Original Article

Gynaecologic Robot-Assisted Cancer and Endoscopic Surgery (GRACES) in a Tertiary Referral Centre

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Abstract

Introduction: Robotic-assisted gynaecologic surgery is gaining popularity and it offers the advantages of laparoscopic surgery whilst overcoming the limitations of operative dexterity. We describe our experience with the first 40 cases operated under the GRACES (Gynaecologic Robot-Assisted Cancer and Endoscopic Surgery) programme at the Department of Obstetrics & Gynecology, National University Hospital, Singapore. Materials and Methods: A review was performed for the first 40 women who had undergone robotic surgery, analysing patient characteristics, surgical timings and surgery-related complications. All cases were performed utilising the da Vinci® surgical system (Intuitive Surgical, Sunnyvale, CA) with 3 arms and 4 ports. Standardised instrumentation and similar cuff closure techniques were used. Results: Seventeen (56%) were for endometrial cancer and the rest, for benign gynaecological disease. The mean age of the patients was 52.3 years. The average docking time was 11 minutes (SD 0.08). The docking and operative times were analysed in tertiles. Data for patients with endometrial cancer and benign cases were analysed separately. There were 3 cases of complications- cuff dehiscence, bleeding from vaginal cuff and tumour recurrence at vaginal vault. Conclusion: Our caseload has enabled us to replicate the learning curve reported by other centres. We advocate the use of a standard instrument set for the first 20 cases. We propose the following sequence for successful introduction of robot-assisted gynaecologic surgery – basic systems training, followed shortly with a clinical case, and progressive development of clinical competence through a proctoring programme.

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Key words: Clinical outcomes, Cost effectiveness, Gynaecology, Learning curve, Robotics

Introduction

Hysterectomy is the most common major gynaecologic operation. Over 600,000 hysterectomies are performed annually in the US.[1] In Singapore, almost 9000 hysterectomies are performed annually. Traditionally, gynaecologic surgeons approached the pelvis through a laparotomy incision. Since its introduction some 20 years ago, laparoscopy has become the preferred option compared to laparotomy because of the cost-effectiveness, patient satisfaction and superior quality of life indices associated with laparoscopy.[2,3] Compared to laparotomy, laparoscopy is associated with significantly lower postoperative infection rates, shorter length of hospital stay and lower overall expenditures.[4] However, laparoscopic hysterectomy has not been widely adopted by gynaecologic surgeons because of its longer operating time, the need for advanced training and the relatively steep learning curve required to consistently obtain good clinical outcomes. Currently, only 23% of all hysterectomies in the US are performed laparoscopically.[5,6]

Robot-assisted surgery was developed in the early 1980s. In 1988, Kwoh et al[7] used the PUMA 650 for robot-controlled neurosurgical biopsy. The developmental vision for surgical robotics was that this technology would augment the capabilities of surgeons performing minimally invasive surgery. Early robotics systems such as the Aesop (Computer Motion Inc., Goleta, CA) and Zeus (Computer Motion Inc.) were cumbersome and controlled only certain elements of the minimally invasive surgical field, such as camera systems or retractors. The most recent platform of the surgical robot, the da Vinci® surgical system (Intuitive Surgical, Sunnyvale, CA) was introduced in 1999, and is the only surgical robot currently approved by the United States Food and Drug Administration (FDA) for clinical use in humans. The da Vinci® surgical system has successfully replicated the dexterity of the human wrist in its robotic

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operative instruments. With this innovation, straight laparoscopic instruments are transformed into dexterous representations of the surgeon's hands. Other advantages of robotic assistance include improved standard 3-dimensional vision that allows the surgeon to be visually immersed in the operative field and the ability for a 2-handed surgeon to have control over 4 robotic arms, including control of the camera, which eliminates reliance on a surgical assistant. The hand-like instruments are powered with bipolar and monopolar energy sources and are operated by the surgeon's hand controls ("masters") at the ergonomic operating console which results in augmented single surgeon capability.

The data from published series suggest that performing surgery using the da Vinci system is intuitive and therefore associated with a shorter learning curve compared to a conventional laparoscopic approach for the same procedure.[8-14]

The GRACES (Gynaecologic Robot-Assisted Cancer and Endoscopic Surgery) programme was launched at the National University Hospital, Singapore in September 2008. This report outlines the initial experience of the surgeons and their surgical teams in terms of the learning curve associated with surgical robotics. This report will also present immediate and short-term patient outcomes for the first 40 robotic cases.

