A Cost-Utility Analysis of Laparoscopic Radical Prostatectomy and Robotic-Assisted Laparoscopic Radical Prostatectomy in Men with Localized Prostate Cancer in Thailand

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Objective: *Robotic machines are being used with increasing frequency in the treatment of clinically localized prostate cancer in Thailand. While robotics may offer some advantages, it remains unclear whether potential benefits offset higher costs. The objective of this study was to evaluate and compare cost utility between standard and robotic-assisted laparoscopic prostatectomy from a health system perspective.*

Material and Method: *The authors created a care pathway and a model to facilitate a comprehensive cost utility analysis. All variables used in our model were derived from our review of the literature, except for cost, utility for erectile dysfunction, and utility for urinary incontinence, which were derived from Chulalongkorn Hospital patient records. All costs described in this report are denominated in Thai baht, with a 2012 currency value. A positive margin was used to simulate the model. Sensitivity analysis was performed to estimate the robustness of the outcome.*

Results: *Thailand utility values for erectile dysfunction and urinary incontinence were 0.86 and 0.81, respectively. The cost of robotic laparoscopy was, on average, 120,359 baht (95% CI, 89,368-151,350 baht) higher than standard laparoscopy and was more effective with a mean gain of 0.05 quality-adjusted life years (QALYs) (95% CI, 0.03-0.08) for the 100 procedures performed each year. The incremental cost effectiveness (ICER) ratio was 2,407,180 baht per QALYs, with a very low probability that robotic prostatectomy would be cost effective at the Thai-willingness-to pay (WTP) threshold of 160,000 baht/ QALY.*

Conclusion: *Robotic-assisted laparoscopic prostatectomy is not more cost effective than standard laparoscopic prostatectomy for the 100 cases performed each year. An increase in the number of cases may result in better economies of scale and a lower ICER, an outcome that may increase the overall value and cost effectiveness of an investment in this technology.*

Keywords: *Cost utility, Laparoscopy, Prostatectomy, Robotic-assisted*

J Med Assoc Thai 2015; 98 (Suppl. 1): S14-S20
Full text. e-Journal: *http://www.jmatonline.com*

Since 1994, the widespread use of prostatic-specific antigen (PSA) as a screening test for prostate cancer has precipitated an increase in prostate cancer diagnosis and treatment in Thailand and around the world. The prevalence of prostate cancer in Thailand has risen from a ranking of twenty-second in 2006 to ninth in 2011, among all cancers in men[1]. The majority of prostate cancer cases diagnosed by the PSA screening program were in the early stage. Although there are various treatment options available for early stage prostate cancer (e.g. open prostatectomy, laparoscopic radical prostatectomy, robotic-assisted radical prostatectomy, radiation, and brachytherapy), most patients have preferred to undergo surgery for a complete surgical extirpation of the prostate[2,3]. A surgical technique of radical prostatectomy, either by standard laparoscopy or robotic-assisted laparoscopy, offers advantages in terms of reduced blood loss, less post-operative complications (e.g. erectile dysfunction and urinary incontinence), and a quicker return to activity over the traditional open surgical approach. Advocates of the more costly robotic laparoscopic system claim greater precision in dissection and suturing and an accelerated attainment of surgical competency over the standard laparoscopic approach[4]. Therefore, the aim of the present study was to evaluate and compare the difference in cost and utility between

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laparoscopic radical prostatectomy and robotic-assisted laparoscopic radical prostatectomy from a health system perspective.

Material and Method

The present study was approved by the Institutional Review Board, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand.

Mapping a care pathway

In this cost analysis study, the authors compared robotic-assisted and standard laparoscopic prostatectomy. The authors defined a pathway for each treatment alternative, according to current Thailand clinical guidelines for prostate cancer. The pathways of care were the same for both the standard and robotic laparoscopic prostatectomy techniques.

Simple decision tree model

The model was created using Microsoft® Excel® for Mac 2011. The model data consisted of cost, quality of life, major complications (e.g. urinary incontinence, erectile dysfunction, and bladder neck contracture), probability of conversion to open surgery, and probability of having a positive margin as the main outcome of the surgery. In our model, only a positive margin was used to make the decision about whether adjuvant treatment (radiation and/or hormonal therapy) was needed. Some necessary data used in the model were obtained from previous systematic reviews, meta-analysis[5], and related literature[6-9]. The values of utility of urinary incontinence, erectile dysfunction, and bladder neck contracture were obtained from Chulalongkorn Hospital patient record data. The probability of positive margin, bladder neck contracture, urinary incontinence, and erectile dysfunction requiring specific treatment was derived from systematic review. The conversion rate to open surgery for each technique was derived from the literature.

