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Application of A Novel Intraoperative Hemodynamic Stabilization Technique During One-Stage Bilateral Partial Adrenalectomy for Multiple Bilateral Pheochromocytomas: A Clinical Case Report

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Abstract: Pheochromocytoma is a rare hormonally active tumor of the adrenal medulla characterized by catecholamine hypersecretion and a high risk of cardiovascular instability. Bilateral multiple forms of the disease represent a particular surgical challenge, requiring operative treatment with simultaneous preservation of cortical tissue to prevent chronic adrenal insufficiency. A critical stage of the procedure is venous outflow control, which is associated with the risk of pronounced arterial hypotension due to the abrupt cessation of catecholamine release into the systemic circulation. Objective. To present a clinical case of one-stage bilateral laparoscopic organ-sparing adrenalectomy for multiple bilateral pheochromocytomas using a developed intraoperative hemodynamic stabilization technique. Materials and Methods. A case of a female patient born in 1983 with clinical and laboratory signs of hormonally active tumors of both adrenal glands is described. Multislice computed tomography revealed bilateral lesions up to 4.7 cm in size. One-stage laparoscopic partial adrenalectomy was performed with maximal preservation of intact cortical tissue. At the stage of controlled venous outflow, rapid reinfusion of previously collected autologous blood (250 mL) synchronized with venous control was applied. Results. No critical intraoperative fluctuations in arterial blood pressure were recorded, and vasopressor support was not required. The postoperative period was uneventful. Plasma metanephrine and normetanephrine levels normalized. Histological examination confirmed the diagnosis of pheochromocytoma (ICD-O 8700/3). Conclusion.

One-stage bilateral laparoscopic organ-sparing adrenalectomy is a feasible and safe treatment option in specialized centers. The use of synchronized autologous reinfusion may be considered a pathogenetically justified method for the prevention of post-clamping hypotension during surgical treatment of hormonally active adrenal tumors.

Keywords: Pheochromocytoma, bilateral adrenal tumors, laparoscopic adrenalectomy, partial adrenalectomy, intraoperative hypotension, autologous reinfusion.

Introduction: Pheochromocytoma is a rare hormonally active tumor of the adrenal medulla characterized by catecholamine hypersecretion and pronounced effects on the cardiovascular system. According to population-based studies, the annual incidence is 2-8 cases per 1 million population. Among incidentally detected adrenal masses, pheochromocytoma accounts for 3-5% of cases. The clinical significance of the disease is determined by the high risk of hypertensive crises, arrhythmias, ischemic complications, and perioperative hemodynamic instability [1].

Surgical removal remains the only radical treatment method [2]. Laparoscopic adrenalectomy is the standard surgical approach. In bilateral disease, preference is given to organ-sparing (partial) adrenalectomy, which reduces the risk of chronic adrenal insufficiency [3]. According to contemporary meta-analyses, the incidence of adrenal insufficiency after bilateral total adrenalectomy is significantly higher, whereas partial resection allows preservation of cortical function, although it may be associated with a higher risk of local recurrence [4].

A key problem in the surgical treatment of pheochromocytoma remains pronounced intraoperative hemodynamic lability: tumor manipulation induces hypertensive reactions, while control of the central adrenal vein may lead to sudden hypotension due to abrupt cessation of catecholamine release into the systemic circulation [1].

At the Republican Specialized Scientific and Practical Medical Center of Endocrinology named after Academician Y.H. Turakulov, up to 50 surgeries for hormonally active adrenal tumors are performed annually, of which approximately 40% are pheochromocytomas. Over the past two years, about 100 patients in this category have undergone surgical treatment.

The present report describes a clinical case of one-stage bilateral laparoscopic partial adrenalectomy for multiple pheochromocytomas using a synchronized autologous reinfusion technique aimed at preventing post-clamping hypotension.

