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ORIGINAL ARTICLE

A cost-conscious approach to robotic adrenalectomy

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Abstract

In recent years, the use of robotic-assisted adrenalectomy (RA) has increased; however, many surgeons question its reported higher cost. In this study, we review our experience and strategies to reduce the cost of RA comparing it to Laparoscopic adrenalectomy (LA). Since May of 2010, 122 consecutive patients underwent minimally invasive adrenalectomy (58 RAs and 64 LA) by a high-volume adrenal surgeon at our institution. A cost analysis was performed for RA versus LA. Cost calculations included anesthesia professional fee, procedure time and consumables fees. The calculated relative costs were \$3527 for RA and \$3430 for LA ($p = 0.59$). The average anesthesia time was 172.4 and 178.3 min for RA and LA, respectively ($p = 0.40$). The mean procedure times (skin–skin) were 124.4 min for RA and 129.1 min for LA ($p = 0.50$). Procedure time for the retroperitoneal approach was significantly shorter than the transabdominal approach for both the RA (101.2 vs. 126.6 min, $p = 0.001$) and LA group (104.4 vs. 135.4 min, $p = 0.001$). The average consumables fees were \$1106 for RA versus \$1009 for LA ($p = 0.62$). The average post-operative hospital stay was 1.7 days for RA and 1.9 days for LA ($p = 0.18$). This study shows that anesthesia and procedure times for RA were similar to those of LA. It also demonstrates that limiting the number of robotic instruments and energy devices while utilizing an experienced surgical team can keep the costs of RA comparable to those of LA.

Keywords Da Vinci · Robotic-assisted adrenalectomy · Laparoscopic adrenalectomy · Cost of adrenalectomy · Anesthesia time · Procedure time

Introduction

The da Vinci robotic system (Intuitive Surgical, Sunnyvale, CA, USA) was FDA-approved for usage in humans well over a decade ago and has been applied in urology, gynecology, cardiothoracic, and general surgery [1–4]. Since 1992 laparoscopic adrenalectomy (LA) has been the standard surgical approach to benign adrenal tumors [5, 6]. After the first robotic-assisted adrenalectomy (RA) was reported in 2001 by Horgan et al. [7], RA has been increasingly utilized. The advantages of using robotic technology include 3-D vision, Endowrist® freedom of movement and surgical precision. Such technologic advantages significantly enhance the surgeon's skill in an ergonomically efficient manner. The wrist-like movements of the robotic instruments allow the surgeon to dissect anatomical structures more easily in tight places, such as the pelvis, retroperitoneum and chest. On the other hand, some frequently cited disadvantages of utilizing the robot include the potential for prolonged operating time and higher costs [8–13].

Costs and charges can be different depending on the institution and country, yet it is clear that the observed cost of robotic surgery may become less as more robotic procedures are performed and the price of robotic systems goes down. Nearly a decade ago, Brunaud et al. [9] reported that the cost of RA was 2.3 times more than LA in their center. Similarly, a study by Bodner et al. indicated that RA was 1.5 times more costly than LA [11]. Finally, Winter et al. found that operative charges were significant higher for robotic versus

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LA ($8645 vs. $6414) [10]. Other studies [8, 12, 13] have also reported that the cost of robotic operative packs, drapes and instruments can be as high as $900–$950 per procedure.

In this study, we analyze the cost of RA as compared to LA performed at a teaching institution by a single high volume adrenal surgeon. Herein we describe how a cost-conscious approach to RA can lead to comparable costings for both RA and LA without factoring depreciation and maintenance of laparoscopic or robotic equipment.

