

# Laparoscopic Adrenalectomy: Review of Complications in 123 Procedures at a Single Brazilian Center

## Adrenalectomia Laparoscópica: Revisão das Complicações em 123 Procedimentos de um Centro Brasileiro

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### ABSTRACT

**Introduction:** The laparoscopic approach to the adrenal gland was first reported in 1992. Since then, many publications about this issue have come from Europe, Japan and North America. We reviewed our 13-year experience with laparoscopic adrenal surgery. **Patients and Methods:** Laparoscopic adrenalectomy was carried out in 132 patients between January 1994 and January 2007. The first 113 procedures, in 77 females and 36 males, were reviewed. Age ranged from 1 to 76 years ( $43.1 \pm 16.2$  years). Nineteen (16.8%) patients had unilateral tumor larger than 4 cm; 25 (22.1%) patients had a Body Mass Index  $\geq 30$  kg/m<sup>2</sup>; and 13 (11.5%) had had previous open upper abdominal surgery. The size of the lesion ranged from 1 to 9 cm ( $3.3 \pm 1.6$  cm). A total of 123 adrenalectomies were performed in 116 operations, of which 109 were unilateral and 7 were bilateral. The lateral transperitoneal approach was employed in 113 cases; a lateral retroperitoneal approach was used in 3 adrenalectomies. All patients were followed for a minimum of 36 months. **Results:** Unilateral procedures took  $107 \pm 33.7$  min (45-250 min); bilateral procedures  $180 \pm 90.6$  min (100-345 min); 5 (4.3%) cases were converted to open surgery. Twenty (17.7%) patients suffered complications, of which 8 (7.0%) were intra-operative and 12 (10.6%) postoperative complications. Six (5.3%) cases were considered major complications. No deaths occurred due to the surgical procedures. The blood transfusion rate was 3.5%. **Conclusion:** Laparoscopic adrenalectomy is feasible and has excellent results in selected patients.

**Key words:** Laparoscopy. Laparoscopic adrenalectomy. Adrenalectomy.

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### INTRODUCTION

The laparoscopic approach to the adrenal gland was first reported in 1992.<sup>1,2</sup> Since then, nearly 1000 articles have been published (*Medline*, May 2007), encompassing thousands of patients. The efficacy and safety of laparoscopic adrenalectomy are well established.<sup>3-7</sup> Studies comparing open surgery and laparoscopic surgery have demonstrated that the laparoscopic intervention should be considered the gold standard for adrenal surgery.<sup>8-13</sup> The criteria for selecting patients, however, is important. The majority of patients who have undergone laparoscopic adrenalectomy since 1992 have involved cases of

benign disease and tumors of up to 8 cm in their greatest dimension. Patients with tumors with evidence of local invasion and patients with more voluminous tumors are better treated with open surgery. The definition of what constitutes a large tumor depends on the personal experience of the surgeon, but the definition of local extension depends on imaging studies and is less subjective.

Most of the reports of laparoscopic surgery of the adrenal gland come from North America, Europe, and Japan. Few studies have come from Latin America.<sup>14-16</sup>

In this study, we present our experience with laparoscopic adrenalectomy, with emphasis on detailed

reporting of complications, comparing them with data already published in the international literature.

## PATIENTS AND METHODS

Laparoscopic adrenalectomy was performed in 132 patients between January 1994 and March 2007. Of these, the first 113, including 77 women and 36 men (2.13:1), were evaluated as they had accumulated at least 36 months of postoperative follow-up. The results were evaluated retrospectively. Two exclusion criteria were applied at the time of the indication for surgery: extra-adrenal tumor invasion observed with computerized tomography (CT) and tumor size exceeding 9 cm in its largest axis. Age varied from 1 to 76 years ( $43.1 \pm 16.2$  years) and the BMI varied from 18.7 to 40.5 kg/m<sup>2</sup> ( $27.4 \pm 4.5$  kg/m<sup>2</sup>). Ten (8.8%) patients were 20 years older or younger; 19 (16.8%) had unilateral tumors larger than 4 cm; 25 (22.1%) patients were considered obese (BMI  $\geq 30$  kg/m<sup>2</sup>); and 13 (11.5%) had previously undergone some surgical procedure in the upper abdomen.

Ninety-eight (86.7%) of the 113 patients presented unilateral solid tumors of the adrenal, 45 on the right side and 53 on the left side. Twelve (10.6%) patients presented bilateral tumors (5 cases) or Cushing's disease of the pituitary (7 cases). Three (2.6%) patients presented cystic tumors of the adrenal measuring 4 to 6 cm in the largest dimension.

The preoperative clinical diagnosis upon which the indications for surgery were based were as follows: nonfunctioning adenoma (33 patients), primary hyperaldosteronism (24 patients), Cushing's syndrome (21 patients), pheochromocytoma (16 patients), Cushing's disease of the pituitary (7 patients), virilizing tumor (4 patients), pseudocyst (3 patients), pheochromocytoma associated with a contralateral nonfunctioning tumor in the same patient (1 patient) and an uncertain diagnosis between functioning and nonfunctioning tumor (4 patients).

