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Robotic Lateral Trans-Abdominal Adrenalectomy: Current Status

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Abstract

Purpose of Review Adrenal tumor surgery is routinely performed by minimal invasive surgery. We aim to overview of updates on lateral approach for robotic adrenalectomy.

Recent Updates In the era of robotic surgery with the feasibility and the ability to provide the surgeon of three-dimensional view, which allows maximum range of motion and precision with the different approaches in adrenalectomy. The lateral robotic approach was the most frequently performed.

Summary Robotic system is safe and effective approach that can be used for adrenalectomy and can be alternative to laparoscopic depending on patient's selection and surgeon's experience.

Keywords Robotic adrenalectomy · Lateral adrenalectomy · Updates in robotic adrenalectomy · Trends in robotic adrenalectomy · Lateral trans-abdominal adrenalectomy · Lateral trans-peritoneal adrenalectomy

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Introduction

Laparoscopic adrenalectomy has been the standard of care for small adrenal tumors since its introduction in 1992 [1]. It is shown to be a safe and effective method for benign adrenal tumors [2]. Nowadays, laparoscopic adrenalectomy is widely used as it reduces the mean perioperative pain, duration of hospitalization, and it improves recovery of patients [3].

However laparoscopic approach has its inherited limitations, which included handheld unstable camera platform, two-dimensional view with poor perception of depth and distance, and finally the rigid instruments with limited motion. Use of robotic systems has been adopted in some high-volume centers in the past two decades as an alternative to traditional laparoscopic approach [4]. The advantages of robot-assisted surgery are mainly manifested in following aspects: Three-dimensional and amplifying view, ergonomics and the activity range of endo-wrists. Robot-assisted surgeries have better comfortableness and shorter learning curve for surgeons [5].

The first introduction of robotic adrenalectomy was reported by Piazza et al. group in 1999 for a patient suffering from a right-sided adrenal adenoma causing Conn's syndrome, using the AESOP 2000 Surgical System (Computer Motion Inc., Goleta, CA) [6]. Soon afterwards, Hubens et al. group reported a left adrenalectomy using the same system for a patient with Cushing's syndrome [7]. In 2001, Horgan et al. group reported the use of da Vinci Robotic System (Intuitive Surgical Inc., Sunnyvale, CA) for adrenalectomy [5].

In this review, we aim to provide updates on the current status on lateral transabdominal approach in robotic adrenalectomy.

Preoperative Assessment

All patients undergoing adrenalectomy should have a recent contrast enhanced CT scan of the abdomen for anatomical delineation, to provide the most updated tumor size and its relationship to adjacent organ.

As in all endocrine disease, patient should have a thorough hormonal workup to confirm functional lateralization of the disease, which should be concordant with the anatomical localization in CT.

In selected patients, adrenal venous sampling may be used for functional lateralization of the disease. Patients with phaeochromocytoma should have adequate preoperative alpha, followed by beta blockade.

Indications

Indications for robotic lateral transabdominal adrenalectomy include hormone secreting tumors (glucocorticoid, estrogen, androgen, aldosterone, catecholamine), hormone inactive incidentaloma with size larger than 4 cm [8]. Other indications include removal of large sized myelolipomas, solitary metastatic tumor. Contraindications include very large tumors, radiological infiltrative adrenal masses, large vascular structure involvement or significant involvement of adjacent organs.

Patient Selection

Patient selection is always the key to success in surgery. This is particularly important when surgeon is still on the learning phase for a procedure [8].

When compared with traditional laparoscopic approach, the robotic approach is more useful for patients with a tumor size larger than 5 cm in diameter or those with BMI larger than 30 kg/m^2 [9].

The lateral transabdominal approach remains the most popular approach adopted by most general surgeons. This is due to the larger working space and the familiarized anatomy when compared with the posterior retroperitoneal approach. Larger working space also means fighting of mechanical arms is avoided.

The posterior retroperitoneoscopic approach was first described by Mercan et al. group in 1995. The posterior approach allows easy access to the Gerota's space retroperitoneally. It has been generally favored by urologist, and especially in patients with previous abdominal surgery. It is also beneficial in patient requiring bilateral adrenalectomies, where there is no need for repositioning of the patient [10].