Methods

From 5/2010 to 9/2017, 122 consecutive patients underwent minimally invasive adrenalectomy; 58 patients underwent RA and 64 underwent LA by a single surgeon at our teaching institution (Table 1). In the RA group, 53 and 5 patients underwent transabdominal and retroperitoneal approach, respectively. In the LA group, 51 and 13 patients underwent transabdominal and retroperitoneal approach, respectively. A cost analysis was performed for RA and LA which included anesthesia professional fees, procedure time fees, and consumables fees. The anesthesia professional fees are based on anesthesia relative value units ($636) plus an additional $106 for every 15 min or portion thereof. The procedure time fees (skin incision to skin closed) represent a base fee for the first 30 min ($162) and an additional fee ($117) for every 30 min (or portion thereof) after that initial time. The consumables for LA were the surgical supplies, trocars and the harmonic scalpel (Ethicon Endo-Surgery, Guaynabo, Puerto Rico, USA) (Table 2). The consumables for RA were surgical supplies, trocars, robotic drapes and robotic instruments, etc. Two robotic instruments (Cardiere Forceps and Permanent Cautery Hook) were used in all RA procedures for $200 per use (Table 2). The surgeon professional fees were not included as they are the same for both LA and RA and they do not vary by time.

Institution-specific data were collected. The following factors were considered: anesthesia professional fees, procedure time fees, surgical supplies and consumables fees. The average operative room anesthesia and procedure times for LA and RA was based on average data from a single high volume adrenal surgeon (CCS) who also teaches the procedure to general surgery residents.

Table 1 Patient data

	RA ($n = 58$)	LA ($n = 64$)	p value
Age (year)	53.2 ± 12.8	49.8 ± 11.2	0.12
Gender			
Male	24	26	NA
Female	34	38	NA
Body mass index (kg/m^2)	30.6 ± 6.5	30.1 ± 6.1	0.5
Left/right side	36/22	40/24	NA
Surgical approach			
Transabdonimal	52	49	NA
Posterior retroperitoneal	6	15	NA
Tomor size (cm)	3.7 ± 1.7	3.3 ± 1.5	0.17
Anesthesia time (min)	172.4 ± 37.1	178.3 ± 39.4	0.40
Procedure time (min)	124.4 ± 38.8	129.1 ± 37.8	0.50
EBL (ml)	22.4 ± 5.4	24.1 ± 6.2	0.10
ASA	3.1 ± 0.6	3.0 ± 0.5	0.31
Hospital stay (day)	1.7 ± 0.1	1.9 ± 0.1	0.18
Pathologic data			NA
Adrenocortical adenoma	31	33	
Pheochromocytoma	13	17	
Metastatic renal cell carcinoma	5	2	
Cushing's	4	6	
Paraganlioma	1	0	
Adenocarcinoma	3	6	

Statistical analysis

Data were analyzed using GraphPad software (GraphPad Software, La Jolla, CA). The t test was used to compare groups. Data were expressed as mean ± standard deviation (SD). Statistical significance was reached at $p < 0.05$.

Results

The average procedure time (skin incision to skin closed) was 124.4 min for RA and 129.1 min for LA ($p = 0.50$). The average anesthesia time was 172.4 min for RA and 178.3 min for LA ($p = 0.40$). The mean procedure times for the retroperitoneal approach were significantly shorter when compared to the transabdominal approach in both the RA (101.2 vs. 126.6 min, $p = 0.001$) and LA group (104.4 vs. 135.4 min, $p = 0.001$). The average post-operative hospital stay was 1.7 days for RA and 1.9 days for LA ($p = 0.18$) (Table 1). The consumables fees were $1106 for RA and $1009 for LA ($p = 0.62$) (Table 2). The relative cost of RA were $3315 for a short case (operating time was shorter than

Table 2 Cost of consumables to robotic versus laparoscopic adrenalectomy (USD)

Variable	RA	LA
Surgical packs, supplies, trocars, etc.	$506	$532
Harmonic shears	N/A	$477
Robotic drapes	$200	N/A
Robotic instruments	$400	N/A
Total cost	$1106	$1009

Table 3 Projected operative costs of robotic versus laparoscopic adrenalectomy (USD)

	RA		LA	
	Short case	Long case	Short case	Long case
No. of patients	42	16	36	28
Procedure time cost	$513	$630	$513	$747
Anesthesia time cost	$1696	$2014	$1696	$2014
Consumables cost	$1106	$1106	$1009	$1009
Total cost	$3315	$3750	$3218	$3770

Table 4 Operative costs: robotic versus laparoscopic adrenalectomy

	RA	LA	*p* value
Procedure time cost	$513	$513	N/A
Anesthesia time cost	$1908	$1908	N/A
Consumables cost	$1106	$1009	0.62
Total cost	$3527	$3430	0.59

average times) and $3750 for a long case (operating time was longer than average times), and for LA were $3218 for the short case and $3770 for the long case (Table 3). The overall comparative costs were calculated to be $3527 for RA and $3430 for LA ($p = 0.59$) (Table 4) (Fig. 1).

