Review Article

# Challenges of training in adrenal surgery

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**Abstract:** While adrenal tumors are common, adrenalectomy is rather uncommon. This is one reason for the many challenges regarding the training of adrenal surgery. Here we focus on issues that are most pertinent regarding training of the young surgeons performing adrenalectomy. Due to the very limited literature, what is presented is mainly based on personal experience and/or from the literature published for other surgical operations and subspecialties. The discussed challenges include indications for surgery, surgical approaches and extent, and intraoperative complications. With advances in adrenal surgery, we expect some old challenges to be resolved, and some new challenges to arise. These challenges will be faced in order to continue to help our younger trainee acquire the knowledge and skills to best care for our patients with adrenal diseases.

**Keywords:** Surgery; adrenal gland; training; challenge

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## Introduction

Training of surgical residents and fellows faces many challenges (1). Traditionally, the training followed the master-apprentice model of learning (2) and in many instances it still does (3). For surgeons, the operating theater is of particular importance since it is mainly there where the apprentice learns technical skills. In this regard, it is important to note that the residency training survey of American College of Surgeons Committee in 2017 found that residents are less prepared in technical skills compared to 10 years ago and this applies to both entering and graduating residents (4). This finding can only partly be explained by the effect of duty-hour restrictions (5,6). Another explanation is that surgical residents spend less time in the operating theater these days (5). The result is that surgical residents in general are less prepared and therefore less autonomous when finishing the residency program (7). Of interest, it appears that the number of laparoscopic procedures performed per resident is increasing while the number of more complex operations is still quite low (8).

Despite these challenges, training of surgical residents and fellows is as important as treating patients; we need to ensure that future patients will be treated at least as well as today's patients. Surgical procedures of the adrenal gland are no exception.

Adrenal tumors are common, with prevalence rates derived from systematic analysis of computed tomography investigations higher than 4% (9). In contrast, adrenalectomy is rather uncommon. The fact that only a minority of adrenal glands have to be operated on is one challenge in itself training surgical residents and fellows adequately with regard to adrenal surgery.

In this manuscript, we will focus on the issues that are most pertinent regarding training of the young surgeons performing adrenalectomy. It is beyond the scope of this manuscript to provide comprehensive information on how to perform specific procedures or how to do the preoperative preparation and postoperative follow-up. We will instead try to address the complexity of challenges when it comes to training in adrenal surgery. Of note, there are very few studies on the training of adrenal surgery (10). One reason is that residents have little or no experience with adrenalectomy, both in the past (11) but even more recently (12,13). From an endocrine surgeons' point of view, this is unfortunate since it has been shown that resident participation does not significantly increase operation time in laparoscopic and open adrenalectomy (10,14). One study reported that endocrine surgery fellows graduated with a median of 13 laparoscopic and 2 open adrenal operations (15). However, the ranges were immense: 0–60 for laparoscopic and 0–35 for open adrenal operations.

Due to the very limited literature, what is presented here is mainly based on personal experience and/or from the literature published for other surgical operations and subspecialties. While very important, we will not address other issues including ethical questions associated with the process of teaching and learning surgical procedures (16), challenges training left-handed surgeons (17,18), professionalism (5,6,19), and academic aspects (20).

## Adrenal tumors

Adrenal tumors are very common, but the underlying diseases can vary. Adrenal tumors can overproduce various hormones, such as aldosterone and cortisol from the cortex and epinephrine, norepinephrine and dopamine from the medulla. However, most primary adrenal tumors are adenomas that do not produce hormones (21).

## Indications for surgery

One main challenge is to teach the indications for adrenalectomy. Despite the numerous indications for adrenalectomy, most adrenal tumors are small non-secreting adenomas and do not need to be operated on. While size is an important criterion, some conditions, such as asymptomatic myelolipoma or simple cyst may not need surgery even if very large. In contrast, some patients with normal size adrenal glands may benefit from resection, such as for Cushing's syndrome due to micronodular hyperplasia or to treat Cushing's disease after a failed pituitary operation. Obviously, understanding the indications for surgery requires deep knowledge of adrenal physiology and pathology.

