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Technical note

The use of ultrasound for postoperative monitoring of cerebral bypass grafts: A technical report

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ABSTRACT

Duplex ultrasound and transcranial Doppler are valuable tools for post-operative monitoring of extracranial-intracranial cerebral bypass grafts. Here we describe our technique for the evaluation of both high-flow and low-flow cerebral bypass grafts over a nine year period. 186 bypass grafts were studied daily during the inpatient period between Jan 2005 and Dec 2014 after surgery for various cerebrovascular pathologies. There was a technical success rate of 97%. Duplex ultrasonographic flow measurements had excellent interobserver reliability with an intraclass correlation coefficient (ICC) of 0.89 ($p = 0.009$). Technical nuances are highlighted and a brief discussion of pathology is undertaken.

1. Introduction

Extracranial to intracranial (EC-IC) bypass is a neurosurgical technique utilized to revascularize the cerebrum, cerebellum and brainstem. Blood flow is often diverted from the extracranial circulation into the circle of Willis using a variety of bypass grafts. Since postoperative brain perfusion is often dependent on blood flow from the bypass graft, the patency of and flow rate through these grafts is of critical importance. Ultrasound interrogation provides a non-ionizing, real-time evaluation of graft patency with velocity and flow data for identification of stenosis and low-flow states which may lead to bypass graft failure.

Bypasses are classified as either low-flow or high-flow based on the donor vessel, recipient vessel and choice of conduit [2]. Low-flow bypass utilizes a superficial temporal artery anastomosed to a middle cerebral artery (STA-MCA) or an occipital artery to a posterior inferior cerebellar artery (OA-PICA) and have flow rates of <65 mL/min. High-flow bypass utilizes an arterial graft, such as the radial artery (RAG), anterior tibial artery (ATAG), or saphenous vein (SVG) as a conduit between either the extracranial carotid artery and the middle cerebral artery (MCA) or the extracranial vertebral artery (VA) and the posterior cerebral artery (PCA). High-flow bypasses have flow rates of 65–200 mL/min, though flow rates for all bypass types vary by hematocrit and radius of the donor and recipient vessels [2].

Choosing to perform a low-flow versus a high-flow bypass depends on the lesion being treated and the size of vascular territory requiring reperfusion. At our institution, low-flow bypass is typically performed for Moya-Moya disease or for complex PICA aneurysms. High-flow bypass is usually indicated for complex ICA or MCA aneurysms, invasive skull base tumors necessitating parent artery sacrifice and occasionally for intracranial atherosclerotic ischemic disease [1,4,3,5].

Careful post-operative monitoring of bypass grafts is critical to ensure the durability of bypass and improve patient outcome. Here we provide a detailed methodology and technique for both high-flow and low-flow bypass grafts after cerebral revascularization using ultrasound.

2. Methods

After institutional IRB approval, all patients who underwent cerebral bypass procedures from 2005 to 2013 were retrospectively reviewed. Select cases of high-flow and low-flow bypasses were reviewed for details of their post-operative monitoring.

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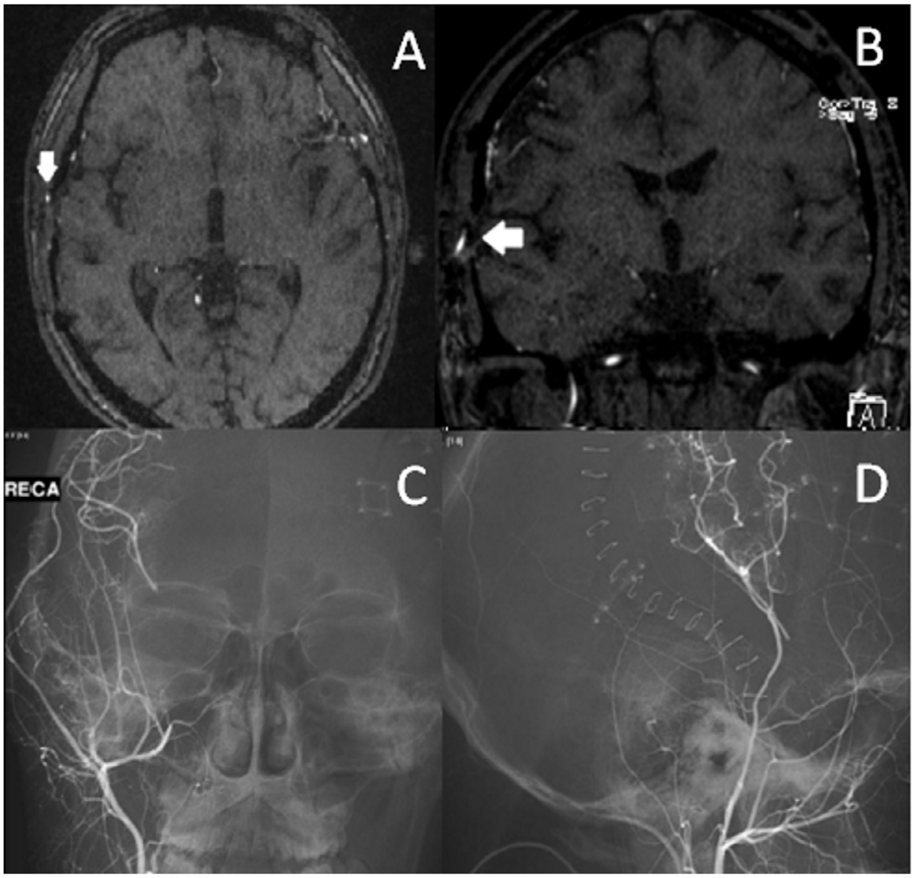

