available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Adrenals

Laparoscopic Adrenalectomy Using Needlescopic Instruments for Adrenal Tumors Less Than 5 cm in 112 Cases

Chun-Hou Liao [a,b], *Ming-Kuen Lai* [c], *Hong-Yuan Li* [d], *Shyh-Chyan Chen* [c], *Shih-Chieh Chueh* [c,*]

[a] *Division of Urology, Department of Surgery, Cardinal Tien Hospital, Taipei, Taiwan*
[b] *College of Medicine, Fu Jen Catholic University, Hsin Chuang, Taipei, Taiwan*
[c] *Department of Urology, National Taiwan University Hospital and College of Medicine, National Taiwan University, Taipei, Taiwan*
[d] *Department of Internal Medicine, National Taiwan University Hospital and College of Medicine, National Taiwan University, Taipei, Taiwan*

Article info

Article history:
Accepted December 14, 2007
Published online ahead of print on December 26, 2007

Keywords:
Adrenal tumor
Adrenalectomy
Laparoscopy
Needlescopy

Abstract

Objective: To examine the safety and efficacy of laparoscopic adrenalectomy with needlescopic instruments for most adrenal tumors less than 5 cm.
Methods: Transperitoneal laparoscopic adrenalectomy with needlescopic instruments for 112 patients with presumptively benign adrenal tumors < 5 cm were enrolled from July 2000 to February 2005. Operative time, blood loss, conversion and complication rates, and postoperative data were analyzed by appropriate statistical methods.
Results: All 112 operations were completed without any mortality or reoperation. Mean operative time was 151 min and mean blood loss was 30 ml. Only one patient required a blood transfusion and application of a hand-assisted device. Conversion to conventional laparoscopic instruments was necessary in another five patients (4.5%). The operative time of the latter 100 cases (147 ± 5.1 min, mean $\pm$ standard error of mean) was significantly shorter than that of the initial 12 cases (183 ± 8.8 min, $p = 0.001$). Larger tumors, previous abdominal surgery, and pheochromocytoma group were independent risk factors of a longer operative time. Except for one leiomyosarcoma, all other tumors were benign adrenal pathologies (57 aldosterone-producing adenomas, 23 Cushing's adenomas, 12 pheochromocytomas, and 20 incidentalomas).
Conclusion: The safety and effectiveness of laparoscopic adrenalectomy employing needlescopic instruments for most adrenal tumors less than 5 cm was feasible with acceptable operative time. Pheochromocytomas can also be managed with a longer operative time. Patients with previous upper midline or ipsilateral upper quadrant open surgery might not be suitable candidates for such a technique.

* Corresponding author. Rm 11-09, National Taiwan University Hospital, No. 7 Chung-Shan S. Road, Taipei 100, Taiwan. Tel. +886 2 23123456x5265; Fax: +886 2 23219145.
E-mail address: scchueh@ntu.edu.tw (S.-C. Chueh).

0302-2838/$ – see back matter doi:10.1016/j.eururo.2007.12.028

1. Introduction

Laparoscopic adrenalectomy, with the benefits of decreased blood loss, less postoperative pain, earlier resumption of oral feeding, and shorter hospital stays, has become the procedure of choice for most benign adrenal tumors [1–4]. Needlescopic instruments, defined as those with a diameter of no more than 3 mm, represent an evolution and sophistication of conventional laparoscopy for minimization of surgical trauma [5,6]. They result in smaller incisions than conventional 5- to 12-mm instruments, and thus better cosmesis. It may further reduce postoperative pain, hospital stay, and recovery time [5–10]; however, some reports do not favor all of these advantages compared with conventional laparoscopy [11,12].

Needlescopic surgery has been performed in a variety of procedures with no apparent increase in conversions, operative time, morbidity, and mortality [7]. Large series of needlescopic cholecystectomy [8] and appendectomy [9] have been reported to be successful. Needlescopic techniques have also been used among a variety of urological surgeries including renal cyst decortication, orchiopexy, lymphocele marsupialization, and pelvic lymph node dissection [10].

