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Hypertension: Classification, Pathophysiology, and Management During Outpatient Sedation and Local Anesthesia

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Hypertension is defined as a systolic blood pressure (SBP) higher than 140 mHg or a diastolic blood pressure (DBP) higher than 90 mmHg; the diagnosis is based on the average of 2 or more readings taken at each of 2 or more visits after an initial screening.[1,2] When determined by these criteria, hypertension affects 20% to 30% of the adult population in most developed countries, and its prevalence appears to increase with the age of the patient.[3-5] Recent publications have shown that the lifetime risk of hypertension for patients who are normotensive at age 55 is 90%.[1] African Americans are affected by hypertension nearly twice as often as whites and seem to be more vulnerable to its complications.[5,6] Hypertension is an important risk factor for cardiovascular accidents, coronary heart disease, cardiac hypertrophy with heart failure (hypertensive heart disease), aortic dissection, and renal failure. Hypertension can also accelerate atherogenesis and can induce changes favorable for aortic dissection and cerebrovascular hemorrhage.[7] Despite the prevalence of hypertension and its associated complications, only 29% of patients with hypertension are treated, and only 45% of those treated with antihypertensive medications have controlled disease.[7,8]

This paper reviews and summarizes the new classification system based on the Seventh Report of the Joint National Committee on the Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC-7). In addition, it reviews the guidelines, pathophysiology, clinical symptoms, and diagnosis of hypertension. Finally, it reviews treatment recommendations for common local anesthetics, conscious sedative agents, and general anesthetics as they pertain to hypertensive patients undergoing oral and maxillofacial surgery.

Oral and maxillofacial surgeons will frequently encounter patients with undiagnosed or poorly controlled hypertension. The recent JNC-7 report addressed the following issues: *1*) the publication of many new hypertension observational studies and clinical trials; *2*) the need for a new, clear, and concise guideline that would be useful for clinicians; *3*) the need to simplify the classification of blood pressure; and *4*) the clear recognition that previous JNC reports were not being used to their full potential.[1]

JNC Review

JNC-7 is summarized by the following key points and alterations: *1*) for patients older than 50, SBP higher than 140 mmHg is a much more important cardiovascular risk factor than DBP; *2*) the risk of cardiovascular disease (CVD) doubles with each increment of 20/10 mmHg above a baseline of 115/75 mmHg; *3*) the lifetime risk of hypertension for patients who are normotensive at age 55 is 90%; *4*) patients with SBP of 120 to 139 mmHg or DBP of 80 to 89 mmHg should be considered pre-hypertensive and require health-promoting lifestyle modifications

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Table 1. CARDIOVASCULAR RISK FACTORS

Major Risk Factors
Hypertension*
Cigarette smoking
Obesity* (body mass index >30 kg/m^2)
Physical inactivity
Dyslipidemia*
Diabetes mellitus*
Microalbuminuria or estimated glomerular filtration rate <60 mL/min
Age (older than 55 for men or 65 for women)
Family history of premature cardiovascular disease (men <55; women <65)
Target Organ Damage
Heart
Left ventricular hypertrophy
Angina or prior myocardial infarction
Prior coronary revascularization
Heart failure
Brain: stroke or transient ischemic attack
Chronic kidney disease
Peripheral arterial disease
Retinopathy

*Components of metabolic syndrome.

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to prevent CVD; *5*) most patients with hypertension will require 2 or more antihypertensive medications to achieve goal BP (<140/90 mmHg, or <130/80 mmHg for patients with diabetes or chronic kidney disease); *6*) if blood pressure is more than 20/10 mmHg above goal blood pressure, consideration should be given to initiating therapy with 2 agents, one of which is usually a thiazide-type diuretic; and *7*) the most effective therapy prescribed by the most careful clinician will control hypertension only if patients are motivated to follow the prescribed regimen. JNC-7 recognizes 3 objectives in classifying hypertension and in evaluating patients for hypertension: *1*) assessing lifestyle and identifying other cardiovascular risk factors or concomitant disorders that may affect prognosis and guide treatment; *2*) revealing identifiable causes of high blood pressure; and *3*) assessing the presence of target organ damage and CVD. A patient's overall cardiovascular status cannot be based on blood pressure alone; risk factors and known causes of hypertension must also be assessed. JNC-7 also provides guidelines for assessing cardiovascular risk factors (Tables 1, 2).

