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Case Report

Extrathoracic Carotid Artery Cannulation in Cardiovascular Reoperations

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Abstract

Cardiac reoperations, especially those involving the aortic arch, pose a significant challenge due to extensive adhesions and an increased risk of injury during resternotomy. In such cases, initiating cardiopulmonary bypass (CPB) through peripheral access before sternotomy may enhance surgical safety. This report presents two cases in which extracorporeal carotid artery cannulation was successfully applied to establish CPB and facilitate antegrade cerebral perfusion (ACP). The first case involved a patient with Type A aortic dissection following a previous Bentall procedure, where femoral and axillary access were considered unsuitable due to anatomical and pathological conditions. The second case involved a complicated coronary artery bypass surgery due to peripheral artery disease and subclavian occlusion. In both cases, CPB was safely initiated via an 8 mm PTFE graft anastomosed to the left carotid artery with venous drainage through the femoral vein. No early neurological or systemic complications were observed postoperatively. These cases demonstrate that extrathoracic carotid artery cannulation is a safe and effective alternative when traditional cannulation sites are unsuitable, providing both safe CPB initiation and reliable ACP in complex reoperations.

Keywords: Cardiopulmonary bypass; carotid cannulation; reoperative cardiac surgery.

Kardiyovasküler Reoperasyonlarda Ekstratorasik Karotis Arter Kanülasyonu

Özet

Kardiyak reoperasyonlar, özellikle de aortik arkı içerenler, yoğun yapışıklıklar ve resternotomi sırasında artan yaralanma riski nedeniyle önemli bir zorluk teşkil etmektedir. Bu gibi durumlarda, sternotomi öncesinde periferik erişim yoluyla kardiyopulmoner baypas (KPB) başlatılması cerrahi güvenliği artırabilir. Bu raporda, KPB oluşturmak ve antegrad serebral perfüzyonu kolaylaştırmak için ekstratorasik karotid arter kanülasyonunun başarıyla uygulandığı iki olgu sunulmaktadır. İlk olgu, femoral ve aksiller girişin kontrendike olduğu, önceki Bentall prosedürünü takiben tip A aort diseksiyonu olan bir hastayı içeriyordu. İkinci olgu ise periferik arter hastalığı ve subklavyen oklüzyon nedeniyle komplike olmuş bir koroner arter baypas cerrahisini içeriyordu. Her iki olguda da CPB, femoral ven yoluyla venöz drenaj ile sol karotid artere anastomoz edilen 8 mm PTFE greft yoluyla güvenli bir şekilde başlatıldı. Ameliyat sonrasında nörolojik veya sistemik komplikasyon görülmedi. Bu olgular, ekstratorasik karotid arter kanülasyonunun, geleneksel kanülasyon bölgelerinin uygun olmadığı durumlarda güvenli ve etkili bir alternatif olduğunu ve karmaşık reoperasyonlarda hem güvenli CPB başlatma hem de güvenilir antegrad serebral perfüzyon sağladığını göstermektedir.

Anahtar sözcükler: Kardiyopulmoner baypas; karotis kanülasyonu; reoperatif kardiyak cerrahi.

Introduction

Cardiac reoperations, particularly those involving aortic surgery requiring antegrade cerebral perfusion (ACP), are associated with high mortality and morbidity due to technical challenges.[1] During resternotomy, the right ventricle, ascending aorta, and bypass grafts may adhere to the

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underside of the sternum, making them susceptible to injury.[2] In such cases, peripheral cannulation before resternotomy can help prevent complications such as massive bleeding or hemodynamic instability. In reoperations involving the transverse aorta, the total circulatory arrest strategy is often avoided due to its time limitations, complications associated with deep hypothermia, and increased risk of cerebral injury. Therefore, adjunctive techniques such as ACP are employed in these procedures.

In adult cardiac surgery procedures – particularly in cases requiring resternotomy – peripheral arterial cannulation is commonly and safely performed using the femoral, subclavian, and innominate arteries.[3] The right subclavian and innominate arteries are of particular importance in aortic surgery due to their ability to facilitate antegrade unilateral perfusion. However, the use of these arteries may be limited by the presence of an intimal flap due to aortic dissection affecting the vessel lumen, arch anomalies, or the need for sternotomy to access the innominate artery. In such cases, extrathoracic carotid artery cannulation offers the benefits of peripheral arterial access while also allowing for ACP without the need for additional surgical intervention. In this study, we present the technique of extrathoracic carotid artery cannulation used in reoperative coronary bypass and aortic surgery cases performed at our center and discuss it in the context of the current literature.