Clinical investigation was carried out by endocrinologists specialized in adrenal disorders with the goal of establishing the diagnosis which best explained the hormonal function of each case. The measurement of the greatest dimension of the adrenal lesion was obtained by means of CT and varied from 1 to 9 cm ( $3.3 \pm 1.6$  cm). One hundred and sixteen surgical interventions were performed in 113 patients. In 109 cases the intervention was unilateral; in seven cases it was bilateral. The total number of adrenal

glands operated was 123. Of the 116 procedures, 113 were performed via a lateral transperitoneal laparoscopic technique and three via a lateral retroperitoneal technique. In three of 113 lateral transperitoneal interventions, a partial adrenalectomy was performed, all three in patients with bilateral disease and functioning tumors smaller than 3 cm, one with pheochromocytoma and two with hyperaldosteronism.

Statistical analysis: Initially all the variables were analyzed in a descriptive fashion. For the continuous variables, the analysis was based on the observation of minimum and maximum values, and in the calculation of means and standard deviations. For the classificatory variables, absolute and relative frequencies are calculated. The analysis of the hypothesis of equal proportions between groups was evaluated by means of the chi-square test and the Fisher exact test. The hypothesis of equality of means between two groups was verified using the Student "t" test. The level of significance for the test was set at 5%.

## PREPARATION OF THE PATIENTS

The preoperative clinical preparation of patients with functioning tumors or Cushing's disease of the pituitary should be performed by the endocrinologists responsible for their respective patients. Basically, this means the correction of metabolic disturbances and control of arterial hypertension. All patients with a clinical or laboratory suspicion of pheochromocytoma should be prepared for surgery with prazosin, an alfa-blocker, with a dose ranging from one to 20 mg per day, during a period that varies from two to six weeks. All patients should undergo routine clinical and cardiologic examinations, and blood should be provisioned for the surgery.

Surgical preparation should follow these general guidelines, adjusted for each case: a light diet two days prior to surgery and a liquid diet on the eve of surgery; enema using 500 ml of glycerin solution to cleanse the sigmoid colon and the rectum; shaving of the abdomen immediately prior to surgery and antibiotic prophylaxis with a broad spectrum antibiotic administered in the operating room and usually maintained for 72 hours. The enema is not indispensable in all cases, but is important in those patients with chronic constipation. Prophylactic

anticoagulation may be appropriate in special cases, but not routinely.

In the operating room patients undergo general anesthesia with orotracheal intubation. Occasionally some patients may also undergo peridural blockade for postoperative analgesia, at the discretion of the anesthesiologist. Nasogastric drainage and a Foley catheter are placed in order to decompress the abdominal cavity. In all patients with a diagnosis of pheochromocytoma, in addition to a central venous catheter, peripheral arterial catheters are placed in order to constantly measure the mean arterial pressure. As in all laparoscopic procedures, partial pressures of oxygen and carbon dioxide are continuously monitored by oximetry.

## OPERATIVE TECHNIQUE <sup>17</sup>

Once anesthetized, patients are positioned on the surgical table in the following manner: for unilateral surgery, lateral decubitus at 45 degrees, elevating the side to be operated; for bilateral surgery, the same applies, one side at a time. Cushions, adhesive tape, and, in some cases, elastic stockings are placed in order to prevent bedsores, burns, nerve damage and venous thrombosis.

Once the routine steps of asepsis and antisepsis are performed, the following technical steps are obeyed:

1<sup>st</sup>) Insufflation of carbon dioxide (CO<sub>2</sub>) into the peritoneal cavity by means of the introduction of the Veress needle into the abdomen, either in the midline, on the edge of the umbilicus, or in the midclavicular line on the same side of adrenalectomy to be performed. In cases of previous abdominal surgery, especially in the upper abdomen, the Veress needle is replaced by an 11 or 12 mm Hasson cannula, inserted by means of a minilaparotomy. In this first step of the procedure, the maximum intracavitary pressure attained varies between 15 and 18 mmHg.

2<sup>nd</sup>) With the pneumoperitoneum established, four trocars of 10/11mm are introduced into the abdomen. In children and in some thin patients two 10/11mm trocars and two 5mm trocars are used. A fifth 5 mm trocar is occasionally introduced in more difficult cases. With the pneumoperitoneum established, the insufflation pressure is adjusted to 12 to 15 mmHg on average, a bit more in obese patients and a bit less in children. For bilateral surgeries, the same protocol is carried out with the surgical team

and the laparoscope stand switching sides, and the introduction of three or four additional trocars.

3<sup>rd</sup>) With the position of the patient on the surgical table and the equipment adjusted, and the abdominal cavity inspected and adhesions lysed, one proceeds with the medial mobilization of the colon and the exposure of the renal fascia and the great vessels, renal vein on the left side, and vena cava on the right side. Occasionally, only the mobilization of the hepatic flexure of the colon is sufficient in the cases where there is greater difficulty in exposing the vena cava. On the left side, the complete mobilization of the colon from the splenic flexure to sigmoid is always necessary.

4<sup>th</sup>) Right side: An adequate upward displacement of the liver almost always requires the partial sectioning of right triangular ligament. Next incising the posterior reflection of the peritoneum immediately below the liver, between the vena cava and the right triangular ligament, one identifies, generally by its characteristic yellow color, the adrenal gland. Proceed then to approach the medial aspect of the gland next to the inferior vena cava, through an incision on the right margin of the vein. Next identify the principal or central adrenal artery, a tributary of the inferior vena cava, which is sectioned between metal clips before manipulating the gland. From the ligature, approach the gland along the aspect that contacts the kidney, by incising Gerota's fascia or renal fascia and separating the adrenal gland from the upper pole of the kidney and from the renal vein. Finally, the superior and lateral borders are separated from adjacent structures, generally by delicate dissection, cauterization, and section of small arterial, veins and lymphatics. An approach medial to the adrenal favors the identification of the inferior vena cava and the adrenal gland, because the gland is pulled somewhat laterally.

