Intraoperative complications of laparoscopic adrenalectomy

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Conflict of interest
None
Abstract

A laparoscopic or retroperitoneoscopic access to the adrenal gland is the standard of care for adrenalectomy in most cases. Although in laparoscopic adrenalectomy the approach is minimally invasive, the procedure is challenging. This is reflected in the scope of possible complications. The surgeon must consider complications related to the anatomical topography of the adrenal gland, which typically encompasses the complications known from open surgery and complications related to the minimal invasive access. In this topic paper we will address the most frequently encountered complications of adrenalectomy: vascular injuries, injuries of the bowel, pleural tears, and injuries to the liver, spleen and pancreas. Fortunately, these complications occur rarely. However, many of these complications can have devastating consequences. Therefore, it’s the surgeon’s obligation to be aware of the possible complications he might encounter during laparoscopic adrenalectomy. This awareness is essential for their prevention and it helps the laparoscopic surgeon to identify complications intraoperatively.
**Introduction**

Similar to many other laparoscopic procedures, the laparoscopic access to the adrenal gland has been rapidly adopted as standard of care for adrenalectomy in most cases since the first description of Gagner and colleagues in 1992 [1]. This has been driven by the potential of laparoscopic adrenalectomy to achieve the same goals as the standard open approach, while offering the patient distinct advantages with regard to the perioperative course [2, 3]. Although in laparoscopic adrenalectomy the approach is minimally invasive, the complexity of the procedure is generally at least equal to its traditional open counterpart. This is reflected in the scope of possible complications. Whatever minimally invasive approach to the adrenal gland is chosen (laparoscopic, lateral or posterior retroperitoneoscopic) basically all approaches share similar possible complications: 1. complications related to the anatomical topography of the adrenal gland which typically encompasses the complications known from open surgery and 2. complications related to the minimal invasive access. Many of these access related complications are shared with other laparoscopic interventions. Therefore, the rules to prevent complications during a laparoscopic procedure apply also to laparoscopic adrenalectomy.

In this review we will discuss the complications that most frequently may be encountered in laparoscopic adrenalectomy including management and prevention strategies.

**Methods**

We performed a Medline search using the following MESH terms: *adrenalectomy* AND *laparoscopy* AND *intraoperative complications* in order to support this review with the most recent available data. However, the quality of reporting complications in the published articles in most cases is poor. The use of standardized instruments such as the Clavien classification to assess the severity of complications is rare [4]. Therefore, this review will focus on the
surgical complications most frequently reported in the literature rather than to present a meta-
analysis of complications associated with laparoscopic adrenalectomy (Table 1). We renounce
to describe rare and anecdotic complications. It is also beyond the scope of the article to
describe in detail pathophysiological alterations associated with adrenal surgery. For each
specific complication we will try to address the recognition, the management and the
prevention where appropriate.

Vascular injury

Vascular injuries encompass reported complications such as intraoperative and postoperative
bleeding, haematoma, and the need for blood transfusions. These injuries are either access
related or occur during dissection [5, 6]. Most commonly, this happens due to inadequate
exposure of the vascular structures leading to either sharp or thermal injury to the vessel.
Vascular injuries represent the most frequently encountered complication in laparoscopic
adrenalectomy. All over, the incidence rates are low and are in the range of 0.7% to 5.4% [7-9]. However, transfusion rates (as surrogate marker for vascular complications) are as high as
10% [10]. Major vascular complications in minimally invasive adrenalectomy are a rare
event. In right sided adrenalectomy the dissection of the vena cava inferior and the right
adrenal vein typically harbour the highest risk of a severe vascular injury [6, 11]. In left sided
laparoscopic adrenalectomy the crucial step bearing a high risk for a major vascular injury is
the dissection of the left renal hilum, thus to identify the left adrenal vein [12]. However, in
most cases these major vascular complications are recognized instantly during the dissection.
In contrast to the former complications, the inadvertent injury to smaller vessels can easily go
unnoticed during the course of the procedure. Especially venous lesions can be missed
intraoperatively as these smaller vessels do not bleed briskly into the operative field. One
important reason for this is the pressure created from the pneumoperitoneum that compresses
the injured vein thereby possibly preventing it from oozing blood. These injuries frequently become manifest only in the postoperative period when haematomas or hemodynamic instability become evident. Occasionally, these bleeders require even blood transfusions or a re-intervention [8].