Case Report

Case 1

A 41-year-old male patient who had undergone a Bentall procedure using a mechanical valved conduit due to an ascending aortic aneurysm secondary to Marfan syndrome in 2022 was being followed for a residual button aneurysm. He presented to the emergency department with sudden-onset severe chest and back pain. On initial assessment, the patient was found to be confused, diaphoretic, and hypotensive. Computed tomography (CT) revealed a Type A aortic dissection (Fig. 1). Due to rapid clinical deterioration, an emergency operation was planned. For surgical safety, sternotomy under cardiopulmonary bypass (CPB) was considered. However, CT imaging demonstrated extension of the dissection flap into the innominate and right axillary arteries, causing significant luminal compromise and rendering these vessels unsuitable for safe arterial cannulation. To avoid potential disadvantages of femoral cannulation, such as propagation of retrograde dissection or embolization, and to allow for unilateral cerebral perfusion without the need for additional procedures, carotid artery cannulation was chosen.[4]

This technique offers the advantage of achieving adequate CPB flow and providing unilateral cerebral perfusion without requiring an additional surgical intervention. Under general anesthesia, arterial cannulation was performed via the left carotid artery using an 8-mm PTFE graft (Jotec Inc, Hechingen, Germany), and venous cannulation was established via

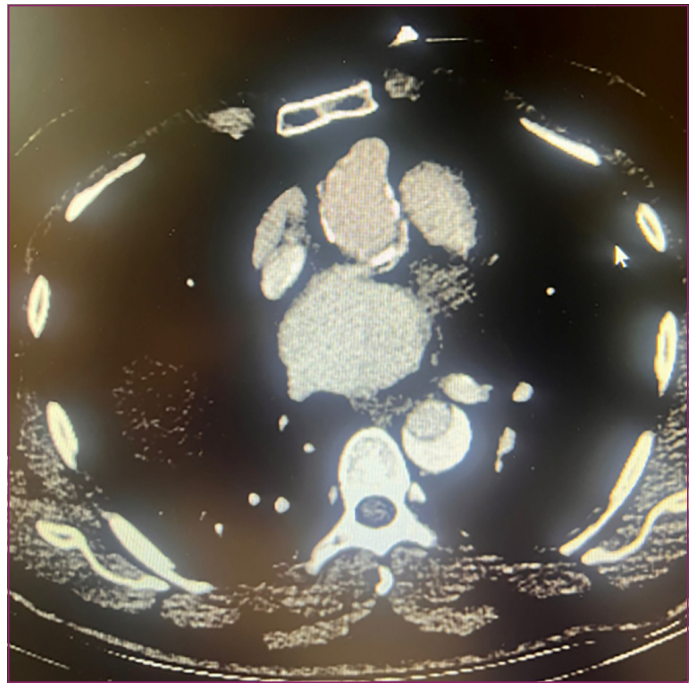

Figure 1. Aortic dissection.

Figure 2. Carotid artery cannulation.

the right femoral vein using a 22 Fr cannula (Edwards, Irvine, CA, USA) (Fig. 2). After sufficient anticoagulation was achieved with heparin, emergency CPB was initiated. The patient was cooled to 22°C, and sternotomy was performed through a midline incision. Adhesions from the previous operation were meticulously released, and the heart and ascending aorta were exposed. The left ventricle was carefully vented, and cardiac arrest was allowed to occur spontaneously. Upon