Gill et al [13] reported the initial series of laparoscopic adrenalectomy with needlescopic instruments and compared the results with conventional laparoscopic adrenalectomy. We also reported a preliminary series of clipless laparoscopic adrenalectomy with solely needlescopic instruments in 12 patients [14]. Outcome data were retrospectively compared with those of 20 conventional laparoscopic adrenalectomies. No major complications, open conversions, or postoperative secondary bleeding occurred.

To our knowledge, there has not been a large series of laparoscopic adrenalectomy using needlescopic instruments to date. To discover whether this technique can be applied to most patients with adrenal tumors, we describe our experience of 112 laparoscopic adrenalectomies using needlescopic instruments for adrenal tumors less than 5 cm.

2. Methods

Between July 2000 and February 2005, 112 patients (74 women and 38 men) with adrenal tumors less than 5 cm, which were presumptively diagnosed as benign lesions from preoperative biochemical and image studies, underwent laparoscopic adrenalectomy performed by a single surgeon (S.C.C.) using needlescopic working instruments. Preoperative estimated size of the tumors was determined by the largest diameter of the mass on image studies. Their data were retrospectively reviewed. Excluded from this analysis were those patients with adrenal tumors larger than 5 cm. (Because they had higher malignant potential [15], they underwent conventional or hand-assisted laparoscopic adrenalectomy [16].) Also excluded from the analysis were the patients who underwent bilateral adrenal surgery, partial adrenalectomy, and concomitant combination with other procedures.

All operations were performed with the lateral transperitoneal approach [1,17], and the operative procedures were described in our previous report [14]. In short, a 12-mm port was created near the umbilicus for a 30-degree telescope, and another two (for left lesions) or three (for right lesions) 2-mm working ports (Tyco Healthcare, Norwalk, Connecticut, USA) were created along the ipsilateral subcostal region. Careful dissection was done with the use of a 2-mm hook or scissors electrocoagulator. The adrenal vein of the lesion side was isolated and controlled with a 2-mm mini-bipolar coagulation apparatus (Tyco Healthcare) for a long segment. The vein was then transected closer to the adrenal gland, leaving the coagulated stump at the renal vein or vena cava as long as possible, even when a short right adrenal vein was encountered. Then the adrenal gland with the tumor was dissected from its surrounding tissues after several tiny vessels were transected with the needlescopic instruments mentioned above. The specimen was put into a retrieval bag and removed through the umbilical port.

Long-term follow-up was conducted by review of postoperative medical records and telephone interviews with patients. Data of present medication, and measured blood pressure and body weight were collected from medical records. The interview questions included ''Has the patient's health condition improved after surgery?'' (hypertension in pheochromocytomas and aldosterone-producing adenomas [APAs]; body weight and habitus in Cushing's adenomas) and, ''Does the patient still need related medications now?'' According to the responses, we classified the patients into four groups; (1) cured (no medication), (2) improved (medication still necessary, but symptoms better under control), (3) no change or worse, and (4) death.

Data were expressed as mean $\pm$ standard error of mean (SEM), median, and ranges for continuous variables, and as percentages for categorical variables. The perioperative and postoperative data of the latter 100 patients were compared with the initial 12 patients in our previous report [14] to understand our learning curve. The Wilcoxon rank sum test was used for continuous variables and Fisher exact test was used for categorical variables.

Operative time and postoperative hospital stay were logarithmically transformed to approximate normal distribution. Multiple linear regression models were performed with logarithmic-transformed operative time and postoperative hospital stay used as the dependent variables. During our data review, minimal blood loss or blood loss less than 20 ml were all recorded as 20 ml. Because they were not recorded as continuous numbers, logistic regression was used to identify risk factors of patients with blood loss greater than 50 ml. All potential clinical characteristics including age, sex, body mass

index (BMI), tumor laterality, tumor size, case number, functional status of tumors, previous medical history, and abdominal operative history were used in the regression models. Indicator variables for the functional status of tumors were used in the model with APA used as the reference group to compare with Cushing's adenoma, pheochromocytoma, and nonfunctioning tumor, because APA was the most common tumor with the shortest mean operative time.

