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Robotic surgery in gynecologic oncology: Impact on fellowship training

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ABSTRACT

Objectives. To report the impact of a new robotic surgery program on the surgical training of gynecologic oncology fellows over a 12 month period of time.

Methods. A robotic surgery program was introduced into the gynecologic oncology fellowship program at Northwestern University Feinberg School of Medicine in June 2007. A database of patients undergoing surgical management of endometrial and cervical cancer between July 2007 and July 2008 was collected and analyzed. Changes in fellow surgical training were measured and analyzed.

Results. Fellow surgical training for endometrial and cervical cancer underwent a dramatic transition in 12 months. The proportion of patients undergoing minimally invasive surgery increased from 3.3% (4/110 patients) to 43.5% (47/108 patients). Fellow training transitioned from primarily an open approach (94.4%) to a minimally invasive approach (11% laparoscopic, 49% robotic, 40% open) for endometrial cancer stagings, and from an open approach (100%) to an open (50%) and robotic (50%) approach for radical hysterectomies. Fellow participation in robotic procedures increased from 45% in the first 3 months to 72% within 6 months, and 92% by 12 months. The role of the fellow in robotic cases transitioned from bedside assistant to console operator within 3 months.

Conclusions. Fellow surgical training underwent a dramatic change with the introduction of a robotic surgery program. The management of endometrial and cervical cancer was impacted the most by robotics. Robotic surgery broadened fellowship surgical training, but balanced surgical training and standardized fellow training modules remain challenges for fellowship programs.

Introduction

In April of 2005 the da Vinci surgical system was approved by the Food and Drug Administration for use in gynecologic procedures and was shown to have a role in gynecologic procedures [1–6]. This technique has been shown to be feasible in gynecologic oncology for early endometrial cancer staging procedures [7–12] as well as radical hysterectomies for early stage cervical tumors [13–18]. The benefits of this surgical modality include overcoming several barriers to the use of traditional laparoscopy, including limitations of the human hand (seven degrees of movement and elimination of hand tremors), elimination of the fulcrum effect of traditional laparoscopy (the robotic arms imitate the movements of the surgeon's hand), improved visualization (three-dimensional stereoscopic imaging), and increased independence of the operating surgeon. The learning process may be accelerated, with a marked decline in operative time after 20 cases [19] and a more recent report of a large series of cases in which the mean operative time was reached after only 9 cases [12].

As more gynecologic oncologists incorporate this technique into their practices, fellowship training programs have started incorporating robotic surgery. A recently presented survey of fellows and fellowship directors indicated that an increasing proportion of fellowship training centers own robots (90%) and are using them for surgical management of gynecologic malignancies (90%) [20]. This survey was limited by a low response rate (30%) as well as the usual biases of survey-derived data, but indicates that this is an important new aspect of fellow education to explore and describe.

The effect robotics has on fellow surgical training appears to be significant, but quantification of the broad range of these effects is difficult. Safety and feasibility are several aspects of fellow participation in robotics that have been described. Zakashansky et al. reported on perioperative outcomes for robotic radical hysterectomies in which fellows participated, and suggested that the lack of change in perioperative outcomes supports the safety of fellow participation [21]. Mendivil et al. analyzed robotic operative times of cases in which fellows participated and compared them to the times of cases in which the attending alone performed at the console [22]. Authors reported an increased operative time in cases with trainee participation, which represents the cost of training fellows in robotics and is perhaps comparable to the increase in operative time with any other open or

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laparoscopic case in which trainees participate. Although feasibility and safety are important to establish, these authors do not adequately describe the effects of robotics on fellow education that may be a concern of gynecologic oncology fellowship programs prior to introducing robotics at their institution.

We sought to detail the effect of a new robotic surgery program on the experience of fellows at a fellowship training institution after the first year of the program. We will describe the introduction of robotics to fellows, the specific effects the program has had on the surgical practice management of early endometrial cancer and early cervical cancer (the most common indications for robotic surgery in our department), and its effect on the training of fellows.

