RESEARCH ARTICLE

Feasibility of robotic surgery in a developing country, a public sector perspective

Shahriyar Ghazanfar,[1] Sajida Qureshi,[2] Muhammad Zubair,[3] Umer Fateh,[4] Saif Ahmed,[5] Mohammad Saeed Quraishy[6]

Abstract

Objective: To assess the clinical feasibility of robotic platform and to calculate cost for sustaining it.

Methods: The study was conducted at Sindh Government Qatar Hospital and Civil Hospital Karachi from October 11, 2011, to August 30, 2017. Feasibility was assessed in terms of clinical outcome i.e. surgical complications, duration of stay and readmissions. The cost of doing an individual procedure was calculated along with the projected cost for 150, 200 and 250 cases per year. SPSS 23 was used for data analysis.

Results: Of the 119 patients, 45(37.8%) were males and 74(62.2%) were females. Overall mean age was 42.10±13.40 years (range: 21-80 years. Mean hospital stay was 3.59±3 (range: 1-19 days). Complications occurred in 17(14.3%) patients ranging from wound infection 7(5.9%), bleeding 5(4.2%), intra-abdominal abscess 3(2.5%) and recurrence 2(1.7%). The total cost of robotic platform was Rs320 million with an annual maintenance contract of 10% of the total cost. The mean cost of performing a robotic procedure was Rs.389,263.05±39,249.63 (range: Rs252,823.09-Rs456,842.79).

Conclusion: Robotic surgery was found to be a feasible and viable option. The major hindrance was the cost involved in setting up the system and recurring costs in terms of disposables.

Keywords: Robotic surgery, Da Vinci robotic system, Da Vinci Si, Clinical feasibility, Financial implications. (JPMA 69: 44; 2019)

Introduction

Minimally invasive general surgery started in 1985 with the first Laparoscopic cholecystectomy performed by Professor Dr. Erich Muhe of Germany.[1] The advantage of minimally invasive technique is small scars, less postoperative pain, early mobilisation and return to work. The drawbacks were many, including technical limitations hindering complex procedures that were difficult to learn and perform laparoscopically. The video camera that was held by the assistant was often unstable and gave a restricted 2-dimensional vision of the field. This in addition to operating with straight laparoscopic instruments also limited manoeuvrability and forced the operating surgeon to adopt awkward positions while operating.[1]

In 2000, Da Vinci Surgical (DVS) system was approved by Food and Drug Administration (FDA) as the first robotic surgery system.[2] The advantages over traditional laparoscopy included 3-dimensional view, 7 degrees of movements of instruments, increased precision of the surgeon's movements by tremor filtering, depth perception and surgeon's comfort.[2] The drawback was a large patient cart, increased operative time, no tactile feedback and the cost of the procedure and the system. With successive generations, the optics have improved and the patient cart has become less bulky. Development of haptics in newer generation (i.e. systems that recreate tactile sensations for operating surgeon on console including the "feel" of tissues through force feedback) indicates a promising future.[3] It has been widely adopted in a number of different specialties, including urological, gynaecological, cardiothoracic and general surgery procedures.

In Pakistan, first DVS was installed at the Sindh Government Qatar Hospital, Karachi, in 2011, followed by the second system which was a generation higher (DVSi) with more advanced features in the Operation Theatre Complex of Civil Hospital, Karachi, in 2013. The current study was planned to share our combined experience of robotic surgery in the two hospitals along with the financial aspect and its recurring cost.

Material and Methods

The study was conducted at Sindh Government Qatar Hospital (SGQH) and Civil Hospital, Karachi (CHK), from October 11, 2011, to August 30, 2017. All patients who underwent robotic surgery were included. After June 2013, all cases were done by DVSi at CHK (Figure) as the DVS of SGQH had gone out of order. From November,

[1-3,6]Dow University of Health Sciences, [4,5]Sindh Government Qatar Hospital,Karachi,Pakistan.