CLASSIFICATION

The recent JNC-7 has simplified the classification of hypertension into 3 categories: prehypertension (SBP 120 to 139 mmHg, DBP 80 to 89 mmHg), stage 1 hypertension (SBP 140 to 159 mmHg, DBP 90 to 99 mmHg), and stage 2 hypertension (SBP >160 mmHg, DBP >100 mmHg) (Table 3).[9] The correlation between blood pressure and the risk of CVD has been shown to be continuous, consistent, and independent of other risk factors.[1] As blood pressure increases, so does the possibility of heart attack, stroke, and kidney disease. For patients between 40 and 70 years old, each increment of 20 mmHg in SBP or 10 mmHg in DBP doubles the risk of CVD across the entire range from 115/75 mmHg to 185/115 mmHg.[1] The reorganization of JNC classifications recognized that patients with prehypertension are at increased risk of progression to hypertension and that risks are associated with even mildly elevated blood pressure, even pressures in the range previously considered "normal."

HYPERTENSION ETIOLOGY

Most cases of hypertension arise through a chronic disease process; however, some patients will experience sporadic increases and decreases in blood pressure, a condition called labile hypertension. A small percentage of patients may experience accelerated hypertension, known as malignant hypertension. Nearly 90% of cases of hypertension are idiopathic or primary and are classified as essential hypertension. The remaining 10% of cases result from renal failure, cardiovascular disorders, hormonal disease, or neurologic dysfunctions.[5] Essential and secondary hypertension may be caused by genetic or environmental factors.[10] Recent research has not clearly determined whether mutation at a single gene locus or a polygenetic mutation is more commonly responsible for the phenotype of a hypertensive disorder.[3,5,10] Considering environmental factors, nutrition can be used as a potential aid in determining and diagnosing hypertensive risk.[1-3,10,11] Variable contributive causes are high salt intake, alcohol, obesity, and reduced physical activity.[10-12] Early signs and symptoms of hypertension include fluctuating changes in blood pressure and narrowing of the retinal arteries with or without hemorrhage. Symptoms of early hypertension include headache, vision changes, ringing in the ears, or tingling of the hands and feet.[13,14] Later signs may in-

Table 2. IDENTIFIABLE CAUSES OF HYPERTENSION

Sleep apnea
Drug-induced or related causes
Chronic kidney disease
Primary aldosteronism
Renovascular disease
Chronic steroid therapy and Cushing's syndrome
Pheochromocytoma
Coarctation of the aorta
Thyroid or parathyroid disease

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Table 3. CLASSIFICATION AND MANAGEMENT OF BLOOD PRESSURE FOR ADULTS

BP Classification	SBP (mmHg)	DBP (mmHg)	Lifestyle Modification	Without Compelling Indication	With Compelling Indication
Normal	<120	or <80	Encourage		
Prehypertension	120–139	or 80–89	Yes	No antihypertensive drug indicated	Drugs for compelling indications*
Stage 1 hypertension	140–159	or 90–99	Yes	Thiazide diuretics; consider ACEI, ARB, BB, or combination	Drugs for compelling indications* Other antihypertensive drugs as needed (diuretics, ACEI, ARB, BB)
Stage 2 hypertension	>160	or >100	Yes	Two-drug combination† (usually thiazide diuretic and ACEI, or ARB or BB)	

Abbreviations: BP, blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; BB, β-blocker.

*Compelling indications.

†Most compelling indications.

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clude ventricular hypertrophy (based on electrocardiography), hematuria, proteinuria, heart failure, angina, renal failure, or blindness. Secondary hypertension can be caused by diseases of hormonal dysregulation, such as primary aldosteronism, Cushing's syndrome, and pheochromocytoma.[15]

Hypertension varies with the age of the patient. It is interesting to note that younger adults are more likely to have elevated DBP, whereas older adults are more likely to have elevated SBP; DPS plateaus or even decreases with age.[10,13]

Renal failure is a leading cause of secondary hypertension.[5] Hypertension resulting from renal dysfunction develops primarily through the action of renin and angiotensin II. Abnormalities in these systems contribute to essential and secondary hypertension. Diseases or conditions that may alter blood flow through the kidneys include diabetes, renal arterial stenosis, and pheochromocytoma. Another systemic contributor to hypertension is cardiac disease.[5] Cardiac output and total peripheral resistance work in combination to control arterial pressure. Cardiac output is affected by blood volume, which is regulated by systemic sodium levels. Total peripheral resistance is regulated by the diameter of arteriolar vessels, which are under hormonal and neuronal regulation.

