Hypertension (HTN)

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Key facts

1. An estimated **1.28 billion adults aged 30–79 years** worldwide **have hypertension**, most (**two-thirds**) **living** in **low- and middle-income** countries
2. An estimated **46%** of **adults** with hypertension are **unaware that they have** the condition.
3. **Less than half** of **adults** (42%) with hypertension are **diagnosed and treated**.
4. Approximately **1 in 5 adults** (21%) with hypertension have **it under control**.
5. Hypertension is a **major cause** of **premature death** worldwide.
6. One of the **global targets** for "non-communicable diseases" is **to reduce the prevalence of hypertension** by **33**% between **2010 and 2030**.

Overview

Hypertension (high blood pressure) is when the pressure in the blood vessels is **too high (140/90 mmHg** or **higher**). It is **common** but can be **serious if not treated**.

Etiology

a. **Aging** It has long been taught that BP increases as a normal consequence of **aging**. Recent work indicates this may not be so.
b. **Diet & salt:** The rainforest and ingest minimal salt, have the lowest BP of any society in the world. While those have had some exposure to salt, have higher levels of BP, albeit far lower than modern societies.
c. A **modern lifestyle & other**: Additional risk factors for HTN include **family history**, **increased weight**, **sedentary lifestyle**, **cigarette smoking**, and a **diet low in potassium**.

Epidemiology

Systolic blood pressure (SBP) increases progressively into the ninth decade of life. **Diastolic blood pressure (DBP) increases** into the mid-50s, after which it begins to decline, resulting in **increased pulse pressure**.

The **decrease in DBP** seems due to *large artery **stiffness**, resulting in **less** *aortic blood volume and **less** elastic recoil in diastole.

HTN affects approximately **29%** of the **population**, **30%** of **males**, and **28.1%** of **females**. It is more prevalent in **males until about the sixth decade**, after which it is more prevalent in **females.**

Due to the aging population, **obesity** epidemic, and increasing adoption of **sedentary lifestyles**, the prevalence of **HTN** will **continue to rise.**

By 2025, it is estimated that the number of people with HTN will increase to nearly 1.5 billion people worldwide. It is **increasingly affecting children** as well, due to increasing **obesity** and **sedentary behavior** كثير الجلوس in the young.

People with high blood pressure may not feel symptoms. The only way to know is to **get the blood pressure checked**.

Risk factors

1) **Modifiable risk factors** include unhealthy diets (excessive salt consumption, a diet high in saturated fat and trans fats, low intake of fruits and vegetables), physical inactivity, consumption of tobacco and alcohol, and being overweight or obese.
2) **Non-modifiable risk factors** include a *family history of hypertension, *age over 65 years and *co-existing diseases such as **diabetes** or **kidney** disease.

Things that **increase the risk** of having high blood pressure **include**:

1. Older **age**
2. **Genetics**
3. Being overweight or **obese**
4. Not being **physically** active
5. High-salt **diet**

6. Drinking too much **alcohol**

Lifestyle changes like eating a healthier diet, quitting tobacco and being more active can help lower blood pressure. Some people may still need to take medicines.

Blood pressure is written as **two numbers**:

The **first (systolic)** number represents the pressure in blood vessels when the heart contracts or beats.

The **second (diastolic)** number represents the pressure in the vessels when the heart rests between beats.

Hypertension is **diagnosed if**, when it is measured on **two different days**, the **systolic** blood pressure **readings on both days is ≥140 mmHg and/or** the **diastolic blood pressure readings on both days is ≥90 mmHg**.

Symptoms

Most people with hypertension **don't feel any symptoms**. **Very high blood pressures** can **cause** headaches, blurred vision, chest pain and other symptoms.

Checking your blood pressure is the best way **to know** if you have high blood pressure. If hypertension **isn't treated, it can cause other health conditions like *(1) kidney disease, *(2) heart disease and *(3) stroke.**

People with very high blood pressure (usually **180/120 or higher**) can experience **symptoms including**:

1. severe headaches
2. chest pain
3. dizziness
4. difficulty breathing
5. nausea
6. vomiting
7. blurred vision or other vision changes
8. anxiety
9. confusion
10. buzzing in the ears
11. nosebleeds
12. abnormal heart rhythm

If you are experiencing any of these symptoms and a high blood pressure, seek **care immediately**.

