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Usefulness of the axillary artery as vascular access for cardiopulmonary bypass

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***Aim*. In this paper we report our clinical experience with extended utilization of axillary artery cannulation for cardiopulmonary bypass (CPB) and discuss the indications and the results of the procedure in terms of complications and usefulness.**

***Methods*. Between January 1999 and May 2004, 26 patients underwent right axillary artery cannulation for CPB. Fifteen patients presented acute type A aortic dissection and were operated urgently. Axillary cannulation was also used in 11 elective cases: 3 reoperative coronary surgery, 3 valve redo-operations and 5 cases of aortic valve regurgitation+aneurysm of the ascending aorta.**

***Results*. All axillary artery cannulations were successful (21 direct and 5 with a side graft) without neurologic or vascular injuries to the right upper extremities. Hospital mortality was 7.7% and included 2 patients operated in an emergency procedure because of acute type A aortic dissection. In all cases, this cannulation site provided adequate perfusion, with a range of peak flows from 4.1 to 5.7 L/min.**

***Conclusion*. Our preliminary results demonstrate that the right axillary artery may be considered an alternative cannulation site for achieving full CPB and providing antegrade flow, thus avoiding complications related to retrograde flow when femoral artery perfusion is performed. This safe and useful method may be used not only in aortic sugery but in other such complex cardiac procedures as redo-operations.**

KEY WORDS: Cardiopulmonary bypass - Axillary artery - Aortic dissections - Redo operation,

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The femoral artery is considered the most common cannulation site in patients undergoing cardiac surgery when cardiopulmonary bypass (CPB) is required before sternotomy or thoracotomy or in patients with severe atherosclerotic aortic disease. Moreover, peripheral cannulation has come to be regarded as useful in minimally invasive coronary and valve surgery. Nevertheless, femoral artery cannulation has been associated with such complications as lower limb ischemia, perfusion of the false lumen in aortic dissection, neurologic injury, retrograde embolization, and malperfusion.[1, 2] A study conducted by Van Arsdell *et al*.[3] reviewed autopsy findings in 50 cases of acute Stanford type A dissection and demonstrated that a theoretical surgical repair using the open arch technique followed by antegrade perfusion minimizes the risk of false lumen perfusion, reduces both neurological and bleeding complications and improves outcome.

On this basis, axillary artery cannulation has been popularized especially for the repair of type A aortic dissection.[3-5] We initially used axillary artery cannulation in aortic surgery before expanding its indications as reported in the present study.

Materials and methods

Patients

Between January 1999 and May 2004, 26 patients (21 male and 5 female; age range, 58-77 years) underwent axillary artery cannulation for CPB (Table I). Fifteen patients presenting type A aortic dissection were operated within 24 h of the onset of symptoms. Systemic circulation was arrested in all patients; rectal

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TABLE I.—*Surgical procedures and methods of axillary artery cannulation.*

Diagnosis	Operation	No. of patients
Type A Aortic dissection+AI	AVS+AAR	6
	AVS+AAR+EAR	4
	Bentall	1
Type A aortic dissection	AAR	4
AAA+AI	Bentall	3
	AAR+AVR	2
CAD	Redo-CABG	3
AI+MI	Redo-DVR	1
AI	Redo-AVR	1
MS	Redo-MVR	1
Direct cannulation		21
Side graft		5
Total no. of patients		26

AVS: aortic valve sparing; AAR: ascending aorta replacement; EAR: hemi-arch repair; AVR: aortic valve replacement; CABG: coronary artery bypass grafting; DVR: double valve replacement; MVR: mitral valve replacement; AAA: ascending aortic aneurysm; AI: aortic valve insufficiency; CAD: coronary artery disease; MI: mitral valve insufficiency; MS: mitral valve stenosis.

temperature was lowered to 18° C in 5; antegrade cerebral perfusion at 22°C was performed in the remaining 10. The dissected aorta was completely resected, obliterating the false lumen with biological glue and Teflon felt strips as previously reported;[6] the obtained cuffs were sutured to a vascular graft. Ten patients (66.6%) presented aortic valve insufficiency; all valves were preserved with 8 commissural resuspension and 2 commissural plicatio; hemi-arch repair was performed in 5 (33.3%). In 1 Marfan patient (6.6%) with dissected ascending aorta and severe valve insufficiency, aortic root replacement with an appropriate composite tube graft (St. Jude Medical Inc.) was performed.

Axillary cannulation was subsequently planned for elective surgery in 11 patients (Table I): 3 reoperative coronary surgery, 3 valve redo-operations and 5 cases of aortic valve insufficiency + aneurysm of the ascending aorta. This cannulation site was chosen to preserve perfusion to the lower extremities known to be arteriosclerotic and to avoid retrograde flow through the diseased thoracic and abdominal aorta, thus preventing an embolic accident.

