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A Cost-Effectiveness Analysis of Laparotomy, Laparoscopic and Robotic Surgery in Endometrial Cancer

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ABSTRACT

Introduction: In Thailand, minimally invasive surgery for endometrial cancer has increased popularity over the years due to reduced pain, shorter hospital stay, and rapid recovery time without any effects on oncologic outcomes. However, the cost-effectiveness of this approach still remains unknown. We purposefully determine the cost-effectiveness of laparotomy, laparoscopic and robotic surgery in endometrial cancer patients.

Methods: An economic analysis based on our previously published retrospective study and cross-sectional study was conducted to compare total costs of three surgical approaches and health outcomes from both health care provider and patient perspective. Costing data were collected from clinical practice in King Chulalongkorn Memorial Hospital. Health outcomes were quantified in terms of complication-free rate, derived from published data and Quality of Life (QOL) assessed by a Thai version of the FACT-G questionnaire at 4 weeks after surgery. Incremental Cost-Effectiveness Ratios (ICERs) were used to compare costs per complication-free patient gained and costs per Quality-Adjusted Life Years (QALYs) gained. One-way and two-way sensitivity analyses were undertaken.

Results: Minimal invasive surgery was more costly compared to laparotomy but the utility of laparoscopy was more favorable. The mean utilities of robotic surgery, laparoscopic surgery and laparotomy were 0.90, 0.96, and 0.78, respectively. The incremental cost per QALYs gained ratio (ICER) of laparoscopic surgery compared with laparotomy was 1,444 Thai baht (43.2USD)/QALY in patient expense and 28,488 Thai baht (852.9USD)/QALY in health care medical cost. ICER of robotic surgery compared with laparotomy was 141,033 Thai baht (4,222.5USD)/QALY in patient expense and 268,578 Thai baht (8,041.3USD) /QALY in health care medical cost.

Conclusions: In Thailand, laparoscopic surgery in endometrial cancer was the most favorable and cost-effective surgical approach, whereas robotic surgery was the least cost-effective.

Keywords: Cost-effectiveness; Endometrial cancer; Laparotomy; Laparoscopy; Robotic surgery

INTRODUCTION

Endometrial cancer is the most common malignancy of the female genital tract in developed countries, and the third most common gynecologic cancer in Thai women after cervical and ovarian cancer [1]. The cornerstone of treatment for endometrial cancer is hysterectomy and bilateral salpingo-oophorectomy with pelvic and/or paraaortic lymphadenectomy if indicated. The surgery is traditionally performed via laparotomy, but minimally invasive approaches such as laparoscopic and robotic-assisted laparoscopic surgery are promising due to their better surgical outcomes, shorter hospital stay, and quicker resumption of normal daily activities without any effects on oncologic outcomes [2,3].

A recent review in Thailand suggested that Minimally Invasive Surgery (MIS) had more favorable outcomes than conventional laparotomy with similar short-term oncologic outcomes in endometrial cancer patients [4]. A Gynecologic Oncology Group prospective study demonstrated a better Quality of Life (QOL) at 6 weeks after surgery using laparoscopy compared to laparotomy [5]. Since approval was granted in 2005 for robotic surgery, its use has grown exponentially due to the shorter learning curves required than for conventional laparoscopy. The Society of Gynecologic Oncology's Clinical Practice Robotic Task Force stated in 2012 that robotic surgery showed advantages over laparoscopy in managing obese patients with endometrial cancers [6]. However, MIS was assumed to be more costly due to longer duration of surgery and expensive surgical disposable equipment. In contrast, the benefits of shorter hospital stay after MIS may compensate for the procedure-related costs. Leitao compared the direct costs of 3 surgical approaches in 436 women and reported the laparoscopic approach as the least expensive with laparotomy the most expensive [7]. However, cost-effectiveness might be different among dissimilar countries based on disparities between their national health policies and reimbursement mechanisms. Therefore, it is important to understand how the cost discrepancies between these three surgical approaches relate to outcomes in Thailand.

The aim of our study was to determine the cost-effectiveness of laparotomy, laparoscopic and robotic surgery in endometrial cancer patients that is fundamental for policy maker, payers and healthcare providers.