Costs were calculated in Thai baht and are shown in Tables 1 and 2. All costs used were based on 2012 Thailand currency valuation. The estimated useful life of standard laparoscopic and robotic-assisted laparoscopic machines was 5 and 10 years, respectively. The equivalent annual cost of each machine was calculatedusing a 3% discount rate without resale value. The unit cost of equipment for each procedure comprised the sum of the machine, robotic arm, and consumable equipment costs. The number of prostate cancer patients undergoing laparoscopic surgery each year was the average number of all patients derivedfrom all four hospitals in Thailand with robotic machines. The authors used the actual hospital charges for the cost of turning to open surgery, radiation, and hormonal treatments.

Patient quality of life after standard and robotic-assisted laparoscopic prostatectomy was estimated using EQ-5D Thai version, as shown in Table 3. All of the data relating to utility value were collected from 27 patients who visited Chulalongkorn urologic outpatient clinic between January 2013 and December 2013.

The cost-utility predicted by the model was reported as the incremental cost effectiveness ratio

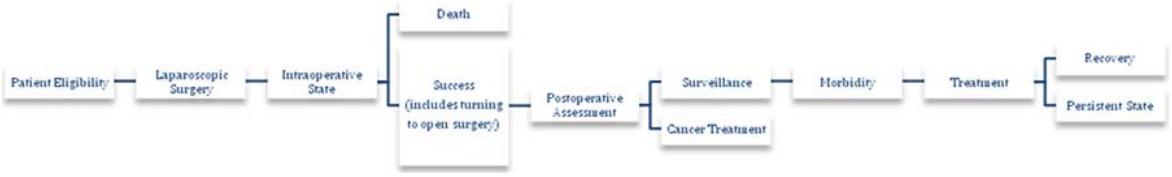

Fig. 1 Care pathway.

Table 1. Procedure cost per person for standard and robotic laparoscopic prostatectomy, calculated at 100 procedures per year

Itemized cost	Standard laparoscopy	Robotic laparoscopy
Direct cost of procedure	57,918	202,931
Hospital care cost	13,500	13,500
Operating room	10,419	8,602
Hospital stay	5,000	5,000
Total	86,837	230,032

(ICER) defined as the difference in the cost between the two procedures divided by the difference in the quality-adjusted life year (QALY) gained by robotic-assisted prostatectomy. The authors applied a 3% discount rate for both cost and utility in our analysis. The authors also modeled survival at 10 years following surgery; the overall survival rate at 10 years was 86%.

Sensitivity analysis

A Monte Carlo simulation with 1,000 samples for each treatment option was used for probabilistic sensitivity analysis to estimate the confidence interval for costs, QALYs, and incremental cost per QALY. The simulation was dependent on having positive margin as a key outcome variable in the model.

In addition, a one-way sensitivity analysis was performed using different numbers of prostatectomies per year to demonstrate changes in unit cost and ICER. Threshold analysis was performed to identify the number of prostatectomies per year needed to exceed the Thai-willingness-to pay threshold

The alternative scenario of having no complications (erectile dysfunction, urinary incontinence, and bladder neck contracture) under robotic-

Table 2. Variable costs associated with events that often follow standard and robotic laparoscopic prostatectomy

Item	Price	Source
Conversion to open surgery	20,000	Chulalongkorn Hospital
Radiotherapy and hormonal therapy	262,800	Chulalongkorn Hospital
Self-management of urinary incontinence	5,874	Chulalongkorn Hospital
Erectile dysfunction management (1 tablet weekly)	9,600	Chulalongkorn Hospital
Bladder neck contracture management	40,000	Chulalongkorn Hospital

Table 3. Utility values associated with each health status

Health status	Utility (range)	Source
No event	0.9 (0.75-1)	Korfage, et al.
Bladder neck contracture	0.72 (0.56-0.93)	Volk, et al.
Erectile dysfunction	0.86 (0.58-1)	Chulalongkorn Hospital
Urinary incontinence	0.81 (0.67-1)	Chulalongkorn Hospital