Clinical Case

A 43-year-old female patient first presented to the Republican Specialized Scientific and Practical Medical Center of Endocrinology on January 20, 2026, with complaints of paroxysmal headaches, numbness of the right half of the body (head, face, upper and lower extremities, trunk), episodes of facial flushing, pronounced nervousness, irritability, and sleep disturbances. She additionally reported previously identified adrenal masses.

According to the patient, these symptoms had been present for approximately two years (since 2024). Initially episodic, the symptoms had significantly progressed over the past three months, with increased frequency of headache attacks, intensification of autonomic manifestations, and the appearance of pronounced paroxysms.

At her place of residence, the patient had been repeatedly consulted by specialists of various profiles. In the early stages, the clinical manifestations were interpreted as a psychoneurological disorder associated with prior psychoemotional trauma. Organic pathology was not suspected for a prolonged period.

With progression of symptoms, including persistent numbness of the right side of the body and pain in the lumbosacral region, multislice computed tomography was performed, revealing multiple space-occupying lesions of both adrenal glands.

At the initial evaluation in the specialized center, arterial blood pressure values were within normal limits; however, analysis of the medical history and the nature of complaints suggested a paroxysmal course of arterial hypertension. Regular self-monitoring of blood pressure had not previously been performed, and antihypertensive therapy had not been prescribed.

The combination of prolonged intermittent disease course, crisis episodes, and detected bilateral adrenal masses allowed suspicion of a hormonally active tumor process.

Examination Results

1) Laboratory Investigations.

Preoperative biochemical analysis (10.02.2026) demonstrated elevated catecholamine metabolites: plasma metanephrine - 112.5 pg/mL (reference 0-90

pg/mL), plasma normetanephrine - 206 pg/mL (reference 0-190 pg/mL). Twenty-four-hour urinary metanephrine was 246.3 µg/day (reference <350 µg/day), and urinary normetanephrine was 198.7 pg/mL (reference 0-190 pg/mL).

Cortisol (10.2 µg/dL), ACTH (3.32 pmol/L), aldosterone (30.7 pg/mL), renin (25.4 mIU/mL), glucose, electrolytes, creatinine, and urea were within reference ranges.

Complete blood count prior to surgery revealed hemoglobin 89 g/L, hematocrit 21%, moderate leukocytosis (10.3×10^9/L), and elevated ESR to 23 mm/h. Arterial blood gas analysis demonstrated metabolic acidosis (pH 7.25) and elevated lactate (2.3 mmol/L).

Postoperatively (15.02.2026), normalization of plasma metanephrine (48 pg/mL) and normetanephrine (95 pg/mL) levels was observed, along with correction of acid-base status (pH 7.37) and reduction of lactate to 1.4 mmol/L. Coagulation parameters remained within acceptable limits.

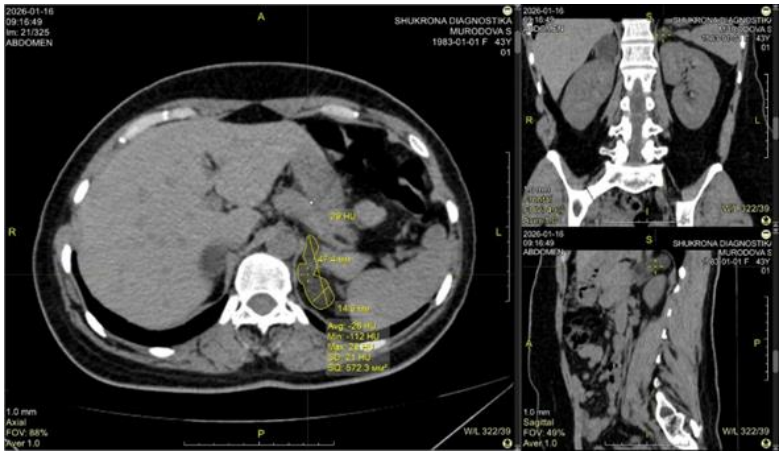
2) Instrumental Investigations

ECG: sinus tachycardia, heart rate 93 bpm; no rhythm disturbances or ischemic changes detected.

