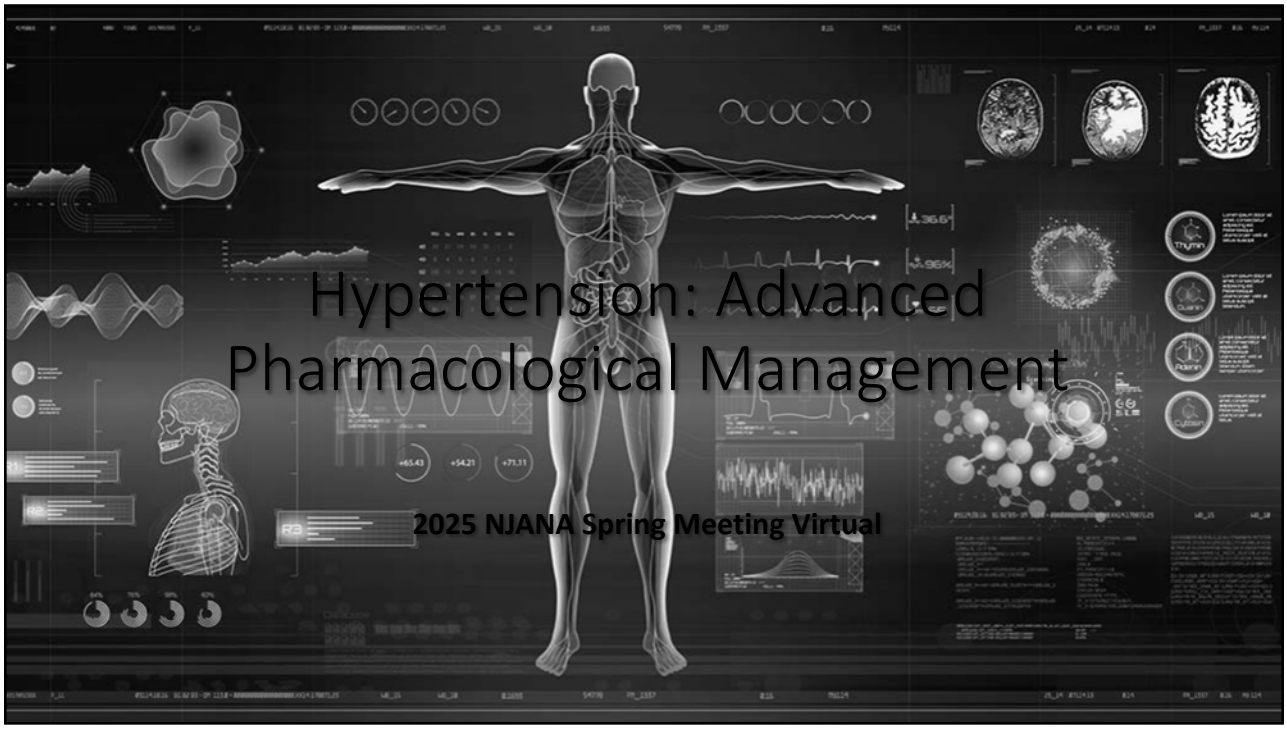


Hypertension: Advanced Pharmacological Management

2025 NJANA Spring Meeting Virtual

1

COI Statement:

I am a current member of the NBCRNA Board of Directors. The content expressed in my lecture is based on my own clinical expertise and in no way reflects any view, opinion or position of the NBCRNA. I have no access to any of the NBCRNA assessment items, content or exam development, including, but not limited to, the CPCA.

2

2

Objectives

The learner will be able to;

- Analyze the pathophysiology and perioperative implications of hypertension and anesthesia practice.
- Evaluate pharmacological strategies for optimizing perioperative blood pressure control.
- Design and implement evidence based anesthetic plans for hypertensive patients undergoing surgery.

3

Hypertension in the Surgical Patient – Overview

- **Prevalence:**
  - Hypertension is **very common** in surgical populations (**over half of patients >45 years**).
  - It is one of the **most frequent comorbidities** encountered by anesthesia providers.
- **Guidelines Impact:**
  - Recent guidelines (ACC/AHA 2017, ESC/ESH 2018) **lowered the BP threshold for diagnosis** (e.g., **≥130/80 mmHg** per ACC/AHA), resulting in more patients being labeled and treated as hypertensive.
  - Many surgical patients arrive on **multiple antihypertensive medications**.

4

Hypertension in the Surgical Patient – Overview

- **Chronic vs Perioperative Goals:**
  - **Chronic HTN management** aims to *reduce long-term CV* risk
  - **Perioperative management** focuses on *preventing immediate complications*.
    - **Perioperative BP targets** may be different from outpatient targets, emphasizing **stability over aggressive reduction**.
- **Significance:**
  - **Uncontrolled hypertension** is a *modifiable risk factor*
  - **Proper management** can reduce the incidence of stroke, myocardial infarction, and other complications around the time of surgery.
  - It sets the context for intraoperative management strategies.

5

Pathophysiology – Mechanisms of Hypertension

- **Primary (Essential) HTN:**
  - ~90% of cases
  - multifactorial etiology (genetics, high salt intake, obesity, stress).
  - Key mechanisms include **chronic sympathetic overactivity** and **renin-angiotensin-aldosterone system (RAAS) upregulation** leading to vasoconstriction and sodium retention.
  - **Result:** increased systemic vascular resistance (SVR) and cardiac output = high BP.
- **RAAS Activation:**
- **Renin release** (e.g., due to renal hypoperfusion or β-1 stimulation) → Angiotensin II (a potent vasoconstrictor) → aldosterone release (Na^+ water retention).
- Chronically, **angiotensin II** also causes *vascular smooth muscle hypertrophy*, sustaining hypertension.

6

Pathophysiology – Mechanisms of Hypertension

- **Sympathetic Nervous System:**
  - **Excess catecholamine activity** (high norepinephrine) stimulates α-1 receptors (vasoconstriction) and β-1 receptors (increasing heart rate and contractility), contributing to higher BP.
  - **Baroreceptors** may reset to tolerate higher pressures.

- **Secondary HTN:**
  - ~10% cases
  - **identifiable causes** (renal artery stenosis, hyperaldosteronism, pheochromocytoma, etc.).
  - Important to recognize if a patient has **refractory or malignant HTN**, as the approach (and preop prep) might involve treating the underlying cause (e.g., **α-blockade for pheochromocytoma**) before surgery.

7

Pathophysiology – Target Organ Effects of Chronic HTN

- **Cardiac Remodeling:**
  - **Chronically elevated afterload** causes left ventricular hypertrophy (LVH) and diastolic dysfunction.
  - The **thickened LV wall** becomes less compliant, raising LV end-diastolic pressure and impairing filling.
  - This can lead to **heart failure with preserved EF** (HFpEF) and increases myocardial oxygen demand.

- **Coronary Perfusion:**
  - **High LVEDP and shorter diastole** (if HR is high) reduce subendocardial blood flow.
  - Coupled with any **coronary artery disease**, this means hypertensive patients are at risk for myocardial ischemia, especially if **tachycardic or if BP drops too low** to perfuse the heart.
  - Coronary perfusion pressure ≈ DBP – LVEDP
  - a stiff LV elevates LVEDP, thus hypertensives may require higher DBP to perfuse the myocardium).

8

Pathophysiology – Target Organ Effects of Chronic HTN

- **Vascular Changes:**
  - **Hypertension** accelerates atherosclerosis in arteries.
  - Patients often have **coexistent coronary artery disease and carotid or peripheral arterial disease**.
  - **Cerebral arteries** can become less compliant
    - **Chronic HTN** is a leading cause of both ischemic and hemorrhagic stroke.
    - Arterial stiffness leads to widened pulse pressure in the elderly.
- **Renal Damage:**
  - Long-standing HTN causes **nephrosclerosis** – thickening of renal arterioles and glomerular damage.
  - This can manifest as **chronic kidney disease (reduced GFR)**.
  - **Hypertensive patients** may have baseline impaired renal reserve and be prone to acute kidney injury if perfusion drops.

9

Pathophysiology – Target Organ Effects of Chronic HTN

- **Autoregulation Shift:**
  - In some organs (brain, kidney), autoregulatory range for blood flow may shift upward in chronic HTN.
  - This means these patients might **require higher perfusion pressures** to maintain adequate blood flow.
  - A "normal" blood pressure for others could be relatively low for them, risking hypoperfusion.

"Stay calm… I'm gonna get a second opinion on your blood pressure."

10

Hemodynamic Implications in Anesthesia

BP Lability:
- Hypertensive patients display **exaggerated hemodynamic responses**.
- Induction and intubation can cause larger BP and HR spikes than normal, and they may also experience precipitous drops in BP with anesthetic induction.
- The **baroreceptor reflex in chronic HTN (DANGER)** is often blunted or reset to a higher pressure, slowing compensation for acute changes.

Autoregulation & Perfusion:
- Because of **altered autoregulation**, aggressive BP reduction can cause organ hypoperfusion.
- A hypertensive patient might depend on higher pressures for coronary and cerebral perfusion.
- For example, lowering MAP to 60 mmHg in someone whose brain is used to MAP 100 could risk cerebral ischemia.

11

Hemodynamic Implications in Anesthesia

- **Induction Concerns: Vasodilatory anesthetics** (propofol, volatile agents) can cause an outsized drop in SVR/BP in volume-depleted hypertensive patients. Conversely, sympathetic surges (intubation, surgical incision) can send BP soaring. **Anticipate greater swings** – both hypotension and hypertension – and be prepared to treat both.

- **Myocardial Ischemia Risk:** The **combination of LVH, possible CAD, and tachycardia under stress** puts patients at risk for perioperative myocardial ischemia if BP and heart rate are not tightly managed. ***Even brief episodes of severe hypertension or hypotension can precipitate arrhythmias, demand–supply mismatch, or infarction*** in susceptible individuals.

- **Careful Titration:** Given this vulnerability, induction agents and anesthetic depth should be titrated carefully. Small incremental doses and vigilant monitoring are key to avoid overshooting in either direction.

12

Perioperative Risks of Uncontrolled Hypertension

Cardiac & Vascular Complications:

- Preoperative hypertension correlates with increased perioperative cardiovascular events. *Studies show a 35% higher risk of complications (myocardial infarction, arrhythmias, heart failure exacerbation) in hypertensive patients versus normotensive*s. Severe BP elevations can precipitate acute heart failure or ischemia during or after surgery.

