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Minimally Invasive Adrenalectomy

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Introduction

Since the first laparoscopic adrenalectomy was described in 1992 by Gagner et al.[1], minimally invasive adrenalectomy has gained its current importance and variety with the developments in surgical technology. Minimally invasive adrenalectomy became a gold standard approach for the treatment of benign adrenal lesions considering less postoperative pain, improved patient satisfaction, and shorter hospital stay and recovery time compared to open adrenalectomy[2].

After the introduction of laparoscopic adrenalectomy, various minimally invasive approaches have been developed for adrenal masses. Another commonly used surgical technique is the posterior endoscopic approach, which was first described by Mercan et al.[3] and provides direct access to the adrenal glands via a retroperitoneal approach. Furthermore, robot-assisted adrenalectomy has also been demonstrated after introducing robotic surgical systems[4]. Several studies have evaluated the suitability of different surgical approaches to adrenal masses. On the other hand, it is still unclear which option is optimal. Therefore, this article reviews different approaches in adrenalectomy regarding the advantages and limitations of each technique.

Laparoscopic Transperitoneal Adrenalectomy

Laparoscopic transperitoneal adrenalectomy (LTA) is the most widely used technique, as it offers the surgeon many advantages in terms of a familiar surgical view and a wide working space. In addition, after the mobilization of the surrounding organs in the lateral decubitus position, the adrenal gland is identified easily with the benefit of gravity. For these advantages, LTA has become a gold standard treatment for adrenal masses. Although the indications were limited at first, according to the developing technology and surgical experiences, the current LTA indications are benign hormone-inactive or active tumors, including pheochromocytoma, cortisol-producing adenoma, and aldosterone-producing adenoma, as well as malignant adrenal tumors, including adrenal cortical carcinoma and malignant pheochromocytoma[5]. The size criterion for the extirpation of benign adrenal tumors is more liberal in LTA than the posterior retroperitoneoscopic approach (PRA) and depends on the experience of the surgeon[6]. However, advanced malignancies (Especially with another organ invasion) or large tumors are still considered indications for open adrenalectomy.

Patient Position and Surgical Technique

The patient should be placed initially in a supine position for induction anaesthesia. An orogastric tube for gastric decompression and a Foley catheter are usually placed, and generally removed at the end of the procedure. The patient is turned in a total lateral left decubitus position for the right and a total lateral right decubitus position for the left adrenalectomy, respectively, with the 10th rib directly over the breakpoint in the table. A cushion/gel is placed under the opposite flank for the side of the surgery. The table is flexed to maximize the space's exposure between the costal margin and the iliac crest, avoiding excessive tension of the abdominal wall[2].

The Veress needle or Hasson technique may be used to access the abdomen. The initial entry is made at the anterior axillary line, 8-10 cm below the costal margin. The authors prefer to use the Hasson technique with a 10 mm trocar and a 10 mm 30° laparoscope. The abdominal cavity should be insufflated to 12-15 mmHg. After the inspection, additional 1 -mm ports are placed medial and lateral to the initial port, making sure that port sites are longer than 8-10 cm apart to allow for mobility of the laparoscopic instruments. Additionally, one more 5 mm port is placed in the right LTA to aid in liver retraction.

The most critical point in providing exposure in right adrenalectomy is the dissection of the liver's right triangular and hepatoparietal ligaments. Thus, the liver is mobilized, and the vena cava and other structures can be easily identified. Then, the adrenal gland is separated from the surrounding tissues by meticulous dissection with hook cautery. Bipolar or ultrasonic energy-based devices seal the arterial structures encountered in dissection. At the prominent landmark of the inferior vena cava, dissection is continued, and the adrenal vein is identified. Next, the adrenal vein is ligated with an energy-based device and cut. Then, dissection is continued with the energy-based device or hook cautery, and the adrenalectomy is completed.

Left laparoscopic adrenalectomy starts with the mobilization of the left colonic flexure. It continues with the dissection of the splenoparietal ligament, which starts at the posterior and inferior edges of the spleen. This manoeuvre allows falling down the whole splenopancreatic block *via* gravity and provides better visualization of the kidney's upper pole and the adrenal gland. The dissection of the left adrenal gland should start on the medial border of the gland from the upper to lower adrenal pole. Thus, the lateral rotation of the adrenal gland is provided, and the area where the adrenal vein runs is revealed. After identifying and sealing the adrenal vein, the gland is released from the surrounding tissues with the help of energy-based devices and hook cautery.

Posterior Retroperitoneoscopic Adrenalectomy

Posterior retroperitoneoscopic adrenalectomy (PRA) was first described by Mercan et al. [3] but was extended and popularized by Walz et al. [7] . Initially, the advantages of PRA over LTA were defined as minimal visceral mobilization, safe application in patients with previous abdominal surgery, and no need for repositioning in patients scheduled for bilateral adrenalectomy. Although it was defined recently with LTA, the two main reasons PRA has not been as famous as LTA are because surgeons are not familiar with retroperitoneal anatomical landmarks and the technique initially described is not as smooth and easily applicable as it is today [7].

