Comparison of DaVinci® Si and Xi robotic platforms for adrenal surgery. Effects on short term outcomes

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Comparison of DaVinci® Si and Xi robotic platforms for adrenal surgery. Effects on short term outcomes

OBJECTIVES: *To evaluate our experience and short term surgical outcomes between two robotic systems.*
METHODS: *The present study retrospectively analyzed 38 cases, who underwent robotic adrenalectomy between 2012-2019 at our center. The patients were divided into Group Si (n=11) and Group Xi (n=27), and the results of these two groups were compared.*
RESULTS: *Demographic characteristics of both groups were similar between two groups. While, 42% of the patients had Cushing syndrome, 22% had Pheochromocytoma and 22% had Conn syndrome in the Xi group, 72% of the patients were non-secreting adrenocortical adenoma in Si group (p=0.005). The mean docking time in Group Xi was shorter than Si group (p=0.027). Console and total operation times were similar in both groups (p=0.312 and p=0.424; respectively). The intraoperative complication rate (p=0.500) and hospital stay (3.2±1.0 vs. 2.52±1.42 days, respectively, p = 0.077) were similar in both groups. Postoperative 4th and 12th hour Visual Analog Scale (VAS) scores were similar (p=0.213 and p=0.857; respectively). The average cost of robotic consumables was $210 higher in Xi group (p=0.495).*
CONCLUSION: *Our study shows that; the Xi robotic system is as safe as the Si system for adrenalectomy operations.*

KEY WORDS: Adrenal gland surgery, Minimally invasive adrenalectomy, Robotic surgery.

Introduction

Minimal invasive approach has been an important milestone in the history of modern surgery. Laparoscopic and robotic surgical methods have been a widely-accepted minimal invasive approaches for adrenal lesions [1]. Robotic adrenalectomy (RA) was described only 7 years after the first laparoscopic adrenalectomy in 1999 [2,3] and since then, many studies verified the safety of this procedure with the complication rates ranging between 2.4 and 20% [4,5].

The robotic approach has provided a high-resolution, 3-dimensional, more stable image and precise dissection with articulated arms, in addition to the advantages of laparoscopic adrenalectomy, such as rapid postoperative recovery, shorter hospital stay and better cosmesis [6]. These advantages of the robotic platform have gained importance in challenging surgeries that require careful dissection in areas close to the main vascular structures like adrenalectomy. Its advantages particularly stand out in some difficult case such as large adrenal mass and/or obese patients with adrenal lesions [1,6].

Intuitive Surgical, Inc. (Sunny Valley, CA) developed the Da Vinci® Robotic Surgical System in 1999 and launched

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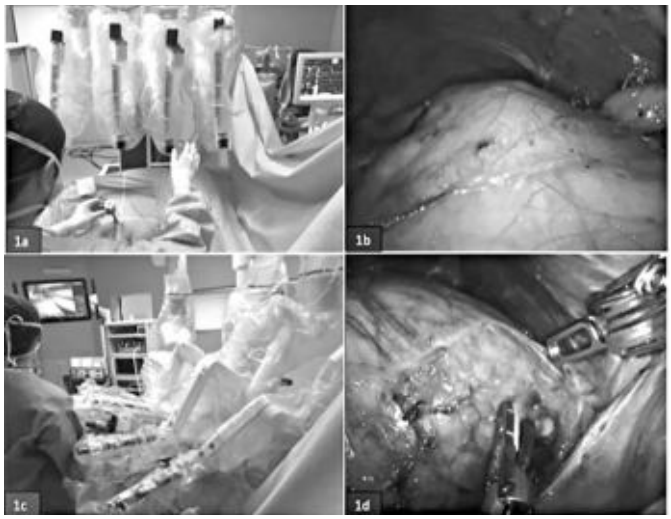

Fig. 1: New features in Xi system (1a-c): Laser Guided trocar positioning system (1a), Auto-targeting system's optimal positioning for the targeted organ (1b), Thinner universal robotic arms that are mounted on a rotating beam (1c); Dissection of a large adrenal cortical mass with ultrasonic energy device (1d).

