جامعة الملك سعود
King Saud University

Arterial Blood Pressure

Index:
Red: important Grey: extra information Green: doctor's notes yellow: numbers
Purple: only in female slides Blue: only in male slides

Physiology Team437

Physiology 437 teamwork

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OBJECTIVES

by the end of this lecture you will be able to:

- Define Arterial blood pressure
- Systolic and Diastolic blood pressure
- Normal values of Systolic and Diastolic blood pressure
- Hypotension and Hypertension
- Physiological significance
- Describe physiological variation in arterial blood pressure.
- Explain the effect of gravity on arterial blood pressure.
- Pulse pressure, Mean Arterial pressure
- Describe how BP is measured
- Clinical features and complications of Hypertension
- Concepts of blood pressure.
- Normal levels of Arterial Blood Pressure.
- Calculating Pulse & Mean Arterial Pressures.
- Factors affecting & determining blood pressure.
- Relationships between blood pressure, Cardiac Output, & Total Peripheral Resistance.

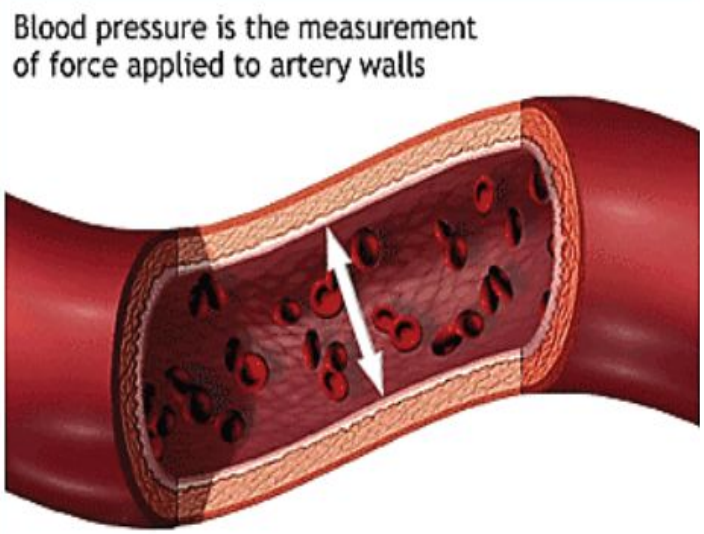
We recommend you to watch this before you start studying the lecture

Types of Blood Pressure

Depending on the nature of the blood vessels:

- **Arterial Blood Pressure.**
- Venous Blood Pressure.
- Capillary Blood Pressure.

Arterial Blood Pressure: It is the lateral pressure force applied on the arterial wall exerted by the blood flow.

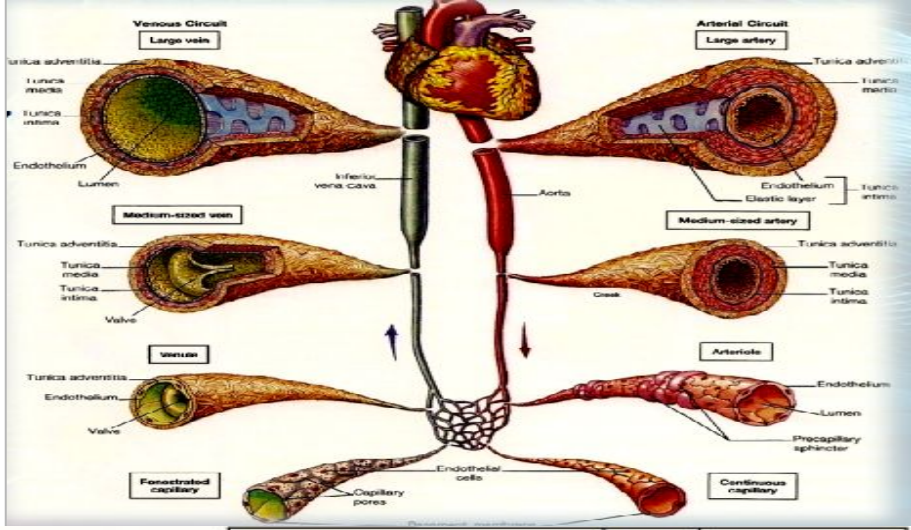


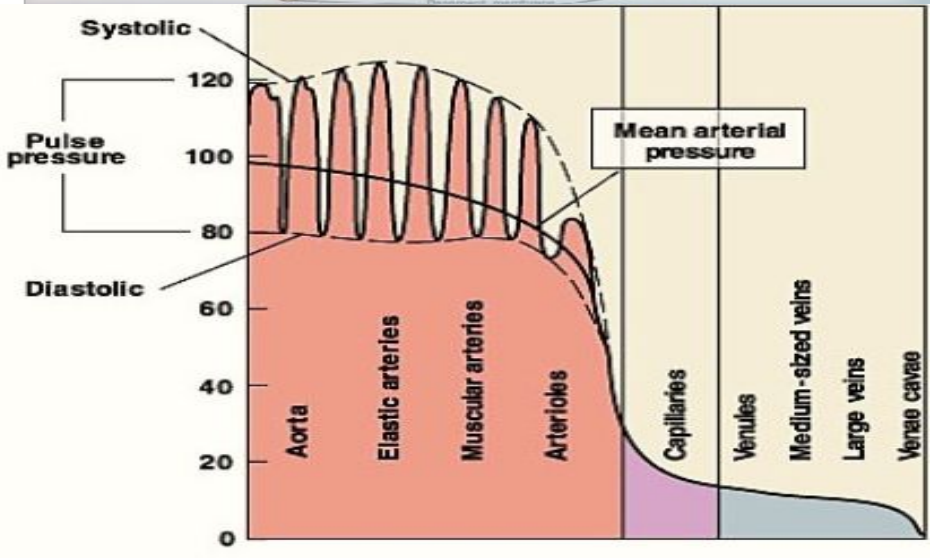
- BP is one of the most important vital signs.
- It is important to keep normal levels of blood pressure for proper blood flow to the body's organs & tissues.
- Measured in (mmHg), & sometimes in (cmH2O).

