Physiology of cardiovascular system

Blood pressure, pulse, hyperemia
Blood pressure

One of the oldest measured parameters

Observation of BP allows dynamical observation of disease/pathology of cardiovascular system, and its influence on other system in the organism

generally when we say pressure we mean **arterial blood pressure**

„creator“ of BP is heart

Value of BP depends on 3 determinants:

- heart output
- diameter of vessels
- amount of blood

Values of BP should be lower than 120/80 mmHg

systolic blood pressure (sBP) / diastolic pressure (dBP)
Blood pressure

Higher values increase the risk of AMI and stroke

Lower values increase the risk of lower perfusion and oxygen delivery to organs such as brain resulting in stroke

„Normal“ values of BP are INDIVIDUAL

Pulse pressure (PP) = sBP - dBP

Mean arterial pressure (MAP)
average pressure during 1 heart cycle
movement force of peripheral perffusion

MAP = dBP + PP/3

MAP = 2/3 dBP + 1/3 sBP

sBP and dBP can vary in arterial system, but MAP should be under normal circumstances normal, i.e. it is responsible for perffusion
Movement force of blood flow

Central venous pressure = 0 mm Hg

Aortic pressure = 85 mm Hg (MAP)

\[ \Delta P = 85 - 0 = 85 \text{ mm Hg} \]
Pressure and flow gradient

(a) Flow = 20 mL/min

(b) Flow = 0

(c) Flow = 20 mL/min
## Blood vessels type

<table>
<thead>
<tr>
<th>Average internal diameter (mm)</th>
<th>Average wall thickness (mm)</th>
<th>Special features</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>1.0</td>
<td>Muscular, highly elastic</td>
</tr>
<tr>
<td>0.03</td>
<td>0.006</td>
<td>Muscular, well innervated</td>
</tr>
<tr>
<td>0.008</td>
<td>0.0005</td>
<td>Thin-walled, highly permeable</td>
</tr>
<tr>
<td>0.02</td>
<td>0.001</td>
<td>Thin-walled, some smooth muscle</td>
</tr>
<tr>
<td>5.0</td>
<td>0.5</td>
<td>Thin-walled (compared to arteries), fairly muscular, highly distensible</td>
</tr>
</tbody>
</table>

- **Artery**
- **Arteriole**
- **Capillary**
- **Vein**

**Legend:**
- **Endothelium**
- **Smooth muscle**
- **Connective tissue**
Blood flow and arteriols diameter

The flow will change dependently on vascular resistancy

- ↓ resistancy = vasodilatation = ↑ blood flow = ↓ BP
- ↑ resistancy = vasoconstriction = ↓ blood flow = ↑ BP
Blood Pressure Chart

What's your Adult blood pressure?
Draw a line from the Systolic number to the Diastolic number.

"Sweat is the best cardiovascular agent known to man."
- Stanford Cardiologist

**Systolic mm Hg**

<table>
<thead>
<tr>
<th>Stage</th>
<th>230</th>
<th>220</th>
<th>210</th>
<th>200</th>
<th>190</th>
<th>180</th>
<th>170</th>
<th>160</th>
<th>150</th>
<th>140</th>
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<tbody>
<tr>
<td>Very Severe Stage 4</td>
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<td>Moderate Stage 2</td>
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</tbody>
</table>

**Diastolic mm Hg**

<table>
<thead>
<tr>
<th>Stage</th>
<th>140</th>
<th>130</th>
<th>120</th>
<th>110</th>
<th>100</th>
<th>90</th>
<th>80</th>
<th>70</th>
<th>60</th>
<th>50</th>
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</thead>
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<tr>
<td>Very Severe Stage 4</td>
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</table>

- Hypertension - High Blood Pressure
- Normal Blood Pressure
- Hypotension - Low Blood Pressure
- Borderline
- Low Normal
- High Normal

