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Original Article

Outcome and safety of retroperitoneoscopic and transperitoneal laparoscopic adrenalectomy: a comparative study of 178 adrenal tumor patients

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Abstract: Objective: We evaluated the intraoperative characteristics, cost and safety of posterior retroperitoneoscopic adrenalectomy (PRA), lateral retroperitoneoscopic adrenalectomy (LRA) and transperitoneal laparoscopic adrenalectomy (TLA) in 178 adrenal tumor patients who received surgical treatment at our hospital. Methods: We extracted data on patient age, sex, operative history, tumor size, tumor pathology, imaging characteristics and clinical diagnosis. We also retrieved data on operative time, estimated blood loss, conversion to open surgery, perioperative mortality, complications, and tumor recurrence. The primary outcome was median duration of surgery. Results: One hundred seventy-eight patients were eligible for the current study, including 30 patients receiving PRA, 131 patients receiving LRA and 17 patients receiving TLA. The TLA group had the longest mean operative time (83.6±23.1 min) while LRA had the shortest (49.7±13.4 min) (P<0.05). The operative time for PRA (69.5±25.7 min) was significantly longer than that for LRA (P<0.05), but shorter than that for TLA (P<0.05). Furthermore, the TLA group had the longest mean postoperative hospital stay (5.4±1.7 days) (P<0.05) while the PRA and LRA group were comparable in hospital stay (3.7 days). Moreover, TLA incurred the highest cost (RMB (¥) 30267.5±4087.2; US $ 1 = ¥ 6.88) (P<0.05) while the other groups had comparable costs (PRA: ¥ 21166.5 vs. LRA: ¥ 21336.6). Subcutaneous emphysema remained the most common postoperative complication among all three groups. Eight patients (8/17, 47.1%) receiving TLA, 15 patients (11.5%) receiving LRA and 6 patients (20.0%) undergoing PRA developed subcutaneous emphysema (P = 0.001). Conclusion: Compared with traditional laparoscopic adrenalectomy, PRA is a safe, feasible, minimally invasive, and cost-effective surgical procedure. It provides an alternative approach to the treatment of adrenal tumors.

Keywords: Adrenal tumor, adrenalectomy, laparoscopy, retroperitoneal posterior lumbar approach

Introduction

Traditional adrenalectomy entails a longer skin incision and is associated with a slow postoperative recovery. Minimally invasive transperitoneal laparoscopic adrenalectomy (TLA) was first described in 1992 [1] and has since become the gold standard of adrenal tumor surgery [2]. Meanwhile, lateral retroperitoneoscopic adrenalectomy (LRA) and posterior retroperitoneoscopic adrenalectomy (PRA) were introduced [3-5]. Cabalag *et al.* described 13 cases receiving TLA and 10 PRAs and found that PRA had quick learning curve and reduced length of hospital stay compared with TLA [6], a finding later supported by their review of initial 50 consecutive patients receiving PRA [7]. Barczyński *et al.* [8] studied 61 patients randomized to receive PRA (n = 30) or TLA (n = 31) and found that both surgical procedures were safe. Furthermore, they showed that PRA had shorter duration of surgery, lower intraoperative blood loss, shorter length of hospital stay, and lower cost.

PRA has become popular approach for adrenal tumor surgery over the past years at our hospital, especially for larger adrenal tumors and tumors that are spatially close to the vena cava, as it offers direct access, exclusive retroperitoneal dissection, and excellent adrenal gland visualization. A recent prospective study involving 83 patients showed that LTA and PRA had similar operative outcomes, and both were

