Robotic-assisted Laparoscopy versus Conventional Laparoscopy for the Treatment of Advanced Stage Endometriosis

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17 Conventional laparoscopy and robotic-assisted laparoscopy are excellent modalities
18 for the treatment of advanced stages of endometriosis, however robotic-assisted
19 laparoscopy may increase operative time and length of hospital stay.
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Abstract

Study objective: This study aims to compare robotic-assisted laparoscopy to conventional laparoscopy for the treatment of advanced stage endometriosis in terms of operative time, estimated blood loss, complication rate and length of hospital stay.

Study design: Retrospective cohort study involving 420 patients who underwent fertility-sparing surgery for advanced stage endometriosis, either by conventional laparoscopy or robotic-assisted laparoscopy. All procedures were performed by one surgeon between January 2004 and July 2012. Data was collected via chart review.

Design Classification: Canadian Task Force Classification class II2.

Setting: Tertiary Referral Center for Treatment of Endometriosis.

Measurements: Patient demographics, operative time, estimated blood loss, complication rate and length of hospital stay were compared between the two groups.

Main Results: Two hundred seventy-three patients (273) underwent conventional laparoscopy and 147 patients underwent robotic-assisted laparoscopy for fertility-sparing treatment of advanced stage endometriosis. Patients in both groups had similar characteristics regarding age, body-mass index (BMI) and previous abdominal surgeries. There was no significant difference in blood loss or complication rate between the two groups. The conventional laparoscopy group had a mean operative time of 135 minutes (115-156 minutes) and the robotic-assisted laparoscopic group had a mean operative time of 196 minutes (185-209 minutes), with a mean difference in operative time of 61 minutes, $p<0.001$. The

length of hospital stay was also significantly increased in the robotic-assisted laparoscopy group. The majority of patients who underwent conventional laparoscopy were discharged home on postoperative day 0. Among a total of 273 patients in the conventional laparoscopy group, only 63 remained in the hospital overnight. In contrast, all 147 patients in the robotic-assisted laparoscopy group were discharged home on post-operative day 1.

Conclusion: Conventional laparoscopy and robotic-assisted laparoscopy are excellent modalities for the treatment of advanced stages of endometriosis, but the use of the robotic platform may increase operative time and might also be associated with longer hospital stay.

Introduction

Endometriosis is a complex disease that affects between 10-50% of reproductive aged women worldwide [1,2]. Currently, laparoscopic surgery is considered the gold standard for diagnosis and treatment of endometriosis [1,2]. For advanced stage endometriosis (stages III and IV), laparoscopic treatment can be technically difficult and is often reserved for specialists in laparoscopic techniques[1]. For this reason, many surgeons still perform laparotomies for treatment of advanced stage endometriosis.

The advent of computer-enhanced technology, such as the surgical robot, has enabled many surgeons to convert laparotomies to robotic-assisted laparoscopies [3-5]. There are several publications comparing conventional laparoscopy (CL) to robotic-assisted laparoscopy (RAL) for common gynecologic procedures, such as hysterectomy and myomectomy. This data supports robotic-assisted laparoscopy as a feasible approach to minimally invasive surgery for surgeons not comfortable with conventional laparoscopy [5-17]. However, of those publications, only three were randomized controlled trials and there were few specifically addressing advanced stage endometriosis [18-24]. This study aims to evaluate the safety and efficacy of robotic-assisted laparoscopy versus conventional laparoscopy for the treatment of advanced stage endometriosis.

Materials and Methods

This is a retrospective cohort study of all consecutive patients undergoing fertility-sparing treatment of advanced stage endometriosis from January, 2004 to

July, 2012. Institutional review board approval was not pursued due to retrospective nature of the study. Data was collected by review of electronic and paper medical records. This study is a Canadian Task Force Classification class II2.

