Intraoperative Complications

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8.1 Introduction

Minimally invasive adrenalectomy, either laparoscopic or retroperitoneoscopic, has largely replaced open surgery since it was first described in 1992. The initial enthusiasm was factually confirmed over the years; a retrospective comparative study between open (n = 592) and laparoscopic (n = 1980) adrenalectomy performed in the United States of America between 2005 and 2009 showed a 4.6-fold increased risk of serious complications, requiring Intensive Care Unit (ICU) care, and a 4.9-fold increased risk of mortality for laparotomy compared with laparoscopy, despite baseline comorbidities [1]. The excellent results of minimally invasive adrenalectomy have been published in many large series also in recent years, with the rate of intraoperative and postoperative complications reported in the different studies ranging from 0% to 15% for unilateral adrenalectomy, to over 23% for bilateral adrenalectomy [2–8]. However, despite the recognized safety and efficacy of minimally invasive adrenalectomy, the rate of intra- and postoperative complications is not negligible.

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Nowadays, the most widely used minimally invasive adrenal procedures are the transperitoneal laparoscopic adrenalectomy (TLAdr), in the lateral position, and posterior retroperitoneoscopic adrenalectomy (PRA), in the prone position; nevertheless, also a lateral retroperitoneoscopic approach is performed in some centers, and robotic adrenalectomy is being improved [9].

The advantages of TLAdr compared to open surgery, such as less postoperative pain, shorter hospital stay, appealing cosmesis, and fewer intraoperative and postoperative complications, have made this operation the gold standard for adrenal lesions [10]. In a French retrospective study evaluating the complications observed in a series of 169 consecutive TLAdr (performed at the same center, for a variety of disorders), 12 patients (7.5%) had significant complications: three peritoneal hematomas (two of which required a re-laparotomy), one parietal hematoma, three intraoperative bleeding episodes without need for transfusion, one partial infarction of the spleen that regressed spontaneously, one pneumothorax, two deep venous thromboses, and one capsular effraction of the tumor, with an overall average length of hospital stay of 5.4 days (range 3–15 days); mortality was not reported [6].

However, many studies indicate that PRA is superior to laparoscopic adrenalectomy regarding operation time, pain score, blood loss, complications rate, and return to normal activity. The

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posterior retroperitoneoscopic approach to the adrenal glands offers the benefits of the open posterior route and of minimally invasive technique, by a direct and minimal access to the area at the same time.

Between 1993 and 1994, the PRA technique was gradually implemented in different countries. Early descriptions were published from Turkey, the United States of America, Italy, and Germany [1, 7, 11]. Further studies demonstrated operative feasibility and—compared with the laparoscopic approach—shorter operative times and minor blood loss [12, 13]. In the largest series of PRA in the literature—560 procedures performed on 520 patients—Walz and colleagues reported a 2% conversion rate, a mean operating time of 67 minutes, and a very low complication rate (major complications in 1.3% of patients, minor complications in 14.4%) [8]. Intraoperative complications included pleural tears in four patients: these were managed by sealing the leak with pressure or by the placement of a pleural drain until the end of the surgical procedure, and in any case conversion to an open procedure was not required. Postoperative complications included one case of myocardial infarction, two cases of pneumonia, and one pneumothorax. Four patients developed postoperative hematomas, and one of them required a blood transfusion and reoperation. There was a significant rate of injury to the subcostal nerve (47 patients; 8.5%), which led to hypoesthesia and/or relaxation of the abdominal wall; however, these side effects were usually temporary [8].

Several retrospective studies have compared PRA and TLAdr [5–7, 14, 15]. Overall, these studies found a decrease in operating time and intraoperative blood loss with PRA and no difference in long-term outcomes. In two small randomized prospective trials comparing minimally invasive retroperitoneal and transperitoneal approaches, no differences in operating time, complications, or analgesic requirements were found, but both studies considered surgery by a lateral, not a posterior, retroperitoneoscopic approach [12, 15].

This chapter analyzes the complications of PRA, often in a comparison with the most performed TLAdr, using the available data in the literature.

