Chapter 5
Learning Curves, Costs, and Practical Considerations

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Abstract Robotic and conventional laparoscopic technology and applications have penetrated pediatric urology over the last 15 years. Understanding the realities of the ability to learn these technologies, how much they cost, and what information can be disseminated to all fledgling minimally invasive surgeons and programs is vital to ensuring optimal patient outcomes. We provide a synthesis of our experience and observations with analysis from the literature about initiating and maintaining a surgical practice adopting new technology.

Keywords Robotics • Simulation • Surgery • Education • Comparative effectiveness • Training • da Vinci • Pediatrics • Urology

Introduction

Pediatric urology has a strong history of surgical innovation. We tend to embrace new technologies at a pace that does not always mirror the adult urologic practice because we are critical about ensuring that hype does not blind us from fact. The adoption of conventional laparoscopic and robotic surgery in pediatrics clearly demonstrates these principles. In the last 5 years, our field has begun publishing experiences with robotic surgery that show a similar adoption path to the initial

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adult robotic surgery experiences of a decade ago. As robotic surgery gains traction, we owe it to our patients and profession to explore the trajectory of robotic surgery learning, the costs related to pediatric programs initiating and maintaining robotic surgery practices, and to disseminate information about the practical considerations of employing robotics so that future clinicians and programs can learn from our early successes and challenges.

Minimally Invasive Surgery Start-Up

Business Plan

The establishment of a fiscally sound model is crucial for establishing a robotic program. Each institution has individual needs and barriers from the direct costs (such as buying the robotic system) and of the associated material, staff recruitment, and/or staff training. The space for housing the robot has to be taken into consideration such as operating room modifications. Recruitment or development of a physician leader for the program is paramount to establish safety guidelines, as well as ensuring that financial and educational metrics are met by oncoming surgeons. The hospital system must evaluate growth potential with market analysis to estimate the impact a new program will have on the institution. The analysis must encompass the captured and non-captured population, the competition, the analysis of reimbursements and payers, and the learning curve of the program participants with its financial impact on day-to-day business. Estimated surgical volume with outcome metrics must be established to ensure patient safety from the very onset of the program. The actual number of cases needed by each institution to be done a year will vary on the overall financial stability of the hospital system.

Hi-tech surgery comes with an initial expensive price tag. The total cost of surgery can be broken into variable costs and the fixed costs. Variable costs take into consideration all expenses that are needed to execute the individual surgical procedure such as disposables used, medications, and sutures. The fixed cost is a combination of the acquisition of the robotic system and the operating room (OR) time needed to run the robotic program. To offset costs, the mathematical model would favor a high-volume program as to maximize reimbursement and patient population capturing in a competitive market to offset the variable and direct costs of running the program.

Team Building

A surgical director with both administrative and a robust surgical experience is essential to the start-up of the program. This individual would oversee the clinical aspect of the program and strategic growth and monitor outcomes, policing the new surgeons excited to join the program by objective metrics. The surgical director must oversee the training of the entire team.

Contrary to traditional open surgery, robotic surgery implies that the leading surgeon does not have direct contact with the patient being completely immersed in the console; therefore, the OR staff and surgeons in training are typically the ones in direct contact with the patient. A complete understanding of the procedure and the surgical steps is crucial. The availability of having one team for the establishment of the robotics program is critical. The consistency of the team will allow a rapid learning environment where the team can be proficient and safe. Once this team has mastered the nuances of the surgical robot and procedures, they can effectively teach more OR staff to expand the team. The most difficult component is teaching the physicians in training on how to perform these procedures safely and effectively while building the program. It is imperative that the surgical leaders of the program help establish a routine for the OR staff. This may hinder the "hands-on" training needed by residents and fellows. This obstacle becomes easier when the OR team is fully trained, but until then the surgical leaders must ensure that physician training is not compromised.

