Rev Bras Cir Cardiovasc 2009; 24(3): 404-408

Axillary artery in cardiopulmonary bypass: indications and results

Artéria axilar na instalação de circulação extracorpórea: indicações e resultados

Fernando A. ATIK[1], Cristiano N. FABER[1], Ricardo B. CORSO[1], Mateus de Souza SANTOS[2], Karina Pereira MICHELETTE[2], Maria Regina BARROS[2], Luiz Fernando CANEO[3]

RBCCV 44205-1108

Abstract

Objectives: **To determine indications and results of axillary artery cannulation for cardiopulmonary bypass.**

Methods: From January 2005 through December 2008, axillary artery cannulation was used in 48 patients. Mean age was 62 ±11 years and 33 patients (69%) were males. Axillary artery was approached by infraclavicular incision and the cannula introduced in a 8 millimeter Dacron side graft.

Results: **Indications were calcified aorta (N=18, 38%), aortic dissection (N=15, 31%), ascending and/or aortic arch aneurysm (N=11, 23%) and prior to reoperative median sternotomy (N=4, 8%). Changes in intraoperative planning occurred most often in patients with calcified aorta (100% versus 10%, *P*<.0001) than in patients with other indications, which follow their preoperative plan. Cardiopulmonary bypass (deep hypothermic circulatory arrest in 55% and conventional in the remaining) was uneventfully conducted in all patients but one (success rate 98%) due to undiagnosed inominate artery stenosis. Local complication was lymphatic drainage in three patients (6.2%).**

Conclusions: **Axillary artery is an alternative cannulation site in patients unsuitable to aortic cannulation. The type of indication may determine intraoperative changes in surgical planning.**

Descriptors: **Extracorporeal Circulation. Axillary Artery, Aorta.**

Resumo

Objetivo: **Estudar as indicações e os resultados da artéria axilar na instalação de circulação extracorpórea.**

Métodos: Entre janeiro de 2005 e dezembro de 2008, a artéria axilar foi utilizada em 48 pacientes submetidos a cirurgia cardiovascular. A idade média foi 62 ± 11 anos e 33 (69%) pacientes eram do sexo masculino. A artéria axilar foi abordada por incisão infraclavicular e a cânula introduzida no tubo de Dacron de 8 milímetros suturado nos bordos da artéria.

Resultados: **As indicações foram calcificação da aorta (N=18, 38%), dissecção da aorta (N=15, 31%), aneurisma da aorta ascendente e/ou arco aórtico (N=11, 23%) e prévio a reesternotomia (N=4, 8%). A presença de calcificação da aorta**

1. Specialization; Cardiovascular Surgeon.
2. Graduation; Perfusionist.
3. MD; Cardiovascular Surgeon.

Work done at Instituto de Cardiologia do Distrito Federal, Fundação Universitária de Cardiologia, Brasília, DF, Brazil.

Correspondence address:
SQSW 102 bloco D ap 508 Brasília-DF. Brazil .ZIP Code: 70670-204.
E-mail: atikf@mac.com

Article received pn April 4th, 2009
Article accepted on August 31st, 2009

levou mais frequentemente à mudança de tática intra-operatória do que as outras indicações (100% *versus* 10%, *P*<0,0001) que seguiram o planejamento cirúrgico pré-operatório. A condução da circulação extracorpórea (parada circulatória total em 55% e convencional no restante) transcorreu sem problemas em todos os casos, exceto um (taxa de sucesso de 98%) em decorrência de estenose do tronco braquiocefálico não diagnosticada previamente. Complicação local se limitou a linfocele em três (6,2%) pacientes.

***Conclusões:* A artéria axilar é uma alternativa à impossibilidade de canulação da aorta ascendente na instalação de circulação extracorpórea. O tipo de indicação do uso da artéria axilar pode determinar mudanças intra-operatórias do planejamento cirúrgico.**

***Descritores:* Circulação extracorpórea. Artéria axilar. Aorta.**

INTRODUCTION

Axillary artery is considered an alternative cannulation site for cardiopulmonary bypass. Despite of axillary artery cannulation being technically more difficult than the aorta or the femoral artery, it promotes antegrade flow through a vessel usually free from atherosclerotic disease [1]. Indications have been broadened, due to its technique being reproducible and safe [2,3]; and it does include installation of cardiopulmonary bypass in patients with extensive atherosclerotic disease [4], aneurysms [5] or aortic dissection [1], intra-aortic balloon pump insertion [6], and circulatory assistance devices [7,8]. It is important to study the issues related to axillar artery cannulation for cardiopulmonary bypass because of the presence of incidental problems that may limit aortic cannulation.

