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A modified technique to bypass the maxillary artery to supraclinoid internal carotid artery by using radial artery graft: an anatomical study

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Abstract

Objective: This study aims to examine the use of a radial artery graft for bypass of the maxillary artery (MA) to the supraclinoid internal carotid artery (ICA) in treating ICA occlusions.

Study design and setting: This method was carried out on five adult cadaver sides. The MA was reached 1–2 cm inferior to the crista infratemporalis, following a frontotemporal craniotomy and a zygomatic arch osteotomy. Extradurally 2–3 cm lateral to the foramen rotundum, a hole was drilled in the sphenoid bone with a 4 mm tipped drill. A radial artery graft was passed through the hole to the inside of the dura. Before giving the infraorbital artery branch, the MA was dissected from the surrounding tissue and transected. The proximal end of the graft was anastomosed end-to-end with the MA and the distal end of the graft end-to-side with the supraclinoid ICA.

Results: The mean calibre of the MA was 2.6 ± 0.3 mm. The mean calibre of the proximal end of the radial artery graft was 2.5 ± 0.25 mm and the distal end was 2.35 ± 0.2 mm. The mean length of the radial artery graft was 4.0 ± 0.5cm.

Conclusion: This study suggested that the cases with ICA occlusion, which require high blood flow, may be treated as an alternative to current bypass methods requiring long vein grafts.

Key words: Carotid Artery; Internal; Radial Artery; Transplants; Anastomosis; Surgical; Cerebrovascular Disorders

Introduction

It is accepted that patients who have internal carotid artery (ICA) occlusion and no collateral channel demonstrated on angiography, and have recurrent ischaemic episodes should undergo an extracranial–intracranial bypass procedure.[1] Among extracranial–intracranial bypass procedures, the most commonly performed procedure is a bypass between the superficial temporal artery (STA) and a cortical branch of the middle cerebral artery (MCA). If the blood flow supplied by the STA was not adequate, clinical symptoms of ischaemia were significant as a result of hypoperfusion.[2] When the STA calibre was inadequate, other arteries or graft materials (saphenous vein or radial artery grafts) were used for the bypass.[2–6] However, these techniques using graft materials (saphenous vein or radial artery) have certain limitations, such as the length of the graft, especially in extracranial carotid arteries (ECCA) to MCA or ICA bypasses, or the size of the distal anastomosis, as in ECCA to MCA bypasses.[4,7–14]

Vrionis *et al.*[15] described a new bypass between the maxillary artery (MA) and the supraclinoid ICA for the situations in which the cavernous or petrous carotid artery was obstructed by tumour, and needed to be sacrificed. They also described the use of short saphenous vein grafts placed between the pterygoid segment of the MA and supraclinoid ICA, when the length of the MA was inadequate. In addition, they performed a tension-free MA to the supraclinoid ICA bypass in nine of 12 specimens. Karabulut *et al.*[16] reported that the short saphenous vein graft can be used when the length of the MA is inadequate and dissection of the MA in the pterygopalatin fossa is difficult and time consuming. However, the last technique was criticized as it was complex due to the extensive removal of the floor of the middle cranial fossa to the level of the foramina ovale, rotundum and spinosum.

In this study, we aim to modify and simplify the last technique and to practise on cadavers before applying it to a patient.

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Materials and methods

Five adult cadaver sides were dissected. A preauricular frontotemporal skin incision was used and a frontotemporal craniotomy and a zygomatic arch osteotomy performed, after interfacial dissection and downward reflection of the temporal muscle.

The dura of the temporal lobe was elevated from the junction of the sphenosquamous suture and infratemporal crista and separated from the temporal fossa. After the division of the middle meningeal artery, approximately 1.5–2 cm medially, the foramen rotundum was identified and 2–3 mm lateral to the foramen rotundum a hole was created with a 4 mm tipped high-speed drill in the sphenoid bone extradurally (Figure 1) avoiding extensive removal of the middle cranial fossa floor.

The MA was easily identified 1–2 cm inferior to the infratemporal crista. We removed the anterior clinoid process intradurally in order to see the ophthalmic segment of the ICA so as to make a bypass between the MA and the supraclinoid ICA. The MA presented superolaterally projecting loop and revealed the posterior superior alveolar (PSA) and infraorbital (IO) arteries just before entering the pterygopalatine fossa. Before giving off these branches the MA was transected and liberated from the surrounding tissue (Figure 2). A short interposition radial artery graft was passed through the hole after the dura over the hole had been opened to reach the supraclinoid ICA (Figure 3). The proximal end of the graft was anastomosed end-to-end with the MA and the distal end of the graft end-to-side with the supraclinoid ICA, between the origins of the ophthalmic and posterior communicating arteries (Figures 4a and b). The diameter of the MA at the anastomosis site and also the length and diameter of the arterial graft were measured using an electronic calibre.

