On the Cutting Edge of Neurosurgery

Huashan Hospital, located in the heart of Shanghai, is home to one of the finest neurosurgery facilities. The department stands out for groundbreaking research it has conducted on intraoperative MRI as well as its intelligent use.

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Photos: Tang Ting
Shanghai is a bustling city of 24 million people and the largest in China. Huashan Hospital is located right at the center. Hundreds of patients pass through the gates at all hours of the day. It’s a typical scene for a public hospital here. But just a short walk from the main building, a vastly different sight awaits in the hospital’s award-winning Neurosurgery Department. Past the doors and inside the operating suite, the atmosphere is quiet, but there is an air of excitement and purpose. The only sounds are the buzz of computers and the hushed whispers of doctors in blue-green scrubs discussing cases.

We are standing in one of the finest neurosurgery departments in China. With 600 beds, 110 staff and 15 full professors, the department is part of Fudan University’s Medical School, ranked among the top three in this country. This is more than just a clinic, says Neurosurgery Department Chair Dr. Liang-fu Zhou. In fact it is one of the longest established neurosurgery departments in the country, and attracts a large number of patients, both Chinese and foreign. It also attracts cooperation with industry, including with Siemens and IMRIS, whose intraoperative magnetic resonance imaging (ioMRI) technology the hospital uses.

Last year, the department completed almost 16,000 surgeries, among them more than 10,000 craniotomies, making it one of the busiest neurosurgery departments in the world. The department is also ideally suited to conduct research. Roughly 15 percent of last year’s craniotomies were glioma cases, and a team from the department recently won the Journal of Neuro-Oncology Award at the Congress of Neurological Surgeons (CNS) Annual Meeting for the study it did on ioMRI’s impact on patients with glioma.

Brain surgery relies on a tricky balance of cautious and aggressive measures. The doctors must remove as much of the tumor as possible; unfortunately, many tumors lie close to functional brain tissue that controls important functions such as speech and motor skills. Surgeons must be very careful not to remove healthy tissue around those areas but to resect as much tumor as possible without affecting function. That’s where ioMRI, an image-guided neurosurgery technology, has proven to be extremely useful. ioMRI is used in conjunction with neuronavigation – together they help create accurate images of the brain during surgery, leading to impressive results.

**Insight into the Surgeon’s Work**

Through the gallery window, we can look into the operating room as Dr. Zhou performs brain surgery on a patient. This is the department’s 1,017th operation with ioMRI. Today’s patient is a 27-year-old man who suffered from a seizure a month before and has been diagnosed with a right frontal low-grade glioma. A team of five doctors and nurses works together on the surgery, which can last from five hours to up to eight hours. The scanning procedure itself takes about a half hour in all. Giant screens on the walls of the operating room show the patient’s MRI brain scan.

Several other doctors are monitoring a bank of computer screens out in the gallery. One of them points out a distinct mass on the left side of the brain. “There’s residual tumor,” he says. That clear brain map is possible due to the intraoperative MRI scanner system that is used once or, in some patients, twice during the surgery to give the surgeon a precise update on the progress of resecting the tumor. This is just one of the many maps MRI is able to produce to support brain surgery.

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Neurosurgery Department Chair Dr. Liang-fu Zhou (above); a patient’s brain scan (below)
surgery. Other computer screens show a bright rainbow of colored nerve tracts intersecting each other like the traffic on Shanghai’s busy highways. This so-called tractography, as well as other techniques, such as Intraoperative Neurophysiological Monitoring (IONM), electroencephalograms (EEG), blood oxygen level dependent signal (BOLD), or functional MRI, help the surgeons resect enough tissue to remove the tumor while avoiding damage to neuronal tracts that are part of the control system of important body functions like speech and motor skills. This is what surgeons want: to resect as much non-functional tumor tissue as possible while leaving as much functional, healthy tissue as possible. This is crucial for a patient’s fast recovery with minimal rehabilitation. But making those detailed cuts is particularly hard in the brain. The iOMRI helps surgeons to identify residual tumorous tissue and tells them whether they have resected enough or could resect further.

Benefits of iOMRI
Dr. Bernd Hofmann, Neurosurgeon and Head of the Clinical Competence Center Neuroscience at Siemens says, “The most important thing is that you get immediate feedback about the extent of removal, the success of your procedure, and the prognosis of the patient.” According to Dr. Zhou, 3T iOMRI has been an amazing tool benefiting both the hospital’s patients and doctors. “This is more accurate than conventional neurosurgery with or without neuronavigation,” says 72-year old Zhou, who has been leading the department for more than 30 years and remembers each new radical development in image-guided neurosurgery that the department has adopted. Of course, he adds, a surgeon’s experience is crucial and irreplaceable. He quotes Dr. Lars Leksell, the founding father of radio-surgery: “A fool with a tool is still a fool” and adds, “a surgeon should be a master rather than a slave of a tool.”

