ORevolution

Small incisions, instrument miniaturization, high-definition cameras, robotic technology ... Surgery is being revolutionized, all for the benefit of patients.

BY STEVEN K. WAGNER

MEDICINE AND TECHNOLOGY have always been intimately connected: from artificial limbs found on ancient Egyptian mummies to the pacemaker, this is a field historically steeped in invention and instrumentation. For centuries, the thrust in surgery has been to do more—more safely and effectively—in order to save lives. But the past two decades have seen the technological emphasis shift to how much more we can do with less. The same advances in technology that have changed the way we watch movies, listen to music, or drive a car are also changing the way surgery is conceptualized, performed, and experienced.

Eighty percent of all surgeries performed at Cedars-Sinai are minimally invasive—and the percentage continues to increase. Minimally invasive procedures have literally transformed cardiac, gastroenterologic, colorectal, thoracic, orthopedic, and gynecologic surgery. This elegantly efficient approach to repairing the human body is evidently a great improvement on traditional, open-incision operations: Minimally invasive surgical procedures have reduced hospital stays, recovery times, cost, and pain for patients.

In laparoscopic surgery, long, thin surgical instruments and a rod-shaped telescope are inserted through several small incisions in the skin. The surgeon manipulates the tools externally while viewing the surgical site, magnified many times, on a video monitor. Because most of the body's internal organs can now be examined, removed, biopsied, or repaired without large incisions and long hospital stays, laparoscopic techniques have revolutionized many common and not-so-common surgical procedures. Even elderly and frail patients who might be considered poor candidates for open procedures and general anesthesia may benefit from the more easily tolerated laparoscopic approaches.

