*Heart Surgery Forum* 2024; 27(2): E157–E161
doi: 10.59958/hsf.7173


*Article*

# Direct Right Axillary Artery Cannulation as First Choice Strategy during Aortic Surgery Procedures: Results from a Single Experienced Surgical Centre

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Submitted: 22 December 2023 Revised: 16 January 2024 Accepted: 29 January 2024 Published: 20 February 2024

## Abstract

**Objectives**: Since early nineties axillary artery has been proposed as alternative to femoral artery for peripheral arterial cannulation during cardiopulmonary bypass (CPB) in aortic surgery. The aim of this study is to report our single-centre experience using direct axillary artery cannulation during aortic surgery. **Methods**: One hundred consecutive patients, undergoing aortic surgery using direct axillary artery cannulation were enrolled. Patient population ranged between 29 to 87 years and mean age was 65 $\pm$ 13 years. Seventy-seven patients (77%) underwent scheduled complex surgical procedure and 23 patients (23%) underwent emergent surgical procedure. Sixteen patients, furthermore, have had a previous cardiac surgery procedure. **Results**: CPB management using direct axillary artery cannulation was satisfactory in all cases. No case of malperfusion (cerebral and/or visceral) was reported. Out of 100 patients undergoing direct cannulation of axillary artery, no major complications related to the site or the technique of the cannulation were recorded. Local minor complications were reported in 6 patients (6%). In all 6 patients such complications were transitory and there was no residual compromission at the discharge. Overall 30-days mortality was 16%. Twenty-two patients (22%) conversely were discharged directly from intensive care unit (ICU) to chronic rehabilitation center. Sixty-seven patients (67%) were successfully discharged home. **Conclusions**: Our experience clearly shows that direct axillary artery cannulation is a safe, effective and reproducible technique for arterial cannulation during complex surgical procedures involving thoracic aorta. We do support such approach as a first choice strategy in such circumstances.

## Keywords

axillary artery; aortic aneurysm; aortic dissection

## Introduction

Femoral artery cannulation has been considered the gold standard for cardiopulmonary bypass (CPB) in case of aortic surgery for many years since early seventies till recent era [1,2]. The major advantages that lead to worldwide spreading of femoral artery cannulation were feasibility and reproducibility of such technique. On the other hands major criticisms were moved to this approach, mainly concerning retrograde and non-physiological flow within thoracic aorta and the need of separate selected cannulation of epiaortic vessels to achieve cerebral perfusion during cardiocirculatory arrest. To overcome such criticism axillary artery, has been proposed as alternative site of arterial cannulation in early 2000, especially in case of reoperation, aortic calcification or complex aortic arch pathology [3,4].

Hypothetical advantages of axillary artery cannulation (such as the possibility of obtaining a continuous antegrade flow from the aortic arch onwards and the easy achievement of cerebral unilateral flow during systemic circulatory arrest without accessory cannulation), have been clearly confirmed and axillary artery cannulation has become a standard, routine approach in case of aortic surgery in many centers worldwide. Axillary artery cannulation and the worldwide diffusion of anterograde selected cerebral perfusion during complex aortic surgery have been correlated to potential clinical advantages such as the reduction of risk of neurological complication, retrograde dissection and cerebral or visceral malperfusion during CPB [5–7].

Despite being considered nowadays the gold standard approach in achieving arterial access during aortic surgery, several technical aspects related to axillary artery cannulation are still debated including the choice of surgical approach to the axillary artery [8,9] and the use of a side branch graft versus the direct cannulation of the artery [10].

Here we report our single-centre experience using direct axillary artery cannulation at deltoido-pectoralis groove as a standard approach in case of aortic surgery.

## Materials and Methods

Axillary artery cannulation has been introduced in our division since 2006. Due to the satisfactory results it became very quickly our standard approach in case of surgery of aorta or complex REDO procedures and it's currently used by all surgeons in our staff. Study population of this study include 100 unselected consecutive patients undergoing different complex procedures involving thoracic aorta and/or multiple REDO procedure where peripheral arterial cannulation was deemed mandatory. Patients characteristics are summarized in Table 1. Briefly patient population ranged between 29 to 87 years and mean age was 65 ± 13 years. Seventy patients (77%) underwent scheduled complex surgical procedure and 30 patients (30%) underwent emergent surgical procedure. Sixteen patients, furthermore, have had a previous cardiac surgery procedure. Direct cannulation of axillary artery approached at deltoid-pectoralis groove was used in all cases using the previously described technique [8,10] summarized in the following paragraph. Anagraphic, surgical and perfusion data of all patients were prospectively recorded in our database and retrospectively evaluated.

