جامعة الملك سعود
King Saud University

MED438
KING SAUD UNIVERSITY

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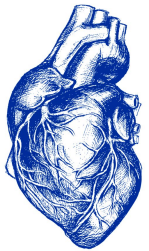
Lecture 11
Arterial BP

- Red: important
- Black: in male / female slides
- Pink: in female slides only
- Blue: in male slides only
- Gray: extra information

Editing file



Physiology
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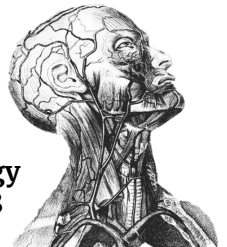


Arterial BP :

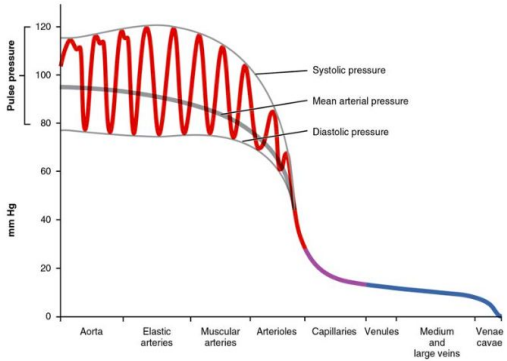
It's the pressure/force exerted by the blood against any unit area of the vessel wall, this force keeps the blood circulating continuously even between heart beats.

$$\frac{120}{80}\ \text{mmHg} = \frac{\text{Systolic pressure: Arterial pressure recorded during maximum ventricular contraction}}{\text{Diastolic pressure: Arterial pressure recorded during ventricular relaxation}}$$

Standard units of BP:
mmHg and sometimes **cmH_2O** (1mmHg = 1.36 cmH_2O)

Pressure changes throughout systemic circulation:

1. Blood falls down in concentration gradient
2. Highest at the heart & decreases over distance
3. Decreases 90% from the aorta to vena cava
4. Greatest drop in pressure occurs in arterioles
5. No large fluctuations in Capillaries & veins
6. BP averages: 120 mmHg in aorta & Drops to 0-2 mmHg in right atrium

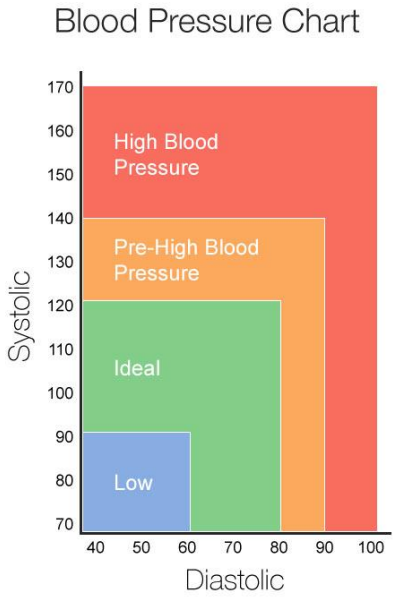


Range & Variations In Arterial BP Levels:

Arterial pressure is pulsatile.

- Aortic pressure: $\frac{\textbf{120}\ \text{systolic}}{\textbf{80}\ \text{diastolic}}$ mmHg
- Average normal arterial pressure: $\frac{\textbf{90 to 120}\ \text{systolic}}{\textbf{60 to 80}\ \text{diastolic}}$ mmHg

JNC 7 BP classification in adults aged ≥ 18 years			
Category	Systolic		Diastolic
Normal	<120 <130	and	<85 <80
Prehypertension	120-139 130– >140	or	85– <90 80-89
Hypertension (stage 1)	140-159	or	90-99
Hypertension (stage 2)	≥160	or	≥100

