EUROX 23 (2024) 100330

Contents lists available at ScienceDirect

European Journal of Obstetrics & Gynecology and Reproductive Biology: X

journal homepage: www.journals.elsevier.com/european-journal-of-obstetrics-and-gynecology-and-reproductive-biology

# An eight-year analysis of robotic surgery in morbidly obese women with endometrial cancer in a tertiary center in Singapore

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ARTICLE INFO

*Keywords:*
Robotic surgery
Endometrial malignancy
Morbid obesity

ABSTRACT

*Introduction:* Surgical management of endometrial cancer is a total hysterectomy, bilateral salphingo-oophorectomy and pelvic lymph node dissection (THBSO-PLND), which is a challenging surgery in the morbidly obese. Data on morbidly obese women undergoing robotic surgery is limited in Asia. We share our experience in Singapore and aim to demonstrate that robotic surgery is safe and effective in morbidly obese women with endometrial cancer.

*Materials and Methods:* We performed a retrospective analysis of patients with BMI > 40 kg/m2, who underwent robotic surgery from January 2016 to September 2023 at the Singapore General Hospital. We recruited a total of 33 patients who underwent robotic surgery for endometrial malignancy and analysed surgical outcomes, operative complications, and survival rates.

*Results:* The average age of patients was 53 years and mean BMI 45.7. The average operative time was 232 min and average blood loss 184 ml. 3 patients had THBSO while 27 underwent THBSO-PLND. None required conversion to laparotomy. 4 patients required a mini-laparotomy for the retrieval of bulky uterus. 12 required adhesiolysis. 6 patients had additional omentectomy done. The average inpatient stay was 4.8 days. The 1-year mortality rate is 0. However, 1 patient passed away 13 months after surgery due to complications from bowel obstruction and another passed away 39 months later due to disease recurrence. 1 patient readmitted on POD6 due to post-op ileus and another for port-site hematoma. Both were managed conservatively.

*Conclusion:* Robotic surgery is a safe and effective alternative surgical tool for women who are morbidly obese with endometrial cancer.

## 1. Introduction

Obesity is a growing issue globally with an estimated 1.9 billion adults worldwide who are classified as overweight with a Body Mass Index (BMI) of > 25 kg/m$^2$, of whom 13 % were classified as obese, a BMI of > 30 kg/m$^2$ [1]. Obesity is a health hazard, with increased risk of endometrial polyps, hyperplasia and cancer [2,3] and is associated with poorer surgical outcomes due to technical difficulties [4]. However, the advent of robotic surgery has provided us an avenue to improve outcome for patients [5–7] and circumvent shortfalls associated with traditional minimally-invasive surgeries (MIS) such as reduced conversion rates due to poor visualisation issues [7] or challenges with angulation of ports or suturing [8].

There has been limited data published on robotic surgery performed on morbidly obese Asians. There are also no large scale meta-analysis on robotic surgery in morbidly obese gynae-oncology patients. Possible reasons include high surgical risks in view of raised BMI and comorbidities. Alternative non-surgical options, such as hormonal treatment, radiotherapy, or chemotherapy, for purposes of palliation or symptom control may have been preferred. By sharing our experience in a cosmopolitan Asian country, we hope to evaluate the safety and of robotic surgery in this group of patients with endometrial cancer.

## 2. Materials and methods

### 2.1. Patient selection

Patients diagnosed with endometrial cancer and planned for surgery at the Singapore General Hospital (SGH), a single tertiary centre, with BMI ≥ 40 kg/m$^2$, between the periods of January 2016 to September

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https://doi.org/10.1016/j.eurox.2024.100330
Received 3 April 2024; Received in revised form 24 June 2024; Accepted 26 July 2024
Available online 2 August 2024

2023, were deemed eligible for robotic surgery using the Da vinci Surgical System (Intuitive Surgical Inc, Sunnyvale, CA). Only patients with histologically confirmed endometrial cancer were recruited. A previous abdominal or pelvic surgery was not a contraindication to robotic surgery.

Approval to perform the study was obtained from the internal review board (IRB) based at SGH. Patient demographics of age, BMI, parity, co-morbidities, and previous surgical histories were analysed. (Table 1).

