# Clinical Factors Affecting Postoperative Antihypertensive Efficacy in Patients With Adrenal Tumors Complicated by Hypertension: A Retrospective Study

*Ann. Ital. Chir.*, 2026 97, 5: 848–854
https://doi.org/10.62713/aic.4526

Yaning Tian[1], Qing Yang[2], Penghui Ye[3], Tianbei Zhu[3], Xiangjian Chen[3]

[1]Department of Cardiovascular Medicine, Zhejiang Xin'an International Hospital, 314033 Jiaxing, Zhejiang, China
[2]Department of Urology, Shanghai Ninth People's Hospital, Shanghai JiaoTong University School of Medicine, 201999 Shanghai, China
[3]Department of Urology, Zhejiang Xin'an International Hospital, 314033 Jiaxing, Zhejiang, China

AIM: Clinically, patients with adrenal tumors are prone to secondary hypertension. This study aimed to identify key factors influencing the antihypertensive effect of surgery by retrospectively analyzing clinical data from patients with adrenal tumors complicated by hypertension, to provide a reference for clinical prognosis evaluation, guide individualized treatment planning, and improve treatment success rates.

METHODS: A total of 82 patients diagnosed with adrenal tumors by imaging and complicated by hypertension were included, and all underwent laparoscopic adrenal tumor resection. According to the antihypertensive effect at 6 months postoperatively, patients were divided into an effective antihypertensive group and an ineffective antihypertensive group. Clinical data of both groups were collected. Univariate analysis was performed to screen differential variables, and variables with statistical significance were included in a multivariate logistic regression model to identify independent factors affecting the short-term surgical antihypertensive effect.

RESULTS: No significant differences were observed between the two groups in age, gender, other general characteristics, or perioperative indicators of laparoscopic surgery (operative time, intraoperative blood loss, postoperative hospital stay, and complication rate) ($p > 0.05$). Univariate analysis showed significant differences between the two groups in hypertension disease course, tumor pathological type, preoperative systolic blood pressure (SBP) level, preoperative aldosterone/norepinephrine levels, and tumor maximum diameter ($p < 0.05$). Multivariate logistic regression analysis showed that hypertension duration $\geq$6 years, non-functional adenoma, and preoperative SBP $\geq$170 mmHg were independent factors affecting the surgical antihypertensive effect ($p < 0.05$).

CONCLUSIONS: Laparoscopic surgery is an effective treatment for adrenal tumors complicated by hypertension. However, patients with long-term hypertension, non-functional adenoma, and markedly elevated preoperative SBP may experience a poor short-term postoperative antihypertensive effect.

**Keywords:** adrenal tumor; hypertension; laparoscopic adrenalectomy; blood pressure control

## Introduction

Adrenal tumors are common endocrine-related neoplasms in urology, and their clinical characteristics are closely associated with endocrine function [1,2]. The primary mechanism by which adrenal tumors induce hypertension involves abnormal hormone secretion or the indirect effects of tumor mass. As the most common type of functional adrenal tumor, aldosteroma can activate the renin-angiotensin-aldosterone system (RAAS) through excessive aldosterone secretion, leading to sodium and water retention as well as potassium loss. This process not only elevates blood pressure but is also accompanied by refractory hypokalemia, thereby further increasing the risk of myocardial injury and arrhythmia [3]. Pheochromocytoma, in contrast, induces marked vasoconstriction through the paroxysmal release of catecholamines (epinephrine and norepinephrine). Patients with this tumor often experience sudden hypertensive crises, which are prone to triggering life-threatening complications such as cerebral hemorrhage and acute myocardial infarction [4,5]. Even adenomas clinically classified as "non-functional" may contribute to blood pressure fluctuations by compressing normal adrenal tissue or indirectly modulating sympathetic nervous activity [6].

Previous studies have shown that approximately 60%–80% of patients with functional adrenal tumors are complicated by hypertension. This form of hypertension is often characterized by poor responsiveness to pharmacological therapy and significant blood pressure variability. Over time, it may lead to severe complications, including cardiovascular and cerebrovascular events (e.g., stroke and myocardial infarction) as well as renal dysfunction, thereby significantly increasing the risks of mortality and disability [7,8].