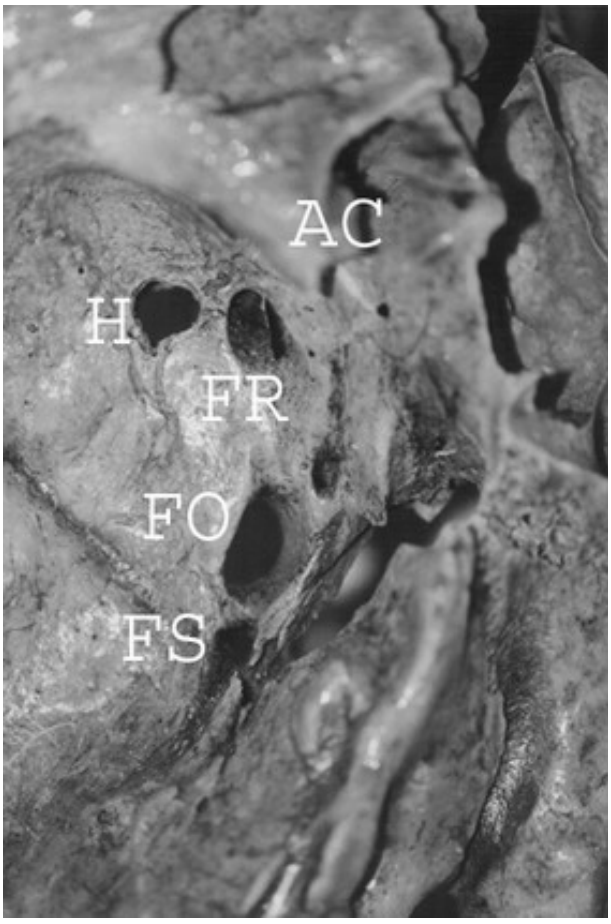

FIG. 1

A hole (H) which was opened extradurally 2–3 mm lateral to the foramen (FR) rotundum is seen. (FO: foramen ovale, FS: foramen spinosum, AC: anterior clinoid process).

FIG. 2

Before giving branches the maxillary artery (MA) is seen in the infratemporal fossa (ITF).

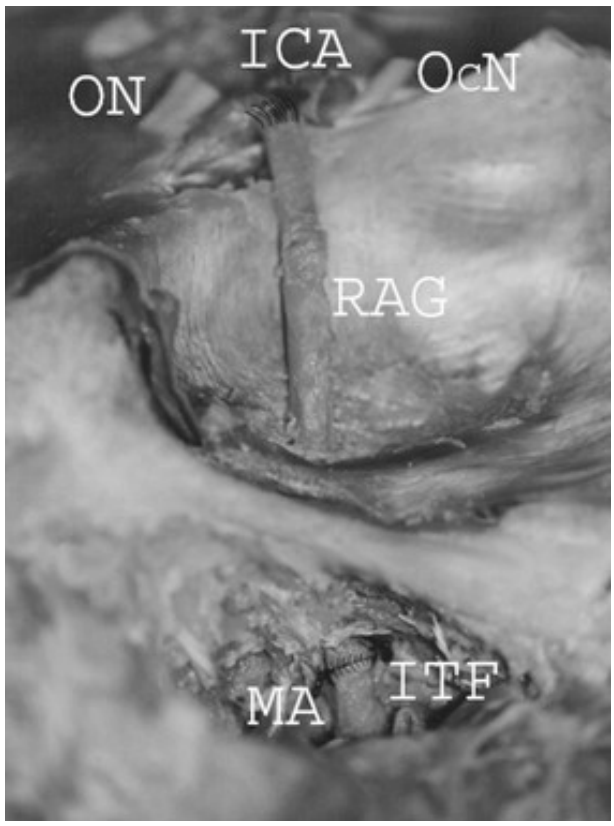

FIG. 3

The radial artery graft (RAG), which was anastomosed end-to-end to the maxillary artery (MA) and anastomosed end-to side to the supraclinoid internal carotid artery (ICA). The thick sutures show the anastomosis sides. The temporal lobe was resected in order to demonstrate the MA to the supraclinoid ICA bypass. (ON: optic nerve, OcN: oculomotor nerve, ITF: infratemporal fossa).

