Adoption of Robotic Technology in Surgical Practice

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2.1 Introduction

Technological innovations continue to help advance surgical technique as well as aid in the development of new less invasive procedures. Robotic-assisted laparoscopic (RAL) surgery is increasingly utilized by surgeons for minimally invasive surgery and as a way to potentially overcome limitations of traditional laparoscopy. Although RAL surgery was initially utilized by surgical subspecialties such as urology as a preferred tool for performing minimally invasive surgery (prostatectomy), it has gained momentum among general surgeons due to its broad-based application for complex procedures, including hernia repair.

In this chapter, we review the general advantages and disadvantages of RAL surgery, facilitators and barriers to adopting robotic technology, as well as the training requirements necessary to incorporate RAL surgery into practice. There is a lack of literature regarding adoption of robotics in practice, which makes an evidence based review of this topic difficult. We will aim to note the evidence, where available, to support our discussion.

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2.2 Advantages

Since 2003, when then first RAL ventral hernia repair was performed [1], multiple series have been published highlighting the feasibility and potential advantages of this technique [2–8]. The majority of the data are limited to retrospective studies as well as large database reviews. RAL techniques have been reported in the repair of all types of abdominal wall hernias, including diaphragmatic hernias [9, 10]. Additionally, robotic hernia surgery has facilitated novel approaches to extraperitoneal mesh placement, including transabdominal preperitoneal, total extraperitoneal, as well as minimally invasive retrorectus approaches [3, 6, 11–13]. RAL surgery differs from traditional laparoscopy by placing a user interface between the surgeon and patient. The use of RAL techniques continues to increase. Although it is frequently thought of as a method to convert open operations to their minimally invasive counterpart, this is not always the case [14].

Features provided by RAL platforms include a surgeon console, stereoscopic vision, intuitive movements, tremor filtration, motion scaling, and wristed instruments. Purported benefits of these features include potential ergonomic advantages (not always uniformly reported, however) [15], improved visualization, camera stability, depth perception, dexterity, and precision and accuracy of movements that allows ease of the performance of complicated technical maneuvers, including intracorporeal suturing. Specific advantages in hernia surgery may include the enhanced ability to remove the hernia sac, perform primary fascial closure, suture (as opposed to tacking) mesh in place and easier performance of the retrorectus and posterior component separation (transversus abdominis release) in a minimally invasive manner [16]. In certain cases, it allows surgeons to forgo the need for a bedside assistant. These features are thought, in part, to help facilitate the more widespread dispersion and adoption of RAL surgery. In general, in abdominal wall surgery, outcomes of robotics are superior that of open operations, and are generally equivalent to their laparoscopic counterpart [16].

It is important to note that specifically with ventral/incisional hernias, there is certainly room for improvement in surgical technique. Minimally invasive ventral hernia repair does not necessarily decrease recurrence rates, but has been noted to decrease surgical site infection rates [17]. However, adoption of laparoscopic ventral hernia techniques by surgeons continues to be low. Recent estimates from large database reviews demonstrate that although the use of laparoscopic ventral hernia repair techniques is increasing, only 23% of ventral hernia repairs are performed laparoscopically. Additionally, only 6% of patients with complex incisional hernias undergo laparoscopic surgery [18, 19]. With newer platforms and technologies, robotics may finally start to fulfill the promise of being able to increase the number of minimally invasive hernia repairs performed, not by conversion of laparoscopic to robotic cases, but by converting traditionally open to minimally invasive cases.

2.3 Disadvantages/Barriers

Robotic technology potentially aids in the ability to overcome some important challenges that have prevented the more widespread dissemination of minimally invasive hernia surgery. However, there are some important disadvantages to note. The loss of tactile feedback/haptics is a major limitation and can affect how surgeons apply, develop, and master their skill set with the current generation of robotic platforms. Haptic feedback is integrated into some of the newer RAL platforms (TransEnterix, Morrisville, NC).

The physical space required for current robotic platforms can pose challenges to operating room setup. Newer robotic platforms have overcome some of these limitations by allowing for flexibility of the robotic patient side cart position. Lengthy set-up and docking times can be overcome with proper training, communication, and practice. Although decreased operative times tends to come with increasing experience [20], potential areas for rapid time savings, even early in the learning curve, include decreasing the time from incision to docking and sitting on the console, as well as efficiency with instrument exchange and undocking of the robotic platform. The anticipated development of other robotic platforms could advance these areas of improvement further.

