Pathophysiology of Hypertension

Hypertension (HTN) is a chronic medical condition characterized by persistently elevated blood pressure (BP ≥ 140/90 mmHg). Its pathophysiology involves complex interactions between the nervous system, renal system, vascular endothelium, and hormonal mechanisms.

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1. Key Mechanisms in Hypertension Development

A. Increased Sympathetic Nervous System (SNS) Activity

✓ Stress, obesity, and genetics can cause hyperactivation of the SNS, leading to:

- Vasoconstriction (narrowing of blood vessels) → Increased peripheral resistance
- Increased heart rate & cardiac output
- Overstimulation of β1-receptors in the heart → Increased BP

Example: Chronic stress → Excess norepinephrine → Persistent BP elevation

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B. Renin-Angiotensin-Aldosterone System (RAAS) Overactivation

✓ RAAS plays a crucial role in blood pressure regulation through fluid balance & vasoconstriction.

✓ Overactivation leads to:

- ↑ Renin release (kidney) → ↑ Angiotensin II → Vasoconstriction
- ↑ Aldosterone → Sodium & water retention → Increased blood volume

Example: Kidney ischemia → Renin release → Angiotensin II surge → Chronic hypertension

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C. Endothelial Dysfunction & Reduced Nitric Oxide (NO) Production

✓ Endothelium-derived NO is a natural vasodilator.

✓ In HTN, there is ↓ NO & ↑ endothelin-1 (vasoconstrictor), leading to:

- Arterial stiffness
- Increased vascular resistance
- Chronic inflammation → Atherosclerosis → Worsening hypertension

Example: Diabetes & smoking → Oxidative stress → Endothelial damage → Hypertension

D. Sodium Retention & Fluid Overload

✓ Excess dietary salt intake leads to:

- Water retention → Increased blood volume → Increased cardiac output
- Reduced sodium excretion (in salt-sensitive individuals)

Example: High-sodium diet → Increased plasma volume → Sustained BP elevation

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E. Hormonal & Metabolic Factors

✓ Insulin Resistance & Obesity

- Hyperinsulinemia → Activates SNS & RAAS → Increases BP

  ✓ Leptin & Adipokines (From Fat Cells)
- Leptin ↑ SNS activity & BP
- Adiponectin ↓ in obesity → Less NO production → Vasoconstriction

Example: Obesity → ↑ Leptin, ↓ Adiponectin → Vasoconstriction → Hypertension

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F. Genetic & Environmental Influences

✓ Family history of hypertension increases risk.

✓ Epigenetic changes due to lifestyle (smoking, alcohol, stress, diet) contribute to vascular dysfunction.

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2. Long-Term Effects of Hypertension

✓ Heart: Left Ventricular Hypertrophy (LVH), Heart Failure, Coronary Artery Disease

✓ Brain: Stroke, Cognitive Decline

✓ Kidneys: Chronic Kidney Disease (CKD)

✓ Eyes: Hypertensive Retinopathy

✓ Vessels: Aneurysms, Peripheral Artery Disease

Conclusion

✓ Hypertension is a multi-factorial disease involving SNS overactivity, RAAS dysfunction, endothelial damage, and sodium imbalance.

✓ Uncontrolled HTN leads to organ damage, making early intervention crucial.

✓ Treatment involves lifestyle changes + antihypertensive medications targeting specific mechanisms.