Consensus on blood pressure management in the perioperative period by medical and pharmaceutical experts

GuangDong Pharmaceutical Association April, 2019

Recent data shows that the prevalence of hypertension among residents aged 18 and above in China is as high as 27.9% [1]. With the annual increase in hypertension prevalence, the number of hypertensive patients undergoing surgical procedures is also gradually rising. Patients with a history of hypertension, especially those with a diastolic blood pressure (DBP) exceeding 110 mmHg, are more likely to experience hemodynamic instability during the perioperative period, posing a higher cardiovascular risk [2]. For instance, elevated blood pressure during the perioperative period can lead to severe complications such as cerebrovascular rupture and acute left heart failure in surgical patients with a history of hypertension [3]. Additionally, patients with normal blood pressure may also experience fluctuations due to perioperative stress and the effects of anesthetics; factors such as tracheal intubation, catheterization, inappropriate depth of anesthesia, or inadequate analgesia can trigger perioperative hypertension. Surgical procedures involving the heart and major blood vessels, or compression of the heart and major vessels due to gauze packing or retractors, as well as traction on the viscera, peritoneum, and direct stimulation of the vagus nerve, along with excessive intraoperative blood loss and transfusion reactions, can lead to a sharp drop in blood pressure [4]. It is evident that blood pressure management during the perioperative period has become a common clinical issue. Therefore, this consensus aims to summarize and consolidate the blood pressure management of different perioperative patients through discussions between physicians and pharmacists, and to propose a medical-pharmaceutical co-management model for perioperative blood pressure management as a reference for clinical practice.

1 Medical-Pharmaceutical Co-Management Model for Perioperative Blood Pressure Management

Perioperative blood pressure management refers to the management of blood pressure during the hospitalization of surgical patients (including preoperative, intraoperative, and postoperative periods, generally 3-4 days). Currently, clinical attention has been given to blood pressure monitoring in hypertensive patients during the perioperative period, but there is less focus on monitoring blood pressure in non-hypertensive patients. Modern stress theory suggests that when individuals are subjected to or about to

undergo harmful stimuli (such as surgery or trauma), the neuroendocrine system releases catecholamines, which can lead to increased heart rate and elevated blood pressure, even in patients without a history of hypertension. Various stress responses can also cause fluctuations in blood pressure postoperatively, where excessively high blood pressure can lead to risks such as anastomotic rupture, bleeding, and cerebrovascular accidents, while excessively low blood pressure can result in inadequate blood supply to vital organs. Therefore, monitoring blood pressure changes in non-hypertensive patients during the perioperative period should also be strengthened.

Surgeons and anesthesiologists often overlook issues outside their specialties, such as perioperative hypertension, and most surgical residents have insufficient experience with antihypertensive medications (especially since the commonly used medications for perioperative hypertension differ from those for general hypertension [5-6]), which may lead to untimely or inadequate treatment of hypertensive patients during the perioperative period. Currently, the management of abnormal blood pressure in hospitalized patients is primarily the responsibility of cardiology specialists, but due to limited medical resources, cardiologists cannot participate in the management of every patient with abnormal blood pressure during the perioperative period, and most blood pressure management is carried out by the nursing staff of the respective departments, with limited specialist guidance.

Research both domestically and internationally has shown that collaboration between physicians and pharmacists is a better model for blood pressure management [7-8]. Currently, relevant treatment standards abroad have included pharmacists in hypertension management teams, such as the American Heart Association (AHA) "2017 Guidelines for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults," which recommends a team-based approach to control hypertension in patients, advocating for a multidisciplinary team approach for hypertension management in adults. Team members primarily include patients, primary care providers, and other professionals (such as physicians, nurses, pharmacists, physician assistants, nutritionists, social workers, and community health workers) [9-11]. Pharmacists are an important member of this team. With the gradual advancement of clinical pharmacy work in China, many hospitals have begun to provide pharmaceutical services targeting hypertensive patients, and the benefits brought to patients have gradually been confirmed [12]. Meta-analysis of clinical pharmacists' involvement in hypertension management indicates that their participation helps improve treatment outcomes [7].

Currently, the involvement of clinical pharmacists in blood pressure management in China is mostly focused on cardiovascular specialty patients, with limited pharmaceutical care provided for surgical perioperative patients, and there is a lack of

unified norms and standards for reference and adherence. Therefore, this consensus aims to establish a medical-pharmaceutical co-management model for patients with abnormal blood pressure during the perioperative period, providing a reference for clinical practice, with specific processes illustrated in Figure 1.

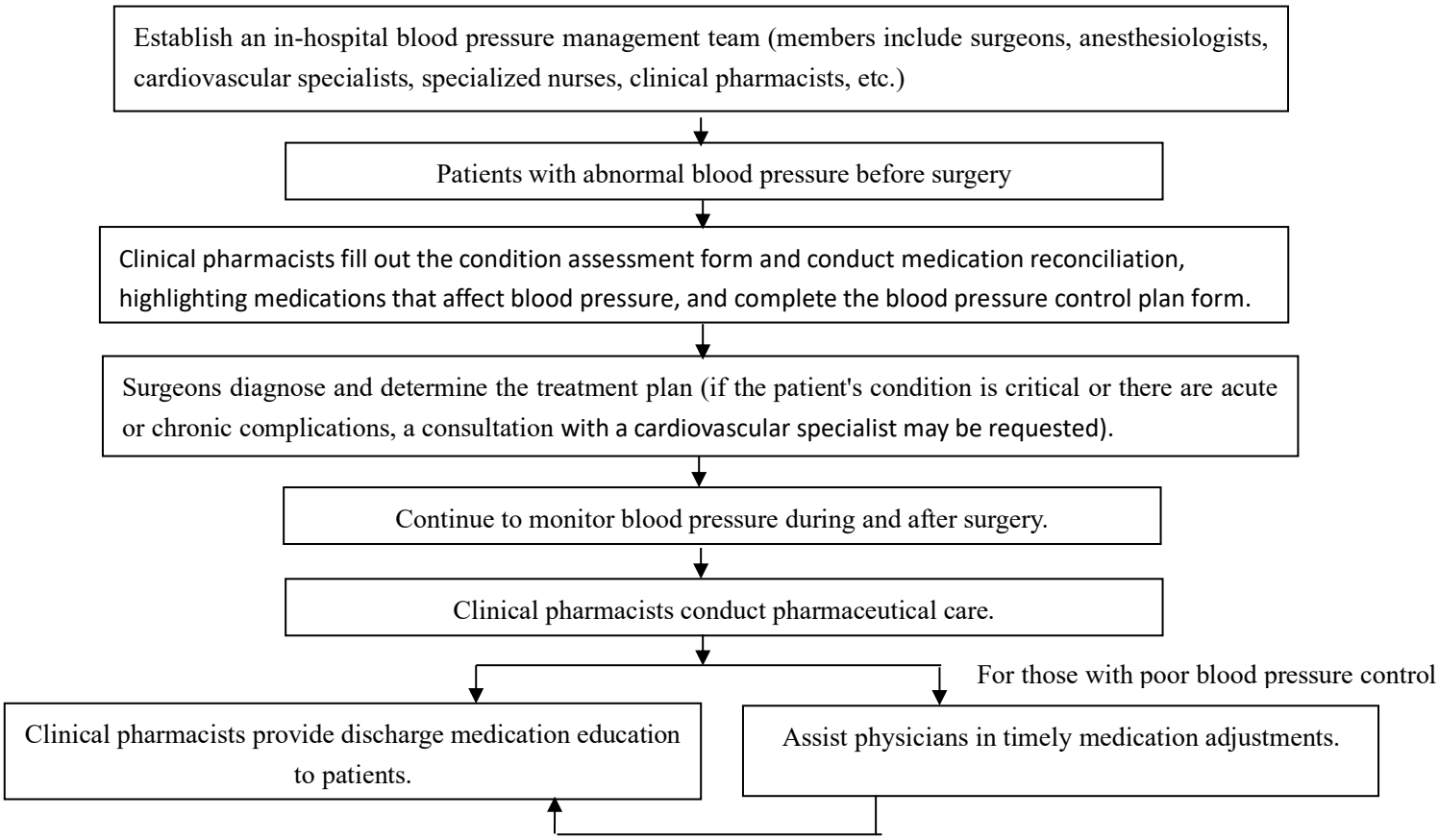

Figure 1: Flowchart of the collaborative management model of physician-pharmacist for perioperative blood pressure management.

To establish a medical-pharmaceutical co-management model for perioperative blood pressure management, an in-hospital blood pressure management team should first be formed, consisting of surgical physicians, anesthesiologists, clinical cardiologists, specialized nurses, and clinical pharmacists. Clinical pharmacists can fully utilize their professional role within the team, closely monitoring the medication status of hospitalized patients and the impact of medications on blood pressure (Appendix 1).

For patients with abnormal blood pressure preoperatively, clinical pharmacists should first complete a condition assessment form (Appendix 2), reorganize medications based on the assessment, and highlight medications that affect blood pressure while filling out a blood pressure control plan form (Appendix 3). The surgical physician will determine the final treatment plan based on the assessment form. If the patient's condition is critical or there are acute or chronic complications, a consultation with a cardiologist

may be requested. If blood pressure control is inadequate or the patient's condition changes during treatment, the clinical pharmacist will provide feedback to the physician for timely adjustment of the plan. For patients about to undergo surgery, the anesthesiologist will select the anesthesia method and drugs based on the patient's condition and surgical requirements during the preoperative visit, and the depth of anesthesia should be closely controlled to match the intensity of stimulation, addressing blood pressure fluctuations during anesthesia. After surgery, specialized nurses will continue to monitor the patient's heart rate and blood pressure (measuring blood pressure and heart rate once per hour), and once stable, daily blood pressure monitoring will be conducted according to the physician's orders, while also observing factors that may cause elevated blood pressure, such as cold, pain, anxiety, insomnia, and urinary retention, addressing any abnormal issues promptly or reporting to the physician for re-evaluation. Postoperatively, clinical pharmacists can continue to provide pharmaceutical monitoring, including tracking blood pressure monitoring results (Appendix 4, to be filled out with the assistance of nurses), monitoring for adverse reactions, etc.; if the patient's blood pressure remains poorly controlled, they will assist the physician in timely adjusting medications. For discharged patients, clinical pharmacists should provide health education to improve medication adherence (including methods for taking oral antihypertensive medications, prevention of hypotension, etc.).

2 Classification and High-Risk Factors of Perioperative Blood Pressure Abnormalities

2.1 Classification of Perioperative Blood Pressure Abnormalities

Mainly divided into perioperative hypertension and perioperative hypotension.

2.1.1 Blood Pressure Measurement Methods

Blood pressure should be measured using a mercury sphygmomanometer that meets metrological standards or a validated electronic blood pressure monitor. Before measuring blood pressure, the subject should rest quietly in a sitting position for at least 5 minutes, refrain from smoking or drinking coffee for at least 30 minutes, and empty the bladder before measurement. At the start of measurement, the subject should sit, preferably in a chair with back support, with the upper arm exposed and at the same level as the heart. Blood pressure should be measured in both the left and right upper arms during the first visit, and subsequently, the arm with the higher reading is usually measured. In special circumstances, measurements can be taken in a supine or standing position. Elderly patients, diabetic patients, and those with orthostatic hypotension should have their standing blood pressure measured. Standing blood pressure should be measured 1 minute and 5 minutes after changing from a supine to a standing position.