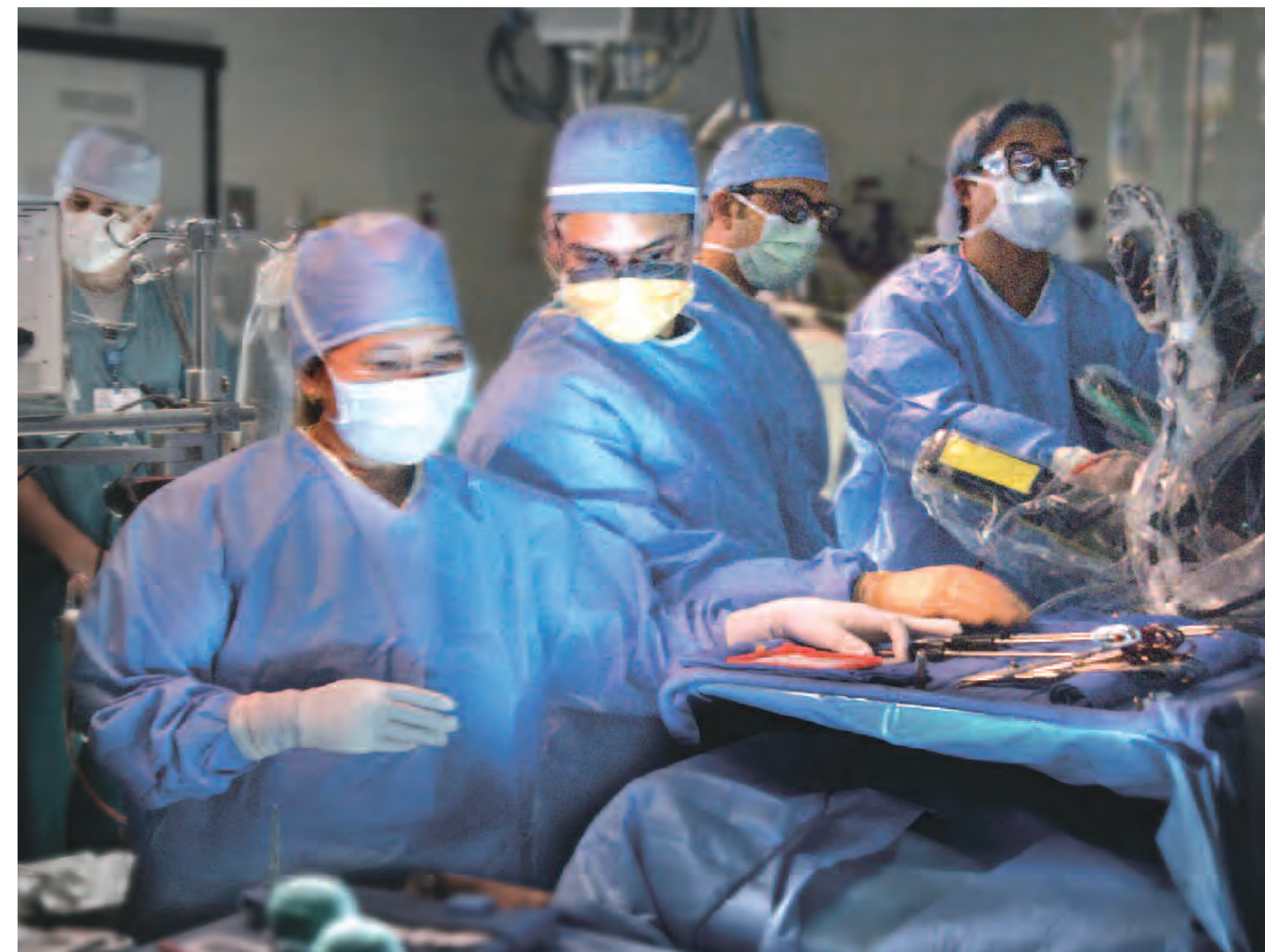


Photo: Medical Media Photo Department, Cedars-Sinai

Dr. Alfredo Trento (in background) and his surgical team perform a mitral valve procedure on a patient using robotic technology with the daVinci Surgical System (right).

In similar fashion, endoscopic procedures take advantage of high-resolution displays and miniaturized instrumentation. Long, flexible tubes fitted with fiber-optic technology are inserted into natural openings such as the esophagus and colon to evaluate tissues and organs, remove tissue for biopsy, and perform surgical procedures, such as the removal of growths (polyps) in the colon.

Many of the minimally invasive technologies that we now consider standard we owe to George Berci, MD, a world-renowned medical pioneer in endoscopy, fluororadiology, and laparoscopy. "He's a legend," says Sarah Lee, MD, a surgical fellow at Cedars-Sinai Medical Center.

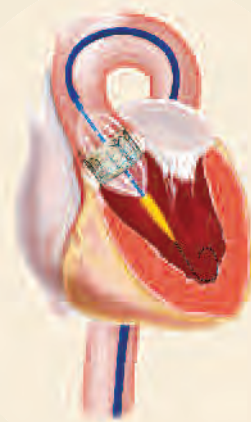
Since joining Cedars-Sinai in 1970 as head of its then-new Division of Surgical Endoscopy—one of the first such programs in the country—Dr. Berci has focused on research and training. Now 86, Berci is senior director of Minimally Invasive Surgery Research at Cedars-Sinai Medical Center; director of the Surgical Simulation and Training Laboratory, where residents hone their minimally invasive surgical techniques (see article page 18), and director of the Endoscopic Research Laboratory, where the focus is on future techniques and procedures.

His accomplishments speak volumes. Dr. Berci was instrumental in introducing a new endoscopic image-transmitting system, the Hopkins rodlens, into clinical practice following extensive research. Features of the system included increased light transmission, improved image quality, and miniaturization. He also led the introduction of diagnostic and therapeutic laparoscopy for gynecology on the West Coast.

Dr. Berci developed a laryngoscope that enables quick examination of the entire larynx in an outpatient setting; introduced the tele-otoscope, a device for examining the ears of pediatric patients; and introduced colonoscopy and endoscopy on the West Coast. Perhaps most importantly, he revolutionized operative radiology by introducing fluorocholangiography, an X-ray exam of the bile duct, as a key facet of biliary tract surgery.

HEART VALVE REPLACEMENT: New Minimally Invasive Procedure Shows Promise

Doctors at Cedars-Sinai Medical Center's Heart Institute recently performed the first "transcatheter" minimally invasive replacement of an aortic heart valve in the western United States.