Materials and methods

In June of 2007, a dedicated robotic surgery program was introduced at Northwestern University, an ABOG designated fellowship training program. In addition to serving as an educational tool for fellows, robotics was introduced to serve as a technique to shorten the learning curve for minimally invasive surgery, expand the patient population eligible for minimally invasive surgery, and allow minimally invasive performance of more complex procedures. The program was initiated under the guidance of one gynecologic oncologist, who served as proctor for the four other gynecologic oncologists in the group after their required company-sponsored training program. Surgical videos were reviewed and an institutional porcine-based laboratory session was attended by all faculty and fellows-in-training in the division of gynecologic oncology. A dedicated operating room team composed of a scrub technologists and circulating nurses was developed and trained in robotic technology. A company-sponsored training program was not part of the required training of fellows. Initial fellow participation was as first assistant where knowledge and proficiency of the robotic surgical system were obtained and step-by-step instruction of the robotic procedures for endometrial cancer staging was demonstrated by the attending gynecologic oncologist. Fellow participation as console operator in the procedures was based on a step-wise progression through various aspects of the surgery and demonstration of competency with each aspect prior to progression to a more challenging component of the surgery. The step-wise progression started with closing of the vaginal cuff, moved on to a single side of the hysterectomy, then pelvic lymph nodes and omentectomy were performed, and lastly the para-aortic lymph node dissection. Fellow progression and demonstration of competency was determined by the attending gynecologic oncologist.

A prospective database of all patients undergoing surgical staging of endometrial cancer and radical hysterectomy for early cervical cancer via laparotomy, traditional laparoscopy, and robotics at Northwestern University between July 2007 and July 2008 was collected. Approval for this study was obtained by the Northwestern University Institutional Review Board prior to data collection. After the diagnosis of clinical early stage endometrial cancer or cervical cancer, patients were counseled on all 3 surgical modalities, with the exception of laparoscopic radical hysterectomy, which was not offered. Patient preference dictated surgical modality, with referral of the patient within the group to a surgeon comfortable with the surgical modality of choice if necessary (robotic radical hysterectomy performed by 2 of the 5 faculty). Limitations of patients eligible for minimally invasive surgery included multiple prior abdominal surgeries with a documented history of abdominopelvic adhesions, evidence of disease outside the uterus, and large uterine size. Body mass index (BMI) was not a limiting factor for minimally invasive approaches. Patients underwent informed consent, and those electing robotic surgery underwent a discussion of the limited extent of robotics previously performed at the institution. Surgeries were performed by the faculty members of the Division of Gynecologic Oncology and clinical fellows.

Variables effecting fellow experience were collected and analyzed, including proportion of staging surgeries performed at our institution with minimally invasive surgery and length of hospital stay. The experience of our residents with robotics is currently being collected, and will be reported separately. The number of cases of each of the three modalities attended by the fellow and role of the fellow in those cases was collected. The fellow was considered first-assist if she/he performed up to 50% of the case via laparotomy or laparoscopy, or sat at the surgeon's console. Practice management variables were compared with the year prior to introduction of the robotic surgery program. Progress in fellow participation was tracked by comparing the successive 3-month blocks after introduction of robotics. Demographic data and perioperative outcomes were collected and were reported elsewhere [23].

Results

In the first 12 months of the fellowship's robotics program, a total of 75 cases were performed with the robot to treat both benign and malignant gynecologic conditions. Procedures performed during that time included simple and radical hysterectomy, dissections of the pelvic and para-aortic lymph nodes, omentectomy, and removal of adnexal masses. Disease processes treated robotically included endometrial adenocarcinoma and sarcoma, cervical cancer, borderline ovarian tumors, benign ovarian masses and benign uterine pathology. As a result of program growth and faculty buy-in, the division of gynecologic oncology at our institution has performed over 200 robotic cases from July 2007 to April 2009 [18,23].

The management of endometrial and cervical malignancies significantly changed from the year prior to the robotics program to the year following introduction of the program. The proportion of patients undergoing primary surgical management for endometrial and cervical cancer of any histologic type via minimally invasive surgery increased from 3.6% (4/110 patients) from June 2006 to June 2007 to 43.5% (47/108 patients) in July 2007 to July 2008. Four of 5 faculty members completed the company-sponsored robotics training program and completed the divisional requirement of 5 proctored cases on the da Vinci Surgical System under the supervision of a skilled gynecologic oncologist within that time period. The clinical fellows underwent a similar training protocol, including review of surgical videos, the in-house porcine-based laboratory training session, and observation in the operating room.