The Setup

The patient is intubated under general anaesthesia. The patient is placed on right or left lateral decubitus position with cushion support, and the table is flexed at the level of umbilicus to open up the patient's costo-diaphragmatic angle. An incision is made just below the umbilicus and a 12 mm optical trocar is introduced. This first port would serve later as an assistant port for subsequent suction, clipping device and specimen retrieval. After the peritoneal space is entered, pneumoperitoneum is created and maintained with CO_2 pressure at 15 mmHg. Following insufflation, four robotic 8 mm trocars are inserted below costal margin in a linear array under direct laparoscopic vision.

In our center we employ total five ports (four robotic arms and one assistant) for both left-sided and right-sided adrenalectomies. After diagnostic laparoscopy, docking of robotic system is performed. Some centers would only employ the five port for right-sided adrenalectomy for the retraction of liver. However, we believe adding the fifth port would allow better visualization of surgical plane with retraction and counter-traction, hence shorter operative time. The addition of one more port does not affect patient's recovery as length of stay for most patients is 1 day.

The Procedure

Robotic Left-sided Transperitoneal Adrenalectomy

The procedure starts with medial mobilization of colon alone the line of Toldt, Fig. 1. Then the splenocolic and splenorenal ligaments are divided. This allows the spleen, colon and the pancreatic tail to further mobilize medially to expose the adrenal gland. Then, the periadrenal fat is dissected to identify the superior pole of the kidney laterally, the left renal vein inferiorly, the tail of the pancreas and splenic vessels medially and psoas muscle posteriorly, Fig. 2. The adrenal vein was then identified between the adrenal gland and left renal vein. The adrenal vein is then controlled with hem-o-loks and divided, Fig. 3. Adrenalectomy was finished with help of robotic harmonic device. The robotic trocars placement is illustrated in Figs. 4 and 5.

Robotic Right-sided Transperitoneal Adrenalectomy

A robotic monopolar hook is used to divide the triangular. ligament.

The procedure starts with division of the triangular ligament with use of the robotic monopolar hook. The liver is gradually retracted upwards with help of the fourth

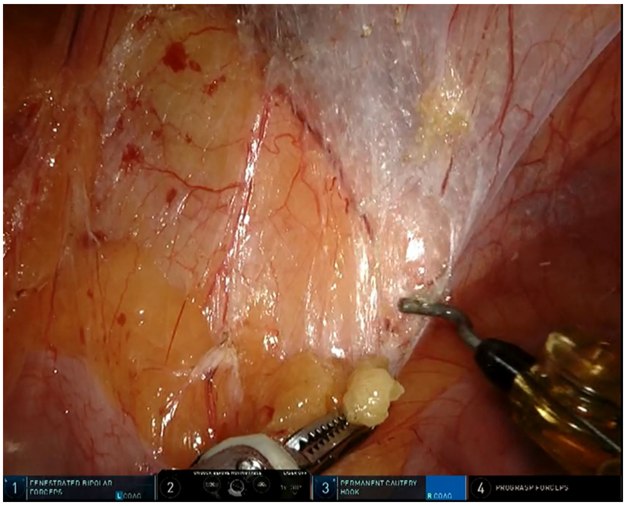

Fig. 1 Mobilization of descending colon along ligament of Toldt

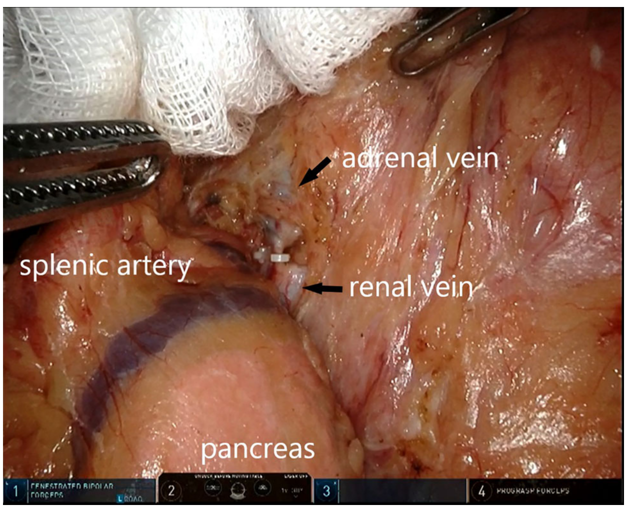

Fig. 2 Anatomy showing relationship of the splenic artery, pancreatic tail, left adrenal vein and the renal vein