A special variety of vascular complications are severe hemodynamic changes and arrhythmias that might occur during the course of adrenalectomy. The risk of these serious complications is highest in patients with pheochromocytoma. To avoid these complications, a close collaboration with endocrinologists and anaesthetists is necessary. It is mandatory to administer an α.-adrenergic blockade well in advance of the scheduled surgery. During the course of the procedure the surgeon is obliged to inform the anaesthetist about any violation or disruption of the adrenal gland. Additionally, the surgeon should inform the anaesthetist timely when he is about to ligate the main adrenal vein in order to be prepared to treat any severe blood pressure fluctuations immediately.

**Prevention and management of vascular injuries**

One important key to prevent major vascular injuries is a sound understanding of the vascular anatomy in general as well as the vascular anatomy of the specific patient. Typically, the right adrenal vein drains into the inferior vena cava and on the left side the main adrenal vein drains into the left renal vein. However, this pattern shows variations in up to 10%. The most frequent variations are drainage of the right adrenal vein into the right renal vein or into right hepatic veins. Thus, prior to laparoscopic adrenal procedures that involves dissection of major vessels a radiologic examination, which shows the vascular anatomy in the region of interest should be obtained and carefully studied. It is the authors’ personal preference to use hemolock clips to control the main adrenal vein and to use an ultrasonic dissection device to control for the numerous small periadrenal vessels.
Depending on the severity of the vascular injury and the surgeon’s experience, appropriate measures range from simple application of pressure to immediate conversion to open surgery. The first step in the management of a vascular injury is the application of pressure to the source of the bleeding. Effective application of pressure usually requires a small pad or at least a sponge gauze to be pressed onto the bleeding site via a laparoscopic instrument (e.g. grasper). Additionally, the pneumoperitoneum should be increased temporarily up to 25mmHg to reduce venous bleeding. Pooled blood around the site of the lesion can then be aspirated and a slow retraction of the pad should reveal the site of the injury. In minor vascular injuries, application of pressure for a couple of minutes alone may solve the problem. A good option is the additional application of hemostyptic agents like oxidized regenerated cellulose and fibrin glue. Only with adequate exposure of the injured vessel electrocautery or clips can be applied to control the bleeding. However, in a major vascular lesion clips, electrocautery and hemostyptic agents usually are inadequate measures. It is important not to loose precious time and thus increase the blood loss while attempting to solve the problem with these insufficient measures. Again, only with adequate exposure of the injured vessel the application of a stapling device might be considered. If the repair of the vessel is vital, laparoscopic suturing of the injured vessel should only be attempted by the very experienced laparoscopic surgeon [13]. Usually, additional ports should be placed to optimize distance and angle of the instruments for laparoscopic suturing. In most cases of major vascular injury, however, it is advisable to convert quickly to an open procedure.

The incidence of vascular injuries and complications increases with the complexity of the procedure and in adrenal surgery this possibly applies to the removal of large tumours, adrenal metastases and pheochromocytomas [14-16]. Nevertheless, many authors advocate a laparoscopic approach also for pheochromocytomas, adrenal metastases and large adrenal tumours [17-19]. However, in these cases extensive experience in laparoscopic surgery is mandatory [12, 14].
Bowel injury

Delayed recognition of a bowel injury is a potentially life threatening complication of a minimally invasive adrenalectomy. Therefore, it is essential to recognize bowel injuries intraoperatively [20, 21]. However, only 1 out of 3 intestinal lesions that occur during a laparoscopic procedure are diagnosed intraoperatively [20]. In patients with delayed recognition of a bowel injury up to 1 out of 4 patients will die as a result of the complication [22, 23]. The small bowel is the most commonly injured part of the intestine and therein an injury to the duodenum is associated with the most serious sequelae. Injuries to the colon and the stomach occur less frequently. Robust data on bowel injuries related to minimally invasive adrenalectomy are not available. However, in the urologic literature the incidence rates of bowel injuries in general and in retroperitoneal laparoscopic surgery in particular range from 0% to 1.3% [5-7, 9, 20].

Basically, any type of sharp or blunt instrument can harm the bowel. However, the most frequent origin of bowel injury during laparoscopic surgery is induced by electrocautery followed by access related injuries. In a comprehensive review, thermal damage induced by inadvertent electrocautery activation accounted for 50% of all bowel lesions [20]. Typically, these injuries remain unnoticed intraoperatively due to the delayed breakdown of the intestinal wall [24]. It’s in the nature of the limited field of view inherent to laparoscopic adrenalectomy and other laparoscopic procedures that such injuries can easily be missed.