In a value based society, and important in the discussion of actual cost is the debate regarding cost effectiveness of RAL surgery. For example, the actual cost difference of a robotic ventral hernia repair may be as high as 25% more [21]. In a recent retrospective analysis of 3665 cases from the National Inpatient Sample, the average cost of the robotic group was $13,441 versus $10,739 when performed laparoscopically. Zhamak et al. did conclude that additional costs are lower in high volume robotic centers [21]. There are multiple ways surgeons can reduce procedure costs, including minimizing the number of disposable instruments used, elimination of tackers/staplers, transition of traditionally open operations to their minimally invasive equivalent (such as with open abdominal wall reconstruction), and reduction of operating time with increased experience.

Increased costs associated with RAL technology, without a consistent improvement in outcomes, are frequently noted as one of the most pressing limitations for more widespread adoption. Initial (capital) purchase costs, annual maintenance expenses, as well as the cost of disposable instruments all contribute to the increased costs associated with RAL surgery. Historically dominated by a single company, Intuitive Surgical, Inc. (Sunnyvale, CA), over a dozen RAL surgical platforms are anticipated to enter the market over the next several years [22]. The introduction of new, competing platforms, some with specialty specific indications, will hopefully drive competition and potentially decrease cost. Additionally, pilot programs to determine the cost-effectiveness of RAL platforms in cost-constrained environments are underway, including a unique program from Intuitive Surgical, Inc. that has resulted in donation of RAL platforms to five county hospitals across the United States.

2.4 Training Requirements

Professional standards as well as institutional requirements must be met in order for a surgeon new to robotic-assisted surgery to safely incorporate this technology into clinical practice. Adoption of robotic technology in resident education is discussed in detail in the previous chapter. Though we recognize that no standardization for robotic procedures exists currently, there are several resources for surgeons considering the adoption of RAL techniques into their practice that are available.

Similar to Fundamentals of Laparoscopic Surgery and Fundamentals of Endoscopic Surgery, required now for current graduates of general surgery residency programs for eligibility for board certification by the American Board of Surgery, a Fundamentals of Robotic Surgery curriculum has been developed and is currently undergoing validation studies (www.frssurgery.org). Structured robotic surgery training programs for fellows are offered through multiple specialty groups including the Association of Program Directors for Colon and Rectal Surgery (APDCRS) as well as the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) [23, 24]. The majority of recently surveyed general surgery residency programs have formal structured curriculums for resident robotic surgery training [25]. Many surgical residents/surgeons who want to pursue further structured training in robotic surgery elect to do minimally invasive surgery and related fellowships accredited by The Fellowship Council (Los Angeles, CA), some of which offer robust robotic surgery training experiences.

The training of surgeons who are already in practice deserves discussion. There are a multitude of training resources available. Intuitive Surgical, Inc. (Sunnyvale, CA) has created training programs to help assist surgeons who wish to perform RAL surgery. These pathways are generally designed to help meet the requirements for hospital credentialing, however, one will have to refer to their own hospital for additional specific institutional requirements. A company representative must first observe the surgeon's current laparoscopic or open technique in a live case. The surgeon is then introduced to robotic surgery through the use of the robotic simulator platform. Basic tasks such as trocar placement, docking and undocking of the robot, camera and instrument control, and suturing with wristed instruments is emphasized. The surgeon must attend a case observation hosted by an epicenter surgeon. An epicenter surgeon has performed at least 500 robotic cases. This is a time where the two surgeons discuss the value of robotics in relation to their practice and how the learning curve can be best managed. The epicenter surgeon will often also serve as the post-training proctor. The surgeon selects a training date and two days of post training. The surgeon will attend several practice sessions consisting of skill drills on the simulator and must complete a series of online modules and assessments. The online module certificate is submitted to the training lab prior to the training date. On training day, the surgeon will perform various skills on a cadaver led by a proctoring surgeon and Intuitive trainer. Upon completion, the surgeon will be awarded a training certificate from Intuitive Surgical, Inc. The surgeon will then submit this certificate to their hospital, in addition to any specific institutional requirements, to begin the approval process. A proctor is selected to attend the surgeon's first 3–5 robotic cases (this varies with individual hospital bylaws). The proctor will complete an evaluation of the surgeon's robotic skills after each case and submit them to the hospital. After the proctored case series is completed and the surgeon is granted robotic privileges by the hospital, the surgeon may perform robotic-assisted cases independently.

