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FEATURE STORY

Surgeons and Robots

BY BEVERLY A. CALEY

Minimally invasive technologies transform the landscape of cancer surgery.

"The future of cancer surgery is minimally invasive surgery," and the future of minimally invasive surgery is to move beyond the human hand and bring the power of computers into the operating room. That's the outlook according to Mani Menon, MD, a pioneer in the field of robotic surgery.

Surgery, often curative for early-stage cancer, has evolved with advances in technology, including flexible scopes that can be thread anywhere in the body and computer-assisted instruments that can make more precise movements than those made by the unassisted human hand. Minimally invasive surgery is the general term that encompasses any surgical procedure performed by making an incision smaller than that which would be made in a traditional, or open, procedure. Minimally invasive techniques are being used in numerous types of surgeries and for treatment of cancer virtually anywhere in the body, resulting in faster recovery times, shorter hospital stays, and less risk of complications.

Science Fiction Surgery

Dr. Menon, director of the Vattikuti Urology Institute at the Henry Ford Health System in Detroit, says, "Robotics is really a different way of doing surgery. What we're doing is merging the power of computers and information technology with the mind and the hands of the surgeon."

Robotic surgery, a concept first developed by NASA during the 1970s, can have dramatic benefits for today's patients. Dr. Menon recently operated on a kidney cancer patient who was diabetic, had survived a stroke, and had numerous other health problems. The surgical team removed his kidney robotically and the patient was able to go home just 12 hours later.

One early robot commonly used in cancer surgery was the automated endoscope system for optimal positioning, or AESOP. The first AESOPs allowed surgeons to control the robotic arm manually, with a foot switch or a hand control. Further

changes to the AESOP system resulted in the ZEUS robot, which combined an AESOP for holding a camera with two additional robotic arms to hold surgical tools. The ZEUS robot is now being phased out and a new robot, called the da Vinci Surgical System, is favored by today's surgeons.

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The da Vinci, the only surgical robot approved by the Food and Drug Administration, has two main sections: a control console and a surgical cart holding four robotic arms—one with a camera and the other three holding the surgical instruments. The camera provides a magnified three-dimensional view inside the patient's body, while the tiny surgical instruments are controlled by the surgeon using hand tools. The robot filters hand tremors, allowing for more precise control of fine movements than the human hand.

View Illustration: The da Vinci Robot

The da Vinci Robot

"You can use the robot to place the camera anywhere in the body, whereas in open surgery, you are just looking at what you can see from above," Dr. Menon says. In addition, software can be used to enhance images, block out colors, and adjust for minor points of bleeding.

Patients who have a robotically assisted prosta-tectomy have an average hospital stay of a little over one day compared with about three to four days for an open procedure. In addition, the use of the technique developed by Dr. Menon results in a return of erectile function within one year in 97 percent of patients compared with 74 percent with the conventional procedure.

This information was highly persuasive to Marlin Mallory. When he was diagnosed with prostate cancer in 2006 at age 43, he consulted two urologists. One strongly recommended a minimally invasive procedure using the da Vinci system, and the other strongly recommended an open procedure. "As an engineer, I seek information when I don't like the way things are." So Mallory studied the data and decided the robotic procedure was the way he wanted to go.

Dr. Menon says although he never directly sees or touches the patient, the device and procedure feels very natural. "Your sense of touch is actually enhanced, because visual cues from changes of tissue that can be seen on the monitor are much more sophisticated than actual touching. So you end up doing a much more precise operation because you see changes you never would have been able to see otherwise."

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Surgeons at the Vattikuti Urology Institute have used the da Vinci robot for 28 different kinds of procedures, including “every possible urological kind of cancer,” according to Dr. Menon. “We’ve used it to fix problems caused by radiation treatment in the bladder and vagina. When I see someone now who needs some kind of surgery, I ask my associates, ‘Can I do this better with the robot than I can do it open?’ Ninety-five percent of the time, the answer is yes. In the other 5 percent of cases, the procedure is so simple that the robot doesn’t add anything, or the procedure is so difficult that I don’t want to do it with the robot. It does take some time to develop these procedures.”

In addition to prostatectomy, the da Vinci system is routinely used for hysterectomy to treat cervical and endometrial cancer, gastric bypass, and mitral valve repair. The robot may soon be used for some bladder cancers as well as thoracic procedures.