### 2.2. Pre-operative preparations

SGH is a tertiary referral centre for complex cases. Pre-operatively, each patient was assessed systematically before recommendation for their treatments was given. All patients were referred to our oncology centre for review by gynae-oncologists and subsequently planned for imaging such as Magnetic resonance imaging (MRI) pelvis or Computed tomography (CT) thorax, abdomen and pelvic scan. Relevant investigations were then discussed at a Multi-Disciplinary Team (MDT) meeting, attended by the gynaecology-oncology team, radiation-oncology team, medical-oncology team and trained nurse specialists. All patients who were radiologically staged 1 to 3, were usually recommended surgery.

At the subsequent clinic appointment, recommendations from the MDT were explained and discussed with patients. If the patient is agreeable for surgery, informed consent is obtained, and all patients were counselled about the possibility of a mini laparotomy for specimen retrieval or conversion to open surgery (laparotomy) if deemed necessary to complete surgical goals. The patient was referred to the Anaesthesia Pre-operative Assessment clinic for a review for fitness to tolerate general anaesthesia. The anaesthesia assessment was done with the STOP-BANG scoring system for obstructive sleep apnoea or the Apnoea-Hypopnea Index (AHI) scoring system. Where appropriate, patients were referred for lung rehabilitation or started on respiratory devices such as continuous positive airway pressure (CPAP) or incentive spirometry. The appropriate referrals to other disciplines were also made where indicated: cardiovascular medicine (CVM), physiotherapy (PT) or endocrinology for further assessment and optimization. Typically, CVM would review the patient's transthoracic echocardiography for ejection fraction and to exclude conditions such as pulmonary hypertension. All referrals and investigations were done in a time-sensitive manner in view of primary malignancy status. (Fig. 1).

Surgeries are performed within four to eight weeks from diagnosis, depending on co-morbidities and time required to optimise patients. Chronic medications of patients are reviewed by anaesthesiologists and adjustments were made. Clopidogrel is stopped for seven days prior to surgery whereas Aspirin is continued. Routine blood tests (blood count, renal panel), chest X ray and electrocardiography (ECG) were performed prior to surgery.

**Table 1**
summary of patient demographics recruited for study.

| Patient demographics | | N = 33 |
|---|---|---|
| Mean age in years (range) | | 52.9 years (29 - 78 years) |
| Mean BMI in kg/m$^2$ (range) | | 45.7 kg/m$^2$ (40 – 63.0 kg/m$^2$) |
| Parity (%) | Nulliparous | 20 (61 %) |
| | Parous | 13 (39 %) |
| Co-morbidities (%) | Chronic hypertension | 19 (58 %) |
| | Sleep Apnoea (on CPAP) | 7 (21 %) |
| | Chronic Kidney diseases | 3 (9 %) |
| | Heart disease | 7 (21 %) |
| | Diabetes mellitus (%) | 10 (36 %) |
| | Others: thyroid disease, autoimmune etc | 6 (18 %) |
| Past surgical history (%) | **Total number of patients with previous surgeries:** | |
| | Abdominal surgeries | 5 |
| | Pelvic surgeries | 10 |
| | Orthopaedic surgery | 4 |
| | Surgeries in other areas (thyroid, ENT, abscesses etc) | 5 |
| Pre-operative radiological staging (%) | Stage 1 A | 24 |
| | Stage 1B | 4 |
| | Stage 2 | 3 |
| | Stage 3 | 1 |
| | Stage 4* | 1 |
| Anaesthesia assessment | | |
| ASA grade (%) | Grade 1 | 0 |
| | Grade 2 | 10 |
| | Grade 3 | 23 |
| STOP-BANG score (%) | **Average score across assessed patients (n = 24):** | |
| | Score 1 | 2 |
| | Score 2 | 1 |
| | Score 3 | 12 |
| | Score 4 | 5 |
| | Score 5 | 5 |
| | Score 6 | 1 |
| | Score 7 | 1 |
| AHI score | **Average score across assessed patients (n = 3): 50.67** | |

* This patient received 6 cycles of chemotherapy and demonstrated good response with no residual disease except tumour confined to uterus. She was subsequently offered palliative THBSO surgery.

