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ROBOTIC SURGERY (E BERBER, SECTION EDITOR)

Robotic Adrenalectomy: Updates on Lateral Transperitoneal Approach

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Abstract

Purpose of Review Adrenal tumor surgery is routinely performed by minimal invasive surgery.Our aim to overview of updates on lateral approach for robotic adrenalectomy. Through online research we obtained more than 30 articles in this review.

Recent Finding 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 the condition of the case and other factors.

Keywords Robotic adrenalectomy · Adrenal tumors · Adrenalectomy · Laparoscopic adrenalectomy

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Introduction

Laparoscopic adrenalectomy has been introduced in 1992 for the treatment of small adrenal tumors [1]. Currently, this strategy is the gold standard for the treatment of benign adrenal disorders [2]. Laparoscopic adrenalectomy is widely used as it reduces the mean perioperative pain, duration of hospitalization, and it improves recovery of patient [3].

Use of robotics has been increased in the operating theatre. Robotic adrenalectomy has been adopted by some high-volume tertiary centers, as an alternative of conventional laparoscopic adrenalectomy [•4]. Regarding surgery of adrenal gland, minimally invasive surgery has been considered as more effective than open surgery [•4]. Robotic adrenalectomy is associated with three-dimensional perception and has been proven to be a safe, effective and feasible method [5]. The first introduction of robotic adrenalectomy was reported by Piazza et al. in 1999 for Conn syndrome and performed a right adrenalectomy with the AESOP system [6]. Horgan et al. in 2001 described a robotic approach using the da Vinci surgical robot system [7]. This review aims to highlight the update on transperitoneal lateral approach for adrenalectomy.

Methods

We used scientific websites such as Google scholar and Pubmed to obtain articles related to this subject using several keywords such as " robotic adrenalectomy", "laparoscopic adrenalectomy", "adrenal removal", "comparison", "complications". We obtained 32 articles. Among those articles, all papers which did not mention the

use of robotic system or those published before 2010 were excluded. Overall, twenty articles and 2 duplications were excluded. Overall, this study focused mainly on recent publications and we included 8 articles which were published between January 2013 and 2020.

Preoperative Assessment and Surgical Indication for Lateral Transperitoneal Robotic Adrenalectomy

The most important factor for robotic adrenalectomy is the careful selection of cases as any other robotic operation, especially when the surgeon is early experienced [8]. Lateral robotic adrenalectomy is routinely performed in patients when robotic platform is available. The robotic approach could be more useful for patients with a tumor size larger than 5 cm in diameter or/and those with BMI larger than 30Kg/m^2. Other very good candidates for this approach include patients with severe hypercortisolism and patients with large pheochromocytoma with dense peritumoral [2]. One study [••9] reported that BMI of patients, tumor size and side did not have a negative impact on perioperative and post-operative outcome of robotic approach.

Indications for lateral robotic adrenalectomy include solitary small pheochromocytomas, rare lesions such as myelolipomas, hormonal secreting tumors (glucocorticoid, estrogen, androgen, aldosteronoma), hormone inactive lesions >3 cm which show growth over time and tumor diameter >5 cm. Special indications include removal of metastatic tumors. The difficulty of the procedure is increased by the size of the tumor and the suspicion of malignancy. Contraindications include very large tumors, infiltrative adrenal masses, large vascular structure involvement or significant involvement of adjacent organs. Severe cardiac insufficiency, uncorrected coagulopathy and serious cardiac conditions are also general contraindications [8]. In one study [8] adenomas represented the most of masses (60%), followed by pheochromocytoma as the second most frequent indication (16.7%).

Selection of Posterior Retroperitoneal Versus Transabdominal Lateral Approach

In case of tumor diameter larger than 6 cm, then transabdominal lateral approach should be indicated, whereas posterior retroperitoneal approach is more indicated when the tumor size is less than 6 cm [•10]. Selection of the surgical approach also depends on the presence of other criteria in favor of posterior approach: such as the abdominal adhesions that would preclude transabdominal lateral approach, or when the measured distance by CT scan between the skin and Gerota's fascia is less than 5 cm [•10].

