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Robotic Adrenalectomy

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Abstract

Purpose Even though laparoscopy is still the gold standard technique of adrenal surgery, many of the recent reports noted the safety and efficacy of robotics. However, there are still scant data and debates regarding outcomes of robotics in adrenal surgery. The aim of this review was to discuss recent literature and provide institutional experience on robotic adrenalectomy.

Recent Findings Due to improved maneuverability, robotics have certain advantages especially in patients with large tumors or those needing fine dissection; however, longer operative times and increased costs are still major drawbacks for this technique.

Summary By excluding the disadvantages of conventional techniques, enhanced 3-dimensional view, articulated instrumentation, and comfort makes the robotic technique more striking. Although the use of robotic system has increased since 2010, we expect that the increase in use will continue as newer technologies and advanced surgical techniques pervade all corners of oncologic care.

Keywords Robotics · Robotic surgery · Adrenalectomy · Minimally invasive surgery · Adrenal tumors

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Introduction

When compared with conventional open surgery, minimally invasive techniques are associated with similar oncological outcomes while achieving better cosmetics, shorter hospital stay, reduced blood loss, and less postoperative pain [1–3]. Laparoscopic surgery is the gold standard technique for adrenal surgery and its application has been increasing recently. However, regarding minimally invasive approaches, the robotic system is the most recent invention. Although robotics was originally used primarily for cardiac surgery, several other specialties accepted its use and its popularity increased dramatically especially in the last two decades.

In this review, we sought to evaluate recent data regarding robotic adrenalectomy including surgical outcomes and, new inventions, and compared it with laparoscopy, the gold standard approach.

Patient Selection and Determination of the Surgical Technique

To date, several different surgical techniques have been introduced for the treatment of adrenal pathologies. While the approaches can be grouped related to the position of the patient as anterior transabdominal, lateral transabdominal, and posterior retroperitoneal, the surgery can be also be performed as open, laparoscopic, or robot-assisted with multiple ports or from a single site. However, the selection of the most appropriate approach and technique is still debatable regarding the experience of the surgeon and volume of the institution [4–6]. According to the Society of American Gastrointestinal and Endoscopic Surgeons' Guideline, the most appropriate approach is basically described as the one in which the surgeon is most familiar with [7•]. On the other hand, in a recent nationwide study, Samreen et al. reported that they were not able to clearly figure out specific patient-related factors that led to differentiate the individual approaches and specific choice of technique by surgeons [8].

Among the approaches, the most widely used one is lateral transabdominal. This approach also allows the surgeon to perform concomitant intra-abdominal surgeries and provides good exposure of the intra-abdominal structures [9, 10]. Moreover, in patients with locally invasive tumors involving adjacent organs, tumors larger than 10 cm, or those who need extensive lymph node dissection, open technique can be preferred to minimally invasive ones [11, 12].

The other approach used mostly by urologists is the posterior retroperitoneoscopic approach. The main advantage of this is the ease of direct access to the adrenal gland from retroperitoneum. It is generally preferred in patients with history of previous abdominal surgeries or patients with bilateral tumors. However, due to a small retroperitoneal working space, it is known to be unfavorable for large tumors [13]. Regarding this technique, in two studies, Berber et al. reported external collision of the robotic arms may occur based on patient body habitus; however, in another recent study, Feng et al. recommended the use of obesity trocars regardless of patient size to eliminate this major drawback [14–16].

On the other hand, the most recent challenge in minimally invasive adrenal surgery is the robotic single-incision adrenalectomy, which was first performed by Park et al. in 2011 [17]. After nearly 8 years, it is still a new concept for robotics, and only few studies have reported their experience related to this technique [18••, 19–21]. This year (2018), Intuitive Surgical Inc. received FDA approval for the da Vinci Sp™ single-port system. According to the limited data, Lee et al. demonstrated safety and feasibility of robots for single site adrenalectomy in two of their studies [19, 20]. However, due to lack of prospective series and large data in the literature, it is early to confirm the suggested advantages of single-port robotic adrenalectomy including oncological safety, superior cosmetics, and less postoperative pain.