Therapy and Anesthesia for Hypertensive Patients Undergoing Oral and Maxillofacial Surgery

Hypertension is associated with increased morbidity and mortality rates among patients with CVD and/or renal disease.[16] One of the goals of antihypertensive therapy for the hypertensive patient undergoing oral and maxillofacial surgery is to reduce the morbidity and mortality rates associated with surgical procedures that involve local anesthetics, conscious sedation, or general anesthesia. JNC-7 recommends guidelines for the general management of hypertension; its recommendations include single or combination therapy with diuretics, β-blockers, or both for uncomplicated hypertension. The treatment of complicated hypertension may require various combinations of medication, including ACE inhibitors, angiotensin II receptor blockers, α-blockers, α/β-blockers, β-blockers, calcium antagonists, and diuretics.[1,16,17] When multiple drugs are used to achieve a target blood pressure of approximately 130/80 mmHg, the possibility of adverse drug interactions increases.[18] Clinicians should become aware of the side effects and interactions of these medications and should know when the use of these agents is an appropriate treatment option.

Effective perioperative management of the hypertensive patient requires controlling stress and anxiety and knowing the uses and adverse interactions of antihypertensive drugs.[13] The greatest concern for the oral and maxillofacial surgeon is the perioperative management of acute and emergent hypertension. Parenteral drugs outlined in Table 8 can be used for hypertensive emergencies and urgencies. Preoperative and postoperative pain control have been shown to be important factors contributing to blood pressure management for oral and maxillofacial surgery patients.[12,19]

LOCAL ANESTHETICS

In 1986, a joint report of the American Heart Association and the American Dental Association stated

Table 4. INJECTABLE LOCAL ANESTHETICS AND RECOMMENDED DOSE

Generic Drug	Maximum Adult Dose	Maximum Pediatric Dose
Articaine HCl 4% with 1:100,000 epinephrine	7 mg/kg	<4 yr: unknown 4–12 yr: same as adult
Bupivacaine HCl 0.5% with 1:200,000 epinephrine	90 mg	<12 yr: unknown
Lidocaine HCl 2%	4.5 mg/kg Maximum: 300 mg	5 mg/kg
Lidocaine HCl 2% with 1:100,000 epinephrine	7 mg/kg Maximum: 500 mg	4–5 mg/kg Maximum: 100–150 mg
Mepivacaine 3%	6.6 mg/kg Maximum: 400 mg	5–6 mg/kg Maximum: 270 mg
Mepivacaine HCl 2% with levonordefrin 1:20,000	6.6 mg/kg Maximum: 400 mg	6.6 mg/kg Maximum: 180 mg
Prilocaine HCl 4%	8 mg/kg Maximum: 600 mg	<10 yr: dose >40 mg rarely needed
Prilocaine HCl 4% with 1:200,000 epinephrine	8 mg/kg Maximum: 60 mg	<10 yr: dose >40 mg rarely needed

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that vasoconstrictors should be used only when the procedure would be shortened or when the depth of anesthesia would be more profound.[20] Local anesthetics are recommended for patients with hypertension because they can decrease pain and increase comfort. True allergy is the only contraindication for the use of such anesthetics.[21] The selection of a local anesthetic solution is based primarily on the duration of the procedure, the need for hemostasis, and the required degree of pain control.[21] Vasoconstrictors are added to local anesthetics to aid in hemostatic control and to increase the duration of the drug's effect. A solution of 2% lidocaine with 1:100,000 epinephrine is the formulation most commonly used to achieve the necessary degree of anesthesia for most dental situations.[22] Bupivacaine is the longest-acting local anesthetic agent generally used. The maximum doses for injectable local anesthetics given to healthy adult and pediatric patients are listed in Table 4.

A risk in the administration of local anesthesia for the hypertensive patient is the inclusion of epinephrine and its sympathomimetic effect on cardiac β_1-receptors. The current maximum recommended dose of local anesthetic solution for a patient with hypertension (poorly controlled ASA Class III or all class IV) is two 1.8-ml cartridges (for a total dose of 3.6 ml) with 1:100,000 epinephrine per appointment [12,13,23] If lengthy procedures are anticipated, the epinephrine should be diluted to a ratio of 1:200,000.[23] Niwa and colleagues[24] showed that patients with mild CVD can withstand a dose of 1.8 ml of 2% lidocaine with 1:80,000 epinephrine without cardiovascular hemodynamic complications.