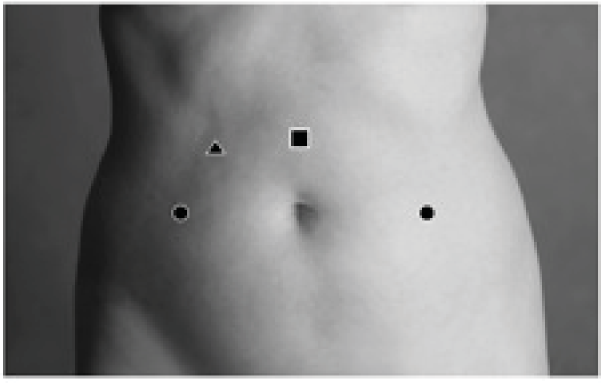

Fig. 1

■ 12 mm Camera port

● 8 mm Robotic Instrument port

▲ 5 mm Assistant port

Notes on Relative Port Positions

- The 12 mm camera port is placed in the midline.
- The 8 mm instrument ports are placed in the same horizontal line drawn through the umbilicus.
- The port positions describe a rough arc. This is a modification on some standard placements that describe an "M" where accessory or assistant ports are placed cephalad to the 12 mm camera port. We have found that in our population, the arc configuration is better suited to a relatively shorter distance between the xiphoid process and pubis.

Materials and Methods

A retrospective chart review was performed for the first 40 patients undergoing robot-assisted gynaecologic surgery within the Department of Obstetrics and Gynaecology of the National University Hospital, Singapore. This study was approved by the National Healthcare Group Domain-Specific Review Board.

The operative time was from skin incision for port placement to skin closure. The total docking time was calculated from the completion of port placement to the time when all the instruments were in situ in the operative field. The total console time was from the time the console surgeon sat down at the console to start operating till he or she got up from the console to undock the robot and close the skin incisions.

Robot-assisted laparoscopic procedures were performed using the da Vinci® surgical system (Intuitive Surgical, Sunnyvale, CA). All 40 operations were performed using the standard system with 3 arms. Four ports were inserted through the anterior abdominal wall (Fig. 1). A 12-mm trocar was inserted approximately 4 to 5 cm above the umbilicus for the camera port. Two 8-mm robotic ports were placed at the lateral borders of the rectus sheath (10 cm from the camera port and the line joining both 8 mm ports roughly at the level of the umbilicus). An additional 5-mm port was placed within the right upper quadrant and at a distance of 7 cm from both the camera port and the right 8-mm robotic port. The instrumentation was standardised for all cases: fenestrated bipolar graspers in the "left hand", monopolar scissors in the "right hand" which is subsequently swapped for a robotic needle driver for suturing and vaginal cuff closure.

Results

Of the first 40 cases of robot-assisted gynaecologic surgery, 17 (56%) were for endometrial cancer and the rest for benign or precancerous gynaecological disease (Table 1). The mean age of the patients was 52.3 years. The average docking time was 11 minutes (SD 0.08). The cases were divided into 3 groups for analysis, based on the temporal sequence that they were operated on. Comparing the first, middle, and last tertiles in this series, a pattern of improvement in the time required to set up the robotic system was observed. For the first, second and third consecutive groups of patients, the average docking times were 17 minutes (SD 0.008), 10 minutes (SD 0.002) and 8 minutes (SD 0.002), respectively (Table 2). The shorter docking times for the middle and last tertile of cases indicate that about 10 to 20 cases are sufficient for a "naive" team to gain familiarity with manoeuvring the docking system.

In comparison, operative times took longer to show a discernible improvement. Only the last 10 cases showed a 30-minute improvement in the operating time, with the average console times being 3 hours in the first and second tertile of cases. This suggests that there may be room for improvement, and more than 30 cases would be required for the team to achieve maximal efficiency.

The mean age of the 17 patients with endometrial cancer was 55 years (range, 37 to 70 years). The preoperative histological diagnoses of the patients were as follows: one patient had clear cell carcinoma, 10 patients had grade 1 and 6 patients had grade 2 endometrioid adenocarcinoma. Robot-assisted total hysterectomy, bilateral salpingo-oopherectomy (THBSO) and pelvic lymph node dissection was performed in 15 cases. As such, the average times were skewed because of the performance of robot-assisted total hysterectomy and pelvic lymphadenectomy. Out of the 17 cases of endometrial cancer, the average console time was 3:20 hours (range, 1:30 to 4:43 hours; SD 0.52) compared to 1:58 hours (range, 1:04 to 3:00 hours; SD 0.032) for the 10 benign gynaecological cases (Table 1).