Robotic systems have some drawbacks. Currently, about 400 facilities in North America have a da Vinci at a cost of about $1.5 million per robot with disposable equipment costs and annual maintenance fees included, according to da Vinci manufacturer Intuitive Surgical.

In addition, as with any surgical technique, complications can occur. Mallory made the 2,000-mile trip from Washington to Detroit for his prostatectomy, and things seemed to go smoothly. But after he returned home, a blood clot damaged the connection created between his urethra and bladder.

He had emergency surgery in Washington, but elected to go back to Detroit to complete treatment for the complications. “It wasn’t their fault; it just happened. I wanted nothing more than to be back in their capable hands for follow-up treatment,” he says.

Patient demand has led to more robotic surgeries in recent years, but for now, the impact on survival remains unknown, though data being compiled by Dr. Menon of more than 1,600 patients looks promising in terms of recurrence rates.

Hands-on Approach

Beginning in the 1990s, the use of laparoscopy began a transformation in cancer surgery. Laparoscopy makes use of a thin, tube-like instrument (a laparoscope) with a light and a lens for viewing, and tools used for removing tissue. Compared with open surgery, laparoscopy performed by the human hand results in similar benefits as that performed with the robotic hand—shorter hospitalization, faster healing, less scarring, and possibly less risk of short-term complications. Just

like any surgical technique, experience is key.

Surena F. Matin, MD, urologist at M.D. Anderson Cancer Center in Houston, helps lead the center's Minimally Invasive and New Technology in Oncologic Surgery program, known as MINTOS. Dr. Matin says when considering minimally invasive surgery, it's important to match the new technologies with what's appropriate to a specific kind of cancer or a specific organ system.

"We can apply minimally invasive techniques to, for example, tumors that arise in the skull base, lung cancer, kidney cancer, prostate cancer, and some of the gynecological cancers," he says. "These can be just as curative in appropriate cases as open surgery, but with the benefits of a minimally invasive approach."

Data from several colon cancer surgery studies showed the average length of an incision was 18 inches during open surgery, but just 6 inches during laparoscopic-assisted surgery. In addition, patients who had the laparoscopic procedure were hospitalized for one fewer day and took oral analgesics for one fewer day. For patients who have kidney cancer that has not spread beyond the kidney, laparoscopy usually also requires less recovery time and fewer days in the hospital. Traditional open surgical procedures for removal of all or part of a kidney involve making a 10- to 20-inch incision and sometimes require removal of a rib.

Several small incisions are made with laparoscopic surgeries. This can include one somewhat larger incision if it is necessary to remove an entire organ. A study of patients with kidney cancer showed those who had a laparoscopic procedure had half as much blood loss during surgery as those who underwent open surgery. For the laparoscopy group, the average hospital stay was two days with an average recovery time of four weeks compared with five days and six weeks, respectively, for patients who had the open procedure.

Laparoscopy has become the standard of care for most patients with early-stage or intermediate-stage kidney cancer, says Dr. Matin. In advanced kidney cancer, a role for open surgery still exists. A patient may have a high number of enlarged lymph nodes or kidney cancer that has spread into the veins as a solid core of tissue, and in those cases, laparoscopy is more difficult.

"If the procedure is anatomically more difficult, the surgeon may need to have a hand inside the body to guide the procedure by feel," Dr. Matin says. "In laparoscopy we are primarily guided by what we see. That is why the early-stage tumors are usually better suited for minimally invasive treatment with currently available technologies. But this is a rapidly evolving field, and it is sometimes just a matter of a new technology breaking a barrier or a creative individual applying a known technology in a new way."

Direct to Video

Rodney Landreneau, MD, surgical director of the Lung Center at the University of Pittsburgh Medical Center, performs many kinds of procedures designed to treat cancers of the lung, esophagus, and other areas of the chest. Dr. Landreneau and his colleagues also use minimally invasive techniques to diagnose and stage lung cancer.

In video-assisted thoracoscopic surgery, or VATS, the surgeon gets inside the chest cavity through two to four tiny openings between the ribs while viewing the inside of the patient on a video monitor. Each incision measures about 1 inch compared with the 6- to 10-inch incisions frequently needed in open thoracic surgery. Using a narrow tube-like instrument called a trocar, the surgeon gains access to the chest cavity through a space between the ribs. An endoscope (a tiny scope connected to a video camera) is inserted through the trocar, giving the surgeon a magnified view of the patient's internal organs on a television monitor.