Table 4. Various probability values associated with robotic and standard laparoscopy

Parameter	Robotic	Laparoscopic	Source
Operative time (hours)	3	4	Chulalongkorn Hospital
Conversion to open surgery	0.003 (0-0.006)	0.009 (0-0.018)	HTA(5)
Positive surgical margin	0.18 (0.12-0.23)	0.24 (0.08-0.39)	HTA(5)
Urinary incontinence	0.043 (0.007-0.224)	0.079 (0-0.357)	HTA(5)
Erectile dysfunction	0.23	0.36	HTA(5)
Bladder neck contracture	0.008 (0.002-0.052)	0.021 (0.008-0.15)	HTA(5)

Table 5. Various probability values used in the model

Parameter	Surgery	Radiation + Hormonal therapy	Source
Positive surgical margin	0.238	N/A	HTA(5)
Urinary incontinence	0.11	0.11	HTA(5)
Erectile dysfunction	0.19	-	Hu JC et al.
	-	0.60	Prescrire Int'l. 2013
Bladder neck contracture	0.05	0.05	HTA(5)

assisted laparoscopic prostatectomy was used as the best-case scenario.

Results

Operative times for standard and robotic laparoscopic prostatectomies were 4 and 3 hours, respectively. The means of utility values derived from Chulalongkorn Hospital patient data were 0.81 for urinary incontinence and 0.86for erectile dysfunction.

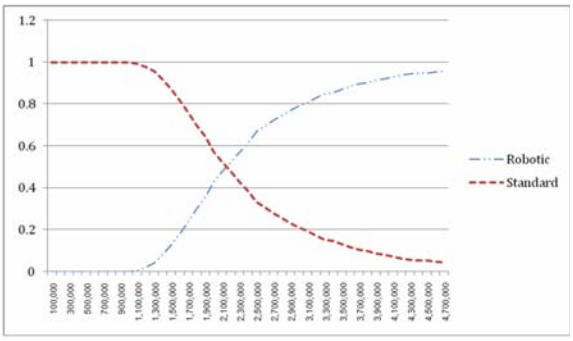

Fig. 2 Cost-effectiveness acceptability curve for robotic prostatectomy and laparoscopic prostatectomy (Prediction based on 100 prostatectomies performed each year, post-surgery survival rate of 10 years and, 2012 estimated cost in Thai baht).

Method effectiveness and cost-effectiveness

Robotic laparoscopy, being on average 120,359 baht (95% CI, 89,368-151,350 baht) more expensive than standard laparoscopy, was more effective with a mean gain in QALYs of 0.05 (95% CI, 0.03-0.08) for the 100 procedures performed annually. The ICER was 2,407,180 baht with a 0% probability that robotic-assisted prostatectomy was cost-effective at a Thai-willingness-to pay (WTP) threshold of 160,000 baht/QALY (Table 6, Fig. 2).

Sensitivity analysis

Approximately 385 robotic-assisted prostatectomies per year was the minimum number considered to be cost-effective at the Thai threshold (Table 6). In a best-case scenario with no complications following surgery, robotic-assisted prostatectomy was 119,645 baht more costly than standard laparoscopic prostatectomy and gained 0.14 QALYs. The ICER was 828,921 baht/QALY, based on 100 procedures per year.

Discussion

Robotic-assisted laparoscopic prostatectomy comes at a high cost, but will likely become a cost-effective method, as it is associated with fewer positive surgical margins, less conversions to open surgery,

