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Review Article

Robotic surgical training: Where are we?

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HIGHLIGHTS

- Proficiency with robotic hysterectomy and lymphadenectomy occurs after the first 20–30 cases.
- Mastery does not occur until much later.
- The learning curve for robotic surgery is comparable between fellows and attending physicians.
- Most robotic educational curriculums incorporate a didactic and a graduated hands-on experience.

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ABSTRACT

Background and objective. Over the past 10 years, robotic surgery has revolutionized the advancement of MIS in gynecologic oncology. As the use of robotic surgery has increased, so has the interest in the surgical training of gynecologic oncology fellows. The purpose of this review is to summarize the state of robotic surgical education in Gynecologic Oncology.

Methods. Several electronic databases were searched to identify studies that discussed robotic surgical education in gynecologic oncology. Particular attention was given to articles that discussed educational curriculum. The various curriculums were compared and summarized.

Results. The first reports of robotic surgery curriculums in gynecologic oncology emerged in 2008. Prior to that the early adapters had to rely on less structured curriculums that essentially used live animal models and cadaveric dissections on the robot to simulate live surgery. More recent surgical curriculums are more structured and include the same basic components: didactics and a graduated hands-on experience. There is also an accredited robotic educational curriculum, the Fundamentals of Robotic Surgery (FRS), which combine an on-line curriculum with dry lab and operating room components that can be scored using a validated assessment tool.

Conclusions. Robotic surgical education has come a long way in the decade that the robotic platform has been available in the U.S. Although there is still no standardized curriculum, most fellowship training programs in gynecologic oncology have fairly consistent training. Simulation training is another tool that can help a surgeon achieve proficiency quicker.

Contents

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1. Introduction

The role of minimally invasive surgery (MIS) in gynecologic cancers was initially described in the 1990s with the first reports of laparoscopic lymphadenectomy for gynecologic malignancies by Childers et al. [1–4]. Although the concept of MIS was innovative, and had clear potential advantages, it required a great deal of "laparoscopic dexterity" that was simply not taught in gynecologic oncology fellowship training programs at the time. As a result, only a few centers had surgeons with the skills to perform such procedures, resulting in a slow uptake of the use of MIS in gynecologic oncology. However, as technology improved, interest in MIS grew, and as gynecologic fellowship training programs incorporated MIS training, more centers were able to perform MIS for gynecologic malignancies. The uptake of this technology was slow and far from universal. It was not until the emergence of robotic technology that MIS was universally adopted. In the 2015 state of the subspecialty report, the Society of Gynecologic Oncology reported that over 99% of gynecologic oncologists now perform MIS [5].

Over the past 10 years, the advancement of robotic surgery has revolutionized MIS in gynecologic oncology. In 2005, the da Vinci Surgical System by Intuitive Surgical Inc. was approved by the Food and Drug Administration (FDA) for gynecologic surgery. Compared to conventional laparoscopy, robotic surgery incorporates 3-dimensional stereoscopic vision and 'wrist-like' instrumentation with improved dexterity and precision. This technology allowed for a broader adoption of MIS, because of the improved user comfort and 'ease of use' of the da Vinci Surgical System. There is no better example of this than the use of MIS for radical hysterectomy in the United States, which prior to the introduction of robotic surgery was performed by very few highly experienced laparoscopic surgeons. As the robotic surgical platform gained popularity and became universally adopted, MIS became an ideal option for the treatment of early stage cervical cancer and for staging of endometrial cancer [6–8].

As the use of robotic surgery in gynecologic oncology increased, so has the interest in the surgical training of gynecologic oncology fellows. In a recent survey of U.S. gynecologic oncology fellowship directors, 95% of institutions report utilizing robotic surgery; and 94% of the responding gynecologic oncology fellows in training plan to perform robotic surgery in their independent practice after fellowship [9]. The Society of Gynecologic Oncology (SGO) acknowledges the importance of MIS training, specifically robotic surgery, in the development of gynecologic oncologists that are proficient in both robotic and conventional laparoscopy [8]. However, there is currently not a clear "standard of training" for robotic surgery. Each individual gynecologic oncology fellowship training program relies on their own institutional training guidelines.