**No** Foods
- High-salt
- Medium-salt
- No hydrogen, oils
- Reduce saturated fat
- Reduce protein

**Yes** Foods
- (High K, Ca)
- Apples
- Avocado
- Bananas (K)
- Broccoli (K)
- Fish
- Grapes
- Oats
- Orange Juice (K)
- WATER

**BP Lowering Tactics**
- Stop smoking
- Reduce weight
- Exercise
- Low salt
- Low protein
- No Caffeine
- Mild sedation
- Sufficient rest
- Don't oversleep

**Vitamins**
- Vitamin C - 1000mg
- Vitamin E - 400mg
- B complex - big-mg
- Folic Acid - 400mg

**Amino Acids**
- CoQ10 - 120mg
- Carnitine - 1000mg
- Taurine - 500mg

**Foods**
- Flax oil - 1 tbl
- Fish oil - EPA 600mg
- DHA 400mg

**Herbs**
- Hawthorne Berry - 1.5g
- Garlic - lcts (selenium)

**Minerals**
- Calcium - 666mg
- Magnesium - 285mg
- Zinc - 10mg

These are the personal thoughts of the author - nothing is implied, promised or guaranteed - no advice is intended.
Means of blood pressure measurement

**Blood pressure**

1. Noninvasive
   - Palpatory (Riva-Rocci method)
   - Auscultation
   - USG
   - Oscilometric
   - Tonometric

2. Invasive
   - Intravascular sensor
   - Extravascular sensor

**Blood flow**

3. Noninvasive
   - USG - Doppler
   - Laser Doppler flowmetry
   - Electric impedance pletysmography
   - Photoelectric pletysmography

4. Invasive
   - Dye
   - Temperature
   - Radioisotopes
Indirect methods of BP measurement
BP measurement

Non-invasive

**Brachial artery** – most often used
near heart
simple

Other sites:
forearm / radial artery
wrist

Auscultation + oscillatory method – most often used techniques
Palpatory method (Riva-Rocci)

When deflating cuff we can palpate pulse on the wrist \( P_{\text{cuff}} = \text{sBP} \)

**Adantages**

+ BP can be measured in loud room
+ you need only cuff

**Disadvantages**

- only sBP can be measured
- in hypertensive and newborns, it is not very precise
Auscultation method

Pulse waves are propagated through brachial artery and Korotkoff phenomenas are created /turbulent flow/

5 phases can be auscultated, that will define sBP and dBP

Precision is +/- 2mmHg (sBP) and +/- 4mmHg (dBP)
Auscultation method

**Advantages**

+) simple
+) precise

**Disadvantages**

-) cannot be used in loud environments
-) results are different from observer to observer
-) mechanical error increases the risk of error
-) result not always corresponds to real intraarterial pressure
-) not precise in newborns and hypotensive patients
Arterial pulse

• Pulse is measured whole ages but standard it is from the 19th century

Information it gives:

1. frequency, regularity
2. artery passage
3. characteristics of arterial pulse pressure and so blood flow
During pulse palpation, heart auscultation serves as „control“

Factors, that determine pulse:
- cardiac output
- speed of output
- vessels compliance
- peripheral resistency
- heart frequency
- pulse pressure
- vessel diameter
- distance from heart
Normal arterial pulse wave

- Percussion wave
- Tidal wave
- Dicrotic notch
- Anacrotic notch
- Incisura
Arterial pulse

Steeper increase, higher systolic peak in periphery
Dicrotic notch is decreased towards periphery
So for pulse characteristics you need central arteries
Reactive hyperemia

- When arteriols are closed for a short time, then after opening the blood flow is increased because of metabolites in affected part.
Significance

• Payment of oxygen debt and/or removal of metabolites
  – Which ones?

• Clinical practice
  – Indicator of blood vessels „health“
  – „marker“ of cardiovascular problems/diseases as is atherosclerosis, DM
Humoral regulation

- adrenalin (alpha, beta)
- noradrenalin
- angiotensin
- vazopresin
- bradykinin
- histamine
- prostaglandins
- endotelin
- atrial natriuretic peptid
- NO