The adrenal gland is located deep in the retroperitoneum beneath the diaphragm. Open surgery via anterior transabdominal, posterior and flank approaches, is difficult and technically demanding, and is associated with complications and lengthy convalescence. Since the first report on laparoscopic adrenalectomy (LA) by Gagner et al in 1992 [1], the laparoscopic approach has become the preferred technique to remove benign functioning and non-functioning tumors of the adrenal gland. However, there are very few head-to-head comparisons between laparoscopic and open methods at the same institution. The objectives of this study are to report our experience and the benefits of minimally invasive techniques in adrenalectomy. We retrospectively evaluated the operative and postoperative parameters of laparoscopic adrenalectomy for adrenal tumors and compared the results with those of traditional open adrenalectomy. Eighty-eight patients with adrenal tumors underwent adrenalectomy between January 1997 and October 2008 at our institute. Clinical data were retrospectively collected after assigning the patients into Group I (n = 51), who underwent the laparoscopic method, and Group II (n = 37), who underwent the traditional open method, by reviewing the patients’ charts and related data. Patients in Group I experienced significantly less blood loss (88.6 ± 93.0 mL vs. 321.4 ± 265.4 mL, p < 0.01), shorter hospital stay (6.7 ± 4.3 days vs. 11.3 ± 5.4 days, p < 0.01) and earlier oral intake (1.5 ± 0.6 days vs. 2.2 ± 0.8 days, p < 0.01) postoperatively. In Group I, eight patients had adrenal tumors larger than 6 cm and no statistically significant differences were found compared with the other patients in Group I. Two patients in Group I had malignancies and no local or port site recurrence was found at regular follow-up. There was no mortality in either group. Laparoscopic adrenalectomy is a safe, effective and minimally invasive approach with the advantages of better cosmesis, less blood loss, shorter hospital stay and more rapid recovery. We recommend that laparoscopic adrenalectomy is considered as the gold standard procedure for adrenal tumors, irrespective of whether the tumor is benign or malignant.

Key Words: adrenalectomy, adrenal tumor, laparoscopy, pheochromocytoma
parameters of LA for adrenal tumors and compared the results with those of traditional open adrenalectomy (OA).

**Patients and Methods**

Eighty-eight patients with adrenal tumors undergoing adrenalectomy between January 1997 and October 2008 were enrolled in this study at our institute. Fifty-one patients who underwent LA were assigned to Group I while 37 patients who underwent OA were assigned to Group II. The choice between laparoscopic or open surgery was made according to the clinical condition, the patient’s preference and the surgeon’s professional specialty. Data from both groups were compared.

In Group I, the laparoscopic procedures have been performed since February 2001 with either lateral transabdominal adrenalectomy (LTA) or retroperitoneal endoscopic adrenalectomy (REA), as selected by the surgeons. At least three trocars were inserted, including one camera trocar to insert a 30° laparoscope and two working trocars. The camera trocar was placed over the periumbilical area in the LTA and 2 cm above the iliac crest in the midaxillary line in the REA. Pneumoperitoneum or pneumoretroperitoneum up to 12–15 mmHg in pressure was established with CO2 insufflation. The adrenal gland was mobilized carefully from its lateral and posterior attachments using a harmonic scalpel and the adrenal vessels were clipped with titanium clips and divided. At the end of the procedure, the specimen was removed via one of the ports, which was extended according to the tumor size. By contrast, the open surgical procedure in Group II was performed via anterior transabdominal, posterior and flank approaches, with a transperitoneal or retroperitoneal incision line of 15–20 cm in length.

The operating time was recorded in laparoscopic operations as the time from insertion of the Veress needle for insufflation to skin closure and in open operations as the time from skin incision to completion of skin closure. Blood loss was estimated by swab weight and/or suction volume. The charts and data, including demographic details, intraoperative and postoperative data, were reviewed retrospectively. Statistical analyses for between-group comparisons were performed using the Mann-Whitney U test. A two-tailed \( p \) value of <0.05 was considered statistically significant.

**Results**

Fifty-one of the 88 patients with adrenal tumors underwent LA (Group I), of whom 13 underwent LTAs and 38 underwent REAs; 37 of the 88 patients underwent OA (Group II). The patients in both groups were included over the same period of time. Variables including age, tumor size, operation time, postoperative hospital stay, time to oral intake and complications with blood loss were compared between both groups. Table 1 lists the demographic data, characteristics of the adrenal tumor and perioperative parameters.