In general, adrenalectomy is indicated, if

(I) The tumor overproduces hormones,

(II) Malignancy is suspected or proven,

(III) The tumor exceeds a certain size (often 4–6 cm in diameter is chosen as a threshold because of an increased risk for non-secreting adrenocortical cancer), or is causing symptoms due to its size.

It is beyond the scope of this manuscript to discuss details regarding the recommended investigations for adrenal tumors or for excess adrenal hormone production. Detail recommendations have been published by the European Society of Endocrinology (22).

## Surgical approach

Open approach, usually transabdominal, is the traditional approach to the adrenal gland (23). It offers good access. However, because of the deep retroperitoneal location, high in the retroperitoneum deep inside the rib cage, several abdominal organs may have to be mobilized to access the adrenal gland. On the right side, the liver usually needs to be mobilized and sometimes this may include the hepatic flexure of the colon or the duodenum. On the left side, the splenic flexure of the colon, distal pancreas and spleen may have to be mobilized.

In open adrenalectomy, the initial steps can often easily be seen and followed by the trainee. However, as the surgeon dissects deeper into the retroperitoneum, visual access is more challenging and it becomes more difficult for the trainee to follow every surgical step.

## Endoscopic procedures and surgical simulation

Compared to open approaches, endoscopic approaches have several advantages. Because of a direct, well-lit and magnified operating field, the trainee can see exactly what the teacher does. Endoscopic approach has become the preferred approach in the majority of adrenal surgery. In endoscopic adrenalectomy, the teacher faces similar challenges as in other endoscopic procedures. These include entry approaches, lack of depth perception with 2D image and instruments with limited mobility (except in robotic operations) (24). Although laparoscopic adrenalectomies are uncommon, cross-specialty program can be implemented by training with the more common types of other laparoscopic procedures (25). Robotic adrenalectomy is performed in some institutions, but the benefit is small and the cost is high (26,27). Use of robot for adrenalectomy would also require another set of skills and training.

Animal surgery and surgical simulators have been used to improve trainees' performances (2,28,29). The anatomy of animal adrenal glands, such as that of the pig, is not similar enough to the human anatomy, so animal surgery may only be useful to teach general laparoscopy but not sufficient to teach adrenalectomy. Simulation could improve performance of laparoscopic operations through practice (29). While performance of some tasks can be improved with simulation, these skills acquired through simulation may or may not be transferable to the operating theater (2). The decreased haptic feedback in endoscopic surgery contributes to this problem (30). Therefore, a predictive validity has not been established for training laparoscopic procedures using simulation (24).

Three-dimensional printed models based on computed tomography have been used to recreate the anatomy of the adrenal gland and tumor, for preoperative planning of approaches to adrenalectomy (31). However, high-fidelity simulators such as those available for laparoscopic cholecystectomy (32) do not yet exist for adrenal surgery.

## Learning curve

It is acknowledged that individual surgeons will have a personal learning curve that for laparoscopic transperitoneal approach is deemed to be approximately 30 cases (depending on previous experience/expertise with laparoscopic surgery) and for retroperitoneoscopic approach can be between 20–40 cases (33). As the workload of most surgical units around the world remains very limited, there is probably no chance for a trainee to complete his/her own personal learning curve during training. The need and benefits for centralizing adrenal surgery cannot be overestimated. The 2019 meeting of European Society of Endocrine Surgeons (ESES) will aim to review the evidence for volume-outcome correlation and its impact on training and, hence, formulate guidance for a process of establishing and assessing 'centres of excellence' that might provide the care for such patients in the future.