Table 6. Cost-effectiveness ratios varying by number of annual cases

Number of cases	Procedure	Cost	QALY	Difference in costmean (95%CI)	Difference in QALY mean (95%CI)	ICER
50	Robotic	446,162	7.58	272,218 (242,726-301,710)	0.05 (0.03-0.8)	5,444,360
	Standard	173,944	7.53			
100	Robotic	278,385	7.58	120,359 (89,368-151,350)	0.05 (0.03-0.8)	2,407,180
	Standard	158,026	7.53			
150	Robotic	222,053	7.58	69,333 (37,301-101,363)	0.05 (0.03-0.8)	1,386,660
	Standard	152,720	7.53			
200	Robotic	194,868	7.58	44,801 (12,434-77,168)	0.05 (0.03-0.8)	896,020
	Standard	150,067	7.53			
250	Robotic	177,350	7.58	28,875 (-1,610-59,358)	0.05 (0.03-0.8)	577,500
	Standard	148,475	7.53			
300	Robotic	166,799	7.58	19,385 (-11,471-50,241)	0.05 (0.03-0.8)	387,700
	Standard	147,414	7.53			
350	Robotic	158,450	7.58	11,794 (-19,790-43,378)	0.05 (0.03-0.8)	235,880
	Standard	146,656	7.53			
400	Robotic	152,489	7.58	6,402 (-24,784-37,588)	0.05 (0.03-0.8)	128,040
	Standard	146,088	7.53			
450	Robotic	149,010	7.58	3,365 (-28,688-35,417)	0.05 (0.03-0.8)	67,300
	Standard	145,645	7.53			
500	Robotic	144,693	7.58	-598 (-32,093-30,896)	0.05 (0.03-0.8)	-11,960
	Standard	145,292	7.53			

less complications, fewer blood transfusions, and fewer deaths. Although the cost of the robotic device is very similar from country to country, the total cost of the procedure is different. In Southeast Asia, capital and labor costs are lower than in North America and European countries. A simple decision tree model was used that followed the Thailand guidelines for prostate cancer management. The average number of prostatectomies each year in Thailand (100 procedures/year) was lower than in the UK (200 procedures/year)[5]; a statistic that is reasonably attributable to a lower incidence of prostate cancer in Thailand. From the literature review, robotic-assisted prostatectomy is shown to be cost-effective in some countries (e.g. Sweden[10] and Denmark[11]) due to a high volume of prostate cancer patients and a higher willingness to pay threshold. However, Canadian HTA[12] reported no cost-effectiveness.

Unlike developed countries with a higher willingness to pay threshold, Thailand has a willingness to pay threshold of 160,000 baht/QALY, so the use of robotic-assisted prostatectomy is not a cost-effective treatment option. The robotic-assisted option will become cost-effective once the willingness to pay threshold in Thailand increases to 1,100,000 baht/QALY. One major factor that influences the level of cost-effectiveness is the number of prostatectomies performed per year, with a break-even point of 385 procedures. Another important variable used for the simulation in this study was the possibility of positive margins after surgery. Higher rates of adjuvant treatment directly related to higher positive margin rates; an outcome directly affecting both cost and quality of life. By way of example, the cost of radiation therapy and hormonal therapy was almost half that of robotic surgery.

In a comparison of countries, the value of utility was also different. These values of utility differences are mostly attributable to culture and race. The values of utility for erectile dysfunction and urinary incontinence in Thai patients were 0.86 and 0.81, respectively. For patients from the UK, the values of utility for erectile dysfunction and urinary incontinence were 0.84 and 0.83, respectively.

If the authors were to compare laparoscopic prostatectomy with open prostatectomy, we would see a large difference in cost and utility. O'Malley et al reported on a cost-utility analysis that compared open and laparoscopic prostatectomy. The O'Malley et al report estimated the incremental cost for robotic surgery over open surgery to be US$ 2,264, with an incremental gain of 0.093 quality-adjusted life years (QALYs) and an ICER of US$ 24,475.43/QALY. The present study evaluated cost-utility between robotic-assisted and standard prostatectomy, finding a large difference in cost and a small difference in improvement of quality of life. Our report estimated the incremental cost for robotic-assisted versus standard laparoscopy to be 120,359 baht (US$ 4,011), an incremental gain of 0.05 quality adjusted life years (QALYs) and an ICER of 2,407,180 baht (US$ 80,239)/QALY. Notwithstanding the real and potential value and benefits realized by the use of robotic-assisted prostatectomy, the additional cost far exceeds the Thai-willingness-to pay threshold.

Conclusion

Robotic-assisted laparoscopy has a significant impact on many clinical outcomes, including postoperative complications, erectile function, continence rates, and bladder neck contracture. The findings of this study show that robotic prostatectomy will almost always be more costly than standard laparoscopy across a number of possible scenarios, except when the number of prostate cases increases significantly. As such, limiting the number of machines and better coordination and management of the patient referral system to increase the number of cases in each center would be necessary for robotic prostatectomy to become cost effective in a Thai context.

Potential conflicts of interest

None.