Measurements should be repeated at intervals of 1-2 minutes, and the average of two readings should be recorded. If the systolic or diastolic pressure readings differ by more than 5 mmHg, a third measurement should be taken, and the average of three readings should be recorded.

2.1.2 Perioperative Hypertension

Perioperative hypertension refers to an increase in the patient's blood pressure greater than 30% above baseline blood pressure, or SBP $\geqslant$ 140 mmHg and/or DBP $\geqslant$ 90 mmHg, from the time surgery is determined until the treatment related to the surgery is basically completed[1]. A hypertensive crisis during the perioperative period refers to a short-term increase in blood pressure exceeding 180/110 mmHg. Excessively high blood pressure not only increases myocardial oxygen consumption, affects myocardial blood supply, and can induce cerebrovascular rupture, posing significant risks to patients with cardiovascular and renal diseases, but also increases the likelihood of intraoperative and postoperative bleeding. Hypertension combined with target organ damage also significantly increases the risk of anesthesia.

2.1.3 Perioperative Hypotension

Perioperative hypotension is relative to the patient's baseline blood pressure, and there is currently no unified standard. The perioperative baseline blood pressure is defined as (blood pressure measured in the preoperative waiting area + blood pressure measured in the operating room during the first measurement) / 2[13]. The most commonly used standard is: SBP less than 80 mmHg, mean arterial pressure 55-60 mmHg, or SBP and mean arterial pressure reduced by more than 25% compared to preoperative baseline blood pressure [14]. Acute hypotension during the perioperative period refers to a sudden and significant drop in SBP from normal or higher levels by more than 30 mmHg, lasting more than 30 minutes [15]. Perioperative hypotension causes low perfusion of tissues and organs, increasing the risk of postoperative delirium, stroke, myocardial ischemia, myocardial infarction, acute kidney injury, and increasing postoperative mortality.

2.2 High-Risk Factors for Perioperative Blood Pressure Abnormalities

2.2.1 High-Risk Factors for Perioperative Hypertension

The high-risk factors for perioperative hypertension are shown in Table 1.

Table 1: High-risk Factors for Hypertension during the Perioperative Period

Influencing Factors	Specific Situations
Anesthesia	Inadequate anesthesia or insufficient analgesia
Surgical Procedures*	Clamping the aorta, stimulation of cranial nerves V, X, IV, adverse stimuli from tracheal intubation, urinary catheterization, drainage tubes, excessive fluid infusion, etc.

Endocrine Factors	Pheochromocytoma, hyperthyroidism, primary hyperaldosteronism, etc.
Primary Diseases	Hypertension
Type of Surgery	Cardiac surgery, major vascular surgery, neurosurgery and head and neck surgery, kidney transplantation, and major trauma (burns or head injuries), etc.
Psychological Factors	Nervousness, anxiety, fear, insomnia, etc.

Note: *See Appendix 5 for details.

2.2.2 High-Risk Factors for Perioperative Hypotension

The high-risk factors for perioperative hypotension are shown in Table 2.

Table 2: High-risk Factors for Hypotension During the Perioperative Period

Influencing Factors	Specific Situations
Anesthesia	Anesthetic drugs such as various muscle relaxants, significant positional changes during anesthesia
Surgical Procedures*	Compression of the heart and vena cava, after pheochromocytoma resection, bone glue reaction, release of tourniquet, massive blood loss during surgery
Adrenal Cortex Insufficiency	Pituitary or adrenal gland resection, prolonged use of adrenal stimulants or corticosteroids, Sheehan's syndrome
Medication Factors	Use of analgesic pump medications
Primary Disease	Valvular disease, heart failure, pulmonary embolism, etc.

Note: *See Appendix 5 for details.

3 Management of Perioperative Blood Pressure

3.1 Preoperative Blood Pressure Assessment and Perioperative Blood Pressure Monitoring

3.1.1 Preoperative Comprehensive Assessment of the Following Factors [1,16]:

(1) Whether there is a history of hypertension. Distinguishing whether preoperative hypertension is a persistent state or caused by anxiety is important, as patients with long-term hypertension often have reduced sensitivity of baroreceptors, leading to hemodynamic instability during surgery.

(2) The degree of hypertension. Determining whether further blood pressure control is needed: Stage 1 and 2 hypertension (BP < 180/110 mmHg) carries a risk similar to that of general patients, and surgery does not increase the risk of perioperative cardiovascular complications. However, Stage 3 hypertension (BP ≥ 180/110 mmHg) that is uncontrolled significantly increases the risk of myocardial infarction, heart failure, and cerebrovascular accidents during the perioperative period, necessitating the

selection of appropriate antihypertensive medications to stabilize blood pressure at a certain level.

(3) Target organ involvement. Hypertension accompanied by significant organ dysfunction significantly increases the risk of anesthesia and surgery. It is important to understand whether there are symptoms of angina, heart failure, hypertensive encephalopathy, diabetes, and complications such as renal dysfunction and dyslipidemia. If there is involvement of the aforementioned target organs or physiological disorders, treatment for comorbidities should be conducted while controlling blood pressure levels preoperatively.

(4) Understanding the patient's preoperative medication: central antihypertensive drugs and β-blockers should not be abruptly discontinued.

(5) The type and site of surgery and assessment of surgical duration: ① High-risk surgeries (cardiac risk > 5%): emergency major surgeries (especially in the elderly), aortic or other major vascular surgeries, peripheral vascular surgeries, long-duration surgeries (> 4 hours), and/or significant blood loss. ② Moderate-risk surgeries (1% < cardiac risk ≤ 5%): carotid endarterectomy, head and neck surgeries, intra-abdominal or thoracic surgeries, orthopedic surgeries, prostate surgeries, etc. ③ Low-risk surgeries (cardiac risk ≤ 1%): endoscopic examinations, superficial surgeries, cataract surgeries, breast surgeries, etc.

(6) Others: Except for emergency surgeries, elective surgeries should generally be performed after blood pressure has been controlled and the function of affected organs has been stabilized.

3.1.2 Perioperative Blood Pressure Monitoring:

Perioperative blood pressure abnormalities mainly manifest as elevated preoperative blood pressure, hypertension during anesthesia induction and at the end of surgery, hypotension during the later stages of induction, intraoperative blood pressure instability, and postoperative hypertension. The degree of preoperative blood pressure elevation is related to baseline blood pressure and the degree of stimulation, and close monitoring of the patient's blood pressure is necessary. In principle, for patients without a history of hypertension, mild to moderate preoperative blood pressure elevation (SBP 140-179 mmHg, DBP 90-109 mmHg) does not affect the surgery and can be closely observed without urgent intervention; blood pressure often returns to normal after stabilizing the patient's emotions and alleviating anxiety. For patients with severe hypertension (> 180/110 mmHg) preoperatively, slow antihypertensive treatment is recommended. For elective surgery patients whose blood pressure remains above 180/110 mmHg upon entering the operating room, it is recommended to postpone the surgery. However, in life-threatening emergencies, surgery should be performed regardless of how high the blood pressure is; for severe hypertension combined with life-threatening target organ damage and conditions, measures should be taken

promptly to improve the function of the threatened organs. Surgical stimuli such as skin incision can cause blood pressure to rise, while significant blood loss and excessive anesthesia can lead to hypotension; a mean arterial pressure drop of 33% lasting more than 10 minutes or a rapid drop of 50% can cause myocardial ischemia, thus continuous blood pressure monitoring during surgery is essential. Postoperative blood pressure is generally related to the degree of preoperative hypertension, whether blood pressure preparation is adequate, the extent of surgical trauma, the amount of blood loss, the type of anesthesia, and the use of vasoactive drugs during surgery. Postoperatively, blood pressure is usually not too high, generally lower or close to normal. However, as clinical volume resuscitation and the effects of anesthetics, sedatives, and hemostatic drugs gradually diminish, blood pressure often rises. Therefore, close observation and timely monitoring of blood pressure changes postoperatively are necessary to detect and address any abnormalities promptly.

3.2 Management of Perioperative Hypertension

3.2.1 Blood Pressure Control Goals and Antihypertensive Drug Selection for General Surgery Perioperative Hypertension

3.2.1.1 Blood Pressure Control Goals for General Surgery Perioperative Hypertension

It is generally believed that for patients under 60 years of age, the blood pressure control target is < 140/90 mmHg; for patients aged 60 years and older without diabetes and chronic kidney disease, the blood pressure control target is < 150/90 mmHg; for patients with diabetes and chronic kidney disease, the blood pressure control target is < 140/90 mmHg. The fluctuation of blood pressure during surgery should not exceed 30% of baseline blood pressure. For elective surgery patients whose blood pressure remains above 180/110 mmHg upon entering the operating room, it is recommended to postpone the surgery; if surgery is necessary (e.g., tumor with minor bleeding), surgery can proceed with family consent. For patients with severe hypertension (> 180/110 mmHg) preoperatively, slow antihypertensive treatment is recommended; otherwise, it often leads to significant ischemia of important target organs and side effects of antihypertensive medications. Mild to moderate hypertension (< 180/110 mmHg) generally does not affect the conduct of surgery[18].

3.2.1.2 Selection of Antihypertensive Drugs in the Perioperative Period for General Surgery

(1) Recommendations for Antihypertensive Drug Use in Hypertensive Patients Before Surgery

Both European and American hypertension management guidelines, as well as those in China, recommend that hypertensive patients undergoing major surgery who are on long-term β-blocker therapy should continue their medication during the perioperative period. Calcium channel blockers have no significant hemodynamic effects at therapeutic doses and can enhance the effects of intravenous anesthetics, inhalational

anesthetics, muscle relaxants, and analgesics, so it is not recommended to discontinue them before surgery. For patients who cannot tolerate β-blockers, initiating this class of medication may be considered. However, RASS inhibitors (ACEI and ARB) increase the risk of perioperative hypotension and vascular shock; ACEI should be discontinued or reduced before surgery, while ARB is recommended to be stopped on the day of surgery or before surgery, to be resumed after fluid volume recovery. Diuretics are recommended to be stopped before surgery due to their ability to reduce vascular smooth muscle reactivity to vasoconstrictors, making intraoperative blood pressure control more difficult, and they may exacerbate fluid loss related to surgery. The specific timing for discontinuation should be determined based on the individual patient's disease condition[16,19,20]. Detailed recommendations for antihypertensive drug selection in hypertensive patients before surgery can be found in Table 3.

Table 3 Recommendations for the Use of Antihypertensive Medications in Hypertensive Patients Before Surgery

Antihypertensive Medications	Perioperative Medication Recommendations	Reasons
β -Blockers	Continue Medication	Can reduce the incidence of postoperative atrial fibrillation, cardiovascular complications, and mortality in non-cardiac surgeries, suitable for preoperative blood pressure control. Sudden discontinuation of β-blockers before surgery should be avoided to prevent rebound heart rate during surgery. The type and dosage of these medications should be maintained during the perioperative period; hypertensive patients who cannot take oral medications can receive them via parenteral administration.
RASS Inhibitors	Discontinue Before Surgery	Includes ACEI and ARB, which increase the risk of perioperative hypotension and vascular shock; ACEI should be discontinued or reduced before surgery; ARB is recommended to be discontinued on the day of surgery and resumed after fluid volume recovery.
Calcium Channel Blockers	No Need to Discontinue Before Surgery	Can improve the balance of myocardial oxygen supply and demand, with no significant hemodynamic effects at therapeutic doses. At the same time, it can enhance the effects of intravenous anesthetics, inhalational anesthetics, muscle relaxants, and analgesics.
Diuretics	Need to Discontinue	Reduces the reactivity of vascular smooth muscle to

	Before Surgery	vasoconstrictive substances, increasing the difficulty of blood pressure control during surgery; diuretics may exacerbate fluid loss related to surgery.