robotic arms to expose the adrenal gland and inferior vena cava. The right adrenal vein is identified after precise dissection of vena cava and identifying the major components which include psoas muscle posteriorly and superior pole of the right kidney anteriorly. The adrenal vein is then controlled with hem-o-loks and divided.

Robotic Bilateral Transperitoneal Adrenalectomy

Malley et al. group reported the first bilateral robotic adrenalectomy in 2008 [11]. In this approach, the robotic is required to be undocked and patient is repositioned after one side adrenalectomy was finished, before proceeding to the contralateral side lesion. This synchronous approach is indicated selected patients suffering from persistent Cushing's disease following failure of hypophysectomy and

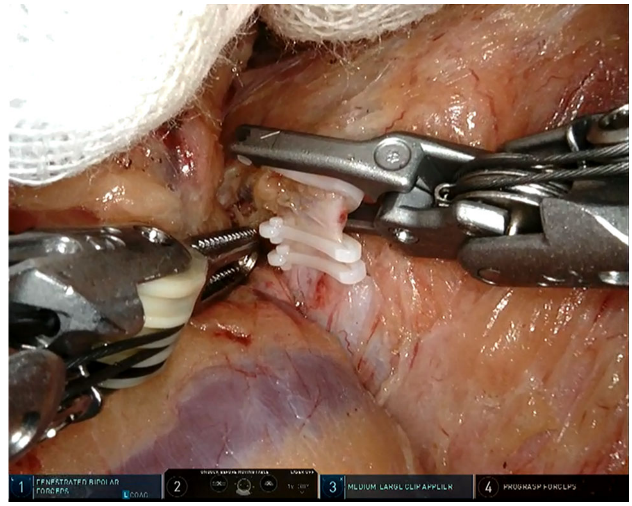

Fig. 3 Control of adrenal vein between haem-o-loks

ectopic ACTH production. Other rarer conditions include bilateral adenomas of large size, congenital adrenal hyperplasia and adrenal metastasis [12].

In a small study with 29 patients comparing bilateral robotic retroperitoneal, bilateral robotic transperitoneal and the traditional bilateral laparoscopic approach, it showed that robotic retroperitoneal approaches had shorter operative time because there is no need for re-docking and repositioning. There is no significant difference in postoperative outcomes in all three approaches [13].

Learning Curve

One of the most commonly criticized area for robotic adrenalectomy is the duration of operation, due to the additional time needed for docking of robots. Literature review showed various degree of learning curve in different centers.

Winter et al. group showed that the use of the robotic system in 30 patients resulted in a significant improvement in mean operative with a rate decrease of 3 min/case [14]. Brunaud et al. group reported that 20 cases should be sufficient to overcome the learning curve [15]. While D'Annibale et al. group stated that only 12 cases were needed for their learning curve [16].

The learning curve in robotic surgery does not only measure the gain in experience of the operating surgeon, but also the setup and docking time for the whole operating team in the theatre. It is important to have a well-organized team for proper docking and functioning of the robotic systems, as well as to tackle any potential problems encountered during surgery. This may explain why there would be difference in the learning curve in different centers, depending on the level of commitment of a well-prepared robotic team members.