## Laparoscopic versus retroperitoneoscopic approaches

The two most common approaches for endoscopic adrenalectomy are transabdominal (laparoscopic) approach and retroperitoneal approach. "Laparoscopy" in generic terms include both transperitoneal and retroperitoneal approaches. In this paper, we use laparoscopy in the narrower meaning to only include the transperitoneal approach. Laparoscopic adrenalectomy was first reported in 1992 (34). Shortly thereafter, the first series on patients operated through a retroperitoneoscopic approach were published (35,36). There is an additional challenge with training for the retroperitoneoscopic approach, because most general surgery trainees are more familial with anatomical landmarks in the abdomen than those in the retroperitoneum. The adrenal gland may be difficult to identify in obese patients with increased retroperitoneal fat obscuring the kidney. The pressure of carbon dioxide insufflation is also different. For laparoscopy, the pressure is often set to 12–15 mmHg. For retroperitoneoscopic approach, the pressure is usually set at 18–25 mmHg to provide a sufficient operating space. Despite this, the retroperitoneoscopic approach has been reported to have a rapid learning curve (37).

## Larger adrenal tumors without infiltration/invasion

Adrenal tumor size limits the choice of surgical approach. The current recommendation by the European Society of Endocrinology is that tumors up to 6 cm in size can be resected by endoscopic approaches (either laparoscopy or retroperitoneoscopy), if no local infiltration is suspected (22). Tumors larger than 6 cm may be technically challenging for the retroperitoneal approach (38). The transabdominal approach can be used for large tumors (up to 8–10 cm for the right and 10–12 cm for the left). The current guidelines recommend an individualized approach in these larger tumors (22). Robotic surgery may be useful for large tumors, because the flexibility of instruments with increased degree of freedom of movement makes dissection easier (27). However, the costs of using robot seem to outweigh its benefits. The additional learning curve required and the rarity of large tumors where robotic surgery may be advantageous also limit its usefulness (27).

## Tumors with signs of infiltration/invasion

If there are signs of invasion to adjacent organs (e.g., vena cava, liver, pancreas, bowels, kidney), an open transabdominal approach is generally recommended (39). Depending on the experience of the "endocrine" surgeon, other specialists may need to be involved (e.g., vascular surgeons, upper-GI-hepatobiliary-surgeons, lower-GI-surgeons, urologists). These cases are particularly difficult to teach, because they are rare and the responsible surgeon usually wants to operate with an experienced colleague, rendering the trainee to be a second assistant.

## Subtotal adrenalectomy

In patients with bilateral adrenal tumors that require bilateral surgery, subtotal adrenalectomy may be indicated to avoid steroid dependency with its side-effects and risks (40). This may be indicated in patients with bilateral pheochromocytomas, or in those with a unilateral pheochromocytoma and a high risk of developing a contralateral pheochromocytoma, e.g., in patients with multiple endocrine neoplasia type 2 or von Hippel-Lindau-syndrome (41). Indication for patients with bilateral adrenal metastases is less clear (42). Subtotal adrenalectomy is rarely useful in patients with aldosteronoma or Cushing's syndrome. If subtotal adrenalectomy is indicated, endoscopic approach is better than open approach because of the magnified operating view (43), making it also better for training.

## Intraoperative complications and collaboration with the anesthesiologist

While communication with the anesthesiologist is very important in any surgery, surgery for some endocrine tumors require particularly close collaboration.

Pheochromocytomas produce catecholamines, and cause hypertension and tachycardia. Most surgeons pretreat these patients preoperatively with alpha-adrenergic receptor blocker, although whether this pretreatment is routinely needed is questioned (44). Some patients may require beta blockers to treat tachycardia. Despite the preoperative treatment, some patients may have extreme fluctuation of blood pressure and heart rate during adrenalectomy, that will require intervention by the anesthesiologist. The hemodynamic changes can be worsened by manipulation of the tumor and sometimes the surgeon may need to pause the operation. Sometime high insufflation pressure can cause increased blood pressure and heart rate, and the insufflation pressure may need to be lowered until the situation improves.