Fig. 1. MRA axial (A) and coronal (B) reveal the location of the superficial temporal artery (STA, white arrow) which was used as a conduit to create a low-flow STA-MCA bypass in this patient with symptomatic Moya-Moya syndrome. Post-operative cross sectional imaging such as this, coupled with the non-subtracted anterior-posterior (C) and lateral (D) unsubtracted angiogram can help localized this smaller diameter bypass graft (~2 mm) for accurate insonation. Key landmarks are the root of the zygoma and external auditory canal as well as superficial landmarks such as skin staples, if present as in this case.

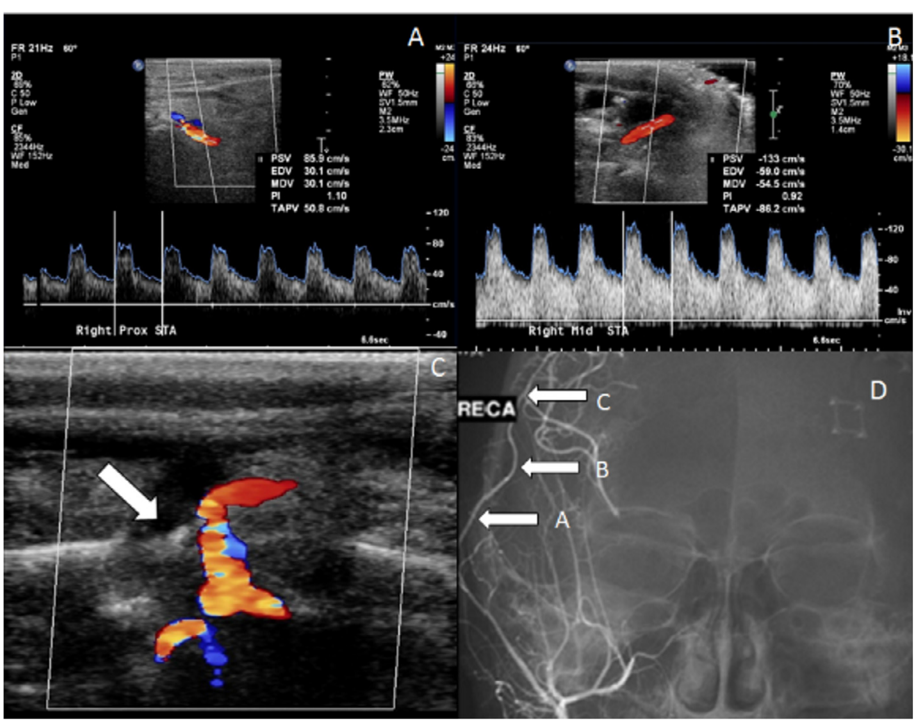

Fig. 2. Duplex imaging with Doppler waveform of a STA-MCA graft. The proximal graft is first visualized near the root of the zygoma (A), followed by the midgraft (B) and distal graft as it enters the cranium (C, arrow showing hyperechoic skull). Panel D shows the anatomical location of the various insonation points on the AP angiogram. Spectral analysis with color Doppler at a 60 degree angle with the cursor aligned parallel to the vessel wall should be maintained to document flow velocity measurements reported as time averaged peak velocities (TAPV) for the extracranial proximal graft (i.e. 50.8 cm/s in Fig. 2A), mid-graft (i.e. 86.2 cm/s in Fig. 2B) and distal graft (not shown).