Left-Sided Robotic Transperitoneal Adrenalectomy

This surgical procedure is performed for the patient while he/she is on the right lateral decubitus position [•4]. Complete medial colonic mobilization may be required for total exposure of the gland. The spleen, colon and pancreas are mobilized medially with caution during mobilization for the tail of the pancreas, mobilization of these organs takes place after dividing the lateral adhesions of the spleen and its ligaments, the mobilization is done until the gland is well visualized to the surgeon. The periadrenal fat then should be 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 in the posterior. A robotic clip applier or a standard laparoscopic clip by the bedside assistant can be used. The robot is undocked after completion of adrenalectomy and specimen retrieval bag is used for the removal of the gland then it is delivered through the auxiliary port site. Trocars are removed after the operative site is irrigated and suctioned [•4].

Right Sided Robotic Transperitoneal Adrenalectomy

It is performed with the patient placed on the left lateral decubitus position. The difference between left and right side is that the right side requires usage of more trocars (from 3 to 5), where one is used to aid for liver retraction. A robotic monopolar hook is used to divide the triangular ligament, whereas laparoscopic retractor is used for liver retraction in order to provide wide exposure of the inferior vena cave [•4]. Gerota's fascia is incised at the level of the upper pole of the kidney. 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. After identification of the right adrenal vein, a clip or vessel sealer is used for division. After dissection is completed using robotic hook, bipolar forceps and vessel sealer, the hemostasis is checked and gland then is removed using specimen retrieval bag [•4].

Bilateral Robotic Adrenalectomy

Single operation for resection of both adrenal glands is possible robotically. Robotic system can be used for this mission either peritoneally or retro-peritoneally [•4]. Bilateral robotic approach was first reported in 2008 [11].

This bilateral approach is indicated in case of persistent Cushing's disease following failure of hypophysectomy and ectopic ACTH production [12]. The other indications, though rare, include bilateral adenomas and adrenocortical

hyperplasia, congenital adrenal hyperplasia and adrenal metastases [3]. In the first publication, this approach was firstly used in the removal of right adrenal gland which lasted for 77 min, then the robot was undocked and the patient was placed into right lateral decubitus position for the removal of left adrenal gland which lasted for 55 min [11]. This procedure was also reported in a 60-year old patient with adrenocorticotropic hormone independent bilateral macronodular adrenal hyperplasia [13].

The bilateral robotic approach did not improve perioperative outcomes compared to laparoscopic approach in a series including 36 patients. However, it should be noted that the main indication was Cushing's disease after failure of hypophysectomy [12]. In another study [14] a comparison was performed between three different approaches regarding bilateral adrenalectomy for hypercortisolism in ACTH-dependent Cushing's syndrome: Simultaneous posterior retroperitoneoscopic, transabdominal robot-assisted and transabdominal laparoscopic. Shorter duration time was significantly observed for simultaneous posterior retroperitoneoscopic patients compared to transabdominal laparoscopic and transabdominal robot-assisted as it does not require repositioning of the patient. However, transabdominal robot-assisted patients showed a shorter hospital stay compared to the other two groups of patients. The three approaches showed no significant difference regarding intraoperative and postoperative complications [14]

Effectiveness of Robotic Adrenalectomy

Robotic lateral adrenalectomy is safe and feasible, documenting its effectiveness.

Reduction in Operating Time (Learning Curve)

A study by Winter et al. demonstrated 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 [•15]. In a study that evaluated the use of robotic-assisted unilateral adrenalectomies among the first 100 cases, there was a significant difference in the operative time between first and last cases and mean operative time decreased from 101 to 88 min [•16]. The reduction in time was more important for juniors, where it was found [•16] that operative time reduced from 123 to 97 min corresponding to 21% for juniors whereas it was reduced from 90 to 81 min corresponding to 9% for senior surgeons. In a cohort study including 100 patients, the authors found that operative time decreased significantly with experience over time [17].