Stroke Risk:

- Both intraoperative and postoperative strokes are more frequent in patients with uncontrolled HTN. Marked hypertension can lead to cerebral hemorrhage or hypertensive encephalopathy; conversely, aggressive BP drops in a chronically hypertensive patient can cause ischemic stroke. **Postoperative systolic BP >180 mmHg is linked to higher stroke risk**.

Bleeding & End-Organ Damage:

- High blood pressure can compromise surgical hemostasis – e.g., it may contribute to excessive bleeding at the surgical site or disrupt vascular suture lines. It's also associated with postoperative bleeding complications such as intracranial hemorrhage or hemorrhage at graft sites.

13

Perioperative Risks of Uncontrolled Hypertension

- **Overall Cardiac Risk vs BP Reading:**
  - Importantly, hypertension often coexists with other risk factors (diabetes, CAD, CKD). Current guidance emphasizes assessing the patient's **overall cardiac risk** rather than using an isolated BP cutoff for decision-making. A well-controlled hypertensive with stable coronary disease might be lower risk than an uncontrolled hypertensive with LVH and renal failure.
- **Indicator of End-Organ Disease:**
  - Uncontrolled HTN on the day of surgery might indicate inadequate chronic management or possible target organ damage. That's why we look for **signs like ECG LV strain, elevated creatinine, or neurologic symptoms** – these findings elevate perioperative risk and warrant optimization and closer monitoring.

14

Preoperative Evaluation & Risk Stratification

Thorough Assessment:

- Evaluate the hypertensive patient for end-organ effects and comorbidities.
- Key points: history of angina/MI or heart failure (heart), stroke or TIA (brain), kidney disease, and diabetes. Determine functional capacity (e.g., METs) to gauge cardiac reserve. Symptoms like chest pain, dyspnea on exertion, headache, or visual changes could indicate poorly controlled HTN or end-organ issues.

Accurate BP Measurement:

- Ensure the blood pressure reading is accurate. Use appropriate cuff size and a calm environment. Measure BP after the patient is seated quietly; re-check if initial readings are high. **White-coat hypertension** is real – if a patient claims their BP is only high in clinics, verify with ambulatory or home readings if available. Don't overreact to a single anxious reading.

15

Preoperative Evaluation & Risk Stratification

Medication Review:

- Review all antihypertensive meds and other cardiovascular drugs. Note any recent changes. Check electrolyte levels if on diuretics (potassium), and renal function if on ACEIs/ARBs or if longstanding HTN (for baseline creatinine). Ensure β-blockers, if prescribed, have been taken (or will be given pre-op) to avoid withdrawal issues.

Target Organ Clues:

- Look for signs of hypertensive heart disease (e.g., ECG showing LVH or strain, an S4 gallop on exam indicating a stiff LV). Check for chronic kidney disease (elevated creatinine) and examine for retinopathy if severe HTN (usually done by primary care, but fundoscopic changes reflect chronicity). Document any neurologic deficits (prior strokes). This assessment informs anesthetic risk – e.g., HTN with LVH and CKD is higher risk than HTN alone.

Risk Indices:

- Consider using risk stratification tools (e.g., Revised Cardiac Risk Index) which include hypertension-related factors indirectly (CAD, CHF, CVA, etc.). Hypertension itself isn't a direct RCRI factor, but uncontrolled HTN often accompanies other risk conditions. Use the overall risk profile to plan monitoring and if necessary, get perioperative medicine/cardiology input for optimization.

16

Proceed or Postpone Surgery for High BP?

Traditional Teaching:

- A longstanding rule of thumb was to postpone elective surgery if BP > 180/110 mmHg due to concern for stroke or MI.
- The UK's Association of Anaesthetists/British Hypertension Society guidelines echoed this threshold (180/110) as a point to consider deferral.

Evolving Consensus:

- Recent evidence and the POQI consensus group question using a strict cutoff. They suggest there isn't strong evidence for an absolute BP number to mandate cancellation.
- The decision should be individualized – consider the patient's baseline BP, end-organ status, and urgency of surgery. Many patients with BP slightly above 180/110 can be safely managed with intraoperative control rather than delay.

17

Proceed or Postpone Surgery for High BP?

Mild to Moderate HTN:

- For BP below ~180/110, proceeding with surgery is generally safe as long as you plan for tight intraoperative monitoring. Hypertension alone (especially if asymptomatic and no acute end-organ damage) is not a sole reason to cancel in most cases. Optimize what you can (e.g., give a PRN antihypertensive pre-op if there's time) and proceed with caution.

Severe Uncontrolled HTN:

- If the patient's BP is extremely high (e.g., ≥200/120) or evidence of a hypertensive emergency (acute organ damage, like encephalopathy or angina), it's usually safer to defer elective surgery and treat the BP urgently. In such cases, involve internal medicine or cardiology – the patient may need IV medications and workup (e.g., rule out pheochromocytoma or malignant HTN) before anesthesia.

Emergencies:

- For truly urgent or emergency surgeries, you typically **do not delay** surgery solely for high BP. Instead, address the hypertension as best as possible on the way (quick-acting IV drugs) and proceed, because surgical urgency (trauma, rupture, etc.) outweighs the BP risk. We'll manage the BP intraoperatively rather than risk a delay in a life-threatening situation.

18

Preoperative Medication Management

Continue Most Antihypertensives:

- In general, patients should take their usual antihypertensive medications on the day of surgery (with a sip of water), **with two notable exceptions** (ACE inhibitors and ARBs). Continuing therapy helps prevent rebound hypertension. Beta-blockers or clonidine in particular **must** be continued – stopping them can cause a dangerous rebound BP spike

Beta-Blockers:

- **Continue** chronic β-blockers. Abrupt withdrawal can precipitate tachycardia, angina, or MI. If the patient is high-risk and not on a β-blocker, you might start one preoperatively, but *not* on the day of surgery with a high dose– start low-dose days to weeks in advance if possible. (Per guidelines, if initiating, begin ≥24 hours before and titrate; avoid new high-dose β-blocker on DOS due to stroke risk.)

ACE Inhibitors / ARBs:

- It is often recommended to **hold ACEIs and ARBs on the day of surgery** (stop about 24 hours prior). These agents can cause refractory hypotension under anesthesia by blunting the RAAS compensatory mechanism. Studies (e.g., VISION) show holding them can reduce postoperative adverse events. If the patient has heart failure or severe HTN where these are critical, some practitioners may continue them, but be prepared to manage hypotension (vasopressin is effective if needed). Resume ACEI/ARB post-op once the patient is stable and eating.

19

Preoperative Medication Management

Calcium Channel Blockers:

- **Continue CCBs** (both dihydropyridines and non-dihydropyridines). They provide BP control and anti-anginal benefits. There is a slight concern for increased hypotension or bleeding (CCBs can inhibit platelet function and prevent reflex vasoconstriction), but evidence suggests the benefits outweigh risks. So, don't hold a CCB; in fact, stopping it could lead to rebound hypertension.

Diuretics:

- The recommendation on diuretics is variable. Many clinicians **hold the morning dose of diuretics**(especially if it's a once-daily thiazide) on the day of surgeryto avoid hypovolemia and electrolyte disturbances. If the patient's BP is very dependent on a diuretic, use clinical judgment. Ensure the patient is not volume-depleted – if they took their diuretic, check volume status and potassium. Holding diuretics can reduce risk of intraoperative hypotension and postoperative acute kidney injury. Diuretics can be resumed post-op when oral intake and renal function are adequate.

Other Agents:

- Continue **α-2 agonists** like clonidine – if a patient is on clonidine, do not omit it (or their patch) because stopping clonidine can cause rebound HTN. For patients on vasodilators like hydralazine or nitrates chronically, continue those as well. Also continue statins (they improve outcomes) and most likely continue low-dose aspirin if indicated (unless surgical bleeding risk is prohibitively high, per guidelines).

20

Intraoperative Monitoring & Blood Pressure Management

Invasive Monitoring:

- For patients with significant hypertension or end-organ disease, strongly consider placing an arterial line for continuous BP monitoring. Beat-to-beat measurement allows prompt detection of swings and facilitates tight control (and frequent labs if needed). Noninvasive cuffs may be less accurate in patients with very high arterial stiffness, and cycle intermittently. An art-line is especially indicated if you anticipate rapid BP changes or need to titrate IV infusions closely.

BP Targets:

- Maintain blood pressure within a prudent range around the patient's baseline. Avoid profound hypotension or hypertension. A common goal is to keep intraoperative BP within about ±20% of the patient's usual BP. **European periop guidelines advise keeping BP between 70% and 100% of baseline** to prevent extreme drops or surges. Also use absolute minimums: e.g., try to keep MAP > 65 mmHg (and SBP > ~100 mmHg) at all timesto ensure vital organ perfusion.

Depth of Anesthesia & Analgesia:

- Adequate anesthetic depth and analgesia are frontline tools against hypertension. Preventing pain and sympathetic responses (with sufficient opioid, inhalational agent, or adjuncts) will reduce incidence of intraoperative HTN. Anticipate surges – for intubation, for surgical incision – and blunt them (e.g., administer fentanyl or esmolol before intubation). Conversely, avoid excessive anesthetic that causes undue hypotension; find the balance.

21

Intraoperative Monitoring & Blood Pressure Management

- **Treating Hypertension:** If BP rises significantly (above target range), intervene promptly. First, check and address causes: is the patient light (tachycardic, moving)? Is there inadequate analgesia or some stimulus (e.g., tourniquet pain, distended bladder)? Treat the cause (deepen anesthesia, give analgesic). Additionally, use fast-acting IV antihypertensives: e.g., titrate a **vasodilator** like nicardipine or nitroglycerin infusion, or give a bolus of labetalol or hydralazine, depending on heart rate and situation. For instance, labetalol (which lowers HR and BP) is great if the patient is tachycardic; if bradycardic but hypertensive, a pure vasodilator like nicardipine is preferable.
- **Treating Hypotension:** On the flip side, be ready to support BP if it falls below safe limits. Hypertensive patients can be very sensitive to drops. Have vasopressors available (phenylephrine, ephedrine, or even vasopressin especially if ACEI/ARB was continued). Ensure adequate volume status. Small doses titrated are key – avoid overshooting to hypertension again. Remember, a chronically hypertensive patient might need a slightly higher MAP than normal to perfuse critical organs, so err on the side of caution when defining "too low."
- **Team Planning:** Communicate your BP management plan to the surgical team. If, for example, the plan is to keep BP a bit higher for a carotid surgery or a bit lower to reduce bleeding in a delicate field, everyone should know the goal numbers. The surgeon can also inform you of critical moments (e.g., about to clamp a vessel) so you can adjust BP proactively.

