Gynecologic Oncology 130 (2013) 95–99

Contents lists available at SciVerse ScienceDirect

Gynecologic Oncology

journal homepage: www.elsevier.com/locate/ygyno

Hospital costs for robot-assisted laparoscopic radical hysterectomy and pelvic lymphadenectomy

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HIGHLIGHTS

- Robotic radical hysterectomy can be performed at an equal cost as by laparotomy, given a sufficient case load.
- A substantial implementation time is needed to reach cost neutrality.
- Cost effectiveness requires a restrictive use of instruments.

ARTICLE INFO

Article history:
Received 28 February 2013
Accepted 9 April 2013
Available online 17 April 2013

Keywords:
Hospital costs
Robot-assisted surgery
Radical hysterectomy

ABSTRACT

Objective. To compare robot-assisted laparoscopy and laparotomy for radical hysterectomy and pelvic lymphadenectomy in terms of hospital costs.

Methods. Consecutive women undergoing radical hysterectomy and pelvic lymphadenectomy as a sole procedure between January 2001 and February 2012 were included. We compared OR times, hospital stay, procedure specific costs, blood transfusions and cost for readmissions and re-interventions until three months after surgery for 231 women operated who received either an open ($n = 51$) or a robot-assisted laparoscopic radical hysterectomy ($n = 180$). The hospital internal charges and purchase costs were used for estimation. The specific robotic cost was based on an investment depreciation time of seven years, with 400 operations performed annually, costs for maintenance, robotic instruments, robot-specific assistant's instruments and robot draping.

Results. The estimated mean costs for an open radical hysterectomy was $12,986, for the first 30 robotic radical hysterectomies was $18,382, and for the last 30 was $12,759, with a break even in cost after 90 robotic procedures. The specific robot costs ($3469) was, for the last robot cohort, compensated mainly by an average of 22 min shorter OR time and 4.9 days shorter hospital stay.

Conclusion. Given 400 robot operations annually, and only after a substantial implementation period, it is feasible to perform robot-assisted radical hysterectomy at an equal hospital cost compared with open surgery.

Introduction

The adoption of robot-assisted laparoscopic surgery has provided the potential advantages of minimally invasive surgery for a wide range of advanced procedures [1–4]. So far, the da Vinci system (Da Vinci ® Surgical System, Intuitive Surgical Inc, Sunnyvale CA, USA) is the only laparoscopic robotic surgical system available on the market. The well known features of the robot system may help the surgeon overcome some limitations associated with traditional laparoscopic surgery and may enable a larger proportion of women to benefit from minimally invasive techniques. Short-term data, usually from case–control studies, show less blood loss and shorter hospital stay following robotic surgery compared with open surgery and a similar or higher nodal lymph node yield [5–9]. Compared with traditional laparoscopy robotic surgery may result in a better nodal yield, fewer intraoperative complications and a lower rate of conversion to open surgery [5,10].

Robot-assisted hysterectomy has been associated with an increased risk for vaginal cuff complications [2,11]. However the main concerns for robot-assisted surgery relate to cost effectiveness and the lack of long term oncological data supporting its superiority over traditional laparoscopic or open surgery. Nevertheless, robotic surgery has been introduced in an increasing number of institutions.

The specific costs for robotic surgery are related to acquisition, maintenance, use of specific robotic instruments and robot draping. Within gynecological oncologic surgery, four publications, all reflecting Northern American conditions, have compared costs for robotic staging of endometrial cancer with traditional laparoscopy and/or open surgery. Traditional laparoscopy was considered most cost effective, whereas inconsistent

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0090-8258/$ – see front matter
http://dx.doi.org/10.1016/j.ygyno.2013.04.014

results were reported when comparing robotic surgery with open surgery. Societal cost, if included, and robot-specific costs as well as hospital charges are not uniformly defined [6,9,10,12]. No study has evaluated costs for robotic radical hysterectomy.

The department of Obstetrics and Gynecology at Skåne University Hospital is a tertiary referral unit for both gynecological oncology and complex benign gynecological surgery. Robotic surgery was introduced in October 2005, and to date more than 1400 women have been operated robotically. Designated prospective protocols were used to collect clinical and surgical data on all robotic procedures. Prior to the implementation of the robotic surgery, traditional laparoscopy was regularly used for hysterectomy and pelvic/para-aortic lymphadenectomy whereas only a few radical hysterectomies had been performed laparoscopically.

The aim of this study is to compare hospital costs for open and robot-assisted radical hysterectomy and pelvic lymphadenectomy at a single institution with a longitudinal team perspective.

Methods

We identified all women with early-stage cervical cancer or stage II endometrial cancer undergoing robot-assisted radical hysterectomy and pelvic lymphadenectomy between December 2005 and February 2012 ($n = 223$). Of these, 43 women were excluded due to a significant additional operative procedure, including: para-aortic lymphadenectomy ($n = 22$), omentectomy ($n = 8$), or surgery abandoned in favor of chemoradiation in the case of an intraoperative find of lymph node metastases ($n = 13$). Hence 180 women remained for analysis. These women were chronologically divided in groups of 30 to enable estimation of variations in costs over time. For comparison, we used a cohort of consecutive women from the same institution who had undergone an open radical hysterectomy and pelvic lymphadenectomy between January 2001 and December 2005 ($n = 51$) using the same exclusion criteria. An intention to treat policy was applied in the analysis.