Prevention and management of bowel injuries

Manipulation with instruments outside the field of view (e.g. during change of instruments) is prone to inadvertent violation of bowel and other intra-abdominal structures. Likewise, laparoscopic instruments not in use should always be removed from the patient. For the inexperienced laparoscopic surgeon it is advisable to introduce any new instrument under
direct visual control in order to prevent inadvertent bowel injury outside the field of view. Laparoscopic instruments have to be checked for insulation damage prior to their use in order to avoid inadvertent electrocautery incidents to the bowel. When dissecting close to the bowel, bipolar electrocautery should be the preferred electrocautery mode whenever possible and monopolar electrocautery should be used reluctantly. During medial reflection of the duodenum in right sided adrenal procedures, the use of thermal energy has to be strictly avoided to prevent duodenal injury. In patients with a history of abdominal surgery and thus increased risk of bowel injury, alternatively, a retroperitoneoscopic approach may be an interesting option. However, Meraney reported bowel complications also with this approach [6].

Intraoperatively recognized intestinal lesions can be managed laparoscopically. However, open repair and consultation of a general surgeon should be considered whenever the integrity of the laparoscopically performed repair is questioned [25]. Another area of uncertainty is the extension of the tissue damage associated with monopolar injuries. Usually, the size of the injury is underestimated. Therefore, whenever an electrothermal lesion caused by monopolar cautery is suspected, resection and end-to-end anastomosis of the involved bowel segment with a safety margin of several centimeters is warranted [26].

The high morbidity associated with intestinal complications and the laparoscopic surgeon who is not familiar with advanced laparoscopic bowel surgery should direct the respective surgeon to convert the case to an open procedure or consult a general surgeon.

**Injuries of the liver and the gallbladder**

Injury of the liver during laparoscopic adrenalectomy is a rare complication. Again, these injuries are either access-related or – very rarely – caused by inappropriate retraction of the liver during right-sided renal or adrenal procedures [27]. Alternatively, a tear in the liver
surface can result when adhesions to the liver are strained. To prevent liver injuries during laparoscopic adrenalectomy all adhesions to the liver have to be taken down carefully at the beginning of the dissection. The dissection of larger tumours or pheochromocytomas bears a higher risk for liver lacerations as reported by Kim et al [14]. Alternatively, the adoption of a retroperitoneal approach may represent another strategy to avoid liver injuries.

**Spleenic injury**

Injuries to the spleen during laparoscopic adrenalectomy share the same mechanisms of action as described for liver injuries, thus they are either access-related or caused by to powerful retraction or handling of the organ. Any adhesions to the spleen and the lieno-colic ligaments should be incised very cautiously. Careful attention is required not to injure the fragile organ with retractors or any sharp laparoscopic instrument. This is important especially when the tip of the respective tool is not in the field of view. Specific data for the frequency of this complication in minimally invasive adrenalectomy are not available. However, according to recent reviews, injuries of the spleen complicated 0.5-2.5% of laparoscopic and hand-assisted laparoscopic nephrectomies [28, 29]. Intraoperative recognition is difficult when choosing a retroperitoneal access to the adrenal gland. With a transperitoneal approach, however it is usually not difficult to recognize a splenic lesion.

*Management of splenic and liver injuries*

The majority of splenic and liver injuries during urologic laparoscopic surgery are minor capsular lesions which usually can be managed laparoscopically [30]. Typically, in the first line usually these injuries are sufficiently controlled with a combination of pressure and the application of oxidized regenerated cellulose, absorbable gelatin sponges and fibrin glue.
Optional, coagulation with an argon beam coagulator is useful if available [31]. More extensive splenic lacerations or injuries of the liver typically result in open conversion.

Pancreatic injury
Permpongkosol et al and Fahlenkamp et al. have reported general incidences of pancreatic lesions of 0.2-0.4% in their evaluation of complications in urologic procedures [5, 7]. However, in one single centre series, the incidence of pancreatic complications was found to be 2.1% in laparoscopic left radical nephrectomies and in laparoscopic left adrenalectomies this rate was as high as 8.6% [32]. A pancreatic injury typically occurs during dissection of adjacent structures and normally remains unrecognized during the procedure. Apart from direct observation there is no reliable sign that helps to detect a pancreatic lesion intraoperatively.