(**1mmHg = 1.36 cmH2O**)

Pressure Changes Throughout Systemic Circulation

- Blood flows down a pressure gradient.
- Highest at the heart (driving Pressure), & decreases over distance.
- Decreases 90% from aorta to vena cava.
- Greatest drop in pressure occurs in arterioles which regulate blood flow through tissues.
- No large fluctuations in capillaries & veins.
- BP averages **100 mm Hg** in aorta & drops to **2 mm Hg** in Right Atrium.





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ARTERIAL BLOOD PRESSURE IN DIFFERENT PARTS OF THE CIRCULATORY SYSTEM

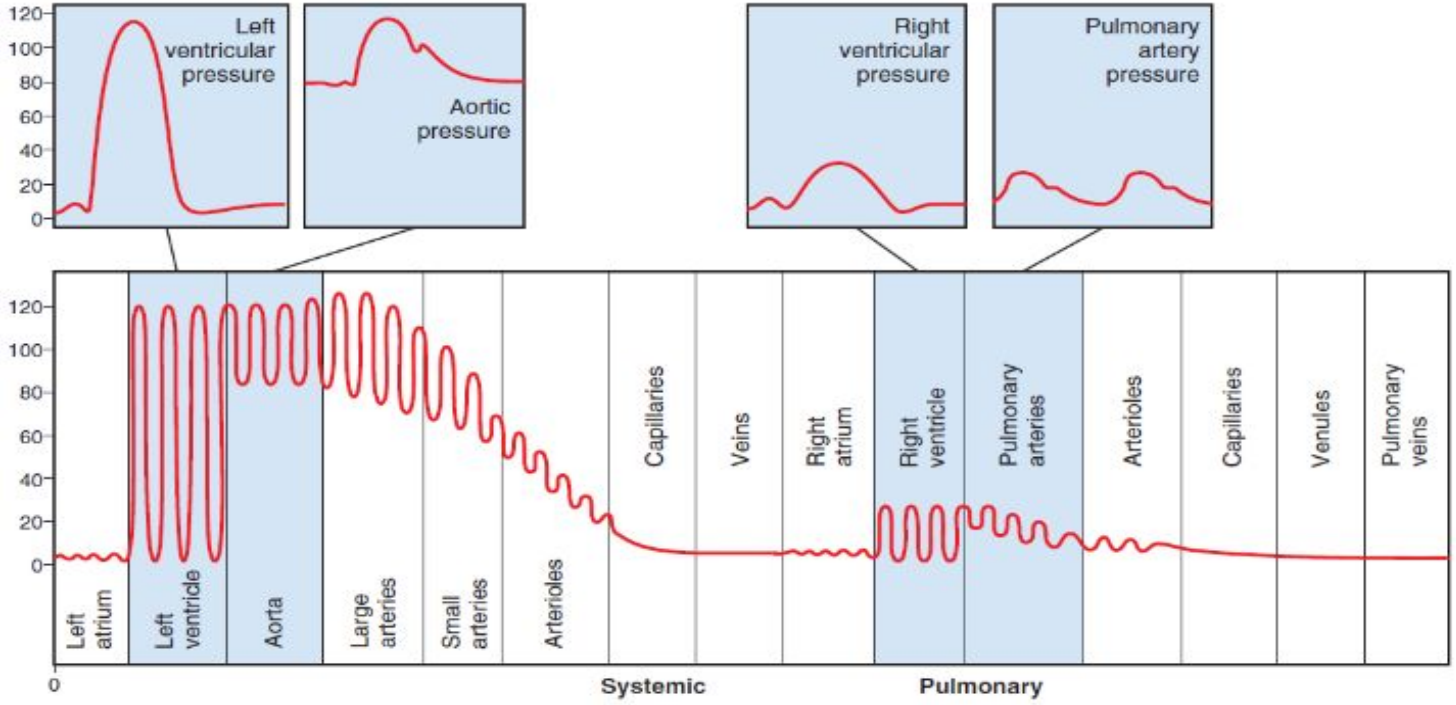


Figure 14-2. Normal blood pressures in the different portions of the circulatory system when a person is lying in the horizontal position.

Guyton and Hall, pp 171

Normal Levels of Arterial Blood Pressure

In normal adult = 120/80 mmHg

- **Top number (Systolic Pressure):**

Arterial Pressure recorded during maximum contraction of the heart.

- **Bottom number (Diastolic):**

Arterial Pressure recorded during maximum relaxation of the heart.

- Both numbers are important to determine the state of the heart health.