**Table 1. Preoperative patient's characteristics and surgical timing.**

| Patients | 100 |
|---|---|
| Sex | |
| Male | 62 |
| Female | 38 |
| Age | |
| Range | 29–87 |
| Mean ± sd | 65.5 ± 13.2 |
| Median | 69 |
| BSA ($m^2$) | |
| Range | 1.34–2.71 |
| Mean ± sd | 1.84 ± 0.23 |
| Median | 1.81 |
| Timing of Surgery | |
| Elective | 77 |
| Emergency | 23 |
| Type of Surgery | |
| AAR | 45 |
| AAR + APL | 17 |
| AAR + AVR | 4 |
| AVR | 6 |
| Bentall | 9 |
| AArcR | 8 |
| AArcR + Bentall | 2 |
| Others | 9 |

BSA, Body surface area; AAR, ascending aorta replacement; APL, Aortic valve plasty; AVR, Aortic valve replacement; AArcR, Aortic arch replacement.

### *Statistical Report*

Patients continuous characteristics were reported as range, mean ± standard deviation and median. Due to the number of patients included in the study discrete variable were reported in table without percentage value in bracket.

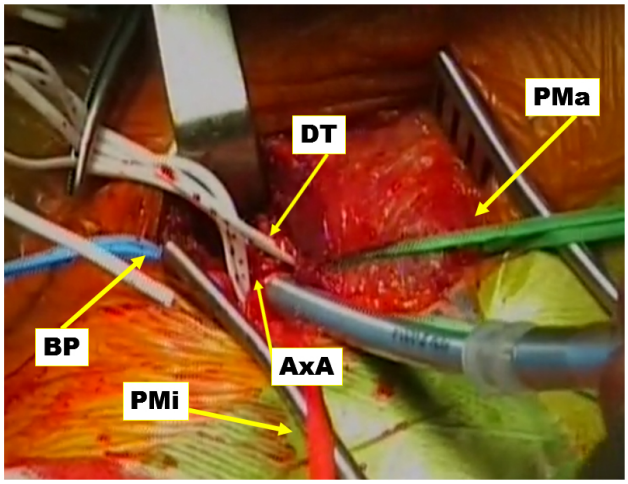


**Fig. 1. Surgical view (see text).** Fibers of Pectoralis major (PMa) and pectoralis minor (PMi) are identified and retracted. Brachial plexus (BP) is also identified and gently retracted. Axillary artery (AxA) is identified, isolated and snared proximally and distally (DT). Aortic cannula is then inserted using a Seldinger technique.

### *Surgical Technique*

After a 5–7 cm skin incision, pectoralis major and minor muscles and clavi-pectoral fascia are identified and retracted using cotton tapes (muscles spare technique). Brachial plexus is then identified and gently retracted using a silicon vessel loop. At this point axillary artery is identified, isolated and surrounded by cotton tapes and vascular snares are applied proximally and distally (Fig. 1). At this stage, usually sternotomy and pericardiotomy are completed to evaluate aortic pathology (unless extreme hemodynamical instability). When the patient is ready for CPB, following full heparinization, a single 5-0 polypropylene purse strings is completed on corresponding tract of axillary artery chosen for cannulation. Afterwards, when the activated clotting time (ACT) achieves the adequate range for full anticoagulation axillary arterial puncture is performed, a guide-wire is inserted and, under accurate trans-esophageal echo (TEE) monitoring to exclude vascular complication, a 16 to 22 Optisite arterial cannula (Edwards Lifesciences, One Edwards Way Irvine, CA 92614) according to the patients body surface area (BSA), is inserted through Seldinger technique. At CPB discontinuation, axillary artery cannula is removed and the purse string

is knotted. Recently according to the surgeon's preference following cannula extraction, the axillary artery is clamped and insertion site is repaired with an open surgical technique through a continue 5-0 or 6-0 polypropylene suture.

