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Case series

EFFICACY AND SAFETY OF THREE - DIMENSIONAL LAPAROSCOPIC ADRENALECTOMY: A SINGLE - CENTER EXPERIENCE

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ABSTRACT

Background: *Laparoscopic adrenalectomy has emerged as the standard treatment for adrenal tumors. Although the application of high - resolution cameras has enhanced visualization in conventional two - dimensional laparoscopy, it has not fully overcome the limitations of depth perception and spatial recognition. However, thanks to significant advancements in three - dimensional technology in laparoscopic surgery, these issues have been totally solved. This study aims to evaluate the outcome of three - dimensional laparoscopic adrenalectomy.*

Methods: *A prospective study included 38 patients with adrenal tumors who underwent three - dimensional laparoscopic adrenalectomy from April 2020 to December 2022 at the Department of Urology, Hue Central Hospital.*

Results: *The mean age was 42.5 ± 5.1 years old. The most common reason for hospitalization was back pain, accounting for 39.5%. Adrenal incidentalomas were detected in 23.7% of patients. The proportion of patients with functional adrenal tumors was 55.3%; nonfunctioning adrenal lesion with progressive growth 13.1% and pheochromocytoma was 7.9%. Computed tomography showed a mean tumor size of 30.5 ± 9.2 mm. The mean operative time was 108.8 ± 12.3 minutes. There were no cases of intraoperative complications or conversion to open surgery. Early postoperative complications include wound infection (5.3%) and fluid accumulation (2.6%). The mean postoperative hospital stay was 5.5 ± 1.9 days. Postoperative pathological reports showed adrenocortical tumors in 81.6%. At follow - up, 35 of 38 (92.1%) cases were asymptomatic and had normal follow - up results in laboratory tests.*

Conclusions: *Three - dimensional laparoscopic adrenalectomy is a minimally invasive, safe, and effective method.*

Keywords: *Adrenal tumor, 3D laparoscopy, laparoscopic adrenalectomy.*

I. INTRODUCTION

The adrenal glands are important endocrine glands that help regulate several bodily functions. In adults, adrenal tumors cause many disorders, they may be hormonally active or nonfunctional as well as malignant or benign. It is important for physicians to determine the characteristics of the lesions and determine the need for any necessary treatment [1, 2]. In 1992, Gagner et al. introduced trans-laparoscopic adrenalectomy with lateral flank access, which has now become the standard approach for adrenal tumor treatment [3]. While high - resolution cameras have improved visualization in standard two - dimensional (2D) laparoscopy, they have not fully addressed the limitations of depth perception and spatial awareness [4]. To overcome these limitations, the development of three - dimensional (3D) technology in laparoscopy provided surgeons with enhanced depth perception, improved identification of anatomical structures, precise manipulation, reduced intraoperative blood loss, and benefits for both experienced and novice surgeons, including shorter operating and training times for residents [4, 5]. Since 2017, 3D laparoscopic surgery has been widely applied in routine clinical practice at Hue Central Hospital. However, there is a lack of studies evaluating the outcomes of 3D laparoscopic surgery in the fields

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of urology, especially adrenalectomy. Therefore, we carried out this study to present our experiences and evaluate the outcomes of laparoscopic adrenalectomy using a 3D system.

II. MATERIALS AND METHODS

2.1. Research subjects

In this study, the selection of research subjects was based on the guidelines provided by the American association of clinical endocrinologists (AACE) and the American Association of Endocrine Surgeons (AAES) in 2009.

Patients were enrolled according to AACE/ AAES guidelines (2009): Hormone - producing adrenal tumors; Pheochromoctoma; Non - functional adrenal tumors or adrenal cysts ≥ 4 cm

Exclusion criteria: Tumors > 7 cm in size; Severe medical diseases that cannot be operated: heart failure, severe renal failure, decompensated cirrhosis, coagulation disorders...

2.2. Methodology

The study was conducted as a prospective study, including patients diagnosed with adrenal tumors who met the selection criteria for 3D laparoscopic adrenalectomy at the Urology Department of Hue Central Hospital, from April 2020 to December 2022.

