



Scalpel, Forceps, Joystick:

Surgeons Turn to Robots
for Minimally Invasive Procedures

In the past decade, surgical departments at more than 1,500 hospitals worldwide have welcomed a 7-foot-tall member to their team. With four arms and a 1,000-pound frame, the newcomer does not resemble any other surgeons – because it is not a surgeon at all, but instead a surgical robot.

Called da Vinci and designed for use in minimally invasive surgeries, the sole FDA-approved robotic surgical system has seen exceptional sales growth since its introduction in 1999. Intuitive Surgical, maker of da Vinci and the only official source of data related to the system, reports that in 2009, 73,000 American men had robotic-assisted prostate cancer surgery – the most common robotic-assisted procedure. Seven years earlier, fewer than 5,000 prostate cancer patients used the option; the year the system debuted, fewer than 1,000 did.

“Very few medical tools have taken hold in the medical community as quickly as this one,” said Sean R. Tunis, MD, director of the Center for Medical Technology Policy, a nonprofit organization that evaluates medical technology.

Despite widespread acceptance, robotic-assisted surgery still draws controversy. The equipment comes at a high cost, and no evidence-based studies have confirmed whether surgical robots produce superior, inferior or equivalent cancer control when compared to pure laparoscopic procedures. Physicians across the country continue to debate the advantages and disadvantages the da Vinci system presents for both clinicians and patients.

“There is a deeply held view across society that the latest technology is by definition the best and safest,” Tunis said. “But with robotic surgery, in reality, we have no idea if that’s true.”

Does Newer Mean Better?

During robotic-assisted procedures, a surgeon sits at a console about 10 feet away from the patient, and the robot sits next to the patient. The surgeon, his fingers in Velcro rings connected to a master controller, operates the robot’s four arms – three for manipulating medical instruments and one for an endoscopic camera. The console shows 3-D images of the surgical area.

These images, according to many physicians, give robotic-assisted procedures an edge over pure laparoscopic procedures.

“Laparoscopic and robotic surgery provide many of the same benefits: smaller incisions, less bleeding and quicker recovery than with open surgery. But with pure laparoscopy, the loss of 3-D visualization is a major drawback,” said Costas D. Lallas, MD ’98, associate professor in the Department of Urologic Surgery and director of robotic surgery at Jefferson. “A high-definition screen that magnifies the surgical area 10 times means I can see anatomy with the robot that I would not be able to see with my naked eye – and that makes for a more precise operation.”

Laparoscopy also involves what Bhavana Pothuri, MD ’95, director of robotics for obstetrics and gynecology at New York University’s Langone Medical Center, calls “counterintuitive movements.” To move the tip of a laparoscopic instrument to the left, a

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Bhavana Pothuri, MD '95

surgeon must move the end outside the body to the right.

“The robot enables a more dexterous, wrist-like motion rather than the more rigid movements of regular laparoscopic instruments,” Pothuri said. “And it filters out hand tremors while basically turning my hands into tiny instruments that can maneuver in spaces where no human hand normally would.”

Surgeons accustomed to spending hours on their feet often welcome the robot’s comfortable console, which features cushioned armrests and a contoured head rest.

“The ability to sit down keeps me from getting tired during long cases,” said Sangeeta Senapati, MD '01, assistant professor of obstetrics and gynecology with NorthShore University Health System in Illinois.

Despite its advantages, robotic-assisted surgery sparks enough debate that some surgeons – like Gerald L. Andriole Jr., MD '78 – refuse to use the technology.

“I’ve performed many robotic-assisted surgeries but now only do pure laparoscopic surgery. I want my hands on the instruments; I want to do all the cutting and sewing myself. With mechanical arms between me and my instruments, I have no tactile feedback – a crucial loss,” said Andriole, chief of urologic surgery at Washington University School of Medicine in St. Louis.

To compensate for the loss of force feedback, surgeons must rely on their other senses, primarily sight, to gauge various feats, such as when a suture is perfectly tied.

“With the robot, I cannot feel how much pressure the scissors must exert in order to make a cut or how hard the robot is squeezing forceps or pushing on a needle,” Andriole said. “Critical intra-operative decisions are made based on the ease with which tissue can be dissected, and I have precious little information if I am using a robot.”

Andriole also emphasized that robots are only as skilled as the surgeons controlling

them. “Overall, the robotic system adds no expertise and simply replicates the movement of the physician’s hands,” he said.

Perhaps the most serious of the disadvantages, Andriole said, is cost.