The aortic valve controls blood flow from the heart's main pumping chamber into the body's largest arterial trunk. Stenosis (narrowing) at the valve reduces the outward flow of oxygenated blood and leads to congestive heart failure as the organ stretches to accommodate a greater-than-normal volume of blood. While replacement mechanical or biological valves can be implanted, this is traditionally done via open-heart surgery.

Transcatheter aortic valve replacement is accomplished in much the way blocked heart arteries are opened with balloon angioplasty and stents. A catheter containing a compressed balloon is inserted into a blood vessel at the groin and threaded up to the heart. The balloon is placed inside the damaged valve and inflated to open the narrowed area. A manufactured "stent valve" is then put into position, and the balloon is inflated to expand the valve. The catheter is then removed, leaving the new, functioning valve in place.

A team led by Raj Makkar, MD, and Gregory Fontana, MD, have now performed the procedure on several patients using a valve developed by Edwards Lifesciences Corp. Cedars-Sinai is one of 15 centers participating in a pivotal clinical trial of the device.

"Many patients with aortic stenosis are not being treated today because they are not considered good candidates for surgery," Dr. Fontana says. "Depending on the outcome of the clinical trial, this technology could open up a new approach to treatment for those who currently have few options."

— Sandy Van

WHILE MINIMALLY INVASIVE SURGERY is often likened to laparoscopic procedures, it encompasses much more. Cedars-Sinai is one of the few institutions currently using robotic technology in cardiac procedures—primarily to repair damaged heart valves.

"The robotic procedure results in less risk of infection, less blood loss, and faster posthospital recovery than traditional surgery ... It is truly amazing technology."

The mitral valve controls the blood flowing into the left side of the heart. When it is damaged, it cannot completely seal the heart's left ventricle. This forces the heart to work harder and may lead to complications like congestive heart failure.

Traditionally, surgeons have repaired mitral valves by sawing open the breastbone and spreading the ribs apart to expose the heart. With the robotic procedure, however, small, dime-sized incisions are made between the patient's ribs on one side of the chest. From a console a few feet away the surgeon views a high resolution 3-D image of the surgical site. The camera and two robotic arms are inserted through the incisions as the surgeon directs the arms from the console. The computer-enhanced system scales the hand movements of the surgeon down to micro-movements of the surgical instruments inside the patient's body. The system relays feedback sensations to the surgeon, providing a substitute for tactile sensation. Every surgical maneuver is controlled by the surgeon, but the robotic arms improve the surgeon's precision and ability to manipulate instruments in small spaces, helping to make the procedures even less invasive.

The daVinci Surgical System™ debuted at the hospital in 2003, and since then nearly 100 mitral valve procedures have been performed—all of them by Alfredo Trento, MD, director of the Division of Cardiothoracic Surgery.

Robotic technology allows surgeons to view the mitral valve in such a way that they gain a much better understanding of the valve's pathology when compared to traditional open-heart procedures. "We can actually see inside the valve," says Dr. Trento. "It is truly amazing technology."

In addition to improved visualization, Trento explains that the robotic procedure results in less risk of infection, less blood loss, and faster posthospital recovery than traditional surgery. "It is certainly a minimally invasive approach to valve surgery, with small incisions and a better outcome. And patients return to normal activities much more quickly."

The same highly advanced robotic equipment is also used to close certain holes in the heart and to repair defective tricuspid valves, and surgeons at Cedars-Sinai hope to soon begin using the system in coronary artery bypass surgery.

"This system is vital," says Dr. Trento. "It is essential for us to stay on the cutting edge with technology such as this—that is what keeps us performing to the best of our abilities."

PATIENTS WITH ATRIAL FIBRILLATION are also benefiting from a major advance in minimally invasive techniques. Atrial fibrillation affects more than two million Americans, according to the American Heart Association. Overactive and irregular nerve impulses cause the two upper heart chambers (the atria) to quiver instead of beating normally. This leads to a variety of complications, including a potential 25 percent reduction in the heart's pumping function and a high risk of stroke.