Marketing

After your institution has made the investment in robotic capital expenses and staff resources to support a robotic surgery program, it is important to let your community know that this patient care opportunity exists. We believe that it is important to market with transparency. Identifying a champion in your respective institution's marketing department who has a particular interest and experience in approaching the community and media about hi-tech innovations is helpful. We found that creating information delivery milestones helped organize our messaging. For example, once you acquire the robotic platform, plan to announce to your community providers that your institution can now offer patients this technology for *some* patients. Include the entire robotic team in any photo opportunities because the success of a program does not solely hinge on the surgeon. Plan to announce to the media when your program has reached patient outcomes comparable to your open practices or when your program has reached certain volume milestones. The former is a very transparent appraisal of your program and resonates well with your community providers; the latter tends to excite the media more because many demonstrations of success in our culture are driven by quantity.

Establishing durability and longevity is vital to building trust in your community. When you reach a chronological milestone (e.g., 5 or 10 years of providing robotic surgical care), organize a media announcement with your marketing colleagues that celebrates this achievement (see accompanying Video 5.1).

If your institution does open houses or gives tours to the community, include a stop at a robotic surgery *station*. In our institution, we annually open our doors to all families in our community to show children what we do. The robotic surgery station where children can sit and manipulate the robotic instruments through a dry lab module has drawn the biggest lines. And engaging the children who visited our station by a "naming-the-robot contest" added to the fun. The winner was awarded a plaque and airtime with our local media outlets.

Patient Selection/Clinical Ramp-Up

The success of your robotics practice will depend squarely on your patient outcomes. You must expect that there will be challenges when you initiate your program so it is important to identify the ideal patients and families. There are three primary variables to the initial success of robotic surgery: the patient, the team, and the surgeon.

When deciding on the ideal patient, we recommend starting with procedures that you are comfortable doing both open and laparoscopically. School-aged patients with ureteropelvic junction obstruction (UPJO) are probably the most reasonable patients to start with. Patient age is important because very young children may pose some size limitations and have a higher complication rate in some series [1, 2]. Patients with UPJO tend also to have few comorbidities and the anastomotic reconstruction is analogous to open techniques. Simple nephrectomies have also been described in robotic surgery [3, 4] and may also be a good case to begin with, but as your practice expands, we believe that the robotic approach tends to facilitate reconstructive procedures more so than extirpative ones.

When your institution invests in a robotic surgery team, there are two approaches to team design: (1) one or two core teams do all the robotic surgeries or (2) many staffers are trained on the robotic setup so that available nurse and surgical technician schedules do not limit utilization of the robot. In Seattle, our choice was to train as many nurses and scrub technicians as possible to mitigate access to knowledgeable robotic staff. In retrospect, we believe that having more dedicated core teams would have facilitated a more rapid learning curve for the team because we effectively diluted the knowledge. In Philadelphia, the latter approach was used. We found that there is only so much in-servicing you can do to train robotics, and actually doing cases is important to solidify the training. Upon initiating a robotics practice, one can expect to do fewer than 2–4 cases a month/surgeon which does not give your staff much ability to become familiar, especially if not using the dedicated core team approach. One method for amplifying experience is also establishing dedicated time for the entire team (staff, surgeons, anesthesia) to do walk-throughs of actual patient cases such as a left-sided pyeloplasty with cystoscopy and retrograde pyelogram. This mimics the realities of how the room needs to be set up and what roles each team member has and when. In addition, identifying champions within the nursing and technician staff who might be particularly interested in learning and being a part of new technologies was helpful.

Once your institution makes the investment in the program, there is desire to encourage many surgeons to consider learning and applying the technology. We have found that success is accelerated if certain robotic surgeon champions in your institution are identified first and supported to build a robotics practice. Unlike our adult colleagues who may have over 100–200 appropriate patients a year per surgeon to apply robotic approaches, pediatric urologists may see 25–50 in a year that would be ideal robotic candidates. And much like the difference between core teams and the omni-staff approach, we believe that one or two surgeons establishing their robotics practice are more effective and safer for our patients [5]. In addition, once learning curves are overcome, we have observed innovation within robotic surgery practices [6, 7]. These champions, once comfortable, can then disseminate knowledge to the other members of the practice or other subspecialties within the institution.

