Pre-operative fMRI valuable in clinical oncology

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Functional MRI (fMRI) is growing in importance for pre-surgical evaluation of oncology patients. fMRI helps to localize functional areas in the brain to aid surgeons in planning their approach during surgery. With fMRI, surgeons are often more confident, and can give patients a better idea of their prognosis.

At the University of Washington Medical Center (Seattle, Washington, USA), Kenneth R. Maravilla, MD, Professor of Radiology and Neurological Surgery Research Affiliate, and Natalia Kleinhans, PhD, Research Assistant Professor, perform about 2-3 fMRI examinations a month using Achieva 3.0T with IViewBOLD. Most of these exams are for pre-operative surgical planning prior to brain tumor resections or in patients with epilepsy or arteriovenous malformations (AVMs). fMRI maps areas of brain activity after presenting a paradigm to the patient. Different paradigms are designed for language or motor activity mapping. “Surgeons use this fMRI information to help them plan their approach ahead of time, plan what they are likely to do, plan how long it is going to take and to give patients somewhat of a prognosis of likely outcome in terms of problems, extent of resection, or the risk of complications,” explains Dr. Maravilla.

For presentation of paradigms the University of Washington Medical Center uses a computer-controlled digital projector outside the room, which projects through a wave guide into the magnet bore and onto a back projection screen so the patient can see it via the mirror on the head coil. Patients are fitted with earphones to hear the commands, and respond via the microphone in the magnet.

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Standardized scans, real-time processing

Dr. Maravilla says the fMRI paradigms, MR acquisition and processing are all standardized. “For our fMRI activation maps we use single shot EPI-BOLD imaging in two basic dynamic configurations: one with 72 volumes and one with 81 volumes. Processing and analysis are also standardized. We use IViewBOLD real-time processing, so we are acquiring fMRI maps in real time as the subject is performing each task. We can tell as the task is unfolding whether or not we’re getting useable results and, if necessary, communicate with the patient, make sure they understand what is going on, and then rerun the task again to get a better result, if needed.”

Dr. Maravilla also runs a three-dimensional T1-weighted TFE with inversion prepulse for co-registering the fMRI data with an anatomical image for final processing, which is done offline after the study is complete. This is what is generally shared with the surgeons to plan the surgery. “Most of our referrals come from neurosurgeons. Many of them rely on fMRI and feel very confident using the results to help plan the surgery,” he adds.

“We keep the fMRI study short so we can easily insert it in the MR patient schedule – short-term planning is often required for pre-operative studies,” says Dr. Maravilla. “Also, we don’t want the patient to get tired and do poorly on the tasks. We generally perform an entire fMRI exam in under 30 minutes, and that is usually presenting six or more paradigms.”

Patient positioning is an important part of the setup. “We balance good padding to restrict motion with keeping the patient comfortable,” explains Dr. Maravilla. “Some patient motion can be corrected in postprocessing, but too much motion can ruin the examination.”
Selecting and processing paradigms

Dr. Kleinhans’ training in neuropsychology helps her in designing the paradigms and tailoring them to individual patients. “We always do five language tasks (see table). Motor tests vary, depending upon the clinical question and the patient’s condition,” says Dr. Kleinhans. Using offline processing, Dr. Kleinhans combines together the five language tasks into a single parametric map. “That helps our confidence, especially for lateralization results. In some patients it is also useful to split the tasks into expressive and receptive language in order to generate more specific parametric maps of the expressive language areas and receptive language areas,” she explains.

“We sometimes do visual presentations such as checkerboards to determine visual activation,” she notes. “We have done facial motor activations in patients who have seizures in the face motor area. This helps to pre-operatively localize where the face motor area is, when we suspect the functional region is relatively close to an area of congenital malformation or seizure focus.”

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FMRI autism research shows promise

Apart from using fMRI in clinical routine, Dr. Maravilla estimates the University of Washington has about 60 fMRI research projects running concurrently, across multiple disciplines of oncology, psychiatry, neurology, neurosurgery and radiology.

Dr. Kleinhans is currently running two autism studies. “The first one is studying activation in adults with autism upon presenting emotional faces, using eye tracking. Eye tracking helps to ensure that the patient is actually looking at faces, because there is evidence that people with autism don’t look at faces.” The study also includes DTI, to correlate reduced activation with the integrity of white matter connection between limbic regions. The second study involves younger, more severely affected participants with autism who are scanned under light anesthesia. “We’re trying to see if we can get functional activation maps from them by collecting a resting state fMRI under light anesthesia and also trying a receptive language task. They listen to stories under anesthesia and then we look at their functional connectivity. We are trying to relate current functional connectivity impairments to the rate of early brain growth from when they were two and three years old.”

The language paradigms

1. Object naming (based on the Boston naming test – classic neuropsychological test)
2. Letter fluency (based on a classic neuropsychological test)
3. Category fluency (based on a classic neuropsychological test)
4. Sentences
5. Semantic information

Proper patient instruction is crucial to success

Next to avoiding patient motion, pre-examination patient training is key to getting a successful study. Dr. Kleinhans sees patients for 30 to 45 minutes before the procedure, to walk them through each paradigm before they actually go into the scanner. “It’s absolutely critical that patients know what they are doing inside the scanner – otherwise the data is useless. Depending on how cognitively intact the patient is, I use different levels of difficulty. We want to make sure patients are able to respond appropriately, especially with language tasks, so some tailoring is always required. If the task is too hard it may tell us a lot about their cognitive status, but it’s not very useful in obtaining language maps. We’ve had patients with limited motor capabilities, and I’ve had to adjust the task so it’s well within their capability; it’s already difficult to keep the head perfectly still even without struggling to perform a motor task.”

When a person is young and has no cognitive impairment, Dr. Kleinhans might only need 20 minutes for the walk-through, as opposed to older adults who may have more cognitive problems. She will occasionally go through everything twice to be sure patients feel confident, which helps improve the reliability of the fMRI results.

Reimbursement brings new challenges

Although there is a new CPT code for fMRI procedures, which helps with reimbursements, the clinical and academic value of the procedure is what is driving fMRI forward. “Reimbursement helps maintain the team we have, but it definitely does not influence our decisions,” says Dr. Maravilla. “We absolutely feel that there are certain situations where fMRI is very beneficial to the patient.”

Despite the fMRI workshops and software springing up since the addition of the CPT code, highly trained clinicians such as Dr. Maravilla and Dr. Kleinhans are vital to successful fMRI practices. There are several potential pitfalls that the functional brain imager needs to be aware of to avoid misinterpretation of a study. For example, excess amounts of iron from past hemorrhage may cause large susceptibility artifacts that can interfere with the study. Likewise, hemodynamic changes from a very vascular tumor or an arteriovenous malformation may give a false localizing or a false negative result. Dr. Kleinhans explains, “It’s easy to get an answer with fMRI, but to be able to evaluate whether the result is valid or not is often very difficult. One needs a great deal of training to be able to do it well, not just attendance at a weekend workshop.”

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