"Just in the past few years, we have made real progress in curing these patients," says Gregory P. Fontana, MD, a specialist in minimally invasive cardiothoracic procedures who serves as vice chairman of Surgery for Pediatric Surgical Services. One of the major advances is the use of the MiniMaze procedure, which is accomplished by placing a thoracoscope and thin instruments through several short incisions in the chest. The surgeon, viewing the surgical site magnified on a monitor, identifies the target area of the heart and uses short bursts of radio frequency energy to destroy a small amount of tissue and disrupt the overactive nerves that cause the rhythm disturbance.

"There are other minimally invasive maze procedures being attempted, but they appear to have lower success rates. We have been using that procedure for about two years and have had very good success with it, and so have other hospitals around the country," says Dr. Fontana, adding that Cedars-Sinai cardiothoracic surgeons are part of a national working group that is evaluating the technique.

Dr. Fontana has performed over 40 MiniMaze procedures during the past year. He and his colleagues at Cedars-Sinai are believed to have the most extensive experience with surgical AF treatment in the western United States.

"The procedure takes about an hour-and-a-half," Dr. Fontana says. "Patients are in the hospital for one to three days. We have had some patients back swinging a golf club within a couple of weeks."

Such innovations have kept Cedars-Sinai at the leading edge of minimally invasive surgery longer than any other medical center, according to Edward H. Phillips, MD, executive

Dr. Alfredo Trento has performed nearly 100 robotic mitral valve repair surgeries since 2003, a surgical volume that ranks fourth in the U.S. among cardiovascular surgeons who perform this highly skilled surgery.

vice chair of the Department of Surgery and Karl Storz Endowed Chair in Minimally Invasive Surgery in Honor of George Berci, MD. He is considered a leading surgeon, clinical researcher, and authority in laparoscopic surgery, a technique to which he was introduced by Dr. Berci. “When I was introduced to the technology here at Cedars-Sinai, I thought: ‘This is incredible. We should be able to do more with it.’ I started developing instrumentation, and we tried to apply the technology to every surgery in the abdomen and then, eventually, outside the abdomen.”

Dr. Phillips holds patents on several instruments he developed for use in minimally invasive surgical procedures, such as a suction/cautery/irrigation device. Cedars-Sinai’s physicians/researchers are also responsible for developing an effective video intubation device, performed the world’s first laparoscopic exploration of the common bile duct, and the world’s first minimally invasive splenectomy.

Although he enjoys creating and adapting laparoscopic instruments for new applications, Phillips emphasizes that the development of new tools is not an end in itself.

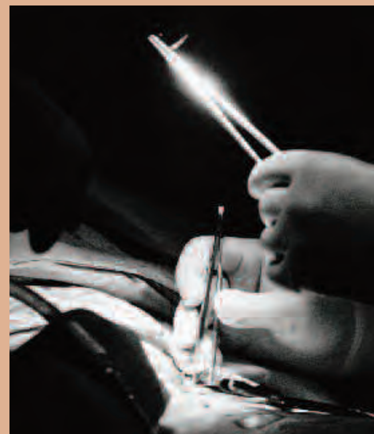
“We don’t just do technology for technology’s sake. We analyze the technology with an emphasis on clinical outcomes,” he says. “We look at all approaches with an open mind, with results to be supported by the evidence, and we follow our patients to see how they are doing. By analyzing and studying outcomes we can improve the preoperative evaluation and the actual operation so we can continue to provide the safest, most efficient, most appropriate surgery. And because we conduct clinical trials, our patients may have access to technologies and techniques that may not be available in other places. What we are doing is simply translating surgical research and advances into patient safety.”

PUTTING RESEARCH INTO PRACTICE

RESEARCH IS KEY IN THE EFFORT TO ENHANCE MINIMALLY INVASIVE SURGICAL TECHNIQUES. The Simulation and Training Lab, the Surgical Research Lab, and the Minimally Invasive Surgical Technology Institute allow scientists at Cedars-Sinai Medical Center to work closely with clinicians to develop a new generation of minimally invasive tools and techniques.