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การศึกษาต้นทุนอรรถประโยชน์ระหว่างการผ่าตัดส่องกล้องและการผ่าตัดส่องกล้องโดยมีหุ่นยนต์ช่วยผ่าตัดในผู้ป่วยมะเร็งต่อมลูกหมากในระยะแรกในประเทศไทย

ชาดชื่อ-นามสกุล ผู้นิพนธ์ทุกท่าน

ภูมิหลัง: ปัจจุบันการนำหุ่นยนต์มาช่วยในการผ่าตัดรักษามะเร็งต่อมลูกหมากระยะแรกในประเทศไทยมีจำนวนมากขึ้น ทำให้เราได้รับประโยชน์จากหุ่นยนต์ช่วยผ่าตัดหลายประการแต่อย่างไรก็ตามจากค่ารักษาที่สูงขึ้น ทำให้เราไม่ทราบถึงความคุ้มค่าของการลงทุนที่เกิดขึ้นในประเทศไทย

วัตถุประสงค์: เพื่อศึกษาต้นทุนอรรถประโยชน์ระหว่างการผ่าตัดส่องกล้องและการผ่าตัดส่องกล้อง โดยมีหุ่นยนต์ช่วยผ่าตัดในผู้ป่วยมะเร็งต่อมลูกหมากในระยะแรกในประเทศไทย

วัสดุและวิธีการ: โดยการใช้แนวทางการรักษาและการสร้างแบบจำลองสำหรับวิเคราะห์ต้นทุนอรรถประโยชน์ โดยต้นทุนของการรักษาทั้งสองวิธีคำนวณจากต้นทุนที่เกิดขึ้นโดยใช้ต้นทุนที่เกิดขึ้นในโรงพยาบาลจุฬาลงกรณ์ในปี พ.ศ. 2555 เป็นตัวแทนและค่าคุณภาพชีวิตในแบบจำลองได้มาจากผู้ป่วยในโรงพยาบาลจุฬาลงกรณ์ ผลลัพท์ความไวของต้นทุนอรรถประโยชน์ทำโดยการวิเคราะห์ความไวแบบอาศัยความน่าจะเป็นโดยการแปรผันค่าของตัวแปรอัตราหลงเหลือของมะเร็งที่ขอบรอบชิ้นเนื้อ วิเคราะห์ความไวโดยกำหนดค่าของตัวแปรที่คาดว่าดีที่สุดและการกำหนด จำนวนผู้ป่วยที่ได้รับการผ่าตัดต่างๆ กัน

ผลการศึกษา: ค่าของคุณภาพชีวิตของผู้ป่วยหย่อนสมรรถภาพทางเพศและการกลั้นปัสสาวะไม่อยู่เท่ากับ 0.86 และ 0.81 ตามลำดับ ค่าใช้จ่ายโดยการใช้หุ่นยนต์ช่วยผ่าตัดสูงกว่าการผ่าตัดส่องกล้อง 120,359 บาท โดยมีค่าความเชื่อมั่น 95% ที่ 89,368 บาท ถึง 151,350 บาท และค่าประสิทธิผลที่เพิ่มขึ้นในรูปของจำนวนปีสุขภาวะเท่ากับ 0.05 โดยมีค่า ความเชื่อมั่นที่ 0.03 ถึง 0.08 โดยคิดจากจำนวนผู้ป่วยที่ได้รับการผ่าตัด 100 รายต่อปี อัตราส่วนต้นทุนประสิทธิผลส่วนเพิ่มเท่ากับ 2,407,180 บาท โดยมีความเป็นไปได้ที่จะคุ้มทุนเมื่อใช้มูลค่าความเต็มใจที่จะจ่ายของประเทศไทยที่ 160,000 บาท เท่ากับร้อยละ 0

สรุป: จากการศึกษาไม่พบว่าการผ่าตัดส่องกล้องโดยมีหุ่นยนต์ช่วยผ่าตัดจะมีความคุ้มทุนเมื่อเทียบกับการผ่าตัดแบบส่องกล้องที่จำนวนการผ่าตัด 100 รายต่อปี การเพิ่มขึ้นของจำนวนการผ่าตัดอาจทำให้มีโอกาสที่ความคุ้มทุนเพิ่มขึ้นมาอยู่ในระดับมูลค่าความเต็มใจที่จะจ่ายของประเทศไทย