Discussion

Laparoscopic adrenalectomy has been the standard approach for managing benign adrenal tumors since 1992 [5, 6]. After the first RA was reported in 2001 by Horgan et al. [7] the use of RA has gained popularity [8–10]. Robotic surgeons are strongly in favor of the new technology while non-robotic surgeons often state that procedures that can be performed laparoscopically should continue to be done that way and argue that robotic technology is associated with higher cost, prolonged surgical times and hospital stays [8–13].

The higher costs related to robotic surgery include the expense of the robotic system, annual maintenance fees and sometimes more expensive instruments. Because our institution already made the decision to purchase robotic systems, we chose not to include the cost of such systems and their depreciation. The same argument can be made regarding laparoscopic equipment maintenance and depreciation. The da Vinci robotic systems have higher fixed costs, with prices ranging from $1 to $2.5 million per unit [12]. Because previous studies include the robotic system cost in their analysis, [8–13] the reported costs of RA may vary. Winter et al. [10] showed that the cost of RA was $8465, Brunaud et al. [9] calculated that RA was 2.3 times costlier than LA (4155 vs. 1799 Euros) while Morino et al. [8] reported that RA costs $3467 and LA costs $2737. This study calculates the cost of RA to be $3527 as compared to the cost of LA $3430 (Table 4).

In this study, the expense of RA was not significantly different than that of LA. Possible ways of lowering the cost of RA include: reducing the costs of the robotic system, limiting use of instruments and robotic arms to only what is necessary and working with an experienced and efficient operating room team.

Surgeons can reduce costs by avoiding the use of unnecessary robotic instruments/arms and energy devices. The trocars (5 and 10/12 mm), 5 mm Hem-o-lok clips® (Teleflex Medical, Morrisville, NC, USA) and the Endopouch

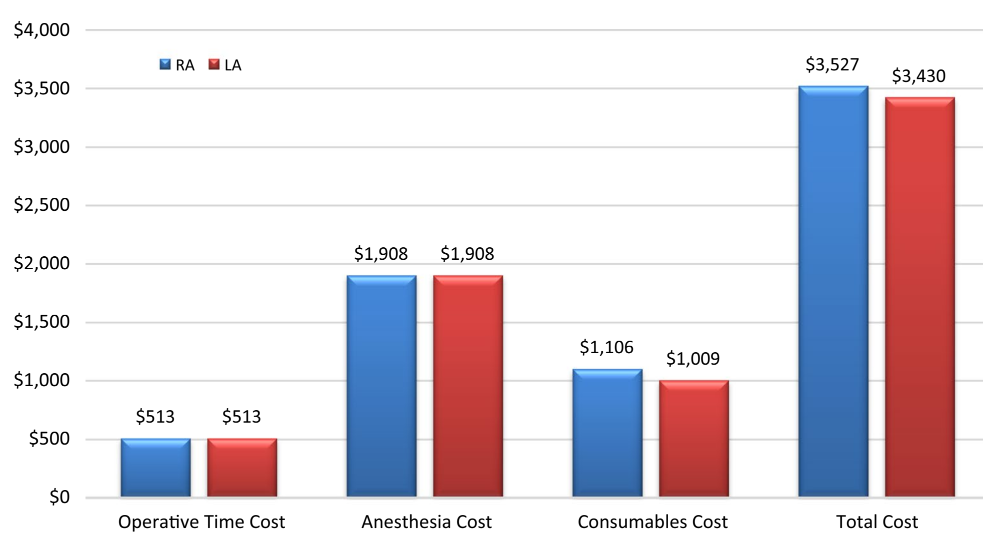

Fig. 1 Mean cost differences between robotic adrenalectomy (RA) and laparoscopic adrenalectomy (LA)