The side effects of absorbed epinephrine in a stage 2 hypertensive patient must be weighed against the benefits. Many clinical situations will contraindicate the use of epinephrine. The apprehensive, sweating, or nervous patient likely has increased levels of endogenous epinephrine. Because plasma levels of epinephrine are dose dependent, administration of epinephrine to the nervous or apprehensive stage 2 patient would be contraindicated. The type of injection that is administered (block versus infiltration) as well as vascularity of the area where the local anesthetic is being deposited is also a factor.

Norepinephrine or levonordefrin should be avoided because of their unopposed activation of α_1-receptors in the hypertensive patient.[12,23] This activation could lead to uncontrolled increases in blood pressure. Other contraindications to local anesthetics containing vasoconstrictors include severe uncontrolled hypertension, refractory arrhythmia, myocardial infarction or stroke within 6 months, unstable angina, coronary bypass grafting within 3 months, uncontrolled congestive heart failure, and uncontrolled hyperthyroidism.[13] Clinicians should be cautious when administering local anesthetics at dosages higher than recommended; they should also be aware of the potential interactions between commonly used local anesthetics and antihypertensive drugs such as tricyclic antidepressants, adrenergic neuron blockers, nonselective β-blockers, and inhalation anesthetics. Table 4 lists the most recent dosing recommendations for commonly used local anesthetics.

CONSCIOUS SEDATION

An inherent difficulty exists when comparing the effects on hypertension of unrelated drugs used for conscious sedation. The doses and titrations of drugs used for conscious sedation differ for each patient, and reports of morbidity and mortality rates can be conflicting.[22,25] Many studies have been performed with healthy subjects, who can be significantly different from hypertensive patients. The outcomes of drug administration will vary on the basis of health status.

Surgeons and educators may use different techniques when administering anesthetics, and several different approaches may be safe and effective.

Drugs commonly administered for conscious sedation include benzodiazepines, given alone or in combination with a barbiturate, propofol, an opioid, an antihistamine, ketamine, and/or droperidol.[25] These drugs have been shown to be effective in relieving pain and anxiety, which are important factors in the management of hypertension.[19]

Benzodiazepines, when given at sufficient dosages, cause a generalized depression of the central nervous system and a loss of muscular coordination. It has been suggested that benzodiazepines function by increasing the inhibitory activity of the neurotransmitter γ-aminobutyric acid (GABA), an important inhibitory transmitter in the brain.[26] Rodrigo and coworkers[27] reported that the incidence of unifocal ventricular ectopic dysrhythmias is increased during conscious sedation with midazolam. Roelofse and van der Bijl[28] reported that the administration of midazolam with a local anesthetic can increase the incidence of cardiac dysrhythmias; however, they pointed out that this finding is contradicted by those of other researchers, who found that the incidence of dysrhythmias was decreased when certain benzodiazepines were used in conjunction with local anesthetics. These authors argued that the incidence of dysrhythmias is so common that this complication should be considered a normal sequelae of dental surgery among healthy patients.[28]

A study by van der Bijl and colleagues[22] found that the various benzodiazepines differentially increase mean arterial pressure and average heart rate; other researchers found that changes in blood pressure or heart rate are usually insignificant when these drugs are carefully titrated.[25] It is generally agreed that the benzodiazepines rarely cause adverse cardiovascular effects, even among patients with substantial cardiac disease.[26] There are no significant contraindications for the use of these agents in dental practice[21] (Table 5).

Barbiturates act by enhancing metabolic enzyme function and depressing ascending neuronal conduction to the cerebral cortex and to the limbic and reticular activating systems. These drugs can achieve a wide range of depression, from light sedation to hypnosis, general anesthesia, coma, and death.[21] Barbiturates have unpredictable effects on analgesia and can render patients restless and difficult to treat when they are in pain.[21] The effects of these agents are proportional to their accumulation and excretion. The cardiovascular system is generally resistant to the physiological changes induced by these agents.[26] However, because some researchers have found that the use of barbiturates is associated with hypotension, cardiac dysrhythmias, and bradycardia, these agents should be used with caution for patients with congestive heart failure[21] (Table 5).