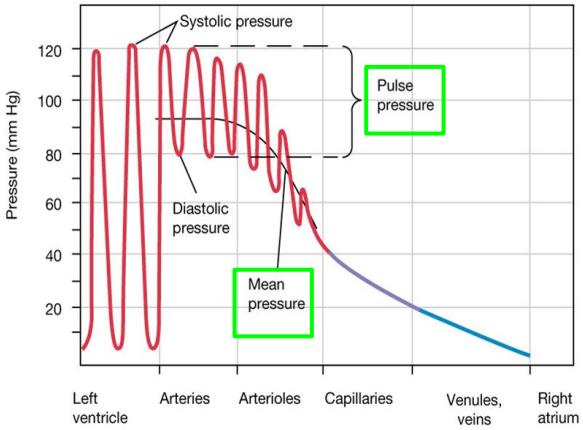


Pulse and Mean Arterial Pressures:

Mean arterial pressure: responsible for driving blood into the tissues throughout the cardiac cycle. It's a better indicator of perfusion to vital organs than systolic blood pressure.

★ **Pulse pressure** = systolic - diastolic

★ **MAP** (average) = Diastolic + ⅓ Pulse pressure **OR** 1/3SBP +2/3(DBP)



Factors Affecting Arterial BP:

Pregnancy

BP ↑ due to ↑ metabolism

Sleep

BP ↓ due to ↓ venous return

Exercise

BP ↑ due to ↑ venous return

Age

BP ↑ with Age (diabetes, atherosclerosis..)