Range & Variations in Arterial Blood Pressure Levels

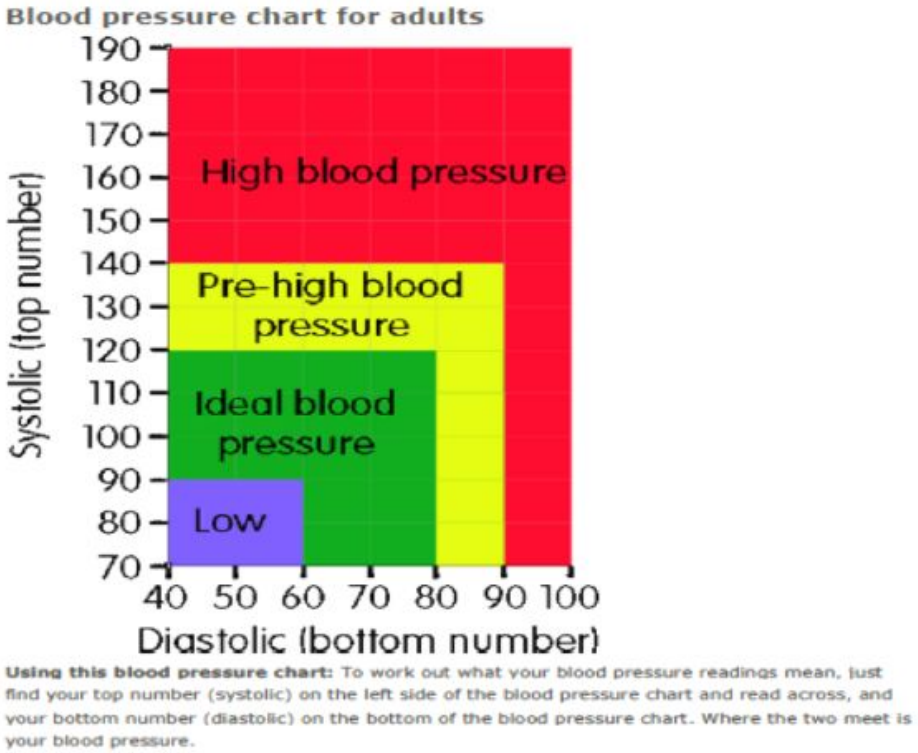
Arterial pressure is **Pulsatile(characterized by a rhythmic pulsation)**.

Aortic Pressure:
- **120 mmHg** systolic.
- **80 mmHg** diastolic.

Normal Arterial Pressure:
- **90 – 120 mmHg** systolic.
- **60 – 80 mmHg** diastolic.

Greater numbers than the ideal range indicate that the heart is working too hard to pump blood to the rest of the body.

Blood Pressure Chart



National Heart, Lung, and Blood Institute

JNC 7 Blood Pressure Classification In Adults Aged ≥ 18 Years

Category	Systolic		Diastolic
Normal	<120	and	<80
Prehypertension	120-139	or	80-89
Hypertension, Stage 1	140-159	or	90-99
Hypertension, Stage 2	≥160	or	≥100

National Heart, Lung, and Blood Institute. *JNC 7 Express. The Seventh Report of the Joint National Committee on the Prevention, Detection, Evaluation and Treatment of High Blood Pressure. 2003.*

American Heart Association
Blood Pressure Categories under new guidelines.

