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ORIGINAL ARTICLE

Designing a robotic colorectal program

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Abstract Designing a successful robotic colorectal program requires consideration and implementation of several important concepts with continued perseverance through many obstacles that may arise. The ideal strategy is to establish a core group of committed individuals, define the goals and vision of the program, enlist corporate partners, and gain financial support with a sound business, educational, and research plan. Factors such as cost, limited availability, and demanding training are often hindrances to the implementation of a new robotic colorectal program while scheduling conflicts and inadequate resources may present obstacles to developing a colorectal program in institutions with existing robotic surgical programs. In developing a business plan one should consider the potential for increased patient referrals and the benefits of reduced hospital stay, decreased infection and complication rates, and quicker recovery compared with open surgical procedures. The optimal robotics surgical staff will include those most eager to be trained, as they are highly motivated and have the greatest enthusiasm to succeed. The early foundation of accomplishment will be vital to the long-term success of the program. In addition to building the ideal surgical team, patient selection is one of the most crucial considerations in developing a successful robotics program. Initiating a positive impression for robotic-assisted laparoscopic colorectal procedures will be an important precursor to continued success. Likewise, maintaining a regular schedule of procedures may advance the team's competencies and deter complacency. Proper planning, deliberate implementation, and sustained perseverance are key to the successful initiation of a robotic colorectal program.

Keywords Robotic-assisted laparoscopic surgery · Laparoscopic surgery · Colorectal surgery · Training · Education

Introduction

The development of robots for surgical use arose from the need to execute tasks requiring considerable skill and dexterity, limit potential human error, reduce operative times, and improve patient outcomes [1, 2]. The use of robotic-assisted laparoscopic surgery (RALS) has been demonstrated to be both safe and feasible for a variety of standard laparoscopic procedures [3]. The da Vinci® robotic system (Intuitive Surgical, Sunnyvale, CA, USA) is approved by the FDA for use in general and colorectal surgery, urology, gynecology, mitral valve repair, endoscopic atrial septal defect closure, coronary anastomosis during cardiac revascularization with adjunctive mediastinotomy, as well as oropharyngeal, laryngeal, and hypopharyngeal resections [4, 5]. As utilization of robotic surgery has grown, the benefits of the technology have also generated much interest. Studies comparing certain robotic and standard laparoscopic procedures have shown that operative and pathological data, complications, and hospital stay were comparable between groups, although robotic operations appeared to result in less strain on the surgeon [6]. In addition, RALS procedures have been

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associated with reduced blood loss, hospital stay, and operative complications following gynecologic oncology procedures [7, 8]. The number of procedures performed through minimally invasive robotic approaches is growing considerably with improvements in technology and technical skills of surgeons [5, 9–13].

Advantages and limitations of robotic-assisted laparoscopic surgery

Since the introduction of minimally invasive surgery (MIS), studies have shown that the conventional laparoscopic approach results in shorter hospital stay, earlier return to preoperative activity, decreased postoperative pain and complications, and enhanced cosmesis [14–16]. Nonetheless, laparoscopic surgery may present several challenges for surgeons, such as a steep learning curve amongst other inherent limitations [17]. In some circumstances, acute inflammation and the confined nature of the operative field may limit visualization and prohibit proper dissection and mobilization through laparoscopic technique [18]. Difficulty with mobilization, increased operative times, and lack of tactile and tensile feedback have also been reported [19, 20]. The development and introduction of RALS was intended to surmount many of the limitations associated with standard laparoscopic surgery while maintaining a minimally invasive approach [4, 21–24].

RALS has been shown to be comparable to traditional laparoscopic surgery and is expected to maintain or potentially enhance the benefits of MIS. The addition of RALS can augment many existing MIS procedures, as it affords several advantages including precision, three-dimensional visualization, tenfold magnification, camera stability, and computerized instrumentation offering "wrist-like" movement with additional freedom of motion (internal pitch, internal yaw, rotation) and tremor reduction [16, 21, 25]. In addition to these benefits, RALS may serve as an enabling technology, allowing an open surgeon to realize the benefits of MIS when they are unable to overcome the limits of conventional laparoscopy [26, 27]. Moreover, it may enable experienced laparoscopic surgeons to further the use of MIS beyond their present limits.

While the RALS approach affords technological advances over conventional laparoscopic surgery, there are intrinsic limitations, including increased operative times, a fixed operative field, loss of tactile feedback, and the need for repositioning of instruments [19, 20, 28]. Cost, limited availability, and a high degree of technical training remain the major limiting factors in the implementation of a RALS program [1]. Currently, the average base cost of a da Vinci® system is 1.5 million U.S. dollars (USD), while the new da Vinci® Si HD System, released in 2009, sells for USD 1.75 million [5]. In addition, there is a per case disposable fee for the robotic instruments of approximately USD 200 per instrument used and a yearly maintenance contract requirement of USD 100,000 per system [29]. To reduce per procedure costs, the use of the da Vinci® system can be shared with various service lines, such as general surgery, urology, gynecology, cardiovascular surgery, and other specialties, such as colorectal surgery.