Propofol is a sedative-hypnotic agent; its clinical use is comparable to that of barbiturates. It causes a decrease in cerebral metabolism, blood flow, and intracranial pressure. It has been shown to cause profound hypotension when given as a bolus; this effect is most likely due to direct myocardial depression and a decrease in systemic vascular resistance. Its administration to patients of advanced age has been associated with alterations in the cardiovascular response[26] such as inotropic effects or a decrease in systemic blood pressure because of decreased peripheral resistance.

Ketamine is a general anesthetic that provides profound analgesia and amnesia. It causes an excitatory dissociative state that is not associated with the use of other anesthetic drugs.[26] Ketamine is the only intravenous anesthetic that routinely produces an increase in heart rate, arterial blood pressure, and cardiac output. It causes the release of endogenous catecholamines and is therefore contraindicated for patients with hypertension. Ketamine is commonly and effectively administered to pediatric patients (Table 5).

Opioids can produce profound analgesia. The effects of these drugs include analgesia, drowsiness, mood swings, and mental confusion. There are 3 groups of opioid analgesics: opioid agonists, which interact with central nervous system receptors to produce a physiologic response; opioid antagonists, which occupy a receptor site without a physiologic response; and opioid agonists/antagonists, which possess properties of both groups. Research has shown that the anticholinergic effects of opioids can lead to increases in heart rate because of the vagolytic properties of these agents.[26] When used as conscious sedative agents, opioids have been associated with hypotension, peripheral circulatory collapse, and cardiac arrest.[21] However, hypertension does not contraindicate the use of opioids.

Droperidol (a neuroleptanesthetic) is an effective tranquilizing agent, especially for pediatric patients. Its effects are seen in its ability to alter the action of dopamine in the subcortical levels of the central nervous system, thereby inducing a sedative state. Droperidol causes a sleepy, psychologically detached state in which the patient can still respond to commands. Its use is contraindicated for patients with CVD because it blocks the vasopressor activity of epinephrine. Orthostatic hypotension is also a contraindication for the use of this agent. Table 5 lists common conscious sedative agents and their maximum recommended dosages.

Table 5. INTRAVENOUSLY ADMINISTERED CONSCIOUS SEDATIVE AGENTS AND RECOMMENDED DOSES

Drug Class	Generic Name	Maximum Adult Dose	Maximum Pediatric Dose	Onset/Duration	Hypertensive Complications
Benzodiazapenes					
	Diazepam	30 mg	NE	0–15 min/45–120 min	Minimal hemodynamic changes
	Midazolam	<60 yr, unpremedicated: 5 mg IV >60 yr, debilitated, or chronically ill: 3.5 mg IV	<6 mo: NE >6 mo–5 yr: 6 mg IV 6–12 yr: 10 mg IV	1–5 min/30 min	Minimal hemodynamic changes
Opioids					
	Meperidine	NE	50 mg	5 min/4–6 hr	Mild hypotension, decreased vascular resistance, orthostatic hypotension, renal or liver disease; may increase CNS toxicity; decreased CO
	Fentanyl	NE	4–5 μg/kg	Immediate/0.5–1 hr	Bradycardia (children), cardiovascular instability
	Pentazocine	Up to 360 mg/day	NE	2–3 min/2–3 hr	Depressed myocardial contractility, increased peripheral resistance, contraction of plasma catecholamines
	Nalbuphine	20 mg single dose 160 mg/day	NE		No increases in blood pressure or heart rate
	Butorphanol	NE	NE		Increased cardiac work; increased systemic arterial pressure
Propofol		NE	50–200 μg/kg	9–51 sec/3–10 min	Depressed MAP; no effect on heart rate; hypotensive effects are dose related
Barbiturates					
	Methohexital	100 mg	NE for children <3 yr	Immediate/5–7 min	Circulatory depression
	Phenobarbital	NE	NE	5 min/2–3 hr	
Ketamine		NE	5–10 mg/kg deep sedation general anesthesia	1–2 min/7–11 min	Increased heart rate, CO; AVOID for patients with hypertension
Antihistamines					
	Promethazine	NE	NE	20 min/1–2 hr	Minimal hemodynamic changes
	Diphenhydramine	NE	300 mg/day	1–3 hr/4–7 hr	Minimal hemodynamic changes
Droperidol		NE	NE	Immeditate/2–4 hr	Blocks α_1-receptors, decreases TPR

Abbreviations: NE, not established; CNS, central nervous system; CO, cardiac output; MAP, mean arterial pressure; TPR, total peripheral resistance.

