SCIENTIFIC PAPER

Comparison of Robotic-Assisted Hysterectomy to Other Minimally Invasive Approaches

Mona Orady, MD, Alexander Hrynewych, MD, A. Karim Nawfal, MD, Ganesa Wegienka, PhD

ABSTRACT

Objective: To compare surgical outcomes for robotic-assisted total laparoscopic hysterectomy (RH) to other minimally invasive hysterectomy (MIH) types, including total laparoscopic hysterectomy (TLH), laparoscopic-assisted vaginal hysterectomy (LAVH), and vaginal hysterectomy (VH).

Methods: Retrospective cohort study of all patients who underwent RH or MIH for benign indications between January 2007 and May 2010 at 2 Henry Ford Health System teaching hospitals. Age, race, body mass index (BMI), procedure duration, estimated blood loss (EBL), peri-operative hemoglobin change, uterine weight, length of hospital stay (LOS), and complications were collected from electronic medical records and were compared between RH and MIH groups.

Results: Included in the analysis were 135 RH and 162 MIH cases (n = 34 VH, n = 82 LAVH, n = 46 TLH). There were no differences in age, race, or BMI between groups, but RH patients had significantly larger uteri (P = .007; RH, 13.5%>500g; MIH 4.0%>500g). MIH patients had significantly greater EBL (P < .001) and drop in hemoglobin (P = .02) than RH patients with a 150 mL difference in median EBL (200 mL versus 50 mL) between groups. RH had longer procedure durations than MIH (P = .0002) overall, but not compared to the TLH subgroup. RH patients had a shorter LOS than MIH patients had (P = .02) who had a longer LOS for LAVH patients. Although readmission and major complication rates were similar in both groups, minor adverse events occurred more frequently in the MIH group (21.6%) than the RH group (8.9%) (P = .003).

Conclusion: RH has comparable surgical outcomes, and possibly decreased blood loss, shorter length of stay, and fewer minor complications than other methods of MIH.

Key Words: Robotic surgery, Hysterectomy, Robotic hysterectomy, Laparoscopic, Laparoscopic hysterectomy, Vaginal hysterectomy, Minimally invasive surgical procedures.

INTRODUCTION

The benefits of a minimally invasive approach to hysterectomy are well known, including decreased pain, smaller incisions, less scarring, and faster recovery, discharge from hospital, and return to normal activities.[1,2] In the past, the choices for route of hysterectomy included only abdominal or vaginal approaches, the latter regarded by many to be the original "minimally invasive hysterectomy." With the addition of laparoscopy, laparoscopic-assisted vaginal hysterectomy (LAVH) evolved to assist in dissection of adhesions and identification and treatment of adnexal pathology. In 1989, the first total laparoscopic hysterectomy (TLH) was described allowing for the performance of hysterectomy with laparoscopy alone when the vaginal approach was not optimal.[1,2] A 2009 Cochrane review[3] compared outcomes of abdominal, vaginal, and laparoscopic hysterectomies. The authors concluded that vaginal hysterectomy should be favored but that laparoscopy may negate the need for the abdominal route when the vaginal route alone was not feasible. Thus, the goal is to approach as many patients as possible with a minimally invasive technique, while maintaining good outcomes and low complication rates.

Currently, more than 600,000 hysterectomies are performed annually in the United States.[4,5] However despite the acknowledged advantages of a minimally invasive approach to hysterectomy, the vast majority of hysterectomies were still performed through laparotomy. The

Department of Gynecology, Obstetrics, and Women's Health, Henry Ford Health System, Detroit, MI, USA (Drs. Hrynewych, Nawfal).

Department of Biostatistics and Research Epidemiology, Henry Ford Health System, Detroit, MI, USA (Dr. Wegienka).

Obstetrics and Gynecology and Women's Health Institute, Cleveland Clinic, Cleveland, OH, USA (Dr. Orady).

The authors have no commercial, proprietary, or financial interest in the products or companies describe in this article.