The retroperitoneoscopic approach is indicated for biochemically functional (< 7 cm) or benign (4-7 cm) adrenal neoplasms and isolated metastases [8,9]. Adrenocortical carcinomas or tumors that appear potentially carcinomic (based on imaging characteristics) can be approached laparoscopically if they are less than 6 cm [10].

Patient Position and Surgical Technique

The patient is positioned prone, lying on a pillow that allows the abdominal wall to hang ventrally through with a 90° angle between the body and the legs (Figure 1A). A 1.5 cm skin incision is made at the level of the 12th rib, and the retroperitoneal area is entered by blunt and sharp dissection with scissors. The surgeon's index finger is inserted into the space, and the tip of the 11th rib is localized. A 5 mm port is inserted under the guidance of the finger just below the tip of the 11th rib. Carbon dioxide insufflation at a pressure of 20-25 mmHg is started before the insertion of the third (medial) port [11]. Next, a 10 mm blunt trocar with an inflatable balloon (Applied Medicine, California, USA) is inserted into the initial incision site. That prevents air leaks around the port. The working space is created by blunt dissection with the endoscope looking at the diaphragmatic crus. Therefore, the 10 mm medial port is inserted under the view of the endoscope (Figure 1B-C). The endoscope is inserted into the medial 10 mm port, and dissection starts. The Ligasure Maryland Jaw 5 mm (Medtronic, Minneapolis, USA) is generally preferred for dissection and vessel sealing.

Adrenal gland dissection starts with determining the upper pole of the kidney and identifying its border with the lower pole of the adrenal gland. Then, continuing from lateral to medial, the inferior vena cava on the right and the adrenal vein on the left are visualized. On the right side, after dissecting the retrocaval arteries, the dissection is continued cranially to reach the adrenal vein. The main adrenal vein is sealed and cut with an energy-based vessel sealing system. Adrenal gland manipulation should always be performed with blunt instruments to prevent unwanted bleeding and rupture of the gland capsule. The dissection is then carefully completed cranially and ventrally without damaging the peritoneum. The adrenal gland is removed through the middle incision with a 10 mm EndocatchÒ (Medtronic, Minneapolis, USA).

Robot-Assisted Laparoscopic Adrenalectomy

Robot-assisted laparoscopic adrenalectomy (RLA) is a method that is positioned as a safe, feasible, and effective option since it is considered to be associated with three-dimensional perception, a tremor-free operation, and enhanced range of motion of multi-joint robotic arms. Due to these advantages, RLA has taken its place in current endocrine surgery practice as an alternative option to conventional laparoscopic adrenalectomy[12,13]. Although the indications for RTA are almost the same as for LTA, some authors have stated that it may be helpful in large adrenal masses and patients with obesity (BMI > 30 kg/m^2)[14].

Patient Position and Surgical Technique

The patient position is given as in conventional LTA, but there are a few differences in port placements. DaVinci Si or Xi robotic surgical systems (Intuitive Surgical Sarl, Aubonne, Switzerland) are the most common Robotic systems used for RLA. These systems include the three-arm robotic manipulator and remote-control surgical console. Four or five ports are used for the procedure. The first incision for the camera port (12mm) is made above and lateral to the umbilicus, at the lateral border of the abdominal rectus muscle across from the 12th rib. After entering through the abdominal cavity with the Hasson technique, the camera port is inserted. Next, a 30 degree-endoscope is placed through the port, and the abdomen is carefully inspected to rule out accidental injuries or other intra-abdominal masses. Two 8 mm ports for robotic arms and one 12 mm for manual assistance (and one additional for right-sided to aid in liver retraction) are inserted under the guidance of the endoscope[15].

The ports must be placed about 8–10 cm from each other to avoid clashing between the robotic arms. The role of the assistant on the surgical table is to change the robotic instruments when necessary, assist in dissection through the assistant's port, attach the clip to the adrenal vein or seal with the vessel sealing device, and perform the wash & aspiration process. After port placement, the circulating nurse places the robotic cart for docking at 11 o'clock from the patient's head for right adrenalectomy and at 1 o'clock for left adrenalectomy.

On the left side, as in LTA, a complete medial colonic mobilization may be needed for the perfect adrenal gland exposure. After dividing the lateral adhesions of the spleen and splenorenal ligaments, the spleen, colon, and pancreas are mobilized medially until the adrenal gland is visualized. Next, dissection continues into the periadrenal fat to identify the following landmarks[15]:

- inferiorly the left renal vein
- laterally the superior pole of the kidney
- medially the tail of the pancreas and splenic vessels
- posteriorly the psoas muscle

Then the adrenal vein is carefully dissected and sealed via an energy-based vessel sealer devise. Before the mass is removed from the abdomen, it is advised to wait 3–4 minutes after the intra-abdominal gas is evacuated and re-check the operation site for bleeding control. After the adrenalectomy is complete, the robot is undocked, and the gland is removed using an endoscopic retrieval bag and delivered through the auxiliary port site.