We further sorted these patients into four groups according to the function of these tumors (ie, APA, Cushing's adenoma, pheochromocytoma, and nonfunctioning tumor) to evaluate whether the hormonal function of the tumor influences the perioperative data (ie, operative time, blood loss, hospital stay, complication rate, and conversion rate). Statistical comparisons of continuous data between different functional groups were performed by using analysis of variance (ANOVA) and the Kruskal-Wallis test. In ANCOVA models, age, sex, BMI, tumor size, case number, and previous medical and operative history were considered to be potential confounders and were adjusted. The Bonferroni test was used for post hoc comparisons. The Fisher exact test was used for categorical variables. A p value less than 0.05 was considered significant. Stata/SE Version 9.0 for Windows (StataCorp LP, College Station, TX, USA) was used for statistical analyses.

3. Results

All of the 112 operations were completed without any mortality or reoperation. The demographic characteristics and perioperative data of these patients is listed in Table 1. Intraoperative complications consisted of only one ipsilateral diaphragmatic perforation, which was suture repaired successfully under laparoscopy. None of the patients required a conversion to open surgery. The majority of these cases had a small amount of blood loss (~20 ml), 16 patients (14%) had blood loss more than 50 ml, and only 5 had blood loss more than 100 ml. Only 1 patient required a blood transfusion (400 ml brisk bleeding with transient unstable vital signs), which was rescued by a conversion to the use of a hand-assisted device (HAD). Conversion to conventional laparoscopic instruments was necessary in another 5 (4.5%) of the 112 cases (detailed in Table 2).

Preoperative diagnosis of these 112 patients included 57 APAs, 23 Cushing's tumors, 24 nonfunctioning tumors, and 8 pheochromocytomas. Review of the pathological reports showed an intact surgical capsule in all the tumors. The final pathological findings of 24 preoperative nonfunctioning tumors included 13 adenomas, 2 hyperplasia, 2 ganglioneuromas, 2 pseudocysts, 1 leiomyosarcoma, and 4 pheochromocytomas. These 4 pheochromocytomas were reassigned into the pheochromocytoma group during later analysis.

Nineteen patients (17%) had received 21 previous abdominal operations including laparoscopic cholecystectomy (LC), open cholecystectomy, appendectomy, hysterectomy or myomectomy, partial gastrectomy, ureterolithotomy, and autotransplantation of kidney. Most of these patients had lower abdominal scars or small scars owing to LC. Only 4 patients had long upper abdominal scars including 1 upper midline scar, 2 ipsilateral upper quadrant scars, and 1 contralateral upper quadrant scar. The mean operative time of these 4 patients was 242 min, and 2 of these 4 patients needed conversion to complete the surgery. Preoperative comorbid conditions except hypertension were noted in 29 patients (26%). The mean American Society of Anesthesiologists (ASA) score was 2.7 ± 0.1 (range, 2–4) among all patients and was 3.5 ± 0.1 among those patients with comorbid conditions.

Four postoperative complications (3.6%) occurred. One patient had peptic ulcer bleeding and was discharged 7 d postoperatively after medications.

Table 1 – Demographics and perioperative data of the 112 patients who underwent laparoscopic adrenalectomy with needlescopic instruments

	Mean ± SEM[a]	Median	Range
Age (yr)	44.6 ± 1.1	44	22–83
Body weight (kg)	61.6 ± 1.2	59	37–111
Body height (m)	1.61 ± 0.01	1.59	1.46–1.88
BMI (kg/m^2)	23.6 ± 0.4	23.1	17.3–36.5
Follow-up (mo)	61.8 ± 0.4	61	28–82
Tumor laterality (left; %)	70 (62.5%)	—	—
Tumor size (cm)	2.6 ± 0.1	2.5	1.0–5.0
Operative time (min)	151 ± 4.5	143	80–355
Estimated blood loss (ml)	30 ± 3.8	20	20–400
Postoperative narcotic use	26 (23%)	—	—
Postoperative hospital stay (d)	3.8 ± 0.2	4	1–17

BMI, body mass index; SEM, standard error of the mean.
[a] All continuous variables are presented as mean ± SEM.