Collaborative work between these research laboratories and clinical departments is focused on the development, testing, and introduction of new noninvasive technologies into everyday surgical practice. Some of the technologies currently being investigated include:

- Using lasers and the natural fluorescence in tissue to instantaneously identify cancer on-site during minimally invasive procedures designed to confirm clear surgical margins and pave the way for faster treatment.
- Using the “operating room of the future,” where vital patient data is provided to surgeons as it becomes pertinent. Researchers are developing a patient safety algorithm that would identify relevant patient safety hazards used to alert physicians as they enter critical phases of an open or minimally invasive operation.
- Evaluating whether physicians can acquire more information visually and thus operate more safely using high-definition monitors to view patient anatomy. High-definition monitors are finding their way into minimally invasive surgery.
- Testing the behavior of the dominant and nondominant hands of surgeons. Early results have shown that the nondominant hand is often more efficient. This information that might eventually prove useful in training surgeons to more efficiently complete both open and minimally invasive procedures.



SMALL TOOLS, TINY PATIENTS

Pediatric Surgery Relies on Miniaturization and Small Incisions

SEVEN-YEAR-OLD BRADEN WAS BORN WITH pectus excavatum, also known as sunken or concave chest. As he got older and the condition worsened, he could not play with the kids in his class because he would easily tire and get out of breath. Today, his life is full of play—he enjoys baseball, swimming, and riding his bicycle—all thanks to a minimally invasive surgical procedure performed at Cedars-Sinai.

Traditional operations for children with pectus excavatum require a long incision across the chest, taking out ribs, and breaking the sternum. This aggressive surgery is extremely hard on the patient, and requires lengthy hospital stays and prolonged recuperation. But Steve Chen, MD, chief of Pediatric General Surgery at Cedars-Sinai, used a radically different minimally invasive technique to treat Braden.

The Nuss procedure begins with a “keyhole” incision of three to five millimeters in the armpit area to insert a scope. Through another small incision, an arch-shaped steel bar is inserted under the sternum, where the expected normal chest contour would be. The bar is left in place for about two years to reshape the chest wall, pushing it forward in the same way that braces realign teeth.

Each year at Cedars-Sinai, hundreds of minimally invasive surgeries are performed on children and babies just a few weeks old to treat congenital anomalies like pectus excavatum or traumatic injuries. “We are one of very few medical centers dedicated to exploring minimally invasive surgery for children,” says Gregory P. Fontana, MD. “Children are not small adults. They have very unique diseases and anatomical features, and they require very specific surgical tools and techniques to treat them.”

> “Children are not small adults. They have very unique diseases and anatomical features, and they require very specific surgical tools and techniques to treat them.” ~ Gregory P. Fontana, MD

Surgeons use robotic-assisted devices no larger than knitting needles. Instruments are scaled to the size of the patients, generally two to three millimeters in diameter, compared to 10-15 millimeters for instruments used on adults, and are only a little longer than Q-tips. Dr. Fontana likes to compare them to jewelers’ tools. Equally important, advanced imaging techniques can enhance the image of a tiny organ 100 times, with pristine clarity.

To decrease the size of incisions whenever possible (in small patients each incision dramatically increases the risk of infection or other serious problems), the surgical team works in partnership with researchers at Cedars-Sinai’s Minimally Invasive Surgical Technology Institute (or MISTI, see sidebar page 10) to develop new tools and procedures. Current research efforts are focusing on instrument miniaturization, imaging, and robotic technology. “Most robotic surgical equipment used today was designed for large beings,” says Dr. Fontana, “and we can’t simply scale it down for babies and children. We are working on re-engineering the equipment altogether.”

Dr. Fontana and the MISTI researchers are also developing specialized imaging for tissue analysis. “Because minimally invasive surgery utilizes instruments to enter the anatomic region to operate, surgeons are no longer able to use touch to determine what is healthy tissue and what is not. Tissue imaging allows the surgeon to remove only abnormal tissue.”

Dr. Fontana admits to feeling incredibly fortunate to be part of a dedicated and skilled team of pediatric surgical specialists, pediatric anesthesiologists, and researchers. “This is exciting and important work,” he says. Work that is making a lifetime of difference for the littlest patients, their families, and the community at large.

—Robin Heffler