Emotions

BP ↑ due to Neuronal & hormonal factors

Hormones

EPI, NE and Thyroid H ↑ BP

Gravity

BP ↑ in lower limbs than upper limbs

Race

Dietary factors, stress

Body mass index

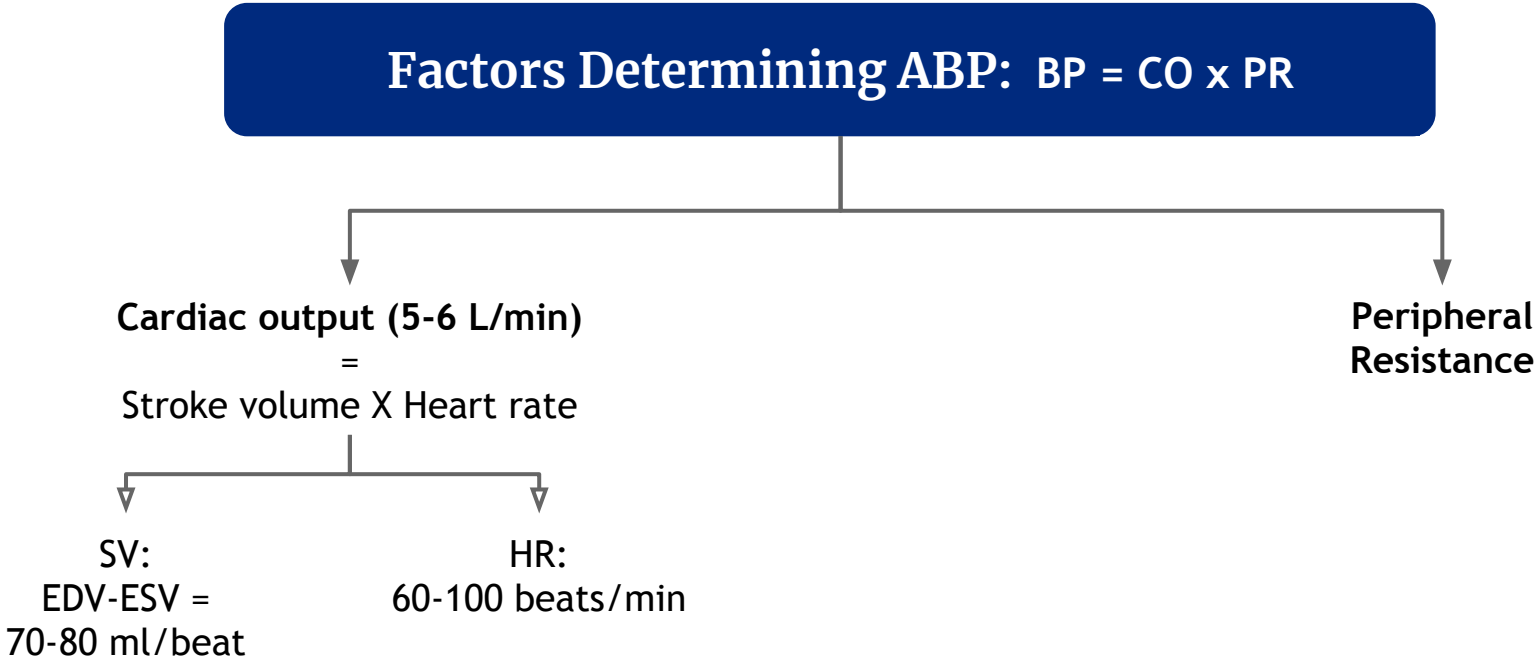
BP ↑ with body size

Sex

Male > Female But equal at menopause

Temperature

BP↓ with heat due to vasodilation &↑ with cold due to vasoconstriction



Blood Volume: (male slides)

- An increase in blood volume increases the CO → ↑ABP
- A decrease in blood volume as in hemorrhage, dehydration decreases VR → decreased CO → ↓ ABP

Effects of gravity on BP:

- **Increases** the BP of vessels **below** the level of the heart.
- **Decreases** the BP of vessels **above** the level of the heart.
- The gravitational effect = 0.77 mmHg/cm, e.g:

-A normal adult in upright position has MAP=100 mmHg at the heart level, calculate the MAP of an artery at the head (50 cm above the heart) = 100 − (0.77x50) = 62mmHg.

We add(+) instead of subtracting(-) if the distance is under the level of the heart.

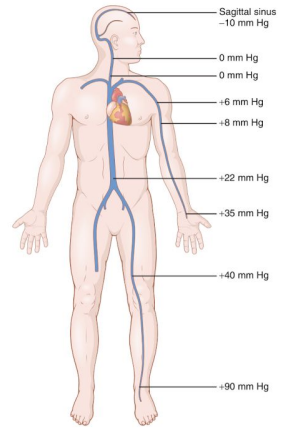


Figure 15-10. Effect of gravitational pressure on the venous pressures throughout the body in the standing person.

Factors affecting vessel diameter

vasodilators	vasoconstrictors
• Nitric oxide  • Histamine. • Atrial natriuretic peptide (ANP). • Prostacyclin (PGI_2).	• Norepinephrine. • Angiotensin II. • Vasopressin. • Endothelin-1. • Thromboxane A_2.

Blood Flow:

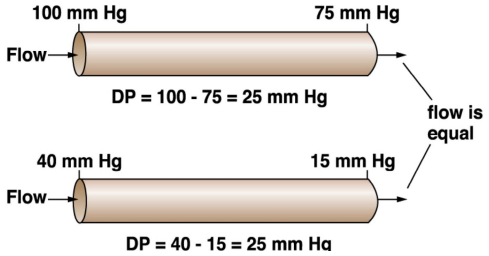
Female slides

- Amount of blood moving through a vessel in a given period of time (ml or L / min or sec).
- Generally is equal to Cardiac output.
- Affected by Pressure & Resistance: $Q = \frac{\triangle P}{R}$ (Ohm's law)
- Directly Proportional to pressure differences and inversely proportional to resistance

Blood Flow and pressure:

- Blood flows down a pressure gradient.
- Absolute value of pressure isn't important to flow, but **the difference in pressure △P is important to determine the blood flow**.

The resulting pressure is called the "**Deriving pressure**" in the vascular system.



Blood Flow and resistance :

➔ It's the tendency of the vascular system to oppose flow.

➔ Resistance is affected by: **L**ength + **r**adius of the vessel and viscosity of the blood **η**.