For estimation of cost generating factors common for open and robotic procedures we used operating room (OR) times (from patients' entry to patients' departure from the OR), admittance fee, hospital stay, blood transfusions and cost for re-interventions (taking into account all of above) until three months after surgery. Access to computer-based patient files from other hospitals in the recruitment area ensured that all re-interventions from these hospitals were also identified. The hospital internal charge, based on the average real cost for the respective parameter, by June 2011 was used for estimation. For instance, the per minute charge for use of the OR is based on last year's mean institutional cost and includes the operating theater, two surgeons, surgical staff, anesthetic staff, cleaning and basic expendables such as gowns and gloves. The standard OR staff for both open and robotic procedures were the same: one scrub nurse, one circulating nurse, one anesthesiology nurse or anesthetist and two gynecological surgeons. All patients were operated under general anesthesia with muscle relaxant and assisted ventilation and, as a rule, without an epidural for analgesia.

We then calculated the procedure-specific cost for robotic and open surgery respectively. The robot-specific cost was divided into "basic cost" (investment and maintenance), "procedure-specific robot cost" (robotic instruments and robot draping) and "robot-associated specific cost" (defined below) and summarized. The basic robot cost was calculated from the price of the latest purchased da Vinci SI system using a depreciation time of seven years, the annual maintenance fee (taking into account the first year free of charge) and an annual turnover of 400 procedures. The procedure-specific robot cost included the cost for the actual number of robotic instruments used for each case retrieved from the robot database. The robot-associated specific cost included patient draping a 4-arm robot draping, sterilization of all reusable instruments including robotic instruments, and cost for disposable assistant's instruments specifically used for robotic surgery: the assistant's port (Xcel® Ethicon Endo-surgery Inc., Guaynabo Puerto Rico), a 5 mm suction-irrigation (Stryker endoscopy, San Jose CA, USA) and a reinsertable lymph node retrieval bag (Endopouch® tissue retrieval system, Laparosurge, Hertfordshire, UK). Apart from these, the assistant used only reusable traditional laparoscopic instruments. As a rule, we used a modified Storz reusable trocar for the robot optics (Ternamian Endotip, Karl Storz GmbH & Co KG, Tuttlingen, Germany). For vaginal manipulation we used a sponge on a stick or a reusable vaginal tube. Disposable sealing/cutting laparoscopic instruments were never used. Hence, the use of disposable instruments was kept to a minimum.

The procedure specific cost for an open radical hysterectomy included patients draping, sterilization of instruments and a single-use monopolar diathermy handpiece and suction. We used standard reusable surgical instruments only. We estimated the depreciation cost of reusable instruments to be the same for robotic and for open procedures.

In-patient treatment protocols regarding the use of prophylactic antibiotics, thrombosis prophylaxis and perioperative pain relief remained substantially unchanged over the years. Prescribed postoperative medications were paid by the hospital also for discharged patients according to Swedish reimbursement rules. For costs charged in SEK (Swedish Crowns) or € (Euros) we used the mean currency exchange rate between US dollar and SEK/€ for the year 2011 as estimated by Swedish tax authorities (1$ = 6.4969 SEK and 1$ = 0.7192 €).

According to the approval of the ethical committee of Lund University, patients with robot-assisted surgery all gave their consent to this surgical approach whereas an opt-out principle was used for the retrospective part of the study.

For statistical analyses we used the Chi square test, the student's t-test or the Mann–Whitney test as appropriate. The Gaussian distribution of the groups was tested by Kolmogorov–Smirnov fitness test. If needed a Bonferroni correction was applied to address the multiple comparison problem. All tests were two-sided and p values <0.05 were considered significant.

Results

A total of 180 robot-assisted and 51 open radical hysterectomies were included. No patients were lost to follow-up. Demographic and clinical data are presented in Table 1. Median age, Body Mass Index and the proportion of women with significant comorbidity (American Society of Anesthesiologist physical status group (ASA) ≥3) were equal between groups. The proportion of women with previous abdominal surgery (open 20/51; robot 41/180, $p = 0.02$) and the proportion of cervical cancer FIGO stage ≥1B2 was, apart from the last robot cohort, higher in the open surgery group (39% compared with 11%, $p = 0.01$). The cost was equal for small and large cervical tumors in the open group ($13,412 compared to $13,074 $p = 0.66$). Overall, consultant surgeons performed all procedures of which 86% were performed by either of the three surgeons.

The total mean cost for open radical hysterectomy and pelvic lymphadenectomy was $12,986 of which $7777 was cost for OR use,

Table 1
Demographic and clinical data on women with a radical hysterectomy and pelvic lymphadenectomy performed by robot-assisted laparoscopic or open surgery at a single institution.

	Open ($n = 51$)	Robot all ($n = 180$)	$p =$ [a]
Age (years)	52.0	49.9	0.38
BMI	26.1	25.8	0.31
Comorbidity[b]	35%	33%	0.74
Prior abdominal surgery	39%	23%	0.02
Cervical cancer ≥1B2	39%	11%	0.01

[a] All open compared to all robotic.
[b] American Society of Anesthesiologist physical status classification ≥3.