

Laparoscopic Pheochromocytoma Surgery Management with PiCCO: Three Cases

PiCCO ile Laparoskopik Feokromositoma Cerrahisi Yönetimi: Üç Olgu

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ABSTRACT

Pheochromocytoma is a rare tumor that originates in the adrenal medulla and causes serious hemodynamic fluctuations due to excessive catecholamine secretion. In the preoperative period, patients' blood pressure and cardiac functions were stabilized using alpha-blockers, beta-blockers, and fluid therapy. Hypertensive responses related to medications, laryngoscopy, and surgical stimulation were controlled during anesthesia induction through train-of-four and surgical pleth index monitoring, utilizing lidocaine, propofol, rocuronium, and remifentanyl. Sevoflurane and remifentanyl were used during the maintenance period. Intraoperative hemodynamic stabilization was achieved with continuous monitoring of dynamic parameters such as cardiac output, global end-diastolic index, systemic vascular resistance index, extravascular lung water index, global ejection fraction, stroke volume variation, and pulse pressure variation using the PiCCO (Pulse Contour Cardiac Output, Pulsion Medical Systems SE, Feldkirchen, Germany) monitoring method. Postoperatively, patients were extubated and followed closely in the intensive care unit under multimodal analgesia. The findings indicate that PiCCO is an effective tool in hemodynamic management and in the prevention of complications during pheochromocytoma surgery. These results emphasize the value of PiCCO in optimizing perioperative outcomes.

Keywords: Pheochromocytoma, PiCCO, hypertension

Öz

Feokromositoma, adrenal medulladan köken alan ve aşırı katekolamin salınımı nedeniyle ciddi hemodinamik dalgalanmalara yol açabilen nadir bir tümördür. Preoperatif dönemde hastaların kan basıncı ve kardiyak fonksiyonları alfa-blokerler, beta-blokerler ve sıvı tedavisi kullanılarak stabilize edilmiştir. Anestezi induksiyonu sırasında ilaçlara, laringoskopiye ve cerrahi uyarana bağlı hipertansif yanıtlar, train-of-four ve surgical pleth index monitörizasyonu eşliğinde lidokain, rokuronyum, rokuronyum ve remifentanil kullanılarak kontrol altına alınmıştır. Anestezinin idame döneminde ise sevofluran ve remifentanil kullanılmıştır. İntraoperatif hemodinamik stabilizasyon, Pulse Contour Cardiac Output (PiCCO, Pulsion Medical Systems SE, Feldkirchen, Almanya) monitörizasyon yöntemiyle, sürekli olarak ölçülen kardiyak output, global end-diastolik indeks, sistemik vasküler direnç indeksi, ekstrasvasküler akciğer suyu indeksi, global ejeksiyon fraksiyonu, atım hacmi varyasyonu ve nabız basıncı varyasyonu gibi dinamik parametreler izlenerek sağlanmıştır. Postoperatif dönemde ise hastalar ekstübe edilerek multimodal analjezi uygulaması eşliğinde yoğun bakım ünitesinde yakından takip edilmiştir. Bulgular, PiCCO yönteminin hemodinamik yönetiminde ve feokromositoma cerrahisinde komplikasyonların önlenmesinde etkili bir araç olduğunu göstermektedir. Bu sonuçlar, perioperatif sonuçların optimize edilmesinde PiCCO kullanımının önemini vurgulamaktadır.

Anahtar sözcükler: Feokromasitoma, PiCCO, hipertansiyon

INTRODUCTION

Pheochromocytoma is a catecholamine-producing neuroendocrine tumor originating from chromaffin cells in the adrenal medulla (1). Depending on the type of catecholamine secreted, the clinical picture may be asymptomatic or lead to life-threatening hypertensive crises. The most common symptoms include hypertension (90%), paroxysmal hypertension (35-50%), headache, palpitations and sweating (2). Pulse Contour Cardiac Output (PiCCO), a minimally invasive mon-

itoring technique, provides instantaneous volume parameters via transpulmonary thermodilution and is widely used by providing important information in critically ill patients through automatic calibration of the arterial pulse curve (3). It enables instant monitoring with the dynamic parameters of Cardiac Output (CO), Global End-Diastolic Volume Index (GEDV), Systemic Vascular Resistance Index (SVRI), Extravascular Lung Water Index (ELWI), Global Ejection Fraction (GEF), Stroke Volume Variation (SVV) and Pulse Pressure Variation (PPV) (4).

