


Comparison of Surgical Outcomes Among Open, Laparoscopic, and Robotic Surgeries in Women with Obesity Diagnosed with Endometrial Cancer: Results from a Quaternary Hospital in Thailand

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Purpose: We compared the surgical outcomes of robotic surgery (RS), laparoscopic surgery (LS), and open surgery (OS) in Asian women with obesity diagnosed with endometrial cancer.

Patients and Methods: In this retrospective cohort study, the data of 248 patients with a body mass index (BMI) of ≥ 25 kg/m², who were treated between 2019 and 2024 (129 OS, 66 LS, and 53 RS), were analyzed. Clinical and surgical information was extracted from the electronic health records and compared between the OS, LS, and RS groups using the chi-square test or Fisher's exact test for categorical variables and the Student's t-test or Kruskal–Wallis test, as applicable, for continuous variables.

Results: Compared with the OS and LS groups, the RS group had a significantly higher median BMI and higher rates of obstructive sleep apnea, yet demonstrated superior perioperative outcomes. Sentinel lymph node dissection was performed predominantly in the RS group, whereas systemic lymphadenectomy was more commonly undertaken in the OS and LS groups. However, after adjusting for the type of lymphadenectomy, no significant effect on estimated blood loss (EBL) was observed. RS was associated with the lowest EBL, no transfusion requirements, and significantly reduced postoperative pain and opioid consumption compared with LS and OS ($p < 0.001$). Furthermore, RS resulted in the shortest median hospital stay (42 h) compared to LS (64 h) and OS (86 h). The overall complication rates were markedly lower in the RS group (9.4%) than in the LS (30.3%) and OS (44.2%) groups, with no high-grade complications or conversions to laparotomy observed in the robotic cases.

Conclusion: These findings suggested that robotic surgery is a safe and highly effective approach for Asian women with obesity, offering reduced morbidity and accelerated recovery, despite higher baseline patient complexity.

Keywords: body mass index, obese, safety, minimally invasive surgery

Introduction

Endometrial carcinoma represents the most prevalent gynecological cancer in developed nations and ranks sixth among cancers affecting women globally. In 2022, over 420,000 new cases were reported worldwide.¹ The incidence and mortality rates of this disease have increased substantially over the past decade. While the highest incidence rates are observed in high-income countries, there are significantly increasing incidence trends in various Asian countries, with the largest annual average percentage change in Japan, followed by India, Korea, and Thailand.² Despite improvements in early diagnosis rates, the global incidence of endometrial cancer is increasing, especially in postmenopausal women. This can be attributed to an aging population and the escalating rates of obesity, a recognized risk factor. Furthermore, mortality rates have surged in certain areas, highlighting the necessity for enhanced therapeutic approaches.^{3,4}

Obesity represents a significant risk factor for endometrial cancer, correlating with an increased incidence and poorer outcomes.^{5–7} Its prevalence is rapidly increasing worldwide. In South and Southeast Asia, the prevalence of obesity is predicted to double between the years 2010 and 2030. The relationship between body mass index (BMI) and adiposity differ among distinct ethnic groups. Asian populations often experience obesity-related health complications at lower BMI values than other populations, such as Caucasians. Consequently, lower BMI cutoff points are used to define overweight and obesity in Asian adults to more accurately reflect their associated health risks. In Asian countries, obesity is defined as a BMI ≥ 25 kg/m², whereas a BMI ≥ 30 kg/m² is typically used in Caucasian populations.⁴ This distinction may influence the preoperative assessment and surgical outcomes, with Asian women who are classified as obese by these specific criteria potentially facing different risks than their Caucasian counterparts.

In early-stage endometrial cancer, the standard treatment is total hysterectomy and bilateral salpingo-oophorectomy, often accompanied by lymph node evaluation. Traditionally, this procedure is performed via laparotomy. However, of late, minimally invasive surgery (MIS) such as laparoscopy and robot-assisted surgery are preferred. Nodal assessment has also undergone a paradigm shift, moving from systematic lymphadenectomy to sentinel lymph node dissection (SLND) to minimize surgical morbidity. The robotic platform is particularly well-suited to this transition, as its integrated near-infrared imaging facilitates precise sentinel lymph node mapping, thereby contributing to improved perioperative outcomes.⁸ These techniques are associated with lesser bleeding, shorter hospitalization, and faster healing than are standard open surgical procedures.^{9,10}

Despite the clear advantages of MIS for endometrial cancer, a significant gap remains in the literature regarding the comparative surgical outcomes of different approaches in this specific population. Most studies on this topic have been based on Western populations, where the prevalence of morbid obesity and BMI cutoffs for risk vary. To our knowledge, no study has conducted a comprehensive analysis of surgical outcomes across various surgical techniques in Asian women with obesity diagnosed with endometrial cancer. In this study, we aimed to address this critical gap by providing valuable evidence-based data to facilitate informed surgical decision-making and improved clinical outcomes for this growing patient group.