### 2.3. Surgical techniques

Patients were scheduled for admission on the day of surgery. The lead surgeon for each case was experienced with the robotic surgical system used at SGH. Surgeries were performed under general anaesthesia, in lithotomy and Trendelenburg position. Peri-operative antibiotic prophylaxis of Cefazolin and Metronidazole were given; Clindamycin and Gentamicin were used in patients with allergy to penicillin antibiotics. The abdomen and vagina were cleansed with povidone iodine solution and the bladder drained with Foley catheter. Intraoperatively, both legs were fitted with sequential compression devices for venous thrombosis prophylaxis. Advincula arch Uterine manipulator with Koh-efficient cup was routinely used.

Umbilical incision was made. Pneumoperitoneum was created to 20 mmHg after a trans-umbilical Veress needle was inserted. A 12 mm port was inserted in the umbilical incision, followed by three 8 mm robotic trocars in the right iliac fossa, left iliac fossa and left lower quadrant medial to antero-superior iliac spine. The Da Vinci system was used, and the main body of the docking station was positioned to the patient's left. An additional assistant port of 12 mm was placed in the right upper quadrant approximately 6 cm from the umbilical trocar. Peritoneal washing was collected for cytology. Surgery was performed using laparoscopic scissors and Maryland graspers. Lymph nodes dissected were retrieved via endo-bag vaginally. Colpotomy was performed abdominally. Vaginal vault closed by stratafix 0/0. Umbilical port and assistant port were closed with Endoclose. The skin of remaining ports were sutured.

In surgical cases where specimen cannot be safely delivered vaginally, the Advincula arch was first removed and cervical stitches were placed to close cervix to prevent tumour spillage. Vaginal vault would then be washed with normal saline, after which an Inzii retrieval bag 12/15 mm would be introduced via the assistant port and the uterus specimen would be placed into the bag. Subsequently, vaginal vault was closed robotically. After hemostasis was achieved from all surgical sites, the patient was undocked from the robot. We would then perform mini laparotomy via an 8 cm Pfannenstiel incision below umbilicus (due to the abdomen being pendulus in our morbidly obese patients, as well as concerns of wound infection and healing), and the specimen would be removed while contained in the bag in order to avoid spillage.

Post-operatively, patients were monitored in our high-dependency unit and subsequently stepped down to general ward the following day. Post-op, patients are encouraged to resume fluids and diet. Routine post-op blood tests were not taken unless indicated.