Correspondence: Shahriyar Ghazanfar. Email: shahriyar.ghazanfar@duhs.edu.pk

2015 to May, 2017, the robotic platform at CHK also remained shut down on account of maintenance. Therefore the actual duration of study was 4 years and 2 months. All procedures were done free of cost and were covered by the hospitals concerned. All case files were evaluated and a proforma was filled for each patient. The CHK urology department started using robotic platform in 2017 and has done more than 100 cases. These cases were not included in the current study. Patient data, including demographics, indication, type of robotic surgery, time taken for docking and surgery, robotic instruments used during surgery, conversion to either laparoscopic or open surgery and its reason, postoperative stay and any morbidity or mortality during stay was documented. Docking time was measured after insertion of the ports when the patient cart was mobilised to the time when all the arms were attached to the ports and instruments inserted. Surgery time was taken from the insertion of the robotic instruments till the undocking of the patient cart. Where the data was missing or incomplete, patients were followed up by telephone interview and in some cases through outpatient department (OPD) follow-up. All patients with incomplete files, missing data and who were unable to be contacted were excluded. Feasibility was assessed in terms of clinical outcome i.e., surgical complications, duration of stay and re-admissions. The cost was calculated in terms of Pak rupee. The total cost of installation of robotic platform was not included in the cost calculation of the procedure. Similarly, the theatre time and use of other resources were excluded from the total cost. Only the robotic hand instruments, drapes and maintenance charges were taken into account when the overall cost was being calculated. Cost was projected for 150, 200 and 250 cases per year. Data analysis was done using SPSS 23.

Results

Of the 119 patients, 45(37.8%) were males and 74(62.2%) females. Overall mean age was 42.10±13.40 years (range: 21-80 years). Mean hospital stay was 3.59±3 (range: 1-19 days). Mean duration of surgery was 161.9±77.85 minutes (range: 75-540min). Mean docking time was 19.33±9.21 minutes (range: 5-45 min) (Table-1).

Table-1: Summary of results.

n=119	
Age in years (mean(range))	42.10±13.40 (21-80)
Male:Female	45(37.8%): 74 (62.2) 1:1.64
Hospital stay in days	3.59±3 (1-19)
Duration of Surgery in days	161.9±77.85 (75-540)
Docking time in minutes	19.33±9.21 (5-45)
Conversions to open surgery	7 (5.88%)
Cost per procedure (Pak. Rs)	389,263.05±39,249.63 (252,823.09-456,842.79)

Table-2: Mean cost, docking time and duration of surgery according to robotic surgery.

Surgery	Diagnosis	n	%	Cost Pak.Rs	Docking time (min.)	Duration of surgery (min.)
Robotic Cholecystectomy	Cholelithiasis	32	26.9	348,985.98± 2697.39	23.63±8.35	125±23.06
Robotic hysterectomy	Uterine fibroids	18	15.1	401,522.89	21.11±2.19	152.78±19.94
Robotic TAPP	Inguinal Hernia	15	15.1	351,339.79± 24,586.52	8.17±3.68	104.72±26.82
	Ventral Hernia	3				
Robotic IPOM	Ventral hernia	13	10.9	405,922.09	9.15±2.07	118.08±9.69
Robotic prostatectomy	BPH	7	5.9	401,522.89	22.29±5.31	167.14±20.59
Robotic anterior resection	Carcinoma Rectum	5	4.2	420,989.73± 32,729.22	30.8±6.87	314±43.36
Robotic APR	Carcinoma Rectum	5	4.2	420,989.73± 32,729.22	27.2±12.19	278±59.33
Robotic Appendicectomy	Acute Appendicitis	5	4.2	450,310.09	19.6±1.67	124±9.62
Robotic Right hemicolectomy	Carcinoma Cecum	3	4.2	450,310.09	17.2±7.66	218±24.9
	TB mass right colon	2				
Robotic HellersCardiomyotomy	Achalasia	3	2.5	450,310.09	29.33±2.3	253.33±41.63
Robotic sutured rectopexy	Rectal prolapse	2	1.7	450,310.09	32±0	299±55.15
Robotic Mesh Rectopexy		1	0.8	450,310.09	25	180
Robotic sigmoid Colectomy	Carcinoma Sigmoid	2	1.7	450,310.09	28±0	289±69.30
Robotic Esophagectomy (Thoracic portion)	Esophageal Carcinoma	2	1.7	397,087.69	12.5±3.53	147.5±31.82
Robotic repair of paraesophageal hernia	Paraesophageal hernia	1	0.8	405,922.09	10	180

TAPP: Transabdominal preperitoneal
IPOM: Intraperitonealonlay mesh
BPH: Benign prostatic hyperplasia
APR: Abdominoperineal resection
TB: Tuberculosis.