In all cases, the indication for surgery was pain and/or infertility. Inclusion criteria consisted of all patients who underwent fertility-sparing treatment of endometriosis during this time period. Patients were selected to have robotic-assisted laparoscopy or conventional laparoscopy based strictly on the availability of the patient for the robot operating room day. No clinical parameters were used to guide surgical modality. Exclusion criteria consisted of patients who were found to have stage 1 or 2 endometriosis or if they needed bladder, ureteral or bowel resection (including disc excision), hysterectomy, myomectomy or thoracoscopy.

All surgeries were performed at a tertiary endometriosis referral center by the primary author who has extensive experience with both conventional laparoscopy and robotic-assisted laparoscopy. The primary author has also been involved with the original development and testing of the DaVinci robot [25], so his experience dates back to the laboratory testing of the robotic surgical system.

For all cases, the patient was placed in conventional dorsal lithotomy position with legs in Allen stirrups. Once the abdomen was entered, hysteroscopy and chromopertubation were performed and a HUMI manipulator was placed in the uterus. Three 5 millimeter-trocars were placed for conventional laparoscopy. For robotic-assisted laparoscopy, one 12mm trocar, two 8mm trocars and one 5mm assistant trocar were used until 2011, when the 8mm trocars were replaced by 5mm robotic ports. The majority of cases also included cystoscopy and proctoscopy

at the end of the surgery in order to early recognize and treat potential genito-urinary and/or gastro-intestinal injuries, respectively.

For robotic-assisted laparoscopy, the DaVinci robotic surgical system (Intuitive Surgical Inc., Sunnyvale, CA) was initially docked centrally when using the first generation system, then side-docked on the patient's right side when the second and third generation DaVinci robots became available. The suprapubic trocar was used as the assistant port and the operating surgeon controlled two robotic arms at the console. The use of the third robotic arm is deemed cumbersome by our group. From experience, not only it does increase the possible risk of torching and blind injury to the tissue but it also requires an extra incision.

The instruments used for the robotic-assisted treatment of endometriosis included scissors, a monopolar hook, a grasper, a needle holder and a suction/irrigator probe [26]. For conventional laparoscopy cases, the instruments included a CO2 laser or Plasmajet (Plasma Surgical Inc., Roswell, GA), a grasper, a bipolar system, a suction/irrigator probe, and a needle holder if needed [26].

Electronic and paper medical records were reviewed to evaluate operative time, estimated blood loss, intra-operative and post-operative complications. Operative time was calculated based on anesthesia record of surgery start and end times. This includes abdominal entry, placement of trocars, hysteroscopy, docking of the robot, surgeon console time, undocking, cystoscopy, proctoscopy and closure of trocar sites. Estimated blood loss was calculated from measuring the blood collected in the suction canisters and subtracting the amount of irrigation used during the surgery. We then compared preoperative and postoperative complete

blood counts for accuracy. Complications were graded according to the Clavien-Dindo Classification of Surgical Complications [27]. Only significant complications that classified as grade III-V were recorded.

Comparisons were made between the conventional laparoscopy group and the robotic-assisted laparoscopy group using Mann Whitney test and t-test analysis. P value <0.05 was considered statistically significant.

Results

A total of four hundred and twenty (420) patients underwent conservative treatment of stage III or IV endometriosis during the study time period. Two hundred seventy three (273) patients underwent conventional laparoscopy and one hundred and forty seven patients (147) patients underwent robotic-assisted laparoscopy. Five cases in the conventional laparoscopy group were originally planned as robotic-assisted laparoscopies. However, the robot was not docked due to the presence of extensive extra-pelvic endometriosis. Because the robotic camera is not interchangeable between ports and the arms are not as easily maneuverable for extra-pelvic sites, the use of the robotic platform would have been very time consuming and intricate.

Three cases in the robotic-assisted laparoscopy group were converted to conventional laparoscopy for the same rationale. These three patients were included in the robotic-assisted laparoscopy analysis since the robotic ports were placed, the DaVinci robot was docked, and a portion of the procedures was completed with assistance of the robotic platform.