Materials and Methods

This retrospective cohort study was conducted at Songklanagarind Hospital, Faculty of Medicine, Prince of Songkla University, Thailand, between January 2019 and December 2024. Women with obesity and a histologically validated diagnosis of endometrial cancer who underwent surgical staging as the primary treatment were included. Patients who were not suitable for primary surgery, underwent concurrent surgery for other indications, or had incomplete clinical data were excluded. Obesity was characterized by a BMI ≥ 25 kg/m², consistent with the Asia-Pacific perspective guidelines. The patients were divided into three groups depending on the surgical technique used: open surgery (OS), laparoscopic surgery (LS), and robotic surgery (RS) (Figure 1). At our institute, the standard protocol for triaging patients with endometrial cancer involves counseling all eligible patients for MIS. MIS is generally recommended unless specific contraindications exist, such as anesthetic risks, a bulky uterus that precludes safe extraction without morcellation, or evidence of advanced-stage disease. However, as Thailand's Universal Coverage Scheme does not cover MIS procedures, the higher out-of-pocket costs associated with LS and RS significantly influence patients' final decisions. Regarding the surgical timeline, LS was introduced in 2011, followed by the establishment of RS for endometrial cancer surgery in 2021. Both OS and LS procedures—including total hysterectomy and bilateral salpingo-oophorectomy—were performed by the same team of board-certified gynecologic oncologists, each with at least 5 years of surgical experience.

The decision to perform pelvic and para-aortic lymphadenectomy or SLND was based on tumor risk stratification and the surgeon's clinical judgment. SLND was not performed in the OS group due to the unavailability of a near-infrared camera system for open surgery at our institution during the study period. In this group, lymph node assessment was either performed via systematic lymphadenectomy or completely omitted based on tumor risk stratification. All robot-assisted surgeries were performed using the da Vinci Xi Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA). These procedures were conducted by two board-certified gynecologic oncologists with specialized training in robotic surgery, each performing more than 25 robotic surgeries for endometrial cancer annually. This study complies with the Declaration of Helsinki and was approved by the Research Ethics Committee of the Faculty of Medicine, Prince of Songkla University (approval number: 66–510–12–4).