5<sup>o</sup>) Left side: completely mobilize the left colon medially, from the splenic flexure to the upper narrowing of the pelvis. For the medial mobilization of the spleen and tail of the pancreas, the parietal peritoneum must be incised cranially along the left parietocolic groove up to the diaphragm. This maneuver is facilitated by rotating the surgical table to the right such that the patient is placed in a decubitus position of almost 90 degrees relative to the floor. The force of gravity moves the colon medially making it easier to displace the tail of the pancreas supero-medially. The plane of dissection between the tail of the pancreas and Gerota's fascia or renal fascia

is subtle and can be confused, creating a risk of injury to the pancreas. This is the most delicate moment of the left transperitoneal adrenalectomy. Proceed first, then, approaching the infero-medial aspect of the gland, identifying the upper edge of the renal vein, where one can isolate between clips and section the left adrenal vein. Then, free the gland lateral and superior aspect, taking care to cauterize the arterial vessels originating from the aorta, from the inferior phrenic artery, from the renal artery, all potential sources of bleeding. The left adrenal gland is in close approximation to the renal hilar vessels, which requires careful attention during inferior and lateral dissection. As in the approach to the right gland, the opening of Gerota's fascia between the kidney and the adrenal defines the proper dissection plane.

6<sup>th</sup>) Once completely freed, the surgical specimen is removed intact, without morcellation, from the abdomen, inside a plastic bag introduced endoscopically, by widening one of surgical openings of the abdominal wall, generally the most inferior, close to the antero-superior iliac crest.

7<sup>th</sup>) With the surgical specimen removed, proceed with the inspection of the abdominal cavity and the closing of the surgical wounds, in two planes, fascial and cutaneous, for incisions 10 mm or more, and by skin approximation only for incisions smaller than 10 mm.

### **Retroperitoneal Access**

With the patient in lateral decubitus, exactly as is done in a classic lumbotomy, with the surgeon and assistant surgeon side by side, facing the dorsum of the patient, establish laparoscopic access to the retroperitoneum in the following manner:

1<sup>st</sup>) In the posterior axillary line, between the end of the last rib and the iliac crest, preferably in the inferior lumbar triangle (also known as Petit's triangle), where the musculature is thinner, open the skin 2 cm and after opening the wall by planes introduce the index finger into the retroperitoneum. With the index finger establish a space and free the peritoneum anteriorly. If the plane of dissection is correct you should be able to digitally identify the psoas muscle and the inferior pole of the kidney.

2<sup>nd</sup>) Having created the space digitally, introduce a Gaur balloon or an industrializado ball of silicone, so that it remains between the kidney and the psoas muscle. Inflate the balloon with about one liter of normal saline or air, maintaining

it inflated for several minutes in order to promote hemostasis.

3<sup>rd</sup>) Deflate and remove the balloon from the retroperitoneum. Insert a 11 or 12 mm Hasson cannula, fixed to the aponeurosis, and insert a trocar in the bed created and maintained with CO<sub>2</sub> at a pressure of 15 to 18 mmHg.

4<sup>th</sup>) Under direct visualization three other trocars are introduced in the bed.

5<sup>th</sup>) The dissection partially obtained with the dilating balloon between the psoas muscle and Gerota's fascia or the renal fascia proceeds now agora with clamp and scissors, in order to expose the renal vessels, which are the principal anatomic landmark on both sides. On the right side the inferior vena cava is occasionally identified first.

6<sup>th</sup>) Cranial to the renal vessels, the adrenal gland is encountered; it is isolated from adjacent structures. Rarely can one proceed to ligation of the adrenal vein without first manipulating the gland. It is usually easier to partially dissect the gland and then identify the vein. Finally, complete the separation of the gland from the adjacent structures, in a manner similar to that already described for the transperitoneal approach.

7<sup>th</sup>) Section the adrenal vein between the metal clips and remove the bagged specimen through the incision made for Hasson's cannula.

8<sup>th</sup>) Close the surgical incisions.

### **Partial Adrenalectomy**

The partial adrenalectomy obeys the following technical steps, besides those already described:

1<sup>o</sup>) Approach and dissection of the gland follows the steps described for transperitoneal or retroperitoneal access, except for the ligation of adrenal vein;

2<sup>o</sup>) Section the affected region, with a margin of safety, with a 35mm linear vascular stapler or by incision with ultrasonic bistoury.

3<sup>o</sup>) Confirm hemostasis of the bloody aspect of the gland, removal of the surgical specimen, and closure of the abdominal wall incisions.

## **CRITERIA FOR THE EVALUATION OF RESULTS**

Patients were considered cured when their underlying diseases of the adrenal glands, metabolically active or not, could no longer be identified

by laboratory tests or imaging in the late post-operative period (>6 months).