*Submitted: 6 January 2026 Revised: 25 February 2026 Accepted: 4 March 2026 Published: 10 May 2026*
*Correspondence to: Xiangjian Chen, Department of Urology, Zhejiang Xin'an International Hospital, 314033 Jiaxing, Zhejiang, China (e-mail: Cxj6542@163.com).*
*Editor: Roberto Cirocchi*

At present, surgical intervention remains the primary treatment modality for adrenal tumors. In particular, the widespread adoption of laparoscopic techniques has significantly improved surgical safety and enhanced postoperative recovery outcomes [9,10]. However, in clinical practice, there is still a lack of robust and individualized evidence regarding key issues, including the determination of surgical indications for patients with adrenal tumors complicated by hypertension, the optimal monitoring intervals for postoperative blood pressure and hormone levels, and variations in surgical efficacy among different pathological tumor types. Based on this, the present study systematically summarized the clinical characteristics and surgical outcomes of patients by retrospectively analyzing clinical data from patients with adrenal tumors complicated by hypertension. The aim was to provide a scientific basis for optimizing individualized treatment strategies, thereby improving patients' quality of life and reducing the risk of hypertension-related complications.

## Methods

*Study Subjects*

This retrospective study enrolled 82 patients with adrenal tumors complicated by hypertension who received treatment at Zhejiang Xin'an International Hospital between March 2023 and March 2025. Inclusion criteria: (1) preoperative diagnosis of adrenal tumors confirmed by abdominal enhanced computed tomography (CT), magnetic resonance imaging (MRI), or other imaging examinations, with complete imaging data available; (2) fulfilment of the diagnostic criteria for hypertension as specified in the Chinese Guidelines for the Management of Hypertension [11] (systolic blood pressure (SBP) $\geq$140 mmHg and/or diastolic blood pressure (DBP) $\geq$90 mmHg measured on three non-consecutive days), with a clinical correlation between hypertensive symptoms and adrenal tumors (i.e., biochemical or clinical evidence suggesting secondary hypertension related to a functional adrenal tumor); (3) all patients underwent laparoscopic surgery in Zhejiang Xin'an International Hospital, and all procedures were performed by the same team of experienced surgeons; (4) postoperative pathological examination confirmed that the tumors originated from adrenal tissue, with a definitive pathological diagnosis; (5) postoperative follow-up duration $>$6 months, with complete follow-up data.

Exclusion criteria: (1) presence of other types of secondary hypertension (such as renal artery stenosis, primary aldosteronism not originating from adrenal tumors, or Cushing's syndrome not related to adrenal lesions); (2) presence of surgical contraindications, including severe cardiopulmonary insufficiency, hepatic or renal failure, and coagulation disorders; (3) postoperative pathological findings indicating that the tumor was a metastatic lesion from an extra-adrenal site or of non-adrenal origin; (4) refusal to provide informed consent.

Patients were divided into an effective antihypertensive group and an ineffective antihypertensive group according to the antihypertensive effect at 6 months after surgery [12,13]. Marked effect: after treatment, the blood pressure of patients returned to the normal range (SBP $<$140 mmHg and DBP $<$90 mmHg); Effective: after treatment, blood pressure decreased significantly compared with the preoperative level (SBP decreased by $\geq$20 mmHg or DBP decreased by $\geq$10 mmHg) but did not reach the normal range; Ineffective: failure to meet the above criteria for marked or effective response, i.e., no significant decrease in blood pressure compared with preoperative values (SBP decreased by $<$10 mmHg and DBP decreased by $<$5 mmHg), or blood pressure rebounded to the preoperative level or even increased. The effective antihypertensive group included patients with marked and effective responses, whereas the ineffective group included patients with ineffective responses. This study was approved by the Ethics Review Committee of Zhejiang Xin'an International Hospital (Approval No. XA-K-2025-021) and strictly adhered to the principles outlined in the Declaration of Helsinki. All patients included in the study provided written informed consent.

*Data Collection*

Data for the 82 patients were collected through the hospital's electronic medical record system. The collected variables included: basic information (age, gender, body mass index (BMI), and disease duration); medical history (including the presence of hypokalemia, hyperglycemia, endocrine disorders, smoking history, and history of alcohol consumption); and tumor-related characteristics, including maximum tumor diameter (measured by preoperative imaging examinations), tumor laterality (left, right, or bilateral), and pathological type (confirmed by postoperative pathological diagnosis).