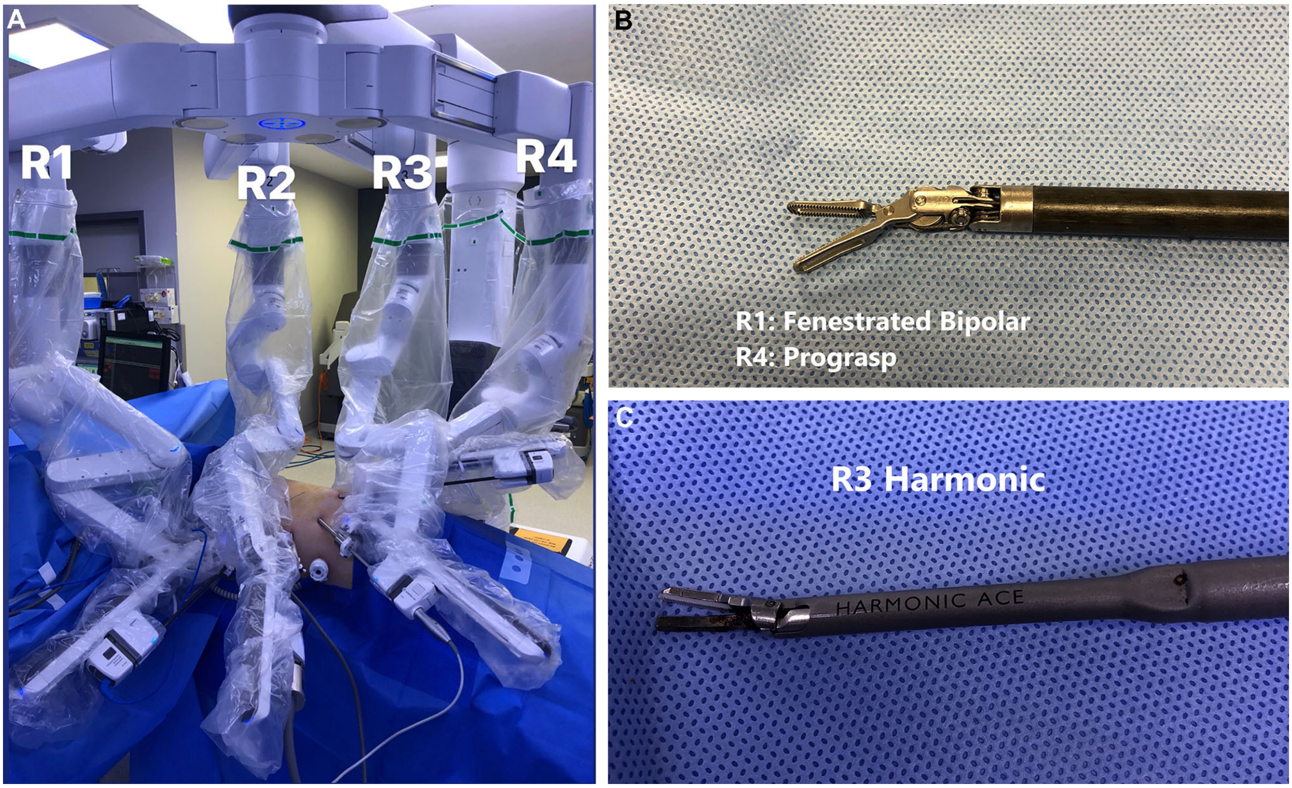

Fig. 4 **A** The robotic arm positions for a robotic left-sided lateral transperitoneal adrenalectomy. R1: Fenestrated biopolar. R2 Camera. R3 Harmonic. R4 Prograsp. **B** instrument photo for R1 and R4. **C** instrument photo for R3

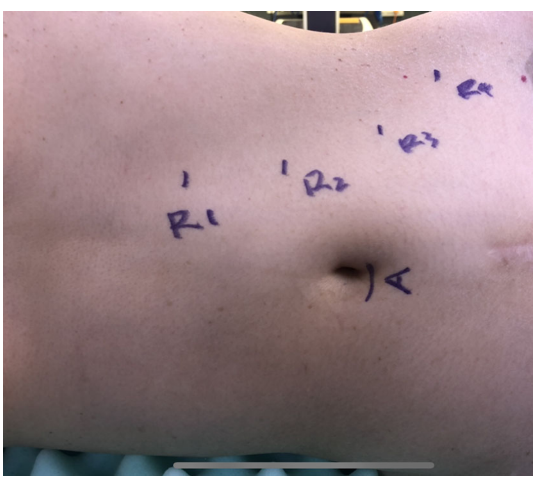

Fig. 5 shows the positions for robotic arms $\mathbf{R_1}$ to $\mathbf{R_4}$, and also the placement of assistant port at position **A**

Conversion Rate

Literature search results suggested conversion rate ranging from 0 to 8%. The main reasons for conversion include hemorrhage and large tumor size [17, 18]. Greilsamer et al. group reported a series of 303 patients receiving robotic adrenalectomy and suggested that tumor size more than 5 cm is the only predictive factor for open conversion [19].

