Chapter 2
The Learning Curve of Robotic Assisted Laparoscopic Colorectal Surgery and How to Start Applying Robotic Technology in Colorectal Surgery

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The mastery of the field of colorectal surgery, with its multitude of complex procedures and ever evolving modalities, begins in general surgery residency, often progresses to fellowship, and continues throughout one's career as a lifelong endeavor. Many learning curves are encountered and overcome at each stage. During the training phase the mastery of new skills is developed in a controlled environment monitored by experienced surgeons. Post-training the surgeon learns, develops, and masters new skills in an environment that is sometimes without a roadmap, yet he or she has to begin successfully implementing this skill in a safe manner for his/her patients. Although learning curves are inevitable, they also impact the subset of patients who fall under the front end of the surgeon's learning curve. During the initial learning curve, many factors contribute to the surgeon's eventual acquisition of the desired skill.

> "The learning curve is usually defined as the number of cases that a surgeon needs to perform before reaching competency for a given procedure based on comparisons with the outcomes of prior standard procedures." [1]

Factors that impact the learning curve are both surgeon and patient related. Surgeon factors can include prior experience and surgical volume while patient factors may include BMI, anatomy, and/or the complexity of surgical disease process.

Laparoscopic and robotic assisted colorectal surgeries are two of the newest surgical modalities that have risen to the forefront of the field over the last 10–20 years. Laparoscopy predates robotics and as such there is much more data on its learning curves and how these curves have been analyzed and implemented, which aids in setting the stage for later uncovering the learning curves for robotic surgery.

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In 1991 M. Jacobs performed the first laparoscopic colectomy and ever since surgeons have been trying to perfect the technique [2]. Initially and even currently one of large challenges of laparoscopic colorectal surgery has been the steep learning curve. Initially surgeons were learning this technique post-residency/post-fellowship. They were well trained and experienced in open surgical techniques with no exposure to laparoscopy so the steep learning curve was due to a complex combination of technology related factors such as learning to use straight, rigid instruments within small spaces, limited degrees of freedom, fulcrum effect, loss of tactile feedback, adapting to two-dimensional visualization, and suboptimal ergonomic design [3]. Many studies were published looking at the learning curve under these circumstances. During this time the patient enrollment in these types of studies began in the early 1990s and continued into the twenty-first century ([4–6). Based on studies from this time in surgical history, the learning curve for laparoscopy is varied ranging from 30–70 cases based on a series of single center or single surgeon experiences ([4, 5, 7]). A retrospective systematic review of the literature between 1995 and 2009 showed that the learning curve is even higher at 88–152 cases when multicenter information is included and multidimensional analysis is applied [8]. Currently, laparoscopy is an intimate part of general surgery residency and every colon and rectal surgery fellowship, which has created a surgeon different than the one cited in these types of studies. This places the learning curve of laparoscopic surgery within the confines of fellowship, and even beginning in residency, and may decrease the high number of laparoscopic cases needed to overcome the learning curve.

Many of these studies have used different methods to analyze the learning curve and have evaluated various end points; several key outcomes are consistently seen throughout all studies. The most common outcome measured can be divided into surgeon dependent factors that relate to the surgeon's ability to complete the task efficiently and are frequently measured by operative time and conversion rate ([4–6]). The other outcomes are related to patient quality and outcome factors such as length of stay, readmission rates, post-op and intra-op complication rates, and patient mortality and morbidity ([4–6]). The long learning curve associated with laparoscopic colorectal surgery and with the rise of robotic surgery, literature is arising to determine if the learning curve of robotic surgery is shorter than in laparoscopy.

The first robotic assisted colectomy was performed in 2001 and interest in applying this technology continued to grow, especially with respect to the challenges of rectal surgery [9]. The potential advantages of robotic surgery over laparoscopic have been described as its multiarticulated instruments, camera stabilization, three-dimensional magnified visualization, and ergonomic operating position [10]. There is interest to know if these potential benefits translate into a shorter learning curve as compared to laparoscopy.

Currently, all published studies of the learning curves of robotic colorectal surgery focus primarily on rectal surgery and particularly with rectal cancer but some benign disease is included. These preliminary studies suggest that the learning curve can be analyzed by evaluating a combination of time related factors: total operative time, surgeon time on the console, robot docking time, total time using the robot as well as non time related factors such as conversion rates and intra and post-operative complications ([3, 9]). It was found that the learning curve had three distinct phases:

Phase One: Initial learning curve (estimated to occur at 11–40 cases)
Phase Two: Additional experience phase—The surgeon is competent to complete the surgery and is starting to tackle more difficult cases (estimate to occur at 12–128 cases).
Phase Three: Concluding phase—The surgeon has mastery of the skill and is consistently pursuing more surgically complex operations ([3, 7, 9–12]).