22

Anesthetic Technique Considerations (GA vs. Regional)

- **General vs Regional Anesthesia:** Both can be used safely in hypertensive patients, but the choice can influence hemodynamics. **Regional nerve blocks** (e.g., peripheral nerve blocks) tend to cause minimal hemodynamic changes and can significantly blunt the surgical stress response for that area. For example, a good epidural or nerve block can prevent pain-related BP spikes during surgery and reduce the required dose of general anesthetic.
- **Spinal/Epidural Anesthesia:** Neuraxial techniques eliminate sympathetic tone in the blocked segments, which **lowers blood pressure**. In hypertensive patients, a spinal or epidural can cause a **significant drop in BP** due to vasodilation, especially if they have a high baseline SVR. This hypotension can be managed – pre-load with fluids and use vasopressors as needed – but must be anticipated. A **graded epidural** (slow dosing in increments) allows more control than a one-shot spinal for titrating the level and hemodynamic effect. If doing a spinal, be prepared with phenylephrine or ephedrine to counteract drops.
- **Combined Techniques:** Often, a **combined general + regional** approach is ideal. For example, in an abdominal case, an epidural analgesia plus light general anesthesia can stabilize hemodynamics: the epidural handles pain (reducing hypertensive surges) and allows a lighter depth of GA (avoiding too much depressant causing hypotension). Careful dosing of the epidural avoids profound hypotension.

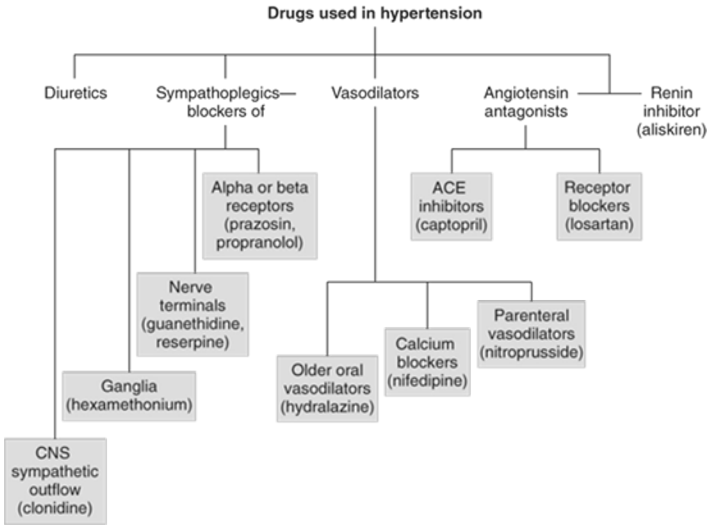
23

Anesthetic Technique Considerations (GA vs. Regional)

- **General vs Regional Anesthesia:** Both can be used safely in hypertensive patients, but the choice can influence hemodynamics. **Regional nerve blocks** (e.g., peripheral nerve blocks) tend to cause minimal hemodynamic changes and can significantly blunt the surgical stress response for that area. For example, a good epidural or nerve block can prevent pain-related BP spikes during surgery and reduce the required dose of general anesthetic.
- **Spinal/Epidural Anesthesia:** Neuraxial techniques eliminate sympathetic tone in the blocked segments, which **lowers blood pressure**. In hypertensive patients, a spinal or epidural can cause a **significant drop in BP** due to vasodilation, especially if they have a high baseline SVR. This hypotension can be managed – pre-load with fluids and use vasopressors as needed – but must be anticipated. A **graded epidural** (slow dosing in increments) allows more control than a one-shot spinal for titrating the level and hemodynamic effect. If doing a spinal, be prepared with phenylephrine or ephedrine to counteract drops.
- **Combined Techniques:** Often, a **combined general + regional** approach is ideal. For example, in an abdominal case, an epidural analgesia plus light general anesthesia can stabilize hemodynamics: the epidural handles pain (reducing hypertensive surges) and allows a lighter depth of GA (avoiding too much depressant causing hypotension). Careful dosing of the epidural avoids profound hypotension.

24

Example for Drugs Used in Hypertension



25

Autonomic Nervous System: Sympathomimetic Amines

- The **sympathomimetic amines** include the three naturally occurring catecholamines epinephrine, norepinephrine, and dopamine and a number of synthetic agents such as phenylephrine and dobutamine.
- **Used to treat**: hypotension, bradycardia, anaphylaxis, shock, heart failure, and cardiac resuscitation.
- **Effects elicited**: stimulation of (Alpha-adrenergic, Beta- adrenergic , and dopamine-1 adrenergic receptors)
- **Efficacy of sympathomimetic amines:** depends on its concentration at the receptor site, its affinity for specific receptors, and the population of receptors available for binding.
- **Direct action of sympathomimetic amines:** occur due to binding of the drug to an adrenergic receptor (e.g., phenylephrine).
- **Sympathomimetic amine indirect effects:** the drug also stimulates the release of endogenous catecholamines (e.g., ephedrine).

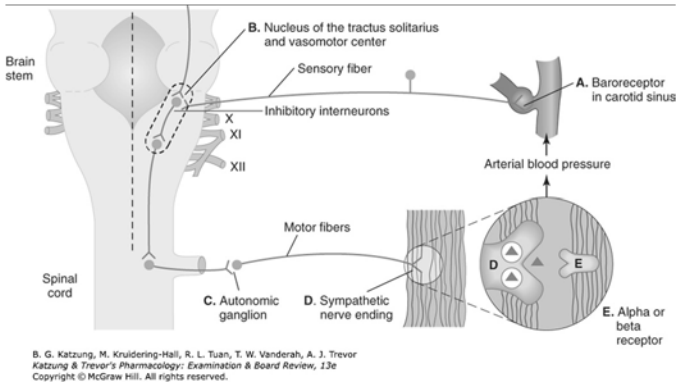
26

High-Yield Terminology: Treatment by **Sympathomimetic Amines**

Baroreceptor reflex	Primary autonomic mechanism for blood pressure homeostasis; involves sensory input from carotid sinus and aorta to the vasomotor center and output via the parasympathetic and sympathetic motor nerves
Catecholamine reuptake pump	Nerve terminal transporter responsible for recycling norepinephrine after release into the synapse; also called norepinephrine transporter (NET)
End-organ damage	Vascular damage in heart, kidney, retina, or brain resulting in diminished perfusion and impaired function
Essential hypertension	Hypertension of unknown etiology; also called primary hypertension
Hypertensive emergency ("malignant hypertension")	An accelerated form of severe hypertension associated with rising blood pressure and rapidly progressing damage to vessels and end organs. Often signaled by renal damage, encephalopathy, and retinal hemorrhages or by angina, stroke, or myocardial infarction
Orthostatic hypotension	Hypotension on assuming upright posture; postural hypotension
Postganglionic neuron blocker	Drug that blocks transmission by an action in the terminals of the postganglionic nerves
Rebound hypertension	Elevated blood pressure (usually above pretreatment levels) resulting from loss of antihypertensive drug effect
Reflex tachycardia	Tachycardia resulting from lowering of blood pressure; mediated by the baroreceptor reflex
Secondary hypertension	Hypertension caused by a diagnosable abnormality, eg, aortic coarctation, renal artery stenosis, adrenal tumor, etc. Compare essential hypertension
Sympatholytic, sympathoplegic	Drug that reduces effects of the sympathetic nervous system

27

Baroreceptor reflex



B. G. Katzung, M. Kruidering-Hall, R. L. Tuan, T. W. Vanderah, A. J. Trevor
Katzung & Trevor's Pharmacology: Examination & Board Review, 13e

Baroreceptor reflex arc and **sites of action of sympathoplegic drugs**. The letters (A–E) indicate potential sites of action of subgroups of sympathoplegics. **No clinically useful drugs act at the baroreceptor** (site A), but drugs are available for each of the other sites. X, XI, XII, cranial nerves; blue triangles, norepinephrine.

28

A. Baroreceptor-Sensitizing Agents

- A **few natural products**, such as **veratrum alkaloids,** appear to increase sensitivity of baroreceptor sensory nerves and reduce SANS outflow while increasing vagal tone to the heart. These agents lower blood pressure but are toxic and no clinically available drugs act at this site.

29

B. Sympathoplegics That Act in the Central Nervous System

- **Alpha$_2$-selective agonists** (eg, **clonidine**, **methyldopa**) cause a decrease in sympathetic outflow by activation of α_2 receptors in the CNS. These drugs readily enter the CNS when given orally. Methyldopa is a prodrug; it is transported into the brain and then converted to **methylnorepinephrine.**
- Clonidine and methyldopa reduce blood pressure by reducing cardiac output, vascular resistance, or both. The *major compensatory response is salt retention*. **Sudden discontinuation** of clonidine causes **rebound hypertension**, which may be severe. This rebound increase in blood pressure can be controlled by reinstitution of clonidine therapy or administration of α blockers such as phentolamine.
- Methyldopa occasionally causes *hematologic immunotoxicity*, detected initially by test tube agglutination of red blood cells (positive Coombs test) and in some patients progressing to **hemolytic anemia**. Both drugs may cause sedation—methyldopa more so at therapeutic dosage. Early studies suggested that **methyldopa protected kidney function** and was safe in pregnancy; it is therefore sometimes preferred for hypertension in pregnancy.

30

Alpha-2 Agonists (Clonidine & Dexmedetomidine)

Mechanism:

- α2-adrenergic agonists work centrally (primarily in the brainstem) to reduce sympathetic outflow.
- Activation of α2 receptors inhibits norepinephrine release. The result is a decrease in systemic vascular resistance (vasodilation) and a decrease in heart rate.
- Essentially, they "trick" the body into a more parasympathetic state by feedback inhibition of the SNS.
- They also have sedative and analgesic-sparing properties by acting in the locus coeruleus and dorsal horn of the spinal cord.