There was 1(0.8%) instance of technical failure when the 4th arm failed but the procedure continued with 3 arms. There were 7(5.88%) conversions to open surgery during the initial training phase of robotic surgery which included 2(1.6%) abdominoperineal resections, 2(1.6%) prostatectomies, 2(1.6%) hysterectomies, 1(0.8%) cholecysetctomy. Also, 1(0.8%) anterior resection was converted to laparoscopic due to difficult posture of the patient as she was kyphoscoliotic. The indication and surgery performed along with the cost was noted (Table-2).

Table-3: Cost analyses in Pak. Rs.

Inventory	Total cost in Rs.	Cost per procedure using 4 instruments in Pak. Rs.
Maintenance	32,000,000 (Annual)	88,888.89 (Daily)
Scissors	710,208	71,020.80
Maryland	599,238	59,923.80
Needle driver with cut	532,224	53,222.40
Cadiere	443,880	44,388.00
Tip cover	44,388	4,438.80
Instrument arm drape	155,358	46,607.40
Camera arm drape	155,358	15,535.80
Camera head drape	110,970	11,097.00
8mm canula seal	32,000	9,600.00
Total in Pak. Rupees	34,783,624	404,722.89

The total cost of the robotic platform was Rs320 million with an annual maintenance contract of 10% of the total cost. The mean cost of performing a robotic procedure was Rs.389,263.05±rs39,249.63 (range:Rs252,823.09-rs456,842.79). The individual cost of instruments and disposables along with the cost of procedure using 4 instruments was noted separately (Table-3). The cost analysis of operating 150, 200 and 250 cases per year was also calculated (Table-4).

Table-4: Cost analyses in Pak. Rs. projected for 150, 200 and 250 cases annually using 4 instruments.

	150 cases annually	200 cases annually	250 cases annually
Maintenance	32,000,000	32,000,000	32,000,000
Inventory	315,834X150	315,834X200	315,834X250
	47,375,100	63,166,800	78,958,500
Total in Rs.	79,375,100	95,166,800	110,958,500

Complications occurred in 17(14.3%) patients ranging from wound infection 7(5.9%), bleeding 5(4.2%), intra-abdominal abscess 3(2.5%) and recurrence 2(1.7%) (Table-5).

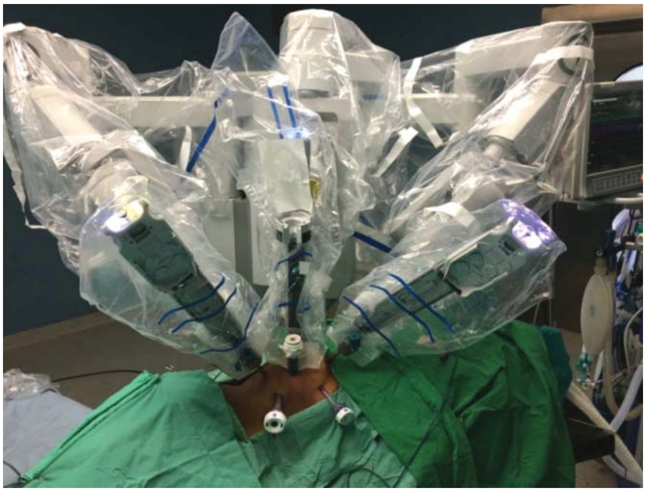

Figure: Robotic Oesophagectomy (Thoracic part) being performed at Civil Hospital Karachi.

Table-5: Clinical feasibility (n=119).

