One-of-a-Kind Surgical Research Facility Uses Advanced Imaging Technology to Promote Innovation and Problem-Solving in the Operating Room

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Surgical visibility and precision are critical to a successful patient outcome — particularly during procedures where a few millimeters can mean the difference between life and death, cure and recurrence, or physical ability and permanent disability. And even in today's advanced operating rooms (ORs), surgeons often find themselves limited by what they are unable to see, such as difficult-to-visualize anatomy or evidence of disease.

At Dartmouth-Hitchcock, we've taken steps to solve these problems by constructing a leading-edge Center for Surgical Intervention (CSI) — one of the few specialized operating rooms of this kind in the United States. Our revolutionary surgical research facility is prioritized for translational research and equipped with the latest, moveable intraoperative 3D imaging technology designed to improve visibility during surgery and promote the development, testing, and validating of pioneering surgical techniques.

About the CSI

Dartmouth-Hitchcock's CSI was developed in collaboration with the Geisel School of Medicine and the Thayer School of Engineering at Dartmouth College, and was funded in part by the National Institutes of Health. The facility contains two operating rooms and two procedure rooms.

The CSI is equipped with moveable MRI and CT machines, as well as fluoroscopy, robotics, and surgical navigation. These advanced tools provide our surgical teams with access to advanced 3D imaging capabilities that can be used right inside the OR — without the need to transport the patient elsewhere.

As a result, our surgeons can provide more precise and comprehensive surgical care for complex cases and work to develop novel surgical approaches that incorporate the latest imaging-based technology. Our surgical teams are currently conducting a range of promising research studies that will advance the field of surgical care.

Intraoperative Innovations in Brain Tumor Excision

The CSI is allowing Dartmouth-Hitchcock physicians to find new ways to deliver better, safer, and more efficient surgical care, particularly in the field of neurosurgery and neurosurgical oncology.

Specifically, our surgical teams are exploring ways to more precisely delineate the margins of brain tumors using fluorescence-guided surgery — which allows for maximum tumor removal with minimal damage to the surrounding healthy tissue. With particular relevance to the treatment of infiltrative brain tumors, new fluoroscopy techniques could translate to higher survival rates, improved surgical outcomes, and better quality of life for patients.

By analyzing how different *in vivo* fluorescent markers are absorbed by different types of brain tumors, our surgeons hope to find better ways to highlight brain tumor margins and improve resection rates and diagnostic methods.

In one study, Dartmouth-Hitchcock researchers found that ABY-029 was 91 percent accurate when used to enhance the visibility of $EGFR^+$ tumor margins under *ex vivo* imaging during tumor excision surgery. The same study found that protoporphyrin IX (PpIX) could be used to enhance the visibility of wild-type tumor margins with 87 percent accuracy, and also suggested that paired use of PpIX and ABY-029 may offer complementary enhancement.

Another study by Dartmouth-Hitchcock researchers found that when quantitative detection methods are used, the diagnostic performance of aminolevulinic acid (ALA)-induced PpIX fluorescence in low-grade gliomas (LGGs) approaches the accuracy associated with visual fluorescence in high-grade gliomas (HGGs). Previous studies of ALA-induced PpIX fluorescence in HGG resection have shown an increase in the likelihood of complete resection and improvement in progression-free survival rates. Although PpIX accumulation in LGGs is below the detection threshold of current visual fluorescence technology, this study determined that efforts to develop new quantitative fluorescence methods may be beneficial in future tumor margin detection for patients with LGGs.

Image-Guided Spinal Surgery

In addition to investigating how fluoroscopy can be used to improve brain tumor resection procedures, Dartmouth-Hitchcock's neurosurgery teams have also utilized the CSI to investigate new ways to improve image guidance used during spinal surgery.

Current methods of spine registration for image guidance have several limitations related to accuracy, efficiency, and cost. Intraoperative stereovision (iSV) has been studied extensively in cranial and other surgical applications, so our team conducted a study to explore how the technique could be applied to spinal surgery.

iSV uses digitized images obtained after surgical exposure to co-register the spine with preoperative images. In a study of porcine spines, Dartmouth-Hitchcock researchers determined the pre- and post-laminectomy target registration error (TRE) and found that the overall mean accuracy of the registration was 2.21 mm — even when bony anatomy was partially obscured by soft tissue or when a partial midline laminectomy had been performed. Dartmouth-Hitchcock researchers, therefore, determined that although the use of iSV in human spine surgeries may introduce other factors that may affect registration accuracy, stereovision nonetheless offers a promising means of registering an open, dorsal spinal surgical field that warrants further investigation.

Advanced Epilepsy Surgery

The intraoperative MRI access at Dartmouth-Hitchcock's CSI also enables our neurosurgery team to offer a new treatment called laser interstitial thermal therapy (LITT) for people with medication-resistant epilepsy. Using a precisely targeted laser and MRI guidance, our surgeons can perform minimally invasive laser ablation on the area of a patient's brain that is causing seizures.

To protect patients during surgery, real-time MRI guidance allows the neurosurgery team to monitor the laser's temperature, as well as the temperature of the brain. This advanced monitoring also ensures that only the target area is treated, sparing surrounding normal brain tissue.

Although research on the long-term outcomes associated with LITT is limited, the procedure has been shown to provide an efficient alternative to typical epilepsy surgeries — which require an incision, hours in the OR, and the surgical removal of brain tissue. Patients treated with LITT also experience shorter hospital stays and faster recovery compared with traditional epilepsy surgery. MRI-guided LITT demonstrates promising outcomes with low rates of complications for patients with epilepsy.

Accomplishing Its Mission

Since its inception in 2013, Dartmouth-Hitchcock's CSI has enabled surgeons to accomplish the mission of improving patient safety, providing more comprehensive surgical care for a range of conditions, and accelerating new surgical treatments for challenging cases.

Our team looks forward to utilizing the CSI to perform bench-to-bedside investigations that allow us to explore new techniques and advance the field of surgical care across a range of disciplines.