Echocardiography: left ventricular ejection fraction 57.7%; cardiac chamber dimensions within normal limits; no myocardial hypertrophy; no structural valve pathology; preserved diastolic function.

Doppler ultrasonography of lower extremity veins: deep veins patent; no signs of thrombosis; varicose superficial veins without thrombotic complications.

Multislice CT of the abdominal cavity: in the region of the right adrenal gland, a cystic lesion measuring 3.5 × 3.8 cm was identified. The medial limb of the right adrenal gland was partially preserved, and the lateral limb was fully preserved. In the region of the left adrenal gland, multiple cystic lesions arranged in a “grape-like” pattern, approximately 2 cm in diameter (3-4 lesions), with an exophytic (pendulous) growth pattern were visualized.



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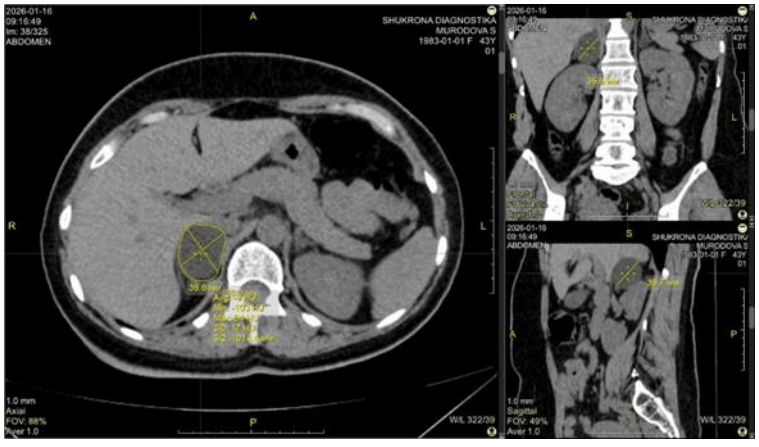


B.

Figure 1. Multislice CT of the adrenal glands: (A) right adrenal lesion; (B) left adrenal lesions.

Multislice computed tomography (MSCT) of the abdominal cavity performed in axial, frontal (coronal), and sagittal projections: In the projection of the right adrenal gland, a space-occupying lesion of oval shape measuring up to 36.6 × 36.9 mm (up to 35.6 mm on frontal reconstruction in individual slices) is visualized. The lesion margins are relatively well-defined; the internal structure is heterogeneous. The mean density according to densitometry is approximately 9 HU, with density values ranging from −103 HU to +64 HU, standard deviation 17 HU, and a measurement area of approximately 1014.4 mm². The lesion is located medial to the upper pole of the right kidney, adjacent to the adrenal limb, without signs of invasion into surrounding structures. The parenchyma of the right adrenal gland is partially preserved, and the lateral limb is visualized.

In the projection of the left adrenal gland, multiple space-occupying lesions are identified, forming a conglomerate in a “grape-like” pattern. The largest lesion reaches 47.4 mm in longitudinal dimension, with a transverse dimension up to 14.9 mm. The mean density is approximately 26 HU, with a range from −112 HU to +29 HU, standard deviation 21 HU, and a measurement area of 572.3 mm². Additionally, in coronal and sagittal projections, separate nodular lesions measuring approximately 35.6-39.7 mm in diameter are visualized. The contours are relatively well-defined; the internal structure is heterogeneous. The lesions are located in the region of the medial limb of the left adrenal gland, with partial preservation of the lateral portions of the gland. No signs of infiltrative growth or invasion into adjacent organs are detected.

Conclusion: MSCT findings consistent with space-occupying lesions of both adrenal glands. On the right - a solid-cystic lesion approximately 3.6 cm in size. On the left - multiple nodular lesions up to 4.7 cm forming a conglomerate. The findings correspond to bilateral adrenal tumors requiring clinical and laboratory correlation (considering hormonal activity).

Surgical Treatment

The operation was performed under general endotracheal anesthesia. The patient was placed in the left lateral position. After preparation of the operative field with povidone-iodine solution, a paraumbilical incision up to 10 mm was made and a 10-mm trocar was inserted. Carbon dioxide pneumoperitoneum was established with intra-abdominal pressure of 14 mmHg.