Space

Identification of the appropriate operating room space is nontrivial. The only commercially available robotic platform for clinical use has three major components that collectively take up over 30 sq ft. and weigh more than 1,000 lbs altogether. There are two philosophies to creating an environment for ease of robotic flow: (1) identify one or two rooms that become the robotic surgery suites or (2) utilize the mobility of the robot (each component is on castors) and move the robot to whichever room needs it. We have taken the approach of maintaining the platform in one of our bigger operating rooms (590 sq. ft.), and we adjust the surgical subspecialty and block time based on the robotic requirement. We have found that this obviates the need to build setup time for transporting the robot itself. In addition, within the room in which the robot in housed, we went from moving the robot to the patient to moving the patient bed to the robot (Fig. 5.1).

For example, when doing left- or right-sided pyeloplasties, we keep the three robotic components in roughly the same floor position and rotate the bed 180°. Initially this created some consternation among the anesthesia team as the head of the patient was now away from the ventilator and anesthesia station. This apprehension was alleviated through dry lab drills simulating this orientation. We found that the bed rotation approach allowed our staff to prep and drape the robot in advance of the patient entering the room.

Learning Curve

As with any new technique or approach, there is an inherent learning curve [8, 9]. Taking steps to accelerate learning curves through identification of early champions; managing expectations; creating preliminary milestones; being forthright with your patients, your nursing staff, and your administration; and understanding the realities of what others have shown with regard to the robotics learning curve will facilitate success in your robotics program.

Fig. 5.1 Patient positioning for left-sided pyeloplasty with bed turned towards the robot

Subspecialty Participation

Pediatric urologists will most likely be the largest adopters of robotic technology in your institution followed by general surgery. We believe that starting with these two surgical disciplines will yield the fastest and safest ramp-up in the program. Cardiac and otolaryngologic pediatric surgeries are now starting to utilize robotics [10, 11], but unless your institution has a member from one of these specialties with existing sound robotic experience, we recommend starting with urology and general surgery teams. There is also ample crossover among the nursing and scrub technician staff between urology and general surgery as our equipment needs, cavity of approach, and target organs are frequently identical. Once your institution has identified one or two starting services, we recommend identifying clinicians who have a strong background in conventional laparoscopy [5]. These champions tend to be more familiar with laparoscopic access, approach, and equipment which are analogous to robotics. There are many examples of surgeons who have become quite facile in robotics with minimal conventional laparoscopic experience [12, 13], and ultimately expanding the ability of all providers to offer the robotic approach is ideal, but minimizing as many aspects of robotic adoption that may be foreign to the starting roboticist is critical for success. It helps to have at least 2 providers in the program at initiation so that (1) communication with your administration and operating room teams can be defrayed and (2) so that idea sharing is possible to accelerate learning and innovation.

Expectations and Milestones

For the classically trained surgeon, the challenge of standard laparoscopy is often overwhelming, whereas transferring the surgical skills in the robotic environment is easier. Laparoscopically naïve surgeons need between 20 and 25 cases to show proficiency [10]. This has also been seen in other works such as a report by Patel et al. that showed a similar learning curve [13]. Unless the surgeon starting a new program is already experienced, there needs to be proper training. This can be accomplished by visiting an already experienced surgeon at their home institution to observe cases. Expert mentoring is also crucial during your first run of procedures to ensure that you are executing all the key maneuvers. Continual video critiquing of your surgical cases is paramount to fine-tune your skills. It becomes most effective when you watch your recorded cases with a colleague who has the same interests as you in robotic surgery.

Following complete training, patient selection is paramount especially early on in program development. Age, anatomy, body mass index, comorbidities, and previous experience with a surgical procedure either in an open or laparoscopic model need to be carefully picked at the beginning of the surgical experience.

Patient Counseling

In our experience, many families are excited about the option of a robotic approach for their children. Honesty is important to help manage expectations when initiating your practice. It will be predictable that despite as much dry lab training and proctoring you receive, in the beginning, your operative times will take longer than your open or even laparoscopic times. In addition, you are not the only ones in the room on his/her learning curve. Your ancillary staff and anesthesia team are also learning, and inconsistency in the teams will amplify operating room times. Tell your patients that you are initiating your robotics practice, and tell your patients if they are one of the first patients in your fledgling experience. Let them decide if they prefer this. We have found that many patients were excited to be the “firsts,” while other families were more apprehensive. Giving the families information about how your outcomes compare to the literature sends a strong message about your integrity and your appreciation for the trust that the families place in you.