Robotic-assisted laparoscopic colorectal surgery

In 2001, Weber et al. [19] performed the first two cases of RALS colectomy (a sigmoid colectomy and a right hemicolectomy) using the da Vinci® system. They noted that use of the robotic platform was safe and feasible for colectomy, and the system offered enhanced visualization, freedom of motion, and ergonomic comfort. Delaney et al. [20] subsequently compared outcomes of robotic-assisted laparoscopic colectomy with case-matched standard laparoscopic procedures. They concluded that RALS colectomy was a safe, feasible, and efficacious procedure although increased operative time and potential expenses presented the need for continued investigation.

In a subsequent study, D'Annibale et al. [30] compared the traditional laparoscopic approach with the robotic technique in the treatment of benign and malignant colorectal diseases. They observed no significant differences between groups in terms of total operative time, specimen length, number of lymph nodes retrieved, recovery of bowel function, and postoperative hospital stay. The authors concluded that the dexterity and three-dimensional view of the da Vinci® system were particularly useful for specific stages of the procedure, such as splenic flexure takedown, dissection within a narrow pelvis, identification of nervous plexuses, and hand-sewing of the anastomosis. However, operating room (OR) and patient preparation required more time in the robotic group as opposed to the laparoscopic group. Robotic surgery has increasingly been shown to be safe and feasible, offering dramatically enhanced operative and visual features during colorectal procedures [6, 28, 31].

We expect that with increased training opportunities and adaptation of the technology, greater utilization of the platform, as experienced in urology, may also occur in the field of RALS colorectal surgery [5, 32]. Intuitive Surgical has expanded its installed da Vinci® base to more than 900 academic and community hospital sites, while sustaining growth in excess of 25% annually. As of December 31, 2009, there have been 1,395 unit shipments worldwide, including 1,028 in the United States, 248 in Europe, and 119 in the rest of the world [5]. While robotic technology is not yet in widespread use, it is expected to play an increasingly important role in the future of surgery. The purpose of this article is to demonstrate the preparation, strategies, and requirements essential for developing and implementing a robotic colorectal program.

Discussion

Business plan

When developing a business plan and timeline for implementation of a RALS colorectal program, the possibility of increasing patient referrals and decreasing patient expenditures through potential reductions in lengths of hospital stay, complication rates, and recovery times versus open surgical and standard MIS procedures should be considered. Likewise, the hospital-related cost of the yearly service contract for the robotic system, the instruments and disposables for each case, and the potential cost of additional training should be presented. Hospital administrators should understand that the addition of a robotic colorectal program can offer an additional dimension to any MIS colorectal program that will benefit the hospital through increased public awareness and perception. Likewise, program growth potential and institutional recognition should be emphasized.

Facility without an existing RALS program

A multi-departmental committee or panel should be assembled when developing a business plan for implementation of RALS in a facility without an already existing program. This could include surgeons and administration from urology, gynecology, cardiovascular and general surgery, as well as additional specialties with whom the colorectal surgeon would collaborate. This multi-specialty team has the advantage of ensuring optimal patient volume for a successful business plan. When available, the committee should also include a core group of pediatric surgeons interested in MIS, the institution's research director, and an associate from the school of engineering [9]. The involvement of the research and hospital leadership is essential for the success of program development.

Members of the committee will need to define and present the overall cost/benefit analysis as well as that for each department. Each expense breakdown should include the cost of the surgical procedure, the equipment and activities necessary to carry out the procedure (e.g., the robotic system and disposable instruments), the overall OR time dedicated to robotics, and the potential need for a dedicated robotics OR (large size, approximately 60 m^2 with LCD screens and appropriate technical controls such as for video equipment). The need for and cost of a dedicated robotics program manager to coordinate administrative staff, bridge the gap between clinicians and marketing, oversee website management, educate patients and other hospital personnel, and execute other crucial applications should be taken into account. A nurse coordinator to oversee the clinical patients, attend to pre- and post-operative issues, and manage the day-to-day functioning of laboratory work should also be considered for each subspecialty in addition to research fellows, surgical residents in training, and a full-time engineer. The inclusion of these staff will ensure maximal efficiency and utilization of the RALS program.