the 4th generation Da Vinci Xi platform in 2014, five years after the Da Vinci Si [7]. Compared to the previous platform (Da Vinci Si), it had additional features including possibility of multi-quadrant surgery, easier docking, wider angle view with a slimmer endoscope, thinner robotic arms with 8 mm trocars, and the ability to attach the camera to all arms [8] (Fig. 1). Although there are articles comparing the effects of these two robotic systems on urological and Gastrointestinal system (GIS) surgeries [8-11], there are limited studies comparing their effects on adrenal surgery [12].
In this article, we aimed to evaluate the differences in short term surgical outcomes of RA between two robotic systems.

Methods

Study Design

The present study retrospectively analyzed 38 cases, who underwent RA between 2012-2019 at our center. The patients were divided into Group Si (n=11) and Group Xi (n=27), and the outcomes of these two groups were compared. The indication for adrenalectomy was made by evaluating the size, hormonal activity and radiological images of the adrenal mass according to current guidelines in the multidisciplinary endocrine board [13,14]. The multidisciplinary endocrine board includes specialists in general surgery, endocrinology, pathology, radiology and nuclear medicine.
Patients' demographic findings, body mass index (BMI), American Society of Anesthesiologists (ASA) scores, imaging results, laboratory findings and medical history were evaluated retrospectively. Surgical findings, duration of surgery stages (docking, console, total surgery times), intraoperative complications, the rate of conversion to laparoscopic or open surgery, perioperative blood loss, postoperative complications, length of hospital stay (LOS), and postoperative pain levels were also determined. Average cost was calculated from the wages invoiced to the insurance. Preoperative complications were evaluated with the Charlson Comorbidity Index (CCI) and postoperative comorbidity with the Clavien-Dindo classification. The pain levels of the patients were evaluated using the Visual Analog Scale (VAS) at the 4th and 12th hours. VAS recorded by asking the patient to give a number from 0 to 10 for the degree of pain ("No pain" is recorded as "0" and "worst pain" is "10"). Postoperatively all patients received 75 mg diclofenac sodium, intramuscularly every 8 hours and if the postoperative VAS score was >3, 50 mg tramadol was added.

Operative Technique

All the procedures have been performed with the da Vinci® Robotic Surgical System (Intuitive Surgical Inc., Sunnyvale, CA) by experienced endocrine surgeons who had completed their online and live training in accordance with Intuitive certification. As we have described in detail in our previous studies [15,16], standard lateral trans-peritoneal adrenalectomy operation was performed under general anesthesia by applying mild flexion at the level of the kidney with the patients lying in lateral decubitus position. Although the locations of the trocars vary

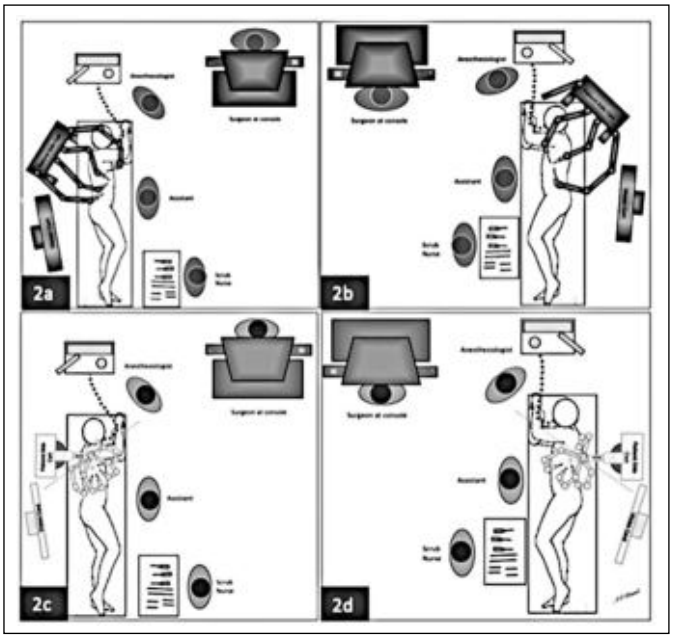

Fig. 2. Operation room and system setting for RA; (2a) Right RA with Si system, (2b) Left RA with Si system, (2c) Right RA with Xi system, (2d) Left RA with Xi system.