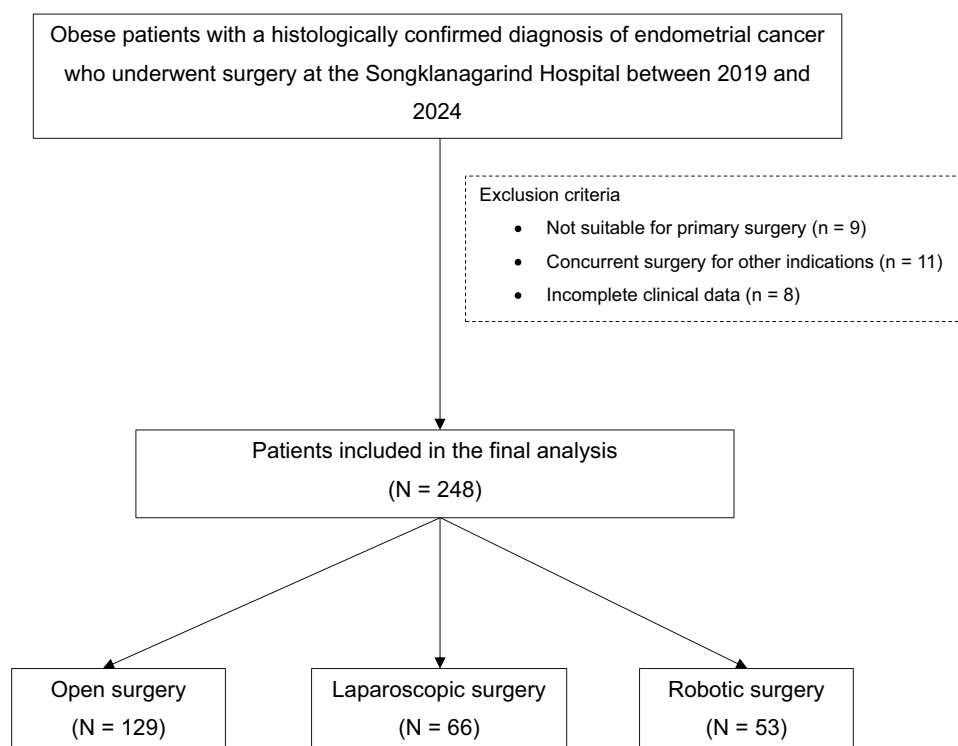


Figure 1 Flow diagram illustrating the selection process of the study cohort.

Clinical and surgical information was extracted from the electronic health records of the institution. Patient characteristics such as age, BMI, and comorbidities were recorded. Tumor characteristics, including histology, stage (FIGO 2009),¹¹ and grade, were also documented. The key surgical outcomes measured included anesthetic induction time (defined as the time from the start of anesthesia induction to skin incision), operative time, estimated blood loss (EBL), and the number of retrieved lymph nodes. For robotic cases, the docking and console times were also recorded. Postoperative data, including the length of hospital stay (defined as the duration from the end of the procedure to the time of discharge), conversion to laparotomy, postoperative complications (evaluated within 30 days after surgery and graded by the Clavien–Dindo classification¹²), pain scores (numeric rating score in the first 24 h), and opioid dosage were also collected.

Statistical analyses were conducted using R software version 4.3.2. Categorical variables are represented as frequencies and percentages and were analyzed using the chi-square test or Fisher’s exact test. Continuous variables were evaluated for normality; those conforming to a normal distribution are expressed as mean \pm standard deviation and were compared using Student’s *t*-test. Variables not adhering to normality are reported as median and interquartile range and were analyzed using the Kruskal–Wallis test. A significance threshold was defined as a *p*-value of <0.05 .

Results

Patient Demographics and Tumor Characteristics

In total, 248 patients who underwent surgery for endometrial cancer were included: 129 (52.0%) in the OS group, 66 (26.6%) in the LS group, and 53 (21.4%) in the RS group. **Figure 2** illustrates the annual distribution of surgical approaches among obese women with endometrial cancer at our institute from 2019 to 2024. Over this period, a clear paradigm shift from traditional OS to MIS was observed. The proportion of open surgeries steadily declined from constituting the vast majority in 2019 to a minority by 2024. By contrast, LS maintained a relatively stable intermediate presence, whereas RS demonstrated rapid and continuous growth following its introduction. The patient demographics and baseline tumor characteristics are presented in **Table 1**. There were no intergroup differences in baseline variables, including patient age, parity, use of antithrombotic medication, and the presence of concurrent malignancy.