A systematic review in 2014 showed that the most common cause of conversion from robotic to laparoscopic adrenalectomy or open laparotomy was bleeding (2.2%). Other causes included inadequate visualization (1.6%), prolonged operation time (0.5%), and tumor adhesion (0.5%). Patients with complications, such as bleeding or tumor invasion, were converted to open laparotomy, whereas those with minor problems, such as inadequate visualization, were converted to laparoscopic procedures. Overall conversion rates were similar for robotic and laparoscopic adrenalectomy [20].

Complications

The most common complications from robotic adrenalectomy include wound infection, hemorrhage, intraabdominal collection, incisional hernia and injuries to adjacent organ. Potential adjacent organ injuries for left-sided adrenalectomy include the left kidney, splenic flexure of colon, left renal vein, spleen, pancreatic tail, fundus of stomach and the diaphragm. While for right-sided adrenalectomy, the liver, hepatic flexure of colon, inferior vena cava and the diaphragm can be injured [4].

In a systematic review published in 2004, there were actually no unique complications related to robotic adrenalectomy. Types of complications in patients undergoing robotic procedures included pneumonia (1.6%), wound problems (1.6%), urinary tract infection 0.5%), postoperative ileus (0.5%), chylous ascites(0.5%), hyponatremia (0.5%), vomiting (0.5%), atrial fibrillation (0.5%), and postoperative bleeding requiring blood transfusion (0.5%) [20].

A meta-analysis published in 2017 including 1162 patients (747 treated with robotic adrenalectomy and 415 treated with laparoscopic adrenalectomy) showed that there was no significant difference between the robotic and the laparoscopic groups for intraoperative complication, postoperative complications and mortality. The overall risk of intraoperative complications for robotic adrenalectomy was 5.8% and that of postoperative complications was 6.8% [21].

Another systematic review carried out by Heger et al. group included 26 trials with 1710 cases showed that there is no significant difference between laparoscopic and robotic approaches regarding postoperative complications [22]. These results were again supported by a systematic review by Agrusa et al. [23] group published in the same year, which included 13 papers of 798 patients.

Risk Factors for Complications

Body Mass Index

Relevant literature on body mass index in robotic adrenalectomy remains controversial. Brunaud et al. group observed that the robotic approach offered advantages in obese patients with a BMI between 30 and 44 [15]. In contrast, Aksoy et al. group reported no significant difference in perioperative outcomes [24].

A recent paper carried out by Greilsamer et al. group analyzed 303 consecutive patients undergoing unilateral transabdominal RA. They showed that body mass index was not a significant risk factor for conversion, capsular rupture, or postoperative complication [19].

It is therefore likely that both the laparoscopic and robotic approach can manage obese patients well, depending on surgeon's experience.

Age

Thompson LH et al. group suggested that age does not increase incidence of intraoperative complications [25]. Calcatera et al. group also showed that age does not increase the chance of open conversion [26].

Tumor Size

In a study by Thompson et al. group published in 2017 who analyzed 659 patients undergoing adrenal surgery, 250 of whom underwent robotic surgery. In multivariable analysis, tumor size was associated with a higher risk of conversion to open surgery [25]. In a recent study of 111 patients receiving robotic lateral transperitoneal adrenalectomy published in 2020, tumor size more than 5 cm is an independent risk factor for open conversion. It is also associated with increased risks of postoperative complications and rehospitalization [27].

Hence, it is recommended that patients with tumor size more than 5 cm should be referred to high-volume endocrine surgery centers [19].

