Contrast-Enhanced MRI of Occlusive Arterial Disease

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Introduction

Percutaneous treatment of arterial occlusive disease has gained popularity in recent years with the dramatic reduction in restenosis rates attributed to the use of drug-eluting stents. Despite the benefits of percutaneous treatment, clinicians often do not attempt the crossing of an occlusion due to technical difficulties, primarily the inability to cross a chronic occlusion with a guide-wire.

MRI has a significant potential role in characterization of occlusion attributes such as inflammation and neovascularization. These may be critical determinants of successful guide-wire crossings and may also be important considerations in treatment selection. This study investigates the use of two different MRI contrast agents, Omniscan (GE Healthcare) and Clariscan (GE Healthcare), for characterizing occlusive arterial disease in an animal model of total occlusion.

Materials and Methods

Total occlusions were created in 11 rabbit femoral arteries by surgically isolating the arteries with ligatures and then occluding these arteries with local injections of bovine thrombin (Serologicals, USA). These occlusions were confirmed angiographically at the time of the procedure. This occlusion model shares several characteristics with human coronary occlusions including development of mature fibrous tissue and multiple small intraluminal vascular channels [1, 2]. The femoral vein adjacent to the occlusion was removed at the time of surgery to avoid venous signal contamination during imaging. Imaging was performed on a 3T GE Excite Scanner (GE Medical Systems, USA), using a custom 3-cm surface coil. Occlusions of varying age (1-17 weeks) were imaged using an elliptic centred FSPGR sequence (TR/TE/flip=8.3/2.1/30, 31kHz bandwidth, resolution of 0.25mm in plane, 1mm through plane). Images were obtained before and at 4s after the injection of 0.1cc/kg Omniscan. After allowing 40min for the Omniscan to clear, imaging was repeated as above at a higher resolution (0.25mm in plane, 0.6mm through plane) 16s after the injection of 0.05cc/kg Clariscan (Fig 1). Regions of interest were then selected within the occlusion and the relative distribution volume of contrast agent was determined using methods similar to [3]. Specimens were sent for serial histological staining.

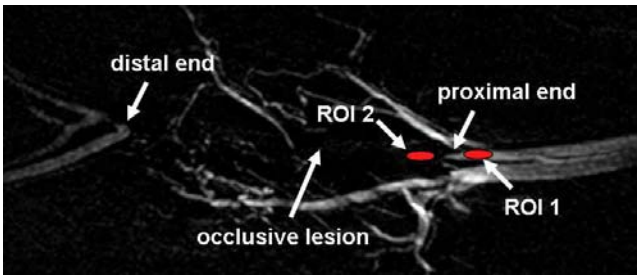

Fig 1. Clariscan image of an occlusive legion. Example regions of interest (ROIs) in patent lumen (1) and occlusion (2) used to calculate relative distribution volume are shown.

Results and Discussion

Fig 2 depicts the calculated distribution volume of Clariscan and Omniscan against the age of the occlusion. The distribution volume of Omniscan, a Gadolinium based extra-cellular contrast agent, 4s after injection is likely related to the directly filled microvasculature and interstitial volume adjacent to highly permeable vasculature within the occluded vessel. The distribution volume of Clariscan, a physically larger and intra-vascular agent, is likely related to complete vascular volume (given the longer filling time). Based on this interpretation, the data shown in Fig 1 suggests that endoluminal neovascularization increases over the initial 10 weeks and is followed by a progressive collapse of these neovessels. These results also suggest that an increase in permeability and associated interstitial space (possibly inflammation) is experienced over the initial 3-5 weeks and subsides over time. This is consistent with current theories of the progression of occlusive disease [4] and is confirmed by initial histological samples (Fig 3). In addition, a second set of images was obtained 60s after Omniscan injection. In all cases, the distribution volume at 60s was found to be substantially greater than both the 4s time point and the 16s Clariscan measurement suggesting that Omniscan eventually reaches a more extensive vascular and interstitial space.

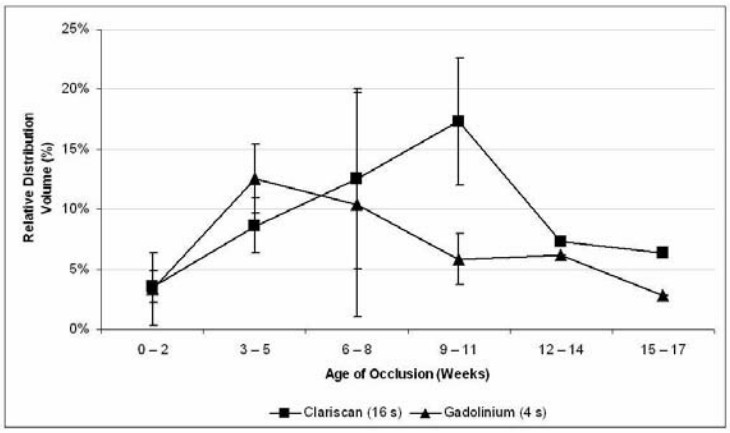

Fig 2. Relative Volume Distribution of Clariscan (imaged 16s after injection) and Omniscan (imaged 4s after injection) plotted as a function of occlusion age.

Conclusion

The use of contrast-enhanced MRI was investigated in the characterization of occlusive disease. The distribution volume of Omniscan and Clariscan were calculated within the occluded vessels of varying ages to provide a direct characterization of interstitial volume and vascular volume respectively. These measurements may play an important role characterizing lesions as well as improving the prediction of guide-wire crossing success.

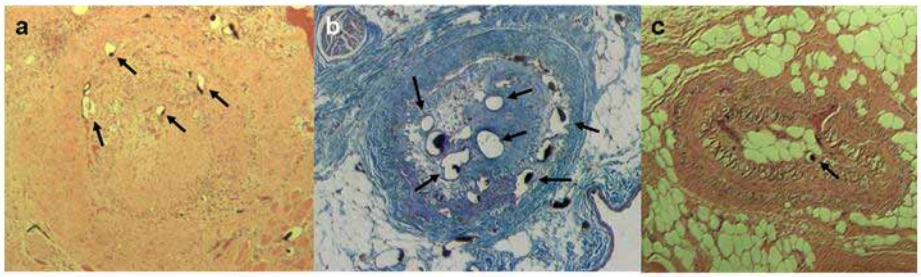

Fig 3. a) Histology slide of a 2 week old occlusion induced in the rabbit femoral artery stained with H+E. Small microvessels can be seen (arrows). b) 5 Week old occlusion stained with Massons trichrome. More microvessels are visible in this occlusion. c) Histology slide of a 15+ week old occlusion – a distinct lack of microvessels is seen when compared to a) and b).

References

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