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The "Medical Cost" of Robot-Assisted Laparoscopic Surgery in Endometrial Cancer in Terms of Anesthesia Comparison with Traditional Laparoscopic Surgery

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Abstract: Minimally invasive surgeries have important advantages such as lower morbidity, shorter hospital stay and earlier return to routine life. In this study, we investigated the results of Robot-assisted laparoscopic surgery (RALS) and conventional laparoscopic surgery (TLS) in terms of anesthesia management and postoperative process in patients with endometrial cancer. Patients over 18 years of age with an American Society of Anesthesiologists (ASA) score II-III who were operated for endometrial cancer with TLS or RALS between January 2020 and March 2022 were included. Patients' age, ASA scores, duration of surgery and anesthesia, peroperative fluid management, urine output, bleeding, postoperative Visual Analogue Scale (VAS) scores, post-anesthesia care unit (PACU) hospitalizations and hospital stay were obtained from the standard anesthesia record form. A total of 75 patients, 44 patients in the RALS group and 31 patients in the TLS group, were included in the study. Peroperative intravenous fluid volume RALS average 1500 ml, TLS average 2450 ml ($p<0.0070$), bleeding amount RALS 80 ml and TLS average 350 ml ($p< 0.0001$), RALS group was statistically lower than TLS group. The mean hospital stay was shorter in the RALS group compared to the TLS group ($p<0.0070$). Our result support that RALS decreases the medical cost of surgical treatment of endometrial cancer patient, providing lower peroperative intravenous fluid, bleeding and urine output volumes and shorter mean hospital stay in RALS group. ©2023 NTMS.

Keywords: Anesthesia; Cancer of Endometrium; Laparoscopic Surgery; Postoperative Pain; Robotic-Assisted Surgery.

1. Introduction

Endometrial cancer, which is the most common gynecological malignancy, is the fourth most common cancer in women [1]. The standard treatment procedure is bilateral salpingo-oophorectomy and total hysterectomy [2]. The surgical approach to endometrial cancer has changed over the years. While open abdominal surgery used to performed in endometrial cancer treatment, currently TLS and RALS, as minimally invasive alternatives, are the choice of surgical treatment. Minimally invasive techniques are recommended instead of laparotomy in tumors confined to the uterus (Grade 1A) [3], which have important advantages such as lower morbidity, a shorter hospital stay and earlier return to routine life. TLS has been used in gynecologic oncology for a long time and there are a lot of reported experiences in the literature, but, nowadays RALS plays a leading role in the development of minimally invasive surgery because

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it provides better surgical comfort, higher-quality imaging, and more technical advantages. The most common uses of RALS are gynecological and urological surgeries [4]. Besides its advantages, the cost-effectiveness of RALS is controversial [5]. Although many publications compare RALS and TLS, current literature lacks a "medical cost" perspective regarding RALS and TLS in endometrial cancer. In this clinical study, to investigate "medical cost" of both procedures as we compared the results of anesthesia-related processes such as peroperative fluid management, transfusion requirement, analgesic strategies, postoperative complications, PACU admission ratio and hospital stay in endometrial cancer patients who operated with RALS and TLS.

2. Material and Methods

This retrospective observational study was conducted by the University of Health Sciences Bakırköy Dr Sadi Konuk Hospital and was approved by the Clinical Research Ethics Committee (Proctocol No: 2023/34). Between January 2020 and March 2022, patients over 18 years of age with an ASA score of II-III who were operated on by the TLS or RALS method for endometrial cancer in the Gynecological Oncology Clinic were included in the study. Patients with ASA IV, missing data, or who switched to open surgery were excluded. The patients age, ASA score, duration of surgery and anesthesia, peroperative fluid management, urine output, bleeding, postoperative Visual Analogue Scale (VAS) scores, and PACU application were obtained from the standard anesthesia record form, and the remaining data on preoperative and postoperative hemoglobin (Hb) values, length of hospital stay, and patients with advanced lymph node excision were obtained from the hospital's electronic database (Probel, İzmir, Turkey).