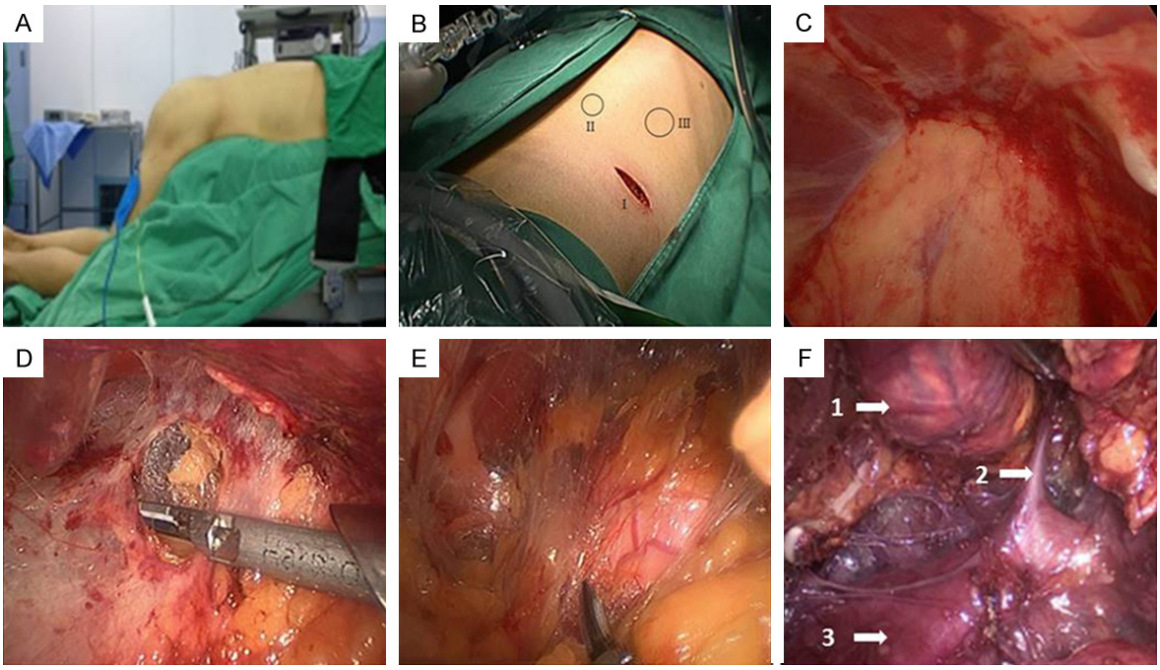

Figure 1. Surgical procedures of posterior retroperitoneoscopic adrenalectomy (PRA). A. The patient is placed in the prone jackknife position; B. Location of the trocar; C. Visual dilation of the retroperitoneal space; D. Blunt dissection of Gerota fascia; E. Exposure of the adrenal tumor; F. The space relationship of peripheral vasculature (1→adrenal tumor, 2→adrenal central vein, 3→IVC).

effective options for the treatment of benign adrenal gland tumor [9]. In the current study, we sought to compare the intraoperative characteristics, cost and safety of LRA, PRA and TLA in 178 adrenal tumor patients who received surgical treatment at our hospital.

Patients and methods

Patients

In this study, we reviewed the clinical data of adrenal tumor patients who sought surgical treatment at Second Department of Urology, First Hospital of Jilin University between Aug. 2013 and Feb. 2015. We extracted data on patient age, sex, operative history, tumor size, tumor pathology, imaging characteristics and clinical diagnosis. We also retrieved data on operative time, estimated blood loss, conversion to open surgery, perioperative mortality, complications, and tumor recurrence. Major exclusion criteria were a previous history of adrenal surgery, or incomplete clinical data, receiving other surgeries, or presence of comorbidities.

The study protocol was approved by the local institutional review board of the authors' affiliated institution and patient consent was not required because of the retrospective nature of the study.

Surgical procedures

All operations were performed by two surgeons similarly experienced in laparoscopic and/or retroperitoneoscopic surgery (AW and YW). TLA was performed as described elsewhere [1, 2] and LRA was done as depicted earlier [3]. PRA was performed was described previously [10, 11]. Typically, if the tumor diameter on high resolution CT was larger than 8 cm, TLA was recommended. PRA was preferred for tumors smaller than 8 cm that were located posterior to or compressing the vena cava; for other tumors smaller than 8 cm, PRA or LRA was performed at the discretion of the operating surgeon.