Intra-operative complications were considered unexpected events in the surgical procedure, whether or not they required emergency measures or whether or not they requiring conversion. Conversion to open surgery itself was not considered an intra-operative complication.

Post-operative complications were considered any departure from the ideal evolution during the first three months after surgery, including the period in the hospitalization.

Major complications were those that contributed to morbidity and/or prolonged the period of convalescence and/or required a blood transfusion.

Patients were considered to have been transfused if they received a unit of packed red cells from the intra-operative period until discharge.

Surgical time was clocked from the beginning to the end of the insufflation of CO<sub>2</sub> in the transperitoneal procedures, this is, from the insertion of the Veress needle until the insufflator was turned off, generally leaving only the suturing of the skin of the four or five surgical incisions in order to complete the surgery. For the retroperitoneal procedures, surgical time was measured from the skin incision until the insufflator was turned off. For those patients who underwent additional procedures, only the time of the adrenalectomy was considered. In patients with previous abdominal surgeries, the time devoted to adhesiolysis was included in the operative time of the adrenalectomy.

Neither the intra-operative blood loss nor the quantity of analgesics administered were objectively evaluated. The time it took for patients to resume eating and ambulating were obtained from the nursing notes; the unit of measure was the day, not the hour.

## RESULTS

One hundred and sixteen surgical interventions were carried out in 113 different patients because three patients with bilateral disease who were operated on two different occasions (two times) at the beginning of our series. In these 116 interventions, 123 glands were removed, 120 totally and 3 partially, with 66 (53.6%) on the right side and 57 (46.3%) on the left side. One hundred and twenty glands were approached through a transperitoneal route and three through a retroperitoneal route.

The unilateral procedures not converted took  $107 \pm 33.7$  minutes (range: 45-250 min.); the bilateral cases  $180 \pm 90.6$  minutes (range: 100-345 min.).

Five (4.3%) of 116 surgical interventions were converted to open surgery because of subperitoneal emphysema (1), intestinal adhesions (1), adherence of a pheochromocytoma to the posterior aspect of the inferior vena cava (1) and uncontrollable venous bleeding (2). (Table 1)

No death attributed to the surgery was observed during the 36 months that followed the surgeries. Nevertheless, two patients with lung cancer and adrenal metastases died because of disseminated disease.

**Table 1** – Conversions (and %) in Different Subgroups.

Subgroup	No of interventions	Conversions (%)
All cases	116	5 (4.3)
Unilateral surgery	109	5 (4.6)
Right sided surgery	52	4 (7.7)
Left sided surgery	57	1 (1.7)
Bilateral surgery in the same operation	7	0
Non obese (BMI <30 kg/m <sup>2</sup> )	88	3 (3.4)
Obese (BMI <sup>3</sup> 30 kg/m <sup>2</sup> )	25	2 (8)
No history of upper abdomen surgery	110	4 (3.6)
Previous upper abdomen surgery	13	1 (7.7)
Tumor > 4 cm	19	1 (5.2)
Tumor ≤ 4 cm	97	4 (4.1)

*There was no statistical difference among different subgroups.*

Twenty (17.7%) patients developed major and minor complications, of which eight (7.0%) were intra-operative and 12 (10.6%) post-operative. Of the twenty patients with complications, six (5.3%) had major complications: intra-operative hemorrhage with conversion and transfusion (2), acute tubular necrosis (2), retroperitoneal abscess (1) and pancreatic fistula (1).

Blood transfusions were necessary in four (3.5%) patients, two in the operating room and two post-operatively. The average post-operative length-of-stay was  $5.7 \pm 15.0$  days (1-140 days). The duration of post-operative follow-up ranged from 36 to 120 months; cases were only included in this series if the patient had attained a minimum of 36 months of post-operative follow-up.

The final anatomico-clinical diagnoses in the 113 patients were as follows: non-functioning cortical adenoma (29), primary hyperaldosteronism (24, including 21 with unilateral adenoma, 1 with bilateral adenoma, 1 with bilateral micronodular hyperplasia, 1 with bilateral macronodular hyperplasia), Cushing's syndrome (20), pheochromocytoma (18), Cushing's disease of the pituitary (7), virilizing disease (4), metastases of lung cancer (3), adrenal pseudocyst (3), ganglioneuroma (2), myelolipoma (1), pheochromocytoma and hyperaldosteronism in the same gland (1), pheochromocytoma and contralateral non-functioning adenoma (1).

In six cases of primary unilateral adrenal tumor, the pathologist considered them malignant, four because of the high mitotic indices and two because of the presence of tumor thrombus in the corresponding central adrenal veins. In all six cases, the tumors were less than 5 cm in the major axis. Three were cases of virilization; two were cases of Cushing's syndrome, and one a non-functioning tumor. In none of these six cases has the supposedly malignant disease progressed. A minimum follow-up of 36 months is justified from an oncologic point of view when considering adrenal tumor disease, given the difficulty of anatomic pathologic interpretation.

Subjected to statistical analysis, the data revealed the following statistically significant differences ( $p < 0.05$ ): unilateral adrenalectomy took longer during the first half of the series than during the second; in the first half of the series right-sided adrenalectomy took longer than left-side procedures (in the second half of the series the times equaled); the operative time was greater in the patients with

tumors  $> 4$ cm in the longest dimension; the complication rate was greater in patients who underwent bilateral surgery; complications were more frequent in patients with Cushing's disease of the pituitary.