2.1. Anesthesia Management

Before the operation, patients fasted for at least 6 hours according to the anesthesia protocol of our clinic. Standard monitoring (blood pressure, electrocardiography, oxygen saturation and capnography) was applied to all patients before the surgical procedure. For continuous intra-arterial blood pressure monitoring, a catheter was placed in the radial artery using the Seldinger method after the Allen test. In both techniques, the patient's arms were fixed by closing them to the sides, and no venous intervention could be performed after positioning. For this reason, intravenous (iv) vascular access (18,16 G) was opened before the position and accesses were provided with extension lines. Intravenous crystalloid fluid infusion of 3-5 ml/kg/hr was started in the operating room and 250 crystalloid bolus infusions were initiated if mean arterial pressure decreased (<60 mm-Hg) and heart rate increased (>90/min) during surgery. Patients were given midazolam (1.5 mg) for premedication, paracetamol (1 g)+tramadol (100 mg) for preventive analgesia. For anesthesia induction, 1-2 mg/kg of propofol, 2 µg/kg of fentanyl, and 0.6 mg/kg of rocuronium were given. Sevoflurane (Minimum alveolar concentration 0.5-1) and remifentanil (0.05-0.5 µg/kg/min) were used for anesthesia maintenance. For mechanical ventilation, pressure regulated volume control (PRVC) mode was selected and 6-8 ml/kg tidal volume, 3-7 cm/H_2O Positive end-expiratory pressure (PEEP), fresh gas flow 1-4 lt/min, I: E=½, frequency 12-16 /min (End-tidal CO_2 between 35-45 mmHg) was set. Paracetamol (1 g)+tramadol (100 mg) was repeated for postoperative analgesia and 3-5 mg of morphine was given. Patients with intraoperative massive blood transfusion, unstable hemodynamics, vasoactive/inotropic drug administration, and respiratory distress were referred to the PACU, and patients with a modified Aldrete sedation score >9 after follow-up in the recovery room were referred to the service.

2.2. Surgical Procedure

The patients, who underwent detailed preoperative examination and imaging, were operated on by the same surgical team after the board's decision. The traditional two-dimensional laparoscopic surgical system (Richard WOLF, Knittlingen, Germany) was used for TLS and da Vinci Si (Intuitive Surgical, Sunnyvale, California, USA) system was used for RALS. In TLS, while the camera was placed from the navel, both lateral ports were placed 3 cm medial to the anterior superior spina iliaca. In RALS, the ports are placed in a single plane around the hub. First, a hysterectomy and bilateral oophorectomy were performed. Advanced pelvic and paraaortic lymph node dissection was decided by the surgical team, according to the intraoperative frozen pathology results.

2.3. Statistical Analysis

GraphPad $V_{5.0}$ (San Diego, California, USA) program was used. Homogeneity was evaluated with the Shapiro-Wilk test. Since the data of the study were not homogeneous, the two groups were compared with the Mann-Whitney U test. Categorical variables (number of patients admitted to PACU or undergoing advanced lymphatic dissection) were compared with the Chi-square test. Median and interquartile range (Q_{25-75}), numbers and percentages were used in statistical representation. $p<0.05$ was considered statistically significant. The length of hospital stay was determined as the primary outcome of the study. The median hospital stay (IQR) values of the laparoscopic and robotic groups were calculated as 7±4 and 4±4 days, respectively. According to these values, the power of the study was calculated at 80% (Gpower 3.1, Düsseldorf, Germany).

3. Results

A total of 75 patient data sets, 44 RALS and 31 TLS groups, were analyzed. The mean age of the patients in the RALS group was 59 years, 58 years in the TLS

group, and the mean ASA score was II in both groups. There was no statistical difference between groups regarding patient ages and ASA scores (p=0.7920, p=0.4140 respectivelly) (Table 1).