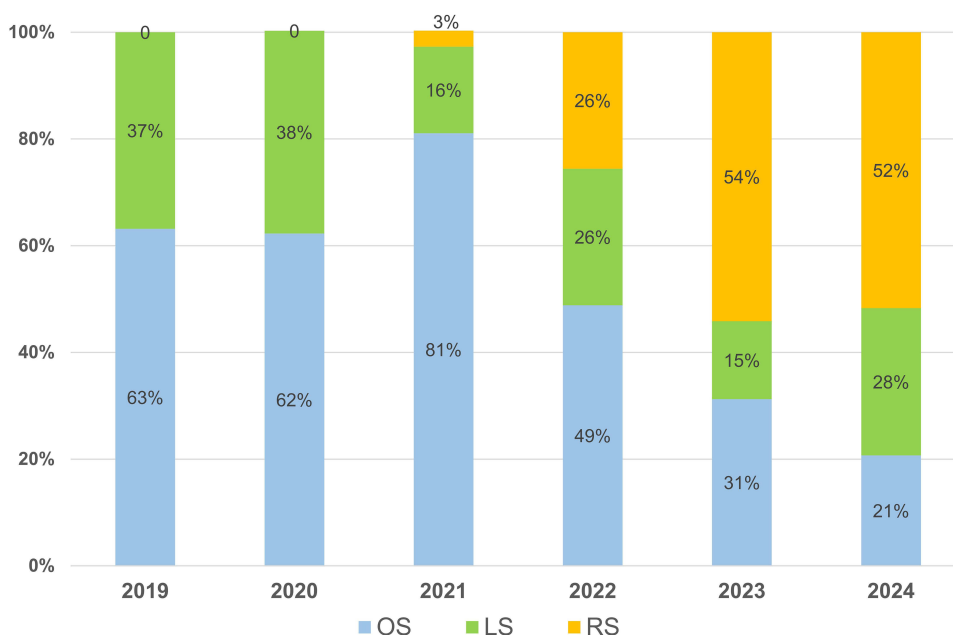


Figure 2 Annual distribution of surgical approaches (open, laparoscopic, and robotic) among obese women with endometrial cancer from 2019 to 2024.

The median BMI was significantly higher in the RS group (33.8 kg/m²) than in the OS (29.4 kg/m²) and LS (30.3 kg/m²) groups (p < 0.001). When classified by BMI, 66.0% (n = 35) of patients in the RS group had a BMI ≥ 30 kg/m², compared to 54.5% (n = 36) in the LS group and 43.4% (n = 56) in the OS group (p < 0.001). The RS group also had a significantly higher

Table 1 Demographics and Tumor Characteristics of Patients

	OS (n = 129)	LS (n = 66)	RS (n = 53)	p-value
Age, years (IQR)	59 (53–64)	61 (54–68)	58 (46–65)	0.242
Parity, n (IQR)	2 (0–3)	2 (1–3)	1 (0–3)	0.163
BMI, kg/m² (IQR)	29.4 (26.6–33.3)	30.3 (27.3–34.1)	33.8 (29–39.8)	<0.001
BMI by grade, n, (%)				<0.001
25–29.99	73 (56.6)	30 (45.5)	18 (34)	
30–34.99	35 (27.1)	23 (34.8)	10 (18.9)	
35–39.99	11 (8.5)	7 (10.6)	12 (22.6)	
40–49.99	10 (7.8)	6 (9.1)	11 (20.8)	
50–59.99	0	0	2 (3.7)	
Previous abdominal surgery, n (%)	64 (49.6)	20 (30.3)	30 (56.6)	0.008
Underlying disease, n (%)	91 (70.5)	52 (78.8)	46 (86.8)	0.055
Hypertension	71 (55)	38 (57.6)	31 (58.5)	0.892
Diabetes	40 (31)	25 (37.9)	19 (35.8)	0.595
Hyperlipidemia	53 (41.1)	36 (54.5)	30 (56.5)	0.075
Cardiovascular	10 (7.8)	2 (3)	2 (3.8)	0.444
Pulmonary	5 (3.9)	5 (7.6)	2 (3.8)	0.455
Obstructive sleep apnea	4 (3.1)	3 (4.5)	16 (30.2)	<0.001
Thyroid	4 (3.1)	2 (3)	2 (3.8)	1
Stroke	4 (3.1)	2 (3)	2 (3.8)	1
Hepatic	2 (1.6)	1 (1.5)	0	1
Renal	0	1 (1.5)	1 (1.9)	0.229
Thromboembolic	3 (2.3)	0	0	0.429

(Continued)

Table 1 (Continued).

	OS (n = 129)	LS (n = 66)	RS (n = 53)	p-value
Charlson comorbidity index, n (%)				0.85
0	78 (60.5)	36 (54.5)	30 (54.5)	
I	39 (30.2)	21 (31.8)	19 (34.5)	
≥2	12 (9.3)	9 (13.6)	6 (10.9)	
Existing antithrombotic medication, n (%)	16 (12.4)	6 (9.1)	4 (7.5)	0.568
History of other cancer, n (%)	3 (2.3)	0	3 (5.7)	0.162
Histology, n (%)				
Endometrioid	111 (86)	63 (95.5)	47 (88.7)	0.136
Non-endometrioid	12 (9.3)	3 (4.5)	4 (7.5)	0.497
Mixed cell	6 (4.7)	0	2 (3.8)	0.194
Tumor grade, n (%) for endometrioid				0.166
Low grade (grade 1–2)	93 (83.8)	59 (93.7)	40 (85.1)	
High grade (grade 3)	18 (16.2)	4 (6.3)	7 (14.9)	
Myometrial invasion, n (%)				0.023
None	7 (5.4)	5 (7.6)	6 (11.3)	
<50%	66 (51.2)	39 (59.1)	37 (69.8)	
≥50%	56 (43.4)	22 (33.3)	10 (18.9)	
Presence of LVSI, n (%)	51 (39.5)	22 (33.3)	16 (30.2)	0.431
Stage (FIGO, 2009), n (%)				0.069
I	102 (79.1)	60 (90.9)	41 (77.4)	
II	6 (4.6)	1 (1.5)	6 (11.3)	
III	21 (16.3)	5 (7.6)	6 (11.3)	
Uterine weight, gm (IQR)	178 (105–276)	120 (82.8–149)	115 (88–155)	<0.001