The only way to detect hypertension is to have a health professional measure blood pressure. Having blood pressure measured is quick and painless. Although individuals can measure their own blood pressure using **automated devices**, an evaluation by a **health professional** is important for *assessment of risk and *associated conditions.

Treatment

Lifestyle changes can help lower high blood pressure. These include:

- Eating a healthy, low-salt diet
- Losing weight
- Being physically active
- Quitting tobacco.

If you have high blood pressure, your doctor may recommend **one or more "medicines"**. Your recommended blood pressure **goal** may **depend on what other health conditions** you have.

Blood pressure goal is **less than 130/80 if you have:**

1. Cardiovascular **disease** (heart disease or stroke)
2. **Diabetes** (high blood sugar)
3. Chronic **kidney** disease
4. **High risk** for cardiovascular disease.

For most people, the **goal** is to have a blood pressure **less than 140/90.**

There are **several common blood pressure medicines**:

1) **ACE inhibitors** including **Enalapril** and **Lisinopril** relax blood vessels and prevent kidney damage.
2) **Angiotensin-2 receptor blockers (ARBs)** including Losartan and Telmisartan relax blood vessels and prevent kidney damage.
3) **Calcium channel blockers** including Amlodipine and Felodipine relax blood vessels.
4) **Diuretics** including Hydrochlorothiazide and Chlorthalidone eliminate extra water from the body, lowering blood pressure.

Prevention

Lifestyle changes can **help lower** high blood pressure and can **help anyone** with hypertension. Many who make these changes will still need to take **medicine**.

These lifestyle changes **can help prevent and lower** high blood pressure.

Do:

1. Eat more **vegetables and fruits.**
2. **Sit less.**
3. Be more **physically active**, which can include walking, running, swimming, dancing or activities that build strength, like lifting weights.
   - Get at least 150 minutes per week of moderate-intensity aerobic activity **or** 75 minutes per week of vigorous aerobic activity.
   - Do strength building exercises 2 or more days each week.
4. **Lose weight** if you're overweight or obese.
5. **Take medicines** as prescribed by your health care professional.
6. Keep appointments with your health care professional.

Don't:

- **eat** too much salty food (try to stay under 2 grams per day)
- eat foods high in saturated or trans fats
- smoke or use tobacco
- drink too much alcohol (1 drink daily max for women, 2 for men)
- miss or share medication.

Reducing hypertension **prevents: (1)** *heart attack, **(2)** *stroke and **(3)** *kidney damage, as well as **(4)** *other health problems (retinopathy) .

Reduce the **risks** of hypertension **by**:

1. Reducing and managing **stress**
2. **Regularly** checking blood pressure
3. **Treating** high blood pressure
4. **Managing** other medical **conditions**.

Complications of uncontrolled hypertension

I.Among other **complications**, hypertension **can cause** *serious "**damage"** to the **heart**. *Excessive pressure can **harden arteries**, "**decreasing"** the *flow of blood and *oxygen to the heart.

This **elevated** pressure and **reduced** blood flow can **cause**:

a) chest **pain**, also called **angina**;
b) **Heart attack**, which occurs when the blood supply to the heart is **blocked** and **heart muscle cells die** from lack of oxygen. The **longer** the blood flow is **blocked**, **the greater** the damage to the **heart**;
c) **Heart failure**, which occurs when the heart **cannot pump enough blood** and **oxygen** to **other vital body** organs;
d) **Irregular heart beat** (**arrhythmia**) which **can lead to a sudden death**.
e) **Hypertension** can also ***burst** or ***block arteries** that supply blood and oxygen to:
   - **i.** The **brain**, causing a **stroke**.
   - **ii.** In addition, hypertension can **cause kidney damage**, leading to **kidney failure**.
   - **iii.** Hypertensive retinopathy.