MATERIALS AND METHODS

Study design

An economic evaluation was conducted based on our previously published retrospective study and cross-sectional study from August 2016 to May 2017 in the tertiary care center at King Chulalongkorn Memorial Hospital, Bangkok, Thailand. This study was approved by the Institutional Review Board, Faculty of Medicine, Chulalongkorn University. The patients were classified into three groups of Robotic Surgery (RS), Laparoscopic Surgery (LS), and Laparotomy (LT). Cost-Effectiveness Analysis (CEA) was conducted from both health care provider and patient perspectives to evaluate the balance between costs and health outcomes. The CEA depicted the additional cost per a complication-free patient that required investment for the three different surgical approaches. In addition, a Cost-Utility Analysis (CUA) was conducted to evaluate the additional cost per utility gained. The CEA results were represented by Incremental Cost-Effectiveness Ratios (ICERs).

$$ICER = (C1-C2)/ (E1-E2)$$

Where, C1-C2 represents the incremental cost as the additional cost of procedure1 compared with procedure 2, and E1-E2 represents the incremental effect as the additional effect of procedure 1 compared with procedure 2.

Assessment of cost

All costs were calculated in Thai Baht (THB) and based on 2016 Thailand currency valuation. The estimated useful lives of robotic-assisted and standard laparoscopic machines were 10 and 5 years, respectively. The equivalent annual cost of machine was calculated using 3% discount rate without resale value. Operative cost, anesthetic cost, labor fee and hospital stay were included in the direct medical cost of each procedure.

For patient costs, the actual total expenses of admission and operation were used. Traveling expense and patients' caregiver

expenses were collected from participants in the QOL survey. Patient income loss for the three groups was calculated from the Thai minimum wage per day of 310 Thai baht and recovery time (days).

Assessment of effect (health outcomes)

Complication-free rate: Data for complication-free rate were derived from a previous retrospective study of endometrial cancer patients in King Chulalongkorn Memorial Hospital [4].

Quality of life (QOL): A Thai version of the Functional Assessment of Cancer Therapy-General (FACT-G) version 4 questionnaire was used to assess the QOL at 4 weeks after surgery [8]. The questionnaire comprised 27 items under four domains of Physical (PWB), Emotional (EWB), Social (SWB) and Functional Well-Being (FWB). The range of possible scores was 0-108, with higher scores indicating a better QOL. The FACT-G scores were calculated to the EQ-5D utility index according to the equation 0.238 + 0.014*PWB + 0.006*EWB + 0.008*FWB [9]. A utility of 1.00 indicates perfect health while a utility of 0.00 indicates death. All participants gave written, informed consent before they responded to the FACT-G questionnaires.

Study population in quality of life survey: Endometrial cancer patients aged more than 25 years who underwent primary surgery at our hospital from August 2016 to May 2017 were included in questionnaire of quality of life. Patients with histological confirmation of uterine sarcoma, synchronous endometrial and ovarian cancer and primary radiotherapy were excluded.

The sample size was calculated by determining the standard deviation of 14 from the result of a previous study [10] with an acceptable error(d) of 10, and α of 0.01 using the formula for estimating an infinite population mean which yielded a number of 14 cases at least per a surgical approach group. All participants were provided written informed consent before participation in post-operative period.

Sensitivity analysis

A one-way sensitivity analysis was conducted using a number of procedures per year as a variable to demonstrate the changes in ICER for robotic surgery compared with laparotomy in health care medical cost.

A two-way sensitivity analysis was conducted using the number of procedures per year and the percentage reduction in the purchase price of the robot as variables to demonstrate the changes in ICER.

Statistical analysis

Descriptive data were reported as mean, standard deviation, median and range, number of patients and percentage. Chi-square or Fisher's Exact test was used to compare categorical data, and the independent t-test was used to test the mean differences between two groups. The Kruskal-Wallis test was used to deal with data that had non-normal distributions, with *p* values of less than 0.05 considered as statistically significant. Analyses were conducted using Microsoft® Excel® for Mac (2011) and SPSS for Mac version 22 (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 58 endometrial cancer patients (18 RS, 18 LS, and 22 LT) were recruited to evaluate the QOL questionnaires and patient expense. Baseline characteristics of all participants are shown in table 1. The median age in the RS, LS, and LT groups was 51.5, 57.0, and 60.5 years, respectively. Most participants were in FIGO stage I. FACT-G scores were calculated to EQ-5D utility index. The mean ± standard deviation utility values of the three groups were 0.9 ± 0.09, 0.96 ± 0.06, and 0.78 ± 0.08 as shown in table 2. Differences of mean utilities between LS and RS (p = 0.018, 95% CI 0.012-0.114), LS and LT (p = 0, 95% CI 0.128-0.221), and RS and LT (p = 0, 95% CI 0.057-0.167) were statistically significant. According to our recent report, the intraoperative complication-free rates were 92.8%, 89.3%, and