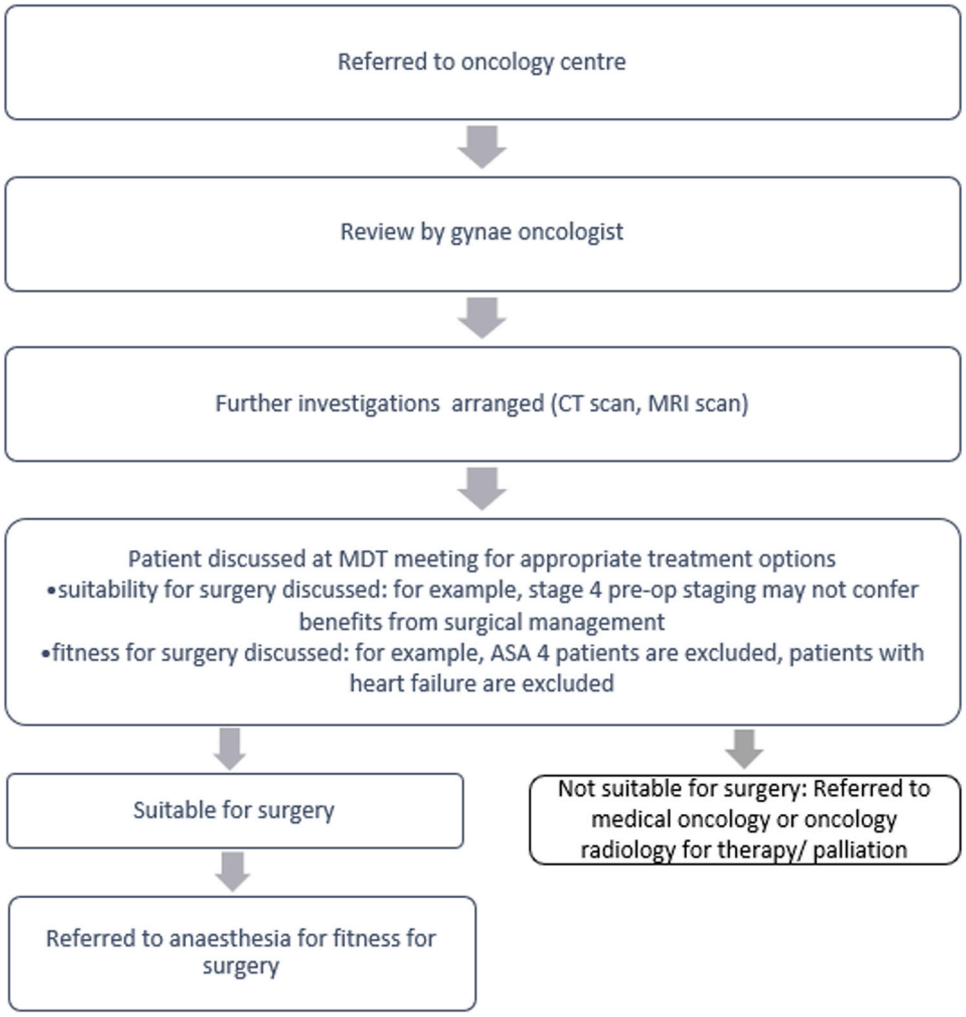



**Fig. 1. :** Flow chart of process of assessment and preparation of patients for surgery.

### *2.4. Statistical and data analysis*

We analysed the effectiveness of robotic surgery by evaluating the following parameters: completion of intended surgical purpose without conversion to an alternative surgical method, number of lymph nodes dissected and duration of surgery.

To evaluate the safety profile of robotic surgery, we analysed the following parameters: intra-operative blood loss, intra-operative complications and post-operative progress (in terms of ambulation, bowels, readmissions within 30 days and mortality within 30 days). We used the Clavien-Dindo scoring system for analysis of post-operative outcomes. We also analysed the survival outcome for our patients with the Kaplan Meier curve.

## 3. Results

### *3.1. Patient demographics*

Thirty-three patients were recruited for our study, with an average age of 52.9 (29 to 78 years old). The BMI of our patients ranged from 40 kg/m$^2$ to 63.0 kg/m$^2$, with a mean of 45.7 kg/m$^2$. There were twenty nulliparous patients (61 %) and 13 parous women (39 %). Twenty-seven patients were assessed with the STOP-BANG score, with an average score of 3.63 (a score of 3–4 was considered intermediate risk and a score of 5 or more high risk for sleep apnoea). Three patients were assessed with the Apnoea-Hypopnea Index (AHI) score, where a score of more than 30 was considered severe. Their scores were 33, 53 and 66, placing all of these patients in the severe category. (Table 1).

### *3.2. Operative analysis*

A total of thirty patients underwent total hysterectomy bilateral salphingo-oophorectomy and pelvic node dissection (THBSO-PLND) while only 3 underwent THBSO without PLND. Two patients had THBS and PLND, with ovaries conserved. Twelve patients required adhesiolysis and six patients had additional omentectomy done. Only four patients required a mini laparotomy for the retrieval of uterus (with uterus size of 439 g, 525 g, 276 g and 346 g). The average uterus size across all patients was 198 g. The average operative time (from first incision made to skin closure) was 232 min (range: 130 min to 365 min) and operative blood loss volume was 184 ml (Table 2).

### *3.3. Post-operative analysis*

Every patient was routinely monitored at the high dependency unit (HDU) immediately postoperative and subsequently stepped down to general ward the next morning. 1 patient was kept in HDU for an additional day for closer monitoring, but she also had an uneventful recovery. There was no postoperative admissions to the intensive care unit. The majority of patients ambulated the next day after surgery (80 %) and opened bowels as well (72 %). On average, POD1 pain was scored at 1 point.

