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Direct Innominate Artery Cannulation as a Sole Systemic and Cerebral Perfusion Technique in Aortic Surgery

Alireza Kashani, MBBS *, **Mathew Doyle, MBBS, Matthew Horton, MBBS FRACS**

St. George Public Hospital, Sydney, NSW, Australia

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Arterial cannulation is often challenging in thoracic aortic surgery due to the location of the surgery and need for cerebral protection during periods of circulatory arrest. Cannulation sites including the ascending and descending aorta, axillary, carotid and femoral arteries have limitations and are associated with complications due to their proximity to surrounding structures. Therefore, the innominate artery can be used by either direct cannulation or indirect cannulation via a graft as an alternative site. We present a technique of sole direct innominate artery cannulation that is able to provide both systemic and selective antegrade cerebral perfusion during aortic surgery.

Keywords Innominate artery • Aorta • Cerebral perfusion • Cardiopulmonary bypass

Introduction

Arterial cannulation is often challenging in thoracic aortic surgery due to the location of the surgery and need for cerebral protection during periods of circulatory arrest. The innominate artery can be used by either direct cannulation or indirect cannulation via a graft as an alternative site. We present a technique of sole direct innominate artery cannulation that is able to provide both systemic and selective antegrade cerebral perfusion during aortic surgery.

Methods

Between 2011 and 2015, 14 consecutive patients underwent surgery involving the ascending aorta using a new innominate artery cannulation technique at our institutions (St. George Public and Private Hospitals, Sydney, NSW, Australia). A retrospective review of their outcomes was performed. The study was approved by the local ethics review committee.

Of the 14 patients, six underwent replacement of the aortic valve, aortic root and ascending aorta with a valved conduit (including three mechanical valve conduits and three Freestyle grafts); four underwent aortic valve and ascending aorta replacement; two underwent ascending aorta replacement only; and one underwent ascending aorta and hemiarch replacement. Concurrent mitral valve replacement was performed in one patient, and coronary artery bypass grafting in two patients.

Surgical Technique

All patients received a median sternotomy. The pericardium was opened and the left brachiocephalic vein was exposed and encircled with an umbilical tape, and retracted cranially to expose the innominate artery. The innominate artery was then encircled with a vascular silastic loop and a purse-string suture was placed using 4-0 polypropylene (Figure 1A) After full heparinisation, cannulation of the innominate artery was then performed using a 20 or 22 French short-tipped cannula (DLP® Flexible Arch Cannulae, Medtronic Inc, Minneapolis,

*Corresponding author.

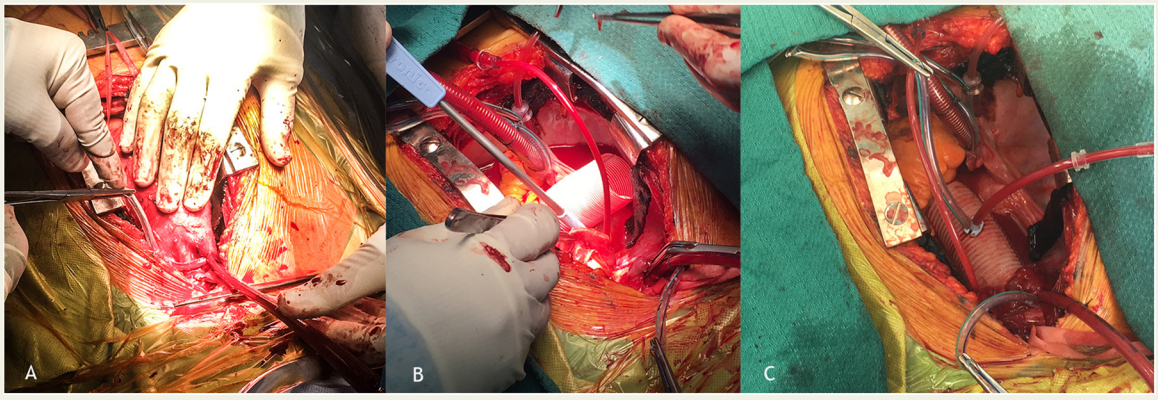

Figure 1

MN, USA) with the tip pointed towards the aorta (Figure 1B). Venous cannulation was established using a two-stage right atrial cannula or bi-caval technique in cases combined with mitral valve surgery. Myocardial protection was provided using cold blood cardioplegia via a combination of retrograde coronary sinus and antegrade aortic root and direct coronary ostial perfusion. Patients were cooled to 17 °C for hypothermic protection.

Following reaching the target hypothermia, circulation was arrested and the innominate arterial cannula was redirected cranially without removing it from the cannulation site. A vascular straight cross-clamp was applied proximal to the cannula and cerebral flows re-established at a rate of 10 ml/kg/min (Figure 1B). A woven polyester graft was used to replace the ascending aorta (Gelweave Graft, Vascutek Ltd., Renfrewshire, UK). The distal aortic anastomosis was performed using open technique. Following completion of the distal anastomosis a cross-clamp was applied to the polyester graft, the innominate artery clamp released, and the innominate cannula redirected towards the aortic arch again to reinstitute systemic perfusion (Figure 1C). The remainder of the procedures were performed in standard fashion.

Results

Patient demographics included: mean patient age 67 ± 15 (range 42–85), male gender 64% (n = 9), mean New York Heart Association class 1.5 ± 1.2 (range 0–3), history of cerebrovascular accident 7% (n = 1), previous cardiac surgery 14% (n = 2),

Table 1 Summary of Postoperative Outcomes.