Regarding the right side, the triangular ligament is separated via a robotic monopolar hook, and the liver is retracted with a laparoscopic retractor for better exposure of the inferior vena cava. After the incision of Gerota's fascia at the level of the upper pole of the kidney, the vena cava is seen clearly. After the detailed dissection of the vena cava, the right adrenal vein is identified. Then the assistant divides the adrenal vein after sealing it with an energy-based sealer device or clipping. Dissection of the adrenal gland is completed with a robotic hook, bipolar forceps, and/or energy-based vessel sealer. Hemostasis is checked as in the left adrenalectomy, and the gland is removed using an endoscopic retrieval bag[15].

Discussion

Minimally invasive adrenalectomy has become standard care for most adrenal tumors, even if malignant [16], and can be performed laparoscopic or retroperitoneoscopic. LTA offers a more familiar view of the anatomy, the ability to explore the whole abdominal cavity, and more space to work with larger tumors [17]. In addition, PRA has several unique advantages over LTA, including avoiding the intraabdominal cavity, a more straightforward approach to the adrenal gland, preventing the need to manipulate intraabdominal structures, and avoiding repositioning patients for bilateral procedures [7]. In a randomized controlled prospective study, Barczyński et al. demonstrated that PRA has earlier oral intake, shorter operative time, less blood loss, shorter postoperative hospital stay, and less postoperative pain on postoperative day one compared to LTA [18]. Although a meta-analysis published by Constantinides et al.[10] stated that there was no difference between the two methods, in the current meta-analysis, PRA was found to be superior to LTA in terms of blood loss, length of hospital stay, postoperative pain, and operation time [19].

On the other hand, it should always be kept in mind that there may be bias in the length of hospital stay in the studies included in the meta-analysis. However, shorter hospital stays may be associated with less postoperative pain. Possible explanations are that the peritoneum is not breached and no manipulation of the viscera occurs in PRA. Additionally, less blood loss in PRA can be explained by high retroperitoneal pressure (20-25 mmHg) and less dissection due to direct access to the adrenal gland. Additionally, The reasons for less blood loss in PRA can be explained by high retroperitoneal CO_2 pressure (20-25 mmHg), providing hemostasis with the compression effect of the minor vessels and less dissection due to direct access to the adrenal gland. At the same time, the high retroperitoneal insufflation pressure could often compress the vena cava or renal vein, reduce venous returns from the adrenal gland and eventually cause less estimated blood loss [20].

After robotic surgical techniques were defined and popularized, the authors compared this technique with conventional laparoscopic adrenalectomy and retroperitoneoscopic adrenalectomy. RLA was advantageous in terms of estimated blood loss and length of hospital stay in a retrospective study comparing three minimally invasive techniques (LTA, PRA, RLA)[21]. Additionally, Brandao et al. stated that RLA provides potential advantages of a shorter hospital stay and less blood loss in a systematic meta-analysis comparing RLA and LTA[22]. It is an expected result that the estimated blood loss will be less with 3D vision support and meticulous dissection provided by the wide-angle robotic arms. On the other hand, in a systematic review, Chai et al. demonstrated that PRA was more effective than LTA, especially in reducing operation time and hospital stay. Still, no evidence showed that RLA was superior to LTA[23].

A recent multi-center study, including more than 1000 patients, shows that RLA resulted in a lower complication rate and shorter hospital stay, compared with conventional laparoscopic adrenalectomy[24]. Furthermore, in a systematic meta-analysis, Gan et al. stated that RLA is a better alternative to conventional laparoscopic surgery in the treatment of adrenal tumors, especial in terms of estimated blood loss, length of hospital stay, and conversion to open surgery[25].

Considering the technical aspects of robotic surgery, RLA may be an alternative to conventional laparoscopic adrenalectomy in patients with BMI > 30 and large adrenal tumors, as it provides ease of working in a limited surgical field. In this regard, Morelli et al. proved that RLA shows potential benefits compared to LTA, particularly in patients with nodules ≥6 cm, BMI ≥ 30 kg/m2, and with previous abdominal surgery[26].

It has been reported that hemodynamic instability and intraoperative blood loss were less in RLA with the ease of dissection provided by quite sensitive wide-angle robotic arms in large pheochromocytomas [27]. Furthermore, Vatansever et al. demonstrated that RLA has fewer postoperative complications than LTA in pheochromocytoma surgery [24]. A randomized controlled prospective study comparing robotic and conventional laparoscopic surgery, including patients with pheochromocytoma, showed that patients with high normetanephrine levels could benefit from less blood loss and operative time when a robotic surgery system was used [28].