Note: RASS: Renin-Angiotensin-Aldosterone System; ACEI: Angiotensin-Converting Enzyme Inhibitors; ARB: Angiotensin II Receptor Blockers.

(2) Selection of Antihypertensive Drugs in the Perioperative Period for General Surgery

Perioperative hypertension differs from clinical hypertension, and the selection of antihypertensive drugs also varies. Clinical hypertension aims to maintain stable blood pressure, advocating for the use of medium- to long-acting antihypertensive drugs; whereas perioperative hypertension focuses on quickly adjusting blood pressure, primarily using fast-acting, short-duration medications. Commonly used antihypertensive drugs during the perioperative period include adrenaline α1 receptor blockers (urapidil), β-blockers (esmolol), and dihydropyridine calcium channel blockers (nicardipine) (see Appendix 6 for details). Additionally, many inhalational anesthetics and some intravenous anesthetics also have antihypertensive effects [6,21].

Patients undergoing general surgery are prone to hypertensive responses under anesthesia. If a patient's blood pressure rises sharply within a short time, exceeding 30% of baseline blood pressure, it should be addressed. Strongly stimulating procedures such as tracheal intubation, skin incision, thoracotomy, laparotomy, and visceral exploration can easily lead to sharp fluctuations in blood pressure. In addition to appropriately deepening anesthesia, additional anesthetics such as propofol and fentanyl can be used to help control blood pressure. If blood pressure remains high, rapid-acting, short-duration antihypertensive drugs such as urapidil or nicardipine can be added, which can effectively lower blood pressure in about 1 minute, with rare subsequent hypotension. If effective control is still not achieved, sodium nitroprusside may be considered, which can rapidly lower blood pressure in a short time, but strict control of dosage and speed is necessary, and intravenous injection is prohibited to prevent hypotension. The choice of antihypertensive drugs for blood pressure control in the perioperative period should be based on the patient's underlying diseases, while also considering the economic aspects of drug use [16].

3.2.2 Blood Pressure Control Targets and Antihypertensive Drug Selection for Special Types of Surgery in the Perioperative Period

3.2.2.1 Perioperative Period for Cardiac Surgery

Cardiac surgery generally requires anesthesia and extracorporeal circulation, so there are many factors affecting blood pressure during the perioperative period. The general target for blood pressure control during this period is SBP < 140 mmHg or mean arterial pressure < 90 mmHg [22], but specific situations have different requirements, which will

be detailed below, with specific processes shown in Figure 2.

Preoperative Blood Pressure Management: Adequate sedation is required before surgery, with anesthesia administered before blood pressure reduction. If hypertension occurs during anesthesia, all factors that induce increased blood pressure must first be eliminated, and appropriate anesthesia depth must be ensured. For patients with excessively high blood pressure, vasodilators can be administered simultaneously, with intravenous injections of nicardipine 0.5-1 mg or urapidil 12.5-25 mg or phenoxybenzamine 1-5 mg [21, 23].

Intraoperative Blood Pressure Management: (1) During Extracorporeal Circulation. Maintain appropriate perfusion flow; during extracorporeal circulation, arterial pressure is generally maintained between 50-80 mmHg. Elderly patients have higher vascular resistance, so perfusion pressure is correspondingly higher, while children may be slightly lower. If mean arterial pressure > 90 mmHg, anesthesia should be deepened or antihypertensive drugs such as urapidil or nicardipine should be used. If blood pressure is too high or too low, all factors inducing abnormal blood pressure must be eliminated, and appropriate measures should be taken based on the cause. Before adjusting perfusion flow, consider the effects of vascular resistance, temperature, and blood dilution on blood pressure [21,23]. (2) Aortic valve surgery is prone to hypertension during extracorporeal circulation and postoperatively, which can be managed with urapidil, nicardipine, or sodium nitroprusside; for patients with concomitant myocardial hypertrophy, blood pressure should be maintained at a higher level. （3）After mitral valve repair, SBP should be controlled to < 120 mmHg [21]. (4) During coronary artery bypass grafting, a higher perfusion pressure should be maintained, with mean arterial pressure > 70 mmHg, avoiding increased heart rate during the blood pressure reduction process, and maintaining mean arterial pressure (mmHg)/heart rate > 1. Sodium nitroprusside is not recommended for blood pressure control to avoid coronary steal. (5) During ductus arteriosus ligation, SBP should be reduced to 70-80 mmHg or blood pressure should not drop more than 40% from baseline; attention should be paid to postoperative rebound hypertension, with timely sedation and antihypertensive treatment using urapidil, β-blockers, or calcium channel blockers [21,23].

Postoperative Blood Pressure Management: Ensure adequate analgesia, eliminate causes of hypertension, and control blood pressure reasonably based on cardiac function status.

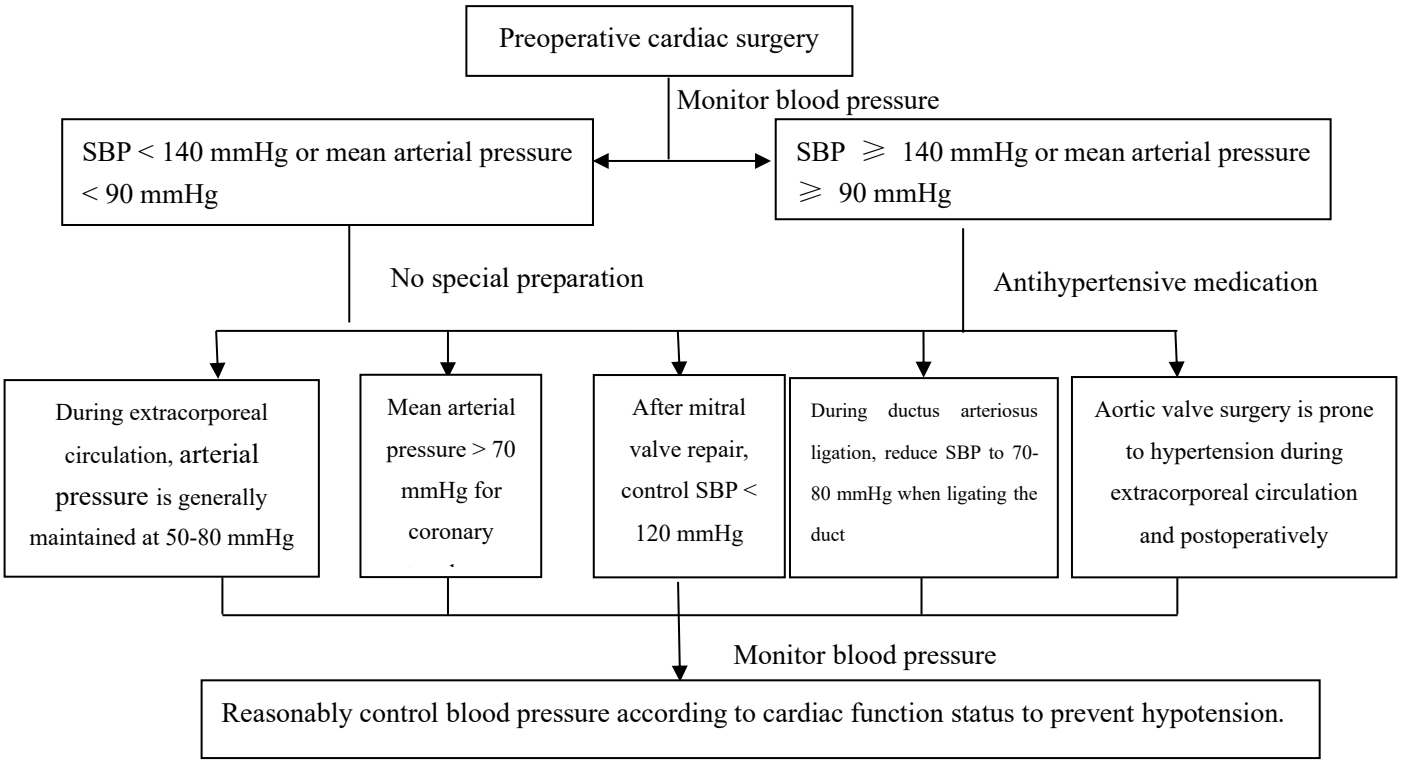

Figure 2 Perioperative Blood Pressure Management Flowchart for Cardiac Surgery

3.2.2.2 Perioperative Period for Hypertensive Disorders in Pregnancy

Hypertensive disorders in pregnancy are unique to the pregnancy period, including gestational hypertension, preeclampsia, eclampsia, chronic hypertension with preeclampsia, and chronic hypertension in pregnancy. The goal of treating hypertensive disorders in pregnancy is to prevent the occurrence of severe preeclampsia and eclampsia, reduce maternal and fetal morbidity and mortality during the perinatal period, and improve perinatal outcomes.

For pregnant women without organ dysfunction, systolic blood pressure (SBP) should be controlled between 130-155 mmHg, and diastolic blood pressure (DBP) should be controlled between 80-105 mmHg; for pregnant women with organ dysfunction, SBP should be controlled between 130-139 mmHg, and DBP should be controlled between 80-89 mmHg. In cases of severe hypertension or organ damage such as acute left ventricular failure, urgent blood pressure reduction to the target range is necessary, with attention to not reducing blood pressure too much, ideally by 10%-25% of mean arterial pressure, achieving stability within 24-48 hours [24-26]. During delivery, blood pressure should be monitored, and antihypertensive treatment should continue, keeping blood pressure < 160/110 mmHg. For patients requiring cesarean section to terminate pregnancy, the rate of blood pressure reduction should be slowed or antihypertensive drugs temporarily stopped, as epidural anesthesia can reduce blood pressure by about 15%. Moreover, under good anesthesia conditions, supine hypotensive syndrome may easily occur, so antihypertensive drugs are usually not needed during surgery, but attention should be paid to blood pressure rebound after anesthesia effects within 30

minutes post-surgery, with timely administration of antihypertensive drugs to control blood pressure fluctuations. If postpartum blood pressure rises to ≥ 150/100 mmHg, antihypertensive treatment should continue. For women with preeclampsia, the postpartum period of 3-6 days is the peak period for high blood pressure, and symptoms such as hypertension and proteinuria may still recur or worsen, so blood pressure should be monitored daily during this period. Women with severe preeclampsia should continue using magnesium sulfate for at least 24-48 hours postpartum to prevent postpartum eclampsia. Attention should be paid to the occurrence of late-onset preeclampsia and eclampsia (occurring after 48 hours postpartum). During breastfeeding, antihypertensive drugs used during pregnancy can continue, except for methyldopa; those using methyldopa can switch to ACEI and ARB antihypertensive drugs (except captopril and enalapril). Persistent postpartum hypertension should prompt evaluation and exclusion of other systemic diseases [27].