**Table 2**
summary of operations performed.

| Summary of specific operative components | | |
|---|---|---|
| Average operative time in minutes (range) | | 232 (130 - 365) |
| Average blood loss volume in ml (range) | | 184 (50 – 500) |
| Average uterus size in g (range) | | 198 (65 – 525) |
| Average size of tumour in mm | | 41.2 |
| Procedure | Patient who had THBSO only | 3 |
| | Patients who had THBS and PLND, with ovaries conserved | 2 |
| | Patient who had THBSO and PLND | 27 |
| | Patients who had radical hysterectomy BSO | 1 |
| | Patient who had conversion to laparotomy | 0 |
| Average number of lymph nodes dissected (range) | | 30 (4–40) |
| Additional surgical procedure | Adhesiolysis | 12 |
| | Omentectomy | 6 |
| Complications | Mini laparotomy for retrieval of bulky uterus (%) | 4 |

One patient readmitted on POD6 due to ileus. She was managed conservatively. Another patient was readmitted for post-site haematoma, which was also managed conservatively. (Table 3).

### 3.4. Survival outcome

We used the Kaplan Meier curve to analyse the survival outcomes of patients. (Graph 1) One patient passed on 1 year and 1 month after her operation after she developed bowel obstruction. She underwent emergency bowel surgery but had a turbulent recovery complicated by sepsis and multi-organ failure. There was also a second patient who passed away 3 years after her surgery due to a recurrence of endometrial cancer. The 30-day mortality rate is 0.

### 3.5. Literature review

We searched PubMed central and Cochrane data bases using keywords of “endometrial cancer”, “endometrial malignancy”, “robotic surgery”, “obesity” and “morbid obesity”. We only included studies written in English and included papers between January 2001 to May 2024. Duplicate studies or studies that did not specify the indicators we were comparing were exclude.

**Table 3**
post-operative outcomes summarized.

| Post-operative outcomes | | |
|---|---|---|
| Post-op monitoring | ICU | 0 |
| | HDU | 33 |
| Average Haemoglobin levels | Pre-operative | 11.1 |
| | Post-operative | 10.9 |
| Final histology stage | 1 A | 20 |
| | 1B | 5 |
| | 2 | 2 |
| | 3 A | 2 |
| | 3B | 1 |
| | 3C1 | 2 |
| | 4B | 1 |
| Post-operative adjuvant therapy | | |
| Chemotherapy only | | 3 |
| Chemotherapy and radiotherapy | | 5 |
| Radiotherapy only | | 1 |
| Vault brachytherapy | | 7 |
| No adjuvant therapy | | 17 |
| Readmissions within 30 days | | |
| On POD 6 due to post-op ileus, managed conservatively | | 1 |
| Port-site haematoma, managed conservatively | | 1 |

The literature search provided us with 408 papers, of which, after our exclusion criteria, 25 articles were read in full. We analysed a total of 6 papers [5,9–13] and compared their findings with our results (Table 4).

## 4. Discussion

### 4.1. Main findings and interpretations

Robotic surgery provides enhanced visualization and flexibility for the surgeon to perform complex surgical manoeuvres, such as intra-pelvic suturing and knot-tying with robotic-arm wrist movements [8]. In our study, all cases were successfully completed with robotic surgery without requiring conversion to laparotomy for completion of surgery. Jones et al. analysed the rate of conversion for robotic surgery to laparotomy over 5 years from 2006 to 2011 and found that 40 of the 459 (8.7 %) analysed surgeries required conversion [14]. Meta-analysis by Wang et al. in 2020 indicate that the rate of conversion is reduced when compared to laparoscopic surgery [15]. Similarly, another study in 2019 by Cusimano et al. also revealed that robotic surgeries had a 6 % conversion rate compared to 31 % for laparoscopic surgeries [7]. While we had a zero-conversion rate in our study, four patients required a mini-laparotomy for the retrieval of bulky uterine specimens.