*Indicators Monitoring and Follow-Up*

All patients underwent continuous monitoring and follow-up for 6 months postoperatively: (1) Blood pressure monitoring: blood pressure was measured four times daily (fasting in the morning, at 10:00 AM, 4:00 PM, and before bedtime) within 1–3 days before and after surgery, and changes in systolic and diastolic blood pressure were recorded. Outpatient follow-up was conducted at 6 months postoperatively; blood pressure was measured three times, and the average value was used as the indicator for blood pressure assessment. (2) Electrolyte and blood glucose monitoring: serum potassium, serum sodium, and blood glucose levels were measured before surgery to evaluate the improvement of hypokalemia. (3) Endocrine hormone monitoring: levels of aldosterone, epinephrine, norepinephrine, and cortisol were measured preoperatively.

**Table 1. Baseline characteristics of patients.**

| Variable | Effective group (n = 65) | Ineffective group (n = 17) | $t/Z/\chi^2$ value | $p$-value |
|---|---|---|---|---|
| Age (years, mean ± SD) | 51.8 ± 10.2 | 54.5 ± 11.3 | 0.950 | 0.345 |
| Gender (male/female, n (%)) | 35 (53.8)/30 (46.2) | 10 (58.8)/7 (41.2) | 0.135 | 0.713 |
| BMI ($kg/m^2$, mean ± SD) | 25.4 ± 3.0 | 26.2 ± 3.3 | 0.959 | 0.340 |
| Hypertension duration (years, median [IQR]) | 5.0 (2.5–7.9) | 7.9 (5.8–13.4) | 2.842 | <0.010 |
| Diabetes mellitus (n (%)) | 9 (13.8) | 4 (23.5) | 0.360 | 0.548 |
| Coronary heart disease (n (%)) | 6 (9.2) | 2 (11.8) | 0.021 | 0.884 |
| History of smoking (n (%)) | 17 (26.1) | 7 (41.2) | 0.833 | 0.361 |
| History of alcohol consumption (n (%)) | 10 (15.4) | 4 (23.5) | 0.187 | 0.665 |
| Preoperative SBP (mmHg, mean ± SD) | 162.3 ± 17.8 | 178.5 ± 19.2 | 3.288 | <0.010 |
| Preoperative DBP (mmHg, mean ± SD) | 97.8 ± 10.1 | 101.2 ± 10.5 | 1.226 | 0.224 |
| Tumor maximum diameter (cm, median [IQR]) | 2.9 (1.7–3.9) | 4.0 (2.4–5.2) | 2.030 | 0.042 |
| Tumor laterality (left/right/bilateral, n (%)) | 28 (43.1)/36 (55.4)/1 (1.5) | 8 (47.1)/9 (52.9)/0 | 0.324 | 0.569 |
| Pathological type (n (%)) | | | 10.276 | 0.023 |
| Aldosteronoma | 28 (43.1) | 4 (23.5) | | |
| Pheochromocytoma | 19 (29.2) | 2 (11.8) | | |
| Non-functional adenoma | 10 (15.4) | 8 (47.1) | | |
| Cortisoloma | 6 (9.2) | 1 (5.9) | | |
| Others | 2 (3.1) | 2 (11.8) | | |
| Surgical approach (simple resection/adrenalectomy, n (%)) | 42 (64.6)/23 (35.4) | 9 (52.9)/8 (47.1) | 1.746 | 0.189 |
| Operation time (minutes, mean ± SD) | 94.5 ± 25.3 | 98.6 ± 26.9 | 0.586 | 0.558 |
| Intraoperative blood loss (mL, mean ± SD) | 24.8 ± 6.5 | 27.2 ± 5.9 | 1.380 | 0.171 |
| Complications (n (%)) | 4 (6.1) | 1 (5.9) | NA (Fisher's exact test) | 1.000 |
| Transient hypotension (n (%)) | 3 (4.6) | 1 (5.9) | - | - |
| Infection | 1 (1.5) | 0 | - | - |

Note: SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; IQR, interquartile range; NA, not applicable.