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CASE REPORT

This study presents a case series and does not require formal ethics committee approval according to local regulations. However, written informed consent was obtained from all patients for publication of their anonymized clinical data.

CASE 1

Laparoscopic adrenalectomy was planned for a 56-year-old female patient who presented with headache, palpitations, and hypertensive crisis, and was preliminarily diagnosed with pheochromocytoma. The patient had comorbidities including diabetes mellitus (DM) and hypertension (HT). In the preoperative evaluation, the 24-hour urinary metanephrine level was $8799 \mu\text{g } 24 \text{ h}^{-1}$ (reference: $52\text{--}341 \mu\text{g } 24 \text{ h}^{-1}$), and the normetanephrine level was $2387 \mu\text{g } 24 \text{ h}^{-1}$ (reference: $88\text{--}444 \mu\text{g } 24 \text{ h}^{-1}$). The glycated hemoglobin (HbA1c) level was 7.6% (reference: $<6.5\%$). Other laboratory parameters were within normal limits, and no significant abnormalities were noted. Echocardiographic assessment revealed a left ventricular ejection fraction (EF) of 60%, and the dimensions of the right heart chambers were within normal limits. Prior to preoperative intervention, the patient's vital signs were recorded as follows: systolic blood pressure (SBP) 178 mmHg, diastolic blood pressure (DBP) 100 mmHg, mean arterial pressure (MAP) 126 mmHg, and heart rate 55 beats min^{-1} .

CASE 2

Preoperative evaluation of a 57-year-old male patient diagnosed with paroxysmal HT due to pheochromocytoma was performed. The patient's urine metanephrine level was $450 \mu\text{g } 24 \text{ h}^{-1}$ ($52\text{--}341 \mu\text{g } 24 \text{ h}^{-1}$), and normetanephrine level was $970 \mu\text{g } 24 \text{ h}^{-1}$ ($88\text{--}444 \mu\text{g } 24 \text{ h}^{-1}$). Other laboratory parameters of the patient, who was receiving doxazosin and propranolol dual antihypertensive therapy due to HT, were monitored within reference ranges. No abnormal findings were observed in the preoperative echocardiography. Preoperative vital parameters were measured as SBP 182 mmHg, DBP 142 mmHg, MAP 155 mmHg and pulse rate was 95 beats min^{-1} .

CASE 3

A 33-year-old male patient has a history of DM, HT, recent aortic dissection, gout, obstructive sleep apnea syndrome (use of continuous positive airway pressure therapy), active smoking, and previous COVID-19 infection. As a result of biochemical evaluation, the patient's urine metanephrine level was $1800 \mu\text{g } 24 \text{ h}^{-1}$ ($52\text{--}341 \mu\text{g } 24 \text{ h}^{-1}$) and normetanephrine level was $28.300 \mu\text{g } 24 \text{ h}^{-1}$ ($88\text{--}444 \mu\text{g } 24 \text{ h}^{-1}$), and surgery was planned due to the diagnosis of pheochromocytoma. In the echocardiography, EF was measured as 55% and concentric hypertrophy was detected in the left ventricle. Mean pulmonary artery pressure was calculated as 30 mmHg (15–

18 mmHg) and the width of the right heart chambers was within normal limits. In addition, first-degree aortic regurgitation and tricuspid regurgitation were detected, and the diameter of the ascending aorta was measured as 3 cm. While the patient was under triple antihypertensive therapy with doxazosin, propranolol and carvedilol, preoperative vital parameters were measured as SBP 146 mmHg, DBP 48 mmHg, MAP 81 mmHg and pulse rate was 59 beats min^{-1} .