Abbreviations: OS, open surgery; LS, laparoscopic surgery; RS, robotic surgery; BMI, body mass index; FIGO, The International Federation of Gynecology and Obstetrics; LVSI, lymphovascular space invasion.

rate of previous abdominal surgery (56.6% vs. 49.6% in OS and 30.3% in LS) and a significantly higher prevalence of obstructive sleep apnea (30.2% vs. 4.5% in LS and 3.1% in OS, $p < 0.001$). The Charlson Comorbidity Index scores were comparable among groups. Regarding tumor characteristics, the histological type, tumor grade, presence of lymphovascular space invasion, and FIGO stage did not differ significantly between groups. However, the OS group had the highest percentage of tumors with >50% myometrial invasion (43.4%) and the highest median uterine weight (178 g vs. 120 g for LS and 115 g for RS; $p < 0.001$).

Surgical Outcomes

The operative data are summarized in Table 2. All patients (100%) in the RS group underwent a complete procedure including total hysterectomy, bilateral salpingo-oophorectomy, and lymph node evaluation; this rate was significantly higher than that in the OS (79.8%) and LS (72.7%) groups ($p < 0.001$).

Table 2 Operative Outcomes

	OS (n = 129)	LS (n = 66)	RS (n = 53)	p-value
Operation type, n (%)				
H + BSO	26 (20.2)	18 (27.3)	0	<0.001
H + BSO + lymphadenectomy	103 (79.8)	36 (54.5)	6 (11.3)	<0.001
H + BSO + SLND	0	12 (18.2)	47 (88.7)	<0.001
Harvested lymph node, n (IQR)				
Pelvic lymph node	13.5 (9–19)	11 (7–15)	3 (2–5)	<0.001
Paraaortic lymph node	3.5 (2–5)	3 (3–5.8)	1.5 (1–2.8)	0.268

(Continued)

Table 2 (Continued).

	OS (n = 129)	LS (n = 66)	RS (n = 53)	p-value
Anesthetic induction time, min (IQR)	25 (20–30)	35 (30–40)	45 (40–55)	<0.001
Operative time, min (IQR)	250 (212.5–275)	285 (228.8–325)	275 (230–340)	<0.001
Docking time, min (IQR)	–	–	9 (7–11)	
Console time, min (IQR)	–	–	205 (165–263)	
Total theatre time, min (IQR)	280 (245–315)	343 (272–377)	355 (305–410)	<0.001
Estimated blood loss, mL (IQR)	300 (200–500)	50 (50–150)	30 (15–50)	<0.001
Blood transfusion, n (%)	22 (17.1)	1 (1.5)	0	<0.001
Pain score (IQR)	4 (3–5)	3 (2–4)	2 (1–3)	<0.001
Morphine use, mg (IQR)	20 (9–24)	6 (0.8–16.5)	3 (0–3)	<0.001
Hospital stays, h (IQR)	86 (67–93)	64 (48–69)	42 (40–48)	<0.001
Conversion rate, n (%)	–	1 (1.5)	0	0.48
Overall complication rate, n (%)	57 (44.2)	20 (30.3)	5 (9.4)	<0.001
Clavien–Dindo complication classification, event (%)	68	22	5	
Class I	29 (42.6)	2 (9.1)	1 (20)	0.009
Class II	21 (30.9)	15 (68.2)	4 (80)	<0.001
Class III	14 (20.6)	2 (9.1)	0	0.405
Class IV	4 (5.9)	3 (13.6)	0	0.564

Abbreviations: OS, open surgery; LS, laparoscopic surgery; RS, robotic surgery; H, hysterectomy; BSO, bilateral salpingo-oophorectomy; SLND, sentinel lymph node dissection.