## DESCRIPTION OF THE COMPLICATIONS

### Intra-operative Complications

Complications occurred during surgery in eight (7%) of 113 patients. Two of these eight cases were converted to open surgery in order to repair a significant lesion of a vein. In the other cases complications were of a lesser importance and did not add morbidity to the patients.

In case 5 (the cases are numbered in chronologic order) at the moment that the surgical specimen – a tumor of 5.5 cm in diameter – was being removed the plastic bag, ill-suited for the procedure, tore and the specimen fell into the peritoneal cavity. To find the specimen, the trocar incision where the specimen would have been removed (originally about 4 cm in length), had to be widened to 7 cm in order to permit the surgeon's hand to be inserted. This maneuver added close to 50 minutes to the surgical procedure. The specimen was found and removed. Apart from the somewhat longer scar, the patient experienced no additional morbidity because of this accident.

In case 9, a 10 year old child with pheochromocytoma, a lesion of the adrenal vein that drains into the liver was torn during a maneuver to free the upper pole of the gland from the liver, required an urgent laparotomy. Beside the morbidity added by the laparotomy, the patient was transfused with five units of packed red blood cells. The hospitalization was prolonged with the patient discharged on POD 11. This case was considered a case with a major complication.

In case 26, a lesion of the epigastric vessels occurred during the insertion of a 10/11 mm trocar into the left iliac fossa. A Foley catheter was introduced, the balloon was inflated and traction applied throughout the procedure. At the end of the procedure the surgical incision was widened to remove the specimen and hemostasis was obtained without difficulty. The patient required the insertion of an extra trocar (5 rather than 4) and this was only alteration that the accident provoked.

In case 38, a man with a non-functioning tumor on the right side, metastasis of lung cancer, very adherent to the vena cava, the detachment of a large lumbar vein that drains into the vena cava occurred. Despite attempts to laparoscopically suture the vein, the bleeding could not be controlled and a median laparotomy had to be performed. The patient received five units of packed red blood cells in the operating room and the adrenalectomy was completed with difficulty due to the adherence of the tumor to the vena cava and the patient's obesity. The patient had no post-operative complications and was discharged on POD 3. This complication was considered a major complication, because of the morbidity added by the laparotomy and because of the transfusion.

In case 43, a non-functioning tumor of the right adrenal, several lacerations of the liver occurred, caused by the use of an improper retractor and because of the lack of experience of the surgical assistant. The lesions were cauterized without success and then tamponaded with gauze for several minutes. The bleeding stopped, the surgery was completed, and no complication occurred in the post-operative period. Blood loss evaluated by hematocrit and hemoglobin was considered insignificant and an ultrasound during the hospitalization did not reveal any abnormality.

In case 48, a right-sided pheochromocytoma, a small lesion of the anterior wall of the vena cava was produced at the beginning of the surgery while probing for a plane of dissection between the vena cava and the duodenum. The lesion was rapidly sutured and the surgery proceeded via laparoscopy without difficulty until its conclusion. Blood loss was insignificant and the patient evolved without other complications.

In case 80, an obese patient with Cushing's Disease, with various clinical complications, who was anti-coagulated (heparinized) because of a recent lower extremity deep vein thrombosis, experienced bleeding during right adrenalectomy because of a superficial lesion of the liver. Using cauterization with an electric bistoury and tamponade with gauze, the bleeding stopped and the surgery was completed. There was no post-operative complication stemming from the accident.

In case 85, during a retroperitoneal dissection to treat a lesion of the right adrenal, a perforation of peritoneum occurred, which hampered but did not impede the completion of the procedure. No

complication occurred as a consequence of the peritoneal lesion.

It was noted that in six (75%) of the eight intra-operative events, surgical access to the adrenal was from the right.

The BMI of patients who presented intra-operative complications ranged from 21.5 to 30.5 (mean: 26.6).

The greatest diameter of the glands that had nodules (there were two normal glands) ranged from 1.5 to 5.5 cm (mean: 3.6 cm).

### **Post-Operative Complications**

Post-operative complications occurred in 12 (10.6%) of the 113 patients.

Case 8, a man with hyperaldosteronism due to a left adrenal tumor, on POD 1 presented a retroperitoneal hematoma that infiltrated the anterior abdominal wall and the scrotum. The hematoma was managed clinically; the patient developed acute renal insufficiency (ARI) and required transfusion with two units of packed red blood cells and several sessions of hemodialysis. He was discharged on POD 16 and has subsequently presented two other late complications: umbilical hernia at the site of one of the 10/11mm trocars and chronic hepatitis C, probably acquired in the hospital from the transfusion or hemodialysis. This case was considered a case with a major complication.

Case 10, an obese woman with Cushing's syndrome due to a left adrenal tumor, developed an abscess of the adrenal bed that twice required open drainage, prolonged parenteral nutrition and an extremely long hospitalization (140 days). Although not confirmed, the presence of a small pancreatic fistula must have been the cause of the complication. The patient evolved without late sequela and was cured of the hormonal disturbance. It is worth noting that the complication occurred in an open surgery after early conversion from a laparoscopic surgery when the patient was found to have a very distended colon that impeded continuation of the procedure. A left subcostal incision was made, and the surgeons proceeded with an open surgery that was uneventful. This case was considered a case with a major complication.