Hemodynamic interventions and PiCCO parameters during key surgical phases are graphically presented in Figures 1–3. These figures illustrate the dynamic changes in cardiac index, vascular resistance, and fluid status alongside the administration of vasoactive agents. Real-time PiCCO data allowed for titrated and timely therapeutic decisions in each case.

Preoperative Preparation and Anesthesia Management

In accordance with the recommendations of the relevant branches, alpha-blocker doxazosin was started 14 days before surgery in cases 1 and 2, and beta-blocker propranolol was added to both patients on the 10th day of treatment. Case 3 had been receiving doxazosin, propranolol and carvedilol for more than three months. In the preoperative period, 30 mg $\text{kg } 24 \text{ h}^{-1}$ crystalloid loading was administered two days before surgery. After obtaining both written and verbal consent from the patients, the relevant cases were admitted to the premedication room.

Following monitoring in the premedication room patients were administered 2 L min^{-1} nasal oxygen and then premedicated with 0.01 mg kg^{-1} midazolam. Patients were placed in the prone position for the application of the erector spinae plane block and the area to be blocked was sterilized. Under strict aseptic conditions and ultrasound guidance (low-frequency 2–5 MHz convex probe), a 22 G, 80 mm echogenic block needle was inserted in-plane at the T7 transverse process on the surgical side. After negative aspiration, 20 mL of 0.25% bupivacaine was injected incrementally. The block was performed unilaterally to provide targeted analgesia for the laparoscopic adrenalectomy incision. When the patients were admitted to the operating room, electrocardiogram, pulse oximetry and non-invasive blood pressure monitoring were provided. In addition to PiCCO, SPI monitoring with the Datex-Ohmeda system allowed precise titration of remifentanyl and ensured effective nociception control, contributing to smoother hemodynamic courses during tumor manipulation and ligation. Train-of-Four (TOF) (ulnar nerve - adductor pollicis muscle) monitoring was initiated as neuromonitoring, followed by intravenous administration of 1 mg kg^{-1} lidocaine. Anesthesia induction was achieved with 2 mg kg^{-1} propofol and 0.6 mg kg^{-1} rocuronium and 1 $\mu\text{g } \text{kg}^{-1}$ bolus remifentanyl, and patients with a TOF value of zero were intubated. Anesthesia maintenance was achieved with 1 minimum alveo-

