermia during operation, we prefer a body temperature of 24 °C for the period of circulatory arrest. The wider use of cerebral perfusion techniques during aortic arch surgery has encouraged a trend toward the routine use of moderate-to-mild hypothermia (28–35 °C). Even so, some major

centers favor the performance of aortic surgery with deep hypothermic CA, even in the absence of additional perfusion.<sup>13</sup> In 2007, Kamiya and colleagues<sup>14</sup> reported on possible neurologic sequelae to prolonged lower-body CA (>60 min) in the presence of moderate hypothermia (28 °C). In a subgroup analysis, they observed a 6-fold increase in death and ischemic spinal cord injury. Supported by these and other<sup>15</sup> comparisons of recent approaches to aortic arch surgery, we prefer to stay on the safer side, with hypothermia at less than 25 °C.

Banbury and Cosgrove<sup>7</sup> were the first to report BC artery cannulation via a graft. In their paper, published in 2000, they claimed 4 major advantages for this technique: 1) it eliminates the need for a 2nd incision, 2) it provides a higher flow rate without the need for higher pressure, because the BC artery is larger than the axillary artery, 3) it enables blood pressure monitoring via the right radial artery during ACP, and 4) it avoids the brachial plexus injuries associated with axillary artery cannulation.

When a graft anastomosis has to be performed for axillary cannulation, the anastomosis can bleed and become a major site of blood loss. On the other hand, any blood loss from the graft or the anastomosis at the BC artery is within the same operative field and can be returned to the reservoir via a simple vent catheter. Di Eusanio and colleagues<sup>8</sup> have reported, in their series, similar advantages of the technique. Direct cannulation of the BC artery with the routinely used arterial cannulas has also been suggested,<sup>9</sup> but that technique carries a higher risk of sequelae.<sup>3</sup> Rerouting of the cannula tip toward the aortic arch during warming and cooling, and toward the brain during CA, requires extra manipulation. Closure of the arteriotomy after decannulation also carries the risk of creating a stenosis.<sup>3</sup>

In a report from the Texas Heart Institute,<sup>11</sup> 68 patients were cannulated via the BC artery, all through a side graft. Coselli and colleagues had outstanding results: only one 30-day death (1.5%), 3 strokes (4.4%), and 7 patients with temporary postoperative confusion (10.3%). At variance from our practice, they perfused both cerebral hemispheres in 63 of the 68 patients (having added another perfusion catheter through the left common carotid artery).<sup>11</sup>

Brachiocephalic artery cannulation can of course have disadvantages in specific situations. When the BC artery is involved in the lesion, as in the case of a dissection or atherosclerotic plaques, it is not suitable for cannulation. In fact, in one of our patients, the BC artery was involved in the dissection, rendering cannulation impossible at that site. Graft anastomosis for cannulation adds approximately 15 to 20 minutes to the total operative time. Still, in comparison with axillary cannulation from a 2nd incision and with additional grafting, this time loss might be no worse than the alternative loss. Last, when the diameter of the BC artery is

less than 9 mm, the placement of a side clamp for graft anastomosis could further attenuate distal flow.<sup>3</sup>

### Limitations

These operations were performed in 4 different medical centers by a single surgeon (MU) within the specified time period. Because of the lack of a suitable system for collecting follow-up data and the failure of patients to adhere to follow-up protocols, the long-term results cannot be evaluated.

This study also has the classical limitations of a retrospective design. There was no opportunity to compare these patients with a similar group of patients who underwent surgery with other arterial cannulation techniques, because the authors used only this method within the specified time period. The follow-up period was short because of very low patient compliance with follow-up protocols. Still, we believe that the early post-operative period provided good insight into the effectiveness of this operative technique.

### Conclusion

In proximal aortic surgery that necessitates CA, arterial cannulation via a graft anastomosed to the BC artery is safe and effective. It can be applied to a wide variety of patients with ease. It eliminates the need for a 2nd incision, permits ACP, and enables monitoring of right radial arterial pressure during ACP. The larger size of the BC artery enables higher flows at lower blood pressures. The risk of brachial plexus injury that is associated with axillary arterial cannulation is also eliminated.

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