**The Circulatory System**

It includes the heart and blood vessels, which circulates blood throughout the entire body, The circulatory system has two divisions, systemic circulation and pulmonary circulation.

The network of blood vessels includes

1- large elastic arteries (Aorta, right and left subclavian Arteries).

2- large veins (inferior and superior vena cava).

3- middle sized arteries e.g. (axillary artery) and veins( femoral veins).

4- smaller arterioles and venules .

5- capillaries that join venules with arterioles.

The circulatory system is closed in vertebrates, which means that the blood never leaves the network of blood vessels.

**Anatomy of Blood Vessels**

The arteries and veins have three layers

1- The tunica intima, is the inner layer, and it is the thinnest layer. It is a single layer of flat cells (simple squamous epithelium) .

2- The tunica media is middle layer which is the thickest layer in arteries. It consists of circularly arranged elastic fiber, The tunica media in arteries is rich in vascular smooth muscle, which controls the caliber of the vessel. The tunica media is thicker in the arteries rather than the veins.

3- The outer layer is the tunica adventitia , It is entirely made of connective tissue. It also contains nerves that supply the vessel as well as nutrient capillaries (vasa vasorum) in the larger blood vessels.

When blood vessels connect to form a region of diffuse vascular supply it is called an anastomosis. Anastomoses provide critical alternative routes for blood to flow in case of blockages.

A **Capillary** is a small blood vessel from 5 to 10 micrometres (μm) in diameter. Capillaries are composed of only the tunica intima, consisting of a thin wall of simple squamous endothelial cells. they convey blood between the arterioles and venules. These microvessels are the site of exchange of many substances with the interstitial fluid surrounding them. Substances which cross capillaries include water, oxygen, carbon dioxide, urea, glucose, uric acid, lactic acid and creatinine. Lymph capillaries connect with larger lymph vessels to drain lymphatic fluid collected in the microcirculation.

the movement of fluids and substances out from and to capillaries depends on multiple variables: Capillary hydrostatic pressure , Interstitial hydrostatic pressure , Capillary oncotic pressure , Interstitial oncotic pressure

**The Pulmonary Circulation**

Oxygen-deprived blood from the superior and inferior vena cava enters the right atrium of the heart and flows into the right ventricle, from which it is then pumped into the pulmonary artery to the lungs. Gas exchange occurs in the lungs, whereby CO2 is released from the blood, and oxygen is absorbed. The pulmonary veins returns the oxygen-rich blood to the left atrium. This circle from heart to lung then heart is called Pulmonary Circulation.

**The Systemic Circulation**

The systemic circulation is a circuit loop that delivers oxygenated blood from the left heart (left ventricle) to the rest of the body through the aorta and many braches then blood is returned to the heart through inferior and superior vena cava.

**Peripheral vascular resistance**

The heart pumps blood forcefully in blood vessels , the resistance to this pump by peripheral arterioles is used to create blood pressure. When blood vessels constrict (vasoconstriction) this leads to an increase in vascular resistance (VR) so increasing Bp. When blood vessels dilate (vasodilation), this leads to a decrease in VR and hence decrease Bp. resistance within the pulmonary vasculature, is called pulmonary vascular resistance (PVR) while in systemic is called systemic vascular resistance SVR.

Peripheral vascular resistance is mediated locally by metabolites like nitric oxide (cause vasodilatation) and endothelin (cause vasoconstriction) which are released from endothelial cells, and systemically by neuro-hormones mainly adrenalin (Epinephrine) and nor-adrenalin (nor epinephrine) which are released from adrenal medulla.

During an adrenergic response where norepinephrine gets released into the bloodstream, it binds to the smooth muscle cells of the vasculature binding to an alpha-1 receptor which leads to contraction of the smooth muscle in tunica media. Other molecules that cause vasoconstriction on a cellular level include angiotensin II, vasopressin, dopamine.

The autonomic nervous system causes both vasoconstriction and vasodilation. Alpha-1 receptor activation causes vasoconstriction, and beta-2 receptor activation causes vasodilation.

**Blood Pressure**

Blood pressure is mediated by a balance between the **cardiac** output and the **peripheral vascular resistance** (mediation of this resistance is at the level of the arterioles) and the **plasma volume**.

Blood pressure is used to maintain organ perfusion. In conditions such as shock, there is a decrease in vascular resistance thus causing decreased organ perfusion which leads to organ malfunction and failure.

**Renin Angiotensin Aldosterone System (** RAAS)

When renal blood flow is reduced, juxtaglomerular cells in the kidneys convert the precursor pro-renin (already present in the blood) into renin and secrete it directly into the circulation. Plasma renin then carries out the conversion of angiotensinogen, released by the liver, to angiotensin I. Angiotensin I is subsequently converted to angiotensin II by the angiotensin-converting enzyme (ACE) found on the surface of vascular endothelial cells, predominantly those of the lungs.