PRA

For PRA, the patient was placed in the prone jack knife position on the operating table (**Figure 1A**). A 15 mm transverse incision was made along the posterior axillary line and at 2 cm above the iliac crest (**Figure 1B**). After sharp and blunt dissection, the retroperitoneal space

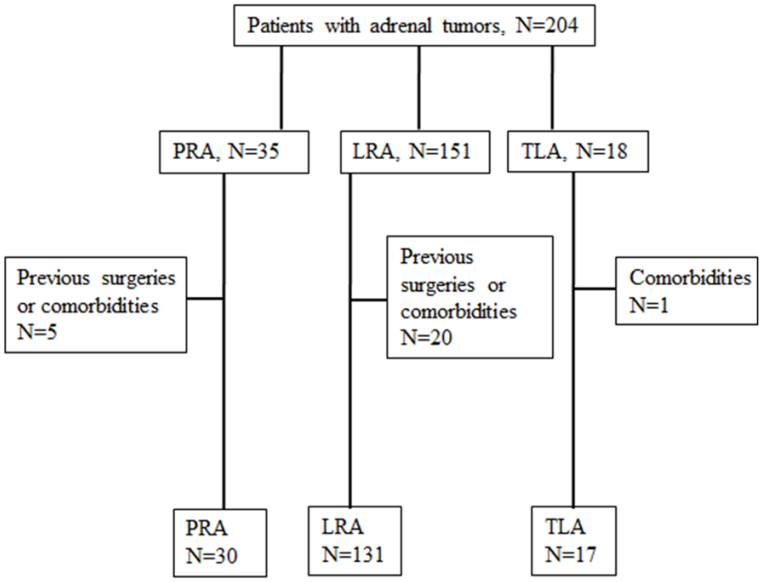

Figure 2. The study flowchart. LRA: lateral retroperitoneoscopic adrenalectomy, PRA: posterior retroperitoneoscopic adrenalectomy; TLA: transperitoneal laparoscopic adrenalectomy.

was easily accessed by digital perforation of the dorsolumbar fascia. Subsequently, an artificial cavity was created using a visual balloon dilator with 500-700 mL air for 5 min (**Figure 1C**). After the balloon was removed, a 10-mm trocar was introduced through the initial incision as an observational channel (**Figure 1B** I). After the creation of the working space, a 5-mm trocar was placed 1 cm lateral to the sacrospinalis besides the spinous process (**Figure 1B** II). A lateral 10-mm trocar was placed along the posterior axillary line below the tip of the 12th rib (**Figure 1B** III). Blunt dissection was performed through the retroperitoneal areolar tissue and Gerota fascia (**Figure 1D**), allowing identification of the superior border of the kidney. The lower aspect of the adrenal gland was then separated from the superior pole of the kidney, which was retracted caudally. The location of tumor was confirmed visually (**Figure 1E**). Partial adrenalectomy was carried out without clipping the adrenal vein (**Figure 1F**). The fatty tissue around the adenoma was removed and then the tumor was resected using an ultrasonically activated scalpel and extracted through the middle port with a retrieval bag system.

Statistical analysis

Comparisons of continuous variables among three groups were analyzed using one-way ANOVA; Student-Newman-Keuls test were further performed for comparisons between two groups. Comparisons of categorical variables were performed with Chi-square. All statistical analysis was performed using two-tailed test, and $P<0.05$ was considered statistically significant. Data were analyzed using SAS 9.3 software (The SAS Institute, Cary, NC, USA).