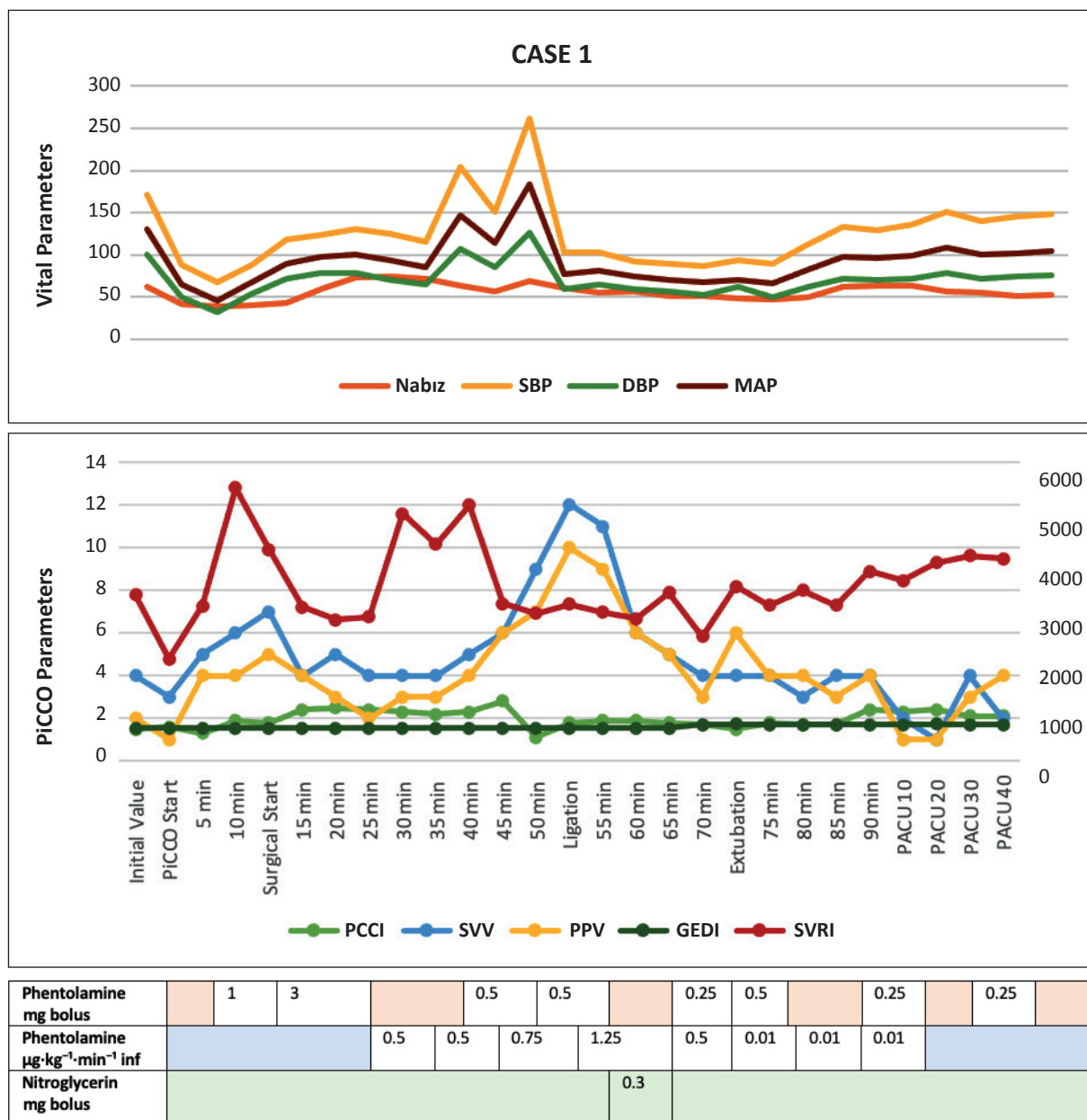


Figure 1. Hemodynamic parameters obtained via the PiCCO monitoring system, vital signs, and administered pharmacological agents of Case 1. **SBP:** Systolic blood pressure (mmHg), **DBP:** Diastolic blood pressure (mmHg), **MAP:** Mean arterial pressure (mmHg), **PCCI:** Pulse contour cardiac index (L min m^2), **SVV:** Stroke volume variation (%), **PPV:** Pulse pressure variation (%), **GEDI:** Global end-diastolic index (mL m^2), **SVRI:** Systemic vascular resistance index ($\text{dyn}\cdot\text{s}\cdot\text{cm}^{-5}\cdot\text{m}^2$), **PACU:** Post-anesthesia care unit.

lar concentration sevoflurane and remifentanyl infusion ($0.3 \text{ mg kg}^{-1} \text{ min}^{-1}$) was titrated to maintain SPI within the target range; 0.5 mg kg^{-1} boluses were administered whenever SPI exceeded 50 to suppress nociceptive responses. Radial artery cannulation was performed under local anesthesia and in an awake state in Case 3. Calibration of PiCCO was performed with 15 mL of cold 0.9% saline in patients who underwent radial artery cannulation, femoral artery PiCCO catheterization, and right-sided internal jugular vein catheterization. Patients were positioned in lateral decubitus position with the surgical

side facing upward, and lung protective ventilation was applied in PCV-VG mode. High PEEP strategy was adopted and intermittent recruitment maneuvers were performed. Intermittent blood glucose monitoring was performed during the intraoperative period. For analgesia, 0.05 mg kg^{-1} morphine, 2 mg kg^{-1} tramadol and 1 g paracetamol were administered, and 0.1 mg kg^{-1} ondansetron was administered for nausea and vomiting prophylaxis. Morphine patient-controlled analgesia was administered to patients admitted to the postoperative care unit. Patients with numeric rating scale scores of

