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Research Article

Comparison of robotic-assisted laparoscopic hysterectomy to total laparoscopic hysterectomy in terms of operational complications at a regional institution: A retrospective study

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ABSTRACT

Objective: With the increased use of total laparoscopic hysterectomy (TLH), the use of robotic-assisted laparoscopic hysterectomy (RALH) has increased due to its technical advantages. On the other hand, RALH has some disadvantages, including its high cost, which includes not only the purchase price of robotic technology systems but also the running cost and long preparation time for setting assistant robots. Therefore, an overall understanding of the characteristics of RALH is needed.

Study design: We reviewed the medical records of 432 patients with TLH and 93 patients with RALH from January 1, 2015, to December 31, 2022. In this analysis, we excluded certain cases with concomitant laparoscopic cystectomy (LC) and a heavy uterus (> 400 g). First, the patient characteristics of the TLH and RALH groups, including operation time and blood loss amount, were compared. Then, among these cases, we sought to predict difficult cases for TLH and RALH by identifying risk factors related to each of the following three categories of operational complications: "long operation time", "massive blood loss" and "other complications". For this purpose, multivariate logistic regression analyses were performed to assess the influence of each of 7 representative factors, namely, "advanced age", "high body mass index (BMI)", "nulliparity", "concomitant pelvic lymphadenectomy (PLA)", "heavy uterus", "abdominal adhesion", and "large leiomyoma".

Results: In the simple comparison without various factors, there was an advantage of RALH in both the average operation time and blood loss amount. However, in the multivariate logistic regression analyses, a significant risk was detected in the following relationships: 1) between "long-term operation" and "abdominal adhesion" and 2) between "other complications" and "heavy uterus".

Conclusions: RALH has sufficient advantages over TLH regarding at least in terms of blood loss amount; however, since RALH may have potential weaknesses in the context of complex cases, additional cases and analyses are needed.

1. Introduction

Since total laparoscopic hysterectomy (TLH) is associated with less pain and a quicker recovery than conventional abdominal hysterectomy (CAH), the number of indications for TLH has increased, and TLH has become more widespread [1–3]. However, improved surgical skills and additional experience are needed, and a long operation time is required [4,5]. Because of this, the indications for robotic-assisted laparoscopic hysterectomy (RALH), an approach involving a new device, have also gradually increased, as RALH overcomes these disadvantages while maintaining the advantages of laparoscopic surgery. Consistent with this recent trend, even in our hospital, the number of patients treated with RALH by using the daVinci surgical system has gradually increased, and RALH has been applied to patients with not only leiomyoma/adenomyoma but also low-grade (pre)malignant uterine tumours, including early-stage endometrial carcinoma, (atypical) endometrial hyperplasia

Abbreviations: BMI, Body mass index; CAH, Conventional abdominal hysterectomy; CI, Confidence interval; LC, Laparoscopic cystectomy; MRI, Magnetic resonance imaging; OR, Odds ratio; PLA, Pelvic lymphadenectomy; RALH, Robotic-assisted laparoscopic hysterectomy; TLH, Total laparoscopic hysterectomy; TVUS, Transvaginal ultrasound.

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and cervical intraepithelial neoplasia. On the other hand, RALH has some disadvantages, including its high cost, which includes not only the purchase price of the robotic technology system but also the running cost [6]. The relatively long preparation time for setting assistant robots has also been noted in past reports [7]. For this reason, based on the analysis of past data on cases with TLH and RALH, an overall understanding of the characteristics of RALH is needed.

Here, we included all patients who underwent TLH or RALH and compared the characteristics of these two procedures. To detect difficult cases, we elucidated factors that predicted the possibility of surgical complications, including long operation time and massive blood loss.