Table 2 – Cases of conversion to conventional 5- to 12-mm instruments or a HAD

Conversion number	1	2	3[a]	4	5[b]	6
Case number	12	16	58	87	104	106
Age (yr)	66	40	43	49	51	44
Sex	F	M	M	F	M	F
Side	R	R	L	L	R	L
Tumor size (cm)	2	3	4	3	2	4
Function	APA	Pheo	NFT	NFT	APA	APA
Previous operative history	Nil	Nil	LC, left ureterolithotomy	Ectopic pregnancy	OC	Nil
Indications for conversion	Floppy liver, poor exposure	Floppy liver, retrocaval tumor location	Poorly controlled bleeding	Adhesion around tumor	Severe intraperitoneal adhesion	Diaphragm perforation
Final pathology	APA	Pheo	Hyperplasia	Leiomyosarcoma	APA	APA

HAD, hand-assisted device; APA, aldosterone-producing adenoma; Pheo, pheochromocytoma; NFT, nonfunctioning tumor; LC, laparoscopic cholecystectomy; OC, open cholecystectomy.
[a] Converted to the use of a HAD.
[b] Converted to a retroperitoneal approach.

The other obese (110 kg and BMI = 35.11) patient underwent surgery for APA and had aspiration pneumonia. These two complications occurred in patients with preoperative comorbidity. The other two patients with periumbilical wound infections had pheochromocytoma and ganglioneuroma, respectively. Both infections were mild and treated in clinics.

Among these 112 patients, the operative time (147 ± 5.1 min vs. 183 ± 8.8 min, $p = 0.001$) and blood loss (28 ± 4.3 ml vs. 44 ± 6.6 ml, $p < 0.001$) were significantly decreased in the latter 100 cases in comparison with the initial 12 cases, although their demographics were similar, except for no pheochromocytomas being present in the initial series (Fig. 1). There was no difference in postoperative hospital stay (4.2 ± 0.4 vs. 3.8 ± 0.2 d, $p = 0.157$), complication rate (8% vs, 3%, $p = 0.369$), and conversion rate (8% vs. 5%, $p = 0.502$) between the two cohorts.

Multiple linear regression showed that larger tumor size ($\beta = 0.071$, $p = 0.034$), previous abdominal operative history ($\beta = 0.226$, $p = 0.001$), male sex ($\beta = 0.258$, $p < 0.001$), and tumor type of the pheochromocytoma group ($\beta = 0.239$, $p = 0.023$) were independent risk factors of longer operative time