Address correspondence to: Mona Orady, MD, Director of Robotic Surgery Education, OB/GYN and Women's Health Institute, Cleveland Clinic, 9500 Euclic Ave, A81, Cleveland, OH, USA. Telephone: (614) 477-1338, E-mail: monaorady@hotmail.com

DOI: 10.4293/108680812X13462882736899

route of the hysterectomy is largely determined by surgeon preference and experience, rather than patient characteristics or pathology. In April of 2005, the Food and Drug Administration (FDA) approved the use of the da Vinci robot for gynecologic surgery.[6-8] Its technical advantages include a 3-dimensional view and articulating arms that offer 7 degrees of movement for precise movements controlled from a console that gives improved surgeon comfort.[9] These advantages have allowed gynecologists to more easily extend the performance of laparoscopic hysterectomy to patients with more complex pathology or higher BMI.[10,11] The disadvantage of its use lies in the cost of both the robot itself reaching up to 1.5 million dollars, as well as the robotic instruments that cost approximately $200 per instrument use. Thus, with the increasing use of robotic technology, data must be gathered to better define the role of this new approach to hysterectomy. Large institutions utilizing this approach must thus analyze and report their experience.

The objective of this study was to compare the surgical outcomes and complications of patients undergoing robotic-assisted total laparoscopic hysterectomy (RH) to those in patients undergoing other minimally invasive methods of hysterectomy (MIH) including total laparoscopic hysterectomy (TLH), laparoscopic-assisted vaginal hysterectomy (LAVH), and vaginal hysterectomy (VH).

MATERIALS AND METHODS

This study was designed as a retrospective cohort study of all patients who underwent any form of minimally invasive hysterectomy at 2 Henry Ford Health System hospitals in the Detroit, Michigan area (Main Campus or West Bloomfield medical centers) between January 1, 2006 and May 31, 2010. Both are Wayne State University affiliated teaching hospitals with the Main Campus including an inner-city patient population and West Bloomfield including a more suburban patient population. There were more than 30 gynecologic surgeons of varying levels of experience who performed the procedures over this 4-y period with the assistance of residents and fellows. Between 2008 and 2010 robotic hysterectomy was introduced and 6 surgeons were trained and began performing the procedure during that time period. The Henry Ford Hospital Institutional Review Board approved the study. Patients were identified from the Henry Ford Hospital System claims database, and data were extracted from the electronic medical records (EMR). We excluded emergent hysterectomies, supracervical hysterectomies, hysterectomies performed for malignancy, or hysterectomies performed with concomitant urogynecologic procedures from the final analysis to try to reduce confounding factors.

Demographic and outcomes data that was collected included age, race, BMI, procedure duration (time from vaginal instrumentation including placement of the Foley catheter in RH, TLH, LAVH or speculum placement in VH till procedure completion, estimated blood loss (EBL), change between pre- and postoperative hemoglobin, length of stay (LOS), pathology, and uterine weight. Major complications were defined as any visceral injury or event that prolonged hospital stay, caused readmissions, or reoperation. Minor complications were defined as any patient complaint that required evaluation or treatment. Body mass index (kg/m^2) (BMI) was calculated from preoperative height and weight recorded in the nursing record.

Comparisons were made between the larger groups of robotic hysterectomy and minimally invasive hysterectomy. Then comparison was made between robotic hysterectomy and the 3 subgroups of minimally invasive hysterectomy of vaginal, laparoscopic-assisted, and total laparoscopic hysterectomy. Two investigators reviewed the EMR and recorded the data in the database. The principal investigator reviewed every chart with a complication and every fifth case in the series (20% of the charts) to ensure consistent and complete data collection for quality purposes.

Multivariable models were built to assess whether uterine weight confounded the association between the approach (RH versus MIH) and the outcomes. Logistic regression models were used for the binary outcomes of readmission, any major complication, any minor complication and whether the LOS was more than one day. Linear regression models were used to assess the associations for the outcomes of EBL (log transformed for normality), procedure duration (log transformed for normality) and the absolute change in hemoglobin. Models were built with surgical approach as the predictor. We assessed whether the association with the outcome changed once uterine weight was added to the model for each outcome. Based on a change in effect criteria of at least 20%, uterine weight did not confound any of the observed associations.

