Under Hippocrates’ bodily humors theory, differences in human moods come as a consequence of imbalances in one of the four bodily fluids: blood, yellow bile, black bile, and phlegm.

Among Galen’s major contributions to medicine was his work on the circulatory system. He was the first to recognize that there were distinct differences between venous (dark) and arterial (bright) blood.

Galen contributed to the then current understanding brought about by Hippocrates.

**Aelius Galenus or Claudius Galen**

Galen (AD 129–c. 200/c. 216)

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- Among Galen’s major contributions to medicine was his work on the circulatory system. He was the first to recognize that there were distinct differences between venous (dark) and arterial (bright) blood.
Aelius Galenus

Galen believed that the circulatory system consisted of two separate one-way systems of distribution, rather than a single unified system of circulation. His understanding was that venous blood was generated in the liver, from where it was distributed and consumed by all organs of the body. He posited that arterial blood originated in the heart, from where it was distributed and consumed by all organs of the body. The blood was then regenerated in either the liver or the heart, completing the cycle.

His theories dominated and influenced Western medical science for nearly two thousand years!

William Harvey (1578 –1657)

- His anatomical reports, based mainly on dissection of monkeys and pigs, remained uncontested until 1543, when printed descriptions and illustrations of human dissections were published in the seminal work (De humani corporis) by Andreas Vesalius.

- Galen's theory of the physiology of the circulatory system endured until 1628, when William Harvey published De motu cordis, in which he established that blood circulates, with the heart acting as a pump.
1773 first measurement of blood pressure, and incidently pulse pressure.

Notice in the picture the rubber tube attached to a glass tube.

As the blood pulsed, the blood volume moved up and down in the glass tube.
Blood pressure

Pressure profile along systemic circulation

2012: Blood pressure meter.

Blood Pressure

- In practice, what we mean by blood pressure is the prevailing pressure in the large arteries.
- Blood pressure is the force of blood pushing against the walls of the arteries as the heart pumps out blood.
Blood pressure

- **Systolic arterial pressure**
  - Peak pressure in the arteries, which occurs near the end of the cardiac cycle when the ventricles are contracting.

- **Diastolic arterial pressure**
  - Is the minimum pressure in the arteries which occurs near the beginning of the cardiac cycle when the ventricles are filled with blood (relaxed)

Blood Pressure

Systolic:  
CARDIAC OUTPUT (Pulse x Stroke Volume) l/min  
×  
TOTAL PERIPHERAL RESISTANCE

Diastolic:  
determined by the aortic and large artery end-diastolic blood volume and this in turn on peripheral vascular resistance, and to some extent, the large artery elasticity
Blood Pressure

- A sufficient arterial blood pressure is crucial for maintaining tissue metabolism.
- When we drop below the minimum pressure -> hypotension
  - The cardinal symptom of hypotension is light headedness or dizziness. If the blood pressure is sufficiently low fainting will occur.
  - Low blood pressure causes can be due to hormonal changes, widening of blood vessels, medicine side effects, anemia, heart & endocrine problems.
- Hypertension: Sys>140 mmHg Dia>90
  - Persistent hypertension is one of the risk factors for strokes, heart attacks, heart failures, and arterial aneurysms, and is the leading cause of chronic renal failure.

Finnish BP profile

Heart muscles and blood vessels response to adrenergic stimulation weakens, renin release decreases and baroreceptors sensitivity drops.
Normal blood-pressure and hypertension


<table>
<thead>
<tr>
<th>Luokka</th>
<th>Systolinen paine mmHg</th>
<th>Diastolinen paine mmHg</th>
<th>USA-luokitus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tavoiteltava*</td>
<td>&lt; 130</td>
<td>&lt; 85</td>
<td></td>
</tr>
<tr>
<td>Työntyvä</td>
<td>130–139</td>
<td>85–89</td>
<td></td>
</tr>
</tbody>
</table>

Hypertensio

- lavasti kohonnut verenpaine
  - kohtalaisesti kohonnut verenpaine
    - 140–159
    - 160–179
  - huomattavasti kohonnut verenpaine
    - 180–209
    - 210
- erittäin huomattavasti kohonnut verenpaine
  - ≥ 210
  - ≥ 120

* Mikäli systolinen ja diastolinen arvo johtavat erilaiseen luokittelun, valitaan korkeampi verenpaineen luokka.

- Verenpaineen luokittelut edellyttää asianmukaisesti tehtyjä mitattuksia ainakin kolmella eri käytäntömallilla, kuitenkin vähintään 2–3 mitausta. Luokittelussa käytetään matalinta mittauksiin saatua arvoa.

* Nuorella aikuisella tavoiteltava verenpainetus on vieläkin matalampi (< 120/80).

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**Early Hypertension**

- pulse and minute volume increased
- usually normal periphery resistance
- usually no left ventricle hypertrophy
- general nature: highly active sympathetic signaling.