Conversion Rate

Several studies reported a range of conversion rate from 0 to 8% [•15, •16, 18, 19]. In one study [16] the conversion among 100 cases was 5%, this conversion to laparoscopy was due to camera malfunction in one case and in 4 cases the conversion was to laparotomy (3 of patients were bleeding and the adrenal vein was hard to identify in the other patient). Bleeding is a problem that may lead to conversion, one study showed that both bleeding and dissection difficulties were the two main reasons for conversion to laparotomy in 7% of patients [17]. Tumor size is also a factor that can cause conversion, in one study including more than 300 robotic cases, it was reported that tumor size more than 5 cm was the only predictive factor for conversion to laparotomy [20].

Complications and Morbidity

The complications associated with robotic approach include wound infection, hemorrhage, urinary tract infection, hematoma and injuries of the adjacent organs [• 4]. However, these complications also occur in laparoscopic approach. In a meta-analysis included 27 studies which in turn included 1162 cases, where 747 and 415 patients performed robotic and conventional laparoscopic respectively, the meta-analysis showed that there was no significant difference between the two approaches regarding intra-operative complications [•15]. In a study conducted to evaluate risk factors for conversion during robotic assisted unilateral adrenalectomy, it was found that BMI was not a risk factor for postoperative complication, capsular rupture or conversion, whereas tumor size larger than 5 cm was the only factor predicting conversion to laparotomy. Moreover, both of conversion to laparotomy and age of patient were the predictive factors for postoperative complications [20].

Postoperative morbidity ranges from 4.8 to 20% [•15, •16, 18, 21, 22]. It was found that post-operative complications were observed among older patients in a mean age of 66 years old, and complications were more common among those performed operation for left-sided tumors (18%) than those performed for right-sided tumor [17]. Another study showed that post-operative morbidity and mortality was comparable between conventional and robotic laparoscopic adrenalectomy [5].

Comparison Between Robotic and Laparoscopic Adrenalectomy

Consensus

In 2013, recommendations regarding the surgical technique for adrenal gland pathologies for specific clinical conditions have been approved by the minimal surgical approach protocol of the American Society for Gastrointestinal and Endoscopic Surgery (SAGES), these recommendations are [•4]:

- Retroperitoneal approach may result in shorter operative time and less complications in the presence of previous abdominal surgery;
- In patients undergoing bilateral adrenalectomy, the posterior retroperitoneal approach may be a more appropriate option because of the advantages of not having to reposition the patient during the operation;
- The lateral transabdominal approach in morbid obese patients (body mass index > 35 kg/m^2) and for large tumors (> 6 cm) is more advantageous in terms of applicability compared to other surgical methods.

Time of Surgery and Tumor Size

It was found that the robotic system was more adapted to more difficult cases with larger tumors, where in the laparoscopic group, there was significant increase in time of operation for larger tumors (>55 mm) [23]. In a systematic review including 6 studies, only two studies reported longer operation time for robotic system and the other 4 studies showed no significant differences between robotic and laparoscopic adrenalectomy [24]. In the opposite of this findings there was two studies [25, 26] found that the mean operation time was longer in robotic system and this returns to docking time. In another study [27] the time of operation was similar in robotic group and laparoscopic group; it should be noted that the mean tumor size was larger in laparoscopic group.

Postoperative Morbidity Rate

Several studies reported that the mean rate of post-operative morbidity was higher among laparoscopic group patients [22, 25, 27–29]. One of the previous studies [27] was a meta-analysis that included 9 studies which collectively included 277 robotic and 323 laparoscopic approaches. This meta-analysis reported that robotic system was effective and safe regarding operative time, with shorter hospital stay and lower recurrence of post-operative complications and the conversion rate was similar to laparoscopic approach. One study compared robotic system with conventional laparoscopic and reported that the robotic system may be ideal tool for adrenal lesion surgery and robotic adrenalectomy was effective and safe and could be alternative to traditional laparoscopic adrenalectomy [2].