### *Surgical Methods*

All patients underwent laparoscopic surgery via the transperitoneal approach, and the specific surgical strategy was determined according to tumor size: (1) For patients with a tumor maximum diameter ≤2 cm, simple tumor resection was performed. During the procedure, the tumor was carefully separated from the surrounding normal adrenal tissue under laparoscopic guidance. After complete tumor removal, meticulous hemostasis was performed to avoid damage to the functional regions of the normal adrenal gland. (2) For patients with a maximum tumor diameter >2 cm, ipsilateral adrenalectomy was performed. The resected tumor tissue was sent to the pathology department for paraffin section staining and immunohistochemical examination to confirm the pathological type.

After surgery, patients received routine anti-infective treatment. For patients whose blood pressure did not return to normal or exhibited fluctuations, antihypertensive agents, such as calcium channel blockers and angiotensin-converting enzyme inhibitors, were administered based on blood pressure levels. Other treatments were provided on an individualized basis according to the symptoms of patients.

### *Statistical Methods*

SPSS 26.0 statistical software (IBM Corp., Armonk, NY, USA) was used for data analysis. Measurement data (e.g., age, blood pressure values, and laboratory indices) that conformed to a normal distribution based on the Shapiro-Wilk test were expressed as mean ± standard deviation (SD), and comparisons between groups were performed using the independent samples $t$-test. Variables with non-normal distribution were described as median (interquartile range) and compared using the Wilcoxon rank-sum test. Count data (e.g., gender, tumor laterality, pathological type distribution, and adrenal function recovery rate) were expressed as the number of cases (percentage) [n (%)], and comparisons were performed using the chi-square ($\chi^2$) test. Univariate analysis was used to screen variables with significant differences between the two groups. Continuous variables should be analyzed in their raw numerical form in univariate comparisons. For multivariate logistic regression analysis, the selected continuous predictor variables should be binary-classified based on pre-set clinically relevant thresholds or cutoff values determined based on data distribution to improve the model's interpretability and clinical applicability. Variables with $p < 0.05$ in the univariate analysis were included in a multivariate logistic regression model (dependent variable: postoperative antihypertensive efficacy; effective = 0, ineffective = 1) to identify independent factors

**Table 2. Comparison of preoperative laboratory indices.**

| Variable | Effective group (n = 65) | Ineffective group (n = 17) | *t* value | *p*-value |
|---|---|---|---|---|
| Aldosterone level (pg/mL, mean ± SD) | 298.5 ± 58.6 | 225.3 ± 52.1 | 4.685 | <0.010 |
| Norepinephrine level (pg/mL, mean ± SD) | 442.6 ± 88.5 | 358.2 ± 76.3 | 3.594 | <0.010 |
| Cortisol level (μg/dL, mean ± SD) | 26.2 ± 5.8 | 24.5 ± 5.2 | 1.098 | 0.275 |
| Serum potassium (mmol/L, mean ± SD) | 2.9 ± 0.4 | 3.1 ± 0.4 | 1.835 | 0.070 |
| Serum sodium (mmol/L, mean ± SD) | 142.5 ± 12.8 | 141.8 ± 13.2 | 0.199 | 0.842 |
| Blood glucose (mmol/L, mean ± SD) | 6.5 ± 1.2 | 6.8 ± 1.5 | 0.870 | 0.386 |

affecting the surgical antihypertensive effect. A $p$-value $<$ 0.05 was considered statistically significant.

## Results

### *Baseline Characteristics of Patients*

A total of 82 patients with adrenal tumors complicated by hypertension were treated by laparoscopic surgery. After 6 months of follow-up, patients were grouped according to antihypertensive efficacy (Fig. 1). The results of univariate analysis showed significant differences between the effective and ineffective groups in hypertension duration, tumor pathological type, preoperative SBP level, and tumor maximum diameter ($p < 0.05$). However, no statistically significant differences were observed between the two groups in age, gender, BMI, comorbidities (diabetes mellitus/coronary heart disease), smoking history, history of alcohol consumption, tumor laterality, preoperative DBP level, surgical approach, operation time, intraoperative blood loss, or complication rate ($p > 0.05$). Detailed data are presented in Table 1.