Lymph node assessment varied significantly ($p < 0.001$). SLND was performed more commonly in the RS group and less frequently in the LS group, and it was not performed for any patient in the OS group. Consequently, the median number of retrieved pelvic lymph nodes was the highest in the OS group (13.5), followed by the LS (11.0) and RS groups (3.0), with a significant intergroup difference ($p < 0.001$). The number of retrieved para-aortic lymph nodes exhibited no statistically significant difference between groups.

The RS group required a significantly longer median anesthetic induction time (45 min) than did the LS (35 min) and OS (25 min) groups ($p < 0.001$). Although the median operative time was significantly longer for RS (275 min) than for OS (250 min), it was significantly shorter for RS than for LS (285 min, $p < 0.001$). For RS procedures, the median docking time was 9 min, and the median console time was 205 min. The RS group had a significantly longer median total theatre time (355 min) compared with the LS (343 min) and OS (280 min) groups ($p < 0.001$). By contrast, the RS group demonstrated the lowest median EBL (30 mL vs. 50 mL for LS and 300 mL for OS; $p < 0.001$). To further evaluate the potential confounding effect of the extent of lymphadenectomy on surgical outcomes, a subgroup analysis was performed. There was no statistically significant difference in median EBL between patients who underwent systematic lymph node dissection and those who underwent SLND or selective sampling (250 mL [IQR, 150–400] vs. 300 mL [IQR, 200–500]; $p = 0.18$).

Postoperative Outcomes and Complications

Postoperative recovery metrics (Table 2) showed significant advantages in the RS group. The RS group had the lowest postoperative pain score (2 vs. 3 for LS and 4 for OS, $p < 0.001$), and lowest median morphine usage (3 vs. 6 mg for LS and 20 mg for OS, $p < 0.001$). Reflecting the lower EBL, no patients (0%) in the RS group required a blood transfusion, compared with 1.5% ($n = 1$) in the LS group and 17.1% ($n = 22$) in the OS group ($p < 0.001$). This resulted in the RS group having the shortest median hospital stay (42 h), which was significantly shorter than that in the LS (64 h) and OS (86 h) groups ($p < 0.001$). One patient (1.5%) in the LS group required conversion to laparotomy due to ureteric injury, and no conversions occurred in the RS group; the total complication rate was considerably lower in the RS group (9.4%), followed by the LS group (30.3%) and the OS group (44.2%) ($p < 0.001$). In accordance with the Clavien–Dindo classification, no Class III or IV complications occurred in the RS group. The details of the complications are presented in Table 3. The most common complications in the OS group were surgical site or wound infections, electrolyte imbalance, febrile morbidity, and urinary tract infections. Vaginal stump complications were the most frequent in the LS group. Notably, postoperative

Table 3 Details of Intra- and Postoperative Complications

	OS	LS	RS
Type of complication, event (%)	68	22	5
Surgical site or wound infection	35 (51.8)	3 (13.6)	2 (40)
Vaginal stump complication	4 (5.9)	10 (45.5)	2 (40)
Electrolyte imbalance	8 (11.8)	0	1 (20)
Urinary tract infection	6 (8.8)	1 (4.5)	0
Visceral organ injury	2 (2.9)	4 (18.3)	0
Febrile morbidity	7 (10.3)	3 (13.6)	0
Ileus	3 (4.4)	1 (4.5)	0
Pneumonia	1 (1.5)	0	0
Small bowel obstruction	1 (1.5)	0	0
Incisional hernia	1 (1.5)	0	0

Abbreviations: OS, open surgery; LS, laparoscopic surgery; RS, robotic surgery.

pneumonia, small bowel obstruction, and incisional hernia were observed only in the OS group. While no visceral organ injuries occurred in the RS group, there were two cases in the OS group and four in the LS group.