It is essential to develop a plan to mitigate any potential disadvantages, including the logistics of robotic scheduling and utilization (a primary constraint within a single robot program), subspecialty training of staff, OR space limitations associated with the da Vinci® system, and added OR time. There is also the potential need for multiple assistants during procedures in addition to the regular OR staff, particularly at the beginning of the learning curve. Finally, the need for a continually complete stock of supplementary instrumentation in case of possible malfunctioning should be considered. While developing an adequate business plan appears to be a formidable task, there are external resources available to the committee. Establishing a partnership with Intuitive Surgical or future surgical robotic providers with regards to developing budgets, marketing strategies, implementation, training, and many other facets for initiating a new program is highly recommended.

Facility with a RALS program for other specialties

A facility with an established robotics program for other specialties, most commonly including urology, gynecology, and cardiovascular surgery, represents the ideal opportunity to expand and include a colorectal program. The built-in support system with the hospital and other surgeons promoting RALS is already accounted for, and in these situations, adding colorectal capabilities to the robotic service line almost always receives a welcome reception. However, in some cases, this may pose a utilization problem with other subspecialists, and therefore may have its own inherent problems. In some atypical cases, the addition of another service line may force the hospital into purchasing additional robotics systems. In these cases, a business plan similar to that presented for a de novo robotic program should be considered. When petitioning an institution to purchase additional robotics systems, it is advisable to include other specialists (urology, gynecology) with experience in utilization of robotics in the pelvis. In addition to serving as adequate preceptors during initial introduction to RALS, these members will provide the opportunity for multi-specialty surgery in the same patients with disorders of the anterior and posterior compartments of the pelvis.

Training

Staff

Just as having an adequately trained surgeon is important, it is essential to have motivated and well-trained staff. Intuitive Surgical has predefined protocols for staff training and should be consulted to ensure staff members are effectively trained. The ideal RALS colorectal team would include staff who have performed colorectal procedures and will volunteer to commit themselves to learning and performing robotic colorectal procedures. In cases where this is not an option, robotically-trained staff from other specialties may be recruited if they agree to train for colorectal surgery. The most challenging scenarios are working in a facility without the same team for colorectal and robotic colorectal procedures, or if there are no robotically-trained staff to assimilate into the RALS program. We believe the best robotics staff includes those who are most eager to be trained, as they are highly motivated and have the greatest enthusiasm for success. In cases where a procedure extends beyond the normal shift of trained staff, such as after 3:00 p.m., the surgeon may be forced into working with untrained or minimally trained staff taking over during the latter stages of difficult, challenging cases. All procedures should be scheduled accordingly, such as first start, until the staff have been adequately trained. A nurse coordinator could be highly beneficial in setting the normal routine for scheduling RALS colorectal procedures, facilitating proper staff training, and ensuring the best environment for further promotion.

Surgeon

Robotic surgical training should start with a strong foundation in the basic principles of endoscopic or laparoscopic surgery [9]. Chitwood and colleagues previously described their training program for the da Vinci® system in detail [33], while Ballantyne and Kelley later provided guidelines for credentialing robotic surgeons [34]. Nevertheless, there are currently no widely accepted standards for the training required to perform robotic colorectal procedures. We previously reported a learning curve of 15–25 cases when transitioning from standard laparoscopy to the robotic platform for colorectal surgery [35]. This is similar to the data reported in the urology literature, but may vary depending on the surgeon's MIS experience. The OR staff, including scrub nurses, surgical technicians, and decontamination workers, will need to be trained in the use, cleaning, and storage of the new instrumentation in addition to the surgeons becoming comfortable with the new platform [9].

Table 1 Recommended training regimen for robotic colorectal surgical procedures

Training	Recommended hours
Online training didactic	2–4
Robotic-assisted surgery training course in porcine model*	8
Additional voluntary training in porcine model*	4–10
On-site system overview with operating room staff	2–4
Case observations: 5 robotic pelvic or bowel cases	15–20
Proctored cases: 5 robotic cases with a qualified proctor (or certified preceptor)	15–20
Tabulate and review patient outcomes†	2–4
Review video of proctored cases	5

* Subject to availability of facilities

† Self-reported 30-day outcomes of the initial 5 proctored cases

Table 1 details our training recommendations for surgeons wishing to perform robotic colorectal procedures. The additional voluntary training in a porcine model would take place in a training lab, as in our institution, where we are able to simulate surgical procedures prior to implementation in an actual patient. Alternatively, simulation models have been developed and are excellent for gaining experience and confidence with the technique before commencing with the first procedure. An on-site system overview with OR staff is a very important aspect of the training and is highly recommended. In this scenario, the team would simulate a procedure in the OR suite without an actual patient. This should be done before the first actual surgery (i.e., a "dry" run of what will occur during a case).