Surgical Techniques

Robotic Multi-Port Lateral Transabdominal Adrenalectomy

The patient is positioned in a lateral decubitus position relative to the side of the tumor. Adrenalectomy is performed using 5 ports on right-sided and 4 ports on left-sided lesions. A 12-mm trocar is positioned on the line between the umbilicus and costal margin for optic scope. After the insufflation of CO_2, three 8-mm working arms are placed beneath the costal margin for left-sided tumors. For right-sided cases, one additional trocar is needed for liver retraction, and one of the trocars is routinely used by the first assistant for clip and/or energy-based device application or suction–irrigation. Generally, the abdominal exposure is done laparoscopically. Afterwards, the robot docking is achieved from the ipsilateral shoulder of the tumor side. Regarding instrumentation, the general manner includes use of forceps, a hook, and a 30° angled scope. The other 2 trocars include a liver retractor and instrument(s) for first assistant.

Initially, the dissection begins with the division of the right triangular ligament for right-sided and division of splenocolic and splenorenal ligaments for left-sided cases. The dissection is continued on supero-lateral borders to infero-medial borders of the tumor. Regarding the literature, for the ligation of the adrenal vein, energy-based devices can be safely used in vessels up to 7 mm in diameter; however, in our clinical practice, we prefer to use vessel sealing energy devices for adrenal veins up to 5 mm and clip the larger ones. The largest ones may warrant vascular stapling with a stapler. After the completion of the dissection, the robot is undocked, and the tumor is removed using a specimen retrieval bag.

Robotic Multi-Port Posterior Retroperitoneal Adrenalectomy

The patient is positioned in a jackknife position. The optical trocar is positioned approximately 1 cm below the 12th rib. In order to create a retroperitoneal dissection space, generally a balloon dissector is used. In cases without a balloon dissector, we recommend removing this trocar and performing a finger dissection for the creation of the working space. After the insufflation of CO_2, two 8-mm working arms are positioned to both sides of the 12-mm trocar. These working arms should be positioned separately to prevent the collision of the instruments due to small working space. The robot is docked from the shoulder side of the patient. The dissection planes, division of the adrenal vein, and specimen retrieval are similar to the transabdominal approach.

Learning Curve

The definition of learning curve accounts for the number of procedures needed in order to achieve similar perioperative outcomes with the gold standard technique. Laparoscopic surgery is difficult due to its requirement of psychomotor skills, precise maneuvers, and dexterity when compared to open surgery. Previous reports show a correlation between improved skills and video gaming for laparoscopic surgery

[22–24]; however, the same correlation was not reported in regard to the robotic system [25, 26].

Surgical outcomes such as operative time and postoperative complications can be affected by the surgeon's overall experience, harmony with the instruments, and assistant compliance. Several studies reported significant operative time reduction between their initial and last cases [27–30] and according to the literature the cut-off limit has been reported as 20 cases for robotic adrenalectomy [31–34]. However, these studies are generally from tertiary centers and surgeons are experienced in conventional endoscopic surgery and adrenalectomy [35, 36], which may have shown a false-negative fast decrease in the threshold of the learning curve. In our experience, the robotic system demands installation regulations and system troubleshooting which can be more complex than expected compared to open and laparoscopic surgery. Thus, difficult cases such as cortex sparing partial adrenalectomy or patients with large tumors or malignant lesions which may require lymph node dissections have steep learning curves.

Perioperative Outcomes

It is known that the shorter operative time plays a significant role in the postoperative recovery period of a patient. The published data note a wide range of operative times between studies. In a meta-analysis, Tang et al. reported a significant difference for operative time in favor of laparoscopy, whereas in a recent meta-analysis Agrusa et al. reported a different result that supports no significant difference between both techniques, regarding operative time [37, 38]. In addition, while in most of the studies longer operative times were in the initial portion of the learning curve for robotics, tumor size, previous abdominal surgery, and patient demographics were reported also as important factors effecting the outcome [39].