retriever® (Ethicon Endo-surgery, Cincinnati, OH, USA) were used in both the LA and RA groups. The Harmonic® scalpel (Ethicon Endo-Surgery, Cincinnati, OH, USA) was only used in the LA group. Previous reports describe the use of 5 mm or 8 mm graspers (Prograsp™ or Cadiere), bipolar graspers (Maryland or Fenestrated) and the Harmonic® scalpel for RA [14–17] for RA. Our group has limited the use of unnecessary robotic arms and instruments during RA (transabdominal or posterior approaches) and adopted the use of only two robotic instruments, the cardiere forceps and the cautery hook, while eliminating energy sealing devices. After 58 consecutive RAs using only the above instruments we have not encountered intra or postoperative bleeding complications. The advantage of using the robotic hook versus the Harmonic® scalpel is the wrist such as motion of the robotic instrument, which helps the surgeon precisely dissect critical structures such as the vena cava, adrenal vein and renal hilum. As seen in Table 4 the robotic instrument cost was $400 (Cardiere forceps and cautery hook). Depending on how many instruments/robotic arms, energy sealing devises and other hemostatic agents are used, the costs of adrenalectomy can add up significantly for both approaches LA or RA. Our consumables fees (calculated from our institution doctor preference cards) were $1106 for RA and $1009 for LA (Table 2).

Surgeon experience with any technique is acquired over time. Furthermore, the use of new technology to perform an operation (even with an experienced surgeon) is usually associated with a learning curve. Therefore, it can be said that the surgeon and the operative team experience with the operation and with the new technology are factors that drive cost. The senior author (CCS) has performed minimally invasive adrenalectomies for 15 years. After performing 20 RA, the procedure time was significantly decreased. The mean procedure time for our first 20 robotic adrenalectomy cases (136.8 min) was significantly higher than 118.2 min for the latter 38 cases ($p = 0.01$). The highly-trained surgical team (anesthesiologist, circulator, scrub technician and first assistant) can assist in reducing the operating time by helping with patient positioning, robotic docking and assisting with the course of the operation. We attribute our favorable initial operating times and docking times to the combined laparoscopic and robotic experience acquired by our dedicated surgical team over the last 7 years.

Hospitals are interested in cost efficiency. Several studies showed that the costs of robotic systems could be reduced by performing more robotic cases per year [9, 10]. In other words, the more robotic systems are utilized the more they become cost-effective for the hospital. Hospitals usually need to perform 150–250 robotic procedures per year for 6 years to balance the upfront and ongoing costs of getting a da Vinci system [18]. In the past 14 years, using five da Vinci robotic systems, approximately 9600 robotic cases were performed by urology surgery, gynecology, general/oncology surgery and Head and Neck surgery at our institution.

Table 5 Costs of da Vinci Robotic Instruments (per time used) (USD)

Robotic instruments	S/Si model	Xi model
Fenestrated bipolar forceps	270.00	270.00
Maryland bipolar forceps	270.00	270.00
Prograsp forceps	220.00	220.00
Cardiere forceps	200.00	210.00
Permanent cautery hook	200.00	250.00
Insert ACE harmonic	430.00	N/A
Harmonic ACE curved shears	55.00	327.00

In this study, all the patients underwent robotic-assisted adrenalectomy using da Vinci S/Si models. Since the da Vinci Xi (Intuitive Surgical, Sunnyvale, CA, USA) was launched in spring of 2014, more institutions have acquired this model. The biggest advantage of this Xi system includes the ability to attach the endoscope to any arm (good for robotic-assisted posterior retroperitoneoscopic adrenalectomy), flexibility for visualizing the surgical site (no need for redocking in multiple quadrant surgery), smaller and thinner arms with newly designed joints that offer a greater range of motion and longer instrument shafts designed for greater operative reach. The cost of instruments for the Xi system has increased for Cardiere Forceps ($210) and for Permanent Cautery Hook ($250) (Table 5). Using the Xi system will add another $60–$100 to the cost of RA at our institution. In the future, we plan to analyze the cost of RA after we have completed 20 cases using da Vinci Xi systems at our institution.