Studies of patients with lung cancer have demonstrated significant advantages of VATS procedures. One study found VATS-treated patients were hospitalized for an average of 5.3 days compared with 12.2 days for patients who had an open procedure. The study also found VATS-treated patients returned to their normal activities in an average of 2.2 months, while patients who underwent open surgery needed 3.6 months to recover. A separate study found 14 percent of VATS-treated patients had complications compared with 50 percent of those who underwent an open approach.

Laser Technology

In the past, treatment of head and neck cancer often involved radical surgery to remove the larynx (voice box). Patients sometimes lost the ability to speak and often needed a stoma (opening in the neck) to breathe. These factors resulted in a trend away from surgery and toward treatment with chemotherapy and radiation.

But chemotherapy and radiation carried their own side effects. Many patients still had difficulties with speech and swallowing, even though the larynx and pharynx (throat) were preserved. That motivated head and neck surgeons to explore minimally invasive surgeries, including transoral laser microsurgery—laser surgeries performed through an open mouth rather than by cutting through the neck. (Brain surgery through the nose is also being tested.)

Researchers are combining the da Vinci with surgical lasers. Dr. Holsinger envisions surgeons will soon be able to perform procedures that "20 years ago we couldn't imagine."

According to Chris Holsinger, MD, one of Dr. Matin's colleagues in the MINTOS program, transoral laser microsurgery is an exciting step in the evolution of treatment for early head and neck cancer. "For a solid tumor, if you can remove a tumor with good margins, you are going to cure the patient. In the past, we had to choose between curing the patient and subjecting them to a very morbid procedure to obtain that margin. Now that choice is no longer necessary," he says.

Dr. Holsinger says the side effects associated with radiation to the head and neck include dry mouth, loss of taste, and a remote risk of second tumors. "In selected patients, transoral laser microsurgery can spare radiation and potentially eliminate these side effects."

The procedure is done using a carbon dioxide laser beam as the extremely precise cutting instrument, along with specially designed endoscopes to view the larynx and pharynx. Dr. Holsinger says the development of the laser was an important advance because its precision limited damage to surrounding tissue. In addition, going through the mouth, rather than cutting through the throat, preserves the nerves, blood vessels, and muscles that surround the larynx and are crucial for speech and swallowing. “If this transoral laser microsurgery can preserve function and achieve equal tumor control, then that patient is the perfect candidate for this treatment.”

Technologies to take this one step further are already in the testing stage, says Dr. Holsinger. Researchers are combining the da Vinci robotic system with surgical lasers. Using a recently developed fiberoptic carbon dioxide laser using photonic band gap technology, it will be possible to “contour the resection in a very complex, three-dimensional way,” Dr. Holsinger says. He envisions surgeons will soon be able to perform procedures that “20 years ago we couldn’t imagine.”

Training Surgeons

Surgeons who first developed minimally invasive procedures had to train themselves, says Dr. Landreneau. Younger physicians frequently receive training in minimally invasive surgery as part of their basic medical school education.

Virtual reality and simulator training are used to train future surgeons in the increasingly complex procedures that make use of the latest technology. Simulator training helps trainees develop the skills needed to perform procedures in the three-dimensional reality of the body while viewing a two-dimensional image on a screen. Virtual reality training allows surgical instruments to contact “virtual” tissue, giving the surgeon tactile feedback, similar to how tissue and blood vessels actually feel and react in actual surgical situations.

Small studies have compared the performance of surgeons who were trained using virtual reality with those who were not. The surgeons in one study who were not given virtual reality training were five times more likely to damage an organ or burn non-target tissue.

Dr. Menon associates learning to use the da Vinci robot to learning to play tennis. “You can pick up a tennis racket and learn to hit the ball across the net fairly quickly. But if you want to be a world champion in tennis, you need hours and hours of practice. Likewise, you can sit at a console and learn how to use the instruments fairly quickly, but to understand the subtleties of the robot requires a lifetime of experience.”

Technological advances have vastly expanded the surgical options for cancer treatment, but they have not made old-fashioned human touch obsolete.

Once Mallory narrowed his options to four centers that offered a robotic procedure for minimally invasive prostatectomy, he contacted Vattikuti Urology Institute by telephone. “This was as impressive as anything in the world—a real person answered,” he says. Mallory admits to being “a nervous wreck” at the time, and he chose the Vattikuti Urology Institute in part because the person he talked with was “compassionate and warm.”

Not just the new minimally invasive technologies, but the human beings who use them, are what will make the difference for cancer patients, today and in the future.