Hypercapnia can be caused by carbon dioxide insufflation. It is usually managed by hyperventilation of the patient by the anesthesiologist, but sometime carbon dioxide insufflation needs to be stopped by the surgeon.

Carbon dioxide embolism is a rare but serious complication occurring in both laparoscopic (45) and retroperitoneoscopic procedures (46). The treatment is similar to that for other procedures where carbon dioxide embolism occurs (47).

There are several causes of bleeding during adrenal surgery.

(I) Bleeding of smaller veins or arteries: this can usually be prevented by carefully cauterizing the vessels during dissection. Pheochromocytomas and malignant tumors may have larger pathologic vessels that will require vessel-sealing devices or clipping. Bleeding affects visibility, especially in retroperitoneoscopic approach because of the limited space. If the bleeding cannot be stopped immediately, direct pressure with gauze is recommended. Smaller vessels bleeding will readily stop. Larger, pathologic vessels, in particular veins, may slow but not stop and may require sealing devices or traditional techniques like ligation and/or suturing.

(II) Bleeding of larger veins or arteries: on the right side, the adrenal vein is short and drains directly in into the inferior vena cava. On the left side, the left adrenal vein joins the inferior phrenic vein then drains in into the left renal vein. Because the increased pressure during endoscopic procedures flattens the veins, holes in larger veins may not bleed immediately. Bleeding from large veins can be slowed by increasing the insufflation pressure, especially for the retroperitoneoscopic approach. This is also the reason to desufflate and wait for a while at the end of operation and check the operating field for blood to avoid missing an injured vein. The lower part of the adrenal glands is very close to the main renal artery. Mistakenly ligating the upper pole branch can cause ischemic renal vascular hypertension. Injury to the main renal artery requires immediate action. The bleeding is brisk and delay control can lead to ischemic kidney injury. Immediate conversion to open surgery may be required and immediate reanastomosis should be attempted.

(III) Bleeding of the adrenal capsule: the adrenal is surrounded by a thin and fragile capsule. Damage of the capsule will lead to bleeding. This applies even to the normal adrenal gland. Pheochromocytomas, can bleed profusely.

 

Cauterizing the bleeding capsule often worsens the situation. Instead, applying pressure with a gauze works better. Breaching the adrenal capsule should be avoided whenever cancer is a concern. Even spilling of otherwise benign pheochromocytoma can lead to pheochromocytomatosis. Routinely resecting the periadrenal tissue with the adrenal gland is the best oncological practice and it also avoids capsular injury and bleeding.

(IV) Bleeding of one of the adjacent organs: bleeding of any of the adjacent organs, especially liver, spleen and kidney, is cared for in the usual manner.

## Open surgery

Even when most adrenal surgery is done endoscopically, open surgery is still needed sometimes, either electively because of concerns for invasive cancer or large tumor size, or conversion is required because of bleeding or other difficulty during endoscopic surgery. Teaching open surgery is more challenging because it may be performed in fewer than 10–15% of all adrenal surgery cases (15); this is similarly observed for other mainly endoscopically procedures (8). The judgment required to know when to timely convert endoscopic to open surgery can be complex and it improves with experience. The rarity of conversion (<5%) also makes it difficult to teach.

## Conclusions

Adrenal Surgery is uncommon and has very heterogeneous indications and management issues, thus making training of adrenal surgery a challenge. In this paper, we write from the perspective of two experienced endocrine surgeons and trainers, but with dearth of studies and evidence to firmly support our views and advise. We acknowledge that the trainers and trainees may have different perceptions when assessing training programs and their challenges (48). With advances in adrenal surgery, we expect some old challenges to be resolved, and some new challenges to arise. As teachers of endocrine surgery, we will face these challenges and continue to help our younger trainee acquire the knowledge and skills to best care for our patients with adrenal diseases.

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## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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