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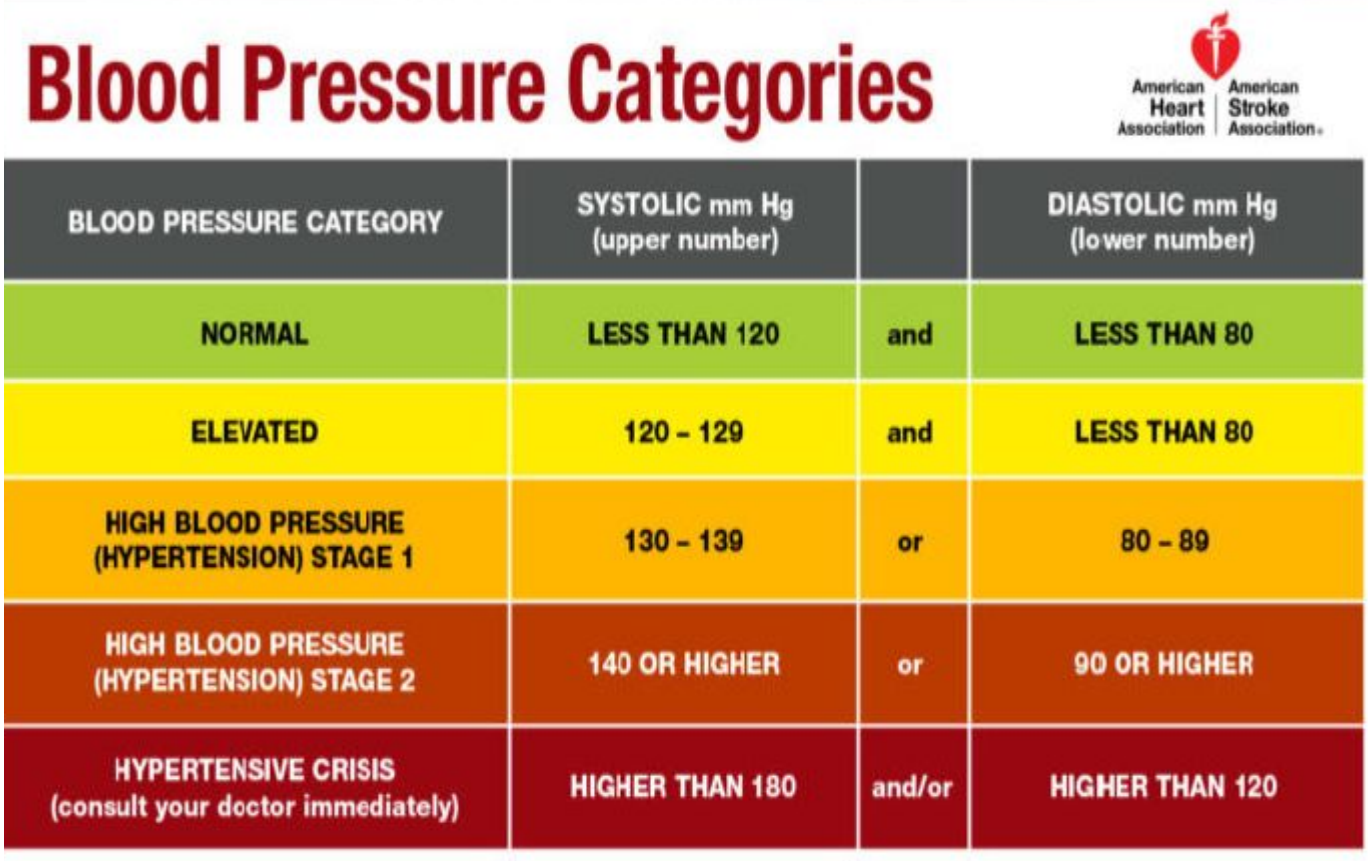
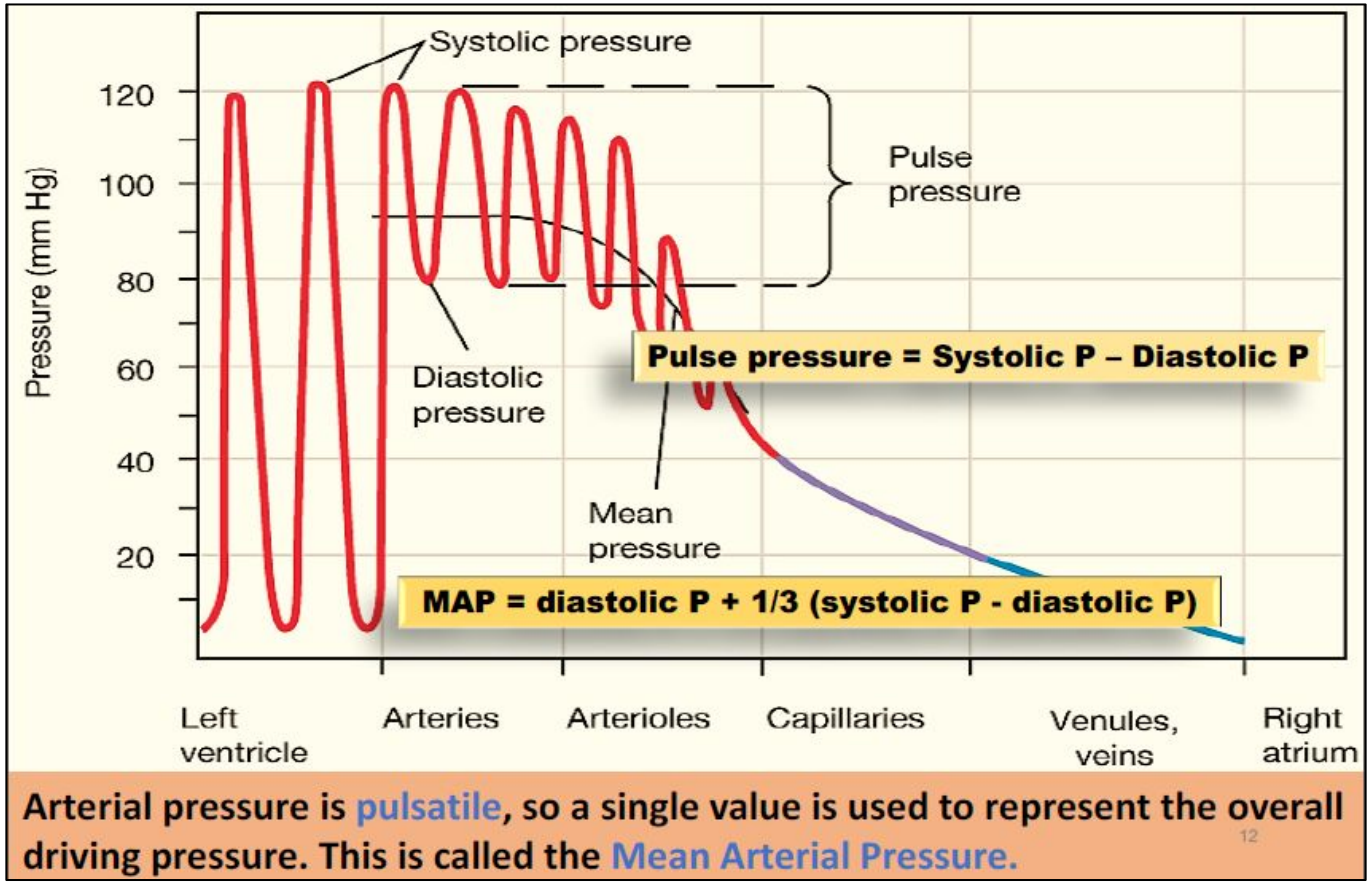


Blood Pressure Categories

American Heart Association | American Stroke Association

BLOOD PRESSURE CATEGORY	SYSTOLIC mm Hg (upper number)		DIASTOLIC mm Hg (lower number)
NORMAL	LESS THAN 120	and	LESS THAN 80
ELEVATED	120 – 129	and	LESS THAN 80
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 1	130 – 139	or	80 – 89
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 2	140 OR HIGHER	or	90 OR HIGHER
HYPERTENSIVE CRISIS (consult your doctor immediately)	HIGHER THAN 180	and/or	HIGHER THAN 120

Pulse and Mean Arterial Pressures



Arterial pressure is pulsatile, so a single value is used to represent the overall driving pressure. This is called the Mean Arterial Pressure.