RESULTS

For the time period studied, a total of 297 hysterectomies met inclusion criteria, 135 robotic hysterectomies and 162 nonrobotic minimally invasive hysterectomies (MIH). Pa-

tient demographics, body mass index, and uterine weights are shown in **Table 1**. The largest recorded uterine weight was 1490 g in the RH group, 1420 g for the TLH group, 410 g for the VH group and 780 g for the LAVH group. The highest body mass index (BMI) was 51.6 in the RH group, 56.4 for the TLH group, 56.6 for the VH group, and 47.2 for the LAVH group. The BMI of patients was similarly distributed among groups while the RH group had the greatest proportion of cases with uterine weight > 500 g ($P = .007$).

Surgical outcomes by hysterectomy type are shown in **Table 2**. The RH surgery mean procedure duration was 25 min longer than the nonrobotic MIH time ($P < .001$). Within the nonrobotic MIH group, the VH had the shortest median duration, 98.5 min. The median length of stay, 1 d, was the same between the RH and the MIH groups, but the LAVH subgroup had the highest proportion of patients staying more than 1 d (54.3%), and the median length of stay was 2 d. Thus, the mean LOS overall was longer for the MIH group ($P = .02$). The highest blood loss was in the LAVH group: 2000 mL EBL in 2 cases, 1000 mL, 700 mL, and 650 mL in 1 case each. Hemorrhage during an LAVH was the cause for 1 out of the 3 conversions to laparotomy in the MIH group. There was no significant difference in blood transfusion rates between the 2 groups. Six patients in the MIH group received blood transfusions (3 in the LAVH group and 3 in the VH group), while 3 patients in the RH group received blood transfusions intraoperatively or postoperatively. Two patients in the RH groups received blood preoperatively secondary to preoperative hemoglobin < 8.5. Hemoglobin change was 1.6g/dL in the RH vs. 1.8g/dL in the MIH group. MIH patients had a median 150 mL greater blood loss than RH patients ($P < .001$). Hemoglobin change also supported this finding for all subgroups ($P = .02$).

Complications and readmission rates are shown in **Table 3**. There were 15 major complications in the RH group and 17 in the MIH group. Most major and minor complications were in the LAVH group. The minor complications were

Table 1.
Demographic and Health Characteristics of Reported Cases

	Robotic	Nonrobotic	TLH	VH	LAVH
n	135	162	46	34	82
Age, Median (Range)	45 (30–68)	45 (21–82)	44 (21–82)	49 (35–76)	45 (31–75)
P vs robotic		0.99	0.05	0.009	0.83
Race, n (% of total)					
Black	83 (61.5)	94 (58.8)	23 (50)	19 (58)	52 (64)
White	50 (37.0)	57 (35.6)	20 (44)	13 (39)	24 (30)
Other	2 (1.5)	9 (5.6)	3 (7)	1 (3)	5 (6)
P for Chi square		0.17	0.12	0.79	0.12
BMI (kg/m2), n (% of total)					
<18.5	3 (2.2)	1 (0.6)	1 (2)	0	0
18.5–25	28 (20.7)	38 (23.6)	10 (22)	9 (27)	19 (24)
25–29.9	34 (25.2)	45 (28.0)	13 (28)	12 (35)	20 (25)
30–34.9	34 (25.2)	37 (23.0)	9 (20)	7 (21)	21 (26)
35+	36 (26.7)	40 (24.8)	13 (28)	6 (18)	21 (26)
P for Chi square		0.71	0.96	0.51	0.74
Uterine size (g), n (% of total)					
<250	87 (65.4)	112 (74)	31 (69)	28 (87.5)	54 (72)
250–500	28 (21.1)	34 (22)	10 (22)	4 (12.5)	20 (26.7)
≥500	18 (13.5)	6 (4.0)	4 (9)	0	1 (1.3)
P for Chi square		0.007	0.72	0.03	0.01

[a]TLH = total laparoscopic hysterectomy; VH = vaginal hysterectomy; LAVH = laparoscopic-assisted vaginal hysterectomy.