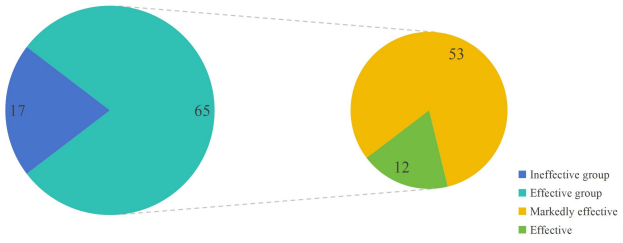


**Fig. 1. Classification of patients according to postoperative antihypertensive outcomes.**

### *Comparison of Preoperative Laboratory Indices*

The preoperative aldosterone level and norepinephrine level in the effective group were significantly higher than those in the ineffective group ($p < 0.010$), while there were no significant differences in preoperative serum potassium, serum sodium, blood glucose, or cortisol levels between the two groups ($p > 0.05$). Detailed data are shown in Table 2.

### *Multivariate Logistic Regression Analysis of Factors Influencing the Surgical Antihypertensive Effect*

To enhance clinical interpretability, some important continuous variables were binary-classified based on their clinical significance and data distribution characteristics before performing multivariate regression analysis. Variables with $p < 0.05$ in univariate analysis were included in the multivariate logistic regression model (assignment criteria: hypertension duration: <6 years = 0, ≥6 years = 1; tumor pathological type: functional tumor = 0, non-functional adenoma = 1; preoperative SBP: <170 mmHg = 0, ≥170 mmHg = 1; preoperative aldosterone: <280 pg/mL = 0, ≥280 pg/mL = 1; preoperative norepinephrine: <400 pg/mL = 0, ≥400 pg/mL = 1; tumor maximum diameter: <3 cm = 0, ≥3 cm = 1). The results showed that hypertension duration ≥6 years, non-functional adenoma, and preoperative SBP ≥170 mmHg were independent factors affecting the surgical antihypertensive effect in patients with adrenal tumors complicated by hypertension ($p < 0.05$). Detailed data are presented in Table 3.

## Discussion

Clinically, active surgical intervention is recommended for endocrine-related adrenal tumors and large non-functioning tumors [14]. Previous studies have reported that the hypertension remission rate after surgical resection in patients with primary aldosteronism ranges from 42% to 84% [15], while the remission rate after surgery in patients with cortisol-secreting tumors is approximately 70% [16]. In the present study, the overall effective rate of blood pressure reduction was 79.3% among 82 patients at 6 months postoperatively, further supporting laparoscopic surgery as a preferred treatment approach for these conditions. Laparoscopic surgery can effectively reduce blood pressure, which is closely associated with tumor resection and the correction of hormonal abnormalities following surgical intervention [17,18]. Analysis based on pathological type revealed that the frequency of patients with aldosterone-secreting adenoma was higher in the effective group than in the ineffective group. The underlying mechanisms are that aldosterone-producing adenomas secrete excessive aldosterone, leading to sodium and water retention; surgical resection reduces aldosterone levels, thereby resulting in a corresponding decrease in blood pressure [19]. Pheochromocytomas release large amounts of cate-

**Table 3. Multivariate logistic regression analysis of factors affecting surgical antihypertensive efficacy.**

| Variable | $\beta$ | SE | Wald | OR | 95% CI | $p$-value |
|---|---|---|---|---|---|---|
| Hypertension duration ≥6 years | 1.508 | 0.562 | 7.199 | 4.517 | 1.501–13.592 | <0.010 |
| Non-functional adenoma | 1.636 | 0.585 | 7.821 | 5.134 | 1.631–16.161 | <0.010 |
| Preoperative SBP ≥170 mmHg | 1.356 | 0.542 | 6.258 | 3.880 | 1.341–11.226 | 0.010 |
| Preoperative aldosterone ≥280 pg/mL | –0.852 | 0.528 | 2.604 | 0.426 | 0.151–1.201 | 0.106 |
| Preoperative norepinephrine ≥400 pg/mL | –0.785 | 0.512 | 2.351 | 0.456 | 0.167–1.224 | 0.125 |
| Tumor maximum diameter ≥3 cm | 0.985 | 0.536 | 3.377 | 2.677 | 0.936–7.656 | 0.066 |

OR, odds ratio.

cholamines, causing marked vasoconstriction; after tumor resection, catecholamine levels decline rapidly, leading to significant improvement in blood pressure [20]. Hyperglycemia in patients with cortisol-secreting adenomas is associated with excessive cortisol secretion, which antagonizes insulin action; surgical tumor resection reduces cortisol levels, thereby improving glycemic control [21].