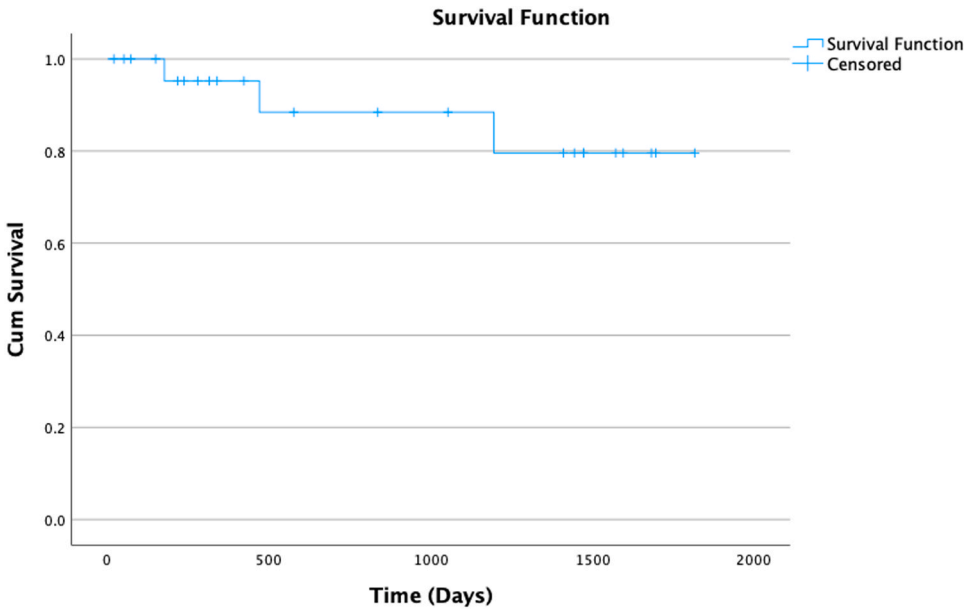
Lymph-node dissection for clearance and staging purposes is required in the surgical management of endometrial cancer. In our study, all patients who were planned for lymph-node dissection, were successfully completed. Pelvic organs are confined in a narrow space surrounded by a bony perimeter and robotic surgery allows for precise articulation of robotic arm intra-corpus and magnified visualization of minute structures such as lymph nodes, allowing for the completion of lymph-node dissection [8]. Wang et al. demonstrated that a greater number of pelvic lymph node dissection was carried out in the robotic surgeries as compared to laparoscopic surgeries [15].

Obesity is associated with cardiovascular and respiratory conditions, which may increase risks associated with general anaesthesia- such as obstructive sleep apnoea [16,17]. Therefore, the duration of the surgery is important. Current literature has been consistent in reporting that the duration of robotic surgery is longer than laparoscopy and laparotomy [8,15,18,19,20]. Nezhat et al. study focused on analysing the time required to assemble and disassemble the robotic unit, which transpired to be 18.9 min and 2.1 min respectively [19]. Our study results are similar to other studies that have evaluated robotic surgery in obese patients. The mean operative time for our study was 232 min, which was comparable to the other studies which matched our patient population for age and BMI.

Our study has demonstrated that robotic surgery in severely obese patients with endometrial cancer is safe and effective. Our studies show that average blood loss was 184mls. A study by Soto et al. compared 77 laparoscopic hysterectomies against 47 robotic hysterectomies and found that estimated blood loss (EBL) for the former was 208 ml and the latter 132 ml [21].

Intra-operative complications are vital in the assessment of surgical safety. Pelvic surgery is challenging due to the confined space which surgeons have to work with. Cusimano et al. conducted a systematic review of 51 studies encompassing more than 10000 obese patients with endometrial malignancy: robotic hysterectomy had a 1.2 % rate of organ or vessel injury while laparoscopic hysterectomy had a 3.5 % complication rate [7]. In our study, we had no intra-operative visceral or vascular injuries.