There were no significant differences in terms of age (mean ± standard deviation; 45.2 ± 10.9 years vs. 46.4 ± 15.7 years), tumor size (3.8 ± 1.7 cm vs. 4.5 ± 2.3 cm) and operation time (158.6 ± 53.6 minutes vs. 149.6 ± 62.8 minutes). Group I patients experienced significantly less blood loss (89 ± 92.9 mL vs. 321 ± 265.4 mL, \( p < 0.01 \)), shorter postoperative hospital stay (6.7 ± 4.3 days vs. 11.3 ± 5.4 days, \( p < 0.01 \)) and earlier oral intake (1.5 ± 0.6 days vs. 2.2 ± 0.8 days, \( p < 0.01 \)).

<table>
<thead>
<tr>
<th>Table 1. Demographic data, characteristics and perioperative parameters of the adrenal tumors*</th>
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<tbody>
<tr>
<td>Number of patients</td>
</tr>
<tr>
<td>Age (yr)</td>
</tr>
<tr>
<td>Postoperative stay (d)</td>
</tr>
<tr>
<td>Tumor size (cm)</td>
</tr>
<tr>
<td>Operation time (min)</td>
</tr>
<tr>
<td>Blood loss (mL)</td>
</tr>
<tr>
<td>Time to oral intake (d)</td>
</tr>
</tbody>
</table>

*Data presented as mean ± standard deviation; †Mann-Whitney U test.
In terms of complications, one episode of spleen injury, one episode of pancreas tail injury and one episode of liver injury were reported in Group I. Argon beam coagulation was used to control the mild liver and spleen bleeding. The pancreas tail injury was treated by suture and drainage placement. Conversion to open surgery was required in one patient in Group I because of a huge pheochromocytoma with uncontrolled intraoperative hypertension. One episode of paralytic ileus, one episode of wound infection and one episode of liver injury were reported in Group II. Blood transfusion was needed in two patients in Group II. There was no re-operation or mortality in either group.

With respect to pathologic diagnosis, 30 of the 88 patients (34.1%) had adrenocortical adenoma with hyperaldosteronism, so called aldosteronoma or Conn’s disease. Eighteen patients (20.5%) had adrenocortical adenoma with Cushing’s syndrome. Seventeen patients (19.3%) had pheochromocytoma. Other pathologic types, sorted by the percentage, were non-functioning adenoma (10.2%), metastases (5.7%), myelolipoma (3.4%), adenocarcinoma (2.3%), androgen-producing adenoma (2.3%), adrenal cyst (1.1%) and lymphoma (1.1%). The types of pathology and prevalence of the adrenal tumors are shown in Table 2.

Table 2. Pathologic characteristics and prevalence of adrenal tumors

<table>
<thead>
<tr>
<th>Pathologic type</th>
<th>n (%)</th>
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<tbody>
<tr>
<td>Adrenocortical adenoma</td>
<td>59 (67.1)</td>
</tr>
<tr>
<td>Aldosteronoma (Conn’s disease)</td>
<td>30 (34.1)</td>
</tr>
<tr>
<td>Cushing’s syndrome</td>
<td>18 (20.5)</td>
</tr>
<tr>
<td>Androgen-secreting adenoma</td>
<td>2 (2.3)</td>
</tr>
<tr>
<td>Non-functioning incidentaloma</td>
<td>9 (10.2)</td>
</tr>
<tr>
<td>Pheochromocytoma</td>
<td>17 (19.3)</td>
</tr>
<tr>
<td>Metastases</td>
<td>5 (5.7)</td>
</tr>
<tr>
<td>Myelolipoma</td>
<td>3 (3.4)</td>
</tr>
<tr>
<td>Adenocarcinoma</td>
<td>2 (2.3)</td>
</tr>
<tr>
<td>Adrenal cyst</td>
<td>1 (1.1)</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>1 (1.1)</td>
</tr>
<tr>
<td>Total</td>
<td>88 (100)</td>
</tr>
</tbody>
</table>

DISCUSSION

LA has become the treatment of choice to remove benign functioning and non-functioning tumors of the adrenal glands. Compared with open procedures, our data revealed that LA was associated with significantly less blood loss, shorter postoperative hospital stay and earlier oral intake. Multiple retrospective comparative studies and case series have confirmed these benefits of minimally invasive surgery for adrenal tumors [2–6]. LA also has advantages such as better cosmesis, use of fewer analgesics, higher patient satisfaction, decreased morbidity, and markedly better economics, shorter hospital stay with reduced hospital costs and earlier return to regular work and activities.