The mean preoperative hemoglobin level was 12.9 g/dL in RALS group and 12.4 g/dL in the TLS group. The mean operative time was 250 minutes in RALS group and 300 minutes in TLS group. The number of patients who underwent advanced lymph node dissection was 21 (47.7%) in RALS group and 9 (29.0%) in TLS group. The number of patients admitted to PACU was 8 (18.2%) in the RALS group and 6 (19.4%) in TLS group. The postoperative mean VAS score was 4 (3 - 4) in both groups. There were no statistical significant differences between the groups regarding the above mentioned parameters, preoperative Hb level, operative time, total anesthesia time, number of PACU admissions, and postoperative VAS scores (p=0.0820, p=0.6508, p=0.1651, p=0.8630, p=0.6283, p=0.6283, respectively) (Table 2).

Statistical analysis of peroperative intravenous fluid volume, bleeding volume and urine output volume, mean postoperative hemoglobin levels, mean hospital stay and mean postoperative Hb levels revealed significant differences between the groups. The mean peroperative crystalloid fluid volume was found to be significantly lower in RALS group than in TLS group (1500 ml and 2450 ml respectively, p<0.0001). The mean peroperative bleeding volume was also lower in RALS group than TLS group (80 ml and 350ml ml, respectively, p<0.0001). The mean volume of peroperative diuresis was 120 ml in RALS group and 200 ml in TLS group (p<0.0001). The mean hospital stay was 4.0 days for RALS groups and 7.0 days for TLS group (p:0.0070). The mean postoperative hemoglobin level was 11.3 g/dL in RALS and 10.5 g/dL in TLS (p:0.0019). Study findings of both groups are listed in Table 2. The median (Q_{25-75}), number of patients, percentages, and p values are shown in Tables 1 and 2.

Table 1: Demographic data of patients in both groups.

	Group TLS (n=31)	**Group RALS (n=44)**	**p Value**
	Median (Q_{25-75})	Median (Q_{25-75})	
AGE (year)	58 (47-68)	59 (50-66)	0.7920
ASA score	2 (2-3)	2 (2-3)	0.4140

TLS: Traditional Laparoscopic Surgery, RALS: Robot-Assisted Laparoscopic Surgery.

Table 2: Perioperative data of patients in both groups.

	Group TLS (n=31)	**Group RALS (n=44)**	**p Value**
	Median (Q_{25-75})	Median (Q_{25-75})	
Operation Time (min.)	300 (180-300)	250 (190-335)	0.6508
Anesthesia time (min)	310 (195-328)	290 (240-350)	0.3747
Length of stay in hospital (days)	7.0 (4.0-10.0)	4.0 (3.0-5.0)	0.0070
Peroperative crystalloid fluid (ml)	2450 (1650-2900)	1500 (1200-2000)	<0.0001
Peroperative bleeding (ml)	350 (200-500)	80 (50-100)	<0.0001
Peroperative diuresis (ml)	200 (150-320)	120 (100-150)	<0.0001
Preoperative Hemoglobin, gr/dL	12.4 (11.4-13.3)	12.9 (12.0-13.6)	0.0820
Postoperative hemoglobin, gr/dL	10.5 (9.9-11.2)	11.3 (10.8-12.0)	0.0019
PACU patient (%)	6 (19.4%)	8 (18.2%)	0.8630
Number of patients who underwent advanced lymph node dissection (%)	9 (29.0%)	21 (47.7%)	0.1651

TLS: Traditional Laparoscopic Surgery, RALS: Robot-Assisted Laparoscopic Surgery

The approximate instrument cost for a standard endometrial cancer case for RALS is around 25.113TL which includes 81.313TL/18 usage prograps forceps (4517 TL), 72.344 TL/15 usage large needle (4822 TL), 88.626/14 usage Maryland bipolar (6330 TL), Seal canula 472 TLx4 (1888 TL), blades obturator 655 TL, aim drape 1.364 x 4 (5456 TL), clinch 357 TL, grasper 431 TL, scissors 357 TL, dressing, 300 TL.

The approximate instrument cost for a standard endometrial cancer case for TLS is around 13.575 TL which includes 10 mm trocar 223 TLx1.5 mm trocar 223x3 TL (669 TL), veres needle 54 TL, camera cover (50 TL), and a laparoscopic ligasure 5mm-37cm. 9000 TL, grasper 431 TLx2 (862 TL), laparoscopic dissector 357 TL, scissors 357 TL, laparoscopic clinch 357 TL, Aspiration 168 TL, endoclip 10mm 582 TL, endoclip 5mm 819 TL, and dressing 300 TL.