WHO response

The World Health Organization (WHO) supports countries **to reduce hypertension as a public health problem.**
In 2021, WHO released a new guideline for on the pharmacological treatment of hypertension in **adults**.
The publication provides evidence-based recommendations for the initiation of treatment of hypertension, and recommended intervals for follow-up. The document also includes **target blood pressure** to be achieved **for control, and information** on who, in the **health-care system**, can **initiate treatment**.

Evaluation and Management of Perioperative Hypertension

This activity **reviews** the **role of the interprofessional team** involved in the **perioperative care of patients** with **hypertension (HTN).**
These **providers** include anesthesiologists, nurses, surgeons, primary care providers such as **internists** and **general practitioners**, and **physician assistants**.
Objectives:

1) **Identify** the **etiology** of perioperative hypertension.
2) **Outline** the appropriate **evaluation** of perioperative hypertension.
3) **Review** the **management options** available for perioperative hypertension for **optimization**.
4) **Summarize** interprofessional team **strategies** for improving care coordination and communication to advance perioperative hypertension and improve **outcomes**.

Quizzes about **Introduction:**

a) Hypertension (HTN) is the **most common** medical diagnosis.
b) It **results** in **end-organ damage** in the vasculature,(i) heart, (ii) brain, (iii) kidneys, and (iv) eyes.
c) It is associated with **more cardiovascular disease (CVD) deaths** than **any other** modifiable **disease**, accounting for an estimated **50% of deaths from (i) "coronary artery disease"** and **(ii) "stroke"** in one large study.
d) It is **responsible for** the **deaths** of approximately **nine million** people **annually** worldwide, is present in more than **60% of people 60 years of age and older**, and is controlled in under 20% of patients globally.

Since most patients are **asymptomatic**, and **associated complications** are **serious**, **HTN** has been labeled the "**silent killer**".
The silent nature of the disease is especially concerning as later onset of treatment is associated with *cardiac and *renal **pathophysiologic changes** and a **higher risk of CVD**, compared with the normal population, **even among treated hypertensives who** achieve the same blood pressure (BP) values as the normal population.

Although **generally managed** by **primary care providers** such as **internists'** أطباء الباطنة , **family** practitioners, and **nurse** practitioners, **severe perioperative HTN may result in:**

1. **Excess** surgical **bleeding**,
2. Myocardial **ischemia** and/or **infarction**,
3. Congestive heart failure (**CHF**)
4. Acute **pulmonary edema** (**APE**).

Therefore, it is **vital** that ***anesthesiologists**, ***nurses**, and ***all healthcare professionals** who manage patients in **preparation for surgery**, and **during the perioperative period**, are **knowledgeable regarding the care of patients with HTN.**

Pathophysiology

1) **HTN results** in the deposition of atherosclerotic plaque in **arteries**. **Coronary artery disease (CAD),** sometimes combined with **plaque rupture**, leads to myocardial ***ischemia** and ***infarction** **(**thromboembolic phenomena**)** .
2) **Increased afterload** due to **HTN** *(i) **increases** the works of the **heart**, *(ii) **resulting** in left ventricular hypertrophy (LVH) and **CHF**.

The **hypertrophied heart** **requires** **more oxygen**, but the **flow** of oxygenated blood is **impaired** in CAD by luminal narrowing of the coronary arteries.

3) **Myocardial infarction** results in **decreased** contractility, which **decreases** **blood flow** to the **systemic circulation** in **systole**.
4) **Coronary blood flow** occurs in diastole, and coronary perfusion is **decreased** in the presence of hypertension-induced **LVH** **because LVH** results in *(i) decreased compliance and *(ii) increased left ventricular end-diastolic pressure (LVEDP).

Examining the equation for "coronary perfusion pressure" (CPP), CPP = DBP – LVEDP, **makes** it readily apparent that **increased** LVEDP **results** in **decreased** "coronary blood flow" (**CBF**) in **diastole**.

One way to improve coronary perfusion (**CP**), **is to slow the heart rate**, which **increases** the proportion of cardiac cycle **time spent in diastole**.

This explains why **tachycardia** can result in myocardial ischemia. Although **CBF** can also be increased by increasing **DBP**, excessive increases in DBP, whether achieved with "volume infusion" and/or "vasoconstrictors", can result in increased lung water and even **APE**.