We analysed post-operative complications and duration of in-hospital stay. 1 patient admitted 6 days after surgery for post-operative ileus which was conservatively managed. The average inpatient stay was 4.6 days (range: 2–8 days). Bernardini et al. evaluated 86 patients and found higher postoperative complication rates and prolonged hospitalisation in patients who underwent laparotomy than those who had robotic surgery [5]. Similarly, Sarlos et al. found that the




**Graph 1. :** Kaplan Meier Curve for analysis of survival of patients.

**Table 4**
Comparison of journals reporting robotic surgery in morbidly obese patients with BMI more than 40 kg/m$^2$ with endometrial cancer, against our findings.

| Journals | Our study | Gitas et al. | Fornalik et al. | Corrado et al. | Bernardini et al. | Shah et al. | King et al. |
|---|---|---|---|---|---|---|---|
| Country | Singapore | Germany | USA | Italy | Canada | USA | USA |
| Year | 2024 | 2022 | 2018 | 2016 | 2012 | 2011 | 2002 |
| Number of patients | 33 | 7 | 76 | 70 | 45 | 43 | 188 |
| Patient demographics | | | | | | | |
| Mean Age (years) | 52.9 | 56.5 | 61 | 60.7 | 61 | 58.2 | 59.9 |
| Mean BMI (kg/m$^2$) | 45.7 | 40 | 47 | 43.6 | 40.3 | 40.5 | 45.5 |
| Most common co-morbidities in morbidly obese patients | | | | | | | |
| Diabetes (%) | 10 (36 %) | Not reported | 46.1 % had 4 or more comorbidities | 75 % had comorbidities | 51 % had 3 or more comorbidities | Not reported | 138 (73 %) |
| Chronic HTN (%) | 19 (58 %) | | | | | | 73 (39 %) |
| Sleep apnoea | 7 (21 %) | | | | | | 26 (13.8 %) |
| Previous surgeries (%) | 24 (73 %) | Not reported | Not reported | 52.9 % | 37.8 % | 67.4 % | 117 (62.2 %) |
| Pre-op radiology stage | | | | | | | |
| 1 A | 24 (73 %) | Not reported | Not reported | 42 (60 %) | 8 (17.8 %) | Not reported | 133(70.7 %) |
| 1B | 4 (12 %) | | Not reported | 12 (17 %) | 16 (35.6 %) | | 14 (7.4 %) |
| 1 C | 0 | | Not reported | 0 | 7 (15.6 %) | | |
| 2 | 3 (9 %) | | Not reported | 8 (11 %) | 3 (6.7 %) | | 13 (6.9 %) |
| 3 or more | 2 (6 %) | | 10.5 % | 8 (11 %) | 10 (22 %) | | 5 (2.7 %) |
| Surgeries performed | | | | | | | |
| THBSO (%) | 9 % | Not reported | 3.9 % | 61.4 % | 40.0 % | 62.1 % | 88.9 % |
| THBSO-PLND (%) | 82 % | | 96.1 % | 38.6 % | 60.0 % | 37.9 % | 11.1 % |
| Conversion to laparotomy (%) | 0 % | | 0 % | 0 % | 0 % | 0 % | 1.06 % |
| Operative outcome | | | | | | | |
| Mean Operative duration (min) | 232 | Not reported | 203 | 164.3 | 270 | 252.6 | 173.3 |
| Mean Estimated Blood Loss (ml) | 184 | Not reported | 150 | 73.2 | 200 | 41.2 | 74.4 |
| Mean uterus weight (g) | 198 | 177 | Not reported | Not reported | Not reported | 176.3 | Not reported |
| Final post-op Histology grade | | | | | | | |
| 1 A | 20 (61 %) | Not reported | Not reported | 19 (27 %) | 27 (60 %) | Not reported | 99 (53 %) |
| 1B | 5 (15 %) | | | | | | |
| 2 | 2 (6 %) | | | 36 (51 %) | 5 (11 %) | | 45 (24 %) |
| 3 or more | 6 (18 %) | | | 15 (21 %) | 5 (11 %) | | 42 (22 %) |
| Post-operative outcomes | | | | | | | |
| Post-operative complications (%) | 6 % (2 cases) | 1 case (BMI not specified) | 15 % (11 cases) | 8.6 % (6 cases) | 17.7 % (8 cases) | 7 % (3 cases) | 5.9 % (11 cases) |
| 5 yr survival | 97 % | Not reported | Not reported (90-day mortality: 0 %) | Not reported | Not reported | Not reported | Not reported |
| Recurrence rate of disease in 3 years | 3 % (1 case) | Not reported | Not reported | 7.14 % | Not reported | Not reported | Not reported |