Conclusion

The current study shows that limiting unnecessary robotic instruments and energy devices as well as having an experienced surgical team can limit the cost of robotic-assisted adrenalectomy when compared to LA.

Compliance with ethical standards

Conflict of interest Zuliang Feng, Michael P Feng, David P Feng, Mark J. Rice and Carmen C. Solórzano declare that they have no conflict of interest.

Informed consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all patients for being included in the study.

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References

1. Buchs NC, Pugin F, Bucher P, Hagen ME, Chassot G, Koutny-Fong P, Morel P (2012) Learning curve for robot-assisted Roux-en-Y gastric bypass. Surg Endosc 26(4):1116–1121
2. Modi P, Rodriguez E, Chitwood WR Jr (2009) Robot-assisted cardiac surgery. Interact Cardiovasc Thorac Surg 9(3):500–505
3. Weinberg L, Rao S, Escobar PF (2011) Robotic surgery in gynecology: an updated systematicreview. Obstet Gynecol Int 2011:852061
4. Babbar P, Hemal AK (2011) Robot-assisted urologic surgery in 2010: advancements and future outlook. Urol Ann 3(1):1–7
5. Higashihara E, Tanaka Y, Horie S, Nutahara K, Homma Y, Minowada S, Aso Y (1992) A case report of laparoscopic adrenalectomy. Nippon Hinyokika Gakkai Zasshi 83:1130–1133
6. Gagner M, Lacroix A, Prinz RA, Bolté E, Albala D, Potvin C, Hamet P, Kuchel O, Quérin S, Pomp A (1993) Early experience with laparoscopic approach for adrenalectomy. Surgery 114:1120–1125
7. Horgan S, Vanuno D (2001) Robots in laparoscopic surgery. J Laparoendosc Adv Surg Technol 11:415–419
8. Morino M, Beninca G, Giraudo G, Del Genio GM, Rebecchi F, Garrone C (2004) Robot-assisted vs laparoscopic adrenalectomy: a prospective randomized controlled trial. Surg Endosc 18:1742–1746
9. Brunaud L, Bresler L, Ayav A, Zarnegar R, Raphoz AL, Levan T, Weryha G, Boissel P (2008) Robotic-assisted adrenalectomy: what advantages compared to lateral transperitoneal laparoscopic adrenalectomy? Am J Surg 195:433–438
10. Winter J, Talamini M, Stanfield C, Chang DC, Hundt JD, Dackiw AP, Campbell KA, Schulick RD (2006) Thirty robotic adrenalectomies: a single institution's experience. Surg Endosc 20:119–124
11. Bodner J, Augustin F, Wykypiel H, Fish J, Muehlmann G, Wetscher G, Schmid T (2005) The da Vinci robotic system for general surgical applications: a critical interim appraisal. Swiss Med Weekly 135:674–678
12. Barbash G, Glied SA (2010) New technology and health care costs—the case of robot-assisted surgery. N Engl J Med 363:701–704
13. Agcaoglu O, Aliyev S, Karabulut K, Siperstein A, Berber E (2012) Robotic vs laparoscopic posterior retroperitoneal adrenalectomy. Arch Surg 147(3):272–275
14. Berber E, Mitchell J, Milas M, Siperstein A (2010) Robotic posterior retroperitoneal adrenalectomy: operative technique. Arch Surg 145(8):781–784
15. Dickson PV, Alex GC, Grubbs EG, Jimenez C, Lee JE, Perrier ND (2013) Robotic-assisted retroperitoneoscopic adrenalectomy: making a good procedure even better. Am Surg 79(1):84–89
16. Karabulut K, Agcaoglu O, Aliyev S, Siperstein A, Berber E (2012) Comparison of intraoperative time use and perioperative outcomes for robotic versus laparoscopic adrenalectomy. Surgery 151:537–542
17. Ludwig AT, Wagner KR, Lowry PS, Papaconstantinou HT, Lairmore TC (2010) Robot-assisted posterior retroperitoneoscopic adrenalectomy. J Endourol 24(8):1307–1314
18. Barbash GI, Glied SA (2010) new technology and health care costs—the case of robot-assisted surgery. N Engl J Med 363:701–704