5) **Diastolic dysfunction (DD)** may be present for years, with *structural and *physiologic **changes**, **before** symptoms develop. Older literature refers to "diastolic heart failure". This language has been replaced with the term **heart failure with preserved ejection fraction (HFpEF)**.

DD that leads to HFpEF is most commonly caused by **HTN**. The underlying pathophysiology **relates** to the increased *wall thickness and *collagen, **resulting** in: **i.** a **stiff** LV, **ii.** with decreased compliance, **iii.** impaired relaxation, **iv.** a smaller cavity, and **v.** increased LVEDP.

6) **LV filling** is impaired in diastole, and elevated left atrial pressure may be transmitted to the **alveoli**, resulting in **fatigue** and/or **dyspnea**.

Since **tachycardia** decreases "diastolic filling time", left-sided pressures rise in the face of **exercise**, or any cause of tachycardia such as **surgical stress.**

Like **systolic heart failure**, **diastolic heart failure** is associated with severely decreased exercise capacity, as well as neurohumoral activation with increased norepinephrine levels, increased brain natriuretic peptide, and decreased quality of life.

HFpEF is predominantly a disorder of older adults, with women more often afflicted than men, especially those with **longstanding** HTN.

DD causes slightly more than half the cases of CHF and explains the occurrence of CHF in patients with normal systolic function.

II. Atherosclerosis in cerebral vessels can *impair blood flow to the **brain**, causing an **ischemic stroke**. Atherosclerotic vessels in the brain may also * burst, resulting in a **hemorrhagic stroke**. Hemorrhagic stroke on the surface of the brain causes a "subarachnoid hemorrhage", **while** a ruptured vessel within the brain results in "intracerebral bleeding".

HTN may also result in embolic stroke when atherosclerotic **plaque** in the **ascending aorta** dislodges and travels to the **brain** where it **occludes** a blood vessel. **Embolic stroke** may also occur **if** atherosclerotic emboli originate in the *venous circulation, but subsequently, **enter** the *arterial circulation via a patent foramen ovale.

Atherosclerosis of arteries to the kidneys impairs oxygen delivery to the nephrons. In time, the glomerular filtration rate decreases, and damaged kidneys lose the ability to filter the blood.

In fact, **HTN is the second most common cause of end-stage renal disease (ESRD)** after diabetes. Damaged kidneys also result in an impaired renin-angiotensin-aldosterone pathway, further elevating BP.

Diagnosis:

1) History and Physical

A- **Most patients with HTN report their diagnosis when presenting for a preoperative visit**. Still, in a study of patients manifesting hypertensive **crises**, more than a **third** were **unaware** they had **HTN**.

Therefore, the **importance of measuring BP at the preoperative visit cannot be overemphasized**. Furthermore, it should be **measured** in **both arms.**

Despite published **guidelines for BP measurement** and a review of BP measurement for anesthesiologists, "inaccurate BP measurement" is common. BP should be measured in a ***quiet** room, with the patient ***sitting**.

i) **Under-sized cuffs** result in erroneously elevated BP, and this is the most common cause of erroneously reported HTN. A **properly sized cuff** has a bladder cuff ***length** that is 80% to 100% the circumference of the arm, while the ***width** of the cuff should be 40% of the upper mid-arm circumference.

ii) **The cuff** should be centered over the brachial artery, directly on the skin. Too large a cuff usually results in an accurate reading.

BP cuffs measure mean arterial pressure (MAP), with SBP and DBP determined by algorithms that vary between manufacturers.

Although cuff BP is most often measured in: i) **the upper arm**, it can be measured in ii) **the legs**. BP is **10 to 20 mm Hg higher in the legs** as compared with the arms.

Quiz: The "white-coat HTN"

i) **If BP** is greater than 130/80 mm Hg but less than 160/90 mmHg, and a patient states they have **white-coat HTN**, it should be **confirmed** that "white-coat HTN" has been properly **diagnosed** with **ambulatory or home BP monitoring**. **One to five percent** (1-5%) of patients with "white-coat hypertension" converts to sustained HTN **annually**.

ii) The **incidence** is greater with: i. older age, ii. obesity, iii. higher initial BP, and iv. Blacks. White-coat HTN has been associated with ***slightly increased CVD risk** and *all-cause **mortality risk**.