Clonidine:

- An oral (or transdermal patch) medication for chronic hypertension and also used for analgesic adjunct. Clonidine lowers BP and HR gradually. Importantly, **avoid abrupt discontinuation** – chronic clonidine use leads to upregulation of receptors, and stopping it suddenly can cause severe rebound hypertension and tachycardia. If a patient is on clonidine, continue it perioperatively. If they can't take PO, consider a transdermal patch or IV substitution (injectable clonidine is not common, but one can use dexmedetomidine as a short-term substitute). Clonidine given as premed (e.g., 0.1–0.2 mg oral) can blunt BP responses to intubation and reduce anesthetic requirements.

Dexmedetomidine (Precedex):

- An IV α2-agonist (~8x more selective for α2 than clonidine). It provides sedation without significant respiratory depression and has analgesic properties. It's often run as an infusion intraoperatively or in ICU for sedation. Dexmedetomidine typically causes a moderate decrease in BP and a notable decrease in heart rate. It's useful in hypertensive patients because it can calm tachycardia and hypertension due to sympathetic overdrive (for example, in an awake fiber-optic intubation, dexmedetomidine keeps the patient calm and BP controlled). Boluses of dexmedetomidine should be given cautiously – an initial bolus can sometimes cause a transient hypertension (from peripheral α₂ stimulation causing vasoconstriction) followed by the desired drop in BP. Usually we infuse 0.2–0.7 mcg/kg/hr without a fast bolus to avoid that spike.

31

Alpha-2 Agonists (Clonidine & Dexmedetomidine)

- **Perioperative Uses:** Clonidine is less commonly used acutely (except as premedication), **but dexmedetomidine is very useful intraoperatively for cases where you want to avoid swings: it smoothens hemodynamics, prevents big increases in BP and HR during stimulation**, and provides sedation (e.g., used in vascular, ENT, neurosurgery, or for sedation during regional anesthesia). These drugs also reduce anesthetic and opioid requirements, which can indirectly stabilize BP by preventing pain or light anesthesia responses.
- **Side Effects:** Both clonidine and dexmedetomidine can cause **bradycardia**. Monitor heart rate – if a patient is already bradycardic (say 50s) and you start dexmedetomidine, they might drop further. In such cases, either avoid or use very low dose and be ready to treat bradycardia (atropine or glycopyrrolate). Hypotension can occur, especially if the patient is volume-depleted; the central sympatholysis may cause significant vasodilation. If too much α2-agonist effect, you can support BP with vasopressors or, in the case of dexmedetomidine, simply turn off the infusion (the effect wears off within minutes to an hour). There is a specific antidote for **α2-agonist overdose: *atipamezole***, an α2-antagonist, though we rarely need to use it clinically.
- **Rebound & Continuation:** If a patient has a clonidine patch or takes clonidine at home, continue it. If they present with the patch, leave it in place (make a note on the anesthesia monitor for that patch). If NPO and on clonidine, consider alternative **BP management but do not just stop clonidine**; you might need to give a small dose of clonidine via NG tube post-op or manage with dexmedetomidine infusion to avoid rebound. Rebound hypertension from clonidine withdrawal can be severe and is treated by re-administering clonidine or using agents like labetalol and hydralazine in the meantime.

32

E. Adrenoceptor Blockers

- **Alpha$_1$-selective agents** (eg, **prazosin, doxazosin, terazosin**) are moderately effective antihypertensive drugs. **Alpha blockers** reduce vascular resistance and venous return.
- The **nonselective α blockers** (phentolamine, phenoxybenzamine) are of ***no value in chronic hypertension*** because of excessive reflex tachycardia.
- **Alpha$_1$-selective adrenoceptor blockers** are relatively free of the severe adverse effects of the nonselective α blockers and postganglionic nerve terminal sympathoplegic agents. They do, however, **cause orthostatic hypotension**, especially with the first few doses. On the other hand, they also relax smooth muscle in the prostate, which is useful in benign prostatic hyperplasia.
- **Beta blockers** are used very heavily in the treatment of hypertension. **Propranolol** is the prototype, and **atenolol, metoprolol,** and **carvedilol** are among the most popular. They initially reduce cardiac output, but in *chronic use* their action may include a decrease in vascular resistance as a contributing effect. The **latter effect may result from reduced angiotensin levels (β blockers reduce renin release from the kidney**). Metoprolol, carvedilol, and labetalol, used chronically, also have beneficial effects in chronic heart failure.
- **Nebivolol** is a β blocker with some direct vasodilator action caused by nitric oxide release. β$_1$-selective blockers with fewer CNS effects may have some advantages over the nonselective and more lipid-soluble agents.

33

Beta-Blockers

Mechanism:

- β-blockers antagonize beta-adrenergic receptors. Blockade of β1-receptors (predominant in heart) slows heart rate (negative chronotrope) and reduces contractility (negative inotrope), thereby decreasing cardiac output and BP. They also reduce renin release from the kidney (lowering RAAS activity). β2-receptor blockade (in non-selective agents) can cause bronchoconstriction and vasoconstriction, whereas β1-selective agents mainly affect the heart. Net effect: reduced myocardial oxygen demand and blood pressure.

Examples:

- *Esmolol* – ultra-short-acting β1-selective IV β-blocker, onset within 1–2 min, duration ~10 min (great for acute control of HR/BP surges, e.g., during intubation or surgical stimulation).
- *Labetalol* – combined α1 and non-selective β blocker (IV pushes or infusion; lowers BP by reducing SVR and HR; commonly used for intraoperative or PACU hypertension).
- *Metoprolol, Atenolol, Bisoprolol* – β1-selective blockers used chronically (IV metoprolol can also treat intraop tachycardia or mild HTN).
- *Propranolol* – non-selective, used less often perioperatively due to β₂ effects but may see it in chronic use.

Perioperative Benefits: β-blockers are proven to reduce perioperative cardiac events in select patients. By controlling heart rate and BP, they reduce myocardial ischemia risk. They also reduce incidence of arrhythmias like atrial fibrillation post-op. Patients with CAD or heart failure particularly benefit from continuation – **stopping a β-blocker can precipitate rebound tachycardia, hypertension, angina, or even MI**. Continuing β-blockers is a Class I recommendation for those already on them.

34

Beta-Blockers

Initiation:

- Initiating β-blocker therapy de novo in high-risk patients (e.g., many cardiac risk factors) can be considered, but it **must be done days to weeks before surgery** and titrated gradually.
- **Starting a high-dose β-blocker immediately before surgery is dangerous** (linked to strokes and brady-hypotension). If needed, start low (e.g., low-dose bisoprolol) at least a week prior and adjust slowly. Intraoperatively, if a patient is not on a beta-blocker but develops severe tachycardia and hypertension, short-acting esmolol can be used without lingering effects.

Considerations/Cautions:

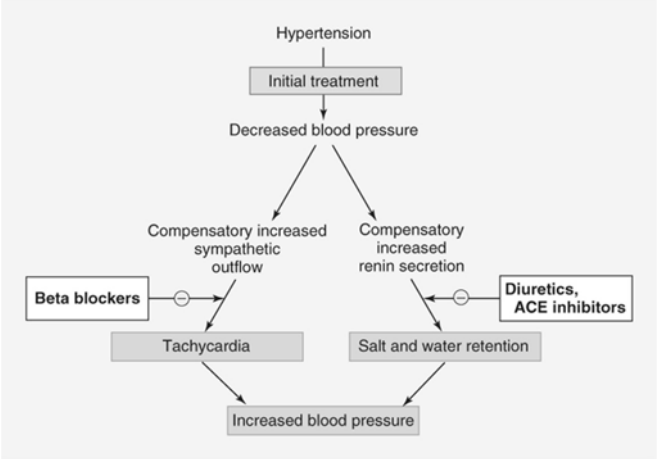
- Ensure the patient's heart rate isn't too low before giving additional β-blockers (avoid symptomatic bradycardia or heart block).
- In asthmatic patients, use β1-selective agents (e.g., esmolol, metoprolol) to minimize bronchospasm risk. In patients with poorly controlled heart failure (low EF), use cautiously – while long-term β-blockade is beneficial, acutely it can reduce contractility; titrate small doses and monitor.
- Have atropine available if excessive bradycardia occurs. Also, remember labetalol's α-blockade will lower BP more than HR relative to pure β-blockers – useful if you need BP reduction with less bradycardia. . . **Prudent Judgement ALL Bradycardia is not bad!!!**

35

Hypertension Treatment: Baroreceptors

- **Less than 20% of cases of hypertension** are due to ("secondary" to) factors that can be clearly defined and corrected. This type of hypertension is ***associated with pheochromocytoma, coarctation of the aorta, renal vascular disease, adrenal cortical tumors, and a few other rare conditions***.
- **Most cases of hypertension** are idiopathic, also called "primary" or "essential" hypertension. The strategies for treating idiopathic hypertension are based on the determinants of arterial pressure. Strategies include: reductions of blood volume, sympathetic effects, vascular smooth muscle tension, and angiotensin effects.
- In primary hypertension, the **baroreceptor reflex and the renin response are reset** to maintain the higher blood pressure. As a result, they respond to a therapeutically lowered blood pressure with compensatory homeostatic responses, which may be significant. Compensatory responses can be counteracted with β blockers and diuretics or angiotensin antagonists.

36



Compensatory responses (orange boxes) to decreased blood pressure when treating hypertension. The initial treatment that causes both compensatory responses might be a vasodilator. Arrows with minus signs indicate drugs used (white boxes) to **minimize the compensatory responses**. ACE, angiotensin-converting enzyme.

37

Vasodilators

- Dilate blood vessels by **acting directly on smooth muscle cells** through **non-autonomic mechanisms** are useful in treating many hypertensive patients.
- Vasodilators act by four major mechanisms:
  1. Blockade of calcium channels,
  2. Release of nitric oxide,
  3. Opening of potassium channels (which leads to hyperpolarization),
  4. Activation of D1-dopamine receptors

38

Vasodilators (Nitroglycerin, Nitroprusside, Hydralazine, etc.)