Removing as much tumor as possible is key, Dr. Hofmann from Siemens agrees. “We can’t cure the patients, but [we can] prolong their survival. We know from the scientific evidence that the patient can survive longer if you take out more tumor.” Studies show that only from a 98% tumor removal upwards, survival rates are increased significantly.

One advantage of iOMRI is that it can alert the surgeon to brain shift, which conventional neurosurgery with or without neuronavigation cannot. Brain shift is the tissue deformation and shift that occurs during neurosurgery when the removal of a tumor results in a loss of the spatial relation established between the patient (brain) and the MR/CT image volumes acquired prior to surgery. It can have a major impact on the safety and accuracy of the surgery, Dr. Zhou says, but updated brain images from an iOMRI scan combined with neuronavigation can help the surgeon compensate for brain shift and modify surgical strategy. “Intraoperative MRI is the most useful and preferable tool right now because it can detect the brain shift during surgery, so the surgeon can correct the strategy. Then the surgeon can remove more of the tumor.” He calls the method “maximum safe tumor resection” and says it is showing to be useful in real-time tumor resection control and accurate functional preservation.

Solutions for an Intraoperative Neurosurgery Setting
There are a variety of different solutions for hospitals wanting to incorporate an iOMRI system. Siemens offers two alternatives for providing patients with MRI for intraoperative neurosurgical imaging method during surgery.

Shanghai’s Huashan Hospital is one of five IMRIS VISIUS Surgical Theatre installations in China, where a Siemens MRI on a ceiling rail is moved between the OR and an adjoining diagnostic imaging room. This has the benefit of ensuring that the patient does not suffer from unnecessary movement, limits the risk of brain shift in the imaging, and also optimizes the use of the scanner, since it allows the equipment to be used for other patients while surgery is in progress next door.

Another solution for neurosurgery from Siemens, is the MAGNETOM® Combi Suite Neurosurgery, specially designed to combine state-of-the-art MRI imaging technology with safe and efficient transfer of the patient between the operating table and the MRI. The facilitator of this transfer is the Combi Dockable Table, enabling single patient transfers each way with direct docking of the table with the MRI system. This flexible solution is compatible with selected OR tables from MAQUET and TRUMPF and enables cost-efficient use of the MRI for standard diagnostic as well as intraoperative imaging supporting one or more operating theatres.
Within the surgical setting, the surgeons can perform an MRI of the brain to keep track of their progress and additional resection may take place if needed within the same surgical procedure. At Huashan Hospital, each patient is intraoperatively scanned an average of 1.88 times within the intraoperative setting. When clinically feasible, additional resection may occur based on the MRI results. The patient operated on today was only intraoperatively scanned once, because the scan showed that the tumor had been totally removed on the first attempt.

**Groundbreaking Research**

The department integrated intraoperative MRI into their surgical setting in 2010. Currently, Huashan is the only department with an ioMRI suite in Shanghai and one of only ten throughout China. Dr. Xiaodong Zhuang, an associate professor in the department, is part of the team of doctors working on this surgery. “It costs more money, it takes more time initially, but it benefits the patients,” he says. It might take a bit more time initially, but both Dr. Zhuang and Dr. Zhou agree that it saves the patient from early relapses and second surgeries due to residual tumor tissue. Dr. Zhou adds, “Using ioMRI benefits the patients because it means that more of the tumor is resected the first time around. And this is good for the hospital too, because patients don’t come for return surgeries.” The hospital has seen another benefit in that it can use the ioMRI system for other nonsurgical scanning purposes as well.

But the impact of Huashan’s Neurosurgical Department’s work extends beyond the individual patients’ prognosis. The Neurosurgical Department stands out for the groundbreaking research they have conducted on the role of ioMRI combined with neuro-navigation in improving extent of resection of gliomas. From 2010 to 2012, a 15-member team led by Dr. Jin-Song Wu began a clinical study on the use of 3T ioMRI with neuro-navigation on 373 patients. The research team measured results and followed up with patients for three months after surgery. The preliminary results released last year in an article in *Chinese Medical Journal* show a marked improvement for 161 patients with cerebral gliomas who underwent surgery using the intraoperative...
MRI method. Before intraoperative MRI surgeries, there was 55.90 percent gross total resection rate. With use of ioMRI, the gross total resection rate was 87.58 percent, a marked improvement. The ratio of benefit in extent of resection was 39.13 percent. 158 of the 161 glioma patients accomplished follow-up at 3 months postoperatively. 12.42 percent suffered from early motor deficit after surgery; late motor deficit was, however, observed in 3.16 percent. 13.04 percent had early speech deficit and only 3.80 percent displayed late speech deficit. In the article, the doctors wrote, “We believe that 3T ioMRI provides neurosurgeons with dynamic functional and anatomical maps of brain structures, which improves the overall accuracy and safety of surgery, and helps decrease permanent surgical morbidity.”