3.2.2.3 Selection of Antihypertensive Drugs in the Perioperative Period for Hypertensive Disorders in Pregnancy

Antihypertensive drugs used to treat hypertensive disorders in pregnancy should be selected to avoid reducing renal and placental perfusion while having minimal effects on the fetus. Commonly used oral antihypertensive drugs for hypertensive disorders in pregnancy include labetalol, nifedipine, and methyldopa, while the use of angiotensin-converting enzyme inhibitors (ACEI) and angiotensin II receptor antagonists (ARB) is prohibited. When using oral antihypertensives, combination therapy is recommended. If oral antihypertensive treatment is not effective, intravenous medications can be switched, commonly including labetalol, nicardipine, nitroglycerin, phenoxybenzamine, urapidil, and sodium nitroprusside (specific dosages and methods can be found in Appendix 7[27-30]).

Most antihypertensive drugs fall under category C in the FDA pregnancy classification, so when selecting medications for patients with hypertensive disorders in pregnancy, it is essential to effectively control blood pressure while fully considering the safety of the drugs for both the mother and the baby, weighing the pros and cons of their use.

3.2.2.4 Perioperative Management of Cerebral Lesions

Hypertension caused by cerebral lesions is often related to increased intracranial pressure, and some pituitary tumors can cause hypertension due to water and sodium retention [15].

If the preoperative systolic blood pressure (SBP) is below 160 mmHg, no special preparation is needed; if the blood pressure is too high, anesthesia induction and surgical stress may lead to complications such as cerebrovascular accidents and congestive heart failure, so appropriate antihypertensive medications should be selected preoperatively to control blood pressure. During acute ischemic stroke intervention (before vascular recanalization), SBP should be maintained at 140-180 mmHg; for

Parkinson's disease deep brain stimulation anesthesia management, the target for SBP control is below 140 mmHg [31]. For patients with spontaneous intracerebral hemorrhage with SBP between 150-220 mmHg and no contraindications for acute antihypertensive treatment, SBP can be reduced to 140 mmHg during the acute phase. For patients with severe aneurysmal subarachnoid hemorrhage, it is recommended to control SBP at 140-160 mmHg before aneurysm treatment [15]; however, it is important to ensure that the cerebral perfusion pressure remains above 60 mmHg while lowering blood pressure. Patients with a history of hypertension can continue using β-blockers and calcium channel blockers during the perioperative period; due to the risk of perioperative hyponatremia and hypokalemia from diuretics, they should be stopped on the day of surgery. If diuretics are being used continuously, potassium levels should be checked the day before surgery, and diuretics should be resumed as soon as possible after surgery. RASS inhibitors (ACEI or ARB) should be stopped on the day of surgery [32]. In cases of hypertensive emergencies during the perioperative period, intravenous antihypertensive medications should be administered, with recommended drugs including urapidil, enalapril, nicardipine, labetalol, or esmolol, while avoiding sodium nitroprusside due to the risk of increased intracranial pressure [31]. Antihypertensive medications should be started at low doses to prevent hypotension.

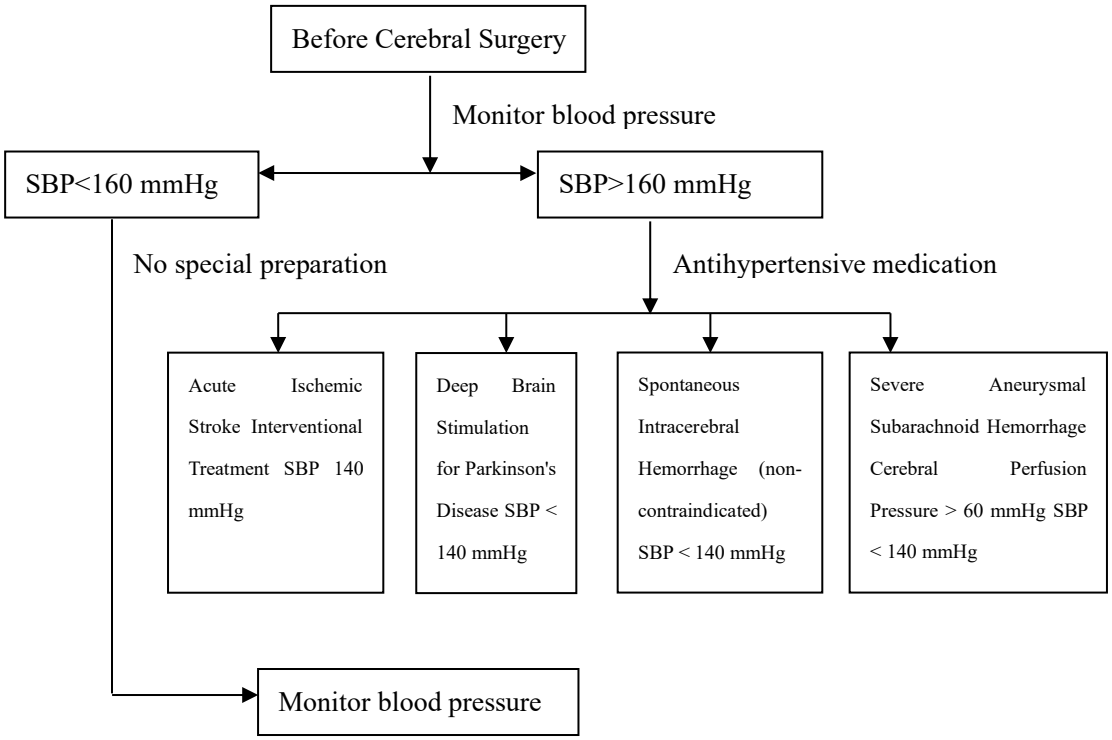

Figure 3 Perioperative Blood Pressure Management Flowchart for Cerebral Lesions

3.2.2.5 Perioperative Management of Pheochromocytoma

Pheochromocytoma can synthesize and secrete large amounts of catecholamines, leading to secondary hypertension. Clinically, it may present as paroxysmal, persistent,

or paroxysmal exacerbation on a background of persistent hypertension. Preoperative antihypertensive treatment should be actively administered while ensuring volume resuscitation, with a general preparation time of at least 2-4 weeks. The final control targets are no blood pressure >160/90 mmHg, blood pressure <80/45 mmHg, and orthostatic hypotension within 24 hours before surgery; no new ECG ST segment or T wave changes in the week before surgery; and no frequent ventricular premature beats [15].

The preferred preoperative antihypertensive medication is α-blockers, which can include non-selective α-blockers: phenoxybenzamine 0.5-1 mg·kg-1·d-1; or selective α1-blockers: prazosin 1-3 mg per dose, three times a day [34]. Clinically, phenoxybenzamine is commonly used at 10-20 mg per dose, two to three times a day, for two consecutive weeks. If the patient experiences tachycardia after taking α-blockers or has catecholamine cardiomyopathy, β-blockers can be added: metoprolol 25-50 mg·d-1, atenolol 25-50 mg·d-1, propranolol 10-30 mg·d-1, but β-blockers should not be used alone without prior use of α-blockers to avoid severe pulmonary edema, heart failure, and hypertensive crises. In patients with pheochromocytoma, it is recommended to add highly selective β1-blockers, which should be used until the morning of the surgery. If blood pressure remains uncontrolled, calcium channel blockers can be added: nifedipine 30-60 mg·d-1, amlodipine 5-10 mg·d-1. Additionally, patients with pheochromocytoma should start oral electrolytes after taking α-blockers and maintain a normal or high-salt (>5 g·d-1) diet, encouraging increased fluid intake; intravenous crystalloid or colloid fluid resuscitation can be administered 1-2 days after admission; and 1 L or more of balanced salt solution can be given before the patient enters the operating room.

The primary goal during surgery is to maintain hemodynamic stability while excising the tumor. (1) Pre-induction preparation: For patients with poor preoperative blood pressure control, larger tumors, and high preoperative catecholamine levels, sedative-hypnotics can be given on the morning of surgery to prevent anxiety-induced hypertensive crises. (2) Anesthesia induction: Propofol can be safely used for induction in pheochromocytoma patients, and etomidate has minimal hemodynamic effects, making it suitable for patients with poor cardiac function and volume depletion. Administering a small amount of lidocaine and esmolol during induction can also reduce sudden increases in blood pressure. Atropine, morphine, and tubocurarine should be avoided before anesthesia, as they can suppress the vagus nerve and induce arrhythmias. Additionally, medications that stimulate the sympathetic nervous system (such as ephedrine, ketamine, etc.), suppress the parasympathetic nervous system, or cause histamine release (such as morphine, atracurium, haloperidol, etc.) should be avoided during surgery. (3) Before tumor excision: Touching the tumor during surgery often leads to excessive catecholamine release and a sharp increase in blood pressure.

When blood pressure rises moderately, 5-25 mg of urapidil or 0.2-1.0 mg of nicardipine can be administered for antihypertensive treatment; when blood pressure rises sharply, continuous intravenous infusion of phenoxybenzamine (100 mg in 500 mL of normal saline) can be used. If the heart rate exceeds 100 beats per minute or there are rapid arrhythmias during surgery, a selective β1-blocker such as esmolol can be injected intravenously after using α-blockers. (4) After tumor excision: After blood supply is interrupted, some patients may experience a rapid drop in blood pressure, and all vasodilators should be stopped immediately, with rapid fluid resuscitation through open peripheral access and central venous access; fluid resuscitation is often more effective than using vasopressor medications.

Managing hemodynamics remains a primary task postoperatively. Most patients' vasopressor medications will gradually be reduced to discontinuation, and blood pressure and heart rate should be closely monitored for 24-48 hours postoperatively. If there is a significant drop in blood pressure or hypotension, α-blockers should be stopped immediately, and blood volume should be rapidly replenished, with vasopressor medications used if necessary [35].

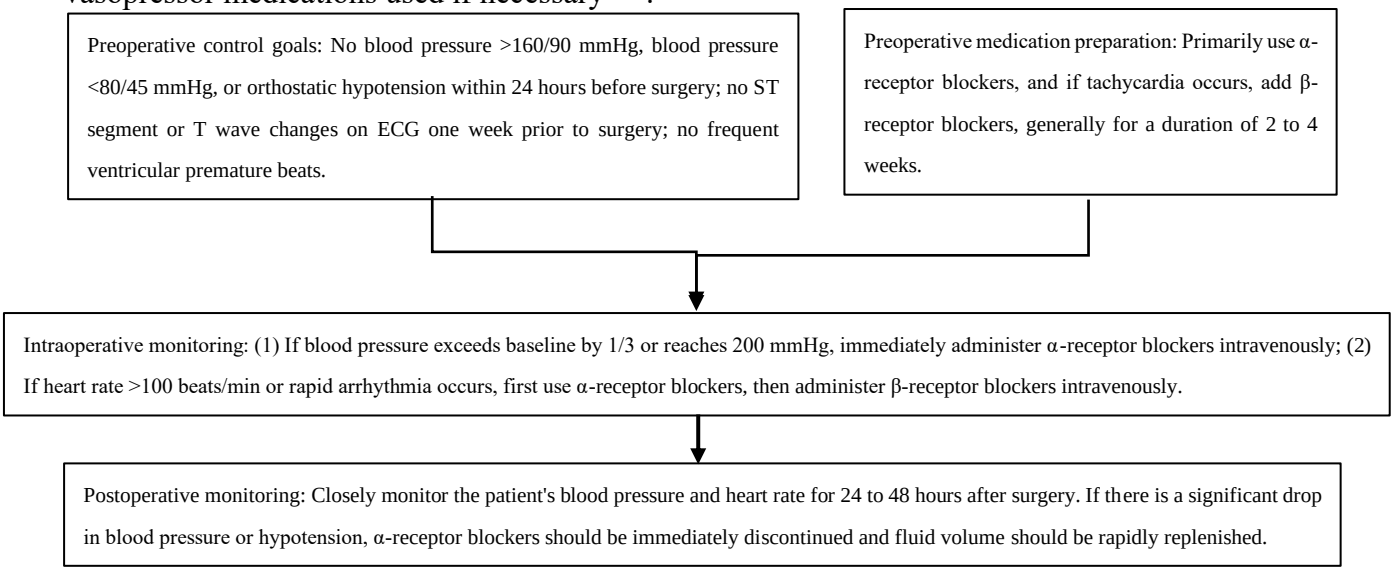

Figure 4: Perioperative blood pressure management flowchart for pheochromocytoma.