Pathology

Thompson et al. group suggest that the presence of a malignant lesion was linked to an increased conversion rate and an increase in postoperative hospitalization, but the pheochromocytoma did not appear to be connected with these events [25]. Greilsamer et al. group also examined hypercortisolism and pheochromocytoma, but found that they did not seem to correlate with a worse intra or postoperative outcome [19].

The lack of tactile feedback during dissection of pheochromocytoma can result in catecholamine liberation and increased perioperative risk [8]. A study by Aliyev et al. group comparing robotic with laparoscopic surgery in the management of pheochromocytoma showed that robotic approach pheochromocytoma seemed to be equivalent to the laparoscopic technique regarding safety and efficacy; there were also no differences between the two approaches regarding the intraoperative hemodynamic parameters [28].

Previous Surgery

Previous surgery resulting in intraabdominal adhesions was a well-known factor that increase technically difficulty during minimal invasive surgery. However, data on this area was scarce in the literature. In the Greilsamer series, history of previous ipsilateral upper mesocolic or retroperitoneal surgical procedure was found to be an independent predictor for capsular tear but did not correlate with the increased incidence of post-operative complications [19].

A consensus guideline for minimal invasive treatment of adrenal pathology was approved by the Board of Governors of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) in Feb 2013, which recommends the following.

- In patients with previous abdominal surgery, a retroperitoneal approach may be associated with less operative time and fewer complications (++ , weak).
- For bilateral adrenalectomies, the posterior retroperitoneal approach may be advantageous, as it eliminates patient repositioning during the case (+ + , weak).
- In morbidly obese patients (BMI > 35 kg/m^2) and for large tumors (> 6 cm), the lateral transabdominal approach may increase the feasibility of the procedure compared with the other approaches (++ , weak).

A recent review article was published in 2020 which focused on the risk factors for developing complications after robotic adrenalectomy. They suggested that tumor size, malignancy type, the completion of learning curve, and previous ipsilateral surgery were risk factors for postoperative complications and for failure of the robotic approach (either converting to laparoscopy or open surgery) [29].

Cost Effectiveness

The da Vinci robotic system cost one to two and a half million dollars per unit, not to mention the subsequent fees of annual maintenance, the cost of expensive instruments with limited reusable time. Approximately from 150 to 250 robotic procedures are required to be performed per year in the hospitals for 6 years to achieve a balance in the costs that paid in advance or ongoing costs of getting a da Vinci system [30].

Brunaud et al. group reported 2.3 times higher cost for robotic adrenalectomy compared with laparoscopic approach [17]. However, Winter et al. group reported no major difference in cost, which probably related to shorter hospital stay in the robotic adrenalectomy in their study [14]. It is reminded that the cost difference in the above studies did not consider the initial expense for the da Vinci system purchase.

Increasing the number of robotic procedures performed per year is an effective method to bring down the cost [31]. Feng et al. group suggested that by limiting the number of robotic instruments and energy devices and utilizing an experienced surgical team, the costs of robotic surgery can be kept similar to those of laparoscopic surgery [32]. Overcosts due to the use of the robotic system could also be balanced by shortening the hospital stay, patients' referral increase, improved postoperative outcomes in more difficult patients [31].

However, to date, there are still no available strong evidence that could balance overcosts associated with the use of the robotic system. The financial model of reimbursement has an important impact on this area. It is difficult to compare these data considering the different systems adopted in various countries, this explains the inhomogeneity of literature on the subject of costs of robotic adrenalectomy.

Conclusion

Robotic lateral transabdominal adrenalectomy is a safe and effective modality for management of common adrenal pathology. The surgical outcomes are comparable to its laparoscopic counterpart. Lateral transabdominal approach may improve the feasible of the procedure in selected patients with obesity and large tumor size. Further prospective controlled trials are needed to define more clearly the role of this technique.

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Compliance with Ethical Guidelines

Conflict of interest Chung Yau Law declares that he has no conflict of interest. Chung Ngai Tang declares that he has no conflict of interest.

Human and Animal Rights This article does not contain any studies with human participants or animals performed by any of the authors.

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