Results

Demographic and baseline characteristics of the study subjects

During the study period, 204 patients diagnosed with adrenal tumor at our institution met the eligibility requirements and were included in the current study. Thirty-five patients received PRA, 151 patients underwent LRA and 18 patients had TLA. After the eligibility criteria were applied, twenty-six patients were excluded. Finally, 178 patients were eligible for the study, including 131 patients receiving LRA, 30 PRA and 17 TLA. The study flowchart is shown in **Figure 2**. Patient demographic and baseline characteristics are shown in **Table 1**. Patients in the three groups were comparable in the demographic and baseline variables ($P>0.05$) except tumor size and pathology type. The LRA group had the smallest tumor size (18.4±10.2 cm) while the TLA group had the largest tumor size (56.4±24.0 cm) ($P<0.001$). Adrenocortical adenoma remained the most common tumor type in the PRA (66.7%) and LRA group (70.8%) while other types were the most common in the TLA group (41.2%).

Operative characteristics and costs

The operative characteristics of the three groups are shown in **Table 2**. The TLA group had the longest mean operative time (83.6± 23.1 min) while the LRA group had shortest mean operative time (49.7±13.4 min) ($P<0.05$). The estimated blood loss of the TLA group was 50 mL while blood loss was negligible in the other two groups. The TLA group had the longest mean catheter indwelling time (3.4±1.7

Table 1. Demographic and tumor characteristics of the study population

Variables	PRA, n = 30	LRA, n = 131	TLA, n = 17	*P*
Age (year), mean ± sd.	46.00±10.72	48.82±11.94	42.35±13.01	0.075
Female gender, n (%)	18 (60.00)	75 (57.69)	9 (52.94)	0.895
Location of tumor, n (%)				0.326
Right side	16 (53.33)	87 (66.92)	12 (70.59)	
Left side	14 (46.67)	43 (33.08)	5 (29.41)	
Tumor size on CT (mm), mean ± sd.	30.33±15.68[a]	18.39±10.23	56.35±23.96[a,b]	<0.001
Pathology type, n (%)				<0.001
Adrenocortical adenoma	20 (66.67)[a]	92 (70.77)	4 (23.53)[a,b]	
Adrenal nodular hyperplasia	0 (0.00)	23 (17.69)	1 (5.88)	
Adrenal pheochromocytoma	4 (13.33)	3 (2.31)	5 (29.41)	
Other types[*]	6 (20.00)	12 (9.23)	7 (41.18)	

Note: [*]including adrenal cyst, adrenal ganglioneuroma, adrenal medullary lipoma, adrenal lymphangioma, adrenal oncocytoma, fat adrenal adenoma, adrenocortical carcinoma, retroperitoneal schwannoma. [a]*P*<0.05, compared with LRA; [b]*P*<0.05, compared with PRA. *P*<0.05

Table 2. Intraoperative characteristics and cost of LRA, PRA and TLA

Variables	LRA, n = 130	PRA, n = 30	TLA, n = 17	P
Operative time (min), mean ± sd.	49.7±13.4	69.5±25.7[a]	83.6±23.1[a,b]	<0.001
Blood loss (mL)	Negligible	Negligible	50 (20.50)	
Catheter indwelling time (day), mean ± sd.	1.8±0.7	1.8±0.8	3.4±1.7[a,b]	<0.001
Drainage tube indwelling time (day), mean ± sd.	2.0±0.8	2.0±1.0	3.9±1.8[a,b]	<0.001
Postoperative hospital stay (day), mean ± sd.	3.7±1.0	3.7±0.9	5.4±1.7[a,b]	<0.001
Cost (¥), mean ± sd.	21336.6±2527.3	21166.5±4216.4	30267.5±4087.2[a,b]	<0.001

Note: [a]*P*<0.05, compared with LRA; [b]*P*<0.05, compared with PRA.