Table 1: Baseline characteristics of patients (N (%)).

	Robotic Surgery	Laparoscopic surgery	Laparotomy	
	N = 18	N = 18	N = 23	*p* value
Median age(range) years	51.5(36-73)	57(31-67)	60.5(35-82)	.07*
Median BW(range)kg	60.5(46-111)	63.95(50-106)	63.65(33-105)	.86*
Median height(range) cm	158(140-166)	158(150-168)	158(140-167)	.62*
Median BMI(range) kg/m2	23.56(18.9-43.4)	24.88(19.1-41.4)	26.59(16.8-38.56)	.85*
FIGO Staging				.11*
stage IA	11(61.1)	13(72.2)	9(40.9)	
stage IB	2(11.1)	3(16.7)	7(31.8)	
stage II	3(16.7)	0(0)	0(0)	
stage IIIA	1(5.6)	1(5.6)	1(4.5)	
stage IIIB	1(5.6)	0(0)	1(4.5)	
stage IIIC	0(0)	1(5.6)	4(18.2)	
Histological subtype				.11[a]
well-diff endometriod	13(72.2)	9(50)	13(59.1)	
mod-diff endometrioid	3(16.7)	3(16.7)	8(36.4)	
poorly-diff endometrioid	2(11.1)	5(27.8)	0(0)	
UPSC	0(0)	0(0)	1(4.5)	
MMMT	0(0)	1(5.6)	0(0)	
Parity				.99[a]
nulliparous	7(38.9)	7(38.9)	9(40.9)	
multiparous	11(61.1)	11(61.1)	13(56.5)	
Menopause	8(44.4)	11(61.1)	17(77.3)	.10[a]
Hormonal use	0(0)	3(16.7)	1(4.5)	.12[a]
Education				.50[a]
primary school	3(16.7)	2(11.1)	8(36.4)	
high school	1(5.6)	1(5.6)	0(0)	
bachelor's degree and higher	12(66.7)	13(72.2)	13(59.1)	
vocational certificate	2(11.1)	2(11.1)	1(4.5)	
Occupation				.80[a]
none	5(27.8)	7(38.9)	9(40.9)	
employee	11(61.1)	9(50)	9(40.9)	
business	2(11.1)	2(11.1)	3(13.6)	
other	0(0)	0(0)	1(4.5)	

*Kruskal-Wallis test, a Chi-square or Fisher's exact test, *p* value < .05
All continuous data were shown in median (interquartile range).

87.4%, whereas postoperative complication-free rates were 82.1%, 85.1%, and 86.7% in RS, LS, and LT groups, respectively. Median hospital stay was 3, 3, and 4 days and recovery times were 14, 17.5, and 28 days in RS, LS, and LT groups, respectively [4]. The average number of laparoscopic surgical staging procedures in our hospital was 20 per year. Health care medical cost of robotic surgery was more expensive than standard laparoscopic surgery and laparotomy (Table 2). Total patient expense of RS was highest, whereas total expenses per patient were comparable between LS and LT (59,260 THB for LS and 56,660 THB for LT) (Table 2). Incremental costs, incremental effects, and incremental cost-effectiveness ratios (ICERs) are shown in table 3. The incremental cost (RS-LS) was 271,015 THB in health care medical cost and 166,640 THB in patient expense. The incremental effect (RS-LS) was 3.5% in intraoperative complication-free rate. Cost-utility analysis was performed to present the worthiness of the procedures. As a result, the utility gained by comparing LS with LT was 0.18, whereas the mean utility of RS (0.9) was inferior to the mean utility of LS (0.96). The incremental cost per QALYs gained (ICER) of LS compared with LT was 1,444 THB/QALY in patient expense and 28,488 THB/QALY in health care medical cost. The ICER of RS compared with LT was 141,033 THB/QALY in patient expense and 268,578 THB/QALY in health care medical cost.