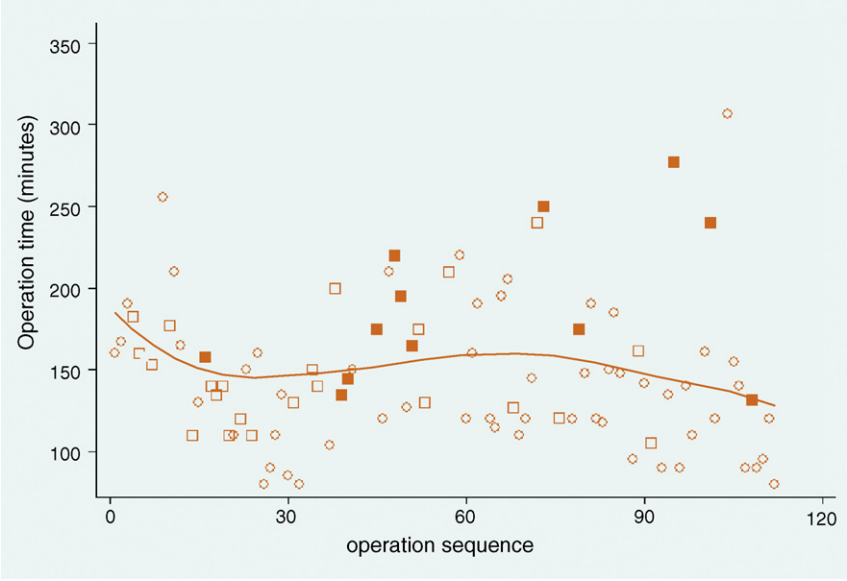

Fig. 1 – Operative time versus case number. The operative time (in minutes, Y-axis) of each individual case was plotted against its respective operative sequence (case number, X-axis) among this series of patients. Lowess curves were derived by plotting a smooth curve through the data points by a weighted linear least squares regression over the span. Solid circle = nonfunctioning tumor; open circle = aldosterone-producing adenoma; solid square = pheochromocytoma; open square = Cushing adenoma.

Table 3 – Comparisons among the various functional groups of patients

	APA	Cushing's adenoma	Nonfunctional tumor*	Pheochromocytoma	*p* value*
Patient number†	57	23	20	12	
Age (yr)	45.7 ± 1.5	35.2 ± 1.4	49.8 ± 2.9	49.0 ± 3.9	<0.001
Men/women	23/34	1/22	10/10	4/8	0.002
Laterality (left/right)	40/17	16/7	9/11	5/7	0.085
BMI (kg/m^2)	23.9 ± 0.5	23.4 ± 0.9	23.6 ± 0.9	22.6 ± 1.2	0.542
Previous medical history (%)	13 (23%)	6 (26%)	6 (30%)	4 (33%)	0.806
Previous operative history (%)	11 (19%)	3 (13%)	5 (25%)	0 (0%)	0.295
Mean tumor size (cm)	1.9 ± 0.1	3.0 ± 0.2	3.7 ± 0.2	3.7 ± 0.2	<0.001
Operative time (min)	140 ± 5.8	149 ± 7.1	160 ± 13	191 ± 14	0.013
Estimated blood loss (ml)	23 ± 1.6	32 ± 7.8	46 ± 18	34 ± 6.6	0.084
Conversion	3 (5%)	0	2 (10%)	1 (8%)	0.363
Postoperative narcotic use	17 (30%)	4 (17%)	2 (10%)	3 (25%)	0.304
Complications	1 (2%)	0	2 (10%)	1 (8%)	0.148
Hospital stay (d)	3.5 ± 0.3	4.7 ± 0.4	3.7 ± 0.3	3.8 ± 0.5	0.011

APA, aldosterone-producing adenoma; BMI, body mass index.
* Kruskal-Wallis test for continuous variables and Fisher exact test for categorical variables; all continuous variables are given as mean ± standard error of the mean.
† Four cases of pheochromocytoma initially regarded as "nonfunctional" were categorized into the "pheochromocytoma group" according to the final pathological diagnosis.

after adjusting age, BMI, case number, and functional status of the tumors. The case number was also correlated with logarithmic postoperative hospital stay ($\beta = -0.005$, $p < 0.001$) and blood loss greater than 50 ml (odds ratio, 0.95, $p = 0.002$) after adjusting other factors.

The demographic and perioperative data in the different functional groups detailed in Table 3. The mean tumor size was significantly smaller in the APA group. Patients in the pheochromocytoma group had a significantly longer operative time than those in the APA ($p = 0.017$) and nonfunctioning tumor ($p = 0.001$) groups. Patients in the Cushing's adenoma group had a significantly longer postoperative hospital stay than those in the APA group ($p = 0.015$).