slightly according to the patient's anatomy, five trocars were used as standard in both the Xi and Si systems for right RA and 4 trocars were used for left RA. One trocar was placed for 30° camera, one trocar for bipolar cautery or grasper and third trocar for hook cautery or robotic ultrasonic sealing device. The 4th arm was used for the retraction of liver at right side and the assistant port for aspiration and clip applier on each side (5th at right and 4th at left). The initial entry to the abdomen was performed through a 12-mm incision for Si and an 8-mm for Xi using an optic trocar. After exploration, the docking process was started. The incision needed for the Xi system was smaller because of the thinner trocars (Fig. 1). Operation techniques were similar in both robotic systems, except the difference in docking systems and robot placements (Xi was placed ipsilaterally, while Si was placed diagonally; Fig. 2).

Ethics

Informed consent regarding the robotic procedure and possible complications was obtained from all patients who underwent robotic surgery for the adrenal gland. All procedures conducted in this study were in accordance with the ethical standards of 1964 Helsinki Declaration and its later amendments. Ethics committee approval was obtained from the local ethics committee (No: 2020-4-44 Date: November 2th, 2020).

Statistical Analysis

Statistical analyses were conducted on JMP® software version 9.0.1 (SAS®, Cary, NC). Continuous variables were expressed as mean ± SD. Categorical variables were expressed as frequencies and percentages. Student's t-test was used to compare parametric continuous variables, and the Mann-Whitney U test was used to compare nonparametric continuous variables. Categorical variables were compared with the Chi-Square test. A p value of less than 0.05 was considered statistically significant.

Results

Demographic characteristics of both groups were similar (Table I). The ASA status and CCI was also similar between two groups (p=0.159 and p=0.731; respectively). Previous abdominal surgery was more common in Group Si (p=0.087) (Table I).
In the Xi group, 42% of the patients had Cushing syn-

Table I - *Demographic findings and characteristics of adrenal masses*

Patient Characteristics	Si Group(n=11)	Xi Group (n=27)	p Value
Age, mean ± SD	47.2±3.6	49.9±2.3	0.525
Gender (n, %)			
Female	9 (81.8)	21 (77.8)	0.781
Male	2 (18.2)	6 (22.2)	
BMI, mean ± SD	24.7±2.9	26.7±5.4	0.498
ASA Status (n, %)			0.159
1	1 (9.1)	0 (0.0)	
2	6 (54.5)	18 (66.7)	
3	3 (27.3)	9 (33.3)	
4	1 (9.1)	0 (0.0)	
CCI, (n, %)			0.731
2-3	7 (63.6)	13 (48.2)	
4-5	4 (36.4)	12 (44.4)	
6-7	0 (0.0)	1 (3.7)	
>7	0 (0.0)	1 (3.7)	
Previous abdominal surgery (n, %)	5 (45.5)	5 (18.5)	0.087
Diagnosis, n (%)			0.005
Pheochromocytoma	0 (0.0)	6 (22.2)	
Cushing syndrome	2 (18.2)	11 (40.7)	
Conn syndrome	1 (9.1)	6 (22.2)	
Non-secreting adrenocortical adenoma	8 (72.7)	4 (14.8)	
Functional mass n (%)	3 (2.3)	23 (85.2)	<0.001
Side (n, %)			0.507
Right	7 (63.6)	14 (51.9)	
Left	4 (36.6)	13 (48.1)	
Tumor size (mm), mean ± SD	34.9±14.8	36±15.9	0.841
>5 cm tumor size, n (%)	2 (18.2)	4 (14.8)	0.796

BMI: Body mass index (calculated as weight in kilograms divided by height in meters squared); ASA: American Society of Anesthesiologists; CCI: Charlson Comorbidity Index.

drome, 22% had Pheochromocytoma and 22% had Conn syndrome. However, 72% of the patients in the Si group had non-functional tumors. (p=0.005). The tumor location was similar in both groups and was mostly on the right side (p=0.507). The mean tumor size was also similar between two groups (p=0.841) (Table I).