3.3 Management of Perioperative Hypotension

3.3.1 Dangers of Perioperative Hypotension

Clinical studies show that intraoperative hypotension may affect postoperative outcomes, being associated with increased incidence of postoperative delirium, stroke, acute kidney injury, myocardial infarction, and increased mortality within one year post-surgery. Additionally, asymptomatic hypotension during surgery (occult hypotension) can lead to low perfusion-related complications postoperatively,

increasing the incidence and mortality of major organ complications [36-37].

For hypertensive patients, the risks of perioperative hypotension far exceed those of hypertension, as prolonged hypertension allows organs to tolerate relatively high blood pressure, while the blood pressure sufficient for organ perfusion in healthy individuals may be relatively low for hypertensive patients. During anesthesia induction, with light surgical stimulation and significant blood loss, blood pressure may drop even lower, further increasing the risk of stroke and myocardial infarction during the perioperative period for hypertensive patients. Therefore, while paying attention to perioperative hypertension [38], it is also essential to actively prevent and manage perioperative hypotension.

3.3.2 Management of Perioperative Hypotension

Data indicate that blood pressure fluctuations within ±20% of baseline blood pressure are physiologically acceptable, as within this range, perfusion to vital organs and tissues is adequate, with no signs of ischemia or hypoxia [39]. When blood pressure drops more than 20%, timely intervention is required, including volume therapy or intravenous administration of appropriate pressor medications until blood pressure returns to within ±20% of baseline: (1) Hypotension caused by sympathetic nerve blockade leading to venous dilation and decreased cardiac output is usually treated with sympathomimetic agents, such as ephedrine or norepinephrine; (2) Hypotension due to surgical bleeding or shock is typically managed with volume resuscitation and vasopressor medications, and in cases of very low blood pressure, sympathomimetic agents such as norepinephrine or dopamine can be used for vasoconstriction. A study comparing dopamine and norepinephrine as first-line vasoconstrictors found no significant difference in prognostic impact, but dopamine had more adverse reactions. If necessary, a combination of low-dose norepinephrine and metaraminol can be considered.

In addition to pharmacological treatment, managing hypotension should also focus on fluid resuscitation to avoid tissue perfusion deficits and organ dysfunction due to low blood volume. Maintenance fluid therapy should meet the physiological needs of the patient: 25-30 mL·kg-1·d-1 of fluid, 1 mmol·kg-1·d-1 of Na+, K+, Cl-, and 50-100 g·d-1 of glucose. Fluid resuscitation is recommended with balanced salt solutions or colloid solutions with sodium concentrations of 130-154 mmol·L-1, rapidly infused at 500 mL within 15 minutes. It should be noted that crystalloid solutions have minimal effects on coagulation and liver and kidney function but have low expansion efficiency and short duration of effect, with only about 20% of the infused volume retained in the vascular space, leading to potential tissue edema and pulmonary edema with large volumes. Colloid solutions are more effective in maintaining blood volume, have a longer duration, and cause less peripheral edema, but they are more expensive and can lead to coagulation dysfunction or kidney damage, as well as allergic reactions, so fluid resuscitation should be tailored to the patient's condition [41-42].

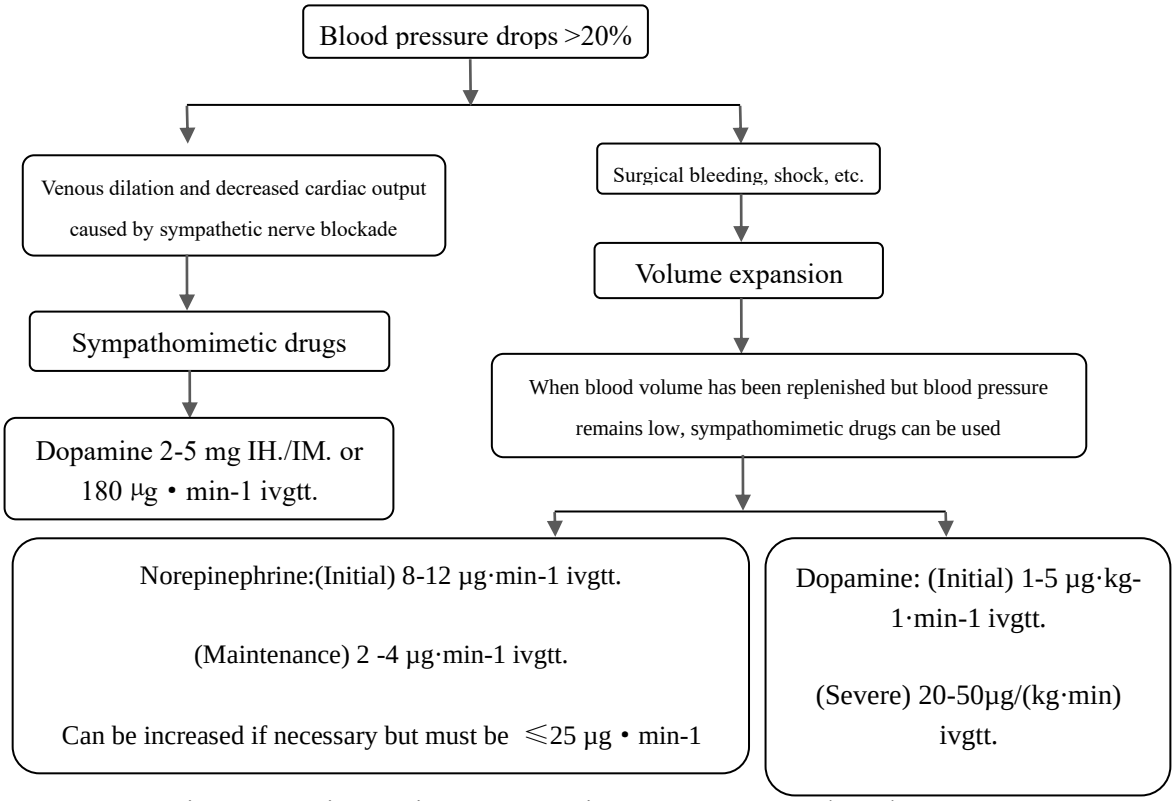

Figure 5 Perioperative Hypotension Management Flowchart

3.4 Common Anesthetics, Muscle Relaxants, and Analgesics' Effects on Blood Pressure

Anesthetics, muscle relaxants, and analgesics used during the perioperative period are the most commonly used medications, utilized by nearly every surgical patient. The effects of these three categories of drugs on blood pressure require special attention. Below is a brief overview of the effects of some commonly used anesthetics, muscle relaxants, and analgesics on blood pressure. The effects of other commonly used medications on blood pressure can be found in Appendix 1.

3.4.1 Common Inhalational General Anesthetics

Common inhalational general anesthetics include: (1) Halothane, enflurane, and sevoflurane, which cause a decrease in blood pressure and a slowing of heart rate. (2) Isoflurane, which can cause hypotension under deep anesthesia.

3.4.2 Common Intravenous General Anesthetics

Common intravenous general anesthetics include: (1) Etomidate, which has no effect on blood pressure in the cardiovascular system. (2) Ketamine and sodium oxybate, which can raise blood pressure. (3) Propofol, midazolam, and dexmedetomidine, which can cause a decrease in blood pressure and an increase in heart rate; however, after a loading dose of dexmedetomidine, there is a transient increase in blood pressure and a decrease in heart rate, with the increase in blood pressure being more pronounced the faster the injection rate. Therefore, it is clinically recommended that the loading dose

be administered within 10-15 minutes. (6) Thiopental sodium can easily cause hypotension and respiratory depression, even cardiac arrest, in patients with insufficient blood volume or head injuries. When used concurrently with large doses of ketamine, hypotension and slow, shallow breathing often occur, and both should be reduced in dosage.

3.4.3 Common Local Anesthetics

Procaine in small doses can increase heart rate and blood pressure, while large doses can decrease blood pressure and increase heart rate. Cocaine and levobupivacaine can lead to hypotension.

3.4.4 Common Muscle Relaxants

Muscle relaxants such as mivacurium, vecuronium, pancuronium, and succinylcholine have no cardiovascular adverse effects. Rocuronium has a slight histamine-releasing effect, but there are no changes in heart rate or blood pressure at clinical doses. Pancuronium has a mild vagal blockade and sympathetic stimulation effect, which can cause dose-related increases in heart rate and blood pressure. The commonly used dose of atracurium does not affect heart function and does not produce symptoms of vagal stimulation such as bradycardia; however, rapid intravenous injection of large doses (greater than 0.5 mg·kg-1) can cause hypotension and bradycardia due to histamine release [43].

3.4.5 Common Analgesics

Large doses of pentazocine can cause an increase in blood pressure. When using large doses of morphine for intravenous general anesthesia, it is often combined with sedative drugs, and hypotension can occur during induction; when surgical stimulation begins, blood pressure may suddenly rise, requiring timely symptomatic treatment. Alfentanil should not be used with monoamine oxidase inhibitors, and it is essential to wait at least 14 days after stopping monoamine oxidase inhibitors before administering it, as severe complications can occur, with blood pressure initially rising and then dropping sharply. Remifentanil can cause a decrease in arterial pressure and heart rate by more than 20%, with the degree of decrease not related to the dose. Blood pressure may drop after intravenous injection of pethidine. Dexamethasone rarely causes hypotension. Sodium butyrate has a mild effect on the cardiovascular system and is suitable for analgesia in patients with cardiovascular diseases or after cardiovascular surgery [44-45].

4 Summary

Good blood pressure control during the perioperative period is crucial for preventing intraoperative complications and improving patient outcomes. Clinically, the management of blood pressure in perioperative patients can be strengthened through a physician-pharmacist collaborative model. Blood pressure management should be individualized based on the patient's specific situation, disease severity, type of surgery,

and duration of surgery.