The benign cases are tabulated in Table 1. The average console time for patients with fibroids was 2:22 hours. As expected, the cases of endometriosis required longer console time, with a mean of 3:15 hours. The shortest console time was for an ovarian cyst, which required 45 minutes.

Table 1. Details of the First 30 Cases Managed using Robot-assistance in the GRACES Programme at NUH

	No. of cases	Average docking time in hours (SD)	Average total console time in hours (range; SD)
Endometrial cancer	17	0:12 (0.09)	3:20 (1:30 to 4:43; 0.52)
Fibroids	5	0:08 (0.02)	2:22 (1:04 to 3:00; 0.45)
Endometriosis (one with fibroid)	2	0:07	3:15 (2:30 to 4:00)
Cervical AIS	1	0:10	1:38
Abnormal vaginal bleeding	1	0:20	2:35
Abnormal bleeding (large intramural myoma)	2	0:13	2:30
Leucorrhoea	1	0:15	1:30
Ovarian cyst	1	0:10	0:45
Average (SD)		0:11 (0.08)	2:53 (0.043)

Table 2. Learning curve: Average Docking and Operative Times Analysed in 3 Sets of Cases According to the Temporal Sequence

	Average docking time (hours)	SD	Average total console time (hours)	SD
Cases 1 to 10	0:17	0.0083	3:01	0.032
Cases 12 to 21	0:10	0.0029	3:03	0.048
Cases 22 to 32	0:08	0.0022	2:38	0.047

SD = standard deviation

An overall trend of increasing technical difficulty from simple to complex was observed in the caseload, culminating in the performance of a modified radical hysterectomy, bilateral salpingo-oopherectomy and pelvic lymphadenectomy. We encountered only 3 complications in our first 30 cases. Of these, 2 complications were unanticipated and patient-related. However, the final complication was procedure-related, and tumour spillage was noted at the time of surgery. The first patient had undergone robotic total hysterectomy for cervical adenocarcinoma in situ, and presented with a cuff dehiscence on postoperative day 12, due to premature resumption of penetrative intercourse. The cuff healed completely within 2 weeks with antibiotic cover and expectant management, without the need for resuturing. The second patient had robotic removal of remnant cervical stump for persistent and recalcitrant leucorrhoea. This patient presented with vaginal bleeding from a cuff angle on postoperative day 7, which resolved with cold coagulation of the bleeder. The third patient had a robotic THBSO and pelvic lymph node dissection for an endometrioid adenocarcinoma of the endometrium. She was noted to have tumour spillage due to a cervical rent when removing the uterine specimen. The site was cleared of all gross tumour and the patient was informed of this complication immediately postoperatively. She was given the option of upfront radiotherapy or a plan for expectant management. The patient opted for expectant management and was noted to have persistent vault disease 3 months postoperatively. This persistent disease was noted at the vaginal cuff; the aetiology was likely to be seeding from tumour spillage as a complication of primary surgery. The patient was treated with radiotherapy to the vault, and when last reviewed was disease-free.

Discussion

With GRACES, our experience with the learning curve has been quite consistent with other published reports. The majority of cases performed during our "learning curve" period were procedures for patients with endometrial cancer.[11-14]

Similar to other reports, the key advantages of the da Vinci robot in our series were improved vision, dexterity and power. The surgeon was now away from the operating table and in an operating console with a 3D standard operative field. This enabled the surgeon to have intuitive movements of the hands in a natural fashion. The introduction of multiple-wristed instruments provided a degree of dexterity and articulation that was similar to and in some instances, superior to the human hand because of its stability, since fine tremors can be eliminated. In addition, the translation of movement from the 'master controls' to the actual instrument can be scaled, which can increase precision in surgery.

The intuitive nature of robotic surgery meant that proficiency could be achieved in a fairly short period of time when compared to achieving proficiency in conventional laparoscopic gynaecologic surgery. This experience has been reported across the spectrum of gynaecologic surgery; from benign to cancerous tumours.[11-13] Comparison between laparoscopic and robotic surgeries for gynaecological procedures is outside the scope of our study. However it is known that robotic surgery resulted in a higher nodal yield and shorter operative times and lower estimated intra-operative blood loss when compared to laparoscopy for endometrial cancers.[15] Across the board comparisons of total hospital bill size for all 3 modalities, open, laparoscopy and robotic surgery cannot be used to effectively answer the question of whether robotic surgery is a cost effective modality as there are multiple technical factors, as well as the pros and cons of each modality to be taken into consideration, as outlined earlier in the paper.