The mean docking time in Group Xi was shorter than Si group (p=0.027). Console and total operation times were similar in both groups (p=0.312 and p=0.424; respectively). The intraoperative complication rate was also similar (p=0.500). The cause of intraoperative complication was colonic serosal injury in the Xi group and diaphragmatic injury in the Si group. Both injuries were sutured robotically. There was no conversion to laparoscopic or open surgery in both groups and the need for intra-operative blood replacement did not occur (Table II).

The length of hospital stay (3.2±1.0 vs. 2.52±1.42 days, respectively, p = 0.077) were similar in both groups. In the Xi group, there were 3 postoperative complications, all of which were Clavien-Dindo 1, such as wound infection, atelectasis and urinary tract infection. No postoperative complications were observed in the Si group. (p=0.142). Postoperative 4th and 12th hour VAS scores were similar (p=0.213 and p=0.857; respectively). One patient in the Xi group was re-hospitalized due to adrenal insufficiency in the postoperative period (Table II). The average cost of robotic consumables was $210 higher (p=0.495) in the Xi group (Table II).

Discussion

This study showed that the Xi system is as safe as Si system for RA and has more satisfactory results in terms of docking time for adrenalectomy operations. Although, the total operation times were equal between the two groups, which may be caused by the higher number of hormone-active tumors in the Xi group causing longer dissection time prolonging the operation. In other articles comparing Xi and Si robots, the shortened docking time has been emphasized and it has been shown that this reduces the total operating time [8,12].

The laser targeting system allows to automatically arranging the robotic arms in relation to the targeted organ and improvements in robotic arms allow facilitating dissection in a narrow area while avoiding external collisions (Fig. 1). Another important benefit of the Xi System for adrenal surgery is that it can be placed anywhere relative to the patient. In this way, the arms can easily reach the adrenal gland of interest. However, the Si system had a fixed position. For adrenal surgery, the Si system should be placed over the patient's shoulder, which may endanger the functioning of the anesthesia team (Fig. 2). Although these technological developments and industrial equipment positively affect the surgical flow, we think it is challenging to show their direct reflection on patient outcomes.

The surgeon's adaptation to a new technological development may affect patient outcomes. While the oper-

TABLE II - *Operative findings and average cost of consumables*

Intraoperative Outcomes	Si Group (n=11)	Xi Group (n=27)	p Value
Docking time (min), mean ± SD	13.4±4.3	10±1.9	0.027
Console time (min), mean ± SD	102.1±30.7	114±33	0.312
Operative time (min), mean ± SD	138.1±39.8	150.7±45.2	0.424
Operative blood loss (min), mean ± SD	54.5±15.1	56.5±14.9	0.719
Complications, n (%)	1 (9.1)	1 (3.7)	0.50
Conversion, n (%)	0 (0.0)	0 (0.0)	N/A
Complications, n (%)			
Clavien-Dindo 1	0 (0.0)	3 (11.1)	0.142
LOS (day), mean ± SD	3.2±1.0	2.52±1.42	0.077
VAS Score, mean ± SD			
4th hour	5.8±0.75	6.5±1.2	0.213
12th hour	2.17±0.75	2.26±1.2	0.857
Readmission (n, %)	0 (0.0)	1(3.7)	0.517
Average cost of robotic consumables	$1.698	$1.908	0.495
da Vinci® Universal Seal	$24	$29	N/A
da Vinci® Arm Drape	$72	$83	N/A
Robotic instruments			N/A
Fenestrated Bipolar Forceps	$432	$432	N/A
Permanent Monopolar Cautery Hook	$320	$320	N/A
Harmonic ACE® Curved Shears	$688	$872	N/A

LOS: Length of Hospital Stay; VAS: Visual Analog Scale; $: United States Dollar. The price of robotic consumables was obtained from Intuitive Turkey (at December 28, 2020)

ations using the Si platform in our series were performed by a single surgeon who has completed the learning curve in robotic surgery, operations using the Xi platform were performed by 3 different surgeons. While one of them was the expert robotic surgeon who also used the Si system, the other two were novice robotic surgeons experienced in laparoscopic surgery who have not completed their learning curve in RA. Feng et al, emphasized that the learning curve is an important factor affecting the operation times, and they reported that the duration was significantly shortened after the first 20 cases [12]. Brunaud et al, stated that in addition to the surgical team, the size of the tumor can also affect the length of the surgery [17].