Baseline characteristics of age, body mass index (BMI) and mean number of previous surgeries were similar in both groups (Table 1). The mean estimated blood loss was 25ml in the conventional laparoscopy group and 40ml in the robotic-assisted laparoscopy group, which did not reach statistical significance. The conventional laparoscopy group had a mean operative time of 61 minutes shorter than the robotic-assisted laparoscopy group (135 versus 196 minutes, $p < 0.001$).

All 147 patients in the robotic-assisted laparoscopy group remained in the hospital overnight and were discharged on post-operative day 1, while in the conventional laparoscopy group, only 63 of 273 (23.1%) patients stayed overnight. The vast majority of the conventional laparoscopy group patients were discharged home on post-operative day 0. This difference is statistically significant ($p < 0.001$). There were no high grade complications in either group according to the Clavien-Dindo Classification of Surgical Complications [27].

Discussion

This large retrospective cohort study supports the use of both conventional laparoscopy and robotic-assisted laparoscopy for the treatment of advanced stage endometriosis. This study is consistent with previous literature showing the use of the surgical robot increases overall operative time [8, 16, 20]. Even with an experienced surgeon and OR team, the average length of operative time was over one hour longer with use of the robotic surgical system, with a minimum of 29 minutes longer and a maximum of 94 minutes longer. There are several factors, in

addition to the time needed to dock and un-dock, which likely contribute to the increased operative time.

For large endometriomas, there are limitations in trocar placement and removal of specimen which may have increased operative time. On occasion, an extra trocar was needed and it was difficult to manipulate the robotic arms, especially if the patient was very thin and/or short. Additionally, there was significant time delay in removing cyst wall pieces or endometriosis specimens as they all must be passed to the assistant's instrument, then removed, and the assistant's instrument replaced and reoriented. Larger specimens were removed through the larger robotic camera port, but again this was associated with time delay to reposition the bulky camera. Alternatively, we had to place an extra 12mm trocar for specimen removal which added extra time, expense, incision and, as a result, possibly more morbidity and overall cost.

Another option was to keep the larger cyst wall in the pelvis until the end of the procedure. However, visualization of the cul-de-sac might be partially obscured and extra time was added if suturing was used to keep multiple pieces aligned in a suture in order not to get them lost inside the abdomen. In contrast, during conventional laparoscopy, the tissue can be rapidly removed in a specimen bag through a 10-12mm umbilical port with concomitant removal of the trocar under direct visualization by a 5mm laparoscope.

Similarly, not using the CO2 laser with the DaVinci Robot is another factor that may have contributed to the increased operative time in the robotic cases. We concur with Berkes et al that, with the CO2 laser, deep infiltrating endometriotic

lesions can be easily and efficiently removed with minimal bleeding (28). This is due to the physics of the CO2 laser compared to radiofrequency energy. The robotic scissors and monopolar hook require extra care and time to prevent injury to surrounding structures. This leads to longer operative time, which in combination with the increased number of incisions and associated pain; we believe is part of the reason why the robotic group had a longer hospital stay.

Not uncommonly, disease can also be found in the upper abdomen, around the liver, the diaphragm, on the appendix, and can consist of very large endometriomas requiring treatment. In robotic-assisted laparoscopic cases of extensive intra-abdominal endometriosis, there is limited flexibility in changing camera locations and instrumentation. For difficult dissections with conventional laparoscopy, the surgeon is able to move the camera to different ports much more readily to assure no inadvertent injury has occurred. With the robotic platform, this can only be accomplished with a hybrid technique of conventional laparoscopy and robotic-assisted laparoscopy as previously described for the management of ovarian cancer [29, 30]. In the hybrid technique, after exploratory laparoscopy is performed and the extent of pathology in the upper abdomen is assessed and treated via conventional laparoscopy, the robotic trocars are placed and the robotic platform is docked for treatment of the disease in the pelvis.