average inpatient length of stay for robotic surgery varied from 2 to 6 days (average 3.3) while that of the laparoscopic group varied from 2 to 7 days (average 3.9) [18]. Robotic surgery has been demonstrated to have good post-surgical outcomes [11,22,23].

Our study shows that the majority of our patients ambulated on POD1 and had low pain score. This could be due to the fact that robotic surgery is less traumatic to the abdominal wall. The fulcrum of movements of instruments in the traditional laparoscopy surgery tends to be centred at the abdominal wall whereas robotic surgery is gentle on the abdominal wall with all of the instruments' articulation occurring intra-abdominally [8].

### 4.2. Strengths and limitations

While obesity in Asia is not prevalent, we do see an increasing trend. However, we are unsure if all patients in Asia were offered staging surgery due to their comorbidities. Performing staging surgery for patients with morbid obesity needs to be balanced against oncological outcomes and surgical morbidities. We hope our report shows that even with advance medical care requirements, after pre-operative optimization and with customised treatments based on patient profile and stage of endometrial cancer, our patients have better survival rates and quality of life, after undergoing robotic surgery for endometrial cancer.

While our numbers are small, our study is very unique in Asia, given the very limited data on robotic surgery for endometrial cancer in morbidly obese patients in the Asian population and in Singapore. We hope that despite the small number, we could still contribute to the existing data pool to facilitate better analysis in future and encourage other tertiary centres in Asia to offer and optimise robotic surgery for the management of endometrial cancer in women with morbid obesity. We also publish our recurrence rates and 5-years survival rates, which is not frequently mentioned by other studies.

## 5. Conclusion

Robotic surgery is a surgical method for morbidly obese women with endometrial malignancy that has been constantly demonstrated as a safe, reliable and effective. However, continued research and recruitment of patients into this field is needed for purposes of a large-scale meta-analysis.

## Key message

Gynae-oncology surgeons should actively consider robotic surgery as a surgical approach when evaluating morbidly obese women for the purpose of endometrial cancer surgery.

## Ethics Statement

An application was submitted to the Internal Review Board (IRB) of the Singapore General Hospital for the exemption from ethics review. This exemption was granted on the 24th of June 2022 as this study aims to evaluate the effectiveness, safety and perioperative outcomes of robotic surgery in obese patient with endometrial cancer in Singapore, using de-identified data. A copy of this letter of exemption is available on request. CIRB reference number 2022/2045.

## Author contributions

Sabrina Lasini Gruhl was involved in the collection of data and the writing of the manuscript. Muhammad Ashraf Yusoff was involved in the collection and analysis of data. Hui Men Selina Chin was involved in the collection of data and editing of manuscript. Ravichandran Nadarajah was involved as a supervisor to guide the direction of this manuscript and the editing of manuscript.

## List of abbreviations

| | |
|---|---|
| AHI | Apnoea-Hypopnea Index |
| BMI | Body Mass Index |
| CT scan | Computed tomography scan |
| MIS | Minimally-invasive surgeries |
| MRI | Magnetic resonance imaging |
| THBSO-PLND | total hysterectomy, bilateral salphingo-oophorectomy and pelvic lymph node dissection |

## CRediT authorship contribution statement

**Ravichandran Nadarajah:** Writing – review & editing, Data curation, Conceptualization. **Sabrina Lasini Gruhl:** Writing – review & editing, Writing – original draft. **Muhammad Ashraf Yusoff:** Formal analysis, Data curation. **Hui Men Selina Chin:** Writing – review & editing, Data curation.

## Declaration of Competing Interest

The authors of this paper contributed in equal portions to this manuscript and declare no conflicts of interest. This study does not involve a clinical trial. We have received no funding support for this paper.

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