Nitroglycerin (NTG):

- A venous vasodilator (at low doses) and moderate arteriolar dilator (at higher doses). It converts to nitric oxide in vascular smooth muscle, causing relaxation.
- ***Primary effects:*** reduces preload (venodilation pools blood in capacitance vessels) and to a lesser degree decreases afterload. It's especially useful in hypertensive patients with myocardial ischemia – it dilates coronary arteries and reduces cardiac oxygen demand by lowering wall stress. IV nitroglycerin has an onset of 1-2 minutes.
- **Typical use**: infusion titrated for angina or BP control (often aimed at keeping BP in a range to prevent ischemia). Be cautious of headache and reflex tachycardia. It tends to be **the agent of choice if hypertension is accompanied by signs of cardiac ischemia (e.g., ST depressions)**, since it both lowers BP and improves coronary perfusion.

39

Vasodilators (Nitroglycerin, Nitroprusside, Hydralazine, etc.)

Sodium Nitroprusside (SNP):

- A potent **arterial and venous** dilator (via direct NO release) with extremely rapid onset and short duration.
- Lowers BP **within seconds** of starting infusion. Ideal for emergencies or controlled hypotension.
- It reduces afterload and preload dramatically.
- **Downside:** it can cause reflex tachycardia and, if overused, can lead to cyanide toxicity (nitroprusside metabolizes to cyanide; risk if high doses > 2 mcg/kg/min or prolonged use, especially in renal/hepatic impairment).
- Also, SNP can steal blood from ischemic myocardium by dilating healthy vessels (coronary steal phenomenon) – so not the best if active coronary ischemia. Use with arterial line and careful titration.
- Light-sensitive (needs covered tubing). Nitroprusside is often used in hypertensive emergencies (like malignant HTN) and in some cardiac cases for afterload reduction.

40

Vasodilators (Nitroglycerin, Nitroprusside, Hydralazine, etc.)

Hydralazine:

- A direct arteriolar dilator (mechanism: likely increases NO or cGMP in endothelium).
- Onset is slower (IV onset 5–15 min) and duration is long (up to 2–4 hours).
- It's ***useful for long-acting BP control when immediate titration is less crucial, such as treating postoperative hypertension in PACU*** that's expected to be sustained.
- Hydralazine tends to cause reflex tachycardia due to drop in SVR, so be cautious in patients with CAD – a β-blocker might be given alongside if needed.
- It's a **good choice for hypertensive patients who are bradycardic** (since it won't lower HR and will actually likely raise it a bit). Also used chronically in combination with isosorbide dinitrate for heart failure (so you may encounter patients on it).
- Intraoperatively, hydralazine is less commonly used for acute spikes because of the delayed effect; you give a dose and the effect is unpredictable until minutes later. But it's quite effective for longer-term control (e.g., if a patient is going to ICU intubated and a bit hypertensive, a dose of hydralazine can cover them for a while).

41

Vasodilators (Nitroglycerin, Nitroprusside, Hydralazine, etc.)

Other Vasodilators:

- ***Fenoldopam*** – a selective dopamine-1 receptor agonist that causes vasodilation, particularly in renal arteries, increasing renal blood flow. It's an IV infusion option for hypertensive emergencies, including those with renal impairment (it may help diuresis). It's seldom used in OR, more in ICU.
- ***Phentolamine*** – an α-blocker used for catecholamine-induced hypertension (e.g., pheochromocytoma or if you accidentally injected epinephrine into tissue). It's given IV for hypertensive crises with high catecholamines (quickly lowers BP by vasodilation).
- ***Magnesium sulfate*** – not a primary vasodilator, but in pregnancy-related hypertension (preeclampsia) it's used for seizure prophylaxis and has some vasodilatory, BP-lowering effects. In hypertensive encephalopathy, IV magnesium can help too.
- **Considerations:** When using potent vasodilators like NTG or SNP, **invasive BP monitoring is recommended due to rapid changes**. Always consider the heart rate: pure vasodilators often cause reflex tachycardia, which in a CAD patient could be problematic. If significant tachycardia occurs, you may need to add a β-blocker. Monitor for signs of **under-perfusion** – if BP is lowered too much, watch mental status, urine output, etc. For nitroprusside, monitor acid-base status (metabolic acidosis can be a sign of cyanide toxicity) and limit dose/duration if possible.

42

Calcium Channel-Blocking Agents

- **Calcium channel blockers** (eg, **nifedipine, verapamil, diltiazem**)
- Effective vasodilators.
- Moderately efficacious and suitable for chronic use in hypertension of any severity.
- **Verapamil and diltiazem** also reduce cardiac output.
- **Nifedipine** is the prototype **dihydropyridine** calcium channel blocker
  - Other dihydropyridines: (**amlodipine, felodipine, isradipine,** etc).
  - Well-tolerated and produce **fewer compensatory responses**
- the calcium channel blockers are much more commonly used than hydralazine or minoxidil.

43

Calcium Channel Blockers (CCBs)

- **Mechanism:** CCBs inhibit L-type calcium channels in cardiac and smooth muscle cells. This leads to muscle relaxation in blood vessels (vasodilation) and, for certain CCBs, decreased cardiac contractility and heart rate.
  - **Dihydropyridines**(e.g., amlodipine, nicardipine, clevidipine) predominantly act on vascular smooth muscle causing arterial vasodilation (reducing afterload).
  - **Non-dihydropyridines** (diltiazem, verapamil) act on the AV node and myocardium more, reducing heart rate and contractility in addition to some vasodilation.

44

Calcium Channel Blockers (CCBs)

Examples for Periop Use:

- ***Nicardipine*** – an IV dihydropyridine commonly used as a continuous infusion for acute BP control. Onset is rapid (minutes) and it's easily titratable up or down. Often used in neuro cases (to prevent hypertension that could cause bleeding) or in ICU for hypertension crisis.
- ***Clevidipine*** – ultra-short-acting IV DHP CCB (half-life ~1 min) in a lipid emulsion; very titratable, useful for fine control of BP if available.
- ***Diltiazem*** – IV form used more for rate control in arrhythmias (like AFib), but its mild BP-lowering effect can help if tachyarrhythmia with hypertension.
- **Oral *amlodipine*** is common for chronic HTN (not IV form periop).

Perioperative Strategy: Continue chronic CCBs through the day of surgery (no need to hold). If a patient is on amlodipine or diltiazem, ensure they took it – it will help maintain stable BP. Intraoperatively, nicardipine infusion is a go-to for managing sustained hypertension, particularly if the patient has a high SVR with normal or low heart rate (since nicardipine won't slow the heart much, it may even cause reflex tachycardia). If tachycardia is present, a non-DHP like diltiazem might be chosen instead to address both.

45

Calcium Channel Blockers (CCBs)

- **Hemodynamic Effects:** CCBs effectively reduce blood pressure by vasodilation. DHPs can sometimes trigger reflex tachycardia (because as BP drops, baroreceptors kick up HR). Non-DHPs will reduce HR and can depress contractility (so avoid large doses in patients with severe LV dysfunction or heart block). CCBs also tend to improve coronary blood flow (they're often used for angina – e.g., verapamil). In the periop period, nicardipine is great for maintaining tight BP control without the bronchospasm risk of β-blockers or the prolonged effect of hydralazine.
- **Safety Notes:** Watch for **hypotension** – titrate carefully. Also, large doses of IV diltiazem or verapamil can cause bradycardia or even AV block, especially if the patient is also on β-blockers – use with caution in combination. CCBs can potentiate the vasodilatory and negative inotropic effects of anesthetic agents (e.g., if on a nicardipine drip, be careful adding high volatile – you might get more hypotension). There is some evidence that CCBs may inhibit platelet function and prolong bleeding, but clinically the consensus is to continue them; bleeding risk increase is minimal and outweighed by BP control benefits. So, for surgery with bleeding risk, we don't stop CCB, but we are mindful to manage BP to not exacerbate bleeding.

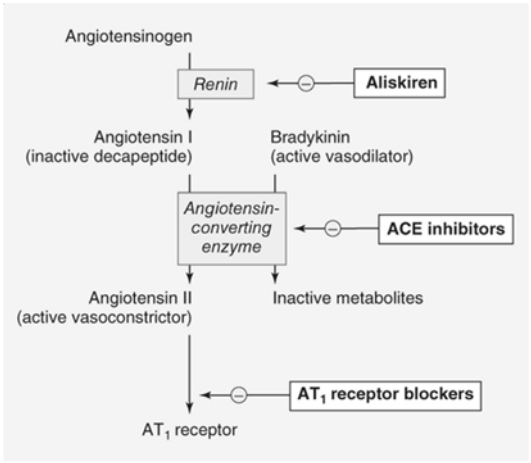
46

ACE Inhibitors (ACEIs) and ARBs

Mechanism:

- ACE inhibitors block the angiotensin-converting enzyme, preventing the formation of angiotensin II.
- This leads to vasodilation (less angio II = less vasoconstriction) and reduced aldosterone release (so a modest reduction in sodium/water retention).
- ARBs (angiotensin receptor blockers) directly block the AT1 receptors that angiotensin II binds, achieving a similar effect (vasodilation, reduced aldosterone effect).
- Both classes reduce SVR and BP, and they alleviate strain on the heart by reducing afterload. They also help reverse or prevent remodeling of the heart and vessels.

47



Actions of aliskiren, angiotensin-converting enzyme inhibitors, and AT_1 receptor blockers. Renin converts angiotensinogen to angiotensin I. Aliskiren blocks the enzymatic action of renin. ACE is responsible for activating angiotensin I to angiotensin II and for inactivating bradykinin, a vasodilator normally present in very low concentrations. Block of this enzyme thus decreases the concentration of a vasoconstrictor and increases the concentration of a vasodilator. The AT_1 receptor antagonists (ARBs) have no effect on bradykinin levels, which may explain the lower incidence of cough observed with these agents.

48

ACE Inhibitors (ACEIs) and ARBs

Chronic Benefits:

- ACEIs/ARBs are cornerstone therapies for hypertension, especially if the patient has heart failure (they improve survival in HFrEF), diabetes or CKD (they protect kidneys by reducing intraglomerular pressure), or post-MI (limit remodeling).
- They are often part of long-term therapy and improve outcomes beyond just BP numbers. For instance, they can regress LVH over time.
- Common examples: *Lisinopril, Enalapril, Ramipril* (ACEIs), *Losartan, Valsartan, Candesartan* (ARBs). Enalaprilat IV is an available ACEI for acute use (rarely used perioperatively unless no other options, due to its slower onset).