Our GRACES programme has maintained a consistent caseload since its inception. This caseload has enabled us to replicate the learning curve reported in advanced robotics programs.[14] In our series, pre-anaesthesia preparation, docking and console times attained a plateau after the initial 20 cases. This was consistent with the reports from other centres.[12,13] We found that the ability to use consistent instrumentation, both in terms of the robotic instruments used and also in terms of the vaginal instrumentation and instrumentation for uterine manipulation significantly affected the surgeons' learning curve. We strongly advocate the use of a standard instrument set for the first 20 cases. Interestingly, the choice of instrumentation did not significantly affect the conduct of surgery for benign cases compared to those with endometrial cancer.

Our experience led us to conclude that for optimal patient safety and outcome, the principal considerations were technical difficulty of the cases vis-à-vis the programme's developmental stage. Successful completion of the first 10 cases allowed us to develop confidence and proficiency to tackle more complicated cases.

Based on our experience, we propose the following sequential steps to introduce robot-assisted surgery into a "naive" gynaecological practice:

1. Plan to undergo basic systems training in a dry lab. This training is usually conducted by the system's vendor and represents the gynaecologic surgeon's introduction to the robotic surgical system, the conduct of robotic surgery and the performance characteristics of the da Vinci robotic surgical system.

2. Systems training should be followed shortly with the first live clinical case. We strongly advise a simple myomectomy as the first case. This will allow sufficient time for the gynaecologic surgeon performing his or her first robotic surgery to get familiar with the logistics of patient positioning, insertion and manipulation of vaginal instrumentation, port placement and robot-docking. As far as the conduct of the case is concerned, there is room for exploration of the dexterity of the robot in the step of dissecting out of the myoma and also in intracorporeal suturing with the robot. These initial experiences will allow the surgeon to gain familiarity with the performance characteristics of wristed instruments within the operative field and to develop a sense of confidence in the robot's dexterity. This, in turn, will allow the surgeon to leverage on the robot's unique abilities to perform a wide range of gynaecologic procedures in a minimally invasive fashion. Finally, this will enable the entire operative team and especially the anaesthesiology and nursing teams to gain competence at supporting robotic surgery.

3. Proctoring and credentialing. The general consensus is that each procedure for which a surgeon is seeking credentialing or proof of proficiency should be proctored or observed by an expert at least twice. An expert can be defined as a surgeon who is already recognised as being proficient in that particular robot-assisted gynaecologic procedure and who performs this particular procedure on a regular basis.[16]

4. Maintenance of excellence. We submit that proficiency is defined no differently in robotic surgery. The surgeon must have a consistent and constant caseload and of a certain level of complexity to continue to be excellent and more importantly, to continue to develop his or her skill set in robot-assisted gynaecologic surgery. If a surgeon does not maintain sufficient experience in a particular procedure, we suggest that he or she must submit to regular assessments of proficiency in the said procedure so as to continue to be credentialed for it.

Conclusion

The application of robot-assistance to gynaecologic surgery represents a significant technological leap forward for surgeons operating in the pelvic areas and more importantly, for women who require gynaecologic surgery.

This is a surgical modality that offers the radicality of open surgery along with all the benefits of minimally invasive surgical techniques, with a relatively compressed learning curve. However a learning curve does exist and sufficient time must be allowed to gain proficiency in robotic gynaecologic surgery.[13,14]

We therefore make the following recommendations in order to shorten the learning curve:

1. Designate a robotic surgical nursing and operating room team. Limit the number of staff new to the procedure till all existing members of the team have consistently been involved in the first 20 cases.

2. Identify the ideal patient positioning early and ensure that this is followed with every case as a standard operating procedure.

3. Identify the form of vaginal instrumentation and robotic instruments that work for your particular casemix and caseload and adhere to it throughout your learning curve.

From our experience, we conclude that a properly executed introduction of robot-assisted surgical technology effectively increases capacity and capability while improving overall patient satisfaction and achieving similar clinical outcomes in a women's healthcare programme.

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