Parameter	Value
Survival	14 (100%)
Neurological Deficit	
CVA	1 (7%)
Prolonged Delirium	1 (7%)
ICU LOS (Days) *	4.62 ± 3.77 (2–13)
Hospital LOS (Days) **	13.07 ± 6.61 (5–26)
Acute Renal Failure	3 (21%)
Creatinine	101.69 ± 38.74 (50–191)§
Atrial Fibrillation	8 (57%)
New	6 (43%)
Pre-Existing	2 (14%)
CHB	1 (7%)
Permanent Pacemaker	1 (7%)
Reoperation for Bleeding	1 (7%)
Deep Sternal Infection	0 (0%)
DVT	1 (7%)
HIT	1 (7%)

Abbreviations: CVA, cerebrovascular accident; ICU LOS, intensive care length of stay (days); Hospital LOS, hospital length of stay (days).
§Absolute creatinine value (mg/L); CHB: Complete heart block; DVT: Deep vein thrombosis; HIT, Heparin-induced thrombocytopaenia.

and ischaemic heart disease 29% (n = 4). The indication for aortic replacement was acute aortic dissection in 14% (n = 2), chronic dissection in 7% (n = 1). The operation was performed as an emergency operation in 21% (n = 3) of patients.

Intraoperative characteristics included: mean cardiopulmonary bypass time 176.9 ± 45.73 minutes, mean cross clamp time 108.3 ± 46.2 minutes. Myocardial protection was performed via retrograde alone (7%, n = 1), combined antegrade and retrograde (93%, n = 13), and direct coronary ostial (7%, n = 1) cold blood cardioplegia. Deep hypothermic circulatory arrest was performed in 13 (93%) of cases with mean circulatory arrest time of 21.6 ± 9.6 minutes (range 4–40 min), and mean temperature during circulatory arrest was 17.5 ± 0.5 °C (16.8–18 °C).

Modified Bentall was performed alone or in combination with CABG in 7% (n = 1) and 36% (n = 5) of cases and ascending aorta replacement was the main procedure in 57% (n = 8) of patients. The latter was combined with aortic valve replacement, mitral valve replacement, and hemi-arch replacement in 27% (n = 4), 7% (n = 1), and 7% (n = 1) of cases respectively.

Postoperative outcomes included: no early or 30-day mortality; one patient (7%) who presented with an acute aortic dissection experienced a postoperative cerebrovascular event; one patient (7%) who had a history of preoperative stroke experienced a prolonged delirium postoperatively; one patient (7%) who underwent aortic valve replacement required insertion of a permanent pacemaker for complete heart block postoperatively; and three patients (21%) experienced acute renal failure which either resolved or improved prior to discharge. None of the patients experienced innominate artery dissection or damage during the procedure. Mean length of intensive care stay was 4.6 ± 3.8 days (range 2–13), and mean length of hospital stay was 13.1 ± 6.6 days (range 5–26). Postoperative outcomes are summarised in Table 1.

Comment

Possible locations for arterial cannulation during thoracic aortic surgery include the ascending and descending aorta, femoral, axillary, carotid and innominate arteries [1]. The benefits, risks and difficulties with these sites are summarised in Table 2 [2,3]. In this series, we demonstrate an innominate artery cannulation technique that is safe, convenient and able to rapidly provide both systemic and selective cerebral perfusion as needed. This technique reduces the

Table 2 Comparison of Different Cannulation Sites.

Cannulation Site	Benefits	Risks/Difficulties
Ascending Aorta	• Antegrade perfusion • No need for further tissue dissection or additional incisions	• Involvement in the pathology • Risk of entering the false lumen in the dissection
Descending Aorta	• Providing antegrade cerebral perfusion • Providing antegrade perfusion to the viscera • Lower risk of dissection	• Need for additional incision or approach
Femoral Artery	• Rapid access to circulation via both arterial and venous system for establishing cardiopulmonary bypass circuit • Simple anatomy	• Retrograde cerebral embolisation • Organ malperfusion • Perfusion of the false lumen • Retrograde dissection due to flow reversal in the thoracoabdominal aorta
Axillary Artery	• Antegrade perfusion • Rapid access to circulation • Providing antegrade cerebral perfusion during circulatory arrest	• Small vessel and requires a side graft • Risk of dissection • Upper extremity malperfusion • Injury to brachial plexus
Common Carotid Artery	• Limited dissection required to access • Antegrade cerebral perfusion	• Risk of dissection • Risk of cerebral mal-perfusion • Small vessel and requires a side graft
Innominate Artery	• Usually large enough to accommodate larger cannulae • Limited dissection is required to access the artery • Antegrade perfusion • Providing antegrade cerebral perfusion during circulatory arrest and avoidance of retrograde dissection and malperfusion • Providing an easy assessment of cerebral perfusion using a right-sided radial artery.	• Requiring careful manipulation of the arterial cannula in an already aneurysmal/dissected artery • Possibility of involvement in dissection • Possible preferential hyperaemia of the right hemisphere • Possible introduction of new site for atherosclerotic disease and further chronic stenosis of the artery

overall operative complexity and lowers the number of incisions and cannulations required [2]. However, one patient suffered perioperative stroke who presented with acute ascending aortic dissection with low levels of consciousness preoperatively. Therefore, it is difficult to ascertain the timing of this event.

It is imperative to note that this technique requires very careful and meticulous handling of the aortic cannula in an already aneurysmal and/or dissected vessel; hence, there is a risk of introduction of new dissection or dislodgement of atherosclerotic plaques with inherent cerebral and/or visceral embolic complications. In addition, unilateral cerebral and upper limb hyperaemia is another potential risk. Moreover, the site of cannulation might introduce a new location for atherosclerotic plaque formation with possible further stenosis of innominate artery.

Overall, despite all the aforementioned risks, this technique can be another additional tool in the armamentarium of an experienced aortic surgeon.

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