On the other hand, regarding outcome measures, duration of hospital stay and time to functional recovery are also other important measures. Several authors reported similar duration of hospital stay between robotic and laparoscopic adrenalectomy procedures [40–43]. A recent systematic review demonstrated that duration of hospital stay was significantly reduced in minimally invasive techniques compared to conventional open adrenalectomy [40]. It has been mentioned that both retroperitoneoscopic- and robotic-assisted adrenalectomies had similar outcomes compared to the laparoscopic technique, in terms of perioperative outcomes including intraoperative time, blood loss, and complication rates in pairwise meta-analysis.

Regarding complications, one of the main debates is related to iatrogenic injury of the robotics. In robotic surgery, there is loss of haptic feedback which makes the surgeon lack of the feel of tissue handling pressure and thus tissue can only be interpreted by visualization. Due to this pitfall, the most frequent complication which is generally seen in large tumors is capsular disruption during the maneuver of the lesion [27, 34]. However, we believe that the rate of this complication can be decreased, depending on the surgeon experience. In a recent study, Greilsamer et al. reported the risk factors for perioperative complications in 303 consecutive patients [42]. In this study, the author observed no capsular rupture of tumor and conversion to open surgery among the eight patients even in patients with adrenocortical malignancies.

In adrenal surgery, there are no data regarding iatrogenic injury of an intra-abdominal organ.

On the other hand, another important variable regarding the perioperative outcomes is blood loss. In a meta-analysis, Brandao et al. noted a significant difference between robotic and laparoscopic adrenalectomies regarding blood loss, in which the robot was confirmed to be superior [44]. However, in several other reports, authors showed a mean blood loss of 50 to 500 ml which is likewise the laparoscopic technique [45, 46].

Another variable considered as an important outcome of a minimally invasive procedure is conversion rate. Even though conversion cannot determine whether a surgery is successful or not, it can significantly affect the prognosis and perioperative outcomes of a patient. To date, conversion rates of robotic adrenalectomies have been reported in several studies as less than 10%; however, in a randomized study, Morino et al. noted the highest conversion rate for robotic adrenalectomy as 40% [47]. The reasons for this high conversion rate were adhesions, bleedings, trocar malpositioning, and anatomical variations. Hence, regarding conversion, the eligible studies showed no significance difference between robotic and laparoscopic techniques [6, 43, 48].

Large Tumors

Large adrenal tumors have been known to be associated with increased intraoperative difficulties. According to the literature, the upper size limit of minimally invasive adrenalectomy has been described as approximately 10 cm [48–51]. According to a recent Swedish nationwide study of 659 adrenalectomies, the authors mentioned the benefits of using robot including increased articulation, enhanced maneuverability in deep corners, and fine dissection for large tumors [52]. Likewise, Brunaud et al. reported the superiority of robotics especially in advanced cases including obese patients, large tumors, and patients with previous abdominal surgeries. [33].

Obese Patients

Obesity and its higher rates of chronic diseases and comorbidities are well-known risk factors for all surgical specialties' outcomes [53]. Few studies described the outcomes of robotic adrenal surgery in obese patients and most of them are case reports. [28, 33, 54, 55]. Regarding other specialties, Michael et al. reported that increased body mass index (BMI) negatively affects the outcomes of robotic radical prostatectomy compared to conventional approaches [56]. Also, like this study, Butt et al. reported significant correlation between obesity and its negative effects on outcomes of robot-assisted radical cystectomy [57].

According to the English literature, the first report comparing outcomes of laparoscopic and robotics in obese patients who underwent adrenal surgery shows similar perioperative outcomes [54]. Moreover, in this study Aksoy et al. reported that a higher BMI negatively affected the outcomes of laparoscopic procedures, especially increasing the operative time, whereas this difference was not noted for the robotic group. Brunaud et al. reported longer operation times in obese patients for the laparoscopic group, when compared to the robotic group in obese patients for adrenalectomy [33]. Contrary to Brunaud's study, in a prospective randomized trial, Morino et al. showed no significant difference between BMI and robotic and laparoscopic adrenalectomy [47]. In our experience of nearly 80 robotic adrenalectomy cases, regardless of the patients' BMI, we observed less blood loss in robotic surgery cases when compared to conventional laparoscopic surgery; however, we did not observe any significant advantages of robotics for obese patients (submitted data).