Table 3. Postoperative complications in the study population

Variables	LRA, n = 130	PRA, n = 30	TLA, n = 17	*P*
Infection of incisional wound, n (%)	2 (1.54)	0 (0.00)	1 (5.88)	0.329
Subcutaneous emphysema, n (%)	15 (11.54)	6 (20.00)	8 (47.06)[a]	0.001
Postcava/renal vein injury, n (%)	1 (0.77)	0 (0.00)	1 (5.88)	0.211
Other visceral organ injury, n (%)	0 (0.00)	0 (0.00)	1 (5.88)	0.096

Note: [a]compared with LRA.

days) (*P*<0.05) while it was comparable in the PRA and LRA group (1.8 days). The TLA group also had the longest mean drainage tube indwelling time (3.9±1.8 days) (*P*<0.001) while the mean drainage tube indwelling time was comparable in the PRA and LRA group (2 days). Furthermore, the TLA group had the longest mean postoperative hospital stay (5.4±1.7 days) (*P*<0.05) while the PRA and LRA group were comparable in hospital stay (3.7 days).

Moreover, the TLA group incurred the highest cost (RMB ¥30267.5±4087.2; US $ 1 = ¥ 6.88) (*P*<0.05) while the other groups had comparable costs (PRA: ¥ 21166.5 vs. LRA: ¥ 21336.6).

Postoperative complications

Subcutaneous emphysema remained the most common postoperative complication among all three groups. Eight patients (8/17, 47.1%) receiving TLA, 15 patients (11.5%) receiving LRA and 6 patients (20.0%) undergoing PRA developed subcutaneous emphysema (*P* = 0.001). Incisional wound infection was reported in 2 patients receiving LRA and 1 patient undergoing TLA and postcava/renal vein injury was seen in 1 patient each in the LRA group and TLA group. The TLA group also had other visceral organ injury in 1 patient. No other complications were reported (**Table 3**).

Discussion

In this retrospective study, we reviewed the clinical data of 178 adrenal tumor patients who underwent surgery at our institution. We found that, consistent with earlier reports [7, 12-14], compared to TLA, PRA had a shorter duration of surgery and a shorter length of postoperative hospital stay and reduced medical cost. Furthermore, compared to LRA and TLA, PRA was a safe surgical approach, with subcutaneous emphysema being the most common postoperative complication.

LRA had the shortest duration of surgery and was comparable to PRA in length of hospital stay. We noticed that patients who received LRA had markedly smaller tumor size than those by PRA and TLA, which contributed to reduction in operative time. This was also true for PRA and TLA as the tumor size for TLA was significantly larger than that for PRA. Another possible explanation for the shorter duration of surgery in LTA was that the surgeons were still in the learning curve for PRA as PRA has just recently been introduced at our center. However, it is worthy of note that Cabalag *et al.* indicated that the learning curve was not steep and did not represent a significant challenge [6]. Consistently, PRA and LTA were comparable in catheter and drainage tube indwelling time, both of which were significantly shorter than that of TLA. Furthermore, the cost of PRA and LTA was markedly lower than that of TLA. These findings are consistent with earlier studies [7, 12-14].

In the past twenty years, minimally invasive adrenalectomy has become the preferred approach for surgical management of benign, primary adrenal masses and isolated adrenal metastasis in some cases [15-18]. TLA has been commonly used due to familiarity with the regional anatomy and skills acquired through the laparoscopic operations. For larger adrenal tumors or tumors that are closer the vena cava, especially behind the vena cava, PRA is preferable as it offers direct access, exclusive retroperitoneal dissection, and excellent adrenal gland visualization compared with a transabdominal approach. Consequently, PRA may avoid certain postoperative complications including adhesions as well as mobilization of intra-abdominal organs in patients with a previous history of abdominal surgery. Furthermore, insufflation in the retroperitoneal space has lesser influences on the hemodynamic and respiratory parameters of patients compared to intraperitoneal insufflation, thus enabling bilateral adrenalectomies to be performed without the need to reposition the patient intraoperatively [10, 19, 20]. We believe that either PRA or LRA works effectively for small adrenal tumors. Since PRA directly reaches the adrenal gland, making it easier to expose the anatomical landmarks and vasculatures such as the adrenal central vein, it should be less traumatic to the patient. PRA has also been used to remove large adrenal tumors. In addition, the drooping of abdominal organs naturally in the prone position creates a larger space for operation. For patients who need bilateral adrenalectomies, traditionally, a different body position is usually required for second surgery; however, PRA can be performed without the need to reposition the patient intraoperatively. For example, one patient in our series had both left adrenal tumor and right renal cyst. The patient was placed only in the prone jackknife position, and PRA was first performed to remove left adrenal adenoma followed by right renal cyst decompression surgery in the same position. Except having a longer operative time (107 min), the catheter and drainage tube indwelling time and postoperative hospital stay were similar to those of other patients undergoing PRA.