Upon inspection of the abdominal cavity, the liver was enlarged (approximately 15 × 11 × 9 cm), with a smooth surface and no focal lesions. The gallbladder showed no visible pathology.

Additional trocars were placed (two 10-mm and one 5-mm). A 10-blade retractor was introduced through the epigastric port, and the right hepatic lobe was mobilized and retracted superiorly and medially.

In the region of the upper pole of the right kidney, the parietal peritoneum was incised, and tissue dissection was performed using the LigaSure system. A right adrenal tumor measuring 4.5 × 5.0 cm arising from the medial limb was visualized. The tumor had a thin capsule, soft-elastic consistency, and a well-developed vascular network. The lateral limb and preserved cortical tissue showed no visible pathology.

Partial adrenalectomy was performed with removal of the tumor along the limbus boundary while maximally preserving intact cortical tissue. Vascular structures were transected using LigaSure; final hemostasis was achieved with bipolar coagulation. Hemodynamics remained stable during the procedure. The specimen was placed in an endoscopic retrieval bag.

The patient was repositioned to the right lateral position. After trocar repositioning, mobilization of the splenic flexure of the colon was performed. The left adrenal gland was exposed at the upper pole of the left kidney.

Multiple nodular tumors arising from the medial limb of the left adrenal gland were identified, arranged in a “grape-like” configuration, measuring 3.0 × 4.0 cm and 2.0 × 2.0 cm. The lateral limb (3.0 × 0.5 cm) was preserved. Partial adrenalectomy was performed with removal of the nodules while preserving functionally significant cortical tissue and the central adrenal vein.

The specimens were placed in an endoscopic retrieval bag and extracted through an incision extended to 2.5 cm. After evacuation of gas, the trocars were removed and the wounds were closed in layers.

Macroscopic Description

Three tumor formations measuring 4.5 × 5.0 cm; 3.0 × 4.0 cm; and 2.0 × 2.0 cm were removed. The specimens were submitted for histological examination.

Diagnosis

Preoperative diagnosis: cystic adrenal formations. Postoperative diagnosis: multiple hormonally active nodular formations of both adrenal glands - pheochromocytoma (D35.0).

Surgical Treatment with Hemodynamic Stabilization

A laparoscopic one-stage sequential organ-sparing (partial) adrenalectomy of both adrenal glands was performed under general endotracheal anesthesia. The patient was placed in the left lateral position; the

operative field was prepared with povidone-iodine solution and isolated with sterile drapes. Through a paraumbilical incision up to 10 mm, a 10-mm trocar was introduced; pneumoperitoneum was established at 14 mmHg. Upon inspection: the liver was moderately enlarged (approximately 15 × 11 × 9 cm) without focal lesions; the gallbladder showed no pathology. Additional trocars (two 10 mm and one 5 mm) were placed; the right hepatic lobe was mobilized with a retractor and retracted medially. In the region of the upper pole of the right kidney, tissue dissection was performed using LigaSure; a right adrenal tumor measuring 4.5 × 5.0 cm arising from the medial limb with a thin capsule and developed vascular network was visualized. Partial adrenalectomy was performed along the limbus boundary with maximal preservation of cortical tissue; hemostasis was achieved by bipolar coagulation; hemodynamics remained stable. After repositioning to the right lateral position, mobilization of the splenic flexure of the colon and exposure of the left adrenal gland were performed. Multiple nodular lesions arranged in a "grape-like" pattern measuring 3.0 × 4.0 cm and 2.0 × 2.0 cm were identified; the lateral limb (3.0 × 0.5 cm) was preserved. Partial adrenalectomy was performed with preservation of the limbus and central adrenal vein. The removed tumors were extracted through an incision extended to 2.5 cm. Macroscopically, three tumors measuring 4.5 × 5.0 cm; 3.0 × 4.0 cm; and 2.0 × 2.0 cm were removed. The preoperative diagnosis was cystic adrenal formations; the postoperative diagnosis was multiple hormonally active nodular formations of both adrenal glands - pheochromocytoma (D35.0).