For patients without a history of hypertension, mild to moderate increases in blood pressure during the perioperative period can be closely monitored without rushing to treat; stabilizing the patient's emotions and alleviating tension can restore blood pressure to normal. For patients with persistently high blood pressure or a history of hypertension, appropriate treatment measures should be taken based on the specific situation to bring blood pressure back to a normal range, especially for patients with stage 3 hypertension (SBP > 180 mmHg, DBP > 110 mmHg). The involvement of clinical pharmacists can effectively assist surgeons in adjusting patients' blood pressure through preoperative assessments and medication restructuring, collaboratively developing blood pressure control plans to maintain stable blood pressure before surgery, ensuring safety and good outcomes. During and after surgery, hemodynamic monitoring should be closely conducted to avoid significant fluctuations in blood pressure and the occurrence of hypotension. If postoperative blood pressure control is inadequate, clinical pharmacists can provide pharmaceutical monitoring to assist physicians in timely medication adjustments.

For low-risk patients without concurrent heart failure, acute renal failure, or cerebrovascular events, short-acting β-blockers are recommended to lower blood pressure. Specific blood pressure targets and treatment plans should also be developed for special types of perioperative hypertensive patients, such as those with pregnancy-induced hypertension, where oral medications are preferred. For patients with a history of hypertension, the risk of hypotension during the perioperative period is far greater than that of hypertension, and sympathomimetic agents such as norepinephrine and dopamine can be used to raise blood pressure. Additionally, special attention should be paid to the effects of perioperative anesthetics and analgesics on blood pressure.

References

[1] Hypertension Alliance (China). 2018 Revised Edition of the Chinese Guidelines for the Prevention and Treatment of Hypertension[J]. Journal of Cardiovascular Disease Prevention and Treatment, 2019, 19(1): 1-44.

[2] Chen Juan, Guan Xiangdong. Perioperative Management of Patients with Combined Hypertension[J]. Chinese Journal of Practical Surgery, 2008, 28(2): 102-104.

[3] Dong Lan, Han Shujun. Perioperative Hypertension[J]. Chinese Medical Journal, 2005, 40(6): 52-53.

[4] Chen Yuanyuan. Management Strategies for Perioperative Hypertension[J]. Chinese Journal of Hypertension, 2017(8): 786-789.

[5] Howell S J， Sear J W， Foex P． Hypertension， hypertensive heart disease

and perioperative cardiac risk [J]． Br J Anaesth，2004， 92（4）： 570－583．
[6] Huang Zhenhua. Treatment of Perioperative Hypertension[J]. Chinese Journal of New Drugs and Clinical Medicine, 2009, 28(5): 329-332.
[7] Wang Fei, Shi Changcheng, Zhu Jiejin, et al. Meta-analysis of Clinical Pharmacists' Involvement in Hypertension Management and Blood Pressure Control[J]. Chinese Modern Applied Pharmacy, 2016, 33(11): 1448-1452.
[8] Hwang A Y, Gums T H, Gums J G. The benefits of physician-pharmacist collaboration.[J]. Journal of Family Practice, 2017, 66(12):E1.
[9] Whelton P K, Carey R M, Aronow W S, *et al*. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American college of cardiology/American heart association task force on clinical practice guidelines[J]. Hypertension, 2017.
[10] Proia K K, Thota A B, Njie G J, *et al*. Team-based care and improved blood pressure control: a community guide systematic review[J]. Am J Prev Med, 2014, 47:86-99
[11] Tsuyuki R T, Al Hamarneh Y N, Jones C A, *et al*. The effectiveness of pharmacist interventions on cardiovascular risk:The Multicenter Randomized Controlled RxEACH Trial[J]. J Am Coll Cardiol, 2016, 67:2846-54.
[12] Li Jing, Lü Qianzhu. Pharmaceutical Services and Their Effects on Hypertensive Patients by Clinical Pharmacists[J]. Pharmacy and Clinical Research, 2015, 23(2): 200-203.
[13] Bijker J B, Persoon S, Peelen L M, *et al.* Intraoperative hypotension and perioperative ischemic stroke after general surgery: a nested case-control study[J]. Anesthesiology, 2012 ;116(3):658-64.
[14] Walsh M, Devereaux P J, Garg A X, *et al*. Relationship between intraoperative mean arterial pressure and clinical outcomes after noncardiac surgery: toward and empirical definition ofhypotension[J].Anesthesiology,2013,119（3）:507-515.
[15] Bijker J B, Persoon S, Peelen L M, *et al.* Incidence of intraoperative hypotension as a function of the chosen definition: literature definitions applied to a retrospective cohort using automated data collection[J]. Anesthesiology, 2007 , 107(2):213-20
[16] Chinese Medical Association Anesthesiology Branch. Chinese Anesthesia Guidelines and Expert Consensus (Expert Consensus on Management of Perioperative Hypertensive Patients 2014) [M]. Beijing: People's Medical Publishing House, 2014, 215-221.
[17] Wright J T, Fine L J, Lackland D T, *et al.* Evidence supporting a systolic blood pressure goal of less than 150 mm Hg in patients aged 60 years or older: the minority view[J]. Ann Intern Med. 2014, 160(7): 499-503.
[18] Weber M A, Schiffrin E L, White W B, *et al*. Clinical practice guidelines for the

management of hypertension in the community: a statement by the American Society of Hypertension and the International Society of Hypertension[J]. J Clin Hypertens (Greenwich). 2014, 16(1): 14-26.

[19] Sousa-Uva M, Head S J, Milojevic M, *et al*. 2017 EACTS Guidelines on perioperative medication in adult cardiac surgery[J]. Eur J Cardiothorac Surg, 2018, 53(1): 5-33.

[20] Port S C. 2014 ESC/ESA guidelines on noncardiac surgery: Cardiovascular assessment and management[J]. European Heart Journal, 2014, 35(35):2344-2345.

[21] Chinese Society of Cardiovascular Anesthesiology, Beijing Hypertension Prevention and Treatment Association. Expert Consensus on Perioperative Hypertension [J]. Journal of Clinical Anesthesiology, 2016, 3(32): 295-297.

[22] Robert M. Bojar. Manual of Perioperative Care in Adult Cardiac Surgery(Fifth Edition) [M]. Chichester: Wiley-blackwell, 2011

[23] Zhao Yupei, Chen Xiaoping. Surgery (8-Year Program, 3rd Edition) [M]. Beijing: People's Health Publishing House, 2016.

[24] Lowe S, Bowyer L, Lust K, *et al.* The SOMANZ Guidelines for the Management of Hypertensive Disorders of Pregnancy 2014[J]. Australian & New Zealand Journal of Obstetrics & Gynaecology, 2015, 55(1): 11-16.

[25] Somerset D. Diagnosis, Evaluation, and Management of the Hypertensive Disorders of Pregnancy: Executive Summary[J]. Journal of obstetrics and gynaecology Canada, 2014, 36(5): 416-438.

[26] Hu Rong, Li Xiaotian. Re-recognition and Management of Hypertensive Disorders in Pregnancy and Prevention of Preeclampsia [J]. Chinese Journal of Practical Gynecology and Obstetrics, 2018, 34(5): 484-488.

[27] Obstetrics and Gynecology Branch of the Chinese Medical Association, Hypertensive Disorders in Pregnancy Group. Guidelines for the Diagnosis and Treatment of Hypertensive Disorders in Pregnancy [J]. Chinese Journal of Obstetrics and Gynecology, 2015, 50(10): 721-728.

[28] Khan K, Zamora J, Lamont R F, *et al*. Safety concerns for the use of calcium channel blockers in pregnancy for the treatment of spontaneous preterm labour and hypertension: a systematic review and meta-regression analysis[J]. J Matern Fetal Neonatal Med, 2010, 23(9):1030-1038.

[29] National Health and Family Planning Commission Expert Committee on Rational Drug Use, Chinese Medical Association Hypertension Professional Committee. Guidelines for Rational Drug Use in Hypertension (2nd Edition) [J]. Chinese Journal of Medical Frontiers, 2017, 9(7): 28-126.

[30] American College of Obstetricians and Gynecologists. Hypertension in pregnancy. Report of the American College of Obstetricians and Gynecologists' Task Force on Hypertension in Pregnancy[J]. Obstet Gynecol, 2013, 122(5):1122-1131.

[31] Anesthesiology Branch of the Chinese Medical Association, Neurosurgical Anesthesia Group. Expert Consensus on Anesthesia Management for Interventional Treatment of Cerebral Diseases in China [J]. Chinese Medical Journal, 2016, 96(16): 1241-1245.

[32] Lei Ting, Sun Wei, Jiang Wei, et al. Translators. Neurocritical Care (2nd Edition) [M]. Wuhan: Hubei Science and Technology Press, 2014.

[33] Chen Jialun. Clinical Endocrinology [M]. Shanghai: Shanghai Scientific and Technical Publishers, 2011, 637-644.

[34] Endocrinology Branch of the Chinese Medical Association, Adrenal Group. Expert Consensus on the Diagnosis and Treatment of Pheochromocytoma and Paraganglioma [J]. Chinese Journal of Endocrinology and Metabolism, 2016, 3: 181-187.

[35] Liao Eryuan. Endocrine Metabolic Diseases (3rd Edition) [M]. Beijing: People's Health Publishing House, 2012, 712-732.

[36] Sudfeld S, Brechnitz S, Wagner J Y, *et al*. Post-induction hypotension and early intraoperative hypotension associated withgeneral anaesthesia[J]. British Journal of Anaesthesia, 2017,119(1): 57-64.

[37] Liu Simeng, Yue Yun. Perioperative Stroke in Non-Cardiovascular Non-Neurosurgical Procedures [J]. Journal of Clinical Anesthesiology, 2016, 32(3).

[38] Zheng Xin. Study on Risk Factors and Effects of Perioperative Drug Intervention in Surgical Hypertensive Patients [D]. Dalian Medical University, 2014.

[39] Anesthesiology Branch of the Chinese Medical Association, α1 Agonist Perioperative Application Expert Group. Expert Consensus on the Perioperative Application of α1 Adrenergic Receptor Agonists (2017 Edition) [J]. Journal of Clinical Anesthesiology, 2017, 33(2): 186-192.

[40] Li Dakui, Jin Youyu, Tang Guang, et al. Martindale: The Complete Drug Reference [M]. 37th Edition. Beijing: Chemical Industry Press, 2014: 1134-1143.

[41] Huang Wenqi. Expert Consensus on Fluid Therapy during Anesthesia and Surgery (2007) [J]. Chinese Journal of Practical Surgery, 2008, 28(6): 485-489.

[42] Zhao Yupei, Yang Yinmo, Lou Wenhui, et al. Expert Consensus on Fluid Therapy for Surgical Patients during the Perioperative Period (2015) [J]. Chinese Journal of Practical Surgery, 2015, 35(9): 960-966.

[43] Anesthesiology Branch of the Chinese Medical Association. Expert Consensus on the Rational Use of Muscle Relaxants (2013) [J]. Journal of Clinical Anesthesiology, 2013, 29(7): 712.

[44] National Pharmacopoeia Commission. Pharmacopoeia of the People's Republic of China Clinical Medication Guidelines for Chemical Drugs and Biological Products [M]. 2015 Edition. Beijing: China Medical Science and Technology Press, 2017.

[45] Chen Xinqian, Jin Youyu, Tang Guang. New Pharmacology [M]. 17th Edition. Beijing: People's Health Publishing House, 2017.