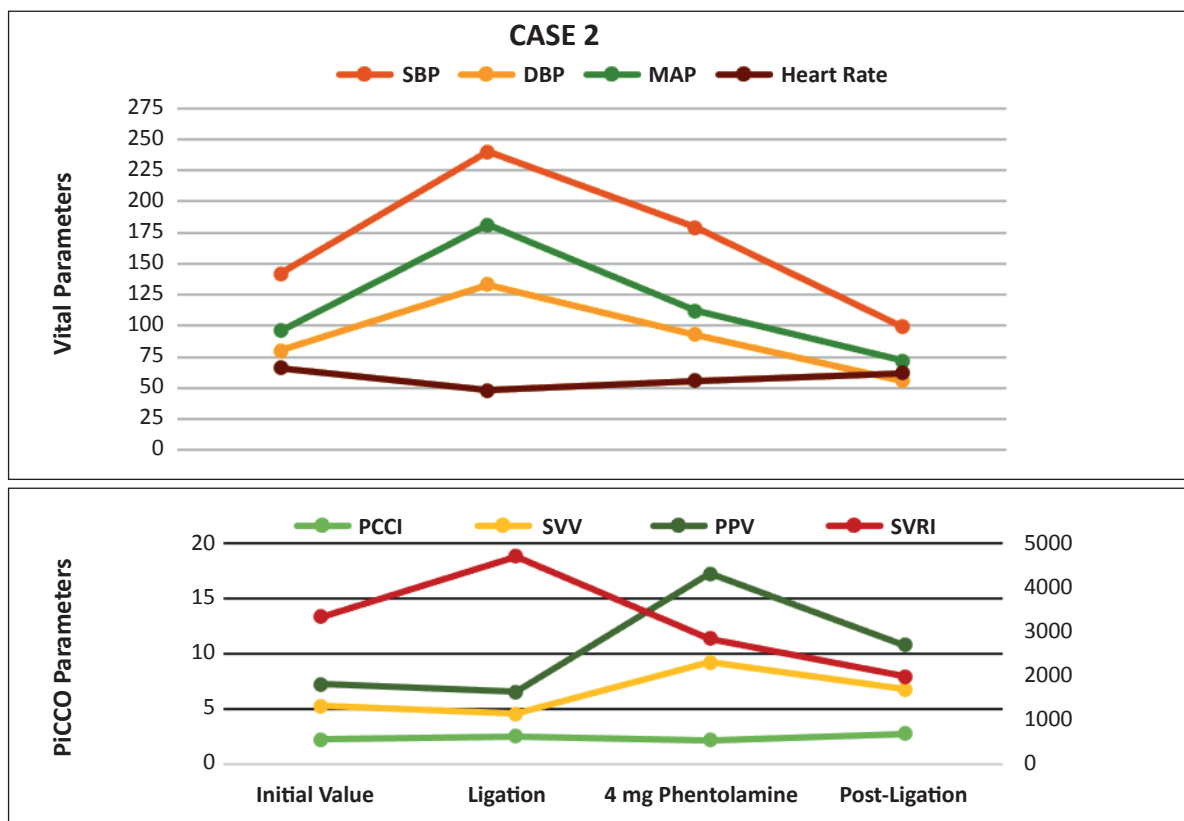


Figure 2. Hemodynamic parameters obtained via the PiCCO monitoring system, vital signs, and administered pharmacological agents of Case 2. **SBP:** Systolic blood pressure (mmHg), **DBP:** Diastolic blood pressure (mmHg), **MAP:** Mean arterial pressure (mmHg), **PCCI:** Pulse contour cardiac index (L min m²), **SVV:** Stroke volume variation (%), **PPV:** Pulse pressure variation (%), **GEDI:** Global end-diastolic index (mL m²), **SVRI:** Systemic vascular resistance index (dyn·s·cm⁻⁵·m²).