Malignancy

Minimally invasive techniques have been generally preferred for benign adrenal pathologies. There are still scant data regarding the surgical approach for malignant lesions and those which are highly suspicious for adrenocortical cancers. In a recent literature review, Ball et al. noted the lack of prospective studies regarding adrenocortical cancers for robotic approach [58]. The conventional open technique is still seeming the most valid and accepted for better oncological outcomes including significant lymph node dissection, en bloc resection of the tumor, and tumors with adjacent organ involvement.

Partial Adrenalectomy

Even though the robotic approach preserves the benefits of minimally invasive surgery over conventional open surgery, it is still unclear whether these beneficial effects are also observed when compared to laparoscopic surgery. It is well known that the robot adds a technical advancement that may prove advantage especially in cases requiring fine dissection by articulated instrumentation and magnified three-dimensional optics [59].

Partial adrenalectomy, which was defined as sparing the parenchyma of the adrenal gland, is one of the more challenging procedures for minimally invasive cases. The first partial robotic adrenalectomy was described in 2006 by Julien et al. [60], and after that, it has been described as a safe and feasible technique in various studies [61–64]. To date, one of the largest series was reported by Asher et al. [62] with an excellent result of no recurrences. Moreover, in another study, Boris et al. also reported 1 recurrence out of 13 patients [63]. As a comparison group, in studies regarding laparoscopic technique, several authors have reported a local recurrence rate of approximately 10% in patients who underwent partial adrenalectomy [50, 62, 65]. According to our clinical practice, these data support the benefits of the robot, compared to the rigid instrumentation of standard laparoscopy in advanced cases for partial adrenalectomies that require fine dissection.

Cost

One of the most well-known critics of the usage of robotics is its high cost [66–68]. To date, the only surgical system on the global market is Intuitive Surgery Inc. the da Vinci system. Although new systems are expected to be released soon, the da Vinci system comes with an approximate capital cost of USD$ 1 to 2.5 million [69].

Even though the reported costs of robotics may vary, most of the authors reported the significant high cost of this technology [70–73]. In a study, Tyler et al. expressed the cost of $3424 for robotic surgery, compared to laparoscopic surgery for the entire hospital encounter [70]. Likewise, Bodner et al. reported the approximate cost difference of robotics compared to laparoscopy as 1.5 times more [72]. In addition to the high cost, Halabi et al. also stated that robotic surgery led to greater costs without any associated advantages compared to laparoscopy [71]. However, in several other studies it has been indicated that, in high volume centers, the cost can decrease to a more suitable level compared to other conventional techniques and could be affordable [47, 73]. In a recent study, Feng et al. reported a comparable cost between robotic and laparoscopic adrenalectomy [14]. In this study, the author also noted that limiting unnecessary robotic instrumentation and energy devices as well as an experienced surgical team may decrease the cost of robotics significantly.

Conclusions

The role of robotics in adrenal surgery continues to progress and has recently been positioned as an acceptable modality for many surgeons. However, there are still scant data regarding high-quality prospective randomized studies on this particular topic. Several studies have failed to demonstrate significant differences between robotic and laparoscopic adrenal surgery in terms of perioperative outcomes.

The choice of approach and technique will depend on tumor characteristics, patient demographics, and the experience of the surgeon. We believe that the main handicap of robotics is only its cost; however, due to its technological advantages when compared to laparoscopy, it is a viable candidate for being the state-of-the art technique for patients with large tumors and for tumors requiring fine dissection especially.

Compliance with Ethical Standards

Conflict of interest Orhan Agcaoglu and Ozer Makay each declare no potential conflicts of interest.

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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