2. Methods

2.1. Data collection

This study was reviewed and approved by the Human Ethical Committee of the University of Teikyo Hospital (trial registration no.: 20-094). The deidentified medical records of 725 female patients who underwent TLH or RALH from June 1, 2015, to December 31, 2022, were reviewed retrospectively. These patients had undergone bilateral salpingectomy or bilateral salpingo-oophorectomy during TLH or RALH. Since there were only a few patients, namely, only 2, among those with the following factors who underwent RALH, 200 patients with TLH were excluded for the following reasons: concomitant laparoscopic cystectomy (LC) (37 cases), heavy uterus ($>$ 400 g) (153 cases) or rare indications other than leiomyoma/adenomyoma and low-grade (pre) malignant uterine tumours (10 cases). The resected uterine weight was measured just after finishing the operations. In total, 432 cases with TLH and 93 cases with RALH were listed. The indications for TLH or RALH were divided into three groups, namely, leiomyoma (313 vs. 41 cases), adenomyoma (62 vs. 2 cases) and low-grade (pre)malignant uterine tumour (58 vs. 50 cases). Since the last indication included mainly early-stage endometrial carcinoma (32 vs. 34 cases) other than cervical intraepithelial neoplasia (13 vs. 3 cases) and atypical endometrial hyperplasia (12 vs. 13 cases), this study included 39 cases of concomitant pelvic lymphadenectomy (PLA) (24 vs. 15 cases). All operations were performed under the direct supervision of at least one of three laparoscopic surgery experts (A.T., A.F. or O.N.).

We extracted various data on patient characteristics, such as age, delivery history, presenting symptoms, and physical examination findings, from medical records. However, we excluded the following factors from the analysis targets since the records were uncertain due to the retrospective nature of the medical record review: 1) a history of gynaecological surgery (96 vs. 58 cases); 2) menstrual disorder, including dysmenorrhoea, menostaxis, menorrhagia, anaemia or abnormal vaginal bleeding, as the presenting symptom (355 vs. 69 cases); 3) abdominal distension, including abdominal pressure, pelvic pain, dysuria or dyschezia, as the presenting symptom; or 4) history of gonadotropin-releasing hormone analogue treatment before TLH or RALH (283 vs. 33 cases).

To evaluate the level of difficulty of TLH or RALH, we classified 525 patients into the following categories of operational complications according to their outcomes and a previous report [8]: 1) "Long operation time" defined as an operation time $\geq$ 5 h (15 vs. 3 cases); 2) "massive blood loss", defined as blood loss $\geq$ 500 ml (8 vs. 0 cases); and 3) "other complications", including postoperative infection (7 vs. 2 cases), bladder injury (5 vs. 0 cases), vaginal cuff dehiscence (2 vs. 2 cases) and skin burn by energy device (1 vs. 0 cases). From our experience, we could predict that the reasons for long operation were the unexpected procedures, for example dissecting adhesions or stopping bleeding. Thus, we focused on the index "long operation time".

2.2. Analysis methods

Comparisons of the characteristics of TLH and RALH were performed by classifying the patients into one of two groups according to the procedure used (432 vs. 93 cases). In this analysis, we compared the following indexes: 1) patient age; 2) patient body mass index (BMI); operation time; 3) blood loss amount; 4) uterine weight measured immediately after the operation; 5) whole uterine size measured with transvaginal ultrasound (TVUS) one day before the operation, defined as the average length of the uterus measured in two or three directions; 6) leiomyoma size measured with magnetic resonance imaging (MRI) before the operation; 7) the number of cases with abdominal adhesion detected during the operation; 8) the number of nulliparous patients; and 9) the number of cases with concomitant PLA.

Second, to detect potential predictors of difficult cases for TLH and RALH, we tried to identify risk factors for the three categories of operational complications, including "long operation time", "massive blood loss" and "other complications". To control for confounding factors, we divided the patients into two groups according to the presence or absence of each factor and performed multivariate logistic regression analysis. In this analysis, we assessed the influence of the following 7 factors: 1) advanced age, defined as an age $\geq$ 50 years; 2) high BMI, defined as a BMI $\geq$ 25 (kg/m^2) [9]; 3) nulliparity, defined as no previous delivery; 4) concomitant PLA; 5) heavy uterus, defined as a resected uterine weight $\geq$ 300 g; 6) abdominal adhesion, defined as abdominal adhesion detected by laparoscopic inspection immediately after the start of surgery; and 7) large leiomyoma, defined as a dominant leiomyoma $\geq$ 8 cm by MRI. In this analysis, we did not adopt uterine size measured by TVUS because this size could not be accurately measured due to the existence of large leiomyomas. Since in our hospital, we could only rarely perform RALH for cases with resected uterine weights over 400 g, this cut-off value was not used to classify a uterus as heavy. The definition of a "heavy uterus" was determined relative to the average uterine weight of 525 patients, namely, the average and standard deviation of the uterine weight of all patients. The criteria for "advanced age", "high BMI" and "large leiomyoma" were determined based on past reports [8, 10–12]. A "high BMI" was defined according to the definition of obesity of the Japan Society for the Study of Obesity. An "advanced age", assuming menopause, was defined according to the definition of the Japan Society of Obstetrics and Gynecology.