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Table 6. GENERAL ANESTHETIC AGENTS

Drug Class	Generic Name	Maximum Adult Dose	Maximum Pediatric Dose	Onset/Duration	Hypertensive Complications
Muscle relaxants					
	Tubocurarine	Initial: 6–9 mg	>1 mo: 0.5–0.6 mg/kg Maintenance: 0.1 mg/kg PRN	2–5 min/20–90 min	Hypotension; reactions more common in patients with preexisting cardiovascular disease
	Succinylcholine	Initial: 0.3–1.1 mg/kg Maintenance: 0.3–1.0 mg/kg PRN	0.1–2 mg/kg PRN	Immediate/10 min	Bradycardia, cardiac arrest, especially in children; after second dose, atropine should be administered
Inhalational agents					
	Halothane	Initial: 0.5–3% Maintenance: 0.5–1.5%	Individualized	Rapid/rapid	Preexisting cardiovascular disease or pheochromocytoma: cardiovascular effects such as dysrhythmias, hypotension, myocardial depression, and peripheral vasodilation
	Sevoflurane	Initial: individualized Maintenance: 0.5–3%	Same as adult	Rapid/rapid	
	Isoflurane	Initial: 0.5–3% Maintenance: 0.5–1.5%	Individualized	Rapid/rapid	Decreases mean arterial pressure, increases heart rate, transient sympathetic activation
	Desflurane	Initial: 0.5–3% Maintenance: 2.5–8.5%	Not recommended for induction Maintenance: 5.2–10%	Very rapid/very rapid	Preexisting cardiovascular disease or pheochromocytoma: cardiovascular effects such as dysrhythmias, hypotension, myocardial depression, and peripheral vasodilation, tachycardia, hypertension
	Nitrous oxide	Induction: 70% and 30% O_2 Maintenance: 30%–70% with O_2	Individualized	Very rapid/very rapid	80% N_2O–20% O_2 causes increased response of vascular smooth muscle to norepinephrine

Abbreviation: PRN, as needed.

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Table 7. DEGREES OF HYPERTENSION

Category (Pressures in DBP)	Signs	Treatment Goal
I. Hypertensive emergencies (<1% of all hypertensive patients)	Evidence of end organ damage in brain, heart, kidneys	Lower blood pressure to level normal for that patient within 30–60 min in a controlled, graded manner
II. Hypertensive urgencies (Usually >115 mmHg DBP)	Elevation of blood pressure levels to a state that may be potentially harmful without evidence of end organ damage	Reduce blood pressure gradually within 24–48 hr; rapid reductions are potentially harmful and should be avoided
III. Uncomplicated hypertension (Blood pressure <115 mmHg DBP)	No signs of end organ damage	Treated acutely and aggressively with follow-up care
IV. Transient hypertension	Resulting from underlying disease or disorder, such as anxiety, pancreatitis, stroke, epistaxis, etc.	Treatment includes resolution of the underlying condition, rather than antihypertensive medication

Abbreviation: DBP, diastolic blood pressure.

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When drugs are combined, the likelihood of cross-reactive complications must be considered. The advantage of drug combinations is that the administered amount of either drug can be reduced, thereby reducing associated morbidity rates and increasing the ability to control the agents' effects. Dionne[25] reported that midazolam, used alone or in combination with other agents, can effectively relieve anxiety. Likewise, the combination of midazolam and fentanyl or of midazolam and methohexital can substantially reduce patients' perceptions of pain. These combinations also have various effects on respiratory rate, oxygen saturation, and mean arterial pressure.[22,24,27,28]

Most studies agree that the most effective treatment for patients at risk of a hemodynamic event during conscious sedation is careful monitoring of respiration, oxygen saturation, and cardiovascular homeostasis (by electrocardiography).[22,24,27,28] Malamed[29] noted that episodic increases in blood pressure were most commonly caused by light anesthesia or sedation and by the patient's experience of pain during treatment.