Case 15, a woman with hyperaldosteronism, developed a fever on the POD 1, apparently caused by pulmonary atelectasis. Com respiratory physical therapy and antibiotics, she improved and was

discharged with fever on POD 2. There were no other post-operative complications.

Case 17, a man with Cushing's Disease, was operated in two steps, at the beginning of the case series. The first surgery was a right adrenalectomy with complications. The second surgery, on the left side, was complicated by fever beginning on POD 4. An abscess of the adrenal bed was thoroughly drained via an open procedure. A low output pancreatic fistula was documented. The patient received parenteral nutrition and was discharged cured on POD 60. This case was considered a case with a major complication.

Case 23, a woman with a left sided "incidentaloma", presented with severe left shoulder pain of one week's duration that was attributed to diaphragmatic irritation or poor positioning of the patient on the operating table. Abdominal ultrasound and radiographs of the shoulder were normal on POD 3. With parenteral analgesia she improved and was discharged on POD 10 with pain. She did not present other complications.

Case 36, uneventful surgery of a non-functioning tumor of the left adrenal, developed marked distention of the small intestine on POD 1. The patient experienced no vomiting and was discharged on POD 4 with mild residual distention, but eating normally. There were no further post-operative complications.

Case 40, a woman with Cushing's Disease who underwent bilateral adrenalectomy and implanting of part of one adrenal gland in the subcutaneous tissue of the forearm, developed fever on POD 1. With broad-spectrum antibiotics – chosen in light of her immunocompromised state – the fever resolved and she was discharged on POD 6. She did not present any late complications.

Case 50, a woman with Cushing's Disease who underwent bilateral adrenalectomy and implanting of part of one adrenal gland in the subcutaneous tissue under the incision made for a trocar in the abdomen, developed fever on POD 1 and signs of inflammation at the implant site. With antibiotics she improved slowly and was discharged on POD 16. She did not present any other late complications.

Case 51, a patient with severe hypertension caused by a right-sided pheochromocytoma measuring 5 cm in its large dimension when evaluated by CT, was found intra-operatively to have a larger tumor, measuring nearly 6.5 cm, partially localized behind and adherent to the vena cava. The surgery was converted. During the operation, after ligation of the adrenal vein,

the patient became hypotensive and developed oliguria and ARI and treated with diuretics and diet. The patient improved and was discharged on POD 5. On POD 12 the patient noted spontaneous drainage of a subcutaneous purulent collection in the wide subcostal incision. The patient improved and presented no further late complications. This case was considered a case with a major complication.

Case 53, a woman with Cushing's syndrome caused by a 3 cm tumor of the left adrenal, had an uneventful surgery, but developed abdominal distention and uncontrollable vomiting. She was managed clinically and was discharged on POD 15. It was later determined that she had chronic calculous cholecystitis, an established diagnosis, but which was overlooked. She progressed well and presented no further complications. She was referred for cholecystectomy.

Case 61, a patient with Cushing's syndrome for bilateral macronodular hyperplasia of the adrenals, underwent bilateral adrenalectomy, and was discharged on POD 6. One month later she presented to the Emergency Room with diffuse abdominal pain and vomiting. An ultrasound, confirmed by CT, showed a small hematoma in the left adrenal bed, apparently unrelated to the clinical presentation. She was treated with a brief fast and analgesics and fully recuperated. She presented no further late complications.

Case 62, a man with a right-sided pheochromocytoma, was operated uneventfully, but developed abdominal distension on POD 1, perhaps because his diet was advanced prematurely. He was discharged on POD 2 without other complications.

The BMI of patients who presented post-operative complications ranged from 21.1 to 36.9 (mean: 27.1).

The largest diameter of the adrenal that contained nodules – four glands found to be normal – varied from one to five centimeters (mean: 2.4 cm).

In an earlier publication, we analyzed our first 94 patients, and presented the complications in different subgroups derived from that cohort<sup>15</sup> (Table 2).

## DISCUSSION

Minor and major complications occurred in 20 (17.7%) patients. There were six (5.3%) major complications that added morbidity or provoked a prolonged hospitalization. Two of these six major complications occurred as consequences of open surgery; these two patients (cases 10 and 51) were