4. Discussion

In this retrospective clinical study, anesthesia related clinical results of RALS and TLS in endometrial cancer patients. Our results revealed that RALS group has shorter operative time, a lower peroperative fluid requirement, a lower peroperative bleeding volume, a higher postoperative hemoglobin level, and a shorter hospital stay than the TLS group.

Laparoscopic surgery is the beginning of minimally invasive surgery and together with technological developments, RALS has become the choice of surgical treatment in many medical disciplines. Better 3D vision, a wider working area, better mobility and ergonomics for the surgeon, and not reflecting movements such as the surgeon's hand tremor to the patient could be listed as thecnological superiority and advantages of RALS over TLS. On the other hands, RALS has some disadvantages. It needs additional surgical training process. Possible longer operating room occupation and expensive robotic instruments may be costly than standart open surgery or laparoscopic surgery. However, it is necessary to think multidimensionally while making cost calculations. The comparison of these two methods should not only be about the surgical aspect and expenses, but the medical and social aspect. That is why our study focused on "medical cost of the procedures" in which we compared the results of anesthetisa aspects of RALS and TLS in endometrial cancer. Because endometrial cancer is one of the most common disease that both robotic and standart laparoscopic techniques are used for surgical teratment, these groups of patients were chosen as in our study.

We have studied a total of 75 patients' data, 44 patients were in the RALS group and 31 patients were in the TLS group. When we analyzed our results, we found important differences between both groups, and these differences may affect the "medical cost" of the procedures. One of our results is that the RALS group had significantly shorter hospital stays. This is a prominent component in cost calculations. Aside from hospital charges, a prolonged hospital stay increases the risk of nosocomial infections and reduces quality of life. Another discussion about the cost of the surgical procedure is the occupation time of the operating room. Preparing the patient and docking the robotic system often increases the overall operation time and operating room occupation. In our study, we could not find a statistical difference between the groups in terms of both the duration of surgery (mean 300 min vs 250 min. in TLS and RALS, respectively, p=0.6508) and total anesthesia time (mean 310 min vs 290 min in TLS and RALS respectively, p=0.3747). While it was not statistically significant, the shorter mean operative time in RALS is clinically important because we believe that a shorter operative time may reduce the complication rates and decrease the medical cost of the surgery.

In addition, RALS can be preferred in terms of patient satisfaction and comfort. In a study comparing robotic surgery and open surgery in terms of perioperative drug use and cost in endometrial cancer surgery by Agarwal et al. it has been shown that less replacement fluid is used in the RALS group, the duration of hospital stay is shortened, and the cost is accordingly lower [6]. Another important result of our study is that perioperative blood loss and the need for crystalloid fluid, blood, or blood product replacement were less in the RALS group. The studies comparing open surgery, TLS, and RALS in literature usually report less intraoperative blood loss, a shorter hospital stay, and a longer operation time in robotic surgery [6-8]. Chuan et al. attributed less blood loss during RALS to better stability of robotic instruments, which reduces hand tremor and potential damage, better 3D vision, and a larger visual field that facilitates detection of vascular and vital structures during surgery [9].

In a recent systematic review involving robot-assisted laparoscopic surgery versus conventional laparoscopic surgery in randomized controlled trials, it was concluded that despite its higher cost, RALS did not result in statistically improved treatment outcomes, except for lower blood loss. [10].