To prevent intraoperative hemodynamic instability, a method of intraoperative stabilization developed by the authors (patent application submitted) was applied. The method is based on preliminary collection (24-48 hours prior to surgery) of 200-400 mL of autologous blood followed by rapid reinfusion synchronized with control of the central adrenal vein for 3-10 minutes. The pathophysiological rationale is prevention of abrupt reduction in systemic vascular resistance and venous return due to sudden cessation of catecholamine release into the systemic circulation after venous ligation. The use of synchronized autologous reinfusion ensures restoration of circulating blood volume, maintenance of cardiac output, and reduction in the need for vasopressor and glucocorticoid support. In the presented patient, the method was fully implemented; no critical arterial pressure fluctuations or pronounced hemodynamic instability were observed during surgery.

Postoperative Course

In the postoperative period, the patient remained in the intensive care unit for the first 24 hours under continuous cardiac monitoring. Hydrocortisone replacement therapy (100 mg intravenously twice daily) was administered with subsequent tapering to 50 mg according to a descending schedule. Hemodynamics remained stable, arterial blood pressure approximately 120/80 mmHg. Subsequently, oral hydrocortisone therapy 10 mg in the morning and 10 mg in the afternoon was prescribed with gradual dose reduction by 5 mg every 3 days under clinical monitoring. Follow-up examination was recommended 1 month after discharge.

Intraoperative hemodynamic parameters are presented in Table 1.

Table 1.

Intraoperative hemodynamic parameters during bilateral adrenalectomy

Stage / Event	Time	SBP/DBP (mmHg)	MAP	HR (bpm)	Infusion / Medications	Comment
Admission to OR (before induction)	T0	125/80	95	82	Crystalloids 300 mL	Normotensive baseline status
Anesthesia induction and intubation	T+10 min	130/82	98	88	Propofol, fentanyl, rocuronium (standard protocol)	Transient response without hypertensive crisis
Creation of pneumoperitoneum (CO_2 14 mmHg)	T+20 min	135/85	102	90	Crystalloids 250 mL	Mild increase in MAP related to pneumoperitoneum
Manipulation of right adrenal tumor (medial limb)	T+50 min	155/95	115	105	Urapidil 20 mg IV bolus (if required), esmolol 20 mg	Transient sympathetic response
Clamping of right	T+60	135/85	102	90	Rapid reinfusion	No critical

adrenal central vein + autologous reinfusion 250 mL	min				of 250 mL autologous blood over 5 min	hypotension due to autologous reinfusion
Completion of right-sided resection, hemostasis	T+70 min	130/80	97	86	Crystalloids 200 mL	Hemodynamically stable, no vasopressors required
Repositioning to right lateral position	T+90 min	125/78	93	84	-	Stable parameters
Manipulation of left adrenal tumors (multiple nodules)	T+125 min	160/100	120	110	Urapidil 20 mg IV bolus (if indicated)	Transient blood pressure elevation during tumor traction
Controlled clamping of left venous collectors + autologous reinfusion 150 mL	T+135 min	130/82	98	90	Rapid reinfusion of 150 mL autologous blood over 3-5 min	Hemodynamic stabilization without vasopressor support
Completion of surgery, CO_2 evacuation	T+165 min	120/78	92	80	-	Stable hemodynamics
0-6 hours postoperatively (ICU)	Post-op	120/80	93	78	Hydrocortisone 100 mg IV ×2, crystalloids 500 mL	Stable blood pressure without vasopressors
Postoperative day 1	POD1	120/80	93	76	Hydrocortisone dose reduced to 50 mg	Hemodynamically stable

Hemodynamic changes during surgery are illustrated in Figure 2.