Appendix

Appendix 1 The Impact of Perioperative Medications on Blood Pressure

Types of Medications	Mechanisms	Effects on Blood Pressure
Corticosteroids	Can cause water and sodium retention, disrupt glucose, protein, and fat metabolism; water and sodium retention enhance the pressor effect of the RAAS system, increases vascular smooth muscle sensitivity to vasoconstrictors, leading to elevated blood pressure.	Increased blood pressure
Androgens	Upregulates the renin-angiotensin system, enhancing vascular and renal vascular resistance response to angiotensin II; stimulates the production of peroxides through the action of NADPH oxidase.	Increased blood pressure
Thyroid hormones	Excites the sympathetic nervous system, raising blood pressure.	Increased blood pressure
Contraceptives	Increases renin substrate, leading to elevated plasma angiotensin II concentration; increased ANG can cause vasoconstriction, promote sodium entry into cells, and increase aldosterone secretion; estradiol has a mineralocorticoid effect, directly acting on renal microvascular cells to cause sodium retention.	Increased blood pressure
Oxytocin	Constricts capillaries and small arteries.	Increased blood pressure
Ergot alkaloids	Contracts uterine smooth muscle, with strong and lasting effects; slightly higher doses can produce tonic contractions.	Increased blood pressure
Posterior pituitary hormones	Constricts capillaries.	Increased blood pressure
Sodium-containing medications	Causes water and sodium retention.	Increased blood pressure
Anti-vascular endothelial growth factor (Bevacizumab, Sunitinib, Sorafenib, etc.)	Anti-angiogenic drugs inhibit VEGF, leading to reduced NO and prostacyclin production, causing vasoconstriction; decreased microvascular density increases peripheral vascular resistance, raising blood pressure; anti-angiogenic drugs have certain	Increased blood pressure

	effects on neuroendocrine, possibly affecting blood pressure through certain hormones.		
Recombinant human erythropoietin	Promotes the release of endothelin-1, increases thromboxane B2 synthesis, decreases prostaglandin I2 and nitric oxide synthesis in endothelial cells, causing abnormal reactivity of peripheral blood vessels, increasing peripheral vascular resistance.	Increased blood pressure	
Decongestants (Ephedrine hydrochloride, Pseudoephedrine, Naphazoline, Oxymetazoline, etc.)	Promotes vasoconstriction of nasal mucosal vessels.	Increased blood pressure	
Immunosuppressants (Cyclosporine, Levamisole)	Water and sodium retention, increased sympathetic nervous excitability.	Increased blood pressure	
Licorice and its derivatives	Corticosteroid effects.	Increased blood pressure	
Antidepressants	Tricyclic antidepressants inhibit the reuptake of norepinephrine and serotonin, increasing their concentrations in the synaptic cleft, producing sympathomimetic effects; monoamine oxidase inhibitors inhibit monoamine oxidase activity, leading to accumulation of catecholamines and serotonin, causing elevated blood pressure.	Increased blood pressure	
Sympathomimetics (Epinephrine, Norepinephrine, Dopamine)	Increases myocardial contractility, heart rate, cardiac output, causes vasoconstriction, increases peripheral resistance, while activating the RAAS system, promoting renin release.	Increased blood pressure	
Ergotamine, L-hyoscyamine	Directly constricts blood vessels.	Increased blood pressure	
Ethanol	Promotes adrenal cortical hormone secretion, raises plasma catecholamines, causing sodium retention, activating the RAAS system.	Increased blood pressure	
Chemotherapy drugs such as Cyclophosphamide,	Direct renal damage leads to acute renal failure, elevated renin levels, causing secondary renal hypertension.	Increased blood pressure	

Chlorambucil, Sulfonamides, Cephalosporins, Aminoglycosides, Amphotericin B		
Macrolide antibiotics	Inhibits cytochrome P450 isoenzyme 3A4, reducing the metabolism of substrates (calcium channel blockers) of cytochrome P450 3A4.	Decreased blood pressure
Clarithromycin, Erythromycin	Imidazole drugs are inhibitors of P450 3A4, reducing the metabolism of substrates (calcium channel blockers) of cytochrome P450 3A4.	Decreased blood pressure
(Azithromycin excluded)	Inhibits centrally regulated pressor reflexes and blocks peripheral α-adrenergic receptors.	Can cause hypotension
Imidazole antifungal agents	In cases of overdose or rapid intravenous injection.	Severe drop in blood pressure, potentially leading to death
Antipsychotic medications	Larger doses or rapid intravenous administration.	Blood pressure may decrease or increase
Chlorpromazine, Sulpiride	Overdose can cause hypotension.	Blood pressure may increase or decrease
Clozapine, Risperidone	When injected too quickly.	Decreased blood pressure
Antiarrhythmic drugs	The effects on blood vessels vary with dosage and injection speed.	Effects on Blood Pressure
Quinidine, Lidocaine, Amiodarone, Propafenone, etc.	Inhibits cyclooxygenase, leading to impaired synthesis of prostacyclin, prostaglandins, etc., causing vasoconstriction, disrupting blood pressure balance, leading to elevated blood pressure. Increased sweating and fever, gastrointestinal bleeding leading to anemia and hypotension.	Increased blood pressure
Sedative-hypnotics	Can cause histamine release, leading to peripheral vasodilation.	Increased blood pressure

Appendix 2 Condition Assessment Form

Department: Bed Number:

Name		Sex		Age		Hospital Number	
Height (cm)		Weight (kg)			BMI（kg/m^2）		
Primary Diagnosis					Scheduled Surgery Date		

Surgical Assessment:

Surgical Type：☐ Elective ☐ Emergency Surgery

Surgical Size: ☐ Routine Large/Medium Surgery ☐ Minor Surgery Special ☐ Type Hypertension Surgery

Anesthesia Method： General Anesthesia ☐ Local Anesthesia or Epidural Anesthesia

High-Risk Factor Assessment:

Underlying Diseases_____

Medication Status_____

Surgical Factors_____

Intraoperative Management_____

Postural/Supine Hypotension_____

Psychological Stress Factors_____

Blood Pressure Control Status:

Baseline Blood Pressure_____

Perioperative Blood Pressure Control Target_____

Complication Assessment:

UREA_____CREA_____UA____Ccr_____

Na^+_____K^+_____

Is there a history of cardiovascular disease:： ☐ Yes ☐ No

Is there a history of cerebrovascular disease: ☐ Yes ☐ No

Is there a history of malignant tumors: ☐ Yes ☐ No

Is the patient critically ill: ☐ Yes ☐ No

Assessment Result: ☐ **High Risk** ☐ **Medium Risk** ☐ **Low Risk**

Clinical Pharmacist Signature:_____ Date: _____

Appendix 3 Perioperative Blood Pressure Control Protocol

Administration Timing	Administration Plan		Blood Pressure (mmHg)
	Selected Medication	Dosage and Administration	
Preoperative			
Intraoperative			
Postoperative			

Physician's Signature:_____ Date:_____

Appendix 4 Blood Pressure Monitoring Tracking Form

Date	7:00 Morning	10:00 Morning	15：00 Afternoon	20：00 Before bed	Blood pressure control Medication plan

Nurse's signature: _____ Date:_____

Appendix 5 The Impact of Surgical Procedures on Blood Pressure

Surgical operation	Effects on blood pressure
Invasive procedures performed under awake conditions	Increased blood pressure
Inadequate depth of anesthesia or insufficient analgesia during the induction phase	Increased blood pressure
Endotracheal intubation, urinary catheter, drainage tube	Increased blood pressure
Cardiac surgery	Increased blood pressure
Major vascular surgery	Increased blood pressure
Neurological and head and neck surgery	Increased blood pressure
Kidney transplantation	Increased blood pressure
Major trauma surgery (burns or head injuries)	Increased blood pressure
Excessive fluid infusion leading to volume overload	Increased blood pressure
Postoperative 24-48 hours extravascular fluid return to the bloodstream	Increased blood pressure
Compression of the heart and major vessels due to packing, retractors, etc.	Decreased blood pressure
Epidural anesthesia (T1 to T4)	Decreased blood pressure
General anesthesia induction phase	Decreased blood pressure
After clamping the opened aorta	Decreased blood pressure
After releasing the tourniquet	Decreased blood pressure
Posterior fossa surgery stimulating the vascular motor center	Decreased blood pressure
Neck surgery compressing the carotid sinus	Decreased blood pressure

Tension on the viscera and peritoneum	Decreased blood pressure
Direct stimulation of the vagus nerve during surgery	Decreased blood pressure
Excessive blood loss during surgery	Decreased blood pressure
Transfusion reactions	Effects on blood pressure

Appendix 6 Common Intravenous Antihypertensive Drugs for Perioperative Hypertension

Antihypertensive Drugs	Indications	Mechanism of Action	Dosage and Administration	Onset Time	Duration	Adverse Reactions	Contraindications
Metoprolol	Perioperative hypertension, sinus tachycardia occurring during induction of anesthesia or during anesthesia.	Selective β1 receptor blocker	3-5 mg IV push, repeat every 5 min, maximum up to 15 mg	5-10 min	5-10 h	Hypotension, heart failure, cardiac conduction block, dizziness, fatigue, depression, bronchospasm, diarrhea, skin itching, rash	Second and third-degree AV block, cardiogenic shock, severe bradycardia (heart rate less than 60 beats/min), systolic blood pressure less than 12 mmHg, heart failure, sick sinus syndrome, and contraindicated in pregnant women.
Esmolol	Perioperative hypertension, sinus tachycardia, control of ventricular rate in atrial fibrillation and atrial flutter.	Selective β1 receptor blocker	0.15-0.3 mg·kg-1·min-1 infusion	1-2 min	10-20 min	Hypotension, bronchospasm, heart failure, cardiac conduction block	Bronchial asthma or history of bronchial asthma, severe chronic obstructive pulmonary disease, sinus bradycardia, second and third-degree AV block, refractory heart failure, cardiogenic shock, and contraindicated in those allergic to this drug.
Labetalol		α, β receptor blocker	25-50 mg IV over 15 min, can be repeated, total up to 200 mg; can also be infused IV at 1-4 mg·min-1, adjusted according to blood pressure	5-10 min	3-6 h	Nausea, scalp numbness, bronchospasm, dizziness, cardiac conduction block, orthostatic hypotension	Bronchial asthma, cardiogenic shock, second and third-degree AV block, severe or acute heart failure, severe sinus bradycardia, severe persistent hypotension, and contraindicated in those allergic to this drug.

Urapidil	Control of blood pressure before surgery. Also used for hypertensive crises.	Peripherally selective α1 receptor blocker, centrally activating 5-HT-1A receptor	25 mg IV push, can be repeated every 2 min, total up to 100 mg, or infused IV at 5-40 mg·h-1, adjusted according to blood pressure.	0.5-3 min	40-90 min	Hypotension, headache, dizziness	Contraindicated in those allergic to this drug, patients with aortic coarctation or arteriovenous shunt (except for shunts during renal dialysis), and contraindicated in breastfeeding women.
Diltiazem	Perioperative hypertension and hypertensive crises, severe and very severe hypertension, refractory hypertension.	Calcium channel blocker	5-10 mg IV push, or 5-15 μg·kg-1·min-1 infusion	2-7 min	0.5-10 h	Bradycardia, AV block, hypotension, heart failure, peripheral edema, headache, constipation, hepatotoxicity	Severe hypotensive patients, sick sinus syndrome, second-degree or higher AV block (except for those with a ventricular pacemaker), cardiogenic shock, acute myocardial infarction with pulmonary congestion, severe congestive heart failure, severe cardiomyopathy, pregnant women or women who may become pregnant, and those allergic to this drug are contraindicated.
Nicardipine	Emergency management of abnormal hypertension during surgery, hypertensive emergencies.	Calcium channel blocker	0.5-10 μg·kg-1·min-1 IV administration, adjusted according to blood pressure	5-10 min	1-4 h	Tachycardia, headache, peripheral edema, angina, nausea, AV block, dizziness	Severe aortic stenosis, intracranial hemorrhage not fully controlled, acute phase of stroke with increased intracranial pressure, and those allergic to this drug are contraindicated.