8.2 Vascular Injury, Hemorrhage, and Cardiovascular Complications

The major potential complication of adrenal surgery is the arterial and venous bleeding: injuries to blood vessels represent the most common intraoperative complication of adrenalectomy, with a reported incidence up to 5.4% [16]. This high number of vascular injuries can be explained by the location of the adrenal gland and by its proximity to the main retroperitoneal vessels. In particular, on the right side, the adrenal vein is very short, and regularly enters the vena cava laterodorsally, so its exposure is the main risk for vein laceration, especially during the dissection of large tumors, which are inevitably associated with greater traction on the vein. A French series on the outcomes of laparoscopic adrenalectomy described four conversion cases (2%) in 204 right-sided operations after intraoperative injury to the inferior vena cava (IVC) [3]. These data are consistent with the results of a German series of 174 minimally invasive surgeries (144 laparoscopic and 30 retroperitoneoscopic), which also describes four cases of conversion for hemorrhage (2.3%), with no further discussion of the cause of the hemorrhage or whether they occurred during laparoscopic or retroperitoneoscopic surgery [14].

The posterior approach allows early transection of the transverse arteries originating from the aorta, thereby facilitating the dissection of the adrenal gland from the vena cava on the right side. Bleeding from venous vessels coming from suprarenal veins or IVC is usually well controlled by clips or compression. Importantly, anatomical variants of suprarenal veins on the right side, such as the common venous trunk between the adrenal vein and accessory posterior hepatic veins, may present difficulties in the dissection and can potentially cause harmful hemorrhagic events. However, given the restricted retroperitoneal space and the high CO_2 insufflation, the total blood loss is usually limited [17]. In fact, the high CO_2 insufflation pressures (> 20 mmHg) used to increase visualization in the retroperitoneum not only allow a sufficiently large working space, but, as an added benefit,

compress small veins, minimizing bleeding and ensuring a dry field.

Although arterial vessel damage is less common during dissection, the renal artery or one of its terminal branches may be injured during both laparoscopy and retroperitoneoscopy. However, there is a lower reported risk of arterial injuries by PRA and the bleeding from small arterial vessels can be easily controlled by clips [17]. Most commonly, careless use of clips or vessel-sealing instruments may lead to unnoticed occlusion of the renal vessels and consequently to segmental infarction of the parenchyma, or, less often, to a complete loss of the ipsilateral kidney [3, 18].

Vascular injury can be also explained by incomplete exposure and accidental direct impact of laparoscopic instruments on the vessels wall or by their thermal damage. Intraoperative management of such lesions requires a high level of expertise in minimally invasive surgery and is the reason for conversions to laparotomy for endoscopically uncontrollable hemorrhage (see Chap. 9 for vascular injuries management). In the series of 560 retroperitoneoscopic adrenalectomies published by Walz and colleagues, no conversion due to vascular injury was observed, and other authors have reported similar results [8, 11, 19]. In a Dutch study involving 112 PRA performed in 105 patients, after operation one patient required re-exploration for persistent bleeding from the muscular part of a trocar insertion site, while minor complications, including flank hematoma, occurred in five patients [19].

The risk of air embolism is theoretically increased with the use of high insufflation pressures; this complication has been rarely reported [20, 21]. It may be caused by tears in large retroperitoneal vessels, mainly the IVC. In fact, normally, the high insufflation pressure during the retroperitoneoscopic approach keeps the vein compressed and does not permit significant bleeding or gas embolism; however, in some cases, a short period of accidental traction may keep it open permitting the embolism (Fig. 8.1). Moreover, while intraperitoneal filling pressures greater than 15 mmHg have been shown to decrease cardiac filling, retroperitoneal insufflation at high pressure increases stroke volume, cardiac output, and mean arterial pressure [22]. Furthermore, in reported extensive experience, no patient had iliac or femoral vein thrombosis or pulmonary embolism [8].

