MR Assessment of Arterial Distribution Territories Prior to and Following Embolization of Meningiomas

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Introduction

Embolization therapy is a technique that aims to block arterial supply via the injection of small (typically 300-700 micron) particulates into superselected arteries. These particulates become lodged in arterioles and devascularize tissue in the distribution territory of the artery into which they are injected. Arteries must be assessed prior to embolization to assure that their distribution territory includes the target tissue and excludes surrounding normal structures. This assessment is typically made with x-ray techniques and selective catheter angiography. A catheter is placed into selected vessels and the bolus passage of iodinated contrast is monitored to infer the distribution territory of the vessel through which it was injected. There are limitations with this technique since the actual tissue is not directly visible and the angiographic images are projections of volumetric structures. On the other hand, conventional venous-injected MR perfusion methods, which provide tomographic information, are unable to identify which artery is supplying a given territory.

We explore the ability of MR dynamic susceptibility contrast (DSC) perfusion imaging, in conjunction with selective intra-arterial Gd-based contrast injection, to reveal the distribution territory of blood vessels in patients undergoing meningioma embolization. Meningioma's are highly vascular brain neoplasms in which embolization has been shown to be effective in mitigating blood loss during surgical resection. Distribution territories of selected arteries are assessed prior to and following x-ray guided embolization.

Methods

A total of six patients undergoing embolization of a meningioma prior to surgical resection were studied in a hybrid XMR suite (Philips Medical Systems). The study protocol was approved by the local IRB and patients provided informed consent. Patients ranged in age from 36-65 (mean = 49) and included four women and two men. All patients underwent a conventional cerebral angiogram with subsequent embolization dependant on whether or not this adjuvant therapy was deemed to be efficacious based on the x-ray angiographic findings. Baseline MR acquisitions were performed the day prior to catheterization in all cases to exclude patients with contrast reactions. Intra-arterial MR perfusion imaging was performed intra-therapeutically immediately prior to and following delivery of embolic agents. Gadolinium based contrast (Omniscan, GE Healthcare) was administered in a selective intra-arterial fashion through an MR safe unbraided catheter (Cook 5F polyethylene angiographic catheter, Bloomington, IN). The MR contrast was diluted (0.05M in saline) and pre-loaded in the catheter prior to injection. Injection commenced after 20s of baseline DSC scanning, which continued for 1 minute following injection (dynamic scan time = 2s). Injection rates varied between 1.0 ml/s (external carotid, vertebral arteries) and 3.0 ml/s (common carotid artery) and were set to be less than those used in conventional x-ray angiography. Injection duration was 4s for all acquisitions. DSC perfusion imaging was typically initially performed with the catheter in the external carotid artery (ECA) and then repeated after the catheter was retracted a sufficient length to enter the common carotid artery (CCA). The spatial distribution of the contrast agent was interrogated by subtracting a pre-contrast acquisition from all other dynamics. DSC data was also fit to a standard gamma variate function on a pixel-by-pixel basis to extract normal DSC perfusion parameters (rCBV, MTT etc).

Results

All patients received pre-intervention MR assessment including IV perfusion and angiographic evaluation of vessels involved with the tumor. One patient was not considered a good candidate for embolization therapy at the time of catheterization based on the predominant tumor supply coming from the internal carotid artery. The remaining five patients received embolization therapy and additional MR examinations including intra-arterial DSC perfusion in a vessel through which embolics were delivered. Embolization was performed via a distal branch of the ECA (4/5) or vertebral artery (1/5). One patient exhibited reflux into the internal carotid artery during an ECA injection and was excluded from further analysis.

Signal attenuation was evident within at least a portion of the meningioma when injecting through a vessel determined by x-ray techniques to be involved with tumor vascularity (Figure 1). MR had the advantage of being a volumetric acquisition rather than a projection and therefore more clearly depicted the portion of the tumor being fed by the selected artery. Arterial involvement with the tumor, as determined by the fraction of the tumor volume that experienced signal attenuation following selective Gd injection, averaged 53% (range: 29-83%) of the tumor prior to embolization and 12% (range: 0-33%) after embolization. In one case DCS perfusion imaging revealed residual tumor supply that was not readily evident on x-ray angiography. Selective injection permitted the use of very small Gd doses while still producing marked signal attenuation on the first pass of the contrast agent.

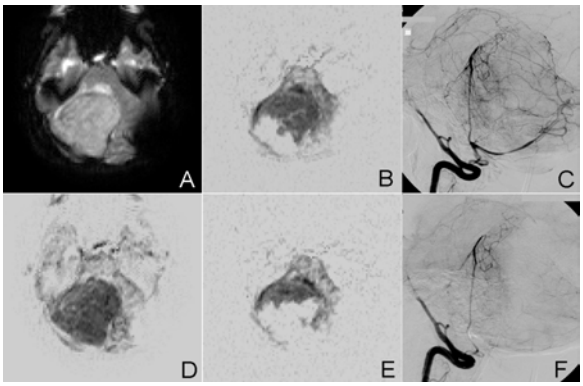

Figure 1: Baseline DCS image (A) of a meningioma along with difference images showing peak attenuation following IV (D) and IA (B-pre embo; D-post embo) Gd injection. X-ray angiograms obtained via the same vessel prior to (C) and following (F) embolization reveal partial devascularization.

Conclusions

Selective intra-arterial injection of dilute MR contrast media is an excellent means of assessing the distribution territory of vessels. Very low contrast dose is necessary, making repeated assessment during therapy practical. MR demonstrated excellent sensitivity for depicting tissue fed by a selected vessel, and had the additional advantage of providing a volumetric assessment.