B- History should focus on **symptoms** associated with **end-organ damage**. **Hypertensive heart disease** may result in *coronary artery disease or *LVH with associated *DD.

The **clinician** should inquire about **symptoms**, including: i. *chest pain or pressure, ii.*dyspnea on exertion, iii.*orthopnea, or *paroxysmal nocturnal dyspnea. iv.*The **distance** a patient can walk on level ground, and the number of **flights of stairs** they can climb before the onset of symptoms should be documented. V. Symptoms of stroke or transient ischemic attacks should be sought. Vi. Symptoms of kidney disease, such as those related to **fluid overload**, are only present in patients with "**severe kidney disease".**

vii. Recent changes in visual acuity may reflect **hypertensive retinopathy**.

Signs of HTN on physical examination **reflect** changes to **end organs:**

a) An S3 gallop may indicate **CHF** in patients with a dilated LV, but may also be present in healthy pregnant women and athletes.

b) An S4 is heard when blood flow from atrial contraction enters a non-compliant LV. Therefore, it may be heard in the presence of LVH or diastolic heart failure.

c) Distended neck veins may indicate fluid overload or CHF, though this may also occur in **isolated pulmonary hypertension.**

d) Rales, also called fine crackles, suggest **CHF** or **APE**, though they may also be caused by infection.

e) With a history of a prior stroke, a **neurologic examination** should document related deficits.

f) **A fundo-scopic examination** can detect **changes** secondary to HTN. These may **include** retinal arteriolar changes and/or hemorrhage, and papilledema may be seen with **hypertensive urgencies** and **emergencies**. However, a fundoscopic examination is not routinely performed as part of preoperative evaluation.

Evaluation

Initial Evaluation of a Hypertensive Patient

a) Ideally, treatment for HTN should be initiated by primary care providers electively**, not immediately** prior to surgery
b) The **initiation of treatment** should be made **after** several measurements of BP on **at least two different occasions**.
c) **Diet in overweight patients, exercise, and decreased salt intake** should be a mainstay of treatment.

The **goal of treatment** should be to reduce both **BP** and risk of **CVD**.
***Primary agents to treat HTN include** "thiazide diuretics", "angiotensin-converting enzyme inhibitors" (ACE), "angiotensin receptor blockers" (ARB), and "calcium channel blockers".
***Secondary agents** include "loop diuretics", "potassium-sparing diuretics", "aldosterone antagonists", "beta-blockers", "alpha-1 blockers", "centrally acting drugs", and "direct vasodilators".

Preoperative Evaluation

Patients with prior medical history should be assessed in a **preoperative anesthesia** clinic a minimum **of one week** prior to surgery. This **affords time** for management changes **to optimize** the **patient's state of health**, including **BP**.
A **new concept**, the **perioperative surgical home**, has been described, using a **team** approach to **both** ***optimize** the patient preoperatively, and ***guide care** during the postoperative period.

1) **If BP is well controlled**, and history and physical examination are unremarkable غير ملحوظة , **further testing** may be unnecessary for *uncomplicated surgery or procedures, **but** is appropriate ملائم if history or physical are concerning, and for *larger and invasive surgeries.

Electrocardiography (ECG), transthoracic echocardiography (TTE) and **transesophageal echocardiography (TEE) detect** the presence of LVH. **Echocardiography** can also measure its severity.
Wall motion abnormalities and **left ventricular ejection fraction (LVEF)** can be detected with TTE and TEE.
DD by **Doppler-echo**, in combination with a **normal LVEF** and a history **of CHF**, suggests a diagnosis of HFpEF.

2) **Referral to a cardiologist** may be **advisable** to determine appropriate preoperative tests, assess perioperative risk, and make focused recommendations for perioperative care.

Cardiac catheterization is usually only performed **when** indicated by symptoms, and the cardiologist believes preoperative intervention may be indicated, such as percutaneous coronary intervention in a patient with worsening **angina**.

