

TECHNOLOGY

Is robotics practical for gynecologic surgery? And will laparoscopy become obsolete?

Over its history, surgery has been defined by the tools available to practitioners. In our era, opportunities to offer patients minimally invasive surgery have expanded dramatically as methods of establishing visualization, achieving hemostasis, and performing tissue dissection have improved. (I remember trying to treat ectopic pregnancy laparoscopically in the early 1980s without benefit of a camera or suction irrigator!)

For surgeons of my generation, the ability to access the abdominal cavity minimally invasively and to clearly visualize the contents was a significant step forward. Hysteroscopic myomectomy was another tremendous incremental im-

provement for patients with submucous myomas. But there is much more in store for the coming years.

Where are we headed in the next wave of gynecologic surgery? Will patients require an incision at all? Is there room to advance beyond laparoscopy and hysteroscopy? What innovations will industry offer us in the 21st century?

In this article, I describe something that is fairly familiar to most of us by now, but which is not yet practical for routine gynecologic procedures—robotically assisted endoscopic surgery. I then move on to a phenomenon that, in many respects, is still being imagined—natural orifice transluminal endoscopic surgery, or NOTES.

Robotic systems are best suited for complex surgery

Laparoscopic surgery is limited by the two-dimensional view and need for hand control of long, rigid instruments through ancillary trocar sites. Although these impediments can be overcome with practice and experience, the inability to see in three dimensions and the compromised range of motion hamper optimal management of some surgical procedures.

A number of technological advances may significantly improve our ability to perform suture-intensive or anatomically challenging operations. Several companies are developing camera systems that will permit a three-dimensional view without the need for multiple visual ports. The technology is borrowed from the world of insects, which “see” through multiple lenses within the same eye. The



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3-D views are a plus in robotic myomectomy

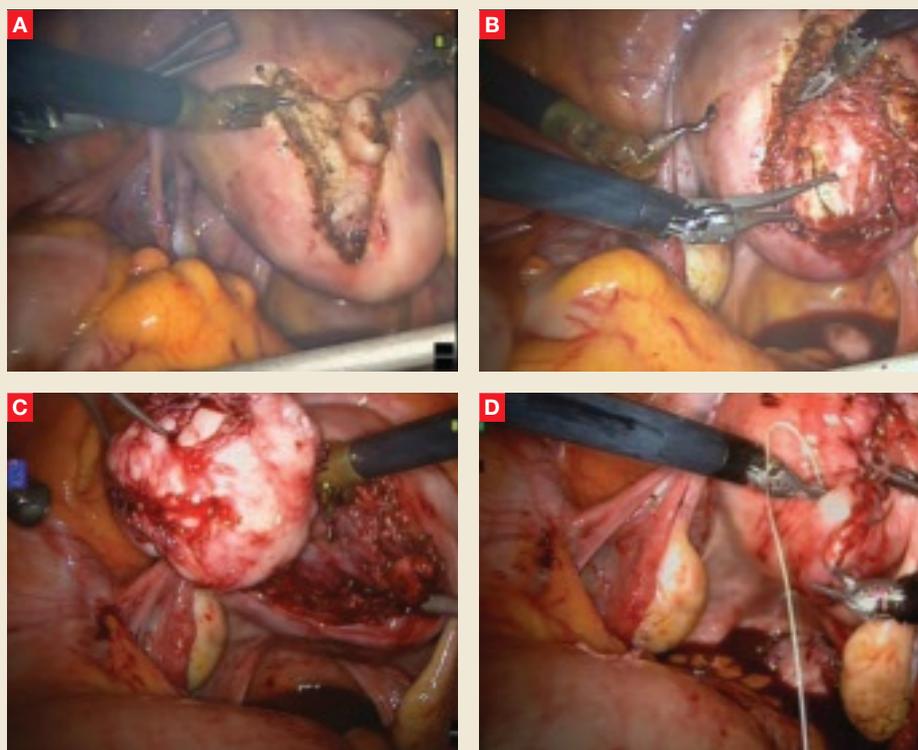
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FIGURE

Robotic myomectomy



A: Using the da Vinci robot, the surgeon incises the myometrium down to the fibroid. **B:** After grasping the fibroid, the surgeon dissects it away from the surrounding myometrium. **C:** As the fibroid is freed, another small tumor becomes apparent at the bottom right, and is also removed. **D:** The myometrium is sutured in layers after removal of the fibroids. Photos courtesy of Paul Indman, MD.

