

So You Think You Want a Robot? Analyzing Cost and Implementation

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Allocating funds to purchase a robotic surgery system at a cost of \$1.5 million may seem the more daunting task in launching a robotic surgery program; however, training and implementation may be a more rigorous process.

Establishing a successful robotics program encompasses a team approach to patient care that transcends routine laparoscopic surgery. Both surgeon and operating room (OR) assistants have to show competency in procedures specific to robotics: patient positioning, laparoscopic port placement, robotic instrumentation, troubleshooting, and safety.

The hospital system is also challenged with establishing new guidelines in credentialing, OR efficiencies, and quality control mea-

asures, along with managing the economic impact of such a system.

HISTORY

The word robot is taken from the Czech *robot* and means “forced labor.” In fact, the term was coined by Czech playwright Karel Capek in his 1921 production *Rossum’s Universal Robots*. It would be more than a half century later that the first laparoscopic surgery was performed: a laparoscopic cholecystectomy in 1987.^{1,2}

The evolution of robots from primitive machines performing menial tasks to present-day highly complex procedures is an interesting journey, as is the crossover of industrial use of robots to medical usage. Robots are routinely used in the manufacturing of microprocessors, deep sea exploration, and workplace situations that are hazardous for human workers.^{1,2}

While minimally invasive surgery has many advantages over open laparotomy (smaller skin incisions, decreased risk of infection, faster recovery time), robotic computer-assisted surgery was developed to overcome the limitations of minimally invasive surgery. These include loss of tactile feedback, compromised hand-eye coordination, and dexterity. Although the human wrist and hand have 7 degrees of motion, current minimally invasive instruments may have 4 degrees of motion.²

With robotic surgery, the surgeon uses a computer console that translates the surgeon’s movements to manipulate instruments attached to multiple robotic arms.

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Further, the robotic system has an integrated tremor filter that corrects for any tremor of the surgeon. There is also a scaling of movements that changes the ratio of movements at the master console to the internal movements of the robotic instruments within the patient.³

In 1999, the *da Vinci*[®] Surgical System (Intuitive Surgical, Inc, Sunnyvale, CA) was introduced. It was approved in 2005 by the FDA for gynecologic procedures. Presently urology is considered the number 1 utilizer, but growing applications are occurring rapidly in all areas of gynecologic surgery.⁴

In 1985, Kwoh et al performed neurosurgical biopsies utilizing the PUMA 560, the first nonlaparoscopic robot. The PROBOT, developed at Imperial College London, was used in 1988 to perform prostate surgery. In 1992, ROBODOC, designed by Integrated Surgical Systems, was introduced for precise femur movements during hip replacement procedures. ROBODOC was the first robot to achieve FDA approval.²

Next in robotic evolution were the

AESOP and ZEUS robotic surgical systems by Intuitive Surgical, Inc, with the *da Vinci* Surgical System and the introduction of Computer Motion in 2003. While the ZEUS is no longer marketed, the *da Vinci* System has FDA approval for a variety of surgical procedures. Currently, there are approximately 1,500 *da Vinci* Systems installed in about 1,500 hospitals worldwide.⁵

ROBOTIC COMPONENTS

Current robotic surgical systems consist of 4 components: the console; robotic cart; camera and vision system; and wristed instruments. The surgeon sits unscrubbed at the console, views the screen, and is able to control the instruments and camera utilizing finger graspers and foot pedals.

The robotic cart has 3 or 4 interactive arms. These arms hold instruments through trocars that are attached (docked) to the patient. A 12-mm 3-dimensional endoscope is placed in the patient's midline. By using image synchronizers and illuminators, a 3-dimensional image of the pelvis is possible with the cam-

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TABLE. The 3 Components of the Surgical-Team Training Program¹⁴

System Training	Procedure Training	Clinical Support
<ul style="list-style-type: none"> • System preparation • Intra- and post-operative system management • Inanimate labs • <i>da Vinci</i> System skills development • Laboratory sessions 	<ul style="list-style-type: none"> • Case study review • Live procedure observation • Laboratory sessions • <i>da Vinci</i> surgical skills development • Surgeon-led training 	<ul style="list-style-type: none"> • Procedure map • Surgeon proctoring • Additional skills/ laboratory sessions • In-services • Procedure dry-run

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era and vision system. Finally, with computer interfaces, the wristed instruments translate the mechanical movements of the surgeon’s hands into instrument direction within the patient.⁶

IMPLEMENTATION

The *da Vinci* Surgical System offers surgeons of all skill levels a broader range of minimally invasive surgical capabilities. Initiating a program with surgeons who are already comfortable with advanced laparoscopy allows the potential for improved efficiency, higher success rates, and decreased surgeon fatigue.

For less experienced laparoscopic surgeons, the intuitive movements and increased degrees of freedom of the instrumentation may allow for more confidence and comfort in minimally invasive surgical procedures. The goal in both circumstances would be to increase cases traditionally done by a laparotomy and successfully complete them as a robotic laparoscopic procedure with improved patient outcomes.