Angiotensin II is **vasoconstrictor** that increases blood pressure and stimulates aldosterone secretion from the adrenal cortex.

Aldosterone causes the renal tubules to increase the reabsorption of sodium which in consequence causes the reabsorption of water into the blood, while at the same time causing the excretion of potassium (to maintain electrolyte balance). This increases the volume of extracellular fluid in the body, which also increases blood pressure.

**Hypertension**

medical condition in which the blood pressure in the arteries is **persistently** elevated in which office Systolic BP values ≥140 mmHg and/or diastolic BP (DBP) values ≥90 mmHg.

Long-term high blood pressure is a major risk factor for stroke, coronary artery disease, heart failure, atrial fibrillation, peripheral arterial disease, vision loss, chronic kidney disease, and dementia. Classification of Blood pressure according to severity

**Classification of office blood pressure****and definitions of hypertension grade**

|  |  |  |  |
| --- | --- | --- | --- |
| **Category** | **Systolic (mmHg)** |  | **Diastolic (mmHg)** |
| Optimal | <120 | and | <80 |
| Normal | 120–129 | and/or | 80–84 |
| High normal  (prehypertension) | 130–139 | and/or | 85–89 |
| Grade 1 HT | 140–159 | and/or | 90–99 |
| Grade 2 HT | 160–179 | and/or | 100–109 |
| Grade 3 HT | ≥180 | and/or | ≥110 |
| Isolated systolic HT | ≥140 | and | <90 |

The overall prevalence of hypertension in adults is around 30 − 45%, with a global age-standardized prevalence of 24% and 20% in men and women, respectively, in 2015. Hypertension becomes progressively more common with advancing age, with a prevalence of >60% in people aged >60 years.

**Pathophysiology**

In most people with established essential hypertension, increased resistance to blood flow (total peripheral resistance) accounts for the high pressure while cardiac output remains normal. The increased peripheral resistance in established hypertension is mainly attributable to structural narrowing of arterioles.

**Classification of Hypertension according to cause**

**I…..Essential Hypertension** (also called **primary** hypertension, or **idiopathic** hypertension) is the form of hypertension that has no identifiable secondary cause. It is the most common type affecting 90-95% of those with high blood pressure. The remaining 10-5% is accounted for by various causes of secondary hypertension.

Risk factors includes

1. **INHERIRED includes** family history , RACIAL, genes
2. **Aging , 3- Obesity 4-Salt 5-Diabetes 6-Lack of exercise 7-Stress**

**II….Secondary hypertension** it is a type of hypertension which is caused by an **identifiable underlying secondary cause**. It is much less common than essential hypertension, affecting only 10-5% of hypertensive patients. It has many different causes including endocrine diseases, kidney diseases, and tumors. It also can be a side effect of many medications.

* 1. **Causes In the kidneys**

1. **Renovascular** hypertension, It has two main types: **fibromuscular** **dysplasia** and **atherosclerosis** of the renal artery resulting in stenosis, decreased perfusion of renal tissue due to stenosis of a main or branch renal artery that will activates the renin–angiotensin system.
2. **polycystic kidney** disease which is a cystic genetic disorder of the kidneys, PKD, which is characterized by the presence of multiple cysts in both kidneys, these cysts leads to activation of Renin angiotensin aldosterone system.
3. **Tumors** of the kidneys can cause hypertension like hypernephroma (RCA) due to multiple mechanisms.
4. **Chronic kidney disease** like chronic renal failure, glomerulonephritis.
   1. **The Endocrine system**
5. [**Pheochromocytoma**](https://en.wikipedia.org/wiki/Pheochromocytoma) – a tumor which results in an excessive secretion of norepinephrine and epinephrine which promotes vasoconstriction.
6. [**Hyperaldosteronism**](https://en.wikipedia.org/wiki/Hyperaldosteronism) ([Conn's syndrome](https://en.wikipedia.org/wiki/Conn%27s_syndrome)) tumor secrets aldosterone leading to salt and water retention.
7. [**Cushing's syndrome**](https://en.wikipedia.org/wiki/Cushing%27s_syndrome) – adrenal tumor with an excessive secretion of glucocorticoids sodium and water retention.
8. [**Acromegaly**](https://en.wikipedia.org/wiki/Acromegaly)pituitary tumor that secrets excess growth hormone, cromegaly is frequently associated with insulin resistance and hyperinsulinaemia which may induce hypertension by stimulating renal sodium absorption and sympathetic nervous activity.
9. [**Hyperthyroidism**](https://en.wikipedia.org/wiki/Hyperthyroidism) excess secretion of thyroid hormone increase heart rate and cardiac output.
10. [**Hypothyroidism**](https://en.wikipedia.org/wiki/Hypothyroidism) decrease secretion of thyroid hormone leads to secondary hypertension due to increase peripheral vascular resistance.