**Table 2 - Complications: intra-operative, post-operative, total, and major in different subgroups of the study.**

Subgroup	No. of patients	Intra-operative Complications (%)	Post-operative Complications (%)	Total Complications (%)	Major Complications (%)
All cases	94	8 (8.5)	12 (12.8)	20 (21.3)	6 (6.4)
Unilateral surgery (85) or bilateral surgery in two steps (3)	88	7 (8)	9 (10.2)	16 (18.2)	6 (6.8)
Unilateral surgery (right)	42	5 (11.9)	3 (7.1)	8 (19)	3 (7.1)
Unilateral surgery (left)	49	2 (4.1)	6 (12.2)	6 (12.2)	3 (6.1)
Bilateral surgery in a single operation	6	1 (16.7)	3 (50)	4 (66.7)	0
Nonfunctioning Tumor	25	2 (8)	2 (8)	4 (16)	0
Hyperaldosteronism	21	1 (4.8)	2 (9.5)	3 (14.3)	1 (4.8)
Cushing Syndrome	17	0	3 (17.6)	3 (17.6)	1 (5.9)
Pheochromocytoma	13	3 (23.1)	2 (15.4)	5 (38.5)	2 (15.4)
Cushing Disease	7	1 (14.3)	3 (42.9)	4 (57.1)	1 (14.3)
Virilizing Tumors	4	0	0	0	0
Metastases	3	1 (33.3)	0	1 (33.3)	1 (33.3)
Pheochromocytoma & hyperaldosteronism	1	0	0	0	0
Pheochromocytoma and incidentaloma	1	0	0	0	0
Ganglioneuroma	1	0	0	0	0
Myelolipoma	1	0	0	0	0
Men	33	4 (12.1)	5 (15.1)	9 (27.3)	5 (15.1)
Women	61	4 (6.6)	7 (11.5)	11 (18)	1 (1.6)
Obese (IMC $\geq$ 30)	22	1 (4.5)	2 (9.1)	3 (13.6)	1 (4.5)
Non-obese (IMC < 30)	72	7 (9.7)	10 (13.9)	17 (23.6)	5 (6.9)
Nodule >4cm	10	1 (10)	1 (10)	2 (20)	1 (10)
Nodule $\leq$ 4cm	84	7 (8.3)	11 (13.1)	18 (21.4)	5 (5.9)
Converted	5	2 (40)	2 (40)	4 (80)	4 (80)
Previous abdominal surgery	10	1 (10)	2 (20)	3 (30)	1 (10)

Among the various subgroups there were only statistical differences in the subgroup that underwent bilateral surgery in a single operation versus those who underwent unilateral surgery or bilateral surgery in two steps ( $p=0.02$ ); and in male and female subgroups, but only in relation to the subgroup with major complications. ( $p = 0.02$ ).

In the subgroup of anatomic and clinical diagnoses there were no differences among the different subgroups. However, if Cushing Disease versus the sum of the other is analyzed, there is a significant difference in the complication rates ( $p=0.04$ ).

electively converted as the laparoscopy was getting underway. Thus there were actually four (3.6%) major complications. This rate is similar to that reported by authors with similar case series.

The comparative statistical analysis found just three differences: 1) among men and women with respect to the incidence of major complications; 2) between unilateral surgery and bilateral surgery in the same operation; and between Cushing's disease of the pituitary and other anatomic and clinical entities.

There were no differences between left and right sided procedures, nor between tumors smaller and larger than 4 cm, obese and non-obese patients, and patients with a history of prior abdominal surgery.

Tsuru *et al.*<sup>47</sup> demonstrated that there is no statistically significant difference with regard to operating time, hemorrhage, the length of hospitalization, as well as the rate of complications in individuals with tumors greater than 5 cm, when compared to individuals with tumors smaller than 5 cm.

The complications in cases of bilateral disease operated in the same laparoscopic procedure and those with Cushing's Disease of the pituitary were actually the same cases. *Cushingoid* patients are extremely ill, especially those with long-standing and advanced disease. All of our cases of Cushing's disease of the pituitary had already undergone one or two surgeries of the pituitary without success and presented various clinical complications. In truth, these patients are quite ill and complications with either laparoscopic surgery or open surgery are expected.<sup>18,19</sup> Other authors have reported extremely high complication rates, close to 50%, in comparable patients.<sup>20</sup> Thus the nature of this disease, rather than the laparoscopic technique, is likely responsible for this situation.

Pheochromocytoma cases were not statistically different from other subgroups, but the characteristics of the sample and the relatively small number of cases of pheochromocytoma, do not permit a conclusive analysis. Other authors have demonstrated that pheochromocytoma cases are not different from others, except Cushing's Disease cases. Many reports in the literature in recent years

has suggested that pheochromocytoma should be operated primarily by the laparoscope, even when bilateral or associated with a paraganglioma.<sup>21-31</sup> Our experience with pheochromocytoma points in the same direction.<sup>32</sup>

In an article published by Zhang *et al.*,<sup>50</sup> the authors concluded that even in experienced hands, adrenalectomy in patients with pheochromocytoma resulted in a 37.7% rate of severe hypertensive crises, which in turn increase the risks and complication rates of this procedure.

Bilateral surgery, when indicated, should, according to various authors, be performed as a single operation, which is safer for the patient.<sup>8, 33-36</sup>

Porpiglia *et al.*<sup>49</sup> observed that all of the cases of adrenocortical carcinoma studied in their series were larger than 4 cm in diameter and had heterogeneous areas on radiologic examination. In addition, a serious complication in this study was the seeding of tumor cells in the trocar incision, which became evident five months after the surgical procedure.

The results of several authors are presented in table 3.