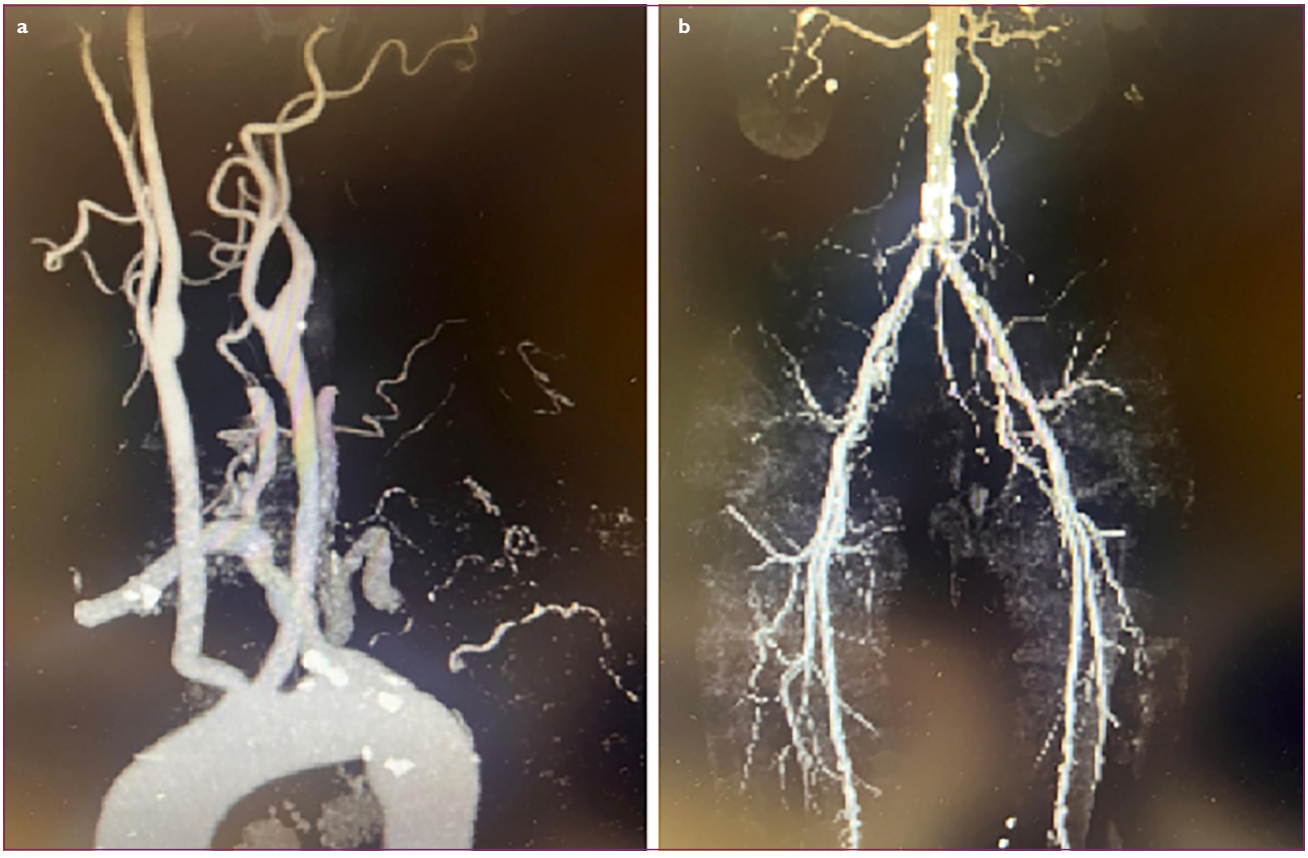

Figure 3. (a, b) Coronary and peripheral angiographic findings demonstrating severe, diffuse atherosclerotic disease.

reaching the target temperature, unilateral cerebral perfusion at a rate of 10 mL/kg/min was initiated. The orifices of the innominate, left carotid, and subclavian arteries were occluded. Cerebral perfusion pressure was maintained between 50–70 mmHg. Following aortotomy, antegrade Del Nido cardioplegia was administered. The dissection was found to originate just above the previous graft in the ascending aorta. Intraoperative inspection revealed no issues with the mechanical valve; the buttons, although aneurysmal, had good tissue quality but were severely adherent to the surrounding structures. The ostia of the arch branches were anatomically intact, without evidence of rupture or complete occlusion. The layers of the aortic arch were reinforced with fibrin glue and Teflon felt. A distal hemiarch anastomosis was performed using a 30-mm Dacron graft (Jotec Inc, Hechingen, Germany). The cross-clamp was then moved onto the graft, and full-body perfusion was resumed after transitioning from unilateral cerebral perfusion. Subsequently, a proximal anastomosis was performed between the 30-mm Dacron graft and the previously placed aortic graft. Once normothermia was achieved, the cross-clamp was removed. After spontaneous recovery of cardiac activity, the patient was successfully weaned from CPB with hemodynamic stabilization.

The total CPB time was 150 min, aortic cross-clamp time was 75 min, and unilateral cerebral protection time was 44 min. The patient recovered uneventfully, with no neurological or systemic complications observed.