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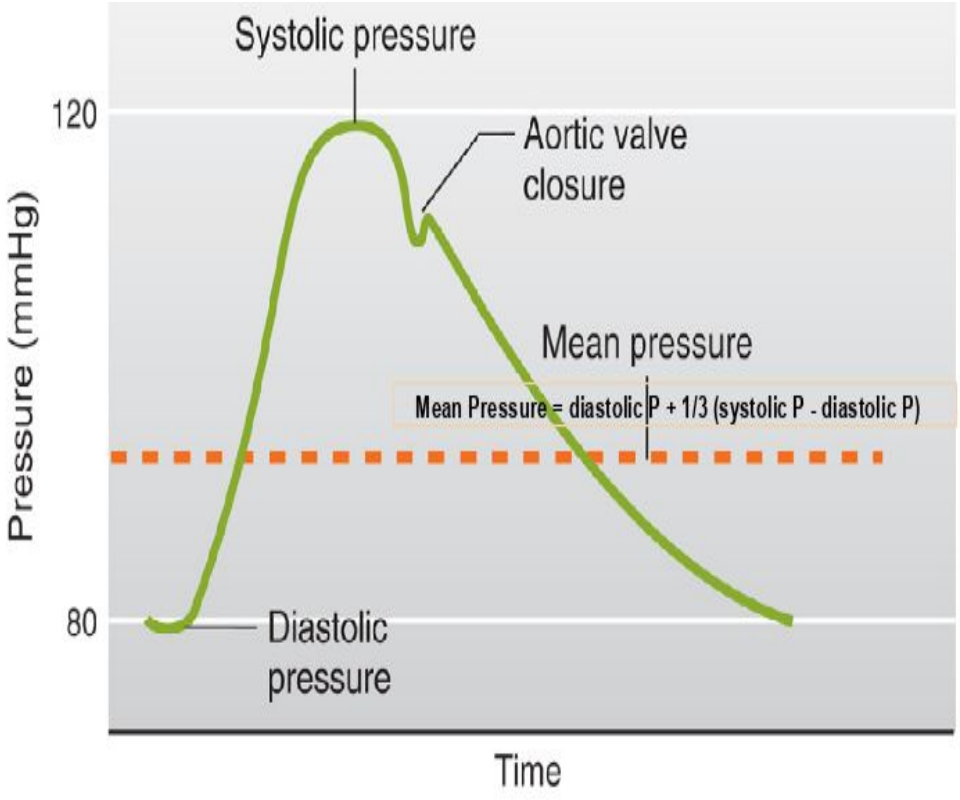
Mean Arterial Pressure

Mean Arterial Pressure:
The average of the arterial pressures measured in millisecond over a period of time.

- It is responsible for driving blood into the tissues throughout the cardiac cycle.
- It is better indicator of perfusion to vital organs than systolic blood pressure.
- It is not equal to the average of systolic and diastolic pressure.



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Mean Arterial Pressure

To calculate a mean arterial pressure, double the diastolic blood pressure and add the sum to the systolic blood pressure. Then divide by 3.

For example, if a patient's blood pressure is 83 / 50 mmHg, his MAP would be 61 mm Hg.

$$MAP = \frac{SBP + 2\,(DBP)}{3}$$

$$MAP = \frac{83 + 2\,(50)}{3}$$

$$MAP = \frac{83 + 100}{3}$$

$$MAP = 61$$

Another way to calculate the MAP is to first calculate the pulse pressure (subtract the DMP from the SMP) and divide that by 3, then add the DMP:

Mean Pressure = diastolic P + 1/3 (systolic P - diastolic P)

$$MAP = 1/3\,(SBP - DBP) + DBP$$
$$MAP = 1/3\,(83-50) + 50$$
$$MAP = 1/3\,(33) + 50$$
$$MAP = 11 + 50$$
$$MAP = 61 \text{ mm Hg}$$