More than 75% of LAs are performed to treat endocrine causes of hypertension such as aldosteronoma, Cushing’s syndrome and disease, and pheochromocytoma [7]. These were consistent with our finding in terms of pathology and diagnosis. In our study, 34.1% of patients had aldosteronoma, which initially presented with hypokalemia and hypertension. Our results demonstrate successful outcomes with LA for aldosteronoma. Postoperatively, most of the patients reverted to normokalemia and showed improvements in hypertension. Removing aldosteronoma by LA has also been reported to have excellent results with low morbidity and mortality [8]. Some authors have even suggested that LA can be performed as an outpatient procedure in the management of aldosterone-secreting adrenal adenoma [9]. Hypokalemia is uniformly cured; however, persistent hypertension has been reported with return-to-normal hormone levels postoperatively. The rates of postoperative hypertension are similar to those with open surgery and can be as high as 34% [10,11].

Almost all adrenal tumors can be resected by minimally invasive approaches. However, some limitations of LA include adrenal tumors larger than 6 cm, pheochromocytomas and malignant neoplasms [12,13].

It is still unclear whether laparoscopic resection is appropriate for large (>6 cm) potentially malignant adrenal tumors because of the risk of incomplete resection and local recurrence. The average tumor size in the LA group in our study was 3.8 cm (1.3–8.5 cm). Eight patients in the LA group had adrenal tumors larger than 6 cm. No statistically significant difference was found between these eight patients and the other patients in the LA group. This was consistent with other studies. Parnaby et al reported 39 patients with adrenal tumor >6 cm who underwent LA [14]; there were no significant differences between the
Laparoscopic adrenalectomy

median total anesthetic time, postoperative complications or postoperative hospitalization comparing the patients who underwent LA for tumors >6 cm versus tumors <6 cm. There was no evidence of local recurrence. Although contemporary series suggest that minimally invasive surgery is a reasonable therapeutic modality for larger adrenal masses [15,16], LA for these large masses is a technically demanding procedure that should only be undertaken by experienced laparoscopic surgeons who are familiar with retroperitoneal anatomy and who are adept with vascular techniques in the event of an open conversion. LA should be avoided if there is evidence of peri-adrenal infiltration preoperatively, and it is necessary to convert the patient to an open approach because of the difficulty in dissection caused by adhesion and fixation of the mass or local tissue reaction, and because of the risk of damaging the capsule of the potential malignancy [17].

The final diagnosis of 17 patients (19%) in our study was pheochromocytoma. Pheochromocytoma is a catecholamine-producing neoplasm of the adrenal medulla and is a major cause of correctable hypertension and its prevalence was 0.1–0.5% in a population of patients with hypertension [18]. Intraoperative hypertensive or hypotensive episodes were often observed in these cases. The hemodynamic changes during LA for pheochromocytoma, compared with those during open surgery, have received considerable attention. In our experience, there were no statistically significant differences between the LA and OA groups.

Series review has shown that the minimally invasive approach leads to similar or fewer hemodynamic fluctuations when compared with the open technique [19,20]. This finding may be due to the added role of anesthesiologists during laparoscopy to better observe the operation and control the patients’ blood pressure. Several comparative studies of LA versus OA for pheochromocytoma have been reported [21–23]. Advantages of LA over OA were observed in terms of mean operating time, hospital stay, need for intensive care, intraoperative hypertension, intraoperative blood loss, postoperative analgesia and return to oral nutrition.

Laparoscopic removal of the adrenal malignancy raised the concern that the laparoscopic approach may result in inadequate removal of malignant adrenal tumors and increase the risk of local and port-site recurrences [24]. Seven patients (8%) in our series were malignant, five (5.7%) had metastases and two (2.3%) had primary adrenal carcinoma; only two patients received LA. In these two patients who underwent LA, no recurrence was found during the regular follow-up. Reviewing the report by McCauley et al [25], LA for primary adrenal malignancy can provide oncologic outcomes that are equivalent to open surgery but without an increased risk of carcinomatosis or port-site recurrence. Although long-term survival for up to 47 months with no recurrence has been reported, the underlying aggressiveness of this tumor has contributed to a rate of recurrence of 39.6% for the contemporary cases reviewed in this article. An evaluation of open approaches revealed a similar or higher recurrence rate. When used to treat solitary metastases to the adrenal gland, LA provides oncologic outcomes that are equivalent to OA. LA for malignancy can be performed in appropriately selected cases with oncologic outcomes that are equivalent to open approaches, while providing advantages in terms of patient morbidity. Caution must be taken to avoid damaging the tumor or leaving tumor tissue in situ because of the potential for local recurrence, port-site recurrence and carcinomatosis that can occur with these aggressive tumors [26].