Sodium Nitroprusside	Emergency management of abnormal hypertension during surgery, hypertensive emergencies.	NO donor	Start infusion at 6.25-12.5 μg·min-1, adjust dose according to blood pressure	Immediate	2-10 min	Hypotension, tachycardia, headache, cyanide and thiocyanate poisoning, nausea, flushing, vomiting, muscle cramps, pulmonary shunting	
Nitroglycerin	Emergency reduction of paroxysmal hypertension before and after surgery; controlled hypotension during anesthesia, hypertensive emergencies.	NO donor	Initial dose 5-100 μg·min-1 IV drip, gradually titrated, maximum dose 200-400 μg·min-1	2-5 min	5-10 min	Hypotension, headache, dizziness, vomiting, rapid tolerance, methemoglobinemia	Compensatory hypertension (such as hypertension associated with arteriovenous shunt or aortic coarctation), congestive heart failure caused by reduced peripheral vascular resistance, symptomatic hypotension, optic nerve atrophy, tobacco poisoning amblyopia, increased intracranial pressure, pregnant women, and those allergic to this drug are contraindicated.

Appendix 7 Common Antihypertensive Drugs Used in the Perioperative Period for Pregnancy-Induced Hypertension

Antihypertensive Drugs	Dosage and Administration	Notes

Labetalol	Oral: 50-150 mg, 3-4 times daily.	Currently the only recommended α/β receptor blocker for pregnancy-induced hypertension; it lowers blood pressure without affecting renal and placental perfusion, making it a first-line medication for pregnancy-induced hypertension and preeclampsia.
Nifedipine	Intravenous injection: Initial dose 20 mg, then 1-2 mg·min-1; if no effective blood pressure reduction after 10 minutes, double the dose, with a maximum single dose of 80 mg until blood pressure is controlled, and a maximum total daily dose of 220 mg; can also be diluted to 50-100 mg for intravenous infusion.	Short-acting nifedipine taken sublingually has a rapid blood pressure-lowering effect, significantly reducing mean arterial pressure within 10-30 minutes after administration, and can easily lead to severe hypotension, myocardial infarction, and poor fetal outcomes. Therefore, sublingual short-acting formulations should only be considered as an alternative for acute, severe hypertension during pregnancy or the postpartum period. When intravenous medications are not immediately available, sublingual administration of 10 mg short-acting nifedipine can be one of the alternatives to intravenous labetalol.
Methyldopa	Available in short-acting and controlled-release formulations; short-acting dosage: 5-10 mg orally, 3-4 times daily, with a maximum daily dose of 60 mg (short-acting nifedipine can be used for emergency blood pressure reduction, 10 mg orally, repeat the above dose if no effect after 30-45 minutes, but not recommended for routine use); controlled-release tablet 20 mg orally, 1-2 times daily or controlled-release formulation 30-60 mg once daily.	Phenoxybenzamine can reduce cardiac afterload, improve pulmonary hypertension, and enhance myocardial oxygen supply, making it the first choice for pregnancy-induced hypertensive heart disease. Urapidil has a rapid antihypertensive effect, suitable for treating hypertensive crises and refractory hypertension, used to control perioperative hypertension.
Nicardipine	250-500 mg orally, 2-3 times daily, adjusting the dose every 2 days until	Due to the risk of fetal cyanide toxicity associated with sodium

	the desired effect is achieved, with a maximum daily dose not exceeding 3g.	nitroprusside, it is not recommended for routine use and is only suitable for hypertensive crises in pregnant women when other antihypertensive medications are ineffective, with a pre-delivery application time not exceeding 4 hours. Magnesium sulfate is the most effective and widely used medication for the treatment of seizures in preeclampsia and for the prevention of eclampsia.
Nitroglycerin	Initial oral dose 20-40 mg, 3 times daily. Intravenous infusion: 0.5-1.0 μg·kg-1·min-1, effective in 5-10 minutes.	Currently the only recommended α/β receptor blocker for pregnancy-induced hypertension; it lowers blood pressure without affecting renal and placental perfusion, making it a first-line medication for pregnancy-induced hypertension and preeclampsia.
Phenoxybenzamine	Starting dose 5-10 μg·min-1 intravenous infusion, increasing the infusion rate every 5-10 minutes to a maintenance dose of 20-50 μg·min-1.	Short-acting nifedipine taken sublingually has a rapid blood pressure-lowering effect, significantly reducing mean arterial pressure within 10-30 minutes after administration, and can easily lead to severe hypotension, myocardial infarction, and poor fetal outcomes. Therefore, sublingual short-acting formulations should only be considered as an alternative for acute, severe hypertension during pregnancy or the postpartum period. When intravenous medications are not immediately available, sublingual administration of 10 mg short-acting nifedipine can be one of the alternatives to intravenous labetalol.
Urapidil	Intravenous infusion: 10-20 mg once, diluted to 100-200 mL with 5%	Phenoxybenzamine can reduce cardiac afterload, improve

	dextrose injection, infusion rate of 10 μg·min-1, should be adjusted based on blood pressure response.	pulmonary hypertension, and enhance myocardial oxygen supply, making it the first choice for pregnancy-induced hypertensive heart disease. Urapidil has a rapid antihypertensive effect, suitable for treating hypertensive crises and refractory hypertension, used to control perioperative hypertension.
Sodium Nitroprusside	Slow intravenous injection of 10-50 mg, monitoring blood pressure changes, with the effect expected to be evident within 5 minutes. If the effect is not satisfactory, the medication can be repeated. After intravenous injection of urapidil, continuous intravenous infusion should be given to maintain the antihypertensive effect, with the infusion rate adjusted based on the patient's blood pressure, recommended initial rate of 2 mg·min-1, maintenance rate of 9 mg·h-1.	Due to the risk of fetal cyanide toxicity associated with sodium nitroprusside, it is not recommended for routine use and is only suitable for hypertensive crises in pregnant women when other antihypertensive medications are ineffective, with a pre-delivery application time not exceeding 4 hours. Magnesium sulfate is the most effective and widely used medication for the treatment of seizures in preeclampsia and for the prevention of eclampsia.
Magnesium Sulfate	0.5-0.8 μg·kg-1·min-1 slow intravenous infusion.	Currently the only recommended α/β receptor blocker for pregnancy-induced hypertension; it lowers blood pressure without affecting renal and placental perfusion, making it a first-line medication for pregnancy-induced hypertension and preeclampsia.

Appendix 8 Common Intravenous Vasopressors During Surgery

Vasopressors	Indications	Mechanism of Action	Dosage and Administration	Onset Time	Duration	Adverse Reactions	Contraindications
Norepinephrine	Hypotension caused by acute myocardial infarction, extracorporeal circulation, etc.;	Sympathomimetic drug (non-selective α receptor agonist)	Intravenous infusion: Initial infusion rate of 8-12 μg·min-1, adjusted to raise blood pressure to the desired level; maintenance dose of 2-4 μg·min-1, may increase if necessary but not exceeding 25 μg·min-1, and must maintain or replenish blood volume;	Immediate	1-2 min	1. Cardiovascular system: arrhythmia, hypertension (possibly accompanied by reflex bradycardia) 2. Urinary and reproductive system: anuria, acute renal failure 3. Allergic reaction: rash, facial edema 4. Others: skin along the venous path may become pale, cyanotic, or reddened during intravenous infusion, and may even cause severe dizziness; extravasation of the drug solution can lead to local tissue necrosis	Hypertension, cerebral arteriosclerosis, ischemic heart disease, oliguria or anuria, acute pulmonary edema, and microcirculatory shock patients, contraindicated in cocaine poisoning.

Phenylephrine	Shock and hypotension due to hypovolemia, or hypotension after pheochromocytoma resection;	Sympathomimetic drug	Intravenous injection: In critical cases, dilute 1-2 mg in 10-20 mL and slowly push while adjusting the dose based on blood pressure; switch to infusion for maintenance after blood pressure rises.	10-15 min (subcutaneous or intramuscular injection), immediate (intravenous infusion)	0.5-1 h (subcutaneous or intramuscular injection), 10-15 min (intravenous infusion)	1. Cardiovascular system: Chest discomfort or pain 2. Respiratory system: Difficulty breathing 3. Nervous system: Central nervous system excitation, dizziness, tremors, weakness 4. Mental: Easily agitated	
dopamine	Hypotension during epidural blockade and maintenance of blood pressure after cardiac arrest resuscitation;	Sympathomimetic drug	Subcutaneous or intramuscular injection: Initial dose of 2-5 mg, may add 1-10 mg based on response if necessary;	3-5 min	5-10 min	1. Central nervous system: Ataxia, headache 2. Endocrine system: Inhibition of prolactin, growth hormone, and thyroid hormone secretion 3. Cardiovascular system: Chest pain, palpitations, arrhythmia 4. Respiratory system: Shortness of breath 5. Urinary and reproductive system: Uremia 6. Gastrointestinal tract: Nausea,	Hypertension, coronary heart disease, hyperthyroidism, diabetes, myocardial infarction, angle-closure glaucoma, prostatic hyperplasia, and allergy to this drug are contraindicated.

						vomiting 7. Others: Generalized weakness; pain or coldness in hands and feet, local ischemia and gangrene	
metaraminol	Treatment of shock and maintenance of blood pressure during anesthesia;	Sympathomimetic drug (α receptor agonist)	Intravenous infusion: Slowly infuse 0.1% solution (100-500 μg), may repeat as needed with at least 15 min intervals; for severe hypotension, infuse 10 mg + 500 mL 5% GS or NS, starting at 180 μg·min-1, reduce to 30-60 μg·min-1 based on response.	5-10 min (subcutaneous or intramuscular injection), 1-2 min (intravenous infusion)	0.5-1 h (subcutaneous or intramuscular injection), 10-20 min (intravenous infusion)	1. Cardiovascular system: Arrhythmia; has a cumulative effect, blood pressure remains high after discontinuation of medication. 2. Metabolic/endocrine system: Long-term use of medication can cause metabolic acidosis. 3. Respiratory system: Pulmonary edema (case report). 4. Urinary reproductive system: Acute tubular necrosis may be observed. 5. Blood: Leukemoid reaction (case report). 6. Others: Tissue necrosis, erosion, or formation of abscesses; high doses may cause headache, dizziness, nervousness,	Contraindicated in cyclopropane anesthesia, rapid arrhythmias (such as ventricular fibrillation), and allergy to this drug.

						palpitations, chest tightness, tremors; rapid and severe hypertensive response can lead to acute pulmonary edema, arrhythmia, cardiac arrest.	