FAST TRACK

The gynecologic laparoscopic procedures best suited to the robot are sacral colpopexy, myomectomy, radical hysterectomy, and lymph node dissection

application of such visual processing to optical systems for endoscopic surgery will be a huge advance for laparoscopy—one that is still being perfected by industry. In 2007, the da Vinci robot system (Intuitive Surgical) offers the best opportunity to achieve both three-dimensional visualization and an ability to “feel” tissue and manipulate instruments with markedly increased range of motion.

Cost is the limiting factor

Although the da Vinci system has revolutionized the practice of urology, enabling radical nerve-sparing prostatectomy, its utility in gynecology is still being investigated. Several centers use the robot for a significant percentage of their laparoscopic gynecologic surgery, but the setup time, learning curve, and intraoperative time required make the da Vinci system

an impractical tool for many routine procedures. Its true advantage lies in suture-intensive procedures and in surgeries that require meticulous dissection close to major structures. In gynecology, the laparoscopic procedures most likely to benefit from the three-dimensional view and articulating instruments are sacral colpopexy, myomectomy (FIGURE), radical hysterectomy, and lymph node dissection.

Although it is interesting and enjoyable to use robotic technology for routine laparoscopic procedures, I believe the cost is prohibitive—several million dollars for each robot. If the financial barriers are removed, however, this system will be a welcome addition to the toolset for gynecologic laparoscopic surgery. Until then, we need to make intelligent use of this powerful tool.

Just as many of us were able to perform laparoscopic surgery without a three-chip camera and high-tech energy system for hemostasis until the cost of those technologies could be recouped in reduced operating room time and fewer conversions to laparotomy, so will today's surgeons have to continue performing laparoscopic adnexal surgery, routine hysterectomy, and treatment of ectopic pregnancy the "old-fashioned" way. For complex procedures, however, the da Vinci system is proving to be a major advance in endoscopic surgery.

Look for other, perhaps less expensive, technologies coming down the road that will, at the very least, permit three-dimensional visualization without the

need for robotics. In addition, as I discuss in the next section, miniaturization of robotics is on the horizon. Only our imagination limits our thinking about how robotic technology may be used in the not-too-distant future.

ROBOTICS IN GYNECOLOGY

Selected studies

Bocca S, Stadtmauer L, Oehninger S. Uncomplicated full-term pregnancy after da Vinci-assisted laparoscopic myomectomy. *Reprod Biomed Online*. 2007;14:246-249.

Elliott DS, Chow GK, Gettman M. Current status of robotics in female urology and gynecology. *World J Urol*. 2006;24:188-192.

Fiorentino RP, Zepeda MA, Goldstein BH, John CR, Rettenmaier MA. Pilot study assessing robotic laparoscopic hysterectomy and patient outcomes. *J Minim Invasive Gynecol*. 2006;13:60-63.

Magrina JF. Robotic surgery in gynecology. *Eur J Gynaecol Oncol*. 2007;28:77-82.

NOTES takes "minimally invasive" to a new level

Imagine performing surgery for ectopic pregnancy or endometriosis in your office, without anesthesia. Think this is impossible? Think again!

A newer, perhaps better, and definitely less invasive version of endoscopic surgery is on the horizon—natural orifice transluminal endoscopic surgery, or NOTES. In May, a surgeon in Portland, Oregon, performed a cholecystectomy by dropping an endoscope through the patient's mouth into the stomach, drilling an opening in the gastric wall, and placing small instruments through that opening to perform the surgery. The specimen was then pulled through the small opening in the stomach and retrieved through the patient's mouth! The stomach was closed with an endoscopic stapling device.

NOTES appears to be the next true advance in minimally invasive surgery. This should come as no surprise to gynecologists. We are the champions of transcervical and transvaginal surgery. General surgeons and gastroenterologists are

recognizing what we have long known—that operating through these natural orifices is less uncomfortable for the patient and provides faster, less complicated recovery. They are also recognizing the challenges involved in such an approach.

A new generation of instruments is in the works

Clearly, operating through the vagina, cervix, or stomach necessitates excellent visualization and instruments flexible enough to navigate through tiny openings but strong enough to transect and retrieve tissue. Many of our industry partners are working diligently to create and perfect new instrumentation for NOTES procedures, and research is under way at many centers in this country and overseas into transgastric and transrectal procedures.