Learning Curve Tracking

In early reports of incorporating robotic surgery into one’s practice, outcomes, fortunately, have tracked the open approaches [14]. Sorenson et al. analyzed their first 33 consecutive robotic pyeloplasties among two pediatric urologists and found that length of stay, postoperative pain scores, and surgical outcomes at a modest follow-up (median 16 months) were analogous between open and robotic approaches. Robotic operative times were consistently longer until a certain threshold of cases (15–20) was approached, whereby operative times fell within 1 SD of the matched open cohort. The majority of this time drop (70 %) was appreciated in the surgical time defined as incision to close. This appraisal showed that the surgeon with a more rapid case volume experience saw a faster drop in his operative times. Complications were clumped towards the initial ten cases and were mostly technical in nature. This study also highlighted the importance of optimal patient selection, a principle not well adhered to by these surgeons. The longest case in the study was a robotic pyelolithotomy and pyeloplasty within the first eight cases of one of the surgeon's overall robotic experience. This study was limited in that it compared the early stages of experience in the robotic approach to the experience of surgeons who had performed the open approach for decades. This is the challenge with appraising comparative effectiveness data because there is virtually no data on the learning curve of open pyeloplasties.

Tasian et al. collected the surgical console times in 20 consecutive robotic pyeloplasty cases of four pediatric urology fellows when they performed 75 % or more of the console time [15]. The console times were compared to 20 consecutive robotic pyeloplasty cases where the attending alone performed 100 % of the console time. All times were validated post procedure by viewing the surgical video and confirming times of console switching. They only evaluated console time. Positioning, prepping and draping the patient, obtaining laparoscopic access, and wound closure were excluded due to participation of other team members. They found the mean console time for the attending operating alone was 54 min. The operative times for the cases in which the fellow performed 75 % of the case decreased with increasing number of cases done (Fig. 5.2).

Assuming the trend of increasing efficiency continues at the same rate, operative times for fellows were projected to be equal to that of the attending urologist once 42 cases have been performed. In their series, all pyeloplasties were successful as demonstrated by postoperative radiologic improvement, and there were no complications (Fig. 5.3).

Future Thoughts

There are opposing forces to how we can provide safe, effective, and cost-responsible care for our patients. On the positive side, more trainees are graduating from residencies and fellowships with robotic experience. This is markedly better than the original generation of robotic pediatric urologists who were mostly self-taught. Furthermore, more operating room staff and anesthesia teams are familiar with robotic surgery. On the negative side, restricted trainee duty hours and nonstandard training and credentialing protocols for robotic surgery threaten to undermine our goals of success.