It was found that as operative experience and number of cases increased, the time related factors (total operative time, docking time, console time) all decreased during phase one ([3, 9–12]). During phase two all time related factors actually increased because as the surgeon's comfort level with the robot increased as he or she began broadening the application for robotic surgery and attempting more complex surgeries and without selection bias excluding cases considered to be more technically challenging ([3, 9–12]). Interestingly, patient factors remained relatively stable across all three phases of learning.

Although these studies begin to give us an idea as to what the learning curve for robotic colorectal surgery might be there are some limitations associated with the group of studies. The currently available studies are the cumulative report of a singular surgeon at a single institution except Jiminenz-Rodriguez et al. [13] who used three surgeons in his study. Can we truly extrapolate a learning curve from a total of nine surgeons and apply it to all surgeons? Also all of the surgeons in these studies were experienced laparoscopic colorectal surgeons. Does that mean that to use the robot in colorectal surgery one needs to have extensive laparoscopic training? Some studies used a hybrid approach, performing laparoscopic splenic flexure mobilization and robotic technique for the pelvic dissection [10–12]. As robotic technology continues to advance outcomes may also alter. These studies were all performed using the daVinci S system and there have been several newer generations of the daVinci robot that have evolved with the most recent being the Xi system. All of these varying factors may contribute to the learning curve of the robot making either negatively or positively, all further investigation into this growing field will answer these questions. For now it seems feasible that robotic colorectal surgery may be an additional technique than may be developed in a shorter time frame than laparoscopy.

Adapting robotic technology to one's practice should start with a needs and purpose evaluation. Every general and colorectal surgeon's operative volume for different disease states is different based on referral patterns and own preference. This will vary from practice to practice and a first step should be a thorough review of case numbers within a time frame for all procedures in which robotic technology is currently applied, mainly robotic rectal procedures (low anterior resection, abdominoperineal resection, proctectomy, and rectopexy) and abdominal procedures (partial colectomy, Hartmann`s reversal, and total colectomy). As discussed in other chapters the patient benefit is mainly seen for rectal procedures if robotic is compared to laparoscopic surgery. But at the same time even the busiest surgeons may lack the adequate procedure number within a reasonable time frame to overcome the anticipated general learning curve.

Surgeons who adapted robotic techniques for colon and rectal surgery in the past had to compensate for the lack of adequate robotic tools for a robotic colectomy, mainly missing a bipolar vessel sealer and stapling technology. With the advent of these new instruments all benefits which are seen with robotic technology, mainly instrument articulation, improved visualization, ability to use a third arm/instrument and last but not least the introduction of the newest Xi platform can be applied to colectomies as well.

Therefore the surgeon should consider adapting robotic surgery for all indicated procedures, pelvic and abdominal. This will allow to quickly accumulating necessary experience to overcome the basic learning curve rather than loosing valuable learning points due to an increased time interval between robotic cases.

Robotic privileging is highly regulated by individual hospitals and medical staff requirements. To date no national guidelines exist to help facilitate the safe introduction of robotic surgery, but there is an increased interest of national societies to help with the process to ensure safe application and monitoring of patient outcomes.

Basic training is provided by the manufacturer as a 1-day animal lab at Intuitive Surgery facilities throughout the nation. These courses focus on the general introduction of the system and allow the surgeon to utilize and practice basic skills such as camera functions and basic instrument manipulation. Following the basic training every hospital mandates initial cases in the range of two to five to be proctored by surgeons who are certified through Intuitive Surgery in their respected specialty. The current proctor requirements are the performance of a minimum of 30 robotic procedures for which the proctor is certified within the preceding 12 months.

A next crucial step after the initially proctored cases is to adapt accepted and standardized guidelines for procedures rather than “reinventing the wheel”. These are available through various sources including guides published by Intuitive Surgical, textbooks, and experienced colleagues. In this initial phase one of the learning curve as described above, the surgeon should consider selecting patients with more favorable characteristics such as a low BMI or no prior abdomino/pelvic surgery. Additionally, the surgeon should start introducing the robotic technology slowly and completing some of the procedure with a more familiar laparoscopic approach. This could for example mean only mobilizing the colon robotically and dividing the central vessels laparoscopically, performing an extracorporeal rather than an intracorporeal anastomosis for a right hemicolectomy or performing the TME dissection robotically only and using laparoscopy for the abdominal portion of a low anterior resection. This will allow safe and efficient introduction of robotics without frustration to the surgeon and safe outcomes.

After the surgeon is comfortable with the basic operations and initial procedure experiences of phase one at 11–40 cases, it is recommendable to attend a specialized multi day training course in robotic colon and rectal surgery available through the manufacturer or national societies. This could be supplemented with additional proctoring on the advanced level throughout phase two of the learning curve.

To summarize, application of robotic technologies in colon and rectal surgery has many benefits for the patient, but a thoughtful and well organized introduction and evolution within ones learning curve is a crucial element for success.

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