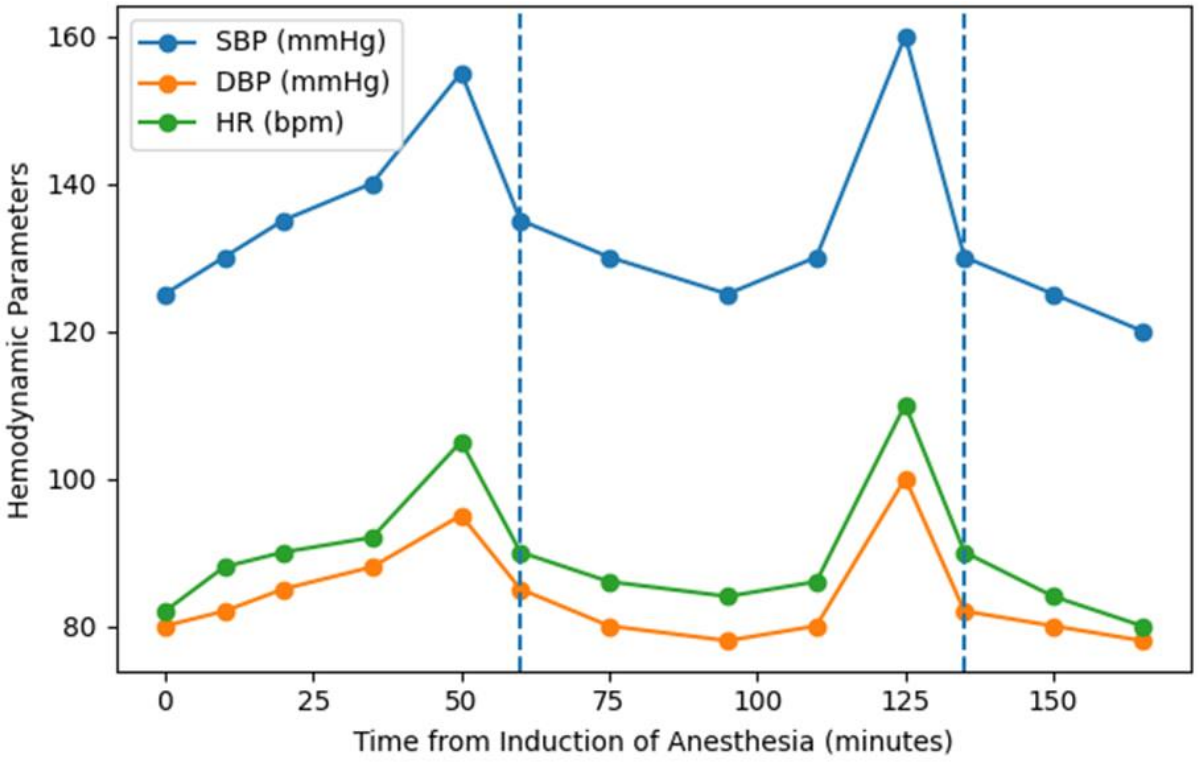
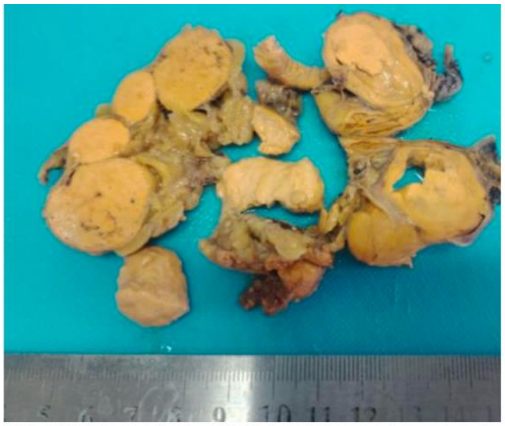
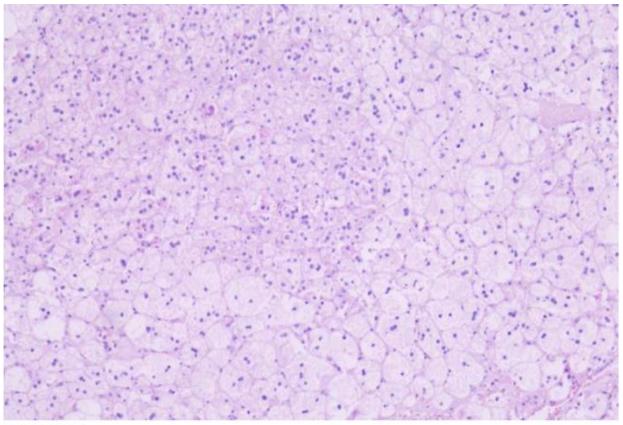