Table 2.
Surgical Outcomes by Hysterectomy Type

	Robotic	Non-Robotic	TLH[a]	VH[a]	LAVH[a]
Procedure Duration	N=133	N=157	N=45	N=32	N=80
Median in minutes (Range)	169 (80–625)	144 (29–398)	194 (103–386)	98.5 (29–286)	144 (67–398)
P vs Robotic		0.0002	0.59	<0.001	0.001
Estimated Blood Loss	N=135	N=165	N=46	N=34	N=82
Median in mL (Range)	50 (10–1000)	200 (25–2000)	150 (25–700)	150 (50–9000)	250 (75–2000)
P vs Robotic		<0.001	<0.001	<0.001	<0.001
Hemoglobin Change	N=130	N=154	N=45	N=32	N=77
Median in g/dL (Range)	−1.6 (−4.4 ±0.9)	−1.8 (−5.8 ±1.0)	−1.7 (−4.2±.5)	−1.6 (−3.9 ±0)	−2.1 (−5.8 ±1.0)
P vs Robotic		0.02	0.52	0.81	0.0008
Length of Stay	N=135	N=162	N=46	N=46	N=34
Median in days [n, (% >1 day)]	1, 44 (32.6)	1, 74 (46.3)	1, 20 (44.4)	1, 10 (29.4)	1, 44 (54.3)
P vs Robotic		0.02	0.15	0.72	0.002

[a]TLH = total laparoscopic hysterectomy; VH = vaginal hysterectomy; LAVH = laparoscopic-assisted vaginal hysterectomy.

Table 3.
Statistical Correlations Between Hysterectomy Method and Complications

	Robotic	Non-Robotic	TLH[b]	VH[b]	LAVH[b]
Readmissions (n, %)	12 (9.0)	7 (4.3)	3 (6.5)	1 (3.0)	3 (3.7)
P for Chi square		0.10	0.60	0.24	0.13
Major Complications[a] (n, %)	15 (11.1)	17 (10.5)	6 (13.0)	2 (5.9)	9 (11.0)
P for Chi square		0.86	0.72	0.37	0.98
Minor Complications[a] (n, %)	12 (8.9)	35 (21.6)	9 (19.6)	10 (29.4)	16 (19.5)
P for Chi square		0.003	0.05	0.002	0.02

[a]Major Complication was defined as any visceral injury, or complication that caused prolonged hospital stay, re-admission, or re-operation; Minor Complication was defined as any complaint that required evaluation and treatment.

[b]TLH = total laparoscopic hysterectomy; VH = vaginal hysterectomy; LAVH = laparoscopic-assisted vaginal hysterectomy.

more prevalent in the MIH group and mostly consisted of vaginal cuff issues such as granulation, minor bleeding, or cellulitis, which comprised 20 of the minor complications. In the robotic hysterectomy group, only 7 patients were found to have these types of vaginal cuff complications. Major complications included recognized cystotomy, port-site herniation, pelvic abscess, postoperative ileus, and pulmonary embolism. Major complications and complication rates did not differ between the robotic or nonrobotic group. Other than vaginal cuff complaints, minor complications were highly varied and included vulvar laceration, labial burns, urinary tract infection, or urinary retention, but there was no difference between groups.