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

In a normal human, **L** is fixed, so blood viscosity **η** & **radius** of the vessels have the greatest effect on resistance

Blood Flow and Poiseuille's Law:

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

- Fluid flow through cylindrical tube ↓ when Resistance ↑
  (i.e when △P ↓, when vessel diameter ↓, or when η ↑).

Total Peripheral Resistance (TPR):

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

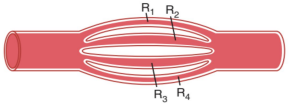
Systemic Circulation	Pulmonary Circulation
$TPR = \frac{\text{Aortic pressure - RAP}}{\text{Flow}} = \frac{120 - 2 \text{ mmHg}}{83.3 \text{ ml/sec } (5 \text{ L/min})}$	$PulR = \frac{\text{Pulmonary pressure - LAP}}{\text{Flow}} = \frac{15 - 3 \text{ mmHg}}{83.3 \text{ ml/sec } (5 \text{ L/min})}$
TPR = 1.4 (PRU's) PRU: peripheral resistance unit	PulR = 0.14 (PRU's) (very low compared to systemic circulation due to low pulmonary pressure)

Resistance to Flow in the CVS Arrangement of vessels:

Female slides

Lower resistance

$1/R_{total} = 1/R1 + 1/R2 + 1/R3$



e.g. **Capillaries**

Parallel Resistance

Series Resistance

Higher resistance

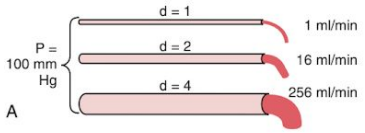
$R_{total} = R1 + R2 + R3$

e.g. **Arterioles**

The effect of radius on blood flow :

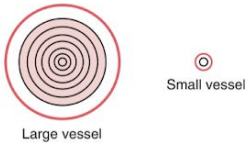
1

According to Poiseuille's law: Blood flow ↑ when vessel diameter ↑



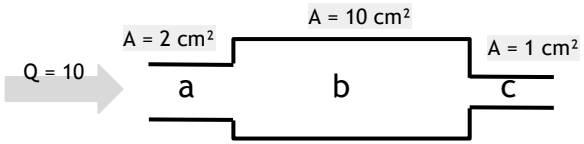
2

Concentering rings of blood flow at different velocities; the farther away from the vessel wall the faster the flow.



The effect of total cross sectional area on velocity :

- ➔ as the diameter ↓ the cross-sectional area ↑ and velocity of blood flow ↓ .
- ➔ because the blood volume flow (Q) must pass through each segment of the circulation each min, the velocity is inversely proportional to the cross-sectional area: **V = Q/A**



Velocity =

a: 5 cm/s b: 1 cm/s c: 10 cm/s

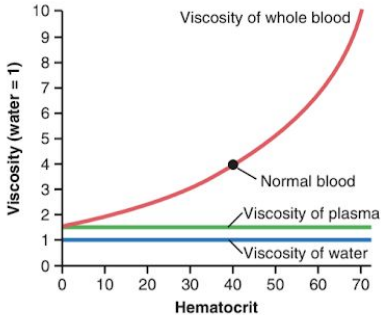
Thus when at rest, velocity = 33 cm/sec in the aorta.
And 0.3 mm/sec in the capillaries.

Recall that when the flow rate at one point is equal to another, the velocity and area at both points will be equal.
Q1=Q2 -> A1V1=A2V2 prep year physics, yeah...

The effect of blood viscosity on vascular resistance and blood flow:

Female slides

- Blood viscosity is due to the large numbers of suspended RBCs and to less extent due to types & concentration of proteins in the plasma.
- Viscosity increases drastically as the hematocrit increases.
- ↑ viscosity → ↑ resistance and ↓ flow.



Compliance (distensibility) of Blood Vessels:

- Compliance is the volume of blood that the vessel can hold at a given pressure. **C = V/P**
- This capability provides smooth, continuous blood flow through the small vessels of the tissue.
- Venous system has the highest compliance & acts as a blood reservoir (↑ volume and ↓ pressure), while the arterial system has the lowest compliance.