Pleural injury
Inadvertent entry into the pleural space in open procedures in the upper retroperitoneum is not uncommon and usually unproblematic. However, in laparoscopic adrenalectomy diaphragmatic and pleural injuries are rare but potentially severe complications. The high intraabdominal pressure associated with the pneumoperitoneum, facilitates the insufflated gas to enter the thorax through a diaphragmatic lesion. This typically leads to ipsilateral pneumothorax and pneumomediastinum. In case an injury to the pleura is not directly observed, signs of pneumothorax can be recognized intraoperatively. The ‘floppy diaphragm sign’, which refers to the billowing of the diaphragm into the abdomen or retroperitoneum with every reduction of the intra-abdominal pressure reflects a loss of the negative pressure in the pleural space [33]. Once this is observed it should prompt a search for a diaphragmatic
injury. The anaesthesiologist should be of assistance in the diagnosis of pneumothorax, because he usually will notice changes in respiratory parameters (increase in airway pressure and end-tidal CO2, decrease of oxygen saturation, reduced breath sound).

In a multi-institutional review, Del Pizzo reported an incidence of pleural injury during laparoscopic renal surgery of 0.6% [34]. In this large multi-centre series 80% of the pleural injuries occurred during dissection. Recently, Aron et al. reported their single center experience with the repair of diaphragmatic injuries during upper abdominal urological laparoscopy [35]. In this study, out of 1850 renal and/or adrenal laparoscopic procedures 13 patients (0.7%) sustained diaphragmatic entry but only in 7 patients (0.4%) this happened inadvertently. Unfortunately, the respective incidence rates of pleural injury for adrenalectomy and nephrectomy are not available.

**Management of pleural injuries**

Usually, experienced laparoscopic surgeons will manage diaphragmatic and pleural injuries endoscopically. The basic principle to manage these injuries is to oversew the diaphragmatic lesion and to evacuate the air or gas from the pleural cavity. Eventually, the insertion of a thoracostomy tube is needed. Depending on the ventilation and the hemodynamic situation of the patient, the procedure may be continued with a lower intra-abdominal pressure than usually established. The main reason to address the pleural injury only at the end of the adrenalectomy is to obtain more space and better visualization of the lesion to perform the repair.

**Discussion**

Careful preoperative evaluation of each individual case, meticulous surgical technique and adequate equipment are prerequisites for a safe laparoscopic adrenalectomy. Additionally, a
close collaboration with the endocrinologist and anaesthetist is mandatory with regard not only to the operative procedure but also to the preoperative preparation and postoperative course of the patient. It is the surgeon’s knowledge about possible mechanisms of complications combined with a high index of suspicion throughout the entire procedure that may lead to the detection of complications. Once complications emerge the surgeon should be aware of a range of appropriate measures to solve the problem. In the individual case the surgeon has to make his decision based upon the respective situation, choosing the solution that least compromises patient safety and the goals of the actual procedure. In many cases the timely recognition allows the surgeon to manage the complication laparoscopically and thereby preserve the patient some of the benefits of the minimally invasive approach. However, in the patient’s best interest this decision should not be biased by the desire to complete the procedure laparoscopically by any means. These are the keys to successful and safe laparoscopic adrenalectomy (table 2).

**Conclusion**

It’s the surgeon’s obligation to be aware of possible complications he might encounter during laparoscopic adrenalectomy. This is essential for their prevention. Additionally, this awareness helps the laparoscopic surgeon to identify complications intraoperatively.

**Acknowledgment**

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References


### Table 1

Most frequent complications during laparoscopic adrenalectomy

<table>
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<th>Vascular injuries</th>
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<td>Bowel injuries</td>
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<td>Injuries to the liver and spleen</td>
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<td>Pleural injuries</td>
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<td>Pancreatic injuries</td>
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### Table 2

Six keys to prevent complications in laparoscopic adrenalectomy

1. Thorough preoperative preparation: (vascular) anatomy, radiologic examinations
2. Careful placement of the trocars, secondary trocars under direct vision.
3. Avoidance of manipulating instruments outside the field of view.
5. Careful completion of the procedure (desufflation, inspection, trocar removal).
6. Choose solutions that least compromises patient safety and the goals of the procedure.