DISCUSSION

With the increasing utilization of robotic technology for minimally invasive surgical techniques, the outcomes of this approach must be compared to other approaches to assess feasibility. The focus of this study was on minimally invasive surgical approaches for benign hysterectomy at a large institution. Such analyses will help better define the role of this new approach to hysterectomy. The advantages of the minimally invasive approach to hysterectomy as compared to laparotomy are well known; however, many approaches to minimally invasive hysterectomy exist including the most recent addition of the robotic ap-

proach, which needs to be reviewed in comparison studies. Experience with vaginal hysterectomy is limited in most obstetrics and gynecology training institutions in the United States, thus it was not available to most patients who do not have small and descendant uteri. Laparoscopic assistance helped in overcoming some of the barriers to performing hysterectomies without laparotomy, but this approach came with another barrier, which is a slow learning curve. The improved vision and enhanced instrumentation of the da Vinci system helped simplify the laparoscopic approach, making it more available to a wider range of patients by assisting surgeons to overcome their limitations.[12–14]

Our analysis of 297 patients demonstrates comparable surgical outcomes between patients undergoing robotic hysterectomy versus other types of minimally invasive hysterectomy with some interesting findings. Similarly, a Swiss case-control study that compared robotic-assisted laparoscopic hysterectomy with total laparoscopic hysterectomy and found no significant differences between the 2 groups regarding complications, conversions to laparotomy, intraoperative bleeding, and hospital stay.[15] Another study by Shashoua et al.[16] with the same comparison reported that robotic TLH was associated with a shorter hospital stay and decrease in narcotic but did show a difference in EBL and drop in hemoglobin. The operative time in RH was longer but was associated with the need for laparoscopic morcellation, BMI, and uterine weight.

When comparing patients who had robotic hysterectomy to those undergoing other minimally invasive hysterectomy procedures in our institution, both groups of patients were similar in demographics and had similar body mass index measures and outcomes. However, women who underwent robotic hysterectomy had statistically significantly larger uteri, with a larger proportion of patients with uteri $>$ 500 g. Several other studies have discussed the advantages of the robotic approach in complex hysterectomy and in hysterectomy for patients with larger uterine weight.[10,17,18] These studies have also shown that the robotic approach allows for completion of TLH with robotic assistance in patients with large BMI, thus suggesting a possible advantage to the robotic approach in these more complex procedures.[19]

In our cohort, all attempted robotic hysterectomy procedures were successfully completed in obese patients and in patients with very large uteri. The 2 conversions occurred for suspicion of malignancy and equipment failure. Comparatively, the 3 conversions in the nonrobotic MIH group occurred because of intraoperative uncontrollable bleeding in a patient with a large uterus, failure to gain intraperitoneal access, and secondary to obesity (BMI = 53), and inability to remove a uterus vaginally secondary to size of the uterus. In one of the pivotal studies by Payne et al.[7] comparing robotic hysterectomy to total laparoscopic hysterectomy after introduction of this new technique in their institution, also showed that the introduction of the robotic approach reduced the conversion rate.

There has been concern about prolonged operative times related to robotic hysterectomy procedures, especially early in the learning curve.[12,13,20] Despite the fact that the robotic hysterectomy procedures in this study included those within the learning curve of the surgeons who were trained in the procedure, overall operative time was only 25 min longer than all other nonrobotic MIH procedures combined and was actually 25 min shorter compared to time for total laparoscopic hysterectomy procedures alone. This contradicts a few other comparisons that reported longer operative time for robotic-assisted versus laparoscopic TLH.[16,20,22] Thus, the procedures that led to reduced operative time were those that included the vaginal approach in the technique.

Several studies[7,8,21,23,24] have commented on the low estimated blood loss associated with robotic hysterectomy procedures, and this can be attributed to the better vision and easier dissection allowing the avoidance of bleeding.[7,8,21,23,24] In our study, estimated blood loss was also less in robotic hysterectomy compared to other types of hysterectomy, and this was statistically significant. This held true for all subgroups as well and was supported by a statistically significant difference in change in hemoglobin. A 100 mL decreased estimated blood loss may not be clinically significant but can reflect a general tendency to less potential for excessive bleeding with the robotic approach. Hospital stays overall were also shorter for robotic hysterectomy compared to vaginal and LAVH procedures, although this was only statistically significant when compared to LAVH procedures that tended to have 2-d long hospital stays in our institution. Hospital stay can reflect recovery and return to normal activities and thus does indirectly reflect the morbidity of a surgical procedure. However, it is also affected by surgeon and institutional experience as well as postoperative nursing care. Because all the procedures included in this study were performed at the same institution, we can consider this as a method of comparing our patients' recovery.