Statistical analyses were performed using Microsoft Excel (Microsoft Corporation, Redmond, WA) and JMP version 12 for Windows (SAS Institute, Inc., Tokyo, Japan) to determine the correlations between the aforementioned 7 factors and 3 categories. The odds ratios (ORs) and 95 % confidence intervals (CIs) were estimated to determine the strengths of the correlations. $P < 0.05$ was considered statistically significant.

3. Results

3.1. Patient characteristics

The average age, BMI, parity, operation time, blood loss volume, resected uterine weight and parity were 48.5 $\pm$ 7.0 (31–84) years, 23.1 $\pm$ 4.0 (15.1–38.9) kg/m^2, 189.1 $\pm$ 50.0 (94–378) min, 77.4 $\pm$ 121.6 (0–1500) ml, 196.5 $\pm$ 90.7 (28–398) g and 1.2 $\pm$ 1.0 (0–4), respectively. Of the 525 cases, abdominal adhesion was detected during the operation in 195 cases. By MRI, the average size of the dominant leiomyoma in 415 patients was 5.1 $\pm$ 2.1 (8–120) cm.

When comparing the results simply between RALH and TLH, shown in Table 1, RALH seemed to be superior to TLH, since the average blood loss amount in the RALH group was less than half of that in the TLH group (37.2 $\pm$ 57.4 (0–254) ml vs. 85.9 $\pm$ 129.7 (0–1500) ml, $P < 0.01$) and the average operation time was significantly shorter (178.3 $\pm$ 51 (107–378) min vs. 191.5 $\pm$ 49.5 (94–375) min, $P < 0.05$). However, the average of resected uterine weights in RALH was lighter than that in TLH (150.8 $\pm$ 77.6 (43.4–390.6) g vs. 206.3 $\pm$ 90.4 (28–398) g, $P < 0.01$), probably because RALH tended to be selected for treating low-grade (pre)malignant uterine tumours in our hospital. Additionally, in the comparison of the differences between anaesthesia time and operation

Table 1
Patient characteristics.

Index	Total	RALH	LH	P value
Age (years)	48.5 ± 7.0 (31–84)	51.2 ± 9.4 (31–84)	47.9 ± 6.2 (34–81)	< 0.01
BMI (kg/m^2)	23.1 ± 4.0 (15.1–38.9)	24.3 ± 5.1 (15.2–38.9)	22.8 ± 3.7 (15.1–38.0)	< 0.01
Operation time (minutes)	188.9 ± 49.6 (94–378)	178.3 ± 51 (107–378)	191.2 ± 49.1 (94–375)	< 0.05
Blood loss amount (ml)	77.3 ± 121.6 (0–1500)	37.2 ± 57.4 (0–254)	85.9 ± 129.7 (0–1500)	< 0.01
Resected uterine weight (g)	196.5 ± 90.7 (28–398)	150.8 ± 77.6 (43.4–390.6)	206.3 ± 90.4 (28–398)	< 0.01
Uterine size (TVUS) (cm)	6.4 ± 1.5 (2.2–10.3)	5.7 ± 1.5 (2.2–9.4)	6.5 ± 1.5 (2.6–10.3)	< 0.01
Leiomyoma size (MRI) (cm)	5.1 ± 2.1 (8–120)	3.9 ± 1.8 (0.8–8.2)	5.2 ± 2.1 (1.1–12.0)	< 0.01
Parity	1.2 ± 1.0 (0–4)	1.3 ± 1.0 (0–4)	1.1 ± 1.0 (0–4)	NS
Abdominal adhesion	n = 195/525	n = 13/93	n = 182/432	< 0.01
Concomitant PLA	n = 39/525	n = 15/93	n = 24/432	< 0.01
Long operation time	n = 19/525	n = 3/93	n = 16/432	NS
Massive blood loss	n = 8/525	n = 0/93	n = 8/432	NS
Other complication	n = 17/525	n = 2/93	n = 15/432	NS