Moreover, among minimally invasive surgeries that treat adrenal tumors posterior to the vena cava, the route of PRA also has unique advantages. It is well known that if the adrenal tumor is located behind the vena cava (Supplementary Figure 1A and 1B), when either TLA or LRA is used, the vena cava would always stay in front of the tumor, causing difficulty in exposing the adrenal tumor. The vena cava would unavoidably be pushed or pulled, which greatly increases the risk of intraoperative vena cava injury and the difficulty level of surgery. PRA offers direct access, exclusive retroperitoneal dissection, and excellent adrenal gland visualization by directly reaching the lesion area, causing less damage to the surrounding tissue and resulting in a lower percentage of surrounding vascular or organ damages (Supplementary Figure 1C-F). Compared with TLA and LRA, there is no occlusion of the vena cava in PRA in the treatment of adrenal tumor that is spatially closely related to the adrenal central vein;

therefore, PRA has a low risk of vena cava injury. In our series, no patients receiving PRA experienced no central adrenal vein or vena cava injury, 13 cases receiving PRA had adrenal tumor that was posterior to the vena cava. On the other hand, a central adrenal vein or vena cava injury was reported in one case each in patients receiving TLR or LRA.

However, there are some barriers impeding wider application of PRA. From a technical standpoint, proficiency is largely dependent on familiarity with anatomy by the surgeon. This approach requires the surgeon to learn a new 'reverse angle' anatomical perspective, which can be readily overcome with experience. Dissection of adrenal tumor does not require any more technical prowess than traditional laparoscopic operations. But manipulation of the endoscope in the retroperitoneum can be rather challenging. Specialized team, optimal patient positioning, correct port placement, high-pressure CO_2 insufflation, aiming the camera and instruments medially, early identification of landmarks and adequate mobilization of the superior renal pole are all crucial steps in ensuring the success of PRA. The smaller working space also means that larger tumors should be treated with TLA or open surgery rather than PRA. The high CO_2 insufflation pressure (18-22 mmHg), which was used to create a working space and tamponade small vessel bleeding, may, theoretically, lead to gas embolism, deep venous thrombosis and hemodynamic instability. However, none of these conditions occurred in our series, nor was it reported in the study by Walz *et al.*, which had an even larger population [21]. In addition, because PRA is carried out in the prone position, there is a potential risk of blocking the airway, but a good anesthetist who is experienced in spinal surgery anesthesia in the prone position should be able to prevent this complication.

Conclusion

Compared with LRA and TLA, PRA is a safe and cost-effective surgical approach. It can be performed to treat a variety of adrenal lesions, especially in large adrenal tumors, adrenal tumors posterior to the vena cava, or bilateral adrenal tumors. PRA may be a preferred approach for the majority of patients undergoing unilateral or bilateral minimally invasive adrenalectomy.

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Disclosure of conflict of interest

None.