Award-Winning Value for Patients
Last autumn, when the team received the Journal of Neuro-Oncology Award, Dr. Wu was quoted in a press release as saying of ioMRI, “This leads to more improved progression-free survival and quality of life than using conventional neuronavigation. Although these are early results we believe they are showing trends to statistical significance and will be the highest level of ioMRI evidence for glioma surgery to date.” According to Dr. Ignacio Vallines, Head of MR collaborations for North East Asia at Siemens, “innovative approaches to combine imaging and therapy in an effective way are at the core of our R&D collaborative efforts with clinical research partners across the globe. We are proud to actively contribute to further develop the clinical and operational value of intraoperative MRI imaging together with Huashan Hospital.”

Although ioMRI requires a substantial initial investment and hasn’t yet been universally adopted, the team’s research is likely to have a strong

Management Summary

Challenge:
To maximize extent of tumor resection within the intraoperative setting while minimizing the impact on functional brain tissue.

Solution:
The 3T ioMRI Integrated Neurosurgical Suite at Huashan Hospital reveals residual tumors in the intraoperative setting and helps compensate for brain shift, enabling the neurosurgeons to achieve a higher extent of resection while minimizing impact on the patient.

Result:
Better treatment for the patient that leads to higher success rate and better hospital workflow. This means better management of brain tumor patients. The research results confirm the improved success of ioMRI for patients and could be the evidence needed to allow the technology to become more widespread.
impact on the spread of ioMRI use throughout the medical world. “Shanghai is the first site performing a prospective trial on a large number of patients which may fulfill all requirements to generate the evidence needed to successfully apply for reimbursement in countries granting reimbursement based on clinical evidence only,” says Dr. Hofmann. He adds, “They are doing what should have been done a long time ago but in early times of ioMRI we didn’t think about it.”

The story of how Huashan Hospital acquired their ioMRI suite is different from private hospitals around the world that have invested in the technology. While private hospitals may see a financial benefit of investing in an intraoperative MRI system, Zhou says that financial payoff was not a factor for his department: “This is a government hospital so we don’t consider profit. We’re one of the largest neurosurgical centers in mainland China. A lot of patients are coming here, not just VIPs, so the government has seen the benefit in providing this technology.”

Not just any hospital in China can invest in one of these systems, because import licenses are hard to qualify for and can take a long time to process. Instead, the Ministry of Health selects leading hospitals to test out experimental technology in order to evaluate its usefulness as a tool. With such favorable results from the Huashan study, the government may issue more import licenses or even prioritize usage of the technology in the government’s next five-year plan.

Wide-reaching Ripple Effects
Looking at surgery success rate and benefit to patients, doctors, and hospitals is important to assess an experimental method. Taking these factors into account, incorporating intraoperative MRI might just trigger the start of a wide reaching ripple effect. Better treatment for the patient can mean a better hospital workflow, fewer follow-up surgeries and lower mortality rates. The farthest reaching ripple is the cost to society. When tumors are resected as precisely as possible the first time around, this will not only benefit the patient, it will also likely benefit the health system, as long-term cost will drop.

In the end, that may be another impact of Huashan Hospital’s work. The research results confirm the improved success of the ioMRI method for patients and could be the evidence needed to allow the technology to become more widespread. And that will have an immeasurable impact on global society as patients benefit from higher total resection rates and both the emotional and financial cost of taking care of patients is reduced.

Rebecca Kanthor is an independent journalist based in Shanghai. Her work has appeared in Nature, Scientific American, and on Public Radio International, CBC Radio, and the BBC.

1 Lacroix M et al, JNS 2001
2 Chin Med J 2012;125(24):4328-4333
3 Clinical Neurosurgery, Vol 61, No. 1, Aug. 2014
4 The products/features (here mentioned) are not yet commercially available in the US and some other countries. Due to regulatory reasons their future availability cannot be guaranteed. Please contact your local Siemens organization for further details.

The statements by Siemens’ customers described herein are based on results that were achieved in the customer’s unique setting. Since there is no “typical” hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption) there can be no guarantee that other customers will achieve the same results.
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