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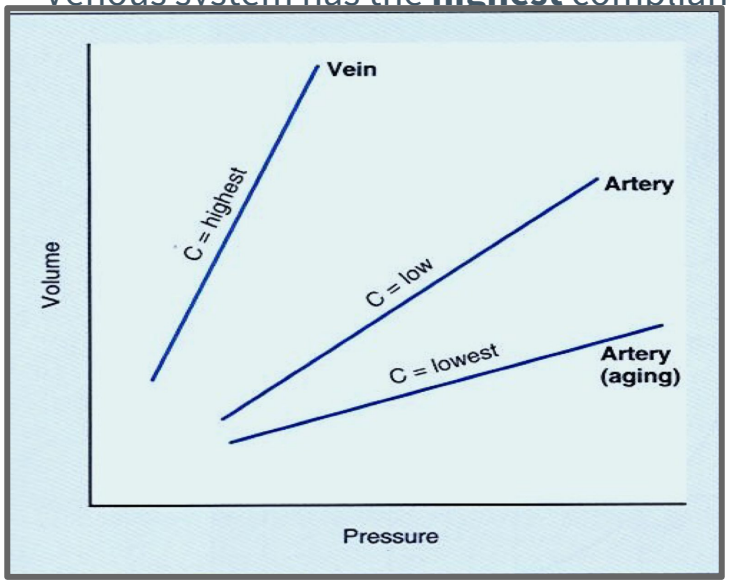
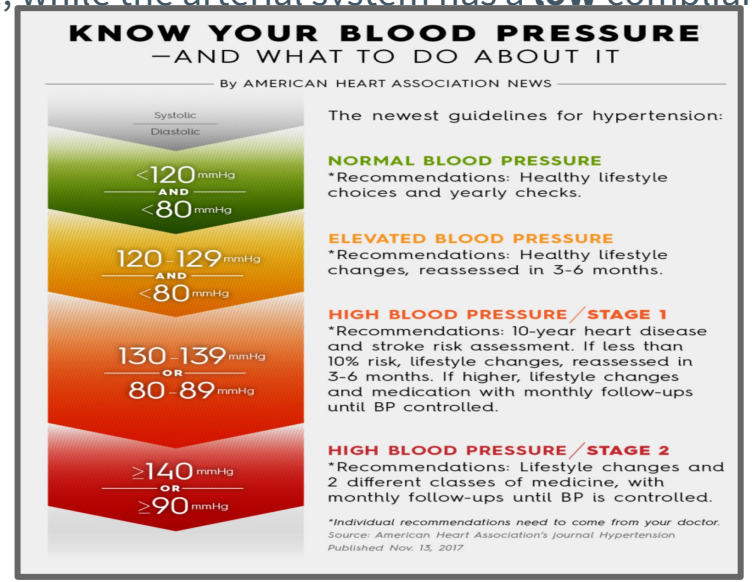
Compliance of Blood Vessels: (Affecting Factors)

$$C = \frac{V}{P}$$

- Compliance= distensibility.
- **Compliance(C) :** is the **volume(V)**of blood that the vessel can hold at a given **pressure(P).**
- Venous system has a large compliance & acts as a blood reservoir (high volume & low pressure).
- Venous system has the **highest** compliance, while the arterial system has a **low** compliance.





Resistance (R) and Flow: Affecting Factors

Resistance= tendency of vascular system to oppose flow.

Flow = 1/R

Resistance is influenced by:

Length of the tube (L)

radius of the tube (r)

viscosity of the blood (h).

In a normal human, length of the vascular system is fixed, blood viscosity & radius of the blood vessels have the largest effects on resistance.

Poiseuille's Law:

$$R = 8\eta L / \pi r^4$$

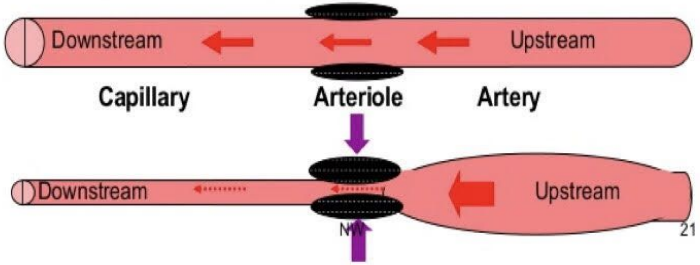
Effect of Radius (r) on flow & Pressure

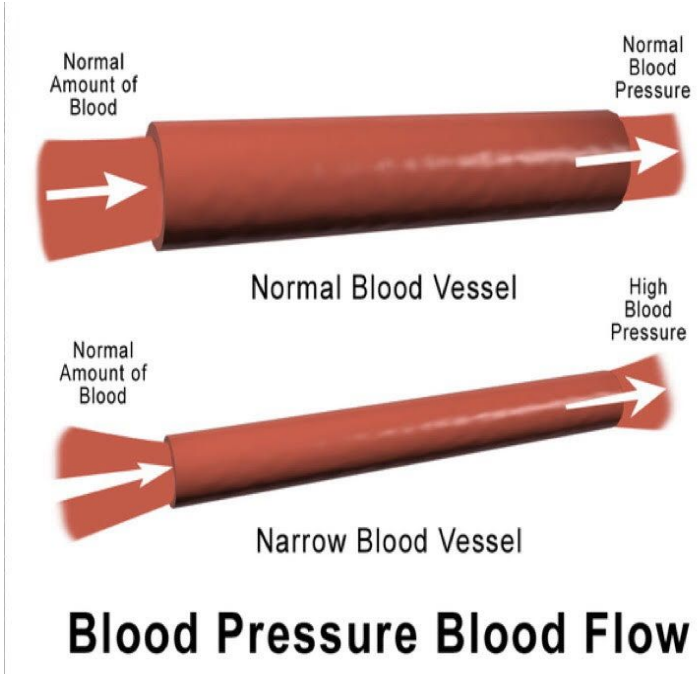
Directly proportional to flow.

Inversely proportional to pressure.

Vascular tone - effects

- Increased tone in a segment of blood vessel
- e.g. **increased arteriolar tone**
- → decreased radius of arteriole
- → greatly increased resistance to blood flow
- → greatly decreased blood flow across the arteriole
- → the effects on blood volume
  - Increased upstream (in the artery)
  - Decreased downstream(in the capillaries)





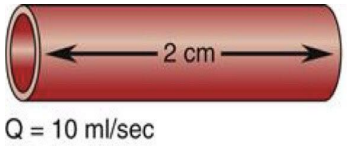
Effect of Viscosity on flow

- Blood viscosity is the thickness & stickiness of the blood.
- It is an important factor that determines the resistance of blood to flow.
- Human blood is five times more viscous than distilled water.
- Viscosity of the whole blood is mainly due to cells, & that of plasma is due to plasma proteins.
- Viscosity is inversely proportional to the flow.