GENERAL ANESTHETICS

General anesthetic agents can have various effects on the hypertensive patient. Common general anesthetic drugs include intravenous induction agents, opioids, neuroleptanesthetics, ketamine, muscle relaxants, and inhalational anesthetics. Intravenous induction agents include the benzodiazepines, barbiturates, ketamine, and propofol. The contraindications for these drugs and those for opioids and neuroleptanesthetics such as fentanyl and droperidol are the same as those for conscious sedation (Table 5). The complications that may be associated with barbiturates and ketamine, when these drugs are used as general anesthetics, are dysrhythmia and tachycardia; in contrast, propofol is associated with bradycardia.[21]

Neuromuscular blocking agents can relax skeletal muscle and facilitate mechanical ventilation during general anesthesia. Neuromuscular blocking agents are classified as nondepolarizing drugs because of their ability to bind to motor end plate acetylcholine receptors, thereby preventing further depolarization. Because of its ability to mimic the effects of acetylcholine, succinylcholine, which consists of 2 acetylcholine molecules linked end to end, is frequently used for general anesthesia. The use of succinylcholine can be associated with profound bradycardia because the drug excites the myocardial acetylcholine receptors. The complications associated with succinylcholine are bradycardia, dysrhythmia, and cardiac arrest.[21] The risk of cardiovascular reaction associated with succinylcholine is higher when patients have experienced hyperkalemia, severe burns or trauma, spinal cord injury, or neuromuscular disease.[21]

Inhalational anesthetics are commonly used after induction agents to produce and maintain general anesthesia. Inhalational agents are contraindicated for patients with coronary artery disease, congestive heart failure, other forms of CVD, or pheochromocytoma. Complications associated with these agents are dysrhythmia and myocardial depression leading to hypotension with or without peripheral vasodilation. Special care should be used when halothane or desflurane is administered to patients with cardiovascular conditions, because these agents are more likely than others to result in cardiovascular stimulation.[21] Desflurane has been shown to cause increases in catecholamine release; its administration may cause hypertensive episodes among healthy patients.[29]

Nitrous oxide has anesthetic properties and can also interact with endogenous opioid receptors. When nitrous oxide is used at a ratio of 80% N_2O to 20% O_2, myocardial contraction is depressed because of the drug's direct action on the heart and the re-

Table 8. PARENTERAL DRUGS FOR THE TREATMENT OF HYPERTENSIVE EMERGENCIES OR URGENCIES

Drug	Dosage	Onset	Adverse Effects
Sodium nitroprusside	0.25–10 μg/kg/min as IV infusion	Immediate	Nausea, vomiting, sweating
Phentolamine	5 mg 1–2 hr before procedure	Immediate	Hypotension, tachycardia, orthostatic hypotension
Esmolol	500 μg/kg/min for first 4 min; then 150–300 μg/kg/min as IV infusion	1–2 min	Hypotension
Intravenous nitroglycerin	5–100 g/min as IV infusion	2–5 min	Tachycardia, vomiting, methemoglobinemia
Diazoxide	1–3 mg/kg up to 600 mg every 5–10 min by IV bolus	5 min	Hypotension, tachycardia, heart failure
Labetalol	10–80 mg by IV bolus every 10 min 0.5–2 mg/min by IV infusion	5–10 min	Vomiting, postural hypotension, nausea
Hydralazine	10–20 mg as IV bolus	5–20 min	Tachycardia, flushing, aggravation of angina
Nifedipine	5–10 mg sublingually	5–15 min Duration: 3–5 hr	Use may be contraindicated due to risk of MI
Clonidine	0.2 mg orally; then 0.1 mg/hr	0.5–2 hr Duration 6–8 hr	Postural hypotension, severe headache, nausea, vomiting

Abbreviations: IV, intravenous; MI, myocardial infarction.

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sponse of smooth muscle to norepinephrine is slightly increased. Nitrous oxide has a very minimal clinically evident effect on the cardiovascular system when used below this ratio (Table 6).

HYPERTENSIVE MANAGEMENT

Hypertensive crisis is described as SBP of at least 250 mmHg, DBP of at least 130 mmHg, or both. Patients with chronic but stable high blood pressure are more likely than others to experience hypertensive crisis.[26] The patient's clinical presentation and health status should be used to determine the need for elective treatment or immediate treatment. Toward this goal, the 4 general categories described by Dym[30] are useful in determining the patient's level of risk and the urgency of treatment (Tables 7, 8).