A primary surgeon or group of surgeons dedicated to program development is critical to maintaining momentum for a new robotics program. The core physician(s) can contribute to the administrative as well as the surgical training duties tied to robotics. They can also serve as mentors to less experienced surgeons and staff.

Surgeon Training

The typical training curriculum begins with an online educational module which familiarizes the surgeon with the *da Vinci* system

and its components. Simulation practice on-site with the *da Vinci* system permits acclimation to robotic control and EndoWrist® functions. This simulation training also includes training for system management, patient preparation, and case management. Surgeons then attend a porcine lab course for live surgical practice. These courses are sponsored by Intuitive Surgical and come at a cost of \$3,000 plus expenses and lost wages to the individual or employer.

Observation of an experienced robotic surgeon or video review of robotic surgical cases is common and encouraged prior to hands-on surgical training. The trainee surgeon’s initial cases are then performed with the supervision and assistance of a proctor. The Table summarizes the Intuitive Surgical training protocol.⁷

Credentialing

Each hospital is challenged to develop a criteria set for *da Vinci* credentialing. Even a previously established system will necessitate revised credentialing requirements as additional specialties seek to utilize the technology. Legal ramifications of a new OR device have already arisen, with claims of inadequate training.⁸ As with much of the medical malpractice climate, these claims may or may not reflect an actual relationship between training and surgical injuries. However, the potential for additional legal risk associated with new technology and the surgical learning curve serve to reinforce the importance of formal training guidelines and credentialing criteria.

Credentialing for newly trained surgeons

FOCUS POINT
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will typically require a specified number of proctored cases. Our facility requires 5 proctored cases, with no specification for the procedure or its complexity. Utilizing experienced physicians within the existing hospital staff for proctoring will dramatically reduce training costs, compared to hiring a traveling proctor.

Learning Curve

Operating times are generally used as surrogates for learning curves. The learning curve for gynecologic and general surgical procedures appears to be associated with decreasing operative times at approximately 20 cases.^{9,10} Performing robotic cases on a regular schedule also impacts efficiency of training.⁹ One dilemma in the training process stems from case complexity. Some authors have proposed a high-volume low-complexity approach to training, using cases such as tubal ligation.¹¹ This does quickly contribute to OR efficiency and staff comfort with robotic technology. However, the contribution of such cases to the surgeon's training is compromised.

Alternatively, introducing more complicated surgical cases speeds surgical experience and confidence, with the potential drawback of out-pacing OR efficiency training. Prospective data are lacking, but a balanced approach may have merit. Wilson advocates using a hybrid approach to more complex surgical cases early in the training period. Initially, the focus is on port placement, docking, and limited use of the robot for surgical management. As the surgeon and support staff gain experience, the robot is used to complete more of the actual surgical procedure.¹²

OR Staff Training

Equally important to surgeon training is the training required for the OR staff. The *da Vinci* technology is labor intensive, cumbersome, and intimidating to some personnel. Patient positioning, docking, and instrument loading are among the

critical skills the OR staff must master to ensure patient safety and surgical efficiency. Robotic cases require significant reliance upon OR staff who are able to assist at the table while the surgeon is at the console. For this reason, undertrained nursing and support staff can be a greater risk to safety and operative efficiency compared to conventional laparoscopy.

RECOMMENDATIONS

We advocate a rigorous formal training curriculum, live-case observations, and proctoring for OR personnel prior to solo deployment in an actual robotic surgery procedure. We also advocate simulation training with the staff. This is useful to identify staff uncertainty and training deficiencies, and to reinforce case flow. In our experience, Intuitive Surgical representatives provide excellent OR support and on-site staff training to facilitate the development of a safe and successful robotic program.

The need to allow for training at each surgeon's pace and skill level precludes procedural limitations on *da Vinci* robot use early in the development of a robotics program. As training transitions to routine clinical use, competition for this expensive resource and the interest in controlling costs will likely require some degree of procedural triage for robotic use. Some surgeons may be tempted to overuse this novel technology, which significantly adds to OR costs with no additional revenue.¹³

For hospital administration, the economics are not as favorable with the utilization of the *da Vinci* Surgical System in cases amenable to a traditional minimally invasive approach.¹⁴ Cost-benefit analysis of robotics requires the impact of several issues including cost savings for reduced postoperative complications and readmissions, shortened length of stay allowing for higher patient turnover, a marketing advantage over the competition, and ultimately increasing the number of patient referrals. Administrative duties will also

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include establishing peer review quality councils that will need to review cases not only for quality but also for OR efficiency. Remedial educational programs will need to be established, along with ongoing evaluation of utilization and costs.

The impact of establishing a robotics program on residency education and the challenges for residents and faculty to teach robotics will be reviewed in part 2 of this article in a future issue.

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