(3) A **neurologist s**hould assess neurologic signs or symptoms before **elective surgery**.
(4) **Urology: Serum creatinine** can indicate impaired renal function, though it needs to be appreciated that approximately 50% of **kidney function** may be lost before creatinine begins to rise.

In patients with **HTN**, a **basic metabolic panel** should be performed to document the preoperative **state of kidney function** with serum creatinine.

(5) **Internist: Electrolytes** should be performed **if** patients are on antihypertensives that impact electrolytes, such as diuretics.
(6) **Complete blood count** and **platelet count** are indicated **if** the procedure may be associated with significant blood loss. Still, many preoperative clinics will perform a complete blood count prior to all but minor procedures.

Treatment / Management

Preoperative Medications

a) **Most patients** with **HTN** are treated initially with a **diuretic**, although calcium channel blockers (CCB), ACE and ARB can be first-line drugs in **non-black patients**. **In Blacks**, first-line treatment should be

initiated with a diuretic or CCB, as there is less cardiovascular and cerebrovascular **morbidity** and **mortality** with these agents as compared with ACE.

b) **All patients** should be treated with an ACE or ARB if they have stage 3 kidney disease or chronic kidney disease with greater than 300 mg/day of albuminuria. Despite these guidelines, patients may be receiving various combinations of antihypertensive medications based upon their *cardiovascular risk and the *presence of end-organ damage.

There is some **disagreement regarding** antihypertensive medications **on the day of surgery (DOS)**. In general, patients should be:

a) Instructed **to take** their oral antihypertensive medications the **DOS with a sip of water.**

b) It is widely **accepted** to **withhold diuretics**, due to the overnight fast.

c) Still, in patients with **severe CHF**, a **reduced dose of diuretic**, or **even the usual dose**, might be considered. Perhaps this decision should be made by the **anesthesiologist** in the preoperative area, after *measurement of BP and *auscultation of the lungs.

d) **Patients on chronic beta-blocker therapy should receive their beta-blocker on the DOS.**

e) However, beta-blockade therapy should not be initiated immediately before surgery, for although it has been shown to **decrease the incidence of cardiac events**, it also **increases** the risk of **bradycardia**, **stroke**, and **death**.

f) Some practitioners **withhold ACE before "noncardiac surgery"**, based on a prospective cohort study that found a **higher incidence** of intraoperative hypotension, and the primary composite outcome of all-cause death, stroke, or myocardial injury.

Still, the effect size was **small**, and while a meta-analysis of 6022 patients undergoing "noncardiac surgery" **supports** the association between the continuation of ACE and ARB on the DOS and intraoperative **hypotension**, it found no differences in mortality, cardiac events, stroke, acute kidney injury (AKI), or length of stay between the groups. **Some continue ACE and ARB in patients with CHF.**

Preoperative Evaluation on the Day of Surgery (DOS)

Patients who present for anesthesia **should have** normal BP on the DOS, although it may be somewhat increased above their usual level due to anxiety.

1. **Once SBP** reaches 170 mm Hg or **DBP** reaches 100 mm Hg, it is likely the patient **will manifest** "BP gyrations" سوف تظهر تقلبات BP, in the perioperative period. These can usually **be managed safely with appropriate** administration of anesthetics, analgesics, and antihypertensives.
2. **If** a patient presents with **SBP** of 180 or **DBP** of 110 and has no prior history of **HTN**, or manifests these BP measurements despite having taken their **BP medications the DOS**, **elective surgery should be postponed until BP is better controlled**.
3. **If** SBP is 180 or DBP is 110 and the patient has not taken their antihypertensives **that morning**, they should be given with a sip of water, or a comparable intravenous antihypertensive administered.

A small dose of an **anxiolytic** such as Midazolam could be administered as well. Changing the order of cases should be considered to afford these agents time to work prior to inducing anesthesia.

The 2017 American College of Cardiology/American Heart Association **guidelines**; label SBP of 180 mm Hg as "**hypertensive crisis**", so a decision to proceed with surgery with SBP of 180 mm Hg should be made with caution, **considering** the *"patient's overall state of health" and *"urgency of the procedure".