After dividing 525 patients into two groups according to performing TLH or RALH, we compared 13 indexes. In this analysis, 9 out of 13 indexes showed significant differences.
Abbreviations: BMI: Body mass index, MRI: Magnetic resonance imaging, NS: No significance, PLA: Pelvic lymphadenectomy, RALH: Robotic-assisted laparoscopic hysterectomy, TLH: Total laparoscopic hysterectomy, TVUS: Transvaginal ultrasound.

time between the RALH and TLH groups, we detected a significantly longer time in the RALH group (74.5 ± 17.5 (43–132) min vs. 55.7 ± 10.8 (31–98) min P < 0.01). As a reminder, we compared these data from 2018 to 2022 (RALH: n = 93 vs. TLH: n = 334) because we introduced RALH in 2018. Since the patient characteristics between the RALH and TLH groups were different, the two groups were analysed separately.

3.2. Influential factors of operational complications

Next, to clarify the advantages and disadvantages of RALH and TLH, we evaluated the significant factors affecting the possibility of operational complications, namely, "long operation time", "massive blood loss" and "other complications", by multivariate analysis of 7 representative factors (Table 2). We could not perform an analysis of "massive blood loss" in the RALH group because none of the patients had over 500 ml of blood loss. This result may indicate the clear advantage of RALH in terms of the decreased blood loss. Therefore, we indicated the relationship between "long operation time" or "other complications" and these 7 factors (Table 3).

According to the analysis, the following two factors affected the rate of operational complications in the RALH group: 1) "abdominal adhesion" for "long operation time" (OR = 14.4, P < 0.05) and 2) "heavy uterus" for "other complications" (OR = 14.2, P < 0.05) (Table 2). On the other hand, in the TLH group, we detected the following two significant factors: 1) "concomitant PLA" for "long operation time" (OR = 6.6, P < 0.01) and 2) "heavy uterus" for "other complications" (OR = 4.3, P < 0.05) (Table 3). We also detected that two factors, "nulliparity" for "massive blood loss" and "high BMI" for "other complications", had the possibility of a low rate of operational complications in the TLH group.

4. Discussion

Due to the advantages of TLH compared with CAH, including a smaller skin incision, more rapid recovery, lower blood loss and fewer infections [4], in our hospital, TLH was performed mainly for both benign and early-stage malignant gynaecological diseases. However, since TLH requires the highest degree of laparoscopic surgical skills [4] and robotic surgery is possibly more of an advantage in technically

Table 3
Influential factors of operational complications for RALH.

RALH	Long operation time		Other complications	
factors	OR (95 % CI, Number)	P value	OR (95 % CI, number)	P value
High BMI	3.5 (0.3–39.6, n = 2/35)	NS	1.7 (0.1–27.7, n = 1/35)	NS
Concomitant PLA	NA (NA–NA, n = 0/18)	NS	NA (NA–NA, n = 0/18)	NS
Abdominal adhesion	14.4 (1.2–171.9, n = 2/13)	< 0.05	NA (NA–NA, n = 0/13)	NS
Advanced age	2.1 (0.2–23.9, n = 2/46)	NS	NA (NA–NA, n = 0/46)	NS
Nulliparity	4.7 (0.4–53.7, n = 2/29)	NS	NA (NA–NA, n = 0/29)	NS
Heavy uterus	7.0 (0.6–88.7, n = 1/7)	NS	14.2 (0.8–255.6, n = 1/7)	< 0.05
Large leiomyoma	NA (NA–NA, n = 0/1)	NS	NA (NA–NA, n = 0/1)	NS

A multivariate analysis of 93 patients with TLH was performed to examine the influence of 7 representative factors on 2 indexes of the difficulty of TLH. The number of patients with each factor, the ORs and 95 % CIs for the occurrence of these complications and the P values are shown in this table.
Abbreviations: BMI: body mass index, CI: confidence interval, NS: no significance, OR: odds ratio, PLA: pelvic lymphadenectomy, RALH: robotic-assisted laparoscopic hysterectomy.

Table 2
Influential factors of operational complications for TLH.