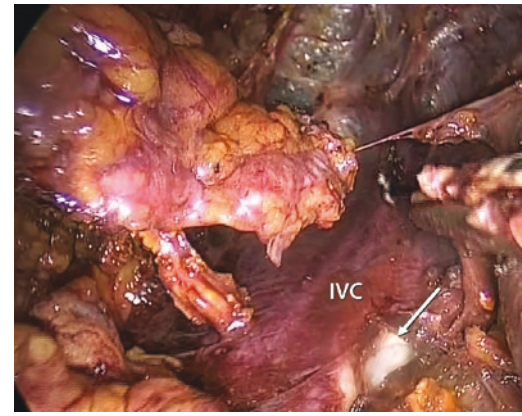

Fig. 8.1 Inferior vena cava (IVC) injury (white arrow) during right posterior retroperitone oscopic adrenalectomy

Although high CO_2 insufflation pressures in the retroperitoneum can result in demonstrable intraoperative hypercapnia, this condition has not been associated with clinically significant intraoperative or postoperative consequences. Interestingly, a recent study that compared patients undergoing PRA with patients undergoing open posterior adrenalectomy found no difference in arterial carbon dioxide pressure ($PaCO_2$), end-tidal CO_2, or arterial pH between groups, although the alveolar-arterial CO_2 gradient indicated that absorption of CO_2 was higher during PRA [23]. Hypercapnia appears to be potentially clinically significant only if surgery is unusually long, and the patient is difficult to ventilate at baseline because of obesity or underlying lung pathology.

8.3 Retroperitoneal Fatty Tissue

Adrenalectomy can present technical issues, especially in patients with a large amount of retroperitoneal fatty tissue, such as in those with hypercortisolism. These patients can benefit from an endoscopic approach that minimizes abdominal wall trauma. One of the major

problems in these patients is the lack of an optimal endoscopic vision of the anatomical structures such as the main vessels. The resection or the suction of the fatty tissue around the upper pole of the kidney and the adrenal gland can facilitate the recognition of the main anatomical landmarks [17].

No specific studies examining the surgical outcomes related to large amounts of fat in the retroperitoneum have been carried out so far in the case of PRA, while some information is available about TLAdr. For example, Erbil and colleagues investigated the implications of the body mass index (BMI) and retroperitoneal fat area (RFA) in surgical outcomes of 51 consecutive patients who underwent TLAdr in a single center, finding out that in patients with high BMI, a high RFA was correlated to longer operating time and higher risk of complications, whereas low RFA was associated with significantly shorter operating time and decreased risk of complications; moreover, complications occurred in 50% of patients with both high BMI and high RFA, mainly because of technical difficulties and associated comorbidities [24].

8.4 Injuries of the Intestine

An accidental lesion of the bowel can occur both at the onset of laparoscopy (primary access) and during dissection. The incidence of bowel lesions after laparoscopic adrenalectomy is reported to be 0–1.3% [16]. Bowel lesions represent a serious complication, being responsible for 20% of deaths since approximately 50% of cases remain undiagnosed for more than 24 h [4]. The bowel may also be injured because of adhesiolysis, or during the dissection maneuvers, involving the duodenum on the right side and the colonic flexure on the left side. Retroperitoneoscopy in the prone position precludes bowel injury because the bowel remains outside the field of dissection. Therefore, it provides the most appropriate access for patients who have undergone previous abdominal operations, potentially presenting a high incidence of adhesions on the visceral side.

8.5 Injuries to Other Organs

All organs mobilized for proper exposure of the adrenal glands during TLAdr can be injured. Kidney and liver may suffer capsular lesions on the right side, whereas the spleen, pancreas tail, and kidney can be accidentally damaged on the left side. The real incidence of such complications is unclear, as most are small capsular lesions that are detected intraoperatively and remain without consequence. Complete mobilization of the pancreatic tail and spleen for left adrenalectomy has ample potential for serious intraoperative and postoperative complications. Rupture of the splenic capsule may be the reason for conversion or, if not recognized intraoperatively, may be responsible for postoperative hemorrhage. Injury to the pancreatic capsule, the incidence of which has been reported as high as 8.6% [19], can lead to pancreatic fistula or abscess formation. In a French study that analyzed the risk factors for complications of adrenalectomy in 462 patients, left adrenalectomy was the only risk factor for surgical complications [8]. In this series, 8 patients developed postoperative fluid retention in the upper abdomen, which required computed tomography-guided drainage in 6 cases. In all six patients, a postoperative pancreatic fistula was causative for the retention. In one case, surgical drainage was necessary in the further course of necrotizing pancreatitis. The kidney is rarely involved, with 3 segmental renal infarctions described in the same series after transection of upper renal polar arteries [8].