There was a drastic increase in the proportion of patients with endometrioid endometrial and early cervical cancer managed with minimally invasive surgery after the introduction of robotics into our fellowship program. The proportion of endometrioid endometrial cancer patients staged with minimally invasive techniques increased from 5.6% (4/71 cases, all laparoscopic) to 60.0% (39/65 cases, 11% laparoscopic and 49% robotic) in the first year of the program (Table 1). The proportion of early cervical cancer patients undergoing radical hysterectomy with minimally invasive techniques increased from 0 (0/16) to 50% (7/14, all robotic) in the first 12 months after introduction of robotics. The groups undergoing minimally invasive surgery had a shorter median hospital stay than those undergoing the open surgical modality (1 day vs. 4 days; $p<0.0001$). The total number of inpatient days for perioperative management of these 2 cohorts of patients decreased from 389 to 185 during the twelve

Table 1
Proportion of cases of endometrioid endometrial cancer and early cervical cancer managed with minimally invasive surgery before and after introduction of robotics.

Disease site	July 2006–June 2007		July 2007–June 2008	
	Laparoscopic	Robotic	Laparoscopic	Robotic
Endometrial	5.6%	0	10.7%	49.2%
Cervical	0	0	0	50%

Table 2
Proportion of cases with significant fellow participation at 3 months, 6 months, and 12 months from the introduction of robotics.

Time from introduction of robotics	Proportion of robotic cases with fellow participation (%)
3 months	45
6 months	72
12 months	92

months before and after the robotic surgery program was established. The total number of cases performed in the 12 months before and after robotics was not significantly different (87 vs. 79, respectively). Complications occurred in 19% of patients in this cohort. Complications included conversion to open for poor access to the pelvis, a cautery injury to the cecum during diagnostic laparoscopy that was excised with the laparoscopic staple device, 3 readmissions for drainage of lymphocysts, and copious serous drainage from one of the trocar incisions. Due to the nature of the complications (post-operative in nature) and the pattern of fellow and attending each performing half of the case, it was difficult to distinguish the fellow complication rate from that of the attending. Conclusions regarding the effect of fellow participation on overall complication rate would be premature.

Participation of the fellow in robotics increased from program inception throughout the first year. The fellow-in-training participated in 45% of all of the endometrial staging surgeries and radical hysterectomies in the first 3 months after robotic surgery was introduced, increasing to 72% in the following 3-month block. By 12 months, fellows significantly participated in 92% of endometrial and cervical cancer procedures (Table 2). Procedures performed by the fellow included hysterectomies, unilateral and bilateral salpingo-oophorectomies, retroperitoneal dissections, pelvic and para-aortic lymph node dissections, ureterolysis and omentectomies. Participation transitioned within the first 3 months from bedside assistant to console operator. Fellows initially performed closure of the vaginal cuff, then hysterectomy with bilateral salpingo-oophorectomy and pelvic lymph node dissections within the first 6 months. Fellows went on to perform omentectomies, ureterolysis and limited para-aortic lymph node dissections within 12 months (Table 3).

Discussion

The transition period of a fellowship program into robotics is both challenging and beneficial. This period is characterized by the loss of participation of trainees in open and laparoscopic cases as first assistant, and the capitalization of surgical participation in robotic cases by attendings being proctored for their own certification. It is also characterized by a significant broadening of fellow surgical education. The traditional perception of trainees is that participating in the case as first-assist is most beneficial. However, the first assistant in robotic surgery has minimal participation as compared to laparoscopic and traditional surgery. To manage this period of transition, the surgeon (faculty and fellows) must accept several other aspects of participation as legitimate methods of learning, most notably: 1) learning a new technology; 2) learning to be an assistant for robotics and troubleshoot for the operative team; and 3) observation of others, which teaches the trainee what to do and, at times, what not to do. The commitment to robotics must cross all levels of training to successfully move through this transition period.

Within 12 months at our institution, the surgical education of fellows in the management of endometrial and cervical cancer drastically changed. The proportion of patients who underwent minimally invasive surgical management for endometrial and cervical cancer increased from 3.3% to 43.5%. In the year prior to the robotics program, all radical hysterectomies and 94.4% of endometrial cancer staging surgeries were done through open techniques. Of note, the increase is minimally invasive surgery was accounted for not only by robotics, but by an increase in laparoscopic endometrial cancer staging surgeries (5.6% to 10.7%). The increase in laparoscopy may be explained by both a limited initial availability of the robot for our department, and an increased commitment to minimally invasive surgery, which has become the preferred modality for the surgical management of early endometrial cancer at our institution. Currently, the robot resides in the women's hospital with significantly improved access, thereby increasing the availability of minimally invasive surgical approaches at our institution. However, the trend clearly favors robotics.