Hypertensive Emergencies

SODIUM NITROPRUSSIDE

Sodium nitroprusside causes direct peripheral vasodilation by acting on arteriolar and venous smooth muscle. It can be used to treat patients with all hypertensive emergencies except pregnancy-induced hypertension.[30] This drug is commonly recommended for managing hypertensive crisis or congestive heart failure. It has a rapid onset of action (<2 minutes). A reasonable goal is a 30% reduction of DBP within 30 to 60 minutes.[30]

β-BLOCKERS

Esmolol is a cardioselective β-blocker that is commonly used to manage perioperative hypertension. At low doses, this agent competitively blocks β_1-adrenergic receptors with minimal effects on β_2-receptors. It has a short half-life of approximately 9 minutes. The total duration of its effects is relatively short, and a return to baseline blood pressure levels occurs in approximately 20 to 30 minutes.

Labetalol blocks α-, β_1-, and β_2-receptors, thereby producing a direct vasodilatory response. It causes a reduction in systolic arterial pressure and a decrease in total peripheral resistance. This agent is indicated for patients with cerebrovascular disease because it does not alter cerebrovascular blood flow. It is a drug of choice for patients who exhibit excessive catecholamine production, such as those with pheochromocytoma; for those with monoamine oxidase inhibitor (MAOI)–induced emergencies; and for those who experience abrupt clonidine withdrawal.[30] Response is rapid; the average half-life of labetalol is 7 to 10 hours. Care should be taken to avoid exacerbations of congestive heart failure or induced bronchospasm from nonselective actions on β-receptors.

INTRAVENOUSLY ADMINISTERED NITROGLYCERIN

Intravenously administered nitroglycerin decreases left ventricular pressure and systemic vascular resistance. Its primary effect is venodilation.

It is an excellent drug for the management of perioperative hypertensive emergencies. Its effects are immediate, and its half-life is 1 to 4 minutes. It is the drug of choice for treating hypertension that complicates angina, myocardial infarction, or pulmonary edema.

HYDRALAZINE

Hydralazine has direct effects as an arteriolar dilating agent with little to no effect on the venous system. It has a moderate onset of action, but its effects can last for 2 to 6 hours. Its use as a sole agent is contraindicated except for younger patients who can handle increases in output without experiencing ischemia.[30]

DIAZOXIDE

Diazoxide inhibits the release of insulin from the pancreas and produces direct relaxation of smooth muscle. Peripheral arteriolar dilation results in decreased total peripheral resistance, which causes reflex tachycardia and increased cardiac output. The potency and toxicity of this agent may be increased when it is administered concomitantly with diuretics or other antihypertensive agents. Its effects peak within 5 minutes and last for 3 to 12 hours.

Hypertensive Urgencies

NIFEDIPINE

Nifedipine inhibits the entry of calcium ions into "slow channels" of smooth muscle and myocardium during depolarization, thus producing relaxation and vasodilation. Recent reports indicate that prompt acting nifedipine may increase the incidence of myocardial infarction.[30] Caution should be used if this agent is administered to patients with coronary disease or electrocardiographic evidence of left ventricular hypertrophy.[31] Other calcium channel blocking agents that can be substituted for nifedipine are verapamil, bepridil, and diltiazem.

ORALLY ADMINISTERED CLONIDINE

Orally administered clonidine is a central $\alpha 2$ agonist that, upon stimulation, decreases the systemic sympathetic outflow of norepinephrine, thus decreasing peripheral resistance. Substantial sedation is a serious side effect that contraindicates the use of this agent for patients with cerebrovascular involvement. The side effects associated with the agent can occur within 30 minutes to 1 hour after administration and can last for as long as 10 hours. Blood pressure should be checked at 15-minute intervals during the first hour after administration and at 30-minute intervals during the second hour.[30]

The new guidelines for the classification of hypertension and the list of cardiovascular risk factors provided by JNC-7 are more helpful to oral and maxillofacial surgeons than previous such documents related to diagnosing hypertension and treating patients with this condition. Cardiovascular hypertensive disorders affect the use of anesthetic treatment regimens for patients undergoing oral and maxillofacial surgery. The majority of the cases that are treated by the oral and maxillofacial surgeon are in settings that are elective, acute, or emergent. Therefore, clinicians should become aware of drug interactions and of the clinical classification of hypertensive stages. Prompt diagnosis and treatment can mean the difference between life and death for patients undergoing procedures that involve local, conscious sedative, or general anesthetic agents.

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