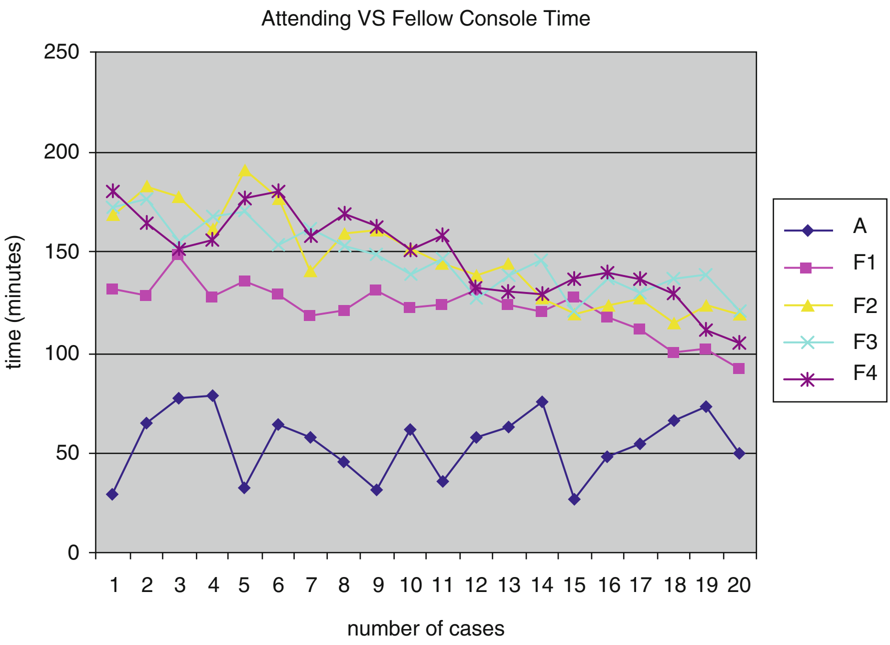

Fig. 5.2 Fellow console time consistently decreased by doing more cases

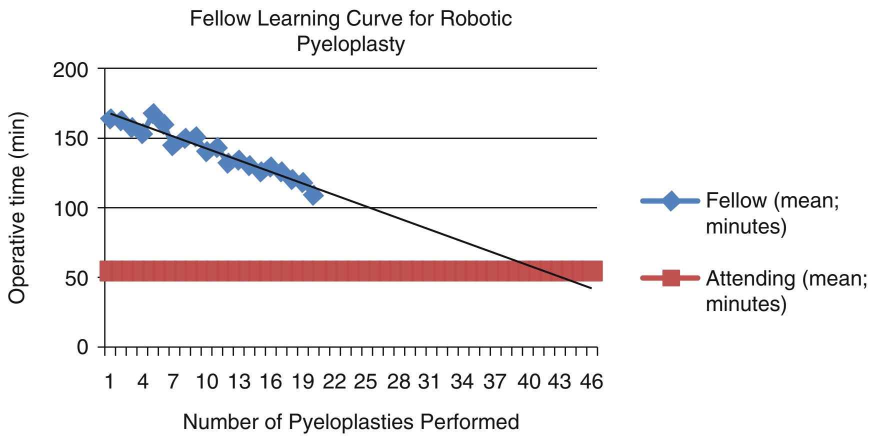

Fig. 5.3 Downward trend of operative times of fellow approaching senior surgeon

Education

Recognizing that our ability to train learners in the operating room setting on live patients has been curtailed, we have an opportunity to standardize training outside of the operating room for our learners (both surgeons and staff). The use of simulation education is standard in many surgical practices [16], but is spotty in robotic surgery. Curriculum has been validated for discriminating robotic surgery skills [17], and the use of virtual reality simulation has reduced the challenges of having access to the robot itself for training [18, 19]. Efforts are under way to standardize training for all new robotic learners in the United States through the Fundamentals of Robotic Surgery (FRS) initiative [20]. This curriculum promises to remain agnostic to the robotic surgery platform used because it is expected that within the next 5 years, there will be additional commercially available platforms. This standard curriculum will include a cognitive or didactics module and a technical skills module. And similar to the Fundamentals of Laparoscopic Surgery (FLS) curriculum that is required to pass for all general surgery residents before graduation from residency, FRS certification may be required by many surgical boards for allowance to perform robotic surgery.

Future Technology

The estimated market for robotic surgery in 2012 was $2.6 billion [21]. And as patents for the existing robotic technology expire over the next few years, one can expect that a number of medical device and technology start-up companies are and will explore robotic surgery research and development. Our pediatric urology community needs to be involved in this surge in technology development to ensure that our patients' special needs are met. Less expensive equipment, miniaturization of instrumentation, and improved tool-tissue interaction feedback are all areas in which we can drive and demand innovation.

Conclusions

Pediatric urologists have an opportunity to lead robotic surgery initiatives within our hospitals, our training centers, and our medical device partners. Approaching robotic surgery programatically instead of individually enhances your practice and reduces potential challenges. We should strive for effective patient care while minimizing the expense footprint, and to do this, we need to establish standard education pathways, create efficiency goals when starting a robotics program, and be good listeners to all team members involved that have an invested interest in the best healthcare we can provide.

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