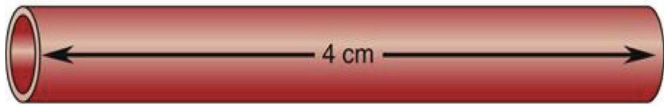
Effect of Length (L) on Flow

Length is inversely proportional to the flow.

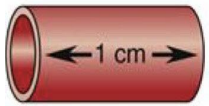
N.B. In a normal human, length of the vascular system is fixed.



Q = 10 ml/sec



Q = 5 ml/sec



Q = 20 ml/sec

Flow and Poiseuille's Law

- Fluid Flow(Q) through Cylindrical Tubes.
- Flow decreases(↓) when resistance increases.
- Flow resistance decreases (↓) when vessel diameter increases.

$$Q = \frac{\Delta P}{R}$$

$$Q = \frac{(Pi - Po)\ \pi\ r^4}{8\eta L}$$

Difference in Pressure

Viscosity

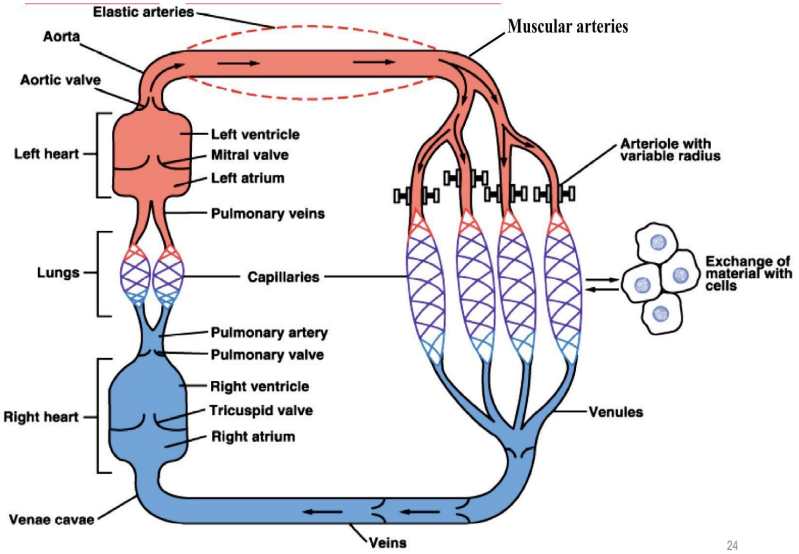
Length

Radius

Vascular system mechanisms

Vascular system possesses different mechanisms for promoting continuous flow of blood to the capillaries:

- Elastic recoil
- Smooth m regulation of diameter
- Sphincter
- Valves

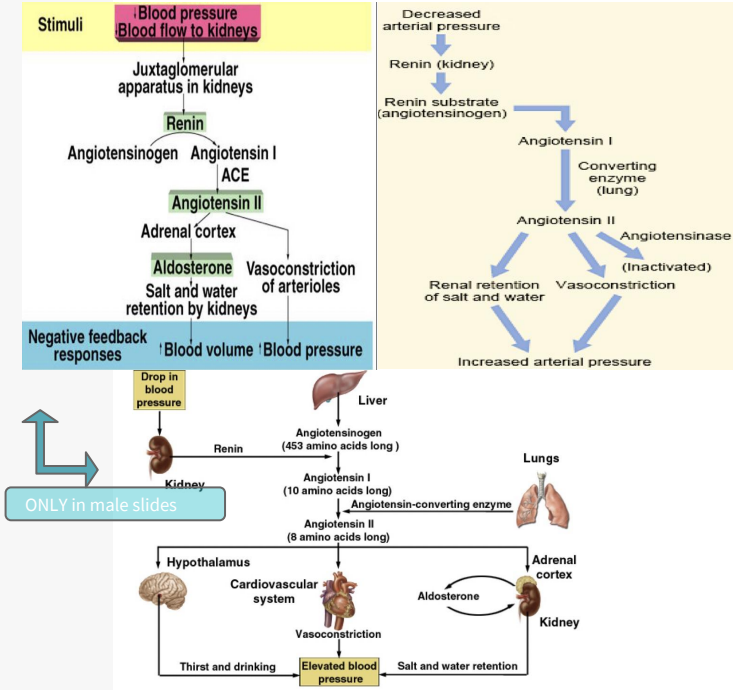


Intermediate Mechanisms: Activated within 30 min to several hrs.

During this time, the nervous mechanisms usually become less & less effective.

1.Renin-angiotensin vasoconstriction mechanism.

Zoom in to see



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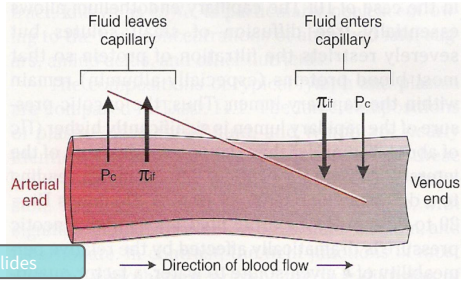
2.Stress-relaxation of the vasculature.

Adjustment of blood vessel smooth muscle to respond to changes in blood volume.

- When pressure in blood vessels becomes too high, they become stretched & keep on stretching more & more for minutes or hours; resulting in fall of pressure in the vessels toward normal.
- This continuing stretch of the vessels can serve as an intermediate-term pressure "buffer."