One-way sensitivity analysis revealed that the ICER of RS compared with LT in health care cost decreased with increasing procedures performed per year. The ICER was 216,318 THB/QALY with 80 cases per year and 206,640 THB/QALY with 100 cases per year (Figure 1).

We also conducted a two-way sensitivity analysis and found that reduction in the purchase price of the robot, combined with an increasing number of procedures per year resulted in decreasing the ICER (Figure 2). The ICER was 221,957 THB/QALY with a 10% reduction in the robot's price combined with 60 operative cases per year and 192,262 THB/QALY with a 30% reduction in the robot's price combined with 100 operative cases per year.

Table 2: Cost and utilities of three approaches.

	Robotic surgery	Laparoscopic surgery	Laparotomy
Cost(USD)			
Health care medical cost / case			
Operative procedure	10,219	2,104	374
Hospital stay	586	586	782
total cost	10,805	2,690	1,156
Patient cost/case			
Direct medical expense	6,553	1,547	1,372
Travelling expense	43	28	34
Caregiver expense	38	37	30
Patient income loss	130	162	260
total expense	6,764	1,774	1,696
Mean Utility(SD), EQ-5D	0.90(0.09)	0.96(0.06)	0.78(0.08)
QALYs (years)	9.00	9.60	7.80
QALYs, Quality-adjusted life years QALYs = life year x utility Life year, post-surgery survival rate of 10 years		(1 USD = 33.4 Thai baht)	

DISCUSSION

Although Minimally Invasive Surgery (MIS) for endometrial cancer has a higher cost procedure, it is associated with better surgical outcome, shorter hospital stays, quicker resumption of normal daily activities, and better QOL. Patricia M et al compared the costs and clinical outcomes of conventional laparoscopy versus robotic-assisted laparoscopy in 312 gynecologic cancer patients [11]. They found that costs were higher in robotics and concluded that the robot would be more cost-effective with a large number of cases. In a retrospective review of 110 patients, Bell et al conducted a cost comparison in robotics, laparoscopy, and laparotomy in endometrial cancer. They demonstrated that cost was highest in the laparotomy group with comparable surgical outcome [12]. However, the difference in cost-effectiveness between MIS and conventional laparotomy is based on the differences in national health policies and reimbursement procedures. Our study evaluated cost-effectiveness and cost-utility between MIS and conventional laparotomy. Results presented a large difference in health care cost and a small difference in improvement of QOL between robotic surgery and conventional laparotomy. Health care cost in Thailand differs from developed countries with lower labor costs and hospital stay expenses. With a lower incidence of endometrial cancer, the average number of staging procedures each year in Thailand is lower than in developed countries [13]. We found comparable patient expense and favorable gain in utility for laparoscopic surgery compared to laparotomy. In a randomized trial, Bijen concluded that laparoscopic staging surgery was preferable over conventional laparotomy techniques based on major complication-free rates as the measure of effect but there was no gain in utility [14]. In contrast, our study found a small improvement in intraoperative complication-free rates, with no significant difference in postoperative complication-free rates for robotic and laparoscopic surgery compared with conventional laparotomy, whereas we recorded a significant improvement in QOL. This result was similar to previous studies, which showed better QOL after laparoscopic surgery for stage I endometrial cancer when compared with laparotomy [5,10]. According to a Thai Willingness to Pay (WTP) per QALYs gained threshold of 325,000 THB, [15] the ICER for LS compared with LT in health care cost from our study was 77,786 THB/QALY which did not exceed the threshold. In contrast, our study demonstrated that robotic surgery was more expensive but its utility was less than laparoscopic surgery. We found that the ICER of 268,578 THB/QALY for RS compared with LT also did not exceed the threshold of Thai WTP but was higher than the ICER for LS compared with LT. Therefore, we concluded that laparoscopic surgery was the most cost-effective in our institute and we suggest the adoption of laparoscopic surgery for the treatment of endometrial cancer is a good decision for healthcare policy makers in Thailand.