Elasticity of blood vessels:

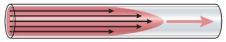
Male slides

- Changes in large vessel elasticity affects ABP.
- For example in atherosclerosis, there is a decrease in compliance ,therefore during systole the vessels don't expand so the pressure increases.

Laminar and Turbulent Blood Flow:

Female slides

1 Laminar Flow:



- Streamlined
- Outermost layer moving slowest & center moving fastest.

2 Turbulent Flow:

- Blood flows crosswise in and along the vessel forming whorls called Eddy currents. It occurs when:

✓ Blood flow rate is too great
✓ It passes by an obstruction in the vessel
✓ It makes a sharp turn
✓ It passes over a rough surface

Hypertension :

male slides

-Clinical features:

-Maybe asymptomatic

→ Headache
→ Dizziness.
→ Confusion.

→ Visual disturbance

→ Nausea.
→ Vomiting.

→ Sleepiness

→ Shortness of breath.
→ Chest discomfort

-It might be a complication of a lot of cases e.g. :

- Diabetes.
- Obesity.
- Family history.
- Smoking.
- Dietary factors.

Measurement of BP

-Small cuff: children, small adults.
-Average cuff.
-Large: overweight, large adults.

Methods

Indirect : Stethoscope with BP cuff

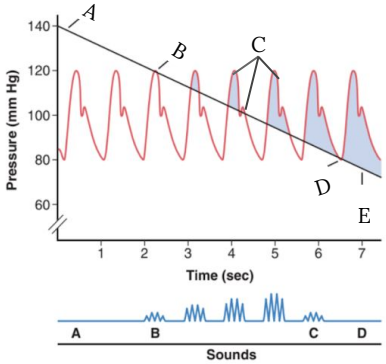
Direct : Arterial catheter

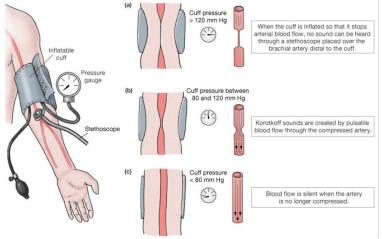
- Mercury sphygmomanometer

- Automatic equipment

- Arenoid equipment

- BP is measured by listening for korotkoff sounds produced by turbulent flow in arteries:
- First sound →Systolic pressure.
- Last sound →Diastolic pressure.





A	B	C	D	E
Cuff p. > Systolic p. = no sound	1st sound is heard at peak systolic p.	Cuff p. < BP Sound is heard	Cuff p. is near diastolic p. = Sound becomes muffled	Cuff p. < diastolic p. = Sound disappears

Quiz

1. if the blood velocity of a certain vessel is 20 m/s , what is the new velocity if the cross-sectional area of the same vessel halved ,and the blood flow doubled?

A. 20 m/s
B. 80 m/s
C. 40 m/s
D. 5 m/s

2. A patient comes in the ER with a SBP of 154 mmHg, which class of BP is this?

A. Hypertension (stage 1)
B. Hypertension (stage 2)
C. Hypotension
D. Prehypertension

3. which of the following structures is the most resistant to blood flow?

A. Heart valves
B. Capillaries
C. Arterioles
D. veins

4. A patient has a pulmonary BP of 17 mmHg, and a blood flow of 90 ml/s, with a pulmonary resistance of 0.15, the left atrial pressure should be:

A. 4.5 mmHg
B. 4 mmHg
C. 3.5 mmHg
D. 3 mmHg

5. A patient comes in to the ER severely dehydrated, what is the most likely change in his BP?

A. Elevated
B. Decreased
C. Normal
D. ¯_(ツ)_/¯

SAQ:

1- Mention two formulas you can calculate the MAP from:

Slide 4

2- Name 4 clinical complications that lead to hypertension :

Slide 11

Answers: B - A - C - C - B

Leaders

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- Arwa AlEmam
- Noura AlTurki
- Ghada AlSadhan
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