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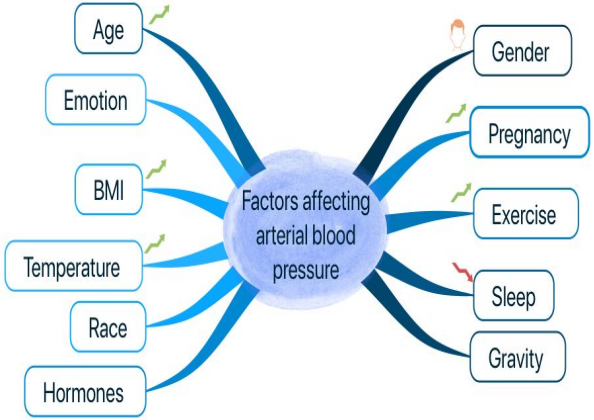
3.Fluid Shift mechanism.

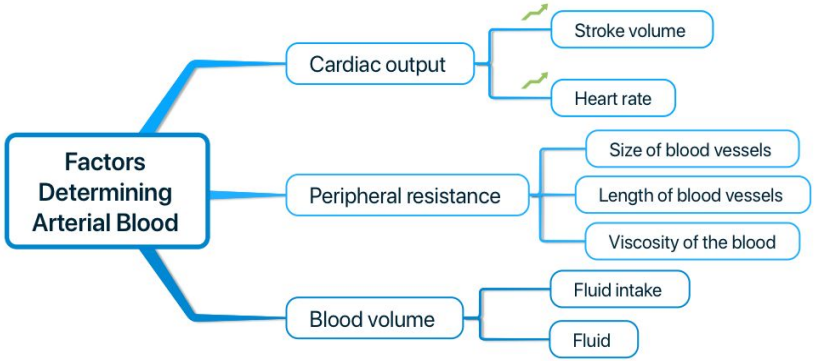
Movement of fluid from interstitial spaces into capillaries in response to ↓BP to maintain blood volume.

Conversely, when capillary pressure ↑too high, fluid is lost out of circulation into the tissues, reducing blood volume as well as all pressures throughout circulation.

Summary

Arterial blood pressure: lateral pressure force applied on the arterial wall exerted by the blood flow.
Blood flows down a pressure gradient (from high pressure to low pressure).
Greatest drop in pressure in Arterioles.
Systolic pressure: Arterial Pressure recorded during maximum contraction of the heart.
Diastolic pressure: Arterial Pressure recorded during maximum relaxation of the heart.





Normal blood pressure = 120/80 mmHg

Summary "laws"

Blood pressure= $\frac{\text{Systolic pressure}}{\text{Diastolic pressure}}$

Pulse pressure= systolic pressure - diastolic pressure

MAP = diastolic pressure + $\frac{1}{3}$ (systolic pressure-diastolic pressure)

Blood pressure= cardiac output * peripheral resistance

Blood flow = $\frac{\text{Pressure deference}}{\text{Resistance}}$

Poiseuille's law: $R = \frac{8\ n\ L}{\pi r^4}$

Blood flow = $\frac{(Pi - Po)\pi r^4}{8\ n\ L}$

Compliance = $\frac{V}{P}$

MAP = Mean arterial pressure
R = Resistance
n = Viscosity
L = Length
P = Pressure
V = Velocity
r = Radius
(Pi -Po) = Pressure deference

Quiz

1.Greatest drop in pressure occurs in
A- venules.
B- Capillaries.
C- veins.
D- Arterioles.

2.If a patient's blood pressure is 93 / 60 mmHg, calculate his Mean Arterial Pressure:
A- 71 mmHg
B- 65 mmHg
C- 61 mmHg
D- 75 mmHg

3. Which of the following has the highest Compliance?
A- Arterioles.
B- Arterial system.
C- Venous system.
D- Both B and C.

4. Which of the following does NOT influence Resistance?
A- Length of the tube.
B- velocity of the blood.
C- Radius of the tube.
D- Viscosity of the blood.

5. The difference between systolic pressure and diastolic pressure is:
A- Pulse pressure.
B- Aortic pressure.
C- mean arterial pressure.
D- Pulmonary artery pressure.

6. How much does the pressure decreases while traveling from aorta to vena cava?
A- 50%
B- 95%
C- 90%
D- 70%

1.D
2.A
3.C
4.B
5.A
6.C

Thank you for checking our work

Team Leader:

العنود سلمان

Male Team:

أنس السويداء
أنس السيف
خالد شويل
ريان الموسى
سعد الهداب
سعود العطوي
سيف المشاري
عبدالجبار اليماني
عبدالرحمن آل دحيم
عمر الفوزان
فهد الحسين
نايف المطيري
نواف اللويمي
محمد الحسن
هشام الشايع
خالد العقيلي
سعد الفوزان
عبدالله الزيد
نواف اللويمي
عبدالمجيد الوردي
يزيد الدوسري

Female Team:

الآء الصويّغ
رناد المقرن
رهف الشنيبر
روان التميمي
روان مشعل
ريم القرني
ليلى الصباغ
فلوة السعوي
نورة بن حسن
نورة الحربي
نورة العثيم
مجد البراك
لينا العوهلي
عهد القرين
مها النهدي
مها بركة
سارة الفليج
هند العريعر
ريناد الغريبي
عائشة الصباغ
ميعاد النفيعي
سمية العقيفي
سارة البليهد

Any questions?

Contact us at

- twitter:@physio437
- physiologyteam437@gmail.com