Consider what we might be able to achieve with this technology! By eliminating the need for transabdominal access, we can vastly reduce the risk of intestinal and major vessel injury and eliminate the

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Natural orifice transluminal endoscopic surgery appears to be the next true advance in minimally invasive surgery

Curb your enthusiasm! NOTES remains unproven

Still in a very early stage of development, natural orifice transluminal endoscopic surgery (NOTES) has generated considerable enthusiasm among physicians leading research and development efforts. Hoping to steer these efforts in a responsible direction—and avoid the problems encountered during the early days of laparoscopic surgery, when many inexperienced practitioners began adopting the technique prematurely—a working group from the American Society of Gastrointestinal Endoscopy and the Society of American Gastrointestinal and Endoscopic Surgeons was formed in 2005, calling itself the Natural Orifice Surgery Consortium for Assessment and Research (NOSCAR). So far, this group has convened two international conferences and penned two white papers, noting that “the overwhelming sense [at the first international conference]...was that NOTES will develop into a mainstream clinical capability in the near future.”¹

Some of the needs NOSCAR has identified are:

- determining the optimal technique and site to achieve access to the peritoneal cavity
- developing a gastric closure method that is 100% reliable
- reducing the risk of intraperitoneal contamination

and infection, given the transgastric route that has dominated NOTES so far

- developing the ability to suture
- maintaining spatial orientation during surgery, as well as a multitasking platform that would allow manipulation of tissue, clear visualization, and safe access
- preventing intraperitoneal complications such as bleeding and bowel perforation
- exploring the physiology of pneumoperitoneum in the setting of NOTES
- establishing guidelines for training physicians and reporting both positive and negative outcomes.

In the meantime, NOSCAR recommends that all NOTES procedures in humans be approved by the Institutional Review Board and reported to a registry.

So far, the technology has been used to perform appendectomy and cholecystectomy in humans. Research grants totaling \$1.5 million have been pledged by industry.

Reference

1. NOSCAR Working Group. NOTES: gathering momentum. White Paper. May 2006. Available at: http://www.noscar.org/documents/NOTES_White_Paper_May06.pdf. Accessed July 3, 2007.

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If the need for transabdominal access is eliminated, the risk of intraoperative intestinal and major vessel injury should be dramatically reduced

risk of hernia. We can also markedly reduce the discomfort associated with abdominal incisions.

How might this technology be applied in gynecology? I anticipate that ovarian pathology, endometriosis, and ectopic pregnancy will be managed transvaginally or via a small opening in the uterus. Transvaginal hydrolaparoscopy—in which warm saline is used as the distention medium instead of carbon dioxide, and access to the pelvis is achieved through a small culpotomy—has been around for many years but is limited by the rigid instrumentation and restricted visualization now available. With flexible instruments that can “see” around corners yet provide a wide visual field, microrobots that can be placed through a tiny opening and then deployed to

accomplish the surgical task, and systems to achieve hemostasis, NOTES may be the next revolution in gynecologic surgery. ■

NATURAL ORIFICE TRANSLUMINAL ENDOSCOPIC SURGERY (NOTES) Selected studies

To date, 19 abstracts on PubMed discuss the impressive opportunities NOTES will provide. Here is a sample:

de la Fuente SG, Demaria EJ, Reynolds JD, Portenier DD, Pryor AD. New developments in surgery: natural orifice transluminal endoscopic surgery (NOTES). *Arch Surg*. 2007;142:295-297.

Fong DG, Pai RD, Thompson CC. Transcolonic endoscopic abdominal exploration: a NOTES survival study in a porcine model. *Gastrointest Endosc*. 2007;65:312-318.

Malik A, Mellinger JD, Hazey JW, Dunkin BJ, MacFadyen BV. Endoluminal and transluminal surgery: current status and future possibilities. *Surg Endosc*. 2006;20:1179-1192.

McGee MF, Rosen MJ, Marks J, et al. A primer on natural orifice transluminal endoscopic surgery: building a new paradigm. *Surg Innov*. 2006;13:86-93.

Wilhelm D, Meining A, von Delius S, et al. An innovative, safe and sterile sigmoid access (ISSA) for NOTES. *Endoscopy*. 2007;39:401-406.