Case 2

A 55-year-old male patient had undergone four-vessel coronary artery bypass grafting (CABG) in January 2012. He presented to our clinic with chest pain, and laboratory testing revealed a troponin I level of 2 671.3 ng/L. His medical history included hypertension and chronic obstructive pulmonary disease. Coronary angiography demonstrated severe, diffuse coronary and peripheral arterial disease, with 80 % stenosis in the left main coronary artery, 90% in the left anterior descending artery, 80 % in the circumflex artery, and 80% in the right coronary artery (Fig. 3a, b). Additional findings included a ventricular aneurysm with an ejection fraction of 35%, left subclavian artery occlusion causing steal syndrome, and severe bilateral iliac artery stenoses. Notably, the patient also exhibited an aberrant, degenerative, aneurysmal right subclavian artery and had a history of cerebrovascular accident. In light of these findings, simultaneous CABG, left carotid–subclavian bypass, and ventricular aneurysmectomy were planned.

Under general anesthesia, arterial cannulation was established via the left carotid artery using an 8-mm PTFE graft (Jotec Inc, Hechingen, Germany), and venous cannulation was achieved via the right femoral vein with a 22-Fr cannula (Edwards, Irvine, CA, USA) (Fig. 2). Adequate anticoagulation was obtained with heparin, and elective CPB was initiated. While the patient was cooled to 32°C, a median sternotomy was performed. Adhesions from the previous operation

were carefully dissected, preserving existing anastomoses, and an aortic cross-clamp was applied. Myocardial protection was provided with antegrade and retrograde blood cardioplegia. Redo CABG consisted of multiple distal anastomoses using saphenous vein grafts. The left internal mammary artery had been utilized during the initial operation and was not suitable for reuse.

After completion of the distal anastomoses, the aneurysmal segment of the ventricular wall was resected, and a linear ventricular aneurysmectomy was performed. Proximal anastomoses were created under cross-clamp. Following rewarming, the cross-clamp was removed, and, once hemodynamic stability was achieved, the patient was successfully weaned from CPB. The left carotid–subclavian bypass was then completed through the arterial cannulation graft. After meticulous hemostasis and protamine administration, the sternotomy was closed, and the patient was transferred to the intensive care unit.

The total CPB time was 200 min, the aortic cross-clamp time was 65 min, and the unilateral cerebral protection time was 55 min. The prolonged CPB time relative to the cross-clamp time was primarily due to the completion of complex re-entry and simultaneous procedures. The early post-operative course was uneventful, with no neurological or systemic complications observed. However, during follow-up, graft infection was detected in the second post-operative month and was successfully managed with graft explantation and redo bypass using a saphenous vein graft.

Discussion

In cardiovascular reoperations, a second sternotomy becomes particularly challenging when the heart and aorta are adherent to the posterior aspect of the sternum. To minimize the risk of injury to these structures during reentry, peripheral cannulation is one of the preferred strategies. It is a safe and rapid means of establishing CPB. Reported indications for initiating CPB through peripheral cannulation in reoperative settings include hemodynamic instability, Type A aortic dissection, a calcified aorta that precludes direct aortic cannulation, minimally invasive surgical approaches, and a high likelihood of injury during resternotomy.[5] In selected patients, instituting CPB before sternotomy is a valid and reproducible option that renders the re-entry phase of cardiac reoperations both safer and faster.[2]

Reoperative cardiac surgery has become increasingly common in cardiovascular surgical practice in recent years due to the growing need for revision procedures. These reoperations may be performed either to revise a previous surgical intervention or to treat newly developed cardiac pathologies. However, reoperative procedures carry a heightened risk of serious complications, including myocardial injury, excessive bleeding, increased need for blood products, and structural cardiac injuries, particularly during resternotomy. Most of these complications occur during sternotomy and mediastinal exploration. Therefore, in cases with dense mediastinal adhesions or complex anatomical challenges, peripheral arterial cannulation is emerging as an increasingly important strategy for establishing safe CPB. In addition, peripheral cannulation serves as a valuable alternative in cases with hemodynamic instability, urgent need for CPB, high-risk central cannulation, or minimally invasive surgical approaches.[6]

Since the initial use of CPB during aortic arch replacement, arterial cannulation techniques have undergone significant evolution.[7] For many years, the femoral artery was systematically utilized, and this cannulation model was first introduced to induce circulatory arrest in patients undergoing intracranial procedures.[8] However, it was later reported that this technique could be harmful in certain patients, potentially leading to serious complications such as embolism, malperfusion, aortic rupture, distal limb ischemia, and pseudoaneurysm formation.[9] Therefore, an optimal arterial cannulation strategy should ideally provide antegrade flow to the entire aorta and allow for effective cerebral protection during arch surgery. In pursuit of this goal, one of the recommended approaches was right axillary artery cannulation, first employed by Sabik et al. in 1995.[10] This technique rapidly gained popularity and was particularly adopted by centers specializing in aortic arch replacement. Over time, however, it became clear that this cannulation method also carries certain disadvantages and complications, suggesting that its systematic use in all patients may not be without risk.