## Results

Axillary artery cannulation allowed for a satisfactory CPB management in all cases as summarized in Table 2. Full flow was obtained in all patients, even in case of obese patients, and no patients required switch to an alternative site of cannulation. Systemic cooling and rewarming were managed according surgical strategy without problems even in case of mild/deep hypothermic circulatory arrest. No case of intraoperative significant cerebral malperfusion, according to near-infrared spectroscopy (NIRS) monitoring, related to arterial cannulation were reported. Out of these 100 consecutive and unselected patients undergoing direct cannulation of axillary artery, furthermore, no major complications related to the site or the technique of the cannulation were recorded. Six patients (6%) experienced minor complications (listed in Table 3) which could be directly related to the axillary artery cannulation. All such complications, however, were transitory with no residual problems at the discharge. In all 6 patients experiencing minor complications, furthermore, a postoperative doppler scan was performed and no flow abnormalities and/or structural damages were detected.

**Table 2. Operative parameters and characteristics of cardiopulmonary bypass (CPB).**

| | |
|---|---|
| Arterial Size Cannula | |
| Range | 16–24 |
| Median | 20 |
| Venous Cannulation Site | |
| Femoral Vein | 29 |
| Right Atrium | 67 |
| Axillary Vein | 4 |
| CPB Flow (L/min) | |
| Range | 3.22–6.51 |
| Mean ± sd | 4.43 ± 0.55 |
| Median | 4.38 |
| CPB Time (min) | |
| Range | 32–510 |
| Mean ± sd | 170 ± 96 |
| Median | 144 |
| Cerebral Perfusion (min) | |
| Range | 0–258 |
| Mean ± sd | 26 ± 33 |
| Median | 18 |
| Esophageal Temperature (°C) | |
| Range | 14.6–36 |
| Mean ± sd | 27.1 ± 3.5 |
| Median | 26.8 |

**Table 3. Summary of axillary artery cannulation related complications (all involving the right arm).**

| | |
|---|---|
| Patient # 1 | Edema |
| Patient # 2 | Edema |
| Patient # 3 | Deltoido-pectoral lymphocele |
| Patient # 4 | Edema, paresthesia and weakness |
| Patient # 5 | Weakness and paresthesia |
| Patient # 6 | Plegia |

## Discussion

Femoral artery cannulation has been considered the gold standard for cardiopulmonary bypass (CPB) in case of aortic surgery [1,7] for many years. Despite its feasibility and easy reproducibility, some technical and physiological concerns have been raised over time.

Evidences related to the risk of malperfusion of the true lumen using femoral artery cannulation in case of acute aortic dissection (De Backey type I) switched the interest for axillary artery as potential preferred site of cannulation in such conditions [9].

On the other hand, the evidence that axillary artery cannulation can be used also to easily provide antegrade cerebral perfusion, thus enhancing cerebral protection, further increased the spread of such technique [10–13]. The hypothesis of the increased cerebral protection using axillary artery cannulation seems to be clearly supported by Hedayati *et al*. [14] in an experimental study on animal model, demonstrating that axillary cannulation reduce cerebral microemboli.

Finally from histological point of view what should also be stressed out is that axillary artery is rarely damaged by atherosclerosis and this together with the increasing incidence of severe peripheral artery atherosclerosis disease and distal extension of the aortic dissection, explains the ongoing switch to the preference for axillary artery as arterial site of cannulation in case of complex procedures.

Axillary artery cannulation has been eventually accepted and considered in many centers as the site of choice for arterial cannulation when standard ascending aorta cannulation is not indicated. It is important to stress that the aim of our study was not focused on comparison with femoral artery cannulation but on some controversial aspects regarding technique of axillary artery cannulation. Indeed the choice between direct or side-graft axillary artery cannulation as surgical technique has been the subject of several reports in literature obtaining good and comparable results in term of mortality, malperfusion or neurological events [2–4].

At the same time, when looking at the literature so far published, however, there is actually no evidence of superiority between the two techniques and the choice is based mainly on personal surgical experience.