The Economics

With a price tag of about \$1.2 million – or \$1.75 million for a more sophisticated version introduced in 2009 – the da Vinci system also brings disposable supply costs of \$1,500 to \$2,000 per procedure, far more than pure laparoscopy. And further academic research is needed to examine whether robotic-assisted surgery produces better outcomes for patients than standard laparoscopic procedures.

One four-year national study of Medicare prostate cancer patients did indicate that procedures using the robot could lead to fewer in-hospital complications, but the trial lumped pure laparoscopy patients among those who had robotic-assisted surgeries, muddling conclusions.

To determine whether the more than \$100 million the U.S. healthcare system spends annually for robotic-assisted surgeries makes sense, \$1.1 billion was included in the 2009 economic stimulus package for research comparing robotic-assisted surgery results to other methods.

“Although we currently know of no difference in cancer control with the robot, we see over and over that patients who have robotic-assisted procedures are discharged earlier, need fewer pain meds and return to work more quickly than patients who have open and even laparoscopic surgery,” Lallas said. “Factoring in those reductions of costs to hospitals, insurance companies and society helps to compensate for the robot’s expense.”

Hospitals spend a lot of money up front to implement a robotic surgical system, but proponents of robotic-assisted surgery deem those costs essential for keeping up with their competitors.

“Patients view hospitals with robots as centers of excellence. We need to cater to what patients want – and they want the robot,” Lallas said.

Even without clear evidence that robotic-assisted surgery produces superior results, patients flock to the technology. Jefferson purchased its first da Vinci robot in 2005 and now has three, all of which Lallas said are in use almost daily. Intuitive Surgical reports that worldwide, close to 100,000 prostatectomies and hysterectomies are now performed with the robot annually. Intuitive provides its customers with an abundance of marketing guidance and collateral to publicize the purchase of a robot.

“The marketing of da Vinci is very good as a whole but above all excels on an electronic level,” Senapati said. “Information about the robots is all over the Web and extremely easy for patients to find. I don’t do robotic procedures exclusively, but patients learn online that I do use the robot and come to me specifically for that reason.”

What the Future Holds

Surgeons hope that expenses associated with surgical robots will diminish as new competition enters the market.

“Since da Vinci came out more than 10 years ago, technology has advanced significantly. Nobody knows where we might be in 10 more years, but I don’t think Intuitive’s monopoly can last, and competitors will drive down costs,” Lallas said.

Physicians, scientists and engineers – some working with Intuitive, some not – are fervently collaborating to develop the next generation of surgical robots, with many efforts focused on decreasing their size, weight and cost as well as enhancing features on the operator’s console.

Some are fine-tuning robotic systems very different from da Vinci. For example, Curexo Technology in Fremont, Calif., has developed

a system that enables orthopaedic surgeons to plan joint replacement procedures on a computer workstation days before an operation takes place. Using 3-D data from a patient's CT scan, surgeons create a "virtual surgery" that is saved and later used to help execute the procedure precisely as planned in the operating room.

The types of surgeries performed using the robot continue to grow. This winter, Cataldo Doria, MD, PhD, the Nicoletti Family Professor of Transplant Surgery and director of the Division of Transplantation at Jefferson, performed the first robotic-assisted liver resection at Thomas Jefferson University Hospital. Doria is among a small handful of surgeons in the United States certified to do so.

And scientists at Jefferson also are designing their own robotic systems. Last fall, after seven years of collaboration, a team of medical physicists, engineers, radiation oncologists, radiologists and urologists began a clinical trial using a new robot they developed to place radioactive seeds into prostate tumors. Prostate brachytherapy requires precise insertion of dozens of radioactive seeds in very specific sites, leaving substantial room for human error. The team hopes the new robot, called Euclidian, will overcome this problem. A physician operates the robot with a handheld controller and a computer interface but is capable of reverting to manual seed insertion at any time.

"Euclidian is very different from da Vinci, but both are about giving patients more options," said Adam P. Dicker, MD, PhD, professor and chair of Jefferson's Department of Radiation Oncology. "Technology is going to continue to advance, and we need to do rigorous large-scale tests to work out all the kinks and use it as efficiently as possible."

Rigorous large-scale tests are exactly what Sean Tunis, the director of the Center for Medical Technology Policy, believes researchers need to complete to boost confidence that robotic-assisted surgery offers legitimate benefits compared to pure laparoscopy.

"Clinicians, scientists and funders need to get more clarity on adequate studies that are both feasible and affordable," he said. "For now, the jury is just out. Not enough is known, and the feedback we do have is primarily anecdotal. That doesn't make the robot useless; it just means it's hard to judge." ■



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