Moreover, identification of retroperitoneal disease can be challenging with the robotic platform as it precludes the use of the laparoscopic suction-irrigator probe to palpate the pelvic floor. This useful technique requires tactile feedback that the robot platform lacks at the present time. For these reasons, there were eight

cases in this study that were planned robotic-assisted laparoscopies and were eventually completed with conventional laparoscopy.

The primary strengths of our study are the number of patients with advanced endometriosis in each surgical group and the experience of the surgical team. To our knowledge, this is the largest study of conservative treatment of advanced endometriosis via laparoscopy or robotic-assisted laparoscopy published to date. There are no randomized controlled trials in the literature investigating the robotic platform in the conservative treatment of advanced stage endometriosis. The majority of the literature discusses definitive treatment of endometriosis with hysterectomy with or without bilateral salpingoophorectomy [31, 32].

The vast experience of the primary surgeon and the OR staff are also a major strength of this study. The primary surgeon assisted in the initial development and testing of the DaVinci robotic system [25]. This experience may resolve the commonly seen bias of longer operative times and increased blood loss during the surgeon's and OR team's learning curve. Our study begins in 2004, well passed the learning curve for the senior author. It should be noted that the experience of different OR teams was not accounted for in this study.

The primary limitation to this study is its retrospective nature and limited follow-up information. Only high-grade complications were reviewed in this analysis, as these tend to have a greater impact on patient care and quality of life post-operatively. The low complication rate is likely a combination of the primary surgeon's expertise and lack of documentation and follow-up due to the referral nature of the practice and retrospective design. Many patients travel from across the

United States and also from foreign countries, and have long term follow up by their local provider. This may also contribute to the under reporting of post-operative complications.

Finally, as the selection of laparoscopic and robotic cases was based solely on schedule availability of the patient and instrumentation, one might see this as a potential flaw. Prospective, randomized studies are indeed needed to further evaluate the different surgical modalities.

For common gynecological procedures, such as hysterectomy and myomectomy, the robotic surgical system allows surgeons who are not comfortable with conventional laparoscopy to perform minimally invasive surgery in a shorter period of time [33]. The limiting factor for operative laparoscopy, with or without assistance of the robotic platform, is skill and experience of the surgeon, and availability of proper instruments [26]. The robotic arm enables the general gynecologist surgeon to convert more laparotomies to minimally invasive surgery. Computer-enhanced technology will have a significant role in the future of surgery, but in its current infancy stage does have limitations.

With an experienced surgeon, it appears that the use of the present robotic platform is safe and effective for the treatment of advanced endometriosis, but is more time consuming and patients stay in the hospital longer compared to conventional laparoscopy. We should keep in mind that longer operative time has been correlated with increased overall cost associated with the robotic platform [17, 34].

As technology advances, the robotic surgical system will overcome its present limitations and enable surgeons to perform more minimally invasive surgeries, specifically for advanced stage endometriosis. We conclude that for the treatment of advanced stage endometriosis, conventional laparoscopy, with and without robotic assistance, is associated with excellent results but the use of the robotic surgical system is more time consuming and associated with longer hospital stay and overall cost. In our experience, cases of severe disease requiring multiple exchanges of camera and instruments and/or large endometriomas were easier to perform with conventional laparoscopy.

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Table 1. Comparison of Conventional Laparoscopy to Robotic-assisted Laparoscopy

	Conventional Laparoscopy (n = 273)	Robotic-assisted Laparoscopy (n = 147)	P value
Age, median (range)	31 (19-42)	30 (21-38)	.211
BMI, median (range)	23 (19-29)	23 (19 – 32)	.814
Number of previous abdominal surgeries, median (range)	1 (0-3)	1 (0-3)	.901
Number of patients with previous cesarean section	37	22	.346
Number of patients with previous laparoscopy for endometriosis	65	12	< .001
Number of patients with previous laparoscopic appendectomy	5	1	.273
Operative time, mean	135 minutes	196 minutes	< .001
Estimated Blood Loss, mean	25ml	40ml	.859
Intraoperative and Postoperative Major Complications	0	0	n/a
Number of patients with hospital stay > 24h	63	147	< .001