Discussion

The management of endometrial cancer in women with obesity presents a formidable surgical challenge compared to traditional OS. Minimally invasive surgery (MIS), which includes both conventional LS and RS, has become the preferred standard of care.⁸ This study significantly contributes to the evolving literature by providing a contemporary comparative analysis of all three modalities in this high-risk group, specifically defining obesity using the Asia-Pacific perspective classification ($\text{BMI} \geq 25 \text{ kg/m}^2$). This is a critical distinction, as earlier studies on the surgical outcomes of robotic surgery in Asian women with endometrial cancer have reported cohorts of women without obesity.^{13–17} By contrast, our study specifically investigated Asian women with obesity, a population in which the prevalence of obesity has increased rapidly in recent years.⁴

The principal finding of our analysis was that MIS, particularly RS, was associated with markedly superior perioperative outcomes compared to OS, including significantly lower estimated blood loss, reduced need for blood transfusions, lower postoperative pain scores, decreased narcotic consumption, shorter hospital stays, and a dramatically lower rate of overall complications. Notably, these advantages were achieved in an RS cohort that presented with a significantly higher baseline BMI and a greater prevalence of obesity-related comorbidities, such as obstructive sleep apnea, suggesting that RS is a particularly effective and safe modality for managing this high-risk patient population.

A critical finding from our demographic analysis is the significant difference in baseline characteristics, which inherently reflects selection biases in a retrospective study. The RS group had the highest median BMI (33.8 kg/m^2) and the largest proportion of patients with morbid obesity ($\text{BMI} > 40 \text{ kg/m}^2$), as well as a strikingly higher incidence of obstructive sleep apnea, a commonly encountered comorbidity in individuals suffering from obesity.¹⁸ This suggests that surgeons at our institution preferentially selected the robotic platform for the most complex patients with obesity, perhaps anticipating the challenges of conventional laparoscopy or the high morbidity associated with open surgery. This finding is crucial, as it indicates that superior outcomes of RS were achieved despite the group's higher intrinsic surgical risk.^{18–21} Conversely, the OS group had a significantly higher median uterine weight, whereas the RS group had a lower proportion of cases with deep myometrial invasion. This suggests a tendency to triage patients with larger, bulkier tumors or potentially more advanced local disease using an open approach, which represents a significant confounding variable.

The perioperative recovery metrics demonstrated a clear stepwise improvement from OS to LS, and again from LS to RS, consistent with those reported in other publications.^{13,21,22} The median EBL in the OS group was six-fold higher than that in the LS group and 10-fold higher than that in the RS group. This clinically significant reduction in hemorrhage translated directly into transfusion requirements: 17.1% of OS patients required a blood transfusion compared to only 1.5% of LS patients and, remarkably, 0% of RS patients. Avoiding transfusions is a major clinical benefit, eliminating

associated risks such as reactions, fluid overload, and immunomodulation. This, combined with superior postoperative pain control, was the primary driver of the accelerated recovery.

Our data align with the principles of Enhanced Recovery After Surgery, which emphasizes multimodal pain management and minimizes opioid use.²³ Patients in the RS group reported the lowest median pain scores and required the least amount of morphine, which was significantly lower than that in both the LS and OS groups; this may be explained by the fact that RS reduces the inflammatory response and minimizes tissue damage compared to LS.²⁴ However, some authors found not only an insignificant difference in postoperative pain score but also in the narcotic region between RS and LS.^{16,25,26} The reduction in pain and narcotic consumption likely contributed to a faster return of bowel function and mobilization, culminating in the shortest median hospital stay. Although the overall length of hospital stay in our cohort may appear prolonged compared with that reported in Western institutions,^{18,26} this likely reflects our regional context. As a quaternary referral center, many patients travel long distances, prompting a more conservative discharge strategy to ensure safe travel. Furthermore, the high prevalence of obesity-related comorbidities, such as obstructive sleep apnea, necessitates extended postoperative monitoring to optimize patient safety. This 44-h reduction in hospital stay compared to OS has profound implications for patient satisfaction, reduced nosocomial risks, and healthcare cost-effectiveness.