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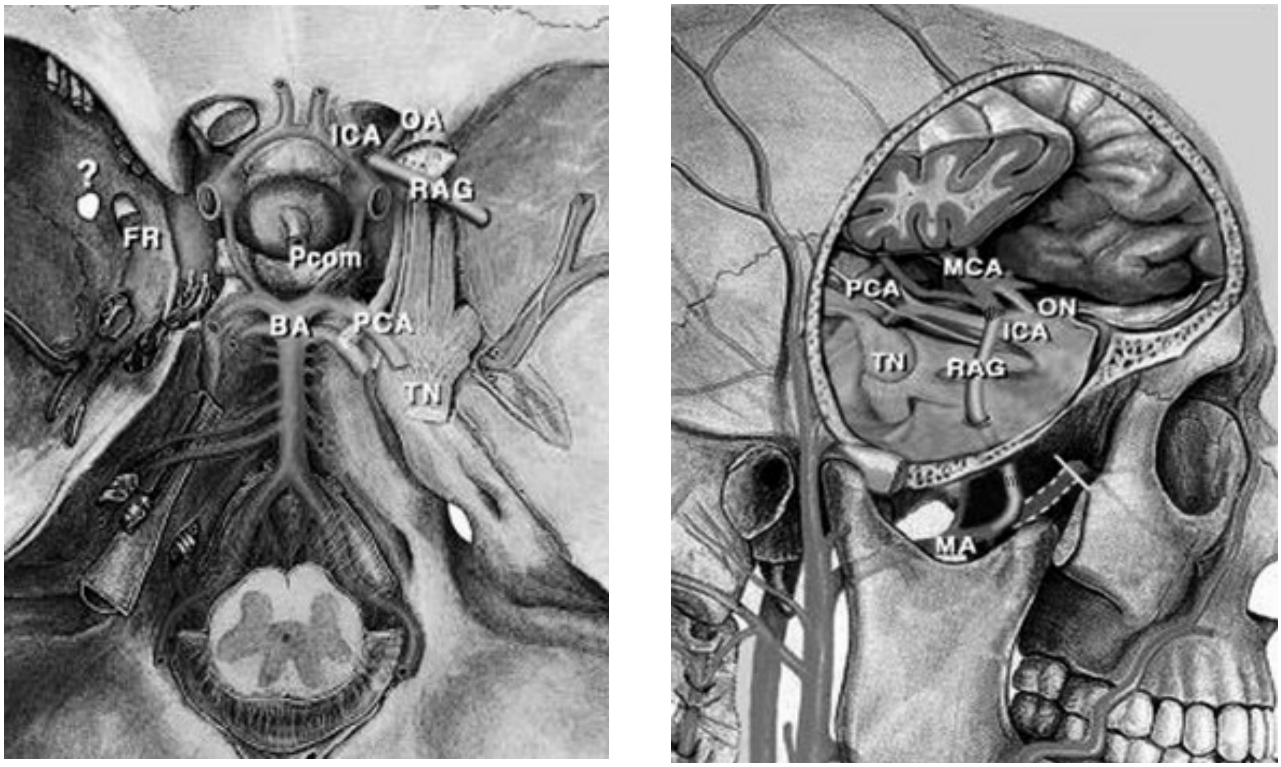

FIG. 4

(a) Schematic illustration of radial artery graft (RAG) for bypass of the maxillary artery to supraclinoid internal carotid artery (ICA) from inside the skull. (b) Schematic illustration of RAG for bypass of the supraclinoid ICA from outside the skull. (TN: trigeminal nerve, FR: foramen rotundum, BA: basillar artery, Pcom: posterior communicating artery, OA: ophthalmic artery, ON: optic nerve, MA: maxillary artery, MCA: middle cerebral artery, PCA: posterior cerebral artery).

Results

The mean calibre of the MA before giving off the infraorbital arteries was 2.6 ± 0.3 mm (range: 2.3 to 2.9 mm). The mean calibre of the proximal end of the radial artery graft was 2.5 ± 0.25 mm (range: 2.3 to 2.75 mm) and the distal end was 2.35 ± 0.2 mm (range: 2.15 to 2.55 mm). The mean length of the radial artery graft was 4.0 ± 0.5 cm (range: 3.5 to 4.5 cm). These results are minimal values as this study was performed on cadavers and no arterial pressure was available.

