NATIONAL INSTITUTE OF BIOMEDICAL IMAGING AND BIOENGINEERING

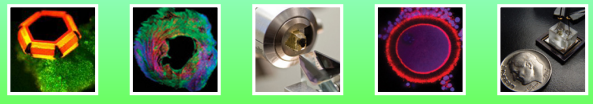


Image-Guided Robotic Interventions

National Institutes of Health

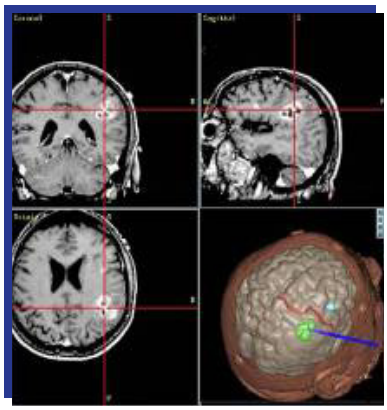
What are image-guided robotic interventions?

Image-guided robotic interventions are medical procedures that integrate sophisticated robotic and imaging technologies, primarily to perform minimally invasive surgery. This integrated technology approach offers distinct advantages for both patients and physicians.

Imaging: In image-guided procedures, the surgeon is guided by images from various techniques, including magnetic resonance (MR) and ultrasound. Images can also be obtained using tiny cameras attached to probes that are small enough to fit into a minimal incision. The camera allows the surgery to be performed using a much smaller incision than in traditional surgery.

Operating room with multiple imaging capabilities

Robotics: The surgeon's hands and traditional surgical tools are too large for small incisions. Instead, thin, finger-like robotic tools are used to perform the surgery. The movement of the robot's "fingers" is controlled remotely by the surgeon through a tele-manipulator, which can be controlled by hydraulic, electronic, or mechanical means. As the surgeons watch the image on the screen, they direct the robotic hands and fingers to make the desired movements.



Images help target exact site of intervention

Robotic tools can also be controlled by computer. One advantage of a computerized system is that a surgeon could potentially perform the surgery from anywhere in the world. This type of remote surgery is currently in the experimental phase. The experiments illustrate the life-saving potential for such surgeries in remote areas, particularly when a delicate operation requires a specially trained surgeon who is in a distant location.

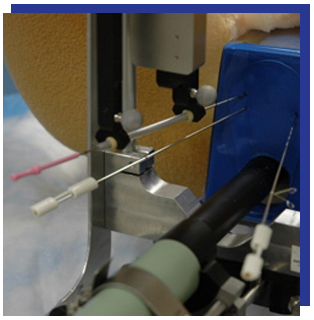
Additionally, doctors can use image-guided robotic interventions to more accurately target tumors when performing biopsies and radiation treatments.

What are the advantages of minimally invasive procedures?

Minimally invasive surgery can reduce the damage to surrounding healthy tissues, thus decreasing the need for pain medication and reducing patients' recovery time. For surgeons, image-guided interventions using robots also have the advantage of reducing fatigue during long operations, allowing the surgeon to perform the procedure while seated.

What are some examples of image-guided robotic interventions and how are they used?

Robotic prostatectomy: Complete prostate removal is performed through a series of small incisions, compared with a single large incision of 4 to 5 inches in traditional surgery. The small incisions result in a shorter post-operative recovery, less scarring, and a faster return to normal activities.