Graft interposition cannulation is supposed to reduce or avoid vascular complications (arterial damage and/or dissection), and this has been reported previously in up to 9% of patients [2]. The primary purpose of this study, therefore, was to elucidate the safety and effectiveness of direct axillary artery cannulation a technique that has been used widely in our center and has also been applied in unusual situations, thus allowing us to gain excellent expertise in this surgical approach [1,15,16].

The first important finding in our experience was the 0% incidence of axillary artery damaging/dissection obtained during direct axillary artery cannulation. Our results were surely obtained thanks to the mandatory cooperation of the surgical team and a TEE monitoring. Absence of local complications included also minor local complications reported by and other some authors [2,6,17] using side graft cannulation.

Incidence of postoperative neurological complications following complex cardiac surgery procedures surely represents a crucial and debated issue. Gulbins *et al*. [18] in a review published in 2007 showed 3.9% and 0.7% of vascular/neuronal complication when direct or side graft cannulation were respectively used. Svensson *et al*. [19] reported a stroke incidence of 4% using a side graft axillary artery cannulation and 7.8% using direct cannulation. Budde *et al*. [20] reported, on other hands, neurological dysfunction in 6.5% of patients that underwent ascending aortic surgery and side graft axillary artery cannulation. We do believe that, providing that selective cerebral perfusion is accomplished, the extension of aortic pathology/dissection together with the accuracy of TEE and NIRS monitoring play a crucial role in avoiding postoperative neurological complications, probably more significantly than the technique of axillary artery cannulation. A further interesting finding of our study is the 0% incidence of transient malperfusion (according NIRS monitoring) during selective cerebral perfusion using direct axillary cannulation. Our experience therefore seems to support results of previous study malperfusion in aortic dissection when side-graft or direct cannulation were used (20% and 0% of cases respectively) [2]. We could speculate that using a side-graft (and therefore a bidirectional flow) the antegrade perfusion towards the innominate artery can be more difficult to monitoring. As a matter of this, occlusion of proximal perfusion to the arm can be necessary in case of side-branched cannulation when impaired NIRS value is shown (as it happens in 3 cases in our limited experience using side branch technique). This complication has been overall reported in literature from 0% to 10% when using axillary artery cannulation [9,21,22].

Finally the extension of direct cannulation technique to all staff members was related to a more diffuse technical teaching possibility as confirmed by the fact that no switching to femoral or different cannulation has been necessary in our experience while it was reported in as much as 3% and 11% of the cases by other authors [2,22].

As far as the surgical approach to the axillary artery, in the present experience we used as routine approach deltoid-pectoralis sulcus approach with a muscles sparing technique. In our mind this is the more comfortable access to axillary artery but subclavear access could be also used depending on personal surgeon's experience.

In conclusion evaluating the gold standard technique and the best way of cannulation for patients who underwent aortic surgery it is probably an unsolvable problem as the series reported in literature are no randomized and focused on non-homogeneous pathologies and procedures.

Considering the purpouse of our study, however, our experience clearly shows as direct axillary artery cannulation is a safe, effective and reproducible technique for arterial cannulation during complex procedure where standard ascending aorta cannulation is contraindicated. In our mind, therefore, such approach should be encouraged and could be considered as first choice approach in such condition.

## Conclusions

Our experience confirms that direct axillary artery cannulation is a safe, effective and reproducible technique for arterial cannulation during complex procedure where standard ascending aorta cannulation is contraindicated. We do support, therefore, such approach to be considered as first choice approach in such condition.

## Availability of Data and Materials

Full set of data are stored in our Institutional archive for privacy reason.

## Author Contributions

PT: Investigation, Methodology, Supervision, Visualization, Writing. FA: Investigation, Methodology, Data curation, review and editing. MM: Design of the work, Writing review and editing (language proof editing). AD: Investigation, Methodology. SP: Design of the work, Supervision. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

## Ethics Approval and Consent to Participate

Institutional ethical committee approval waived. Informed written consent signed by the patient.


## Acknowledgment

Not applicable.

## Funding

This research received no external funding.


## Conflict of Interest

The authors declare no conflict of interest.

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