4. **If SBP** is 200 mm Hg, **elective surgery should be canceled**, as a large retrospective study has **shown** that patients who receive anesthesia with an SBP of 200 mm Hg **have twice the risk of a postoperative rise in troponin**, (Very high levels of troponin are a sign that a heart attack has occurred), and **twice the risk of death**, compared with patients with lower BP.

However, **DBP** of 110 is itself a risk factor for cardiovascular complications. **It has been associated with** ECG changes of myocardial ischemia, **especially** if blood pressure drops to <50% of awake MAP and isolated diastolic HTN is **associated** with increased risk of both CHF and death in the general population.

5. **If surgery is emergent** and must proceed despite poorly controlled BP, precautions should be taken. A recent ECG and echocardiogram should be reviewed. In patients in whom such information is not available, a brief delay to obtain a STAT ECG and echocardiogram may be appropriate.

An increasing number of anesthesiologists are **becoming proficient in "point-of-care TTE",** as the *ability to assess "cardiac function" rapidly is invaluable for the assessment and management of **critically ill patients**.

If "**point-of-care TTE" suggests** significant pathology, a **formal echocardiogram** should be performed and interpreted by a cardiologist.

6. **If surgery is of an emergent natur**e, *careful monitoring of BP with an arterial line is advised, and *pharmacologic therapies should be immediately available to treat HTN. **Such treatment** may need to be continued into the **post-anesthesia care unit** (**PACU**) and/or **intensive care unit (ICU).**

Intraoperative Management

1) **GA:** One of the anesthesiologist's primary responsibilities is to ensure safe levels of BP. This may be **achieved** with *anesthetics, *analgesics, and *antihypertensive agents, with the choice of specific techniques and drugs tailored to the specific patient's comorbidities.

Poor management of BP in the perioperative period may cause **end-organ complications**. However, assuming BP is carefully managed during anesthesia, it is more likely the anesthesiologist **will be tailoring management** of the patient based upon preexisting end-organ complications of HTN, or the measured **BP on the DOS.**

2) **Regional nerve blocks** provide surgical anesthesia with minimal hemodynamic changes. **Spinal and epidural techniques** similarly permit maintenance of spontaneous ventilation, **but BP may drop significantly**. Such decreases may be **ameliorated** with (a) volume **infusion** and/or (b) **vasoconstrictors**. **Rigid adherence** to certain anesthetics for specific procedures is **not recommended**, as each patient's comorbidities need to be considered. Still, the application of regional techniques and patient-controlled analgesia **help** minimize postoperative pain and the stress response. In addition, postoperative mobilization may be more rapid after regional techniques.

Acute complications of HTN can be minimized by maintaining BP in an appropriate range, both **intraoperatively and in the PACU**. Since patients with **poorly controlled BP** may have **DD,** it is important to prevent tachycardia. **Beta-blockers** are appropriate for this purpose.

CCB, ACE inhibitors, and ARB not only *lower BP but, in some studies, have been found to *result in regression of LVH. It is important to maintain normal sinus rhythm (NSR) in the presence of DD.

If atrial fibrillation (AFIB) develops, especially if the ventricular response is rapid, stroke volume may decrease, and pulmonary venous pressures may rise substantially. **Rapid cardioversion** or, at minimum, rate control may be necessary to stabilize these patients. To prevent the recurrence of AFIB, **beta-blockers and amiodarone may be useful.**

Target values for *SBP, *DPB, and *MAP have been recommended. One group reported that variability and area under the curve for SBP outside the range of 105 to 130 mm Hg is **associated with increased mortality after coronary artery bypass graft surgery**.

In patients with stable CAD, SBP <120 mm Hg and DBP <70 mm Hg were each associated with adverse cardiovascular outcomes, including death. Of note, these authors reported a J-shaped curve so that SBP of 140 and DBP of 80 was **associated with** *an increased risk of cardiovascular events.

In other words, **tightly controlled BP** may be important to minimize cardiovascular risk in patients with CAD**. If** 130 mm Hg seems an ideal SBP for the patient with CAD, it seems likely to be safe for patients without CAD as well, although these patients **could likely tolerate SBP lower than 130 mm Hg under anesthesia**, based upon their **age**, **overall state of health**, and the **surgical procedure**.

