

## Clinical Diagnosis and Treatment of Stroke and Trauma in a Neurovascular XMR Suite

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### Abstract:

We present the application of a full interventional XMR suite for the treatment of acute stroke patients using MR during thrombolysis treatment after an insertion of a catheter under X-ray guidance currently in operation at MGH. To allow for quick and robust transport between these two modalities without having to lift the patient from one table to the other, a custom XMR patient transport module (PTM) capable of interfacing to both a SIGNA MR (GEMS 1.5 T NV/i) and an Omega-IV digital subtraction X-ray angiography pedestal (GEMS LCV+) as well as transporting a patient from the intensive care unit or emergency area with full MR compatible patient life support and monitoring equipment was designed and installed. This approach minimizes both the time required to transport patients between the imaging systems as well as minimizing the risk of moving critically ill-patients and switching life support monitors. Clinical interventional neurovascular cases combining MR soft tissue contrast with catheter placement under X-ray guidance show good potential for improving outcomes with no MR artifacts due to the close proximity of the X-ray angiography system in the suite. The XMR suite is particularly well suited to treating large vessel occlusive strokes because of the short time window for effective thrombolytic therapy of ischemic stroke available to these patients. Should the treatment be incomplete or an adverse event is detected, treatment could be restarted more quickly and more easily if the fluoroscopy and MR equipment were close to each other and if multiple bed transfers were not required. The XMR patient transport system minimizes risk of undesired removal of indwelling catheters as well as risk factors associated with transferring acutely ill patients between beds and radiological imaging tables. Clinical treatment of stroke in the XMR suite is currently underway combining catheter placement under x-ray guidance for thrombolysis treatment of acute stroke following MR based perfusion-weighted (PWI) and diffusion weighted (DWI) imaging diagnosis. Other procedures include trauma and coma as well as carotid temporary balloon occlusion. Over 50 neuro interventional cases have been carried out in the suite to date.

### Methods:

Combining the high quality 3D anatomical information obtained from MR with the high spatial and temporal resolution 2D images of x-ray imaging is of potentially great benefit in acute stroke monitoring and treatment as well as other neurological diseases whose treatment requires a short interventional time window. The full capabilities of the XMR suite are used for cases that require catheter angiography and MRI. This includes patients with cerebrovascular diseases such as aneurysms and arteriovenous malformations (AVM) requiring both angiography and MR for proper patient evaluation as well as ischemic stroke. The presence of an MR scanner in the emergency department (ED) greatly enhances the utility of the XMR suite since acute stroke patients, of course, appear first in the ED. The goal is to immediately position the patient on the PTM where they can be monitored and any necessary medications infused even as they are undergoing MR scanning. Patients with a large diffusion/perfusion mismatch become eligible for immediate endovascular recanalization. Patients that meet this criteria are then directly taken to the XMR suite for therapy with the added benefit of being able to perform repeat MR scans to assess the progression of the stroke and the effectiveness of the therapy. Truly rationale, point-of-contact, interventional decisions are thus enabled.

### Results:

Initial clinical trials with stroke patients on both the MR and X-ray side have yielded excellent results.<sup>[2]</sup> Patients undergoing elective neurointerventional procedures, such as a balloon test occlusion (10 cases) and AVM (5 cases), also benefited from the non-invasive assessment of brain physiology whilst the balloon is inflated (during the procedure) to look for undesired regions of abnormal perfusion as well as regions of ischemia due to the planned arterial occlusion. Over 35 aneurysm cases involving catheterization under x-ray guidance and post and pre-operative planning and assessment under MR have also been done in the XMR suite. These include a 59 year old woman with expanding right paraclinoid aneurysm, a 57 year old man with a right MCA aneurysm and a coiled anterior communicating artery aneurysm and a 46 year old woman with a coiled left posterior communicating artery aneurysm, and coiled right superior hypophyseal aneurysm and recurrent, clipped left anterior temporal aneurysm are some example cases that greatly benefited from the XMR suite. In addition, two acute stroke cases have been treated in the suite. Figure 1 shows a most severe type of ischemic stroke, a basilar artery thrombosis, that generally has a 90% mortality rate that was treated in the XMR suite. The clinical presentation was confusing and it was initially thought to be a seizure problem. However, on carrying out an MRI scan, a diffusion abnormality in the brain stem and a basilar artery occlusion was detected. Intra-arterial thrombolysis was performed followed by angioplasty on the XMR x-ray system with excellent angiographic results-Figure 2. MRI performed immediately after the procedure showed that the brainstem DWI abnormality did not increase in size. The next morning the patient was in good recovery and was able to follow commands in multiple language according to the neurologists in the neuro intensive care unit.

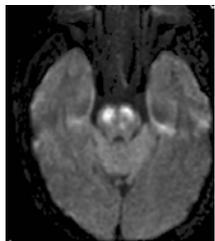


Figure 1: Physiologic and morphologic brain information from an MR evaluation were acquired before and following endovascular procedure. Included in the existing MR exams were assessments, such as diffusion imaging (Fig. 1), which measured the physiologic impact of ischemia. A diffusion abnormality in the brain stem is clearly indicated in this case. Patients undergoing neurointerventional procedures such as a balloon test occlusion benefited from a non-invasive assessment of brain physiology while the balloon is inflated during the procedure to look for regions of ischemia with DWI. Similarly, patients with vasospasms often experienced regional perfusion changes and ischemia resulting from contracting arteries. The combination of MRI with angiography in an interventional suite allows sufficient high sensitivity of detecting both intracerebral hemorrhage and ischemia within offset of symptoms and can identify the hypoperfused brain tissue showing potential occlusion of major arteries with x-ray guidance in the placement of catheters for thrombolysis treatment. Both diffusion and perfusion EPI image quality were minimally affected (not clinically relevant) by the close proximity of the x-ray imaging equipment as well as patient life support infrastructure.

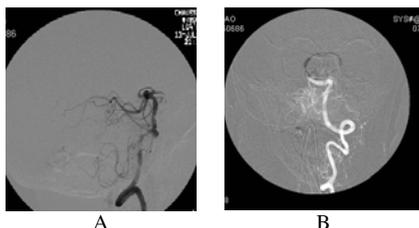


Figure 2: X-ray angiogram showing occlusion (A) and after balloon angioplasty (B) to remove the occlusion which benefited from a non-invasive assessment of brain physiology while the balloon was inflated during the procedure to look for undesired regions of abnormal cerebral blood volume (CBV) in a PWI scan, as well regions of ischemia, with DWI due to the arterial occlusion (Figure 1). The physiological information available from the MR also guided improved balloon sizing and placement.

### Conclusions:

The addition of MR monitoring to neurovascular procedures normally done under X-ray with the ability to quickly interleave an MR exams with an angiogram, without leaving the procedure suite and without undergoing multiple bed transfers promises the great potential in improving outcomes in time critical stroke procedures. Over 50 cases in which both diagnostic angiography and MRI have been carried out in the XMR suite to validate the clinical utility of the suite and the PTM concept. Routine stroke interventional in the suite is now on-going.

### References:

- [1] Moonis M, Fisher M. Imaging of acute stroke. *Cerebrovasc Disc.* 2001; 11:143-150.
- [2] Kiruluta et al. 12<sup>th</sup> Proc of ISMRM, Kyoto, Japan May 2004.

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