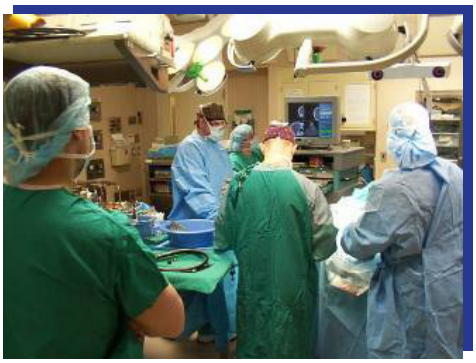
Ultrasound-guided robotic prostate surgery

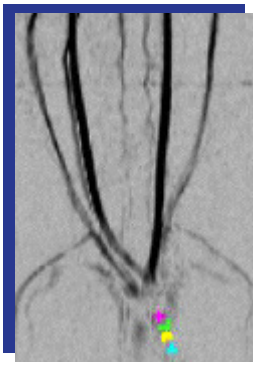
Ablation techniques for early cancers: Patients with early kidney cancer can be treated with minimally invasive procedures to destroy small tumors. Cryoablation uses cold energy to destroy the tumors. Doctors use computed tomography (CT) and ultrasound imaging to position a needle-like probe within each kidney tumor. Once in position, the tip of the probe is super-cooled to encase the tumor in a ball of ice. Alternate freeze/thaw cycles kill the tumor cells. Other minimally invasive methods of destroying early kidney cancers include heating the tumor cells, and surgical removal using a robotic device. Many patients can go home the same day and are able to perform regular activities in several days.

Orthopedics: Image-guided robotic procedures are improving the precision and outcome of a number of orthopedic procedures. For example, partial knee resurfacing surgeries aim to target only the damaged sections of the knee joint. Orthopedic surgeons are combining the use of a robotic surgical arm and fiber optic cameras in such procedures, which results in patients retaining more of their normal healthy tissue. Image-guided robotic procedures also improve total knee replacements, allowing precise alignment and positioning of knee implants. The result is more natural knee function, better range of motion, and improved balance for patients.

What are NIBIB-funded researchers developing in the area of image-guided robotic interventions to improve medical care?

Miniature Robot Traverses the Brain to Remove Tumors.
NIBIB-supported researchers have developed a Minimally Invasive Neurosurgical Intracranial Robot (MINIR) for the removal of brain tumors. Based on lessons learned from the original prototype, the improved MINIR-II is under the direct control of the physician, using images obtained by magnetic resonance imaging (MRI) sensors embedded in the robot. Additional features built into the robot include irrigation, suction, and tumor removal capabilities. The use of MRI will allow development of a tracking and navigation system that enhances the surgeon's view of near and distant structures inside the brain for accurate targeting and removal of the tumor. The robot will also be a disposable, single use device. The researchers hope to initiate clinical trials with MINIR-II in several years.





Magnetic resonance image guides surgical tools (black) to blood clot (color)

Ultra High Tech Scope Stretches Reach of Minimally Invasive Procedures.
An endoscope is a long thin tube with a light and a camera attached, and is used to examine an organ or body cavity. It can be used for biopsies, often assisting in the diagnosis of cancer or other conditions. Researchers are developing an ultrathin (1-2 mm diameter, about the depth of a penny) scanning fiber endoscope with simultaneous 2D and 3D imaging. These novel capabilities will allow physicians to perform a broad range of minimally invasive procedures that were previously not possible. Such surgeries include precise manipulation of delicate organs in the middle and inner ear, and the optic nerves. In addition, the device can be used to create pre-operative 3D images for diagnostic purposes.

An Advanced Remote System for Breast Tumor Biopsies and Ablation.
NIBIB-supported researchers are combining advanced technologies for breast tumor biopsies and tumor ablation. Breast images are obtained using MRI, which has superior capability to image soft tissues. A remotely operated robotic arm guides needle insertion for biopsy and tumor ablation. The device constantly sends high-sensitivity touch feedback to the surgeon operating the robotic arm, which allows precise needle insertion and reduced damage to surrounding healthy tissue. The improved system will use radiofrequency (RF) ablation to destroy tumors. The radiofrequency waves passing through the inserted needle rapidly heat and destroy the tumor. Because radio waves do not stimulate surrounding nerves, RF can be performed without the need for general anesthesia. The new system provides improved accuracy, less damage to surrounding healthy tissues, and reduced discomfort for the many women who must undergo these procedures.

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