Surgical technique

A 5 to 8 cm skin incision is made 1 cm below and parallel to the right mid- and lateral-clavicle. The fibers of the *pectoralis maior* muscle are separated from the clavicle and the *pectoralis minor* muscle is retracted laterally. The cephalic vein is mobilized or divided in the deltopectoral groove to identify the deeper subclavian space. The axillary artery, identified by palpation and exposed medially to the *pectoralis minor* muscle, is freed from connective tissue, mobilized proximally without touching the medial and lateral brachial plexus cords and then suspended by 2 umbilical tapes. Since the artery lies deep to the axillary vein, in many circumstances it is necessary to mobilize and retract the vein. After systemic heparinization, the exposed segment of the artery is clamped proximally and distally, a transverse arteriotomy is performed and a 20 or 22 F cannula (DLP, Medtronic Inc.) is inserted and advanced about 2 cm into the artery, removing the proximal clamp and securing the tape over the artery and the cannula. If direct cannulation is difficult because of sharp angulation of the cannula, a woven Dacron albumin coated (Bard Inc.) or expanded PTFE (W.L. Gore & Associates, Inc.) 8 mm graft is anastomosed to a longitudinal arteriotomy with a 6.0 polypropylene suture (Ethicon, Inc.) and the vascular clamps are then removed to restore flow to the arm. A 22 F cannula (DLP, Medtronic Inc.) is inserted and secured to the graft using heavy ligatures. The arterial pressure monitoring line is inserted into the opposite radial or brachial artery or alternatively into the femoral artery if not dissected. The chest is then opened by median sternotomy and venous cannulation is performed with a two-stage cannula in the right atrium. Closure of axillary arteriotomy is performed using a 6.0 polypropylene running suture when direct cannulation is performed. If a prosthesis is to be used, the graft is amputated 1 or 2 cm from the anastomosis to the axillary artery and secured with 2 polypropylene sutures.

Results

All right axillary artery cannulation attempts were successful, without any requiring conversion to femoral artery perfusion. Only one 1 patients presented posterior and lateral calcification of the axillary artery; however, this did not preclude cannulation and subsequent closure of the vessel. All arteries were closed without the need for thrombectomy or patch reconstruction. In 21 patients (80.7%) the artery was

cannulated directly;, and in the remaining 5 (19.3%) the cannula was inserted into a prosthetic graft anastomosed to the axillary artery (Table I).

The overall hospital mortality was 7.7% (2/26); both patients had all in the group with acute type A aortic dissection. In ; in this series, of 2 patients 2 with preoperative right hemiplegia recovered postoperatively, whereas 1 case of paraparesis was observed 24 hours after surgical repair, with complete resolution resolved 15 days afterlater. Two2 patients required temporary hemodialysis. N; no neurologic or vascular complications regarding of the right upper extremities were observed. Axillary artery peak flows during CPB ranged from 4.1 to 5.7 L/min.

Discussion and conclusions

Use of the axilllary artery for perfusion during CPB in surgery of type A aortic dissection and complex repair of the aortic arch has been widely popularized.[4, 5] On the other hand, it is helpful to remind that also the innominate arterybrachiocephalic trunk can be easily exposed after sternotomy and cannulated by a side-graft to so allowing antegrade perfusion and maintaining flow in the axillary artery without a separate surgical approach.

In acute aortic dissection, the axillary artery CPB perfusion reduces the risk of ischemia strictly related by to the malperfusion due toresulting from the retrograde flow through the femoral artery. Moreover, in this operation, axillary perfusion eliminates the need to cannulate the aortic graft and permits a direct antegrade selective perfusion in the right common carotid artery during systemic circulatory arrest. But tThis consideration is controversial: in fact Svensson and Nadolny [7] assert that, when the cannula is inserted more than 2 cm into the subclavian (not the axillary) artery, it may advance into the carotid artery where it can cause an inadequate blood flow and a relative brain ischemia. The possible reasons are anatomical -- as a too short distance between the cannula and the innominate artery -- or technical -- as an arterial kinking caused by the cannula. In a small number of cases, the subclavian/axillary arteries are involved in the dissected [7] and/or arteriosclerotic process, but this was not observed in our series of patients. In the case of small axillary artery, a side graft is recommended [4, 7] to maintain an adequate flow, particularly in overweight patients, and to avoid ipoperfusion of the upper extremities (compartment syndrome). This technique was applied only in 5 cases (19.3%) to avoid additionally needle stress to the artery wall, graft kinking, and potential leak and to reduce the extra time required to anastomose the graft to the artery and the bleeding from the suture line. In addition, it is preferable to utilize a cannula with an open end to avoid the inability to achieve an adequate flow because of high resistance in the graft and to circulate a small volume to prevent clot formation in the arterial circuit.[8]

Our proposal is to expand the list of indications for the axillary artery as a site for peripheral CPB cannulation. This is in accordance with Bichell *et al.*[9] who suggested an axilloaxillary CPB, so cannulating both the artery and the vein in all patients with known arteriosclerotic peripheral disease, as poor or absent femoral pulses, previous lower extremities extremity revascularization, and claudication. In this way, we believe that axillary artery CPB may be used in cardiac surgical procedures that requiringe an alternative cannulation site, as in aortic dissection or aneurysm, in patients with the a so-called “porcelain aorta”, redo coronary or valvular operations, and minimally invasive surgery.

Our initial results are encouraging: in term of flows which are in excess of over 4 L/min and absence of complications. In fact, none of the described consequences sequelae of axillary cannulation described above, described together with brachial plexus injury and/or arterial thrombosis occurred in our series. Moreover, in the cases patients with type A aortic dissection, we have not found the axillary artery involving in the dissection, whereas a transfemoral perfusion of the false lumen is frequent. With the increasing number of patients with arteriosclerotic disease of the aorta, associated with the risk of embolization or dissection, and the rise in arteriosclerotic pathologies the aortoiliac and femoral axes, the use of axillary artery CPB leads an extensive utilization of the axillary artery CPB.

In conclusion, arterial perfusion through the right axillary artery is safe and simple, without any evidence of complications and it is feasible and useful not only for aortic surgery, but, also in all cases of cardiac surgical procedures, when a peripheral site for CPB is mandatory or at least advisable.

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