Hospital Stay and Blood Loss

A meta-analysis and systematic review conducted to compare robotic and laparoscopic adrenalectomy [30] included 13 studies. The total number of patients in this study was 798 patients, 379 of them performed using the robotic system and 419 underwent laparoscopic adrenalectomy. The two groups showed no significant difference in gender, age, tumor size or laterality. The robotic group showed significant less blood loss and shorter hospital stay. A superiority in favor of the robotic approach regarding blood loss and hospital stay was reported in another meta-analysis including 26 trials and 1710 patients [31]. However, another review included 1162 patients and showed that no significant difference was found between the two groups regarding blood loss [32]. Another study reported a drawback against the robotic system. Some difficulties can be observed when the surgeon is not scrubbed and operating at the console, and a trained laparoscopic assistant is needed at operative table to perform critical surgical steps such as occurrence of sudden bleeding [33]. This situation should be anticipated to avoid its occurrence.

Cost Effectiveness

The robotic system use is associated with over costs. It was reported by Bodner et al. [34] that robotic adrenalectomy was 1.5 times more expensive than laparoscopic adrenalectomy. Other studies concluded different costs ranged from no cost differences to 2.3 times more expensive regarding robotic approach [•15, •16].

The robotic-assisted adrenalectomy was first reported by Horgan et al. in 2001 [35]. The da Vinci robotic surgery is expensive, and the costs ranged between one to two and a half million dollars per unit. These higher costs involve the fees of annual maintenance, the cost of the robotic system in addition to more expensive instruments, as reported by Barbash et al. [36]. It was reported that robotic-assisted adrenalectomy costs did not significantly vary from that of laparoscopic adrenalectomy. In order to drive the cost of robotic-assisted adrenalectomy, there are a lot of ways that include: the surgeon and the operative team should be experienced with using a new technology to perform an operation. Using the arms of robots and instruments only when needed, the expense of the robotic system should be

decreased. The process of minimally invasive adrenalectomies was performed via the senior author for 15 years with a longer procedure time. While the procedure time was significantly decreased ($P = 0.01$) from 136.8 min for the first twenty robotic adrenalectomy cases to 118.2 min for the latter 38 cases after performing 20 robotic-assisted adrenalectomies. The operating time could be reduced through the help of the surgical team who are highly trained [circulator, anesthesiologist, scrub technician, and first assistant] through assisting with operation course and the positioning of the patient and help with robotic docking [37]. It was reported that the expense of robotic systems increased when they are more utilized in the hospital. Approximately from 150 to 250 robotic procedures are required to be performed per year in the hospitals for six years to achieve a balance in the costs that paid in advance or ongoing costs of getting a da Vinci system [36].

Feng et al. [••38] reported that the Xi group patients had anesthesia time (145.8 min) that was significantly ($P = 0.001$) lower than that in the Si group patients (170.4 min). Additionally, Xi group had a significantly ($P = 0.001$) shorter procedure time (92.1 min) than that in the Si group (122.5 min). Also, Xi group had docking time (18.2 min) that was significantly ($P = 0.04$) lower than that in the Si group (20.3 min). The first twenty robotic adrenalectomy cases took a procedure time (136.8 min) that was significantly higher than that time of the latter 40 cases (112.6 min). Feng et al. [••38] indicated that the expense of robotic-assisted adrenalectomy using model Xi ($3375) was lower than using model Si ($3430).

Conclusion

Robotic approach is safe and effective to perform an adrenalectomy. It can be used to perform removal of both adrenal glands during the same session if needed. Incidence of complications after robotic-assisted adrenalectomy is comparable to other techniques. However, risk factors for postoperative complications are considered to be large tumor size, age of patient and the need for conversion.

In conclusion, we find that the robotic system is safe and effective to perform an adrenalectomy with a short operative time, but the effectiveness and superiority of the robotic approach remain dependent on several factors. Further prospective and comparative studies are needed to define more clearly the role of robotic adrenalectomy.

Compliance with Ethical Guidelines

Conflict of interest The authors declare no conflicts of interests with respect to authorship or publication of this manuscript.

Research Involving Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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