In the APA group, hypertension was cured in 24 (42%) and improved in 25 (44%) of the 57 patients. Hypertension was cured in 11 (92%) and improved in the other patient of the 12 patients with pheochromocytoma. Body weight and habitus were improved in all patients with Cushing's adenomas. Three patients died during the follow-up. One patient with adrenal leiomyosarcoma developed liver metastasis 3 yr after surgery; she died from sepsis during chemotherapy. The other 2 patients died from lung cancer and bladder cancer, which were not related to their adrenal conditions. There were no long-term complications of the surgery or recurrence of adrenal tumors in a median follow-up of 61 mo (range, 28–82).

4. Discussion

The technical feasibility of using needlescopic instruments in laparoscopic adrenalectomy had been shown in series of limited case numbers [13,14]. In this series, with 10 times the number of cases in our initial report [14], we confirmed that laparoscopic adrenalectomy with needlescopic instruments can be securely and effectively performed for most (106 of 112, 94.6%) patients with adrenal tumors less than 5 cm in diameter. We also proved that most adrenal veins can be safely controlled with needlescopic instruments and without clips. Conversion to conventional laparoscopic adrenalectomy or use of a HAD is an appropriate option before open conversion in case of uncontrollable bleeding, difficulty in dissection, or any intraoperative complications encountered. The needlescopic ports can be converted in part or totally to conventional laparoscopic ports [6,13,14] depending on the severity of difficulties encountered. Partial conversion may still benefit the patients even if only one or two ports are needlescopic [13,14].

Recently, Zacharias et al [1] demonstrated a beautiful surgical video for conventional laparoscopic adrenalectomy with important notions of technical tricks. Goitein et al [18] and Ku et al [19] reported different maturation rates ranging from 30 to 5 cases, and operative time stabilized at approximately 150 min [19]. Chan et al [20] reported a prospective comparison showing that, although their latter group had more pheochromocytomas, larger tumors, and higher ASA scores, the operative time and blood loss were similar to their early group despite higher minor complication rates and longer hospital stays. For needlescopic surgery, there is also a considerable learning curve, and operative time may be about 20% longer than that of conventional laparoscopic procedures [6]. For needlescopic

adrenalectomy, approximately 5 to 10 cases are necessary even for an experienced laparoscopic surgeon [13]. We had about 70 cases of experience with conventional laparoscopic adrenalectomy before we embarked on the needlescopic technique, and we consider this experience to be paramount because needlescopic instruments are flimsier and more difficult to control [13,14]. In our preliminary report, the mean operative time of the 12 initial cases was 183 min, which was about 50 min longer than our conventional laparoscopic adrenalectomy [14]. In this series, the mean operative time decreased to 151 min, which is similar to that of conventional laparoscopic adrenalectomy [1,2,19]. These results demonstrate that laparoscopic adrenalectomy with needlescopic instruments can be performed in a reasonable time and that the operative time can be reduced once the learning curve has reached a plateau.

In early reports of needlescopic surgery, careful patient selection, with non-obese patients without previous abdominal surgery preferred, was suggested to maximize safety [10]. In conventional laparoscopic adrenalectomy, obesity was not considered a contraindication, although operative time correlating with BMI has been reported [2]. In this series, although most patients were slender, the maximal BMI was 36.5 and 10 patients had BMI $>$ 30. BMI was not correlated with operative time, blood loss, or postoperative hospital stay. In contrast, previous operative history was an independent risk factor of a longer operative time [21]. Three of our 6 converted patients had a history of previous abdominal operations. However, the other 5 patients who had undergone LC had less intraperitoneal adhesion, and laparoscopic adrenalectomy with needlescopic instruments was successfully performed on all these patients. An upper midline/ipsilateral upper quadrant scar is associated with a greater access complication rate even in conventional laparoscopic adrenalectomy [21]. Hence, we would suggest that patients with previous upper midline or ipsilateral upper quadrant open surgery might not be suitable candidates for this needlescopic technique.