**Table 3 - Laparoscopic adrenalectomy results reported by various authors.**

Author	No. of patients	Age in years	Female/male ratio	Nodule Size (cm)	Unilateral time (min.)	Conversions (%)	Total Complications (%)	Death (%)	Transfusion (%)	Hospital stay (days)
Thompson et al. <sup>37</sup>	57	50	1.5:1	2.9	167	12	6	0	3.5	3.1
Mancini et al. <sup>38*</sup>	172	52	1:1.5	4.9	132	7	8.7	1.16	NR	5.8
Gagner et al. <sup>39</sup>	88	46	2:1	1-14	123	3	12	0	NR	3
Filipponi et al. <sup>7</sup>	50	49.6	1.95:1	4.8	110	0	0	0	0	2.5
Imai et al. <sup>13</sup>	41	47.3	1:1	2.8	147	2.4	4.9	NR	2.4	12
Takeda et al. <sup>40</sup>	76	NR	1.45:1	3	203	3.9	NR	0	NR	NR
Terachi et al. <sup>41 *</sup>	370	NR	NR	NR	NR	3.5	15	0	NR	NR
Michel et al. <sup>42</sup>	63	41	2:1	4	120	3	6.3	0	1.6	4
Suzuki et al. <sup>43</sup>	75	51.9	1:1.1	NR	202	6.7	28	0	9.3	NR
Bendinelli et al. <sup>9</sup>	61	NR	1.7:1	NR	96.5	1.6	6.5	0	0	3.4
Henry et al. <sup>44</sup>	159	49.7	1.6:1	3.2	129	5	7.5	0	0.6	5.4
Bonjer et al. <sup>45</sup>	95	50	2.1:1	3.4	114	4.5	11	0.9	NR	2.2
Walz et al. <sup>46</sup>	560	52.4	1.6:1	2.9	67	1.7	15.7	0	1.3	2.8
Tsuru et al. <sup>47</sup>	178	47.9	NR	6.5	176	0	12	0	2.3	5.0
Meria et al. <sup>49</sup>	212	48	1.3:1.0	1.73	102	14	10	0	2.8	3.6
Porpiglia et al. <sup>49</sup>	205	63.8	1:1	5.9	164	0.5	0	0	NR	4.9
Zhang et al. <sup>50</sup>	56	36.1	1:1.3	4.6	50.4	1.0	NR	0	0	5.2
Esta série	113	43.1	2.13:1	3.3	107	4.3	17.7	0	3.5	5.7

NR – not reported.

\* Compilation of multiple services.

## CONCLUSIONS

From a significant personal experience of more than 130 cases operated over the course of more than a decade, combined with an enormous international experience, represented by more than a thousand published articles, it is possible to conclude the following:

1) Laparoscopic adrenalectomy is a well-established technique, which today represents the gold standard for adrenalectomy for most of the cases in which his surgery is indicated, whether total, bilateral, partial, in children and adults, those obese, and the elderly;

2) Large volume tumors, in general those greater than 9 cm in diameter, as well as those tumors with a radiographic appearance suggestive of malignancy or invasion of adjacent structures, should in principle, be operated by open surgery;

3) Approximately 5% or less of all cases of laparoscopic adrenalectomy will be converted to

open surgery for various reasons. Conversion represents only a change in strategy and is not a complication;

4) About 4% of patients may present major complications and close to 10%, minor complications, either because of the grave nature of their underlying disease, especially Cushing's disease, or because of the inherent complications experienced in surgical procedures on the adrenal;

5) When there is an indication for bilateral adrenalectomy, whenever possible both adrenals should be addressed in any single operation, because of the better results obtained when compared to surgery performed in two separate procedures;

6) Complications can be prevented, up to a certain point, when there is a good indication for laparoscopic adrenalectomy, adequate preoperative preparation of the patient, meticulous laparoscopic surgical technique, and conversion to open surgery without hesitation whenever necessary.

## RESUMO

**Introdução:** A abordagem laparoscópica da adrenal foi inicialmente relatada em 1992. A eficácia e a segurança da adrenalectomia laparoscópica já foram claramente estabelecidas. Neste trabalho, apresentamos nossa experiência com a adrenalectomia laparoscópica, com ênfase no relato detalhado das complicações, comparando-as com os dados já publicados na literatura internacional. **Pacientes e Métodos:** Entre Janeiro de 1994 e Janeiro de 2007, 132 pacientes foram submetidos a adrenalectomia laparoscópica. Destes, os 113 primeiros pacientes, dos quais 77 mulheres e 36 homens, foram avaliados. A idade variou de 1 a 76 anos ( $43,1 \pm 16,2$  anos). Dezenove (16,8%) tinham tumor unilateral maior do que 4 cm, 25 (22,1%) pacientes foram considerados obesos ( $IMC \geq 30 \text{ kg/m}^2$ ) e 13 (11,5%) haviam sido submetidos previamente a procedimento cirúrgico no andar superior do abdome. Cento e dezesseis intervenções cirúrgicas foram realizadas em 113 diferentes pacientes porque 3 pacientes com doença bilateral foram operados em dois tempos. Nestas 116 intervenções, 123 glândulas foram removidas, 120 abordadas pela via transperitoneal e 3 pela via retroperitoneal. **Resultados:** Os procedimentos unilaterais não-convertidos demoraram  $107 \pm 33,7$  min. (45-250 min.). Cinco (4,3%) casos foram convertidas para cirurgia aberta. Nenhum óbito decorrente da cirurgia foi observado. Vinte (17,7%) pacientes desenvolveram complicações, das quais 6 (5,3%) foram consideradas complicações maiores. Transfusão sanguínea foi necessária em 4 (3,5%) pacientes. O período de seguimento mínimo foi de 36 meses. **Conclusões:** A adrenalectomia laparoscópica é uma técnica muito bem estabelecida, que representa hoje o padrão-ouro da adrenalectomia para a maioria dos casos que têm indicação de cirurgia.

**Descritores:** Laparoscopia. Adrenalectomia laparoscópica. Adrenalectomia.

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