Our results showed a shorter Median (Q_{25-75}) operative time in the RALS group than TLS (250 vs 300 minutes respectively). Similar to our results, in a randomized study (n=99) for the staging of endometrial cancers, the operative time was found to be 139 minutes (86-197 minutes) in the RALS group and 170 minutes in the TLS group (126-259 min.) [11]. This result of our study is consistent with studies that found that RALS has a shorter operation time than TLS in endometrial cancer surgery [12, 13]. Anesthesia preparation time is excluded from this evaluation. In our study, we have compared both surgical time and total anesthesia time which includes preparation time as well. Unlike TLS, preparation time is longer in RALS because of need for special patient positioning, docking, and after docking, positional manupilations cannot be done during RALS. The deep Trendelenburg position given to the patient may cause difficulty in ventilation, increased intracranial pressure, edema formation around the conjunctiva, nasopharynx, and larynx, subcutaneous emphysema, and peripheral nerve injuries in both the lower and upper extremities. There was no difference between the anesthesia management performed with awareness of these risks and the number of patients referred to PACU in both groups. The total time (preparation and operation time) in robotic surgery may

be longer due to the initial insertion and final removal of the robot arms.

In a meta-analysis study covering the years 2000-2016, in line with our results, it was concluded that robotic surgery has advantages such as less blood loss, less need for transfusion and less hospital stay in 739 robotic and 815 laparoscopic endometrial cancer surgeries [14].

However, they shared in the same meta-analysis that the cost was too expensive to limit clinical application. One of our limitations is that we did not collect detailed data on financial calculations for each patient, but the approximate instrument cost of a standard case is more expensive for RALS than TLS (25,113 TL and 13,575 TL, respectively). In general, we would like to emphasize the risks of complications that may occur with antibiotic use, blood and blood product use, IV fluids, opioids, nonopoidal analgesics, antiemetics, and drug use, rather than making price comparisons on the basis of materials used. The protracted hospitalization and hospital stay should not be ignored.

Staging of endometrial carcinomas is performed surgically [15,16]. Pelvic and paraaortic lymph node evaluation is the main component of the surgical staging procedure for many gynecological malignancies, including endometrial and ovarian carcinoma [17,18]. The approach to lymph node evaluation is controversial, with options such as pelvic-aortic lymph node dissection and sentinel lymph node biopsy. In a study conducted by Japanese researchers, the life expectancy of patients who underwent pelvic and periaortic lymphadenectomy was longer than that of patients who underwent only pelvic lymphadenectomy [19]. In TLS and RALS approaches, the ports are different [20, 21]. In RALS, access to the paraaortic lymph nodes is easier, as the ports are usually located above the navel. In our study, lymph node dissection was performed on 48% and 29% of the patients in the RALS and TLS groups, respectively. However, this difference is not statistically significant. We attributed this result to the fact that the same team performed the surgery.

Postoperative pain is one of the reasons for preferring the surgical method. Reduction of pain facilitates postoperative mobilization, reduces atelectasis, and increases patient comfort. Since minimally invasive procedures were performed in both groups in our study, there was no difference between the groups in terms of postoperative VAS scores. Other publications in the literature also support that there is no difference between the two methods for postoperative pain and antiemetic use [21, 22].

Limitations of our study; retrospective evaluation of our patients, lack of detailed demographic data (BMI, additional features), absence of intraoperative hemodynamic data, blood gas and laboratory data, inability to re-measure postoperative VAS scores in different periods, lack of data such as material prices, cost of patients to the hospital in terms of cost evaluation.

5. Conclusion

In this retrospective study, we compared the results of both surgical techniques, and our results support the conclusion that RALS decreases the medical cost of surgical treatment for endometrial cancer patients by providing lower peroperative intravenous fluid, bleeding, and urine output volumes, higher postoperative mean hemoglobin values, and shorter mean hospital stay in RALS group. However, larger series and multicenter studies are needed.

Limitations of the Study

Retrospective evaluation of our patients, lack of detailed demographic data (BMI, additional features), absence of intraoperative hemodynamic data, blood gas and laboratory data, inability to re-measure postoperative VAS scores in different periods, lack of data such as material prices, cost of patients to hospital in terms of cost evaluation.

Future Insight

We believe that larger-scale prospective randomized studies will contribute more clearly to science on this subject.

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Conflict of Interests

There is no conflict of interest between the authors in this study.

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Author Contributions

Both authors mentioned in the study contributed to data collection, study planning, methodology and article writing.

Ethical Approval

Proctocol No: 2023/34 Date:09/01/2023.

Informed Consent

Informed consent forms were obtained from all patients.

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