In our case review, three cases in the LA group experienced organ injury and two patients in the OA group needed blood transfusion. However, our study still demonstrates the significantly reduced blood loss with LA compared with OA. Laparoscopy offers advantages in terms of better surgical view for a deep operative field, such as the adrenal gland, and allows magnification of structures and even small bleeds. Nevertheless, bleeding is the most common complication during and after LA, and accounts for approximately 40% of all complications [6]. It may occur when a vessel or an organ is injured. Other reported postoperative complications for LA include wound infection or hematoma, and hernia in the long-term, in addition to thromboembolic, urinary, gastrointestinal, pulmonary and cardiovascular problems. Complications specific to laparoscopy include severe hypercarbia and acidosis, port-site bleeding and hernia.

The mean lengths of postoperative hospital stay in the two groups were 6.7 days and 11.3 days, respectively. This is much longer than that in most Western countries. The most likely reason for this difference stems from health insurance policy. Under the National Health Insurance Act, the insurance premiums are low.
and most of the medical cost is covered by insurance in Taiwan. The patients are not normally discharged until they feel that they have recovered completely.

There are some limitations of this study. Most of the urologists at our institution can perform both laparoscopy and open surgery. Preference and specialty exist among the urologists, which may offer advantages and lead to positive outcomes in both the LA and OA groups. It may not change the statistical results of the comparison between the two groups. However, urologists at our institution have different experience in performing laparoscopy, which may contribute to the different outcomes in the parameters of LA versus OA. LA is associated with a learning curve effect and is operator-dependent. Several studies show that, with increased experience, operating time continues to decrease [27,28]. The operating time with experienced laparoscopy surgeons should be less compared with that in current LA group. The operation time may be another factor that is associated with the statistically significant differences between LA and OA when performed by experienced laparoscopic surgeons. On the other hand, selecting LA may constitute a selection bias because patients with smaller and benign lesions are favorable for laparoscopy. More well-designed comparative studies and studies with large numbers of patients are needed.

LA is a safe, effective and minimally invasive approach that offers advantages such as better cosmesis, less blood loss, shorter hospital stay and rapid recovery for the treatment of adrenal tumors. We suggest that LA is the gold-standard procedure for adrenal tumors, irrespective of whether the tumor is benign or malignant.

REFERENCES

針對腎上腺腫瘤腹腔鏡腎上腺切除手術與
傳統手術之比較

王巽玄 1 李經家 1,2 周以和 1,2 王建杰 1,2 吳文正 1,2 黃俊雄 1,2

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針對腎上腺腫瘤之治療，腹腔鏡手術的角色已逐漸被肯定。然而在同一醫療機構內直
接比較腹腔鏡與傳統腎上腺切除手術之文獻仍相當有限。本研究以回溯之方式收集並
評估腎上腺切除手術之術前、術中及術後之各項因子，比較腹腔鏡及傳統手術針對腎
上腺腫瘤治療之差異。從 1997 年 1 月至 2008 年 10 月，共有 88 位病人接受腎上腺
切除手術。病人依其手術方式分成兩組，第一組為腹腔鏡手術，共 51 人；第二組為傳
統手術，共 37 人。結果顯示接受腹腔鏡手術之病人明顯有較少之出血量、較短之住院
天數、及較早恢復進食。腹腔鏡手術病人中有 8 位其腫瘤大於 6 公分，與同組病人
比較起來，術後恢復狀況並無顯著之差異。腹腔鏡手術病人中有兩位其病理報告為惡
性腫瘤，長期追蹤之下並無局部或手術切口復發之情形。無手術死亡之病例。腹腔鏡
腎上腺切除手術是一種安全有效之微創手術，並具有傷口美觀、出血量少、住院天數
短及恢復快等優點。因此我們建議不論良性或惡性腎上腺腫瘤，腹腔鏡腎上腺切除手
術為標準治療方式。

關鍵詞：腎上腺腫瘤、腎上腺切除手術、腹腔鏡、嗜铬細胞瘤

(高雄醫誌 2009;25:438–44)