Discussion

Several techniques can be used for cerebral revascularization in the patient with ICA occlusion. These are the STA to the cortical branch of the MCA, STA to proximal MCA, ECCA to the intracranial ICA or MCA with a long venous graft, STA to MCA with a short saphenous graft and occipital and middle meningeal arteries to posterior temporal or angular branches of the MCA anastomosis.[3,4,9–13,17] A number of different graft materials (e.g. radial artery) have been used for bypass grafting.[4]

Despite the patent anastomosis, some failures have been reported owing to inadequate blood flow.[2] The blood flow rate in a newly performed STA-MCA anastomosis has been stated to be approximately 10 ml/100 g/min, which may not be adequate to prevent ischaemia.[2,10] It has also been stated that anastomosis, where the recipient of the bypass is the ICA or the proximal MCA, are more protected than an STA-MCA anastomosis.[2,10] Although the graft has high-flow rate, there is a higher incidence of delayed thrombosis with the long venous graft, therefore in most cases its patency rate is approximately 60–70 per cent.[5,18] However, the short venous and radial artery grafts have higher patency rates of 80–90 per cent.[3,19] We used the radial artery as a short graft was needed and the calibre of the MA and radial artery matched well, but a venous graft can also be used.[16]

Vrionis *et al*.[15] noted that if the length of the mobilized MA is more than 5 cm, anastomosis can be performed successfully. The length of MA can be assessed with the angiography pre-operatively as to whether the graft is suitable for anastomosis. We think that in cases of ICA occlusion, distal and proximal dissection of the MA and extensive removal of the middle cranial fossa floor are time consuming and there is a possibility of an inadequate length of the MA to perform an anastomosis. Buyukmumcu *et al*.[20] ligated the branches of the MA and mobilized it proximally up to the middle meningeal artery and they used the beginning of the pterygoid (second) segment of the MA. This procedure lengthened the duration of the bypass. In this study, to shorten the bypass time, instead of mobilizing the MA proximally, we have used the

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beginning of the pterygopalatine (third) segment of the MA. Therefore, we prefer to use a short graft passed through a hole which was opened easily by a high-speed drill to simplify the procedure.

- **This is a post-mortem study examining the feasibility of bypassing internal carotid artery occlusions using a radial artery graft**
- **The study suggests that it may be feasible to anastomose the maxillary artery to the supraclinoid internal carotid in such cases**

The advantages of the MA to the supraclinoid ICA bypass may be as follows:

(1) It is entirely in the side of the skull and cannot be affected by head movements.
(2) Its flow capacity is high.
(3) It has a short and a direct course and therefore the risk of thrombosis decreases.
(4) The permenant clip left on the ICA may prevent embolization from the distal end of the occlusion.

Clip application may be dangerous. It may cause embolization from a thrombus. However, during the surgery, one clip is applied proximal to the posterior communicating artery and another clip to the ophthalmic artery before opening the ICA. The first anastomosis must be performed between the radial artery and the supraclinoid ICA, and then the MA can be transected (because the ophthalmic artery can obtain collateral flow from the MA) and the proximal end of the radial artery anastomosed to the MA. This anastomosis can be made easily, but performing an anastomosis between the distal site of the radial artery and the supraclinoid ICA has certain difficulties, i.e. other anastomosis extracranial carotid to supraclinoid ICA. Another disadvantage of the MA to the supraclinoid ICA radial artery bypass is zygomatic arch osteotomy to mobilize the MA. Mini plates can be used to re-approximate the zygomatic arch. Further practice is needed on cadavers before attempting such a bypass. This bypass requires double anastomosis which increases the surgery time compared with a single anastomosis such as the STA–MCA bypass. Continuous suturing may reduce the time. The dura over the hole can be sealed with fibrin glue to prevent cerebrospinal fluid leakage.

Conclusions

This study suggested that the MA to the supraclinoid ICA radial artery bypass may be an alternative method to long venous grafts and STA–MCA anastomosis in ICA occlusions when high blood flow is needed. This operation is ideal for patients who undergo the resection of tumour at the base of the skull. If zygomatic or orbitozygomatic osteotomies have to be done (to resect the tumours at the base of the skull) this bypass procedure is even simpler.

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