Required case observations will likely vary from hospital to hospital. Some institutions allow the colorectal surgeon to observe cases within other specialties if the procedures involve the pelvic anatomy (e.g., robotic prostatectomy, sacrocolpopexy, etc.). The philosophy in these institutions is that the colorectal surgeon understands the anatomy and how to perform the procedure, but lacks exposure to and experience with the application of the robotic system. The focus of the preceptorship is to safely dock the robotic arms, manipulate the instrumentation, and develop spatial awareness in relation to the pelvic anatomy. Other institutions, however, require that the colorectal surgeon observe only colorectal procedures, with the belief that this process most benefits the colorectal surgeon and results in a greater appreciation and preparation for colorectal-specific procedures. This is very important, as there are still very few colorectal surgeons qualified as preceptors or proctors. We recommend that, when practical, it is always best to perform colorectal procedures with a colorectal proctor; however, considering the limited access and availability in some locations, it may be adequate to observe cases from another specialty so long as they are performed by a certified preceptor.

Tabulation and review of patient outcomes should be according to acceptable hospital quality measures. We recommend that following completion of the initial five proctored cases, a review of 30-day postoperative outcomes should be performed to ensure no significant patient detriment. Reviewing the video of proctored cases is an optional but excellent idea for continued surgical education. Although the surgeon may find it painstaking to sit and watch their own video, it is perhaps one of the best ways of identifying shortcomings and adopting more precise and efficient techniques.

Assistant

The ideal surgical assistant is a partner or physician's assistant who is consistently present in all cases. This helps to develop a style of teamwork, standardized approaches, and expectations of the various stages throughout the procedure. Less desirable is a resident or fellow who rotates on and off service. In these situations, it is more difficult to establish consistency, predictability, and a general flow of the procedure.

Implementation

Patient selection

Patient selection is one of the most crucial considerations in developing a successful robotics program. The properly selected patient should be someone who (a) can withstand a prolonged operative time, (b) presents with benign pathology or absence of significant inflammation (e.g., a large polyp of the rectosigmoid or rectal prolapse), (c) is female (pelvic anatomy provides a broad and wide pelvis versus the deep, narrow pelvis of a male), (d) has a virgin abdomen (i.e., no previous surgery), and (e) has a body mass index (BMI) less than 25 kg/m^2. A perfect example might be a case of rectal endometriosis requiring a combined sacrocolpopexy with rectopexy and performed by a gynecologist well versed in robotics. Some advocate the approach of beginning in the right colon and, once comfortable with the technique and instrumentation, transition to performing pelvic surgery. While this is very common for those learning laparoscopic colorectal surgery, in our experience this may not be necessary with RALS as pelvic surgery does not routinely require operating in multiple quadrants.

Team morale

When initially introducing a robotic colorectal program, the first few cases are extremely important for establishing a positive impression of RALS colorectal procedures. As with the introduction of any new procedure, there will be increased interest among the OR staff and colleagues with regard to the initial success or failure of the program. If the first three or four cases are straightforward, expeditious, and successful, then this will be the impression moving forward in the face of more complicated cases. Conversely, if the first few cases are lengthy, complex, and tense, then it may take months of subsequent successful procedures to reverse the early negative or adverse reputation of the robotics program. Furthermore, anesthesiologists, nurses and technicians, the personnel depended on the most, may avoid these cases. The importance of establishing and maintaining team morale underscores the importance of proper patient selection.

Maintenance

Once the program has been launched and the first few cases have been completed, a regular schedule for robotic procedures should be maintained to advance both the surgeon's and trained staff's skills and competencies. The surgeon should avoid situations in which the program gets launched successfully, mainly due to a high level of motivation, but then falls into a lull or drop-off (early burnout) from the training and setup. One common reason for this phenomenon is the exhausting hours dedicated to training and performing procedures early in the learning curve. Mental stress and fatigue developed after 5–10 cases may result in a tendency to take a time-out and revert to familiar approaches. As a result, it would be shrewd to avoid case clustering by scheduling no more than 1–2 robotic procedures per week, especially early in the implementation of a new robotic colorectal program.

Conclusion

The use of robotic-assisted laparoscopic surgery was intended to avert many of the limitations associated with conventional laparoscopic surgery. The modality has also served as a tool to help surgeons make the transition from open to minimally invasive laparoscopic surgery. Since the inception of robotic surgical devices, advances in technology have evolved to afford greater surgical capabilities, increasing utility to many areas of surgery including the management of diseases of the colon and rectum. Despite reports demonstrating its safety and feasibility, RALS has yet to reach its full potential in the field of minimally invasive colon and rectal surgery. Proper planning, deliberate implementation, and sustained perseverance are key to the successful initiation of a robotic colorectal program.

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