Ku et al [19] reported that the operative time and blood loss were similar between nonfunctioning and functioning adrenal tumors. Thompson et al [22] compared the results of laparoscopic adrenalectomy between APAs and Cushing adenomas, and reported that there was no difference in operative time, blood loss, and postoperative recovery. In our series with needlescopic instruments, although patients with Cushing's adenomas had longer postoperative hospital stays than the APA group (as also reported in conventional laparoscopic adrenalectomy [23]), there was no difference in operative time, blood loss, complications, or conversion rates in comparison with the other groups. Pheochromocytomas are relatively uncommon, and several reports have showed that laparoscopic adrenalectomy for pheochromocytoma is associated with a longer operative time, and higher complication and conversion rates [24,25]. In contrast, there was no significant difference in the operative time, blood loss, conversion rate, or postoperative recovery between different functional groups in Eto et al's report [26]. However, it is generally accepted that laparoscopic adrenalectomy can be performed safely for most pheochromocytomas [27,28]. Although laparoscopic adrenalectomy using needlescopic instruments for pheochromocytomas was not reported in our preliminary report [14], 12 pheochromocytomas were excised successfully in the present series. We also showed that treatment with our needlescopic technique resulted in resolution of symptoms and signs induced by excessive hormones of the tumors, even at long-term follow-up, although this might be biased by the follow-up technique of telephone interviews.

The comparisons between the needlescopic versus conventional laparoscopic technique showed benefits for the needlescopic group [13,14]. However, the level of evidence-based medicine might be limited owing to the studies' retrospective nature and small case numbers. We failed to do such a comparison in the present study because it was a single-arm observation without a control group. Having confirmed the technical feasibility of the needlescopic technique in this series, we would like to initiate a new prospective randomized study to compare the advantages accrued by laparoscopic adrenalectomy with needlescopic instruments versus the conventional laparoscopic technique in a more objective and scientific way.

5. Conclusions

Laparoscopic adrenalectomy with needlescopic instruments can be securely and effectively performed in most patients with adrenal tumors less than 5 cm. Pheochromocytomas can also be managed with a longer operative time. The patients with previous upper midline or ipsilateral upper quadrant open surgery might not be suitable candidates for this technique.

Conflicts of interest

The authors have nothing to disclose.

References

[1] Zacharias M, Haese A, Jurczok A, Stolzenburg J-U, Fornara P. Transperitoneal laparoscopic adrenalectomy: outline of the preoperative management, surgical approach, and outcome. Eur Urol 2006;49:448–59.

[2] Assalia A, Gagner M. Laparoscopic adrenalectomy. Br J Surg 2004;91:1259–74.

[3] Liao CH, Chen J, Chueh SC, Tu YP, Chen SC, Yuan RH. Effectiveness of transperitoneal and trans-retroperitoneal laparoscopic adrenalectomy versus open adrenalectomy. J Formos Med Assoc 2001;100:186–91.

[4] Guazzoni G, Cestari A, Montorsi F, et al. Current role of laparoscopic adrenalectomy. Eur Urol 2001;40:8–16.

[5] Gill IS. Needlescopic urology: current status. Urol Clin North Am 2001;28:71–83.

[6] Gagner M, Garcia-Ruiz A. Technical aspects of minimally invasive abdominal surgery performed with needlescopic instruments. Surg Laparosc Endosc 1998;8:171–9.

[7] Mamazza J, Schlachta CM, Seshadri PA, Cadeddu MO, Poulin EC. Needlescopic surgery. A logical evolution from conventional laparoscopic surgery. Surg Endosc 2001;15:1208–12.

[8] Lee PC, Lai IR, Yu SC. Minilaparoscopic (needlescopic) cholecystectomy: a study of 1,011 cases. Surg Endosc 2004;18:1480–4.

[9] Chock A, Seslar S, Stoopen E, et al. Needlescopic appendectomy. Surg Endosc 2003;17:1451–3.

[10] Soble JJ, Gill IS. Needlescopic urology: incorporating 2-mm instruments in laparoscopic surgery. Urology 1998;52: 187–94.