### 3- Other causes of secondary hypertension

* [Obstructive sleep apnea](https://en.wikipedia.org/wiki/Obstructive_sleep_apnea)
* [Scleroderma](https://en.wikipedia.org/wiki/Scleroderma)
* [Pregnancy](https://en.wikipedia.org/wiki/Pregnancy):.
* [Drugs](https://en.wikipedia.org/wiki/Medication): In particular, [alcohol](https://en.wikipedia.org/wiki/Alcohol_(drug)), [NSAIDs](https://en.wikipedia.org/wiki/Non-steroidal_anti-inflammatory_drug), [Steroid](https://en.wikipedia.org/wiki/Steroid) use, oral contraceptives
* [Coarctation of the aorta](https://en.wikipedia.org/wiki/Coarcation_of_the_aorta)
* [White coat hypertension](https://en.wikipedia.org/wiki/White_coat_hypertension), that is, elevated blood pressure in a clinical setting but not in other settings, probably due to the anxiety some people experience during a clinic visit.
* Perioperative hypertension is development of hypertension just before, or during or after [surgery](https://en.wikipedia.org/wiki/Surgery). It may occur before surgery during the induction of [anesthesia](https://en.wikipedia.org/wiki/Anesthesia); intraoperatively mostly by pain-induced [sympathetic nervous system](https://en.wikipedia.org/wiki/Sympathetic_nervous_system) stimulation; in addition, hypertension may develop perioperatively because of discontinuation of long-term antihypertensive medication.

### Resistant hypertension

Resistant hypertension is defined as high blood pressure that remains above a target level, in spite of being prescribed three or more antihypertensive drugs simultaneously with different [mechanisms of action](https://en.wikipedia.org/wiki/Mechanism_of_action).   Some common secondary causes of resistant hypertension include [obstructive sleep apnea](https://en.wikipedia.org/wiki/Obstructive_sleep_apnea), , [renal artery stenosis](https://en.wikipedia.org/wiki/Renal_artery_stenosis), [coarctation of the aorta](https://en.wikipedia.org/wiki/Coarctation_of_the_aorta" \o "Coarctation of the aorta), and [primary aldosteronism](https://en.wikipedia.org/wiki/Primary_aldosteronism).

**Refractory hypertension** is characterized by uncontrolled elevated blood pressure despite five or more antihypertensive agents of different classes, including a long-acting thiazide-like diuretic, a calcium channel blocker, and a blocker of the renin-angiotensin system.

**Investigation**

Kidney = Microscopic urinalysis, protein in the urine, BUN, serum creatinine, abdominal ultrasound with Doppler of renal arteries. Endocrine system= Serum sodium, potassium, calcium, Thyroid Stimulation Hormone , serum and urine epinehrines. Steroid and growth hormone.

Heart and great vessels= ECG , Echo study , CXR and Chest CT.

**Prevention**

* maintain normal body weight for adults (e.g. [body mass index](https://en.wikipedia.org/wiki/Body_mass_index) 20–25 kg/m2)
* reduce dietary sodium intake to <100 mmol/ day (<6 g of sodium chloride or <2.4 g of sodium per day)
* engage in regular aerobic physical activity such as brisk walking (≥30 min per day, most days of the week)
* avoid smoking.
* consume a diet rich in fruit and vegetables

### Management

### Lifestyle modifications

The first line of treatment for hypertension is lifestyle changes, including dietary changes including decrease salt intake stopping smoking , physical exercise, weight loss and discontinuation of harmful medication.

**Medication**

First-line medications for hypertension include [**thiazide-diuretics**](https://en.wikipedia.org/wiki/Thiazide) **(chlorthalidone)** , [**calcium channel blockers**](https://en.wikipedia.org/wiki/Calcium_channel_blockers)( amlodipine, nifedipine), [**angiotensin converting enzyme inhibitors**](https://en.wikipedia.org/wiki/Angiotensin_converting_enzyme_inhibitor) (**ACE** inhibitors like lisinopril, enilapril captopril), and [**Angiotensin Receptor blockers**](https://en.wikipedia.org/wiki/Angiotensin_II_receptor_antagonist) (ARBs like valsartan, candesartan), alpha receptors blockers like labetolol. Most people require more than one medication to control their hypertension

**Complication of hypertension:-**

**1-ischemic heart disease & heart failure,**

**2- strokes,**

**3-peripheral vascular disease,**

**5-aortic dissection.**

**6-chronic kidney disease,**

**7-atrial fibrillation.**

**8-cognitive impairment and dementia.**

**9- hypertensive retinopathy and blindness.**

**Hypertensive Emergency**

**Malignant HT an acute, marked elevation in blood pressure that is associated with signs of target-organ damage. These can include pulmonary edema, cardiac ischemia, neurologic deficits, acute renal failure, aortic dissection, and eclampsia.**

**Management is by hospital admission specifically in intensive care unit and close follow up and gradual decreasing of blood pressure through intravenous drugs.**