1-3, those who did not require rescue analgesics, and those with modified aldrete scores of 9-10 were transferred to the postoperative intensive care unit. Vital parameters and PiCCO data of cases 1 and 3 were recorded at 5-minute intervals. Hemodynamic values of case 2 were recorded at admission, phentolamine administration, at the time of vein ligation and in the postoperative period.

In Case 1, the hypertensive response that developed at the beginning of the case was thought to be due to an increase in sympathetic response, and an intravenous phentolamine bolus was administered. Continuous phentolamine infusion was started for the patient whose arterial blood pressure continued to rise after the bolus. In the intraoperative period, the bolus dose was adjusted by titration according to instantaneous arterial blood pressure and PiCCO data. During the ligation phase, an intravenous bolus of 3 mg nitroglycerin was administered to control the hypertensive response that continued despite phentolamine infusion. After ligation, phentolamine infusion was continued until extubation and the infusion was terminated after extubation.

Hemodynamic and PiCCO data of Case 2 are presented in four stages. The increase in arterial blood pressure that developed during ligation was controlled with intravenous phentolamine bolus dose, and no additional dose was required in the following period.

The hypertensive response that developed in the intraoperative 20th minute of Case 3 was controlled with intravenous phentolamine. Consecutive hypertensive attacks were suppressed with intermittent bolus doses of phentolamine. During ligation, resistant hypertension developed that did not respond adequately to phentolamine, and intravenous 0.2 mg nitroglycerin bolus was administered. In the patient who developed hypotension after ligation, norepinephrine infusion was started to provide hemodynamic stabilization. Norepinephrine infusion was continued for approximately two hours in the postoperative period.

DISCUSSION

The most important factor that significantly reduces perioperative morbidity and mortality in patients with pheochromocytoma is good preoperative preparation (5). Preopera-