Feng et al. stated that the Xi system is suitable when the total patient cost is calculated despite similar consumable costs for RA [12]. The operational costs of the Xi and Si robotic systems in our adrenalectomy series were found partially similar to the literature. We found that, the cost of consumables per case for the Xi system were $210 more expensive (p=0.495) than the Si system, in our study (Table II). Nevertheless, we have noticed that some parameters might be responsible for this higher operational cost of Xi system: Novice console surgeons mostly performed RA in the Xi console, the number of hormonally active masses were higher in Xi group (especially pheochromocytoma cases) which might be in parallel with the increased usage of energy device in the Xi group. Furthermore, some of the consumable costs of the Xi system seems higher than Si system according to official pricing list obtained from Intuitive (especially the ultrasonic sealing device) which might be the other reason of this difference of operational cost in our series (Table II). There are very few data on robotic systems in adrenal surgery to compare the cost analysis we obtained. However, Patel et al. indicated in their study that the Xi system was more cost effective in terms of robotic nephrectomy procedures [11].

We believe that regardless of industrial incentives, good medical practice requires the use of newly developed technological devices in the surgical branch. The facilities provided by robotic technologies require the surgeons to adapt to these systems. While more than a decade ago, it was discussed whether the medical benefits of robotic technologies could outweigh their marketing roles [18], today, we can state that we are leaving these discussions behind. However, the high cost is still the most obvious disadvantage and its use in surgery is limited in many countries including ours. Hopefully the cost effectiveness will increase in the next few years with the development of new technologies.

The limitations of our study are its retrospective nature with a limited number of patients. In addition, the heterogeneity of the tumors of the operated patients in terms of diagnosis and hormone secretion status should also be stated as a limitation.

Conclusion

Our study shows that, the Xi robotic system is as safe as the Si system for RA. Although more complicated cases were operated with the Xi robotic system, similar results were obtained compared to the Si system. However, we believe that the advantages of the new robotic system may emerge in comparative studies with higher volume prospective randomized cases.

Riassunto

Si è voluto valutare la nostra esperienza e gli esiti chirurgici a breve termine tra due sistemi robotici per la surrenalectomia.

Sono stati analizzati retrospettivamente 38 casi, sottoposti a surrenectomia robotica tra il 2012 e il 2019 presso il nostro centro. I pazienti sono stati divisi nel gruppo Si (n=11) e nel gruppo Xi (n=27) e sono stati confrontati i risultati di questi due gruppi.

Risultati: le caratteristiche demografiche erano simili tra i due gruppi. Mentre, il 42% dei pazienti aveva la sindrome di Cushing, il 22% aveva il feocromocitoma e il 22% aveva la sindrome di Conn nel gruppo Xi, il 72% dei pazienti era adenoma corticosurrenale non secernente nel gruppo Si (p = 0,005). Il tempo medio di "attracco" nel gruppo Xi era più breve del gruppo Si (p=0,027). La console e i tempi operativi totali erano simili in entrambi i gruppi (p=0,312 e p=0,424; rispettivamente). Il tasso di complicanze intraoperatorie (p=0,500) e la degenza ospedaliera (3,2±1,0 vs 2,52±1,42 giorni, rispettivamente, p = 0,077) erano simili in entrambi i gruppi. I punteggi della Visual Analog Scale (VAS) postoperatori alla 4a e alla 12a ora erano simili (p=0.213 e p=0.857; rispettivamente). Il costo medio dei materiali di consumo robotici è stato di $ 210 superiore nel gruppo Xi (p = 0,495).

Conclusione: il nostro studio lo dimostra; il sistema robotico Xi è sicuro quanto il sistema Si per le operazioni di surrenectomia.

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