Previous studies suggested various factors that affected decreasing the cost of robotics [10,16-18]. From our sensitivity analysis, increasing the procedures performed per year and reduction of the price of the robot decreased the ICER for RT compared with LT.

We suggest that higher numbers of procedures performed each year and reduction in the purchase price of the robot will increase the cost-effectiveness of robotic surgery and the further study of break-even point may be useful. However, robotic surgery is a new revolutionary technology; it is worthwhile from the medical learning aspect and evolution. Limitations in our study included a tertiary government hospital-based in nature, not a randomized control trial, a short-term health effect, and a small number of participants

Table 3: Incremental cost and ICER.

	Incremental cost (IC) (USD)	IIE1 (%)	IE2 (%)	IE3	IE4	ICER1 (USD/case)	ICER2 (USD/case)	ICER3 (USD)	ICER4 (USD/QALY)
Health care provider perspective									
Robotic surgery *vs* Laparoscopic surgery	8,114	3.50	-3.00	-0.06	-0.60	2,318	dominated	dominated	dominated
Laparoscopic surgery *vs* Laparotomy	1,535	1.90	-1.60	0.18	1.80	808	dominated	8,529	853
Robotic surgery *vs* Laparotomy	9,650	5.40	-4.60	0.12	1.20	1,787	dominated	80,413	8,041
Patient perspective									
Robotic surgery *vs* Laparoscopic surgery	4,989	3.50	-3.00	-0.06	-0.60	1,425	dominated	dominated	dominated
Laparoscopic surgery *vs* Laparotomy	78	1.90	-1.60	0.18	1.80	41	dominated	432	43
Robotic surgery *vs* Laparotomy	5,067	5.40	-4.60	0.12	1.20	938	dominated	42,226	4,223

ICER, Incremental cost-effectiveness ratio
IE, Incremental effect
Effect 1 intra-operative complication, Effect 2 post-operative complication, Effect 3 utility index, Effect 4 QALYs
Dominated approaches are those with higher costs and lower effects

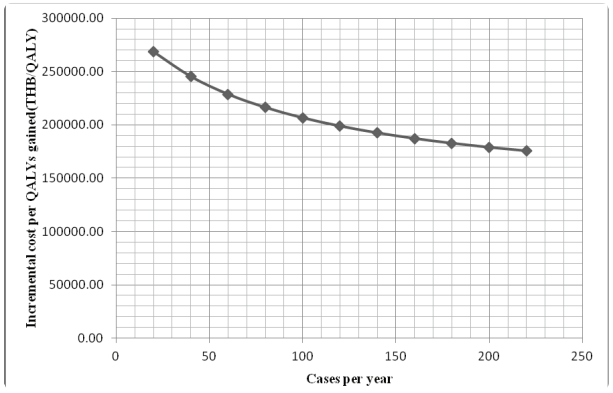

Figure 1: One-way sensitivity analysis: the incremental cost per QALYs gained depending on the number of cases per year.

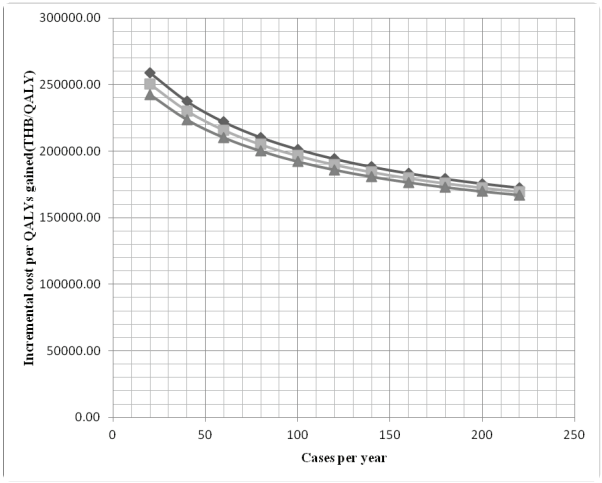

Figure 2: Two-way sensitivity analysis: the incremental cost per QALYs gained depending on the number of cases per year and 10%, 20% and 30% reduction in the robot's price.

in the QOL questionnaire. Thus, its applicability may require further evaluation.

CONCLUSION

In Thailand, laparoscopic surgery was found to be the most favorable and cost-effective surgical approach to treat endometrial cancer.

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