Intraoperative Concerns:

- The big issue with ACEIs/ARBs is **intraoperative hypotension**.
- Patients who have taken these the morning of surgery can have vasoplegia under anesthesia – their blood vessels won't constrict adequately in response to induction. This can lead to **difficult-to-treat hypotension that may not respond well to standard vasopressors (because the RAAS pathway is blocked)**. They might require **vasopressin** or more aggressive measures to maintain BP.

49

ACE Inhibitors (ACEIs) and ARBs

- **Hold vs Continue:** There is debate, but many anesthesia providers hold ACEI/ARB on the day of surgery to avoid this issue. Evidence (like the VISION study) showed that withholding ACEI/ARB 24 h pre-op reduced the risk of hypotension and postoperative adverse events. European guidelines advise holding them unless needed for heart failure. ACC/AHA guidelines, however, say it's reasonable to continue them in some cases, especially if the surgery is minor and the risk of hypotension is low. In practice: if it's a major surgery or the patient is on these purely for hypertension, we usually skip the dose. If it's critical (like for severe HF), we might continue but be ready to manage BP actively.
- **Management if Continued:** If a patient did take an ACEI/ARB and becomes hypotensive after induction, be prepared to use **vasopressin** or epinephrine. Studies find ACEI/ARB-related hypotension often responds to vasopressin (because it bypasses the RAAS pathway). Keep in mind phenylephrine or norepinephrine might be less effective or need higher doses in this scenario.
- **Resumption:** Resume ACEI/ARB postoperatively once the patient is hemodynamically stable and able to take oral meds (usually by postoperative Day 1 or 2). Watch renal function and K+ especially if they got ACEI/ARB and had stresses like hypotension or contrast dye, as these drugs can contribute to acute kidney injury in the setting of intraoperative hypotension.
- **Special Cases:** In patients with **refractory hypertension** (like those with renin-driven HTN), sometimes an ACEI or ARB drip could be considered (enalaprilat IV). But this is rarely needed with all the other IV meds we have. Another point: if a patient has **ACEI-induced cough**, that's more relevant chronically (maybe they'll be on ARB instead, which does not cause cough). And **Angioedema history** – if they ever had ACEI angioedema, obviously that drug is stopped permanently.

50

ANGIOTENSIN ANTAGONISTS & A RENIN INHIBITOR

- The two primary groups of angiotensin antagonists are:
- **angiotensin-converting enzyme (ACE) inhibitors** and **angiotensin II receptor blockers (ARBs).**
- ACE inhibitors (eg, **captopril**), which inhibit the enzyme variously known as angiotensin-converting enzyme, kininase II, and peptidyl dipeptidase, cause a *reduction* in blood levels of angiotensin II (ANG II) and aldosterone and an *increase* in endogenous vasodilators of the kinin family (bradykinin) ACE inhibitors have a low incidence of serious adverse effects (except in pregnancy) when given in normal dosage and produce minimal compensatory responses.
- **ACE inhibitors:** useful in **heart failure and diabetes** as well as in **hypertension**.
- **Toxicities of ACE inhibitors:** cough (up to 30% of patients), hyperkalemia, and renal damage in occasional patients with preexisting renal vascular disease (although they *protect* the diabetic kidney). They cause major renal damage in the fetus and are absolutely contraindicated in pregnancy. In contrast, **beneficial** in chronic heart failure and diabetic renal disease.
- The second group of angiotensin antagonists, the receptor blockers, is represented by the orally active agents **losartan, valsartan, irbesartan, candesartan,** and other ARBs, which competitively inhibit angiotensin II at its AT_1 receptor site. ARBs appear to be as effective in lowering blood pressure as the ACE inhibitors and have the advantage of a lower incidence of cough, although they do cause hyperkalemia. Like the ACE inhibitors, they cause fetal renal toxicity and are thus contraindicated in pregnancy.

51

Renin Inhibitors

- **Aliskiren** inhibits renin's action on its substrate, angiotensinogen. It thus reduces the formation of angiotensin I and, in consequence, angiotensin II.
- **Toxicities** include headache and diarrhea. It does not appear to cause cough, but it is not yet known whether it has the other toxicities of the angiotensin antagonists. It does not show reproductive toxicity in animals but is considered to be contraindicated in pregnancy because of the known toxicity of ACE inhibitors and ARBs.
- **Angiotensin antagonists** and **renin inhibitors** reduce aldosterone levels (angiotensin II is a major stimulant of aldosterone release) and cause potassium retention. If the patient has renal impairment, is consuming a high-potassium diet, or is taking other drugs that tend to conserve potassium, potassium concentrations may reach toxic levels.

52

Diuretics

Mechanism:

- Diuretics lower blood pressure by reducing intravascular volume and altering sodium balance. Over the long term, some (like thiazides) also cause vasodilation through indirect mechanisms.

Types:

- **Thiazide diuretics** (e.g., hydrochlorothiazide, chlorthalidone) act on the distal tubule to inhibit sodium reabsorption – moderate diuresis;
- **Loop diuretics** (e.g., furosemide, bumetanide) act on the loop of Henle – potent diuresis;
- **Potassium-sparing diuretics** (e.g., spironolactone, amiloride) act on the distal nephron to inhibit aldosterone effect or Na channels – mild diuresis but spare K+.

53

Diuretics

Chronic HTN Management:

- Thiazides are first-line for essential hypertension in many guidelines (especially effective in African American and elderly patients). They not only remove some fluid but also over time decrease peripheral resistance. Patients on chronic thiazides may have electrolyte issues (low K+, low Na+) – check recent labs. Spironolactone (a K-sparing diuretic) is often added in resistant hypertension, particularly if hyperaldosteronism is suspected. Diuretics help control BP long-term and reduce stroke risk. Many hypertensive patients will be on a combo like lisinopril/HCTZ.

Perioperative Considerations (Chronic Use):

- If a patient took their diuretic on the morning of surgery, they might be relatively volume-depleted. This can exaggerate hypotension on induction. Also, they might need a bathroom – a practical concern in pre-op! Generally, it's often advised to **hold diuretics on the day of surgery** unless needed for heart failure, to avoid dehydration. Ensure **electrolytes are balanced** – hypokalemia from diuretics can predispose to arrhythmias under anesthesia (e.g., increased risk of arrhythmias if patient on digoxin or with ectopy). If K+ is very low, it should be corrected before elective surgery.

54

Diuretics

Intraoperative Use of Diuretics:

- We typically do *not* use diuretics to treat acute hypertension because they act too slowly for immediate BP control. However, they come into play if hypertension is due to fluid overload. For example, in a patient with acute pulmonary edema (flash pulmonary edema) causing high BP and hypoxia, IV furosemide can reduce BP by reducing preload and clearing the lungs over time. Or during a long case, if the patient becomes volume-overloaded (e.g., positive fluid balance leading to HTN), a dose of furosemide can help diuresis and drop BP gradually. Also, after cardiopulmonary bypass in cardiac surgery, furosemide is often given to shed excess fluid and help control pressure. But acutely, diuretics are slow – furosemide onset is 5–10 min IV, peaking later, so not for moment-to-moment control.

Postoperative Use:

- In the PACU, if a hypertensive patient has low urine output and signs of fluid overload (e.g., pulmonary congestion), a diuretic can treat both issues: it will increase urine output and likely lower BP over 30–60 minutes. Continue chronic diuretics post-op once the patient is eating and hemodynamically stable, keeping an eye on kidney function. If the patient had an epidural, remember diuretics could contribute to hypotension if the epidural causes vasodilation. Coordinate diuretic dosing with overall fluid and BP status.

Monitoring:

- Patients on diuretics may have orthostatic hypotension. In the OR, changes in position (supine to upright) can cause BP drops if volume is low – ensure slow positioning and volume repletion. Monitor urine output intraop; however, note that being on a diuretic may make urine output less reflective of true volume status (they might not pee much if they held diuretic, or they might pee a lot if the diuretic was recent). Replace insensible losses appropriately to avoid compounding diuretic effect.

55

Choosing the Right Antihypertensive Agent (Situational)

Tachycardic & Hypertensive:

- If the patient's blood pressure is high *and* heart rate is elevated (a common scenario with pain or agitation), a **β-blocker** is often a good choice (e.g., esmolol bolus or infusion for immediate control, or labetalol which will address both HR and BP). This will slow the heart and break the cycle of tachycardia-driven hypertension. Ensure adequate analgesia as well, since pain-driven tachycardia needs treating at the source.

Bradycardic & Hypertensive:

- If blood pressure is high but heart rate is on the low side (or normal low), avoid beta-blockers as they could cause problematic bradycardia. Instead, use a **vasodilator**. For instance, nicardipine infusion or hydralazine IV can reduce BP without further lowering heart rate. These reduce SVR and BP while the body may naturally allow HR to rise a bit to compensate (which is acceptable if not extreme).

Hypertension with CAD (Coronary Artery Disease):

- In a patient with ischemic heart disease, control both BP and heart rate to reduce myocardial oxygen demand. **Beta-blockers and nitroglycerin** are ideal. Beta-blockers (like IV metoprolol or esmolol) will prevent tachycardia and lower BP moderately, while nitroglycerin infusion can relieve any chest pain and improve coronary perfusion as it lowers BP. Avoid agents that cause reflex tachycardia alone in active CAD without a beta-blocker onboard. Labetalol is also great here (addresses BP and HR).

56

Choosing the Right Antihypertensive Agent (Situational)

Asthma/COPD with Hypertension:

- Avoid non-selective beta-blockers (they can precipitate bronchospasm). If a beta-blocker is needed, use a **β₁-selective** agent like esmolol or metoprolol and monitor respiratory status. Otherwise, prefer **CCBs or vasodilators** for hypertension management in these patients. E.g., nicardipine is a good choice for an asthmatic with hypertension, or an ACEI/ARB for chronic management.

Acute Hypertensive Crisis (Emergency):

- If faced with a hypertensive emergency (e.g., BP >180/120 with signs of organ injury like encephalopathy or aortic dissection), use **fast, titratable IV infusions**. Nitroprusside or nicardipine can be titrated to quickly lower BP. In aortic dissection, combine **esmolol (to reduce shear force by lowering HR)** and nitroprusside/nicardipine to rapidly lower BP. In stroke or neurosurgery patients, nicardipine is often first-line to gently lower BP into target range. Always avoid dropping BP too precipitously (>20% reduction in first hour) in emergencies to prevent under-perfusion of organs – tailor the agent and speed to the situation.