Parameters:

Pre - operation: Diagnosis of the patient was based on clinical symptoms, adrenal hormone biochemical tests, and computed tomography for tumor imaging evaluation. Patients may present with symptoms such as hypertension, weight gain, or unexplained fatigue. Blood sample analysis is crucial for postoperative hormone assessment and preventing complications following surgery. CT scans allow the surgeon to visualize the structure and size of the adrenal gland and identify any abnormal growths or tumors.

Outcomes: 3D Laparoscopic adrenalectomy was conducted using the transperitoneal approach via the flank in the lateral decubitus position for all patients. Short-term outcomes were evaluated based on operative time, blood loss, transfusion rate, complications, and length of hospital stay. Abdominal drainage was removed on the first postoperative day and postoperative complications were assessed according to the Clavien - Dindo classification. We also compared the mean operative time among different groups based on BMI, tumor location, and tumor size. Surgical outcomes were analyzed and compared with findings from related studies.

Follow - up: Examinations were conducted one and three months after surgery to evaluate symptoms improvement and changes in biochemical tests. In case of post - surgery examinations adrenal biochemical tests show persistent abnormalities, alternative investigation options may be explored.

Statistical analysis: Data analysis was performed using IBM SPSS version 26.0 Software (IBM, Armonk, NY, USA).

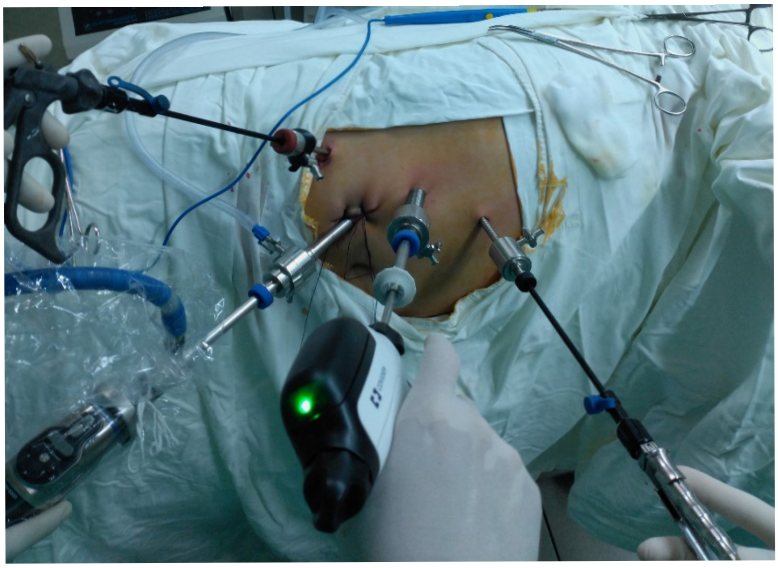

Figure 1: Laparoscopic port placement for right transperitoneal adrenalectomy

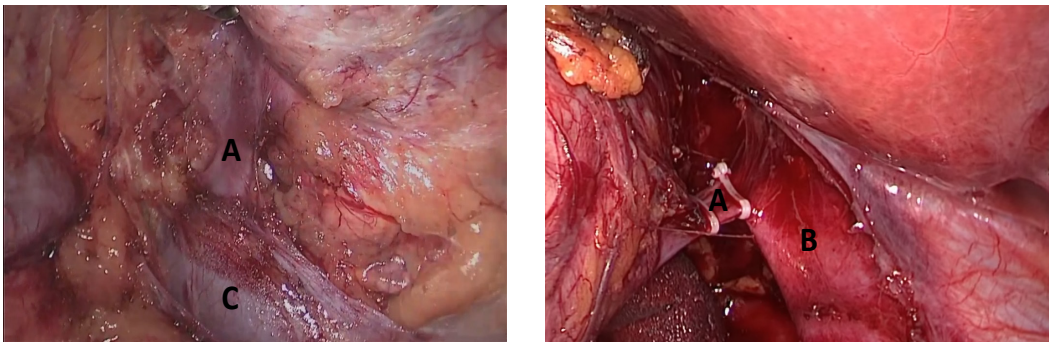

Figure 2: Left: Left adrenalectomy, A: adrenal vein, C: left renal vein
Right: Right adrenalectomy, A: adrenal vein, B: inferior vena cava

III. RESULTS

3.1. Characteristics

Patient demographics and tumor characteristics were shown in Table 1. Our study included 38 patients undergoing 3D laparoscopic adrenalectomy with a mean age of 42.5 years. The majority were male (57.9%). Mean BMI was 22.8 kg/m^2. Tumors were commonly functional (55.3%), right sided (52.6%), and averaged 30.5 mm in size. Hypervascularity was noted in 92.1% of tumors. The most prevalent tumors were cortisol - producing (23.7%), aldosteronomas (31.6%), and pheochromocytomas (7.9%).