Within the first 12 months, 4 of 5 gynecologic oncology faculty were independently performing robotic procedures. Within 18 months, all gynecologic oncology faculty in our division were independently performing robotic procedures. The approach of our division was to encourage all five faculty members to develop robotic surgical skills to establish robotics as a permanent component of our division that would not be affected by faculty migration or retirement, to update our surgical skills with the latest technology, and to maximize the fellow educational experience. The cost of this approach may be a longer learning curve for each physician and the risk of not maintaining robotic expertise if procedures are performed infrequently. Recent evidence from a large multi-institutional research group would suggest the learning curve for robotic surgery is approximately 10 cases. Whereas the achievement of the initial learning curve is often reported, the maintenance of skills is also an important component of any learning curve. The number of cases required to maintain robotic skills has yet to be determined for gynecologic oncology. Institutional requirements of a minimum number of robotic cases per year to maintain privileges may avoid the loss of expertise ensuring surgical competence and ultimately patient safety.

Participation of the fellow in robotic cases increased consistently during the first year after introduction of robotic technology. Participation was initially limited to observation, porcine-based laboratory sessions, video review, and training at the assistant port. Within 3 months, the fellow managed patient positioning, manipulator placement, port placement, and performed as console operator for vaginal cuff closure. The 45% rate of participation as first-assist in endometrial cancer staging cases in the first 3-month block is explained by several factors. Open staging surgeries were initially prioritized by the fellow starting the first clinical year of fellowship. Cases in which fellows did not participate included those that were scheduled at the same time as an open case in another room, those in which other faculty were being proctored, and early robotic cases in which the fellow's role was observation. Within 6 months, the fellow participated in a larger proportion of the robotic cases (72%) and performed as console operator for significant portions of the hysterectomy, bilateral salpingo-oophorectomy and pelvic lymph node dissection. Within 12 months the fellow was performing limited para-aortic lymph node dissections, ureterolysis, and omentectomies. Approximately 5–10 cases were required for fellows to display proficiency at the console in each of the following three portions of the staging surgery: vaginal cuff closure, hysterectomy, and pelvic lymph node dissection. The para-aortic lymph node dissection

Table 3
Type of robotic procedures performed by fellows at 3 months, 6 months, and 12 months after introduction of robotics.

Time from introduction of robotics	Procedure type
3 months	Hysterectomy
	Unilateral/bilateral salpingo-oophorectomy
6 months	Pelvic lymphadenectomy
12 months	Para-aortic lymphadenectomy
	Omentectomy
	Ureterolysis

required more than 10 cases before proficiency was achieved. By 12 months after introduction of robotics, the only limitation to fellow participation in cases was simultaneous open and robotic surgeries, in which case the open surgery went uncovered.

Robotics seems to stand apart from other surgical modalities which are routinely taught to fellows. The primary difference between training fellows in robotics compared to other surgical modalities is the relative independence of the surgeon/trainee when sitting at the console as compared to laparoscopic or open techniques in which the attending surgeon is more directly involved. Current instruction of the console operator varies from simply verbal instruction to a telestration screen on which the proctor may instruct the trainee at the console during the surgical procedure. However, a more direct way for the proctor to become involved is highly desirable, such as through a dual console at which both trainee and proctor could simultaneous operate. This may protect the trainee performing as console operator and potentially shorten the learning curve. At our institution, teaching methods found useful by fellows included verbal feedback, telestration teaching, and demonstration of a portion of the procedure after a first attempt by the fellow. Essential preparation for fellows prior to participation as console operator included observation of 5–10 procedures performed by an attending experienced in robotics, demonstration of knowledge of robotic technology, and development of troubleshooting skills for successful completion of robotic cases. Fellows who become experienced in robotics perceived benefit from observation of attendings inexperienced in robotics, where skills were developed in operative and technological troubleshooting as well as in proctoring and verbal feedback. Fellows at our institution did not attend the company-sponsored robotics training program, however this may represent an additional training opportunity for fellows.