PRA offers undisputed advantages, as it does not require visualization and dissection of the liver on the right and pancreas and spleen on the left. Only the kidney is mobilized during retroperitoneoscopic surgery and may be injured. These capsular lesions can usually be managed intraoperatively without difficulty; renal hematomas, which may form postoperatively, usually do

not require reoperation and can be treated conservatively.

8.6 Abdominal Wall Relaxation and Hypoesthesia

Relaxation and/or hypoesthesia of the abdominal wall are typical complications of the posterior retroperitoneoscopic approach [23]. Abdominal wall relaxation is characterized by a decreased muscle thickness of the affected area, without a gap in the continuity of the fascia, due to the injury of nerve structures, the subcostal nerves above all, during insertion of trocars and surgical maneuvers [24]. Longer operating times and larger wall incisions are often related to a higher risk of development of abdominal wall defect, and the higher density of nerve structures along the spinal cord makes PRA more at risk for this complication.

8.7 Pleural Lesions

Pleural lesions are also one of the complications of adrenalectomy, also for PRA. Recognition of this complication is usually straightforward because a pneumothorax or pneumomediastinum develops. The associated change in respiratory mechanics with increased ventilatory pressures and end-tidal pCO_2 as well as a drop in saturation do not go unnoticed by the anesthesiologist. Most lesions are not hemodynamically relevant and do not require therapy, suggesting radiological surveillance; otherwise, a chest drain, which is removed at the end of the procedure, can be inserted.

8.8 Misplacement of Trocars

During PRA, the peritoneum cavity can be accidentally opened; thus, in such cases, attention should be given to the abdominal organs that eventually become visible, such as the liver or the spleen. Nevertheless, the procedure can be concluded by the retroperitoneoscopic approach since, in this case, an adequate working space is not precluded [17].

8.9 Rare Complications

Wound infections are also described in 1.2–1.4% of cases, with no significant difference in incidence between laparoscopic and retroperitoneoscopic surgery [5].

In addition to the surgical complications summarized above, general complications should also be mentioned. Pneumonia, pleural effusion, and pulmonary embolism, as well as cardiac complications (new-onset arrhythmias, myocardial infarction) and Addison's Syndrome, although with a lower incidence (<2%), have been described in all studies without exception [3, 8, 22]. It is worth mentioning the incidence of postoperative deep vein thrombosis and pulmonary embolism after laparoscopic surgery (up to 1.5% and 0.4%, respectively) compared with retroperitoneoscopic surgery, in which these complications were not observed [3, 5, 8, 22].

8.10 Risk Factors for Intraoperative Complications

Among different risk factors for the occurrence of complications during minimally invasive adrenalectomy, both patient's and tumor's characteristics affect surgical outcomes. Among the former, age and body mass, American Society of Anesthesiologists Class 3 or 4, and diabetes appear to be the most influent; among the latter, the tumor size, and a diagnosis of pheochromocytoma are the most important independent risk factors. Also, a mass larger than 12 cm in diameter and suspected malignancy are usually considered relative contraindications to minimally invasive adrenalectomy because of the higher risk of peri- and postoperative complications [4]. The risk of complications after bilateral adrenalectomy is markedly higher than in uni-

lateral surgery (up to over 23% versus 0–15%) [2, 3, 7, 8]. Any procedural conversion (to hand-assisted or open surgery) is also associated to an increased rate of complications. Moreover, according to a study investigating the incidence of perioperative complications in TLAdr in high- and low-volume surgical departments, regardless of other risk factors, the whole number of complications, conversion rate, and non-surgery-related complications were statistically lower in the referral centers' groups (>30 adrenalectomies performed annually) than the non-referral centers [2]. Accordingly, both length of stay and charges seem to be significantly less for high-volume compared to low-volume centers [15]. Additionally, in a 2009 American study, 3144 adrenalectomies were analyzed to define the impact of surgeon volume and specialty (general surgeons versus urologists) on postoperative outcomes, concluding that patients with adrenal disease should be referred to surgeons based on adrenal volume and laparoscopic expertise irrespective of specialty practice [12].