The aim of this study is to examine indications and the local and systemic results of axillary artery use as cannulation site for cardiopulmonary bypass.

METHODS

From 2005 and 2008, axillary artery was used as a cannulation site for cardiopulmonary bypass in 48 consecutive patients. Mean age was 62 ± 11 years (range 31 years - 81 years), 33 patients (69%) were males, and mean weight was 70 kg ± 13 kg (range 47 kg - 103 kg). Pre, intra and postoperative variables were prospectively collected and saved in an electronic database. The study was approved by the Institutional Review Board according to the Helsinki law.

Preoperative characteristics were expressed in Table 1. The majority of patients were in functional classes I and II (73%). Half of them had coronary artery disease, and 30% had moderate or severe aortic regurgitation. Patients were considered to be high-risk, due to a mean expected logistic Euroscore mortality rate of 18.7% ±17.7%.

Table 1. Preoperative clinical variables in patients submitted to cardiopulmonary bypass with the axillary artery.

Demographic data	
Male	33 (69%)
Age (years)	62 ± 11
Weight (kg)	70 ± 13
New York Heart Association Functional Class	
I	20 (42%)
II	15 (31%)
III	8 (17%)
IV	5 (10%)
Coronary arterial disease	24 (50%)
Number of obstructed coronaries *	
1	2 (4.2%)
2	3 (6.3%)
3	19 (40%)
Carotid disease	6 (13%)
Peripheral vascular disease	7 (15%)
Previous cardiac surgery	6 (13%)
Atrial fibrillation	4 (8.3%)
Ejection fraction (%)	55 ± 13
Aortic insufficiency	
Absent	25 (33%)
Trace or escape	5 (11%)
Mild	3 (6%)
Moderate	8 (17%)
Important	6 (13%)
Co-morbidities	
Diabetes	13 (27%)
Arterial hypertension	39 (81%)
Dislipidemy	18 (38%)
Chronic obstructive pulmonary disease	10 (21%)
Serum creatinine (unit)	1.08 ± 0.43
Surgical risk score	
Addictive Euroscore	8.9 ± 3.3
Logistic Euroscore	18.7 ± 17.7

**luminal obstruction above 70%*

Surgical technique: Artery exposure was obtained through an infraclavicular approach, between the deltoid and pectoralis major muscles. Both skin and subcutaneous tissue were opened in a 6 to 8 centimeter incision, two centimeters parallel to the clavicle lateral two thirds. Pectoralis major muscle fibers were retracted; and the clavipectoral fascia opened, exposing the minor pectoralis muscle which was retracted laterally. Axillary artery was identified by palpation, usually located superiorly to the subclavian vein. Brachial plexus was carefully dissected out off the artery. Proximal and distal control of the artery was obtained. After administration of heparin, an 8-millimeter Dacron side graft was anastomosed to the artery. Anastomotic patency was verified by backflow, presence of arterial pulse and absence of resistance during cardiopulmonary bypass. Invasive arterial monitoring should be placed in the same arm as the cannula insertion, because it may suffer interferences in its determination. Just after the end of perfusion and administration of protamin, the Dacron graft was ligated close to the artery, hemostasis was revised and the incision closed by layers.

Statistical analysis: Categorical variables were presented in frequencies and percentages and continuous variables in means and standard deviation. Medians were used in continous variables with skewed distributions. The influence of indication of axillary artery use on operative planning was determined by chisquare test, with statistical significance considered when *P* value less than 0.05.

RESULTS

Indications of axillary artery use for cardiopulmonary bypass were calcified aorta in 18 patients (38%), aortic dissection in 15 patients (31%), ascending and/or aortic arch aneurysm in 11 patients (23%) and prior to redo sternotomy in four patients (8%).

The moment of indication for axillary artery as arterial cannulation site was preoperative in 28 patients (58%) and intraoperative in the remaining. The presence of calcification of the aorta was most likely responsible for changes in intraoperative planning than other indications (100% versus 10%, $P<0.0001$) which follow the initial preoperative plan.