Complications	
Wound infection	7(5.9%)
Bleeding	5(4.2%)
Intra-abdominal abscess	3(2.5%)
Recurrence	2(1.7%)
Readmissions	6(5.04%)
Conversions to open surgery	7(5.88%)

Discussion

Robotics has evolved over a period of 25 years from the first surgical robot programmable universal machine for assembly (PUMA), which was designed for neurosurgery[4] to the only FDA-approved DVS which is currently in its 4th generation.[5,6] The need for robotic surgery was to increase the precision and accuracy of the surgical technique. Despite its criticism, it is being incorporated into a variety of surgical specialties. The number and type of procedures being done is on the rise. Robotic surgery has several advantages over conventional open surgery. Like laparoscopic surgery there is minimal incision, reduced blood loss, early mobilisation, decreased hospital stay and early return to work.[6] Comparing with laparoscopic surgery it has seven degrees of movements, no tremors, and 3-dimensional view giving depth perception.[6] The camera is under direct control of the operating surgeon and the robotic instruments move with the wrist movements of the surgeon unlike in laparoscopic surgery where the camera and instruments are under opposite control. Additionally, there is an option of scaling down of surgeon's movements that is transferred to the instruments leading to increased precision and making it ideal to work in confined spaces.[7] Another benefit includes reduced learning curve and improved hand-to-eye coordination.[8] The major hindrance to the availability of robotic surgery is its high cost and recurring cost of disposables and service contracts.[9] Other factors that limit its use include loss of tactile feedback, bulky patient cart and long operative times. The use of robotics in general surgery has been a slow process.[9] It has been used in foregut surgery (i.e. fundoplication, myotomy, oesophageal and gastric surgeries), hepatobiliary, colorectal surgery and bariatric surgery.[6,10] Comparative studies with laparoscopic surgery have shown mixed results with most studies showing no benefit over laparoscopic surgery but demonstrating its safety and efficacy.[9,11,12]

The current study was done to give an overview of robotic surgery and its feasibility in Pakistan which is a developing country. There are currently 2 systems in Karachi. The number of cases done is small but this can be dealt with in collaboration with other specialities, including urology and gynaecology, training more surgeons in robotics and increasing theatre times. The cost of a robotic platform is around Rs300 million along with 10% of the cost being the annual maintenance contract. The mean cost due to limited use of instruments (roughly 10 surgeries) is around Rs.529,310.57. Various studies comparing the cost of open, laparoscopic and robotic surgery have shown that robotic surgery is costlier.[13,14] The cost savings usually comes in the form of reduced hospital stay therefore making more beds available for further surgeries and for the patients who return to work earlier.[6,14] The financial impact of robotic system on a hospital has been looked into by various studies which usually assume that justification can be made and return of investment increases as the number of cases increases and hospital days are saved.[6] This model cannot be applied to our setup which is a state welfare hospital where treatment is free of cost. All financial burden, as such, is on the state. Therefore, in this situation the robotics should be used judiciously where it has proven benefits over laparoscopic surgery. The robotic platforms can be used for the introduction and development of robotic technology in a developing country and training and awareness of healthcare professionals.

To keep the robotic system running requires an annual recurring cost of Rs.32 million in the form of annual maintenance contract. If we assume 300 working days in a year, then the annual cost of doing 150, 200 and 250 cases a year amounts to Rs73.75 million, Rs87.67 million and Rs101.59 million respectively.

In terms of clinical outcome, the robotic surgery was found to be feasible. There were 7 conversions to open surgery due to bleeding and one conversion to laparoscopic due to difficult position of the patient causing hindrance to the movements of the robotic arms. This was also in the early period of the study. There were 7 (5.9%) patients with wound infections necessitating opening of the port stitches and drainage of superficial infection, bleeding was seen in 5(4.2%) requiring conversion to open, three patients (2.5%) developed intra abdominal abscess following anterior resection, abdominoperineal resection (APR) and transabdominal preperitoneal (TAPP) inguinal hernia requiring percutaneous drainage under ultrasound guidance. Patient with TAPP had to be explored for the removal of mesh.