Recent work indicates that patients with HFpEF have a greater risk of heart failure with DBP <60 mm Hg, and a greater risk of death and cardiovascular death with DBP of ≥90 and <60 mm Hg.[26]

This work also found that the hazard ratio for hospitalization for CHF and death increased **significantly** between DBP of 100 mm Hg and DBP of 110 mm Hg. Others reported a greater risk of death with **DBP** <70 mm Hg, which

may be due to subclinical myocardial injury. Therefore, **DBP** should be **maintained between 70 to 90 mm Hg perioperatively.**
MAP should be maintained 60 to 65 mm Hg, as a large retrospective study found that, **during noncardiac surgery**, short periods of MAP <55 mm Hg are **associated** with increased risk of adverse cardiac events and **AKI**.

Not only was the risk of these outcomes **increased with** the increasing length of time that MAP was <55 mm Hg, **but MAP below 55 mm Hg,** even for just a few minutes, **was associated with myocardial injury and AKI**.
This is important for **perioperative AKI** is associated with a shortened lifespan.

Poorly controlled HTN may lead to large reductions in BP during the administration of anesthesia, and both *treated and *untreated hypertensive patients **often display** a lower BP nadir than normotensive patients.
Severe HTN and **significant hypotension** are **both** associated with increased risk of perioperative complications.
Maintenance of appropriate intraoperative BP targets is important to minimize the risk of CHF. This is especially important, for in patients **undergoing noncardiac surgery, *(a) non-ischemic heart failure** is associated with a **9.3% 30-day mortality**, and ***(b) ischemic heart failure** is associated with a **9.2% 30-day mortality**, vs. **2.9% for CAD**, and **the risk of postop 30-day mortality** is only marginally lower **for minor surgery.**
Intravenous agents that may be used to treat **severe intraoperative HTN under anesthesia include**: *sodium nitroprusside, *nicardipine, and *nitroglycerin.
Infusion of these agents, with appropriate adjustments, can **provide control of even severely elevated BP**. Rapid dose adjustments can be **facilitated with beat-to-beat arterial line monitoring**.
Once a steady-state is reached, **hydralazine** may be used to provide longer-term control, and to facilitate weaning from such infusions.
Reports of hypotension after hydralazine are generally **associated** with doses of 10 mg or more. Under anesthesia, doses of just 5 mg may decrease **SBP** up to **25 mm Hg or more**.
Furthermore, **onset may be as long as 7 to 10 minutes** when used in small doses, and **the peak effect** may not occur **for 20 to 25 minutes.**
Practitioners who do not appreciate this **may administer a second dose** before the first dose has peaked. Still, if one appreciates these pharmacologic properties, **titrating hydralazine in doses of 2.5, 5, or 10 mg can be effective**, both to decrease continuous antihypertensive infusions and to transition patients to eventual oral therapy.
Beta-blockers such as Labetalol and Metoprolol have been **used to treat intraoperative HTN**.
Since metoprolol is primarily a beta 1-selective agent, its use might result in unopposed alpha action. **Esmolol** is an ultra-short-acting beta 1-selective antagonist. With **onset** after injection of one minute, **it is useful to prevent acute rises in BP,** such as that associated with intubation or other acute stimuli. **Its nine-minute half-life** makes it less practical for ongoing BP control than the other agents described as infusion may require very frequent adjustments.
Though rare for **undiagnosed "pheochromocytoma**" to present during an unrelated surgery, acute and severe intraoperative increases in BP should raise suspicion, especially **if such severe HTN** manifests in relation to *abdominal pressure or *manipulation. **Treatment of suspected pheochromocytoma** should be initiated with Phentolamine or Sodium Nitroprusside, as beta-blockers can result in unopposed alpha action.

In summary, in patients "**with HTN** and/or **significant cardiovascular disease**", overall **appropriate targets** for intraoperative BP can be summarized as (a) SBP approximately 130 mm Hg, (b) MAP 60 to 65 mm Hg, and (c) DBP 70 to 90 mm Hg.
While elevated BP should be decreased, care should be taken to reduce BP cautiously, as reset autoregulation in the brain and kidneys could result in organ injury if BP is reduced dramatically and/or quickly.