Operative characteristics were detailed in Table 2. Most frequently performed procedures were aortic replacement in 33 patients (68%), coronary artery bypass grafting in 22 patients (46%) and aortic valve replacement in 18 patients (37%). The latter was part of the composite valve graft aortic root replacement in 13 patients (27%), associated with replacement of the supracoronary ascending aorta in two patients (4%) and isolated in one (2%).

Conduction of cardiopulmonary bypass (total circulatory arrest in 55% and conventional in the remaining) occurred uneventfully in all but one (success rate of 98%) because of undiagnosed inominate artery stenosis. Mean duration of cardiopulmonary bypass was 174 ± 58 minutes and aortic crossclamping 132 ± 55 minutes. Among patients that required hypothermic circulatory arrest, the cerebral perfusion technique used was antegrade in 24 patients (89%) and retrograde in three patients (11%).

Systemic and local complications are listed in Table 3. The only local complication was limphocele in three patients (6.2%). Hospital mortality was 17% (8 patients). Main morbidities were atrial fibrillation in 15 patients (31%), acute renal failure in seven patients (15%), respiratory insufficiency in six patients (13%) and cerebrovascular accident in five patients (10%).

Table 2. Operative characteristics of 48 patients submitted to axillary artery cannulation for cardiopulmonary bypass.

Surgical procedures*	N (%)
Substitution of Aorta	
Base + ascending	11 (23)
Base + ascending + arch	1 (2)
Base + ascending + arch + descending	1 (2)
Aortic valve + ascending	1 (2)
Aortic valve + ascending + arch	3 (6)
Only ascending	12 (25)
Only arch	3 (6)
Arch + descending	1 (2)
Associate procedures	
Replacement of aortic valve	18 (37)
Myocardial revascularization	22 (46)
Mitral valve plastic	1 (2)
Replacement of mitral valve	4 (8)
Tricuspid valve plastic	2 (4)
Aneurysmectomy of left ventricle	4 (8)
Endarterectomy of carotid	3 (6)

Mutually non-exclusive

Table 3. Local and general complications in 48 patients submitted to cardiopulmonary bypass with the axillary artery.

Local complications	N	%
Lynphocele	3	6.2
Arterial injury	0	
Limb Ischemia	0	
Brachial plexus injury	0	
Aorta dissection	0	
Hospital mortality	8	17
Morbidity		
Brain vascular accident	5	10
Respiratory insufficiency	6	13
Acute renal insufficiency	7	15
Mediastinite	3	6.2
Myocardial infarction	2	4.2
Atrial fibrillation	15	31
Permanent pacemaker	2	4.2
Intensive care time (days)	3.5	2.75 – 11.5

Among five patients with cerebrovascular accident, four had calcification of the aorta and the other acute aortic dissection. Three of them were submitted to aortic replacement under deep hypothermic circulatory arrest and antegrade cerebral perfusion. Mean circulatory arrest time was 44 ± 19 minutes. Two out of five patients were submitted to carotid endarterectomy at the same surgical procedure. Although cerebrovascular accident had occurred more frequently in patients with calcification when compared to those with aortic dissections, it was not statistically significant (22% versus 6,7%, *P*=0.21). There was no statistical association between duration of total circulatory arrest and the presence of cerebrovascular accident.

DISCUSSION

In this study, we demonstrated that the axillary artery is a safe site for installation and conduction of cardiopulmonary bypass in diverse situations in which aortic cannulation is unfeasible. The two most frequently indications were calcification of the aorta and acute aortic dissection, which comprised almost 70% of all cases. On those clinical scenarios, it is believed that axillary artery had theoretical advantages over the femoral artery. However, there are no comparative controlled randomized trials [9]. Patients with important atherosclerosis of the ascending aorta frequently have concomitant atherosclerosis of the abdominal aorta [10], which increases the risk of embolization from femoral retrograde perfusion. That would lead to cerebrovascular accident and visceral organ malperfusion [11]. Moreover, those patients usually present with atherosclerosis on iliacs and femorals, and it may impair the cannulation. Due to unknown reasons, the axillary artery is generally free from atherosclerosis [12]. An experimental study has shown that the axillary artery cannulation reduced cerebral microemboli [13].