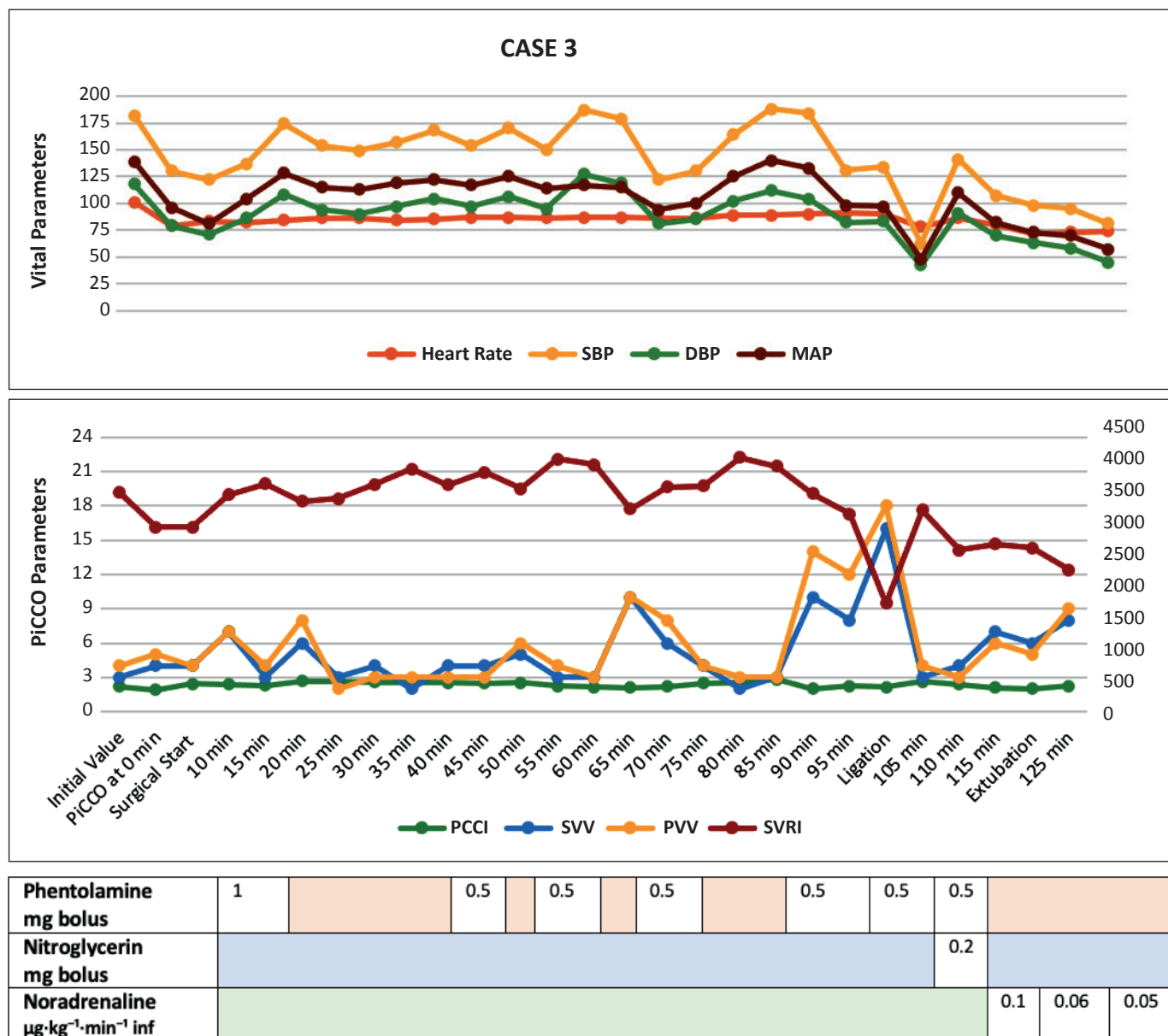


Figure 3. Hemodynamic parameters obtained via the PiCCO monitoring system, vital signs, and administered pharmacological agents of Case 3. **SBP:** Systolic blood pressure (mmHg), **DBP:** Diastolic blood pressure (mmHg), **MAP:** Mean arterial pressure (mmHg), **PCCI:** Pulse contour cardiac index (L min m^2), **SVV:** Stroke volume variation (%), **PPV:** Pulse pressure variation (%), **GEDI:** Global end-diastolic index (mL m^2), **SVRI:** Systemic vascular resistance index ($\text{dyn}\cdot\text{s}\cdot\text{cm}^{-5}\cdot\text{m}^2$).

tive evaluation includes organs affected by hypertension (6). Preoperative alpha-blocker therapy has significantly reduced mortality rates in patients with pheochromocytoma. The fact that alpha-1 selective and short-acting alpha-antagonist agents have a low risk of causing reflex tachycardia, have a short duration of action and cause short-term hypotension in the postoperative period has increased the frequency of clinical use of these agents (1,7). The administration of beta-blocker therapy before alpha blockade triggers alpha-mediated vasoconstriction as a result of antagonizing beta

2-mediated vasodilation, and it leads to hypertensive crisis. Furthermore, the negative inotropic effects of beta-blockers predispose to the development of myocardial dysfunction (8). In our case series, preoperative evaluations were made for the organs affected by hypertension. In addition, by eliminating chronic volume loss with alpha-blockers, beta-blockers and fluid therapy, it was aimed to control blood pressure and heart rate and minimize the effects of catecholamine storm that may occur on the cardiovascular system.