With any minimally invasive procedure, especially when newer techniques are being introduced there is always concern about increasing complications compared to the

traditional approaches to surgery. In our comparison, interestingly, a higher percentage of minor complications, the largest estimated blood loss, and most transfusions were in the LAVH group. LAVH originated to complete hysterectomies vaginally as opposed to performing a hysterectomy through an abdominal incision in patients where the vaginal approach alone was not sufficient. Major complication rates were however stable across all groups. MIH patients had a statistically significant increased number of minor complications, but not major complications, compared to RH patients. Most common minor complications were related to vaginal cuff issues, which had been reported more in robotic hysterectomy procedures in other studies, especially in early reports of robotic hysterectomy.[25] Interestingly, even this type of complication was much more common in the nonrobotic group compared to the robotic group.

One strength of this study is its generalizability based on a wide demographic in both groups of patients and a large sample size. Since the analysis included general experience at both a suburban and inner city population by all the gynecologists at both hospitals, the data may reflect outcomes that may be more typical in the community setting, rather than those reported by expert surgeons. Robotic hysterectomy was compared to multiple other minimally invasive hysterectomy methods, and to our knowledge, this has not been compared previously in one institution. Our combined inpatient and outpatient Electronic Medical Record system provided us with a comprehensive review of the patients' experience allowing us to capture even the mildest adverse effects. The largest limitation of our study is the retrospective study design, as this does not allow control for either surgeon experience or selection bias. Thus, selection of hysterectomy method was left to surgeon preference rather than randomization or criterion for assignment, which thus may not control for confounders. Also, the cases were managed by a surgeon whose experience ranged from resident to seasoned senior staff, and thus there was variable surgeon experience. Controlling for surgeon decision-making and surgical experience requires a prospective study with a limited pool of surgeons who explain their recommendation and perform all the types of hysterectomy studied. However, reports of institutional experience are valuable in that they reflect the real world application of these methods of surgery.

Robotic hysterectomy was found to have comparable outcomes to other methods of minimally invasive hysterectomy without increased risk of conversion or complications. Although procedure duration is slightly increased (25 min) for RH compared to MIH procedures with a vaginal approach, estimated blood loss and minor complication rates may be decreased, and the benefit of short length of hospital stay is maintained or improved. These data also suggest that the robotic approach may allow surgeons to overcome conversions associated with obesity or extremely large uteri, but additional data are required to assess this further. However, it is evident that robotic hysterectomy is an acceptable and safe option that may serve as an alternative method in some patients desiring a minimally invasive approach to hysterectomy.

References:

1. Sokol A, Green I. Laparoscopic Hysterectomy. *Clin Obst Gynecol.* 2009;52(3):304–312.

2. Reich H. Total Laparoscopic Hysterectomy: indications, techniques, and outcomes. *Curr Opin Obstet Gynecol.* 2007; 19(4):337–344.

3. Nieboer TE, Johnson N, Lethaby A et al. Surgical approach to hysterectomy for benign gynaecological Disease. *Cochrane Database Syst Rev.* 2009;Jul 8(3):CD003677.

4. Farquhar CM, Steiner CA. Hysterectomy rates in the US, 1990–1997. *Obstet Gynecol.* 2002;2:229–234.

5. Wu JM, Wecther ME, Geller EJ, Nguyen TV, Visco AG. Hysterectomy rates in the US, 2003. *Obstet Gynecol.* 2007;Nov 110(5):1091–1095.

6. Kho RM, Hilger WS, Hentz JG, Magtibay PM, Magrina JF. Robotic hysterectomy: technique and initial outcomes. *Am J Obstet Gynecol.* 2007;197:113.e1–4.

7. Payne TN, Dauterive FR. A comparison of total laparoscopic hysterectomy to robotically assisted hysterectomy: surgical outcomes in a community practice. *J Minim Invasive Gynecol.* 2008;15:589–594.