TLH	Long operation time		Massive blood loss		Other complications	
factors	OR (95 % CI, Number)	P value	OR (95 % CI, Number)	P value	OR (95 % CI, number)	P value
High BMI	0.9 (0.3–3.3, n = 3/93)	NS	0.5 (0.1–4.2, n = 1/93)	NS	NA (NA–NA, n = 0/93)	< 0.05
Concomitant PLA	7.2 (2.1–24.7, n = 4/24)	< 0.01	NA (NA–NA, n = 0/24)	NS	1.2 (0.2–9.7, n = 1/24)	NS
Abdominal adhesion	2.1 (0.7–6.1, n = 9/182)	NS	1.4 (0.3–5.6, n = 4/182)	NS	0.7 (0.2–2.0, n = 5/182)	NS
Advanced age	2.8 (1–7.9, n = 7/106)	NS	0.4 (0.1–3.6, n = 1/106)	NS	0.5 (0.1–2.1, n = 2/106)	NS
Nulliparity	1.1 (0.4–3.3, n = 6/160)	NS	NA (NA–NA, n = 0/160)	< 0.05	1.5 (0.5–4.2, n = 7/160)	NS
Heavy uterus	0.7 (0.2–3.1, n = 2/78)	NS	2.8 (0.7–11.9, n = 3/78)	NS	4.3 (1.5–12.1, n = 7/78)	< 0.05
Large leiomyoma	1.4 (0.3–6.3, n = 2/44)	NS	1.3 (0.2–10.5, n = 1/44)	NS	2.3 (0.6–8.5, n = 3/44)	NS

A multivariate analysis of 432 patients with TLH was performed to examine the influence of 7 representative factors on 3 indexes of the difficulty of TLH. The number of patients with each factor, the ORs and 95 % CIs for the occurrence of these complications and the P values are shown in this table.
Abbreviations: BMI: Body mass index, CI: Confidence interval, NS: No significance, OR: Odds ratio, PLA: Pelvic lymphadenectomy, TLH: Total laparoscopic hysterectomy.

complicated procedures [13], we introduced the daVinci surgical system in 2018. Since the number of cases with RALH has increased, we tried to analyse these cases determine the advantages and disadvantages of RALH.

In this study, when simply comparing the results of the RALH and TLH operations, RALH showed advantages in terms of the operation time and blood loss amount. Additionally, when considering the results of the multivariate analysis, the effect on blood loss amount seemed to be advantageous. These results may guarantee the validity of expanding the adaptation for RALH. However, we could also point out the following important issues. Since in our hospital, under the present circumstances, the resected uterine weight was less than 400 g in almost all RALH cases, we excluded the cases a resected uterine weight of 400 g or higher and defined "heavy uterus" as a resected uterine weight $\geq$ 300 g. Nevertheless, the average resected uterine weight in the TLH group was significantly higher than that in the RALH group. Considering the results of multivariate analysis of the relationship between RALH and "other complications", in which "heavy uterus" showed a significant increase in the possibility of "other complications", we recognised the necessity of more cases with "heavy uterus" for analysis. Similar to past reports about TLH [8] and CAH [11], in this study, the factor of "heavy uterus" also indicated the possibility of increasing the difficulty of both TLH and RALH (Tables 2 and 3). Although this analysis might be insufficient due to the relatively light weight used to define a "heavy uterus", the results could indicate the possibility of performing RALH with difficulty in patients with a resected uterine weight $\geq$ 300 g.

After expanding the range of indications for RALH, especially for leiomyoma and adenomyoma, our study should be performed again.

Another important factor, namely, "abdominal adhesion", also showed a negative influence on operation time in the RALH group, although this did not affect any operational complications in the TLH group. This result might indicate the need to accumulate more cases of RALH to address with complex cases, such as cases of leiomyoma or adenomyoma with coexistent endometriosis [10]. We could also point out two disadvantages, including the number of skin scars corresponding to trocar sites and the preparation time for setting assistant robots. In our hospital, RALH was performed with 5 trocars, although TLH was performed with 4 trocars. And similar to past reports [7], in our hospital, approximately 20 min of extra time was needed for setting assistant robots, and the average anaesthesia time in the RALH group tended to be longer than that in the TLH group (252.8 $\pm$ 58.1 (168–483) min vs. 245.3 $\pm$ 50.2 (145–439) min P = 0.22). This disadvantage may be improved by accumulating more RALH cases.

5. Conclusions

RALH may show sufficient advantages over TLH in terms of blood loss amount. However, since RALH may have potential weaknesses regarding complex cases and preparation time, we should accumulate further cases and analyses.

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Prior presentation

None.

Consent for publication

Written informed consent was obtained from all patients for the publication of the data.

Precis

RALH has both sufficient advantages and potential weaknesses against TLH in terms of operational complications.

Declarations of interest

None.

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