2. Robotic surgery in the court of public opinion

In 2013, the FDA and other media outlets reported on the complications associated with robotic surgery [10–13]. The Wall Street Journal and The New York Times published articles bringing to light concerns over the safety of robotic surgery; and condemned robotic surgery as not being properly evaluated or monitored [10,13]. The New York Times, in particular, highlighted that one-third of deaths and 43% of injuries occurred during gynecologic procedures. While articles such as these raise public-awareness about the risks of robotic surgery, they can also serve as the impetus for change. In 2015, Cooper et al. published data suggesting the underreporting of robotic surgery complications to the FDA [14]. In their report, Cooper and colleagues included complications over a 12-year period, including 71 deaths and 174 non-fatal injuries. However, when the reported events to the FDA were crossed referenced with electronic records, there were several cases that were either filed years after the event or never reported. As the risks of robotic surgery become more transparent to the public, the creation of a reliable, competency-based robotic surgical curriculum and the ability to reliably assess a surgeon's competency is now not only a matter of "credentialing," but also a matter of public interest.

3. The learning curve

How many cases need to be performed to become 'proficient' in robotic surgery? This question is at the heart of the discussion of robotic surgical training. In 2009, Seamon et al. reported that proficiency in robotic hysterectomy with pelvic-aortic lymphadenectomy for endometrial cancer is achieved after the completion of 20 cases [15]. Proficiency was defined as the point when the slope of the operative time curve becomes less steep. Unfortunately, proficiency is not equivalent with competency. Seamon and colleagues also defined efficiency as the point in the operative time curve where the slope was zero, signifying no further improvement in operative time. Interestingly, this occurred around 80 cases, supporting the notion that proficiency can likely be obtained with the completion of a reasonable number of cases (about 20), but that mastery is an ongoing process that occurs with considerably more cases.

In 2010, Lim et al. compared robotic surgery to conventional laparoscopy and laparotomy, demonstrating that robotic surgery had a steeper learning curve (i.e. it took a smaller number of cases to become proficient) [16]. Proficiency was similarly defined as the point at which the slope of the operative time curve became "less steep"; and this interestingly also occurred after the first 20 cases. The same was not true for conventional laparoscopy, as operative times did not consistently decrease over the first 40 cases, supporting the fact that conventional laparoscopy appears to have a longer learning curve. In 2014, Lin et al. published similar results for the first 100 robotic laparoscopic hysterectomies, with a reported learning curve for proficiency of 20–30 cases [17]. This study was unique in that data was compiled for a single surgeon rather than multiple surgeons. While proficiency was documented relatively quickly in 20–30 cases, improvement was continuous throughout the 100 cases.

The above-mentioned studies consistently demonstrate that the learning curve for a skilled surgeon to achieve proficiency in robotic hysterectomy is fairly quick at approximately 20 cases. Unfortunately, each of these studies evaluated surgeons that have already completed their training, and thus may not be applicable to a surgeon "in training," such as a resident or fellow. Given the limited surgical experience of a resident or fellow, their learning curve may not be the same as attending surgeons. This should be considered when establishing a robotic surgical curriculum, as "expertise in the surgical management of women with gynecologic cancer is the most critical skill set the gynecologic oncologist must possess" [18].

4. The impact of training

Early reports of robotic surgery demonstrated its utility and safety in gynecologic surgery [19–22]. While MIS offers shorter hospital stays and quicker recovery compared to laparotomy, the robotic platform may provide some advantages compared to conventional laparoscopy: 1) 3-dimensional vision compared to 2-dimensional; 2) instrumentation with wrist like movements with 7 degrees of freedom; 3) elimination of hand tremors; 4) resolution of the fulcrum effect in conventional laparoscopy; and 5) increased accuracy and precision with downscaled instrument movements [20]. However, with any new medical or surgical technology, effective training strategies must be developed to ensure competency.

4.1. The early years

After the first report of robotic hysterectomy by Diaz-Arrastia in 2002, Marchal et al. published a series of 30 patients undergoing hysterectomy, including 22 receiving bilateral salpingo-oophorectomy (BSO) and 9 receiving bilateral pelvic lymphadenectomy in 2005 [19,22]. The