The only case of malperfusion during cardiopulmonary bypass occurred because of an undiagnosed inominate artery stenosis. Some groups postulate routine preoperative ultrassonography assessment of braqueocephalic vessels because of this fact [14]. Other potential causes of malperfusion with axillary artery are uncommon. Usually, the axillary artery is not involved in aortic dissections, and a careful anastomosis of a side graft does eliminate the possibility of arm or cerebral selective perfusion. In contrast to the femoral artery, there is no retrograde perfusion through the false lumen in acute dissections [15], which it may cause a catastrophic malperfusion issue during cardiopulmonary bypass.

In this series, 8% of the patients required axillary artery cannulation prior to complex cardiac reoperations, and that approach has been routinely adopted by some groups [16], in order to promote antegrade flow to cerebral arteries and leave the operative field cleaner during the procedure. We also verified that the type of indication for axillary artery use may influence the operative planning. Patients with aortic calcification diagnosed intraoperatively most often required changes in cannulation sites than other indications. That makes sense, since the thoracic aorta computed tomography routinely performed in aneurysms and dissections allow a precise extent of the disease, and alternative cannulation sites are considered in advance. On the other hand, calcification of the aorta may be suspected by individual risk factors, its identification on chest film, but it would only be precisely diagnosed by epiaortic ultrasound. In this series, the diagnosis of aortic calcification was performed by palpation after sternotomy due to unavailability of this technology.

Axillary artery local complications were infrequent and with minor repercussion. The more lateral infraclavicular approach, the careful identification of the artery respecting the anatomic references and the interposition of a side graft were universally applied in this series. These findings are in accordance with other studies [14,16]. Sabik et al. [14] demonstrated that the infrequent local complications (malperfusion, selective perfusion, arterial injury and brachial plexus injury) are minimized with a side graft when compared with direct cannulation. In addition, this technique can be used by a second time in reoperations [17]. Baribeau et al. [3] showed that the more lateral infraclavicular approach reduce the possibility of local complications, especially brachial plexus injury. Another alternative technique is the supraclavicular approach that showed to be safe and with low complication rate [18], or even the carotid artery when there is no calcification or dissection [19].

Outcomes here presented are comparable to the complexity of aortic operations, being the actual mortality as expected by Euroscore. The frequency of cerebrovascular accident may have relation to operative patient profile, especially the presence of severe aortic and carotid atherosclerotic disease, and prolonged total circulatory arrest. It is known that the risk of brain damage exponentially increases when the circulatory arrest time is greater than 30 minutes, despite the employed cerebral protection measures. Methods of cerebral protection here employed are those postulated in the literature. We adopt deep hypothermia, administration of steroids and barbiturates, as well as topic ice. A theoretical advantage of axillary artery would be antegrade cerebral perfusion at the time of total circulatory arrest, after inominate artery balloon occlusion. Despite there is no consensus in the literature regarding this issue, we follow the growing world tendency on aortic arch surgery [16, 20-23].

LIMITATIONS OF THE STUDY

This is an observacional cohort of a limited number of a specific population of patients in which aortic cannulation

was not feasible. It would be interesting to compare these results with femoral artery cannulation. However, the latter is seldomly performed in our center and the number of patients is insufficient for any data analysis. Therefore, the study is purely descriptive due to statistical limitations and lack of control group comparability. The authors do not have the intention to present definite conclusions about this issue.

CONCLUSION

Axillary artery is an alternative to ascending aorta in installation of cardiopulmonary bypass. The indication type of axillary artery use may determine intraoperative changes in surgical planning.

REFERENCES

1. Neri E, Massetti M, Capannini G, Carone E, Tucci E, Diciolla F, et al. Axillary artery cannulation in type a aortic dissection operations. J Thorac Cardiovasc Surg. 1999;118(2):324-9.

2. Strauch JT, Spielvogel D, Lauten A, Lansman SL, McMurtry K, Bodian CA, et al. Axillary artery cannulation: routine use in ascending aorta and aortic arch replacement. Ann Thorac Surg. 2004;78(1):103-8.

3. Baribeau YR, Westbrook BM, Charlesworth DC, Maloney CT. Arterial inflow via an axillary artery graft for the severely atheromatous aorta. Ann Thorac Surg. 1998;66(1):33-7.