Multivariate logistic regression analysis identified three independent factors affecting postoperative antihypertensive efficacy: hypertension duration ≥6 years, non-functional adenoma, and preoperative SBP ≥170 mmHg. Patients with hypertension lasting ≥6 years had a significantly increased risk of poor blood pressure reduction after surgery. The primary mechanism may be that long-term hypertension induces vascular wall remodeling, characterized by atherosclerosis, vascular smooth muscle cell proliferation, and disruption of elastic fibers, leading to reduced vascular compliance and increased peripheral resistance [22]. Even if hormonal abnormalities are corrected surgically, the impaired vascular regulatory function may be difficult to restore. Moreover, long-term hypertension may involve target organs such as the kidneys and heart; for example, renal parenchymal damage can cause abnormal sodium and water excretion, further weakening blood pressure regulation capacity [23].

In the ineffective group, the frequency of patients with non-functional adenomas was higher. This may be attributed to the fact that such tumors secrete little or no hormones, and the associated hypertension is often concurrent essential hypertension, or may result from tumor mass compression of periadrenal tissues and sympathetic plexuses, leading to altered sympathetic nerve activity [24]. Surgical treatment primarily relieves the mass effect but cannot reverse the underlying pathological basis of essential hypertension, such as genetic predisposition and insulin resistance, thereby resulting in limited antihypertensive efficacy [25]. Preoperative SBP ≥170 mmHg indicates severe impairment of blood pressure regulation mechanisms. On the one hand, there may be an overlap of essential and secondary hypertension, which increases the difficulty of blood pressure control. On the other hand, sustained high-pressure states can exacerbate vascular remodeling and may activate inflammatory pathways through oxidative stress responses, thereby aggravating vascular endothelial injury [26].

This study still has several limitations. First, as a single-center retrospective study conducted in a tertiary hospital, the sample size is relatively small. This may limit representativeness and make it difficult to fully reflect differences in postoperative efficacy among patients with varying disease severity. For example, critically ill patients who could not tolerate surgery were excluded, and the generalizability of the findings requires further validation in multi-center studies with larger sample sizes. Second, due to practical constraints in clinical follow-up, the observation period was limited to 6 months, which is insufficient to evaluate long-term surgical outcomes (e.g., 5-year survival and tumor recurrence rates). Future studies should extend the follow-up period to obtain more comprehensive long-term prognostic data. Third, potential confounding factors, such as postoperative antihypertensive medication use, were not included in the analysis. Individual differences in drug regimens and medication adherence may mask or amplify the antihypertensive effect of surgery, thereby introducing bias in the assessment of independent risk factors. In addition, other confounders, including metabolic abnormalities, the degree of target organ damage, and preoperative lifestyle interventions, may indirectly influence postoperative blood pressure recovery through mechanisms such as vascular remodeling and hormonal regulation. The potential impact of these factors on surgical antihypertensive efficacy warrants further investigation. Finally, methodological limitations should be considered. The relatively small sample size may increase the risk of overfitting in the logistic regression model, and dichotomizing continuous variables may lead to loss of information and potential bias in the results.

## Conclusions

The overall effective rate of laparoscopic surgery for adrenal tumors complicated by hypertension is relatively high. A hypertension course of ≥6 years, the presence of a non-functional adenoma, and a preoperative SBP of ≥170 mmHg are significantly associated with short-term postoperative antihypertensive efficacy.

## Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

## Author Contributions

YNT designed the research study and wrote the first draft. QY and PHY performed the research. TBZ and XJC analyzed the data. All authors have been involved in revising the manuscript critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

## Ethics Approval and Consent to Participate

This study was approved by the Ethics Review Committee of Zhejiang Xin'an International Hospital (Approval No. XA-K-2025-021) and strictly adhered to the principles outlined in the Declaration of Helsinki. All patients provided written informed consent.