Despite all these benefits, cost remains a significant limitation for robotic surgery. Agcaoglu et al. estimated that the cost of RLA was higher than LTA due to the fees of additional instruments and annual maintenance [29]. In addition, It has been demonstrated that the cost of general surgery procedures increased significantly when the cases were performed robotically instead of laparoscopically [30,31].

Conclusion

Minimally invasive adrenalectomy remains the gold standard in adrenal gland surgery (except for locally advanced, invasive carcinomas), no matter which approach is performed. Surgeons should choose the most appropriate method wisely after evaluating parameters such as minimally invasive surgical experience, cost, patient diagnosis, tumor size, and previous abdominal surgery.

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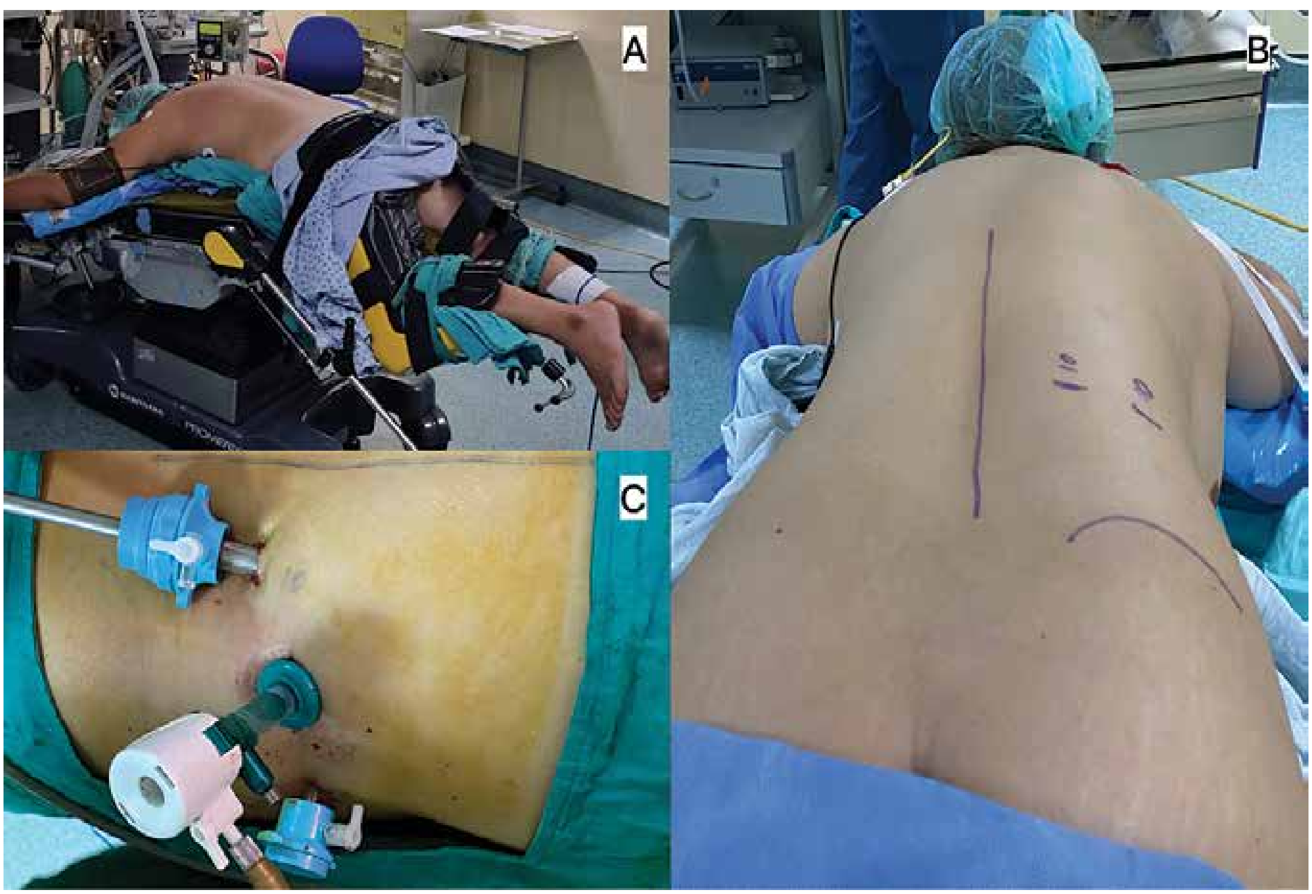

Figure 1: A-Patient position during posterior retroperitoneoscopic adrenalectomy.
B- Identifying port placement according to anatomically landmarks C-Port placement