4. Sabik JF, Lytle BW, McCarthy PM, Cosgrove DM. Axillary artery: an alternative site of arterial cannulation for patients with extensive aortic and peripheral vascular disease. J Thorac Cardiovasc Surg. 1995;109(5):885-90.

5. Atik FA, Navia JL, Svensson LG, Vega PR, Feng J, Brizzio ME, et al. Surgical treatment of pseudoaneurysm of the thoracic aorta. J Thorac Cardiovasc Surg. 2006;132(2):379-85.

6. Blythe D. Percutaneous axillary artery insertion of an intra-aortic balloon pump. Anaesth Intensive Care. 1995;23(3):406-7.

7. Edmunds LH Jr, Herrmann HC, DiSesa VJ, Ratcliffe MB, Bavaria JE, McCarthy DM. Left ventricular assist without thoracotomy: clinical experience with the Dennis method. Ann Thorac Surg. 1994;57(4):880-5.

8. Navia JL, Atik FA, Beyer EA, Ruda Vega P. Extracorporeal membrane oxygenation with right axillary artery perfusion. Ann Thorac Surg. 2005;79(6):2163-5.

9. Gulbins H, Pritisanac A, Ennker J. Axillary versus femoral cannulation for aortic surgery: enough evidence for a general recommendation? Ann Thorac Surg. 2007;83(3):1219-24.

10. Blauth CI, Cosgrove DM, Webb BW, Ratliff NB, Boylan M, Piedmonte MR, et al. Atheroembolism from the ascending aorta. An emerging problem in cardiac surgery. J Thorac Cardiovasc Surg. 1992;103(6):1104-11.

11. Price DL, Harris J. Cholesterol emboli in cerebral arteries as a complication of retrograde aortic perfusion during cardiac surgery. Neurology. 1970;20(12):1209-14.

12. Hedayati N, Sherwood JT, Schomisch SJ, Carino JL, Markowitz AH. Axillary artery cannulation for cardiopulmonary bypass reduces cerebral microemboli. J Thorac Cardiovasc Surg. 2004;128(3):386-90.

13. Sabik JF, Nemeh H, Lytle BW, Blackstone EH, Gillinov AM, Rajeswaran J, et al. Cannulation of the axillary artery with a side graft reduces morbidity. Ann Thorac Surg. 2004;77(4):1315-20.

14. Eugene J, Aronow WS, Stemmer EA. Retrograde aortic dissection during cardiopulmonary bypass. Clin Cardiol. 1981;4(6):356-9.

15. Svensson LG, Blackstone EH, Rajeswaran J, Sabik JF 3rd, Lytle BW, Gonzalez-Stawinski G, et al. Does the arterial cannulation site for circulatory arrest influence stroke risk? Ann Thorac Surg. 2004;78(4):1274-84.

16. Shetty R, Voisine P, Mathieu P, Dagenais F. Recannulation of the right axillary artery for complex aortic surgeries. Tex Heart Inst J. 2005;32(2):194-7.

17. Fabri HA, Cunha CR, Santos PC, Carizzi DMP. Abordagem supraclavicular da artéria subclávia direita para estabelecimento de circulação extracorpórea nas doenças da aorta. Rev Bras Cir Cardiovasc. 2002;17(3):201-7.

18. Souza JM, Rojas SO, Berlinck MF, Mazzieri R, Oliveira PAF, Martins JRM, et al. Circulação extracorpórea pela artéria carótida comum direita na correção de doenças da aorta ascendente, arco aórtico e aorta descendente. Rev Bras Cir Cardiovasc. 2003;18(2):137-41.

19. Hagl C, Ergin MA, Galla JD, Lansman SL, McCullough JN, Spielvogel D, et al. Neurologic outcome after ascending aorta-aortic arch operations: effect of brain protection technique in high-risk patients. J Thorac Cardiovasc Surg. 2001;121(6):1107-21.

20. Reuthebuch O, Schurr U, Hellermann J, Prêtre R, Künzli A, Lachat M, et al. Advantages of subclavian artery perfusion for repair of acute type A dissection. Eur J Cardiothorac Surg. 2004;26(3):592-8.

21. Dias RR, Silva IA, Fiorelli AI, Stolf NAG. Proteção cerebral: sítios de canulação arterial e vias de perfusão do cérebro. Rev Bras Cir Cardiovasc. 2007;22(2):235-40.