Although carotid artery cannulation is used less frequently than femoral or axillary artery cannulation, it offers significant advantages in selected patients. This approach can provide effective cerebral protection in patients requiring ACP. In the literature, a study by Sugiyama et al. reported that perfusion delivered directly through the carotid artery in patients with acute type A aortic dissection did not worsen neurological symptoms and was not associated with intraoperative cerebral infarction.[11] In this context, Urbanski, in 2006, proposed the use of extrathoracic carotid artery cannulation for arterial access throughout the entire CPB period and for cerebral perfusion.[12] Urbanski's technique was applied in combination with femoral artery cannulation and aimed to overcome the limitations of other cannulation sites.

In our study, carotid artery cannulation was preferred in three different reoperative scenarios – one involving type A aortic dissection and two involving CABG – without the need for femoral cannulation. In both cases, carotid cannulation not only allowed for the safe initiation of CPB before sternotomy but also facilitated ACP during bypass.

During thoracic aortic surgery requiring total CPB and deep hypothermic circulatory arrest, left common carotid artery cannulation has been reported to be a safe and effective option. However, the use of carotid artery cannulation for total CPB without circulatory arrest remains unclear in adult patients. Carotid artery cannulation not only facilitates safe re-entry but also provides an effective means of delivering ACP. The current guidelines of the European Association for Cardio-Thoracic Surgery emphasize the importance of cerebral protection strategies in complex aortic surgeries, highlighting the superiority of ACP in terms of organ protection.

[13] In this context, ACP through the carotid artery has the potential to reduce the risk of cerebral ischemia and improve neurological outcomes.

The extrathoracic use of the carotid artery has become technically more feasible with advances in cannulation equipment. However, despite these advantages, the potential complications of this method should not be overlooked. Iatrogenic trauma to the carotid artery may lead to severe bleeding, arterial dissection, embolism, or thrombosis.[14] Case reports have also described complications such as airway obstruction due to cervical hematoma, stroke resulting from arterial thrombosis or cerebral embolism, pseudoaneurysm formation, and arteriovenous fistula.[15] In addition, bleeding at the graft anastomosis site may occur during CPB. To prevent this, biological tissue adhesives may be applied to the anastomotic region. Such complications can be minimized through meticulous surgical dissection, proper cannula selection in intrathoracic approaches, appropriate end-to-side graft choice in extrathoracic techniques, and close monitoring of perfusion pressures throughout the CPB procedure.

In our study, initiating CPB before sternotomy was of critical importance in two patients: one who developed Type A aortic dissection following a Bentall procedure, and another who had previously undergone CABG and required concomitant revascularization due to subclavian artery occlusion. Although intrathoracic cannulation could have been attempted in both cases, carotid artery cannulation was preferred to prevent intraoperative complications during resternotomy and to facilitate both unilateral cerebral perfusion and carotid–subclavian bypass.

In the patient with Type A aortic dissection, femoral artery cannulation could have led to propagation of the dissection flap or malperfusion. In the CABG patient, peripheral arterial disease and severe bilateral iliac artery stenosis made femoral cannulation challenging and increased the risk of cerebral embolism. For these reasons, extrathoracic carotid artery cannulation was selected as the arterial access site in both patients, while the femoral vein was used for venous cannulation. Neither patient experienced cerebrovascular events. No early or late mortality was observed.

During long-term follow-up, graft infection was identified in the patient who underwent carotid–subclavian bypass. The patient was successfully treated in the second post-operative month with graft explantation and redo bypass using a saphenous vein graft. We believe this complication may have been related to the prolonged exposure of the prosthetic graft outside the body during surgery.[16] In addition, the same patient's peripheral artery disease was treated endovascularly in the fourth post-operative month.

Although carotid artery cannulation is not a novel technique, this case report emphasizes its practical value as a primary arterial inflow strategy in complex reoperative cardiac surgery when conventional cannulation sites are unreliable.

Conclusion

We believe that in cardiovascular reoperations and aortic dissections – particularly when conventional peripheral cannulation sites such as the femoral or axillary arteries are deemed unreliable – CPB can be safely established via carotid artery cannulation. Moreover, this cannulation technique offers the dual benefit of retaining the advantages of peripheral cannulation while also providing surgical convenience in cases requiring ACP or carotid–subclavian bypass.

Disclosures

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

Informed Consent: Written informed consent was obtained from both patients for publication of this case report and any accompanying images.

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