## Acknowledgment

Not applicable.

## Funding

This research received no external funding.

## Conflict of Interest

The authors declare no conflict of interest.

## References

[1] Bancos I, Prete A. Approach to the Patient With Adrenal Incidentaloma. The Journal of Clinical Endocrinology and Metabolism. 2021; 106: 3331–3353. https://doi.org/10.1210/clinem/dgab512.

[2] Park SS, Kim JH. Recent Updates on the Management of Adrenal Incidentalomas. Endocrinology and Metabolism. 2023; 38: 373–380. https://doi.org/10.3803/EnM.2023.1779.

[3] Mullen N, Curneen J, Donlon PT, Prakash P, Bancos I, Gurnell M, *et al*. Treating Primary Aldosteronism-Induced Hypertension: Novel Approaches and Future Outlooks. Endocrine Reviews. 2024; 45: 125–170. https://doi.org/10.1210/endrev/bnad026.

[4] Mamilla D, Gonzales MK, Esler MD, Pacak K. Pseudopheochromocytoma. Endocrinology and Metabolism Clinics of North America. 2019; 48: 751–764. https://doi.org/10.1016/j.ecl.2019.08.004.

[5] Lenders JWM, Kerstens MN, Amar L, Prejbisz A, Robledo M, Taieb D, *et al*. Genetics, diagnosis, management and future directions of research of phaeochromocytoma and paraganglioma: a position statement and consensus of the Working Group on Endocrine Hypertension of the European Society of Hypertension. Journal of Hypertension. 2020; 38: 1443–1456. https://doi.org/10.1097/HJH.0000000000002438.

[6] Favero V, Parazzoli C, Bernasconi DP, Chiodini I. Cardiometabolic comorbidities and cardiovascular events in "non-functioning" adrenal incidentalomas: a systematic review and meta-analysis. Journal of Endocrinological Investigation. 2024; 47: 2929–2942. https://doi.org/10.1007/s40618-024-02440-0.

[7] Amin B, Elahi A, Cappiello G, Ištuk N, Dunne E, Krewer F, *et al*. Dielectric characterisation of human adrenal glands and adrenal tumours for the development of microwave ablation technologies for hypertension treatment. Scientific Reports. 2024; 14: 19451. https://doi.org/10.1038/s41598-024-70476-6.

[8] Siemińska L, Siemińska K, Marek B, Kos-Kudła B, Nowak M, Głogowska-Szeląg J, *et al*. Adrenal tumours and subclinical adrenal hyperfunction. Endokrynologia Polska. 2024; 75: 630–642. https://doi.org/10.5603/ep.101940.

[9] Zhang T, Chen T, Zhang W, Tan L, Li L, Zhu Y, *et al*. Clinical diagnosis and treatment of a patient with hypertension, hypokalemia, and bilateral adrenal adenomas. Frontiers in Endocrinology. 2025; 16: 1558841. https://doi.org/10.3389/fendo.2025.1558841.

[10] Fassnacht M, Tsagarakis S, Terzolo M, Tabarin A, Sahdev A, Newell-Price J, *et al*. European Society of Endocrinology clinical practice guidelines on the management of adrenal incidentalomas, in collaboration with the European Network for the Study of Adrenal Tumors. European Journal of Endocrinology. 2023; 189: G1–G42. https://doi.org/10.1093/ejendo/lvad066.

[11] Clinical practice guideline for the management of hypertension in China. Chinese Medical Journal. 2024; 137: 2907–2952. https://doi.org/10.1097/CM9.0000000000003431.

[12] Wang JG. Chinese Guidelines for the Prevention and Treatment of Hypertension (2024 revision). Journal of Geriatric Cardiology. 2025; 22: 1–149. https://doi.org/10.26599/1671-5411.2025.01.008.

[13] Joint Committee for Guideline Revision. 2018 Chinese Guidelines for Prevention and Treatment of Hypertension-A report of the Revision Committee of Chinese Guidelines for Prevention and Treatment of Hypertension. Journal of Geriatric Cardiology. 2019; 16: 182–241. https://doi.org/10.11909/j.issn.1671-5411.2019.03.014.