Despite preoperative preparation, the rate of hemodynamic instability that may occur in the perioperative period due to anesthesia induction, direct laryngoscopy, peritoneal insufflation, surgical stimulation and catecholamine secretion appears to be 27.3% (9,10). Propofol used for anesthesia induction has been reported to be safe in these patients (11). While sevoflurane is widely preferred among inhalation anesthetic agents, desflurane is recommended as an agent to be avoided by some authorities because it causes sympathetic stimulation. Remifentanyl has been found to be effective in suppressing hemodynamic responses due to its high potency, rapid titration and very short half-life (12,13). In our cases, similar to the above studies, it was aimed to minimize hypertensive responses that may occur due to medication, laryngoscopy and surgery by performing TOF and SPI monitoring and using sevoflurane and remifentanyl on lidocaine, propofol, rocuronium and remifentanyl maintenance.

Phentolamine provides optimal blockade of catecholamine-induced vasoconstriction due to its short-acting and non-selective alpha-receptor antagonist properties (14,15). Nitroglycerin stands out as a donor that mimics nitric oxide (NO) and produces NO independently of the vascular endothelium. It is preferred in pheochromocytoma surgery due to its potent, rapid and non-specific venous and arterial vasodilator effects (16). We developed our strategy by evaluating the cause of intraoperative HT with PiCCO [SVRI, ELWI, GEDI, PPV, SVV] and instantly monitoring the patient's vasodilator need and response to treatment. In our case series, PiCCO parameters provided real-time insight into patients' hemodynamic status and guided intraoperative decision-making. For example, in Case 1, an elevated SVRI and low PPV during tumor manipulation prompted vasodilator administration rather than fluid loading, preventing volume overload. In Case 3, a marked drop in GEDI and CO following vein ligation led to early norepinephrine infusion, averting hypotensive shock. In our case series, PiCCO monitoring provided several unique benefits beyond standard arterial pressure measurements. First, dynamic preload assessment via SVV and PPV allowed us to distinguish true volume responsiveness from vasomotor tone changes, guiding fluid administration more precisely. For example, in Case 1, the presence of a high SVV (>13%) despite normal MAP led to the administration of a cautious crystalloid bolus rather than the use of a vasopressor, thus averting potential fluid overload.

Second, real-time measurement of GEDI and CO enabled early detection of post-ligation hypovolemia. In Case 3, GEDI fell from 680 to 520 mL m⁻² immediately after tumor vein ligation, resulting in the initiation of norepinephrine infusion before MAP dropped below 65 mmHg. This preemptive intervention likely prevented hypotensive episodes.

Third, continuous SVRI tracking informed tailored vasoactive therapy: elevated SVRI during tumor handling guided phenolamine and nitroglycerin titration, avoiding reflex tachycardia and myocardial stress. Collectively, these PiCCO-specific data improved intraoperative hemodynamic stability and minimized complications that might not have been detected with standard monitoring alone.

The majority of patients who undergo pheochromocytoma surgery can be extubated, and close monitoring in the intensive care unit is recommended on the first postoperative day (17,18). In the postoperative period, metabolic imbalances such as hypoglycemia, hyperglycemia and hyponatremia, as well as electrolyte and endocrine abnormalities, should be closely monitored (6). Patients extubated in the postoperative period were managed with the principle of multimodal analgesia, and complications that may occur due to inadequate pain management were tried to be minimized. Hypoglycemia or hyponatremia did not occur in our patients. Patients who were hemodynamically stable and had no complications during postoperative intensive care follow-up were transferred to the ward on the morning of the first postoperative day.

CONCLUSIONS

In this case series, perioperative PiCCO monitoring provided real-time hemodynamic parameters that guided fluid administration and vasoactive drug titration during induction, tumor manipulation, and ligation phases. These data appeared to contribute to intraoperative stability and may have minimized hemodynamic complications. While our findings suggest practical benefits of PiCCO in pheochromocytoma surgery, larger prospective studies are needed to confirm its impact on outcomes.

AUTHOR CONTRIBUTIONS

Conception or design of the work: OK

Data collection: TGAU

Data analysis and interpretation: OK

Drafting the article: FKE

Critical revision of the article: AT

Other (study supervision, fundings, materials, etc): OK

The author (OK, TGAU, AT, FKE) reviewed the results and approved the final version of the manuscript.

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