Meningioma Embolization Assessment with Interventional Magnetic Resonance Imaging

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Introduction

Meningiomas are highly vascular brain tumors that are often associated with substantial blood loss during surgical resection. Embolization of meningeal tumors has emerged as a preoperative adjuvant therapy that mitigates surgical blood loss. This procedure involves selective microcatheterization of arteries feeding the neoplasm and subsequent injection of microspheres or other embolic agents. The vascular bed of a meningioma is typically identified with conventional angiography by the presence of residual tissue blush following superselective intra-arterial iodinated contrast injections. The objective of the embolization procedure, therefore, is to identify arteries feeding the neoplasm and to administer sufficient embolic agent to eliminate this tissue blush. Due to the potential for embolization of non-neoplastic tissue, this therapy is typically not administered in any vessel originating from the internal carotid artery. Arteries originating from either the external carotid or vertebral arteries, however, must also be carefully screened to minimize the potential for unintended vascular obstruction in non-neoplastic tissue. We explore the potential benefits that magnetic resonance (MR) assessments might bring to the delivery of embolization therapy. We specifically investigated the role of perfusion imaging based on intra-arterial contrast injections for the determination of vascular territories and correlate these findings with catheter angiographic data.

Methods

A total of 8 patients (5 female, 3 male, mean age = 52, range = 27-75) receiving embolization therapy were studied in an XMR suite (Philips Medical Systems, Cleveland, OH). Perfusion weighted dynamic susceptibility (DSC) MR imaging was added to the clinical workflow and was performed immediately prior to and following delivery of the embolic agent (Embospheres, Biosphere Medical, Rockland, MA), which was guided with conventional x-ray techniques. 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 scanning and continued for a 1 minute following injection (dynamic scan time = 2s). Injection rates varied between 0.5 ml/s (external carotid, vertebral arteries) and 1.0 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 and the following parameters were extracted: relative cerebral blood volume, mean transit time, time to arrival, and time to peak.

Results

Embolization was performed via a distal branch of the ECA (7/8) or verterbral arteries (1/8) in all patients. Patients receiving therapy via the ECA had perfusion scans performed in both the ECA and subsequently in the CCA. One patient exhibited reflux into the internal carotid artery during an ECA injection and was excluded from further analysis. Localized injection into the ECA did not produce signal changes in non-neoplastic brain tissue either ipsilateral or contralateral to the tumor. 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). The MR technique had the advantage of being a volumetric acquisition rather than a projection and therefore more clearly depicted the portions of the tumor being fed by the selected artery. Moreover, the signal attenuation created by the injection of even these small amounts of MR contrast produce substantially greater image contrast than is evident with conventional x-ray techniques. The spatial extent of the region of signal attenuation following selective ECA or vertebral injection was reduced in all cases following embolization. The extent to which this occurred was variable, but correlated well with the expected relative contribution of the treated artery based on a complete angiographic assessment of all possible feeder arteries.

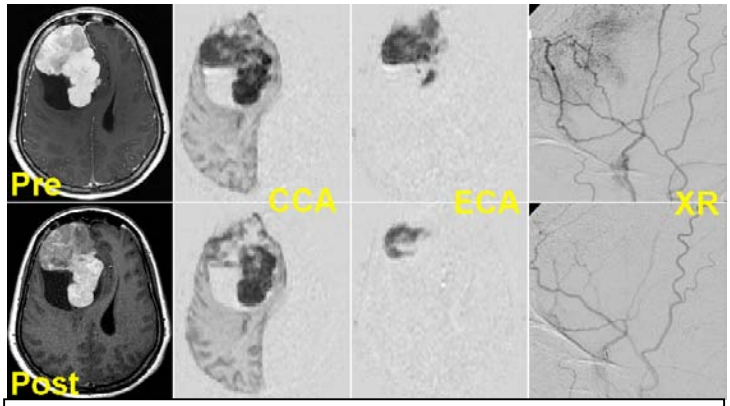

Figure 1: Demonstration of the effects of embolization on a large right frontal meningioma. The upper row depicts the lesion prior to embolization and the lower row following embolization. Shown from left to right are: T1-weighted spin echo (post-contrast), subtracted DSC image at peak enhancement following CCA contrast administration, subtracted DSC image at peak enhancement following ECA contrast administration and selective x-ray angiograms obtained via an ECA injection. Note the reduced enhancement evident on the ECA image after embolization and the reduction in tissue blush evident on the x-ray angiograms.

Conclusions

Selective intra-arterial injection of dilute MR contrast media is an excellent means of assessing the vascular bed of feeding arteries. Very low contrast dose is necessary, making repeated assessment during therapy practical. MR appears to be more sensitive than conventional x-ray angiographic techniques for depicting tissue fed by a selected vessel, and has the additional advantage of providing a volumetric assessment.