When using robotic technology for simple procedures like robotic cholecystectomy, there is considerable cost involved but it also provides a tremendous opportunity for the surgeons to train and acquire advanced skills.[15]

Conclusion

Robotic surgery is in a state of development and future technology will be leaner, smaller and smarter. The future may be truly robotics where the surgeon will only supervise the surgery carried out by robots. Its installation and maintenance is a huge burden on the state. Therefore, careful planning should be done before its acquisition so that it can be used not only for selected patients where it has a definite superior role, but also for the purpose of teaching and training.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

References

1. Park AE, Lee TH. Evolution of Minimally Invasive Surgery and Its Impact on Surgical Residency Training. In: Matteotti R, Ashley S, eds. Minimally Invasive Surgical Oncology. Berlin, Heidelberg: Springer, 2011; pp 11-22.
2. Rabah DM, Zin Al-Abdin O. The development of robotic surgery in the Middle East. Arab J Urol. 2012; 10: 10-6.
3. Bethea, BT, Okamura AM, Kitagawa M, Fitton TP, Cattaneo SM, Gott VL, et al. Application of haptic feedback to robotic surgery. J Laparoendosc Adv Surg Tech A. 2004; 14:191-5.
4. Lanfranco AR, Castellanos AE, Desai JP,Meyers WC. Robotic

Surgery. A Current Perspective. Ann Surg. 2004; 239:14-21.
5. Vilallonga R, Fort JM, Gonzalez O, Caubet E, Boleko A, Neff KJ, et al. The Initial Learning Curve for Robot-Assisted Sleeve Gastrectomy: A Surgeon's Experience While Introducing the Robotic Technology in a Bariatric Surgery Department. Minim Invasive Surg. 2012; 2012:347131.
6. Leddy LS, Lendvay TS, Satava RM. Robotic surgery: applications and cost effectiveness. Open Access Surg. 2010; 3:99-107.
7. Melfi FMA, Menconi GF, Mariani AM, Angeletti CA. Early experience with robotic technology for thoracoscopic surgery. Eur J Cardiothorac Surg.2002; 21: 864-8.
8. Giri S, Sarkar DK. Current Status of Robotic Surgery. Indian J Surg.2012; 74:242-7.
9. Breitenstein S, Nocito A, Puhan M, Held U, Weber M, Clavien PA. Robotic-assisted Versus Laparoscopic Cholecystectomy Outcome and Cost Analyses of a Case-matched Control Study. Ann Surg. 2008; 247:987-93.
10. Giulianotti PC, Coratti A, Angelini M, Sbrana F, Cecconi S, Balestracci T, et al. Robotics in general surgery: personal experience in a large community hospital. Arch Surg. 2003; 138:777-84.
11. Baek SJ, Kim SH, Jae-Sung Cho, Jae-Won Shin, Kim J. Robotic versus Conventional Laparoscopic Surgery for Rectal Cancer: A Cost Analysis from A Single Institute in Korea. World J Surg. 2012; 36:2722-9.
12. Luncă S, Bouras G, Stănescu AC. Gastrointestinal Robot Assisted Surgery. A Current Perspective. Rom J Gastroenterol. 2005; 14:385-91.
13. Ho C, Tsakonas E, Tran K, Cimon K, Severn M, Mierzwinski-Urban M, et al. Robot-Assisted Surgery Compared with Open Surgery and Laparoscopic Surgery: Clinical Effectiveness and Economic Analyses CADTH Health Technology Assessments.2011; 2:11-20.
14. Coronado PJ, Herraiz MA, Magrina JF, Fasero M, Vidart JA. Comparison of perioperative outcomes and cost of robotic-assisted laparoscopy, laparoscopy and laparotomy for endometrial cancer. Eur J Obstetr Gynecol Repro Bio.2012; 165: 289-94.
15. Herron DM, Marohn M. A Consensus Document on Robotic Surgery. Society of American Gastrointestinal and Endoscopic Surgeons. Surg Endosc. 2008; 22:313-25.