57

Choosing the Right Antihypertensive Agent (Situational)

Renal Failure Patients:

- Prefer medications that do not rely heavily on renal excretion or that you can easily titrate. For instance, nicardipine is fine, but be cautious with repeated hydralazine (which is metabolized hepatically but lasts long – in renal patients it can cause prolonged effect). Also, avoid nitroprusside infusions for too long in severe renal failure (risk of thiocyanate accumulation). In renal patients with hypertension, volume overload often contributes – dialysis or diuretics might be needed as part of BP management.

Pregnancy-Related HTN:

- (Though not common in general OR aside from C-sections) Note that **labetalol and hydralazine** are first-line for severe hypertension in pregnancy (pre-eclampsia), while ACEIs/ARBs are contraindicated. Magnesium sulfate is used for seizure prophylaxis and can also help lower BP modestly. Always consider pregnancy status in women of childbearing age when choosing an agent (avoid ACEI in pregnant patients, etc.).

58

THERAPEUTIC STRATEGIES

Drug targets and mechanisms in heart failure.

Target or Drug Class	Drug Examples	Mechanisms	Uses in Heart Failure
Renal sodium transporter inhibitors	Furosemide, spironolactone, other diuretics; SGLT2 blockers	Reduce preload and afterload	Acute and chronic failure
ACE inhibitors Angiotensin receptor blockers	Captopril, others Losartan, others	Reduce preload and afterload, reduce remodeling, other	Chronic failure
Beta adrenoceptor antagonists	Carvedilol, others	Reduce afterload, reduce remodeling, other	Chronic stable failure
Na^+/K^+ ATPase inhibitors	Digoxin	Increases Ca_{ii}, increases cardiac contractility	Chronic failure
Beta adrenoceptor agonists	Dobutamine, dopamine	Increase Ca_{ii}, increase contractility	Acute failure
Vasodilators	Nitroprusside	Reduce preload and afterload	Acute failure
Phosphodiesterase inhibitors	Milrinone	Vasodilation, increase contractility	Acute failure
Natriuretic peptide	Nesiritide	Vasodilation reduces preload and afterload; some diuretic effect	Acute failure
Neprilysin inhibitor + ARB	Sacubitril/Valsartan	Combined increased BNP + ARB effects	Chronic failure

59

Special Considerations – Elderly Hypertensive Patients

- **Physiological Changes:** Elderly patients often have **isolated systolic hypertension** due to stiffening of arteries (arteriosclerosis). This leads to **widened pulse pressure (e.g., 170/70).** They may have orthostatic hypotension as well. Large artery stiffness means they can't buffer changes in BP as well. Additionally, decreased baroreceptor sensitivity in age means slower reflex control of BP.
- **Myocardial Considerations:** Long-standing HTN in the elderly commonly results in **LVH and diastolic dysfunction**. The elderly are very **preload-dependent** for maintaining cardiac output. Aggressive vasodilation or volume removal can cause significant drops in cardiac output. They also often have coexisting coronary artery disease – even if asymptomatic – so they cannot tolerate tachycardia or hypotension well without risking ischemia.
- **Medication Profile:** Many elderly patients are on multiple antihypertensives (**polypharmacy**). They might be on a beta-blocker, ACEI, and diuretic combination, for example. This can make them prone to intraoperative hypotension if all meds are on board. It's important to verify which meds they took and to anticipate interactions (e.g., an elderly patient on an ACEI and diuretic might drop pressure quickly on induction). They also might have altered pharmacokinetics – drugs last longer due to reduced metabolism or renal clearance.
- **Induction and Anesthetic Dosing:** The **elderly require gentler induction**. Reduced anesthetic requirements (sensitivity to anesthetics increases with age) means we should give lower doses and titrate slowly to avoid overshoot hypotension. For example, use maybe 1–1.5 mg/kg propofol instead of 2–2.5 mg/kg, given slowly. Consider etomidate in a very tenuous patient for its stable hemodynamics. Have phenylephrine ready at induction. Intubation response might be pronounced – consider shorter-acting agents to blunt it (e.g., fentanyl or a touch of remifentanil, but carefully to avoid prolonged respiratory depression given slower metabolism).
- **Blood Pressure Goals:** In chronically hypertensive elderly patients, their cerebral autoregulation is likely shifted upward. They may tolerate higher BP and **do poorly with "normal" lower BPs**. For example, an 80-year-old whose baseline is 160/90 might get dizzy or ischemic at 120/70. Intraoperatively, we often accept a **higher MAP for elderly patients – maybe keep MAP >75 or 80 mmHg if that's closer to their normal.** The trick is avoiding both ends: do not allow extreme hypertension (stroke risk) but also avoid "overcorrecting" to a low level. Basically, **maintain perfusion** – when in doubt, slightly higher is better than too low in this population (within reason).
- **Postop and Recovery:** Elderly patients are more prone to postoperative BP fluctuations – e.g., hypotension from residual anesthetics or epidural blocks, or hypertension from pain or agitation (delirium). They also have less physiologic reserve, so a hypertensive crisis or hypotensive episode can have more severe consequences (stroke, AKI, etc.). Use short-acting drugs so that effects aren't prolonged. Monitor them longer in PACU until you're confident BP is stable. Resume home meds carefully – maybe restart one at a time and monitor for orthostatic changes. And remember, some elderly have what's called "pseudohypertension" (cuff readings high but actual intra-arterial pressure lower due to non-compressible arteries) – if something doesn't add up (e.g., super high cuff BP but patient looks fine and art-line shows lower), trust direct measurements.

60

Special Considerations – Emergency Surgery & Hypertension

- **No Time for Optimization:** In emergency cases (trauma, ruptured aneurysm, urgent cardiac, etc.), you often cannot spend hours or days optimizing BP. The focus shifts to **damage control** – proceeding to surgery and managing hypertension concurrently. This means the anesthesia plan must accommodate higher-than-ideal pre-op BP. Expect to manage very high BP during induction or surgical stimulation because the patient hasn't been optimized.
- **Induction Strategy:** For a severely hypertensive patient who needs emergent surgery, consider mitigating BP as you induce. Options: If conditions allow, give a quick-acting antihypertensive bolus (e.g., labetalol 10-20 mg IV or nitroglycerin infusion started) *just before induction* to blunt an extremely high BP. Induce with an agent like etomidate or a higher dose of opioid to reduce the sympathetic response. Rapid sequence induction may be needed (e.g., trauma with full stomach), which complicates gentle control – in that case, ensure you have vasodilators ready immediately after intubation. If intubation causes a dangerous spike (e.g., BP goes to 240), push a dose of vasodilator or turn up a nitroprusside drip rapidly. It's a delicate dance of keeping the patient alive through intubation with high BP.
- **Intraoperative Management:** Place an arterial line as soon as possible (even if it means quickly after induction or during a lull). This gives you fine control. Use infusions early – for instance, in an emergency **aortic dissection**, guidelines say get systolic BP down rapidly with IV infusions plus β-blockade. In less extreme emergencies, like an urgent bowel obstruction surgery where BP is 200/110 on arrival, start a nicardipine infusion and titrate while the surgery starts, rather than waiting. Manage what you can: pain (give adequate analgesia even if patient is unconscious – uncontrolled surgical pain will keep BP high), and avoid additional triggers (don't let them get hypoxic or hypercapnic, which would worsen HTN).
- **Prioritize Life-Threats;** In some emergencies, hypertension might actually be compensatory or less urgent relative to other issues. Example: a trauma patient is hypertensive maybe due to pain or head injury, but more pressing is a bleeding spleen – you focus on getting to hemorrhage control. Or conversely, a traumatic brain injury patient with high BP – you might actively treat BP to reduce intracranial pressure. Always assess what's the biggest threat: if it's bleeding, slight hypertension might help perfuse organs until bleeding is controlled (except in hemorrhagic stroke or aortic dissection scenarios where high BP itself is the threat). So, for each emergency, decide if high BP is friend, foe, or just background.
- **Communication:** Work closely with surgeons – if a patient's BP is dangerously high but the surgery is life-saving, communicate how you will manage it and that you may need a moment to stabilize certain aspects. For instance, "After induction, I'll need 2 minutes to get control of BP with medications before incision." Surgeons generally understand that extreme hypertension can increase bleeding. They might also help by injecting local anesthetics to mitigate pain response or by pausing if BP gets too high while you adjust meds.
- **Post-op ICU:** Emergency surgery patients who were very hypertensive should probably go to an ICU or at least step-down for close BP management post-op. Often, their underlying HTN is poorly controlled (since it was extreme in an emergency), so they will need proper medical management. Ensure an ICU bed is arranged if needed and that any ongoing infusions (nicardipine, etc.) are handed off properly. In emergencies, often the patient's chronic meds are unknown – once stabilized, the ICU team might start a presumptive regimen (like a beta-blocker or ACEI) if needed, but in the acute phase we stick to IV controllable meds.