[14] Yip L, Duh QY, Wachtel H, Jimenez C, Sturgeon C, Lee C, *et al*. American Association of Endocrine Surgeons Guidelines for Adrenalectomy: Executive Summary. JAMA Surgery. 2022; 157: 870–877. https://doi.org/10.1001/jamasurg.2022.3544.

[15] Muth A, Ragnarsson O, Johannsson G, Wängberg B. Systematic review of surgery and outcomes in patients with primary aldosteronism. The British Journal of Surgery. 2015; 102: 307–317. https://doi.org/10.1002/bjs.9744.

[16] Pelsma ICM, Fassnacht M, Tsagarakis S, Terzolo M, Tabarin A, Sahdev A, *et al*. Comorbidities in mild autonomous cortisol secretion and the effect of treatment: systematic review and meta-analysis. European Journal of Endocrinology. 2023; 189: S88–S101. https://doi.org/10.1093/ejendo/lvad134.

[17] Wang J, Zhu Y, Wang Z, Liu C, Liu S, Li X, *et al*. Hypertension Resolution after Laparoscopic Adrenal Tumor Resection in Patients of Adrenal Incidentaloma with Normal Hormone Levels. Urologia Internationalis. 2023; 107: 193–201. https://doi.org/10.1159/000524803.

[18] Chen J, Wu J, Zhu R, Lu L, Ma XJ. Ablation versus laparoscopic adrenalectomy for the treatment of aldosterone producing adenoma: a meta-analysis. Abdominal Radiology. 2021; 46: 2795–2804. https://doi.org/10.1007/s00261-020-02887-8.

[19] Liu JH, Wei XD, Fu CC, Li QX, Hou JQ, Lv JX, *et al*. Long-Term Results of Laparoscopic Partial Versus Total Adrenalectomy for Aldosterone Producing Adenoma. Urology Journal. 2020; 17: 4981. https://doi.org/10.22037/uj.v0i0.4981.

[20] Araujo-Castro M, Herrera A, Wang Y, Wang Z, Śledziński M, Hellmann A, *et al*. Postoperative Outcomes in Normotensive and Hypertensive Pheochromocytomas: An International Study. The Journal of Clinical Endocrinology and Metabolism. 2025; 110: e3719–e3729. https://doi.org/10.1210/clinem/dgaf154.

[21] Wonglhaw W, Santi-Ngamkun A, Ratchanon S, Usawachintachit M, Sowanthip D, Panumatrassamee K. Cardiovascular risk improvement after laparoscopic adrenalectomy in patients with cortisol-secreting adrenal adenoma, a retrospective cohort study. Gland Surgery. 2024; 13: 2128–2136. https://doi.org/10.21037/gs-24-398.

[22] Abdellatif AB, Fernandes-Rosa FL, Boulkroun S, Zennaro MC. Vascular and hormonal interactions in the adrenal gland. Frontiers in Endocrinology. 2022; 13: 995228. https://doi.org/10.3389/fendo.2022.995228.

[23] Harrison DG, Coffman TM, Wilcox CS. Pathophysiology of Hy-

pertension: The Mosaic Theory and Beyond. Circulation Research. 2021; 128: 847–863. https://doi.org/10.1161/CIRCRESAHA.121.318082.

[24] Karatas S, Hacioglu Y, Beysel S. Metabolic syndrome and Visceral Adiposity Index in non-functional adrenal adenomas. Archives of Endocrinology and Metabolism. 2023; 67: 323–329. https://doi.org/10.20945/2359-3997000000547.

[25] Szychlińska M, Rzeczkowska M, Matuszewski W, Bandurska-Stankiewicz E. Could a nonfunctional adrenal incidentaloma be a risk factor for increased carotid intima-media thickness and 10-year cardiovascular mortality based on the SCORE algorithm? A study from a single centre in Poland. Endokrynologia Polska. 2023; 74: 10.5603/ep.95139. https://doi.org/10.5603/ep.95139.

[26] Choromańska B, Myśliwiec P, Kozłowski T, Łukaszewicz J, Vasilyevich HP, Dadan J, *et al*. Antioxidant and antiradical activities depend on adrenal tumor type. Frontiers in Endocrinology. 2022; 13: 1011043. https://doi.org/10.3389/fendo.2022.1011043.