Independence of the robotic surgeon at the console may also affect the response given to patients who request that a faculty member performs the surgery without the involvement of trainees. In teaching institutions, the primary surgeon teaches the fellow through verbal instruction, demonstration, and direct assistance. While this has previously occurred at the patient's bedside, robotics requires that this process takes place remotely from the patient due to the location of the surgeon's console. Our institution has not made robotic cases an exception to its rule of involving fellows in all cases. The faculty surgeon remains involved in robotic cases using the telestration screen and verbal direction when not demonstrating directly at the console. The teaching techniques are the same as those used in open or laparoscopic cases, but faculty have developed comfort with the physical distance from the fellow, the console, and the patient. This approach requires the primary surgeon to develop comfort with teaching in a non-traditional way, and requires fellows to undergo adequate training prior to sitting at the console. An alternative approach may involve the development of a non-teaching service in which fellows are not involved. However, the comfort of the faculty with this surgical modality must be balanced with the institutional commitment to fellow education. Additional robotic teaching tools in which the proctor is more directly involved in the surgery, such as a dual console, may improve faculty comfort in teaching. A new da Vinci Surgical System now incorporates a dual console which could enhance teaching and patient care.

While a training module has been established for attendings, no standardized robotic training module exists for fellows and residents. Attending physicians at our institution become certified in robotics via the following training program: 1) completion of an department-sponsored porcine-based laboratory with a robotic proctor; 2) completion of a company-sponsored laboratory training program involving travel to distant site for a porcine-based laboratory with robotic proctors as well as a didactic teaching module; 3) 5 cases scheduled with an available proctor skilled in performing common gynecologic oncology procedures robotically. The training requirements for fellows, however, are vague, with no industry-required training standards and no guidelines from organizations regulating the education of fellows regarding robotic training for fellows. The provision of privileges for robotics at the completion of training seems to be at the discretion of institutions hiring fellows with varying degrees of robotic experience at the completion of their training. This may be a new concept for educational organizations to address, as no other surgical modality has required standardized training programs. However, the complexity of the technology and independence of the surgeon at the console may justify standardized training and certification for fellows. Our institution is currently discussing the implementation of a limited proctoring program for any recent graduate requesting gynecologic robotic privileges to ensure patient safety and surgical competence with this new technology.

Barriers to widespread training of fellows in robotics include substantial time and financial costs, sophistication of the technology, and lack of guidelines for its use due to relative newness in gynecologic oncology. Initiation of a robotics program in a fellowship training program involves a large cost, with financial investments in the machine itself and the training of faculty and fellows; time investments in training and planning proctored cases; and a philosophical commitment of the hospital, operating room, anesthesiologists, nurses and department [24]. The urology literature estimates the average cost of one attending physician to learn robotics at $217,000, a figure accounted for by extra operative time and associated operative costs [25]. There is a substantial certification process for attending physicians to use robotics, implying that this is a more sophisticated technology which requires more extensive training in technique and troubleshooting. Lastly, the relative newness of robotics is associated with a lack of guidelines for appropriate case and patient selection. Data does not yet exist for patients with early ovarian or papillary serous endometrial cancer who undergo robotic-assisted surgery to ensure us of its equivalence to open staging. Patient selection data is emerging, showing efficacy to open surgery in obese patients. However, other patient characteristics which predispose a robotic case to conversion to laparotomy have yet to be elucidated [26]. Importantly, data regarding recurrence and survival are not yet mature, although the long-term data for laparoscopic endometrial staging is encouraging [27].

Barriers to fellow training in robotics must be balanced by the benefits it provides. Fellows at our institution received training in an additional surgical modality which has been shown to be feasible in a variety of reports for endometrial and cervical cancer [7–19,23,24,28–31]. Fellows perceive that robotics improves their skills and shortens their learning curve for minimally invasive surgery. In a program which performed less than 5% of endometrial and cervical cases laparoscopically prior to introduction of robotics, over 40% of the patients from whom the fellow now learns are managed with minimally invasive techniques.

Once the transition of training programs to robotics has taken place, balance of open, laparoscopic, and robotic experience must be maintained. The commitment of a division and department to robotics must be balanced by a commitment to continued training of traditional and laparoscopic surgery. A fellowship training program, above all, is a training program with an obligation to prepare fellows for independent practice which may or may not include robotics. Graduating fellows hired at institutions without robotic systems will commit their future patients to open surgery if not experienced in laparoscopic staging. However, most portions of laparoscopic staging may be learned performing other procedures (resection of adnexal masses, staging of borderline ovarian tumors, hysterectomy for prophylaxis or dysplasia). The biggest concern is the lack of laparoscopic training in pelvic and para-aortic lymph node dissection. There is currently no requirement of accrediting organizations to provide fellows with training in minimally invasive surgery, or to have balance in the 3 surgical modalities. Perhaps this may be a consideration in the future.

Conflict of interest statement

Dr. M. Patrick Lowe has a consulting relationship with Covidian and Intuitive. The remaining authors declare that there are no conflicts of interest.

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