As surgeons introduce RAL techniques into practice, there are several important considerations in regards to continued development of operative skills. In addition to personal case volume, advanced company sponsored specialty specific robotic surgery training courses are offered. Case observations and mini-fellowships may serve to help hasten the learning curve. Multiple societies offer mentored training experiences, including new programs via the International Hernia Collaboration (IHC), which started as a closed discussion board on Facebook (Menlo Park, CA) for discussion of topics related to hernia surgery [26]. SAGES now offers a MASTERS program, which is designed to offer structured post surgical training in a variety of surgical specialties, including hernia and robotic surgery [27]. Various other social medial platforms, including the Robotic Surgery Collaboration [28], and discussion boards sponsored by SAGES, allow for dispersion of advice to surgeon initiated questions as well as an informal platform to discuss technique, share operative videos, and offer and receive technique related feedback. Additionally, there are now a number of texts focusing specifically on RAL techniques for a variety of operations [29–32].

There are also online services for skill improvement where you can upload your case to a secure site for review by a panel of experts. The panel of experts will then asses various skills including depth perceptions, dexterity, efficiency, force sensitivity, and robotic control and provide scoring and feedback [C-SATS, www.csats.com]. Operative surgical videos are an additional educational resource for learning a specific technique. Numerous surgical societies, associations (including the Clinical Robotic Surgery Association), as well as industry post surgical videos on their websites for surgeons to review and learn from.

2.5 Adoption of Robotics into Practice

Regardless of the number of procedures performed to achieve independent status, the key to being safe, proficient, and efficient with RAL techniques is appropriate case selection and repetition. Avoid initiation of this experience with the most complicated cases. An ideal case for the novice robotic surgeon to begin with may be an inguinal hernia. This procedure provides a confined area with anatomical landmarks that aid in operative consistency. The preperitoneal dissection and suturing technique with peritoneal flap closure performed during robotic-assisted laparoscopic inguinal hernia repair are invaluable skills which can then be translated to more complex procedures. It is also a procedure that can be performed, even during the learning curve, with a similar cost profile to the traditional laparoscopic equivalent (by elimination of the use of dissecting balloons and tackers, for example) [33].

It is imperative that these robotic cases are performed with regular frequency. As the old adage says, practice makes perfect. This is also important for optimization of operating room staff training and efficiency of set-up, including patient and patient cart positioning, sterile coverage of robotic arms, and docking of the robot, all of which can be time consuming when robotic platforms are new to an institution. We also recommend, as mentioned above, the continuation of skill development with the robotic simulator modules, participation in additional case observations, industry courses, and/or mini-fellowships, in addition to having the assistance of an experienced colleague. When performing more complicated procedures, robotic technology should be introduced in a staged or hybrid approach. In gastric bypass, one may consider during the initial cases doing a single portion of the case robotically (i.e., the gastrojejunostomy) and doing the rest laparoscopically. For inguinal hernias, one may start with known direct inguinal hernias and primary, non-recurrent hernias. For ventral hernias, experience with intra-peritoneal techniques is necessary prior to attempting more complex preperitoneal and retrorectus approaches. If mesh fixation takes a prolonged amount of time, consideration of the performance of half of the fixation with robotic suturing, and half with tacks until suturing becomes more efficient. There is a tradeoff between operative time and equipment costs that is sometimes difficult to balance. We emphasize the value of video recording and review of these videos of your own cases.

Once robotic technique for a specific case is optimized, learn to work efficiently and then aim to reduce costs. A robotic surgeon should be knowledgeable of the technological options available to him or her. The key to cost reduction in RAL surgery, specific to hernia surgery, is minimization of the use of disposable instruments. Graspers, for example, can double as a second needle driver. Monopolar shears can often take the place of more expensive energy devices. Industry provided data, to compare individual surgeon costs to the national average may help expose unnecessary increased disposable equipment costs [34]. Use of enhanced recovery protocols in RAL cases may help decrease post procedure hospital length of stay secondary to pain and delayed return of bowel function.

2.6 Conclusion

RAL assisted surgery is growing in popularity, with a pace that often is faster than the data published to support its use. Newer, specialty specific robotic platforms may help to increase efficiency, decrease cost, and improve outcomes, however this remains to be seen. Increased peri-operative times and costs with RAL techniques may still prove advantageous in certain cases, if RAL techniques allow for traditionally open procedures to be performed in a minimally invasive manner. Safe and effective adoption of RAL techniques should be encouraged, but this requires particular attention to appropriate training, initial case selection and experienced proctorship. Additionally, continued learning after initial training through the use of the many resources available to practicing surgeons will provide continuous improvement.

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