Figure 2. Intraoperative changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) during bilateral laparoscopic partial adrenalectomy with synchronized autologous reinfusion.

Histological Examination

Histological examination of the resected macroscopic specimen (adrenal gland lesion with surrounding adipose tissue) revealed nodular structures measuring from 1.5 to 2.5 cm in diameter, ochre-yellow in color, of moderately dense consistency, and homogeneous architecture.





Microscopic examination demonstrated that the tumor was composed of alveolar, trabecular, and predominantly solid structures formed by large polygonal cells with well-defined granular eosinophilic or brownish cytoplasm, focally vacuolated. The nuclei were large, moderately polymorphic, with prominent chromatin. Mitotic figures were identified (more than 3 per 10 high-power fields). Tumor structures were surrounded by congested sinusoidal vessels. The morphological findings correspond to adrenal pheochromocytoma.

ICD-O code: 8700/3 - pheochromocytoma.

DISCUSSION

The contemporary development of endocrine surgery is characterized by the widespread adoption of advanced imaging modalities and minimally invasive surgical techniques, which have significantly improved the safety and efficacy of treatment for patients with hormonally active adrenal neoplasms. Laparoscopic adrenalectomy is currently considered the standard approach for most adrenal tumors due to reduced surgical trauma, lower complication rates, and shorter hospital stay.

Bilateral hormonally active adrenal lesions represent a particular clinical challenge, as total adrenalectomy is associated with a high risk of chronic adrenal insufficiency. The present clinical case demonstrates that, with timely diagnosis, thorough preoperative preparation, and a multidisciplinary approach, one-stage bilateral laparoscopic partial adrenalectomy can be safely performed while preserving functionally significant cortical tissue.

An organ-sparing approach reduces the risk of complete adrenal insufficiency and the need for lifelong glucocorticoid replacement therapy. At the same time, radical removal of hormonally active tumor nodules leads to elimination of catecholamine hypersecretion and regression of associated clinical manifestations, including symptomatic arterial hypertension, thereby significantly reducing cardiovascular risk and improving patient prognosis.

A major challenge in pheochromocytoma surgery remains pronounced intraoperative hemodynamic instability, particularly during control of the central adrenal vein. The intraoperative stabilization technique developed by the authors, based on synchronized rapid autologous blood reinfusion, is aimed at maintaining preload and cardiac output during this critical stage of the procedure. In the present case, application of this method prevented severe hypotension and reduced the need for pharmacological vasopressor support. Nevertheless, further clinical studies are required to confirm the efficacy and reproducibility of this approach.

This clinical case confirms the feasibility and safety of one-stage bilateral organ-sparing adrenalectomy in a specialized center when a multidisciplinary management strategy is applied.

CONCLUSION

1. The diagnosis of hormonally active adrenal tumors should be performed in specialized centers under the supervision of an endocrinologist, with comprehensive clinical, laboratory, and imaging evaluation.

2. Laparoscopic (including robot-assisted) adrenalectomy is the method of choice for the surgical treatment of adrenal tumors and allows safe implementation of organ-sparing procedures in cases of bilateral involvement.

3. The proposed intraoperative hemodynamic stabilization technique based on synchronized autologous blood reinfusion demonstrated clinical effectiveness in the present case and may represent a

promising adjunctive strategy for preventing post-clamping hypotension during adrenalectomy in patients with hormonally active tumors.

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