Table 1: Characteristics of patient and tumor

Variable	n = 38
Age (years, mean ± SD)	42.5 ± 5.1 (19 - 71)
Gender	
Male	22 (57.9%)
Female	17 (42.1%)
BMI (kg/m^2, mean ± SD)	22.8 ± 4.5 (18.3 - 26.9)
Tumor size (mm, mean ± SD)	30.5 ± 9.2 (10 - 52)
Tumor location	
Right	20 (52.6%)
Left	18 (43.4%)
Vascularity	
Hypervascularity	3 (7.9%)
Normal/ hypovascularity	35 (92.1%)
Incidentaloma	
Adrenal cortical adenoma	6 (15.8%)
Myelolipoma	2 (5.3%)
Neurogenic tumor	1 (2.6%)
Nonfunctioning adrenal lesion with progressive growth	
Adrenal cortical adenoma	4 (10.5%)
Adrenal cyst	1 (2.6%)
Functional adrenal tumors	
Cortisol - producing adrenal tumor	9 (23.7%)
Aldosteronoma	12 (31.6%)
Pheochromocytoma	3 (7.9%)

3.2. Surgical outcomes

The average surgical time was 108.8 minutes. Blood loss was estimated to be 81.5 mL. There were no open surgery conversions. In 7.9% of cases, minor postoperative problems occurred, including wound infections (5.3%) and fluid accumulation (2.6%). The average hospital stay after surgery was 5.5 days. The difference in operating time between BMI and tumor size was substantial (Table 2). Patients with a BMI greater than 23 kg/m^2 required more time during surgery than those with a BMI less than 23 kg/m^2 (115.7 vs 99.1 minutes, p = 0.03). Larger tumors with diameters greater than

40 mm had substantially longer operational times than smaller tumors with diameters less than 40 mm (119.1 vs 95.9 minutes, p = 0.01) (Table 3).

Table 2: Surgical outcomes

	n = 38
Operative time (minute, mean ± SD)	108.8 ± 12.3 (80 - 150)
Estimated blood loss (ml, mean ± SD)	81.5 ± 23.7 (10 - 120)
Conversion No Yes	 38 (100%) -
Postoperative complications No complication Clavien - Dindo I - Wound infection - Fluid accumulation	 35 (92.1%) 3 (7.9%) 2 (5.3%) 1 (2.6%)
Postoperative length of stay (day, mean ± SD)	5.5 ± 1.9 (5-9)

Table 3: Mean operative time among various groups

Variable	**Operative time (mean ± SD)**	**P**
BMI (kg/m²) < 23 ≥ 23	 99.1 ± 10.5 115.7 ± 13.4	 0,03
Tumor location Right Left	 106.3 ± 9.6 109.1 ± 14.8	 0,74
Tumor size (mm) < 40 ≥ 40	 95.9 ± 11.5 119.1 ± 10.0	 0,01

3.3. Postoperative biochemical changes

Preoperatively, abnormalities included included hypokalemia (31.6%), hypercortisolism (23.7%), hyperaldosteronism (18.4%), and increased catecholamines (7.9%). Only 7.9% of patients had mild hypokalemia three months after surgery, although others hormonal hypersecretion was disappeared (Table 4).

Table 4. Plasma biochemical parameters follow-up

Plasma biochemical parameters	**Pre-op**	**Post-op**
↓ Potassium	12 (31.6%)	3 (7.9%)
↑ Aldosterone	7 (18.4%)	-
↑ Cortisol	9 (23.7%)	-
↑ Renin	3 (7.9%)	-
↑ Catecholamine	3 (7.9%)	-

IV. DISCUSSION

According to the AACE/AAES guidelines (2009), incidental adrenal masses that are larger than 4 cm on radiographic images should be surgically removed due to the higher risk of adrenal cancer [6]. Since Garner et al initially described laparoscopic adrenalectomy (LA) in 1992, this procedure has become the standard treatment in patients with small benign adrenal masses [7]. In comparison to open adrenalectomy, laparoscopic adrenalectomy provides better clinical outcomes, lower perioperative morbidity and mortality, a shorter hospital stay, and better cosmetic results.