61

Special Considerations – High-Risk Cardiovascular Patients

- **Profile:** These are patients with serious cardiovascular comorbidities – e.g., history of myocardial infarction or angina, heart failure (reduced EF or significant diastolic dysfunction), significant valvular disease (like aortic stenosis), or major arrhythmias. Hypertension in these patients can be especially dangerous (it raises afterload and oxygen demand) and their margin for error is small. They often require meticulous hemodynamic management to avoid tipping into ischemia, pulmonary edema, or arrhythmias.
- **Preoperative Prep:** Ensure optimization of their condition: for example, if possible, recent cardiology eval, optimization of HF (are they euvolemic? on appropriate meds like β-blocker, ACEI, nitrates?), and that they've continued all crucial meds (β-blockers, anti-anginals, etc.). If the patient has a **beta-blocker**, it should be continued– absolutely critical in CAD to prevent rebound ischemia. One might even give a small extra dose pre-op if heart rate is high (with caution). Consider pre-op nitrate paste or infusion in patients with active angina or to preload with anti-ischemia measure if BP tolerates. In some cases, an arterial line can even be placed pre-induction if risk is high (for example, severe aortic stenosis or very labile CAD patient, so you have beat-to-beat from the start).
- **Induction and Monitoring:** Avoid tachycardia and hypotension at induction – these patients may have **fixed cardiac output** or be very preload dependent (like in aortic stenosis or hypertrophic cardiomyopathy). An arterial line early is often indicated. Use invasive monitors liberally (central line for vasoactive drips, or pulmonary artery catheter or TEE in some advanced cases like very low EF). During induction, have vasopressors and vasodilators ready – you might need to treat whichever extreme occurs. For example, in a patient with severe CAD, I'll have phenylephrine ready in case of hypotension (to maintain coronary perfusion pressure) and esmolol ready in case of hypertension/tachycardia (to reduce cardiac stress). Consider etomidate or high-opioid induction (like fentanyl 5-10 mcg/kg for cardiac patients) to blunt response. If they have aortic stenosis, keep them a bit hypertensive (they need afterload) and avoid bradycardia extremes; if they have regurgitant valves, avoid hypertension which worsens regurgitation. Tailor to their lesion.
- **Intraoperative Goals:** *Tight control* – you might aim for a narrower BP range than usual. For instance, keep SBP 120–140 if that's their baseline zone, avoiding <100 or >160. Use continuous infusions for fine tuning (nitroglycerin or nicardipine for upper end, low-dose norepinephrine or phenylephrine for lower end, as needed). Pay attention to heart rate: often **β-blockade** is your friend in high-risk patients (to maintain HR ~60-70 in CAD, or in heart failure to prevent tachycardic decompensation). If patient has a history of heart failure, be cautious with fluids – give smaller boluses and assess (use monitors like arterial line pulse pressure variation, or even TEE to see filling). Hypertensive heart failure patients can go into pulmonary edema if you aggressively fluid load and they get hypertensive – balance afterload reduction (maybe a little nitroprusside if BP tolerates) with avoiding over-transfusion.
- **Emergence:** Avoid surges in BP and HR as they wake up – consider a controlled, smooth emergence plan. For example, in a high-risk cardiac patient, you might extubate deep or under a remifentanil infusion to avoid a big sympathetic surge. Alternatively, just before extubation give a dose of IV beta-blocker or resume NTG infusion to cover that period. Have nitroglycerin ready in PACU if they develop ischemic ECG changes with high BP. Some of these patients may benefit from postoperative ventilation and sedation (e.g., keep intubated in ICU for a few hours to control BP and pain, common in vascular or big abdominal surgeries for high-risk folks).
- **Postoperative Care:** Strongly consider ICU admission for close monitoring. Continue telemetric monitoring of rhythm (risk of afib, etc.). Continue the critical meds: beta-blockers, ACEI, etc., as soon as feasible. Control pain well (consider epidural analgesia in a controlled way – good pain control can avoid spikes, but watch that epidural-induced vasodilation doesn't drop BP too much; in high-risk CAD, one might actually prefer an epidural to minimize systemic opioid needs and keep patient comfortable, but carefully manage the BP effects). High-risk patients often do well with invasive monitoring overnight – for instance, an arterial line in ICU to catch any BP excursions and treat immediately.

62

Postoperative Hypertension – Incidence & Risks

- **Incidence:** Postoperative hypertension is common, especially in the first hours after surgery. Up to ~20% of patients experience significant hypertension in the immediate post-op period. It is particularly prevalent after surgeries like cardiovascular or head/neck surgeries and in patients with pre-existing HTN. Pain and emergence delirium contribute heavily.
- **Typical Onset:** It often starts as the patient emerges from anesthesia in PACU – sympathetic activity returns, pain kicks in, maybe a full bladder or endotracheal tube discomfort is present, all driving BP up. If not managed, this can persist into the first 24–48 hours post-op.
- **Risks of Postop HTN:** Elevated BP after surgery increases the risk of serious complications. **Stroke:** A major concern – the stress of surgery plus uncontrolled high BP can precipitate hemorrhagic stroke. Guidelines often flag SBP >180 mmHg as a trigger to treat to prevent intracerebral hemorrhage. **Cardiac Events:** Postop HTN increases myocardial oxygen demand and can precipitate myocardial infarction or heart failure (flash pulmonary edema can occur when BP surges in susceptible individuals). **Bleeding:** High BP can disrupt surgical hemostasis – for example, it's a known risk factor for bleeding at vascular anastomoses or causing postoperative hematomas (e.g., in neck surgery or intracranial surgery, where a hematoma can be life-threatening). **Arrhythmias:**Surges in BP often come with surges in heart rate and catecholamines, which can trigger atrial fibrillation or other arrhythmias in vulnerable patients.
- **Identification:** It's important to monitor BP frequently in PACU, particularly for patients with a history of HTN. Many institutions have protocols: if SBP >160 or 170 mmHg on two readings, start treatment; if >180 mmHg, treat immediately as "severe" (those thresholds vary, but 180 is often cited as the danger zone). For patients in ICU, continuous monitoring is ideal. Don't rely on patients to report symptoms – many are sedated or analgesed; instead, have a low threshold to treat numbers in a clearly hypertensive range to forestall complications.
- **Patient Factors:** Patients at highest risk of postop HTN include the elderly (less physiological reserve, often undertreated baseline HTN), those with inadequately controlled pre-op HTN, and those who had to have their meds held (e.g., someone whose ACEI/ARB was held might rebound on POD#1 with higher BP if pain isn't well-controlled). Also, any patient who suffers an adverse event like a stroke or cardiac event often shows significant BP lability around that time – cause and effect can go both ways (HTN can cause the event, or the event can cause HTN through stress response).
- **Implications:** Recognizing and treating postoperative hypertension is crucial for patient safety. This often means ensuring a good handoff – the anesthesia team should convey to the PACU nurses if a patient is high risk ("This patient has history of HTN; please keep BP <160, and we have PRN hydralazine or labetalol orders if needed"). Unchecked postoperative hypertension is a preventable contributor to serious complications.

63

Postoperative Management Strategies for Hypertension

- **Pain Control:** The first and foremost step – ensure adequate analgesia. Pain is a leading cause of post-op hypertension. Use multimodal analgesia: IV opioids (in appropriate doses), regional anesthesia techniques (nerve blocks or epidurals if applicable), and non-opioid analgesics (NSAIDs, acetaminophen) to minimize pain-driven sympathetic output. A comfortable patient is far less likely to be hypertensive. Don't forget treating *shivering* (with meperidine or warming) as shivering can double or triple catecholamine levels.
- **Resume Home Meds Early:** Once the patient can safely take oral medications, resume their chronic antihypertensives (unless contraindications emerged). For instance, give their beta-blocker the evening of surgery or next morning to prevent rebound and maintain control. If they're unable to take PO for a while (e.g., intubated in ICU), use IV equivalents: esmolol infusion for beta-blocker, or transdermal clonidine patch, etc., as needed. Continuing background meds will help stabilize long-term control.
- **IV Antihypertensives PRN:** Have standing orders for acute hypertension in the PACU/ICU. Common protocols: IV labetalol in incremental doses (e.g., 5–10 mg) for sustained elevated BP with tachycardia, or IV hydralazine (5–10 mg) for elevated BP with brady/not elevated HR, titrated every 10–15 minutes as needed. Sublingual nifedipine is **no longer recommended** due to uncontrolled drop in BP – avoid that. In an ICU setting or if severe hypertension persists, consider a titratable infusion (nicardipine is often first-line for postoperative hypertension that requires continuous control, as it's easily adjusted). Nitroprusside infusion is an option if extremely high BP needs rapid control, but usually nicardipine or even nitroglycerin (if CAD) is preferred for ease of use.
- **Treat Contributing Factors:** Address any reversible contributors. Is the patient anxious or agitated? Consider a sedative (small dose of a benzodiazepine or dexmedetomidine infusion) if appropriate. Is the bladder full (a very common cause of hypertension in PACU)? If so, ensure it's emptied via catheter. Is there a ventilatory issue like hypoxia or hypercapnia? Correct that with oxygen or improved ventilation. These physiologic stressors can all spike BP. In short, do a systematic check: pain, bladder, temperature, oxygenation.
- **Monitoring & Escalation:** Continue close BP monitoring in the hours and days after surgery, especially for high-risk patients. For those in ICU, an arterial line might be kept until BP is stable. For floor patients, ensure frequent vitals checks initially. If hypertension is severe or difficult to control on the floor, consider transferring to higher level care for IV therapy. Collaborate with medicine/cardiology if postoperative hypertension is persistent – they may need adjustment of their outpatient regimen (maybe they need an additional drug or dose tweaking after surgery due to stress). Also, ensure no sign of hypertensive emergency: check for headaches (could indicate hypertensive encephalopathy), neuro checks for stroke, ECG changes for ischemia, etc., and treat those scenarios emergently if they arise.
- **Special Situations:** Certain surgeries have specific BP targets post-op. For example, after carotid endarterectomy, surgeons often want BP in a tight range (not too high to avoid reperfusion injury, not too low to avoid carotid plaque hypoperfusion). After intracranial surgery, you may have an order like "keep SBP <140." Be aware of these and have drips or meds ready accordingly. Communicate with surgical teams about these targets. Conversely, some patients (like those with chronic hypertension and stroke risk) may have an *intentionally* higher BP goal post-op to maintain perfusion (permissive hypertension in stroke, for instance). So individualize targets.
- **Follow-Up:** Ensure the patient's hypertension is re-evaluated on follow-up. Sometimes, surgery and the periop course reveal that their baseline HTN management wasn't ideal (maybe they were on insufficient meds). The perioperative period can serve as a pivot to improve long-term BP control, in coordination with their primary care – but that's beyond our immediate intra-hospital scope, yet beneficial to mention in discharge planning.

64

65

References

Elisha, S., Nagelhout, J. J., &; Heiner, J. (2021). *Current anesthesia practice: Evaluation & certification review.* Elsevier.

Nagelhout, J. J. (2018). Autonomic and Cardiac Pharmacology. In J. J. Nagelhout and E. Sass (Eds), *Nurse Anesthesia* (6th ed). Elsevier

Wehrwein, E. A., Orer, H. S., & Barman, S. M. (2016). Overview of the Anatomy, Physiology, and Pharmacology of the Autonomic Nervous System. *Comprehensive Physiology*, *6*(3), 1239–1278. https://doi.org/10.1002/cphy.c150037

66

66