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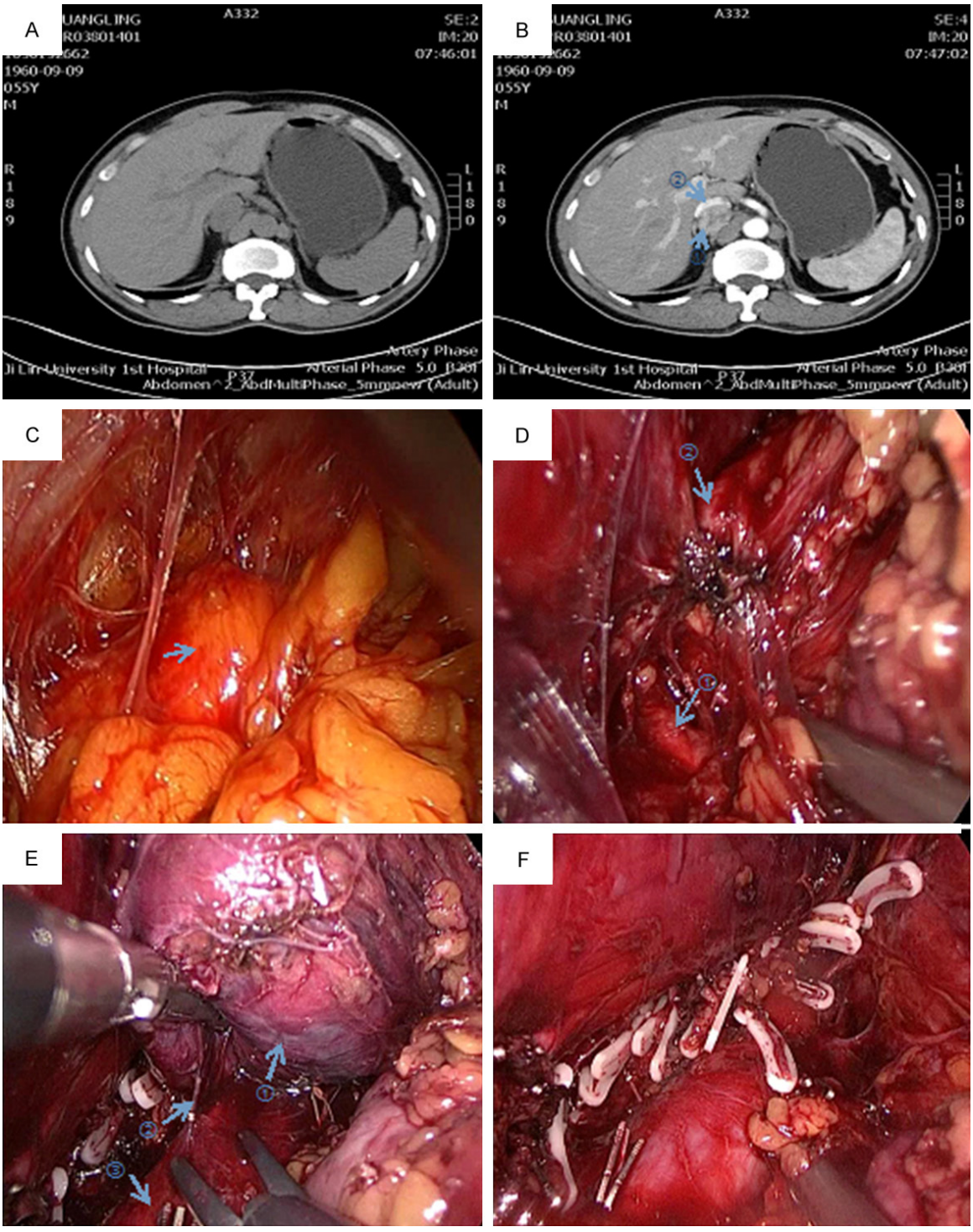

Supplementary Figure 1. Photos showing application of PRA to treat a patient with both adrenal tumor and renal cyst. A. Tumor and the inferior vena cava (IVC) in CT scan; B. Tumor and the IVC in the arterial phase (① tumor, ② IVC); C. Exposure of the tumor; D. The spatial relationship of the renal artery and adrenal tumor (① the renal artery, ② the tumor); E. Separating tumor from the IVC (① the tumor, ② the adrenal central vein, ③ the IVC); F. Resection of the tumor.