[11] Look M, Chew SP, Tan YC, et al. Post-operative pain in needlescopic versus conventional laparoscopic cholecystectomy: a prospective randomised trial. J R Coll Surg Edinb 2001;46:138–42.

[12] Lau DH, Yau KK, Chung CC, Leung FC, Tai YP, Li MK. Comparison of needlescopic appendectomy versus conventional laparoscopic appendectomy: a randomized controlled trial. Surg Laparosc Endosc Percutan Tech 2005;15:75–9.

[13] Gill IS, Soble JJ, Sung GT, Winfield HN, Bravo EL, Novick AC. Needlescopic adrenalectomy—the initial series: comparison with conventional laparoscopic adrenalectomy. Urology 1998;52:180–6.

[14] Chueh SC, Chen J, Chen SC, Liao CH, Lai MK. Clipless laparoscopic adrenalectomy with needlescopic instruments. J Urol 2002;167:39–43.

[15] Grumbach MM, Biller BM, Braunstein GD, et al. Management of the clinically inapparent adrenal mass (''incidentaloma''). Ann Intern Med 2003;138:424–9.

[16] Liao CH, Chueh SC, Lai MJ, Hsiao PJ, Chen J. Laparoscopic adrenalectomy for potentially malignant adrenal tumors greater than 5 centimeters. J Clin Endocrinol Metab 2006;91:3080–3.

[17] Miyake O, Yoshimura K, Yoshioka T, et al. Laparoscopic adrenalectomy. Comparison of the transperitoneal and retroperitoneal approach. Eur Urol 1998; 33:303–7.

[18] Goitein D, Mintz Y, Gross D, Reissman P. Laparoscopic adrenalectomy: ascending the learning curve. Surg Endosc 2004;18:771–3.

[19] Ku JH, Yeo WG, Kwon TG, Kim HH. Laparoscopic adrenalectomy for functioning and non-functioning adrenal tumors: analysis of surgical aspects based on histological types. Int J Urol 2005;12:1015–21.

[20] Chan JE, Meneghetti AT, Meloche RM, Panton ON. Prospective comparison of early and late experience with laparoscopic adrenalectomy. Am J Surg 2006;191: 682–6.

[21] Seifman BD, Dunn RL, Wolf Jr JS. Transperitoneal laparoscopy into the previously operated abdomen: effect on operative time, length of stay and complications. J Urol 2003;169:36–40.

[22] Thompson GB, Grant CS, van Heerden JA, et al. Laparoscopic versus open posterior adrenalectomy: a case-control study of 100 patients. Surgery 1997;122: 1132–6.

[23] Suzuki K, Ushiyama T, Ihara H, Kageyama S, Mugiya S, Fujita K. Complications of laparoscopic adrenalectomy in 75 patients treated by the same surgeon. Eur Urol 1999;36:40–7.

[24] Kim AW, Quiros RM, Maxhimer JB, El-Ganzouri AR, Prinz RA. Outcome of laparoscopic adrenalectomy for pheochromocytomas vs aldosteronomas. Arch Surg 2004;139: 526–31.

[25] Kalady MF, McKinlay R, Olson Jr JA, et al. Laparoscopic adrenalectomy for pheochromocytoma. A comparison to aldosteronoma and incidentaloma. Surg Endosc 2004;18:621–5.

[26] Eto M, Harano M, Koga H, Tanaka M, Naito S. Clinical outcomes and learning curve of a laparoscopic adrenalectomy in 103 consecutive cases at a single institute. Int J Urol 2006;13:671–6.

[27] Wilhelm SM, Prinz RA, Barbu AM, Onders RP, Solorzano CC. Analysis of large versus small pheochromocytomas: operative approaches and patient outcomes. Surgery 2006;140:553–9.

[28] Flávio Rocha M, Faramarzi-Roques R, Tauzin-Fin P, et al. Laparoscopic surgery for pheochromocytoma. Eur Urol 2004;45:226–32.