In conclusion, both TLAdr and PRA should be preferably performed in high-volume specialist centers and by experienced surgeons. When available, robotic approach presents similar outcomes as laparoscopic adrenalectomy, especially for left adrenal lesions; however, clear indications on robotic adrenalectomy are still missing (see Chap. 12).

8.11 Laparoscopic Versus Retroperitoneoscopic Adrenalectomy

A summary of complications after adrenalectomy is shown in Table 8.1, comparing open, laparoscopic and retroperitoneoscopic approach.

TLAdr is considered a safe and standardized procedure, even for bigger tumors (>6 cm). The main advantage of the lateral transabdominal approach is that it allows gravity-facilitated exposure of the adrenal glands. However, based on the data presented, retroperitoneoscopic adrenalectomy appears to offer advantages due to extraperitoneal dissection, although these cannot be clearly demonstrated in a comparative study. A recent meta-analysis comparing laparoscopic (n = 1257), retroperitoneoscopic in the lateral position (n = 471), and retroperitoneoscopic in the prone position (n = 238) also failed to demonstrate a significant difference in postoperative complications. However, splenic injuries and intra-abdominal abscesses were observed only during laparoscopy or retroperitoneoscopy in the lateral position, whereas abdominal wall relaxation and hypoesthesia were documented only during retroperitoneoscopic surgery in the prone position [15]. Abdominal wall relaxation or hypoesthesia, while always transitory, was reported to have an incidence of 8.5% in a 2006 series [8]. In contrast, a prospective randomized study with 5 years of fol-

Table 8.1 Complications of adrenalectomy. Comparison between open, laparoscopic, and retroperitoneoscopic access methods

	Open adrenalectomy	Laparoscopic adrenalectomy	Retroperitoneoscopic adrenalectomy
Conversion due to vascular injury	–	2% [3, 23]	0% [8, 19]
Bowel lesions	Not investigated	Up to 1.3% [16]	Not described
Splenic injuries	Not investigated	1.2% [3] 1.7% [14]	0.7% [15] (in lateral position)
Pancreatic fistula	Not investigated	2.3% [3]	Not described
Abdominal wall complications	Incisional hernia up to 20% [25]	Trocar hernia up to 16% [13]	Trocar hernia 0.1% Hypoesthesia 8.5% [8]
Bleeding	Up to 5.7% [5]	1.5%	0.7% [8]
Blood transfusion	10.9% [23]	2% [23]	0.2% [8]
Pulmonary embolism	1.2% [1]	0.5% [1]	<1% [20, 21]
Pneumonia	Up to 5.7% [5]	2.4% [15]	1.7% [15]
Wound infections	4.6% [14]	1.2% [15]	1.4% [15]

low-up comparing 30 retroperitoneoscopic with 31 laparoscopic adrenalectomies found an incidence of postoperative trocar hernia of 16.1% after laparoscopy vs. 0% after retroperitoneoscopy [13].

Although conversion of laparoscopic surgery is not considered a complication, it favors peri- and postoperative complications. It has been calculated that conversion increases the risk of postoperative complications with an odds ratio of 6.2 [8]. Therefore, the experience of centers is important to reduce the rate of conversion, as demonstrated in an Italian study. In this study, the authors compared the rate of conversion of reference centers (>30 adrenalectomies per year) and other hospitals (<30 adrenalectomies per year) and observed a significant reduction in conversions from 6.0% to 1.6% in favor of the reference centers ($p = 0.003$) [2]. Therefore, the minimum volume regulation already implemented for other surgeries could lead to an improvement in the quality of adrenal surgery, because the appropriate experience can significantly reduce the risk of postoperative complications.

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