8. Beste TM, Nelson KH, Daucher JA. Total laparoscopic hysterectomy utilizing a robotic surgical system. *JSLS.* 2005;Jan–Mar 9(1):13–15.

9. Advincula AP, Wang K. Evolving role and current state of robotics in minimally invasive gynecologic surgery. *J Minim Invasive Gynecol.* 2009;16(3):291–301.

10. Boggess JF, Gehrig PA, Cantrell L, et al. Perioperative outcomes of robotically assisted hysterectomy for benign cases with complex pathology. *Obstet Gynecol.* 2009;Sept 114(3):585–593.

11. Advincula AP, Reynolds RK. The use of robot-assisted laparoscopic hysterectomy in the patient with a scarred or obliterated anterior cul-de-sac. *JSLS.* 2005 Jul–Sep;9(3):287–291.

12. Chen CC, Falcone T. Robotic gynecologic surgery: past, present, future. *Clin Obstet Gynecol.* 2009;52(3):335–343.

13. Lenihan JP Jr., Kovanda C, Seshadri-Kreaden U. What is the learning curve for robotic assisted gynecologic surgery? *J minim Invasive Gynecol.* 2008;15:589–594.

14. Nezhat C, Saberi NS, Shahmohamady B, Nezhat F. Robotic-assisted laparoscopy in gynecological surgery. *JSLS.* 2006 Jul–Sep;10(3):317–320.

15. Sarlos D, Kots L, Stevanovic N, Schaer G. Robotic Hysterectomy versus conventional laparoscopic hysterectomy: Outcome and cost analyses of a matched case-control study. *Eur J Obstet Gynecol Reprod Biol.* 2010;150:92–96.

16. Shashoua AR, Gill D, Locher SR. Robotic-assisted total laparoscopic hysterectomy versus conventional total laparoscopic hysterectomy. *JSLS.* 2009 Jul–Sep;13(3):364–369.

17. Orady M, Nawfal AK, Wegienka G. Does size matter? The effect of uterine weight on robot-assisted total laparoscopic hysterectomy outcomes. *J Robot Surgery.* 2011;5(4):267–272.

18. Payne TN, Dauterive FR, Pitter MC, et al. Robotically assisted hysterectomy in patients with large uteri: outcomes in five community practices. *Obstet Gynecol.* 2010;Mar 115(3):535–542.

19. Nawfal AK, Orady M, Eisenstein D, Wegienka G. Effect of body mass index on robotic-assisted total laparoscopic hysterectomy. *J Minim Invasive Gynecol.* 2011;18(3):328–332.

20. Kilic GS, Moore G, Elbatanony A, Radecki C, Phelps JY, Borahay M. Comparison of perioperative outcomes of total laparoscopic and robotically assisted hysterectomy for benign pathology during introduction of a robotic program. *Obstet Gynecol Int.* 2011;2011:683–703.

21. Reynolds RK, Advincula AP. Robot-assisted laparoscopic hysterectomy: technique and initial experience. *Am J Surg.* 2006; 191:55–60.

22. Nezhat C, Lavie O, Lemyre M, Gemer O, Bhagan L, Nezhat C. Laparoscopic hysterectomy with and without a robot: Stanford experience. *JSLS.* 2009 Apr–Jun;13(2):125–128.

23. Pitter MC, Anderson P, Blissett A, Pemberton N. Robotic-assisted gynecological surgery: establishing training criteria: minimizing operative time and blood loss. *Int J Med Robotics Comput Assist Surg.* 2008;4:114–120.

24. Payne TN, Dauterinve FR. Robotically assisted hysterectomy: 100 cases after the learning curve. *J Robotic Surg.* 2010;4:11–18.

25. Kho RM, Akl MN, Cornella JL, Magtibay PM, Wechter ME, Magrina JF. Incidence and characteristics of patients with vaginal cuff dehiscence after robotic procedures. *Obstet Gynecol.* 2009; 114(pt 1):231–235.