A major finding and significant confounder of this study was the fundamental difference in the surgical procedure performed, particularly concerning lymph node assessment. The OS group primarily underwent full pelvic and para-aortic lymphadenectomies, similar to most patients in the LS group, whereas the RS group underwent SLND almost exclusively. This paradigm shift explains the vast difference in the number of harvested pelvic lymph nodes. Therefore, distinguishing the benefits of the robotic platform from those of the SLND procedure is challenging. Regarding the extent of surgery, we acknowledge that patients in the RS group predominantly underwent SLND, whereas those in the OS group largely underwent systematic lymphadenectomy. However, our additional analysis demonstrated no statistically significant difference in EBL between the systematic lymphadenectomy and SLND/selective sampling groups ($p = 0.18$). This finding suggests that the reduced blood loss observed in the RS group was primarily driven by the advantages of the robotic platform, rather than solely to differences in lymph node assessment methods. It can be argued that the robotic platform, with its enhanced three-dimensional visualization, wristed instrumentation, and stable camera, facilitates the adoption and precision of SLND, particularly in the deep, narrow pelvis of a patient with obesity.^{18,19,27} The SLND approach itself is known to reduce morbidities, such as lymphedema and nerve injury, compared to full lymphadenectomy.^{28–30} This study highlights that the adoption of RS is concurrent with the adoption of SLND, and that the combined effect is a dramatic reduction in surgical morbidity. Furthermore, regarding oncologic safety, the transition from systematic lymphadenectomy to SLND has been proven to be safe and oncologically adequate. Recent literature demonstrates that replacing systematic lymphadenectomy with SLND in early-stage endometrial cancer, including in populations with a high BMI, does not compromise survival outcomes and is associated with comparable recurrence risks. These findings further support the adoption of SLN mapping, particularly via the robotic platform, as a standard of care for these patients.³¹

The most striking finding of our study was the stepwise reduction in overall postoperative complications, similar to previous reports.^{10,32} The nature of these complications differed significantly between the groups. The high morbidity of OS is overwhelmingly driven by the surgical site and wound infections (51.8% of all OS complications), a well-documented risk of large laparotomy incisions in patients with obesity showing impaired adipose tissue vascularity. In LS, the most frequent complication was related to the vaginal stump, potentially reflecting the challenges of laparoscopic suturing and thermal damage during colpotomy.³³ The RS group had the lowest absolute number of complications and demonstrated a notable absence of visceral organ injuries, compared to four in the LS group and two in the OS group. This finding supports the hypothesis that the superior ergonomics and dexterity of the robotic system may translate into increased surgical precision and a lower rate of iatrogenic injury. Furthermore, although the OS group had the highest number of low-grade (Clavien–Dindo I) complications, the RS group had zero high-grade complications (Class III or IV), further underscoring the platform's safety profile in this study.

Our study has some limitations. The retrospective design was the primary source of selection bias, as previously discussed. The nonrandomized allocation of patients to surgical groups based on patient factors (BMI and comorbidities) and tumor factors (uterine size and invasion) makes direct comparison difficult. We were also unable to control for

surgeon experience or the learning curve, which heavily influences operative time and complication rates, especially for complex procedures such as LS and RS. The elevated proportion of SLND in the RS group may obfuscate direct comparisons of the actual operative time for each surgical approach. Nevertheless, the extended operative time will likely ameliorate with an increase in the learning curve.^{34,35} The significantly longer anesthetic induction time for RS (45 min) reflects the complexity of patient positioning and monitoring, although the total operative time was shorter than that for LS. Nonetheless, this interval has the potential to enhance operational efficiency through the establishment of consistent teams and dedicated training initiatives aimed at fostering anticipation and team familiarity.^{36–38} Finally, and most importantly, this study only evaluated short-term perioperative outcomes and provides no data on long-term oncologic outcomes such as disease-free and overall survival. Future prospective randomized controlled trials are needed to validate these findings, control for confounding variables, and, most critically, to verify that long-term cancer-specific survival is not compromised by this shift in surgical techniques.

Conclusion

This study provides compelling real-world evidence that a minimally invasive approach, particularly with a robotic approach, is safe, feasible, and associated with the most favorable perioperative outcomes in Asian women with obesity diagnosed with endometrial cancer. RS demonstrated significant reductions in blood loss, transfusion rates, pain, narcotic use, hospital stay, and overall complications, even when compared with LS and OS. These benefits were observed even though the RS cohort had a higher baseline BMI and more significant comorbidities, suggesting that it is a uniquely valuable tool for this high-risk population. The data also reflected a major shift in surgical practice, linking the use of RS to the adoption of SLND. Importantly, we acknowledge that the superior perioperative outcomes observed in the RS group are likely attributable to a combination of the advantages of the minimally invasive robotic platform and the less invasive nature of SLND, rather than the robotic approach alone. Although these perioperative benefits are evident, the critical question of long-term oncological safety remains.

Ethics Approval and Informed Consent

The Research Ethics Committee of the Faculty of Medicine, Prince of Songkla University approved this study (approval number: 66-510-12-4), which was conducted in accordance with the Declaration of Helsinki. The need for informed consent was waived because of the study's retrospective and anonymous design involving participants.

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