However, LA has limitations in some groups of patients, including patients with a large adrenal tumor and a high BMI. In our study, the mean duration of the surgery was 108.8 ± 12.3 minutes. Our statistical analysis revealed a correlation between the operative time and the patient's body mass index (BMI) as well as the size of the tumor ($p < 0.05$). Specifically, patients with a BMI greater than 23 kg/m² and a primary tumor size exceeding 40 mm displayed a significant association with a longer operative time.

Notably, our operating time was much lower than Agrusa's study (2016)'s with 120-minute for 2D laparoscopy time and only 10 minutes more than their 110 - minute 3D laparoscopy time [4]. Advanced 3D systems offer superior magnification and stereoscopic viewing of anatomical regions, enhancing the understanding of anatomical structures and facilitating precise tissue dissection and coagulation. Using 3D laparoscopic systems, surgeons gain better control in the operating room and can avoid unintended vascular injuries when

dissecting perivascular adipose tissue [4, 8]. Our estimated blood loss of 81.5 mL was also minimal, further demonstrating the safety of this approach.

No intraoperative complications or transitions to open surgery occurred in our study. Prior to surgical intervention for pheochromocytoma, preoperative diagnosis supports careful dissection and examination of the adrenal veins to minimize excessive tumor manipulation. This approach reduces the risk of excessive catecholamine release and the subsequent development of hypertension. Postoperatively, only minor wound complications occurred in 7.9% of patients and especially no intraoperative complications took place which is lower than intraoperative complication rates of up to 7.7% reported in other studies [4, 8, 9]. The mean hospital stay of 5.5 days was consistent with prior studies [4, 8, 10]. At the 3-month follow-up, nearly all patients had resolution of hormone hypersecretion, similar to other reports demonstrating excellent endocrine outcomes after adrenalectomy. However, no patient experienced acute adrenal insufficiency after surgery. Due to fluid accumulation in the adrenal fossa, the patient was discharged within 4 days after surgery and 6 days after ultrasound scanning.

Table 5. Comparison with other studies

Author	Method	Operative time (min)	Intraoperative complications (%)	Postoperative hospital stays (days)
Our study	3D Lap. Trans.	108.8 ± 12.3 (80 - 150)	0%	5.5 ± 1.9 (5 - 10)
Nguyen Thanh Vinh (2020)	2D Lap. Trans.	80.39 ± 27.72 (35 - 170)	5,2%	5.17 ± 1.35 (3 - 9)
Buono (2019)	2D Lap. Trans.	145 (75 - 240)	6,2%	3,7 (3 - 6)
Agursa (2016)	2D Lap. Trans.	120 (100 - 240)	7,7%	-
	3D Lap. Trans.	110 (100 - 210)	0%	-
Hermosa (2020)	2D Lap. Trans.	98.6 ± 40.8 (30 - 235)	-	3 (1 - 11)
	3D Lap. Trans.	62.6 ± 23.2 (20 - 150)	-	2 (1 - 6)

Lap. - Laparoscopic; Trans. - Transperitoneal

Our results add to the growing body of evidence showing 3D laparoscopy as an effective alternative method to traditional 2D laparoscopic adrenalectomy. The improved depth perception and magnification with 3D imaging may translate to better clinical outcomes and shorter learning curves for surgeons, though further comparative studies are needed. This was only a small case series from a single center, further investigation with a larger patient cohort and a control group is necessary to compare treatment outcomes with the conventional 2D laparoscopic approach. Moreover, the larger multi - institutional studies need to define the advantages of 3D laparoscopic adrenalectomy and long - term oncologic outcomes, patient - reported outcomes, and cost - analyses should be examined as well.

V. CONCLUSION

3D Laparoscopic adrenalectomy is a minimally invasive, safe, and remarkably efficient surgical technique.

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