**Well established hypertension**

- pulse and minute volume normal
- periphery resistance increased
- left ventricle hypertrophy
The wall of the heart contains three layers (superficial→deep):
- Epicardium: thin layer covering
- Myocardium: thick layer, composed of cardiac muscle.
- Endocardium: thin layer, lining membrane of the heart that also covers the valves.

The heart has four chambers:
- Right and left atria.
- Right and left ventricles.

R. Atrium inflow of blood to R. Ventricle: Tricuspid Valve (atrioventricular; AV)
L. Atrium → L. Ventricle: Mitral Valve
Aortic valve: the Aorta
Pulmonic Valve: Pulmonary artery.

Normal heart has 3 intrinsic pacemaking tissue
- SA node, AV node, and the Purkinje Fibers
- Any cardiac cell with pacemaker activity can initiate the heartbeat.
- Pacemaker with highest frequency will be the one to trigger an action potential that will propagate throughout the heart.
- SA ~60bps/min, AV ~40bps/min, Purkinje ~20bps/min
The initiation, time, shape, and duration of the action potential are distinctive for different parts of the heart reflecting their different functions.

- The \( \text{Na}^+ \) current \( (I_{\text{Na}}) \) rapid depolarization in atrial and ventricular muscle, and in Purkinje fibers.

- The \( \text{Ca}^{2+} \) current \( (I_{\text{Ca}}) \) rapid depolarization in SA node and AV node.
  - Triggers contraction in all cardiomyocytes.

- The \( \text{K}^+ \) current \( (I_{\text{K}}) \) repolarization in all cardiomyocytes.

- "Pacemaker" current \( (I_f) \) in SA nodal cells, AV, and Purkinje fibers.

The nodal cells lack larger \( I_{\text{Na}} \) currents; their upstrokes are slower than those in atrial and ventricular muscle.

- Slower than that of any other cardiac tissue

This feature in AV nodes leads to electrical delay between atrial contraction and ventricular contraction.

- Permits more time for the atria to empty blood into the ventricles.

\( I_f \) current is a nonspecific cation channel called HCN (Hyperpolarization-activated Cyclic Nucleotide-gated).

Because they are activated by hyperpolarization, physiologists smile and laugh hence its so funny...
Atrial muscle

- $I_{Na}, I_{K}, I_{Ca}$
- Four special conducting pathways
  - Bachman’s bundle is interatrial
  - Internodal pathways to AV (anterior, middle, and posterior)
- If conduction at the AV node is blocked, the ventricles will not contract.
  - Pukinje fiber pacemaker activity may provide the necessary electrical signal. Unreliable.

Ventricular Muscle

Step 1: AP reaches AV node, travels to His-Purkinje fiber network and out into the ventricular muscle.

Step 2: the septum depolarizes from left to right.

Step 3: the anteroseptal region depolarizes.

Step 4: Myocardium always depolarizes from the endocardium toward the epicardium (cells lining the ventricle to the cells on the outsurface).

Step 5: Depolarization spreads from the apex toward the base, carried by purkinje fibers. The last region to depolarize is the posterobasal region of left ventricle.

Step 6: The ventricles are full depolarized.
The cardiac cycle can be divided into phases.

1. Inflow phase: The inlet valve is open, the outlet valve is closed.
2. Isovolumetric contraction: Both valves are closed with no blood flow.
3. Outflow phase: The outlet valve is open. Inlet valve is closed.
4. Isovolumetric relaxation: Both valves are closed, with no blood flow.

Systole: 2 and 3: ventricles are contracting.
Diastole: 1 and 4: ventricles are relaxing.
Atrial Systole
- Passive flow
- 15-20% increase in blood to ventricles

Ventricular Systole
- Atrioventricular valves close
- Isovolumetric contraction
- Semilunar valves still shut.
- Ventricular ejection phase when pressure exceeds pressure in the arteries. During this period, atria relax and start to fill with blood.
- AV valves still closed.

Ventricular Diastole
- Pressure falls below aorta and pulmonary trunk
- Semilunar valves close.
- During this time, atria have continued to fill with blood.
- Increase in pressure opens AV valves.
Measurement methods

- Invasive method (direct, by puncturing the vessel)
  - Catherization.
- Noninvasive method (indirect, eg. sphygmomanometry/painemansetin avulla)
  - This practical work. Auscultatory and Palpatory method.

The measurement

Measurement accuracy
ALL indirect blood pressure measurement procedures have a variety of measurement error sources:

1) The actual Instrument
2) The person measuring
3) Measuring method/technique
4) The person being measured
Laminar versus Turblance

Cuff pressure vs Blood pressure

Mansetin paine (mmHg) (kPa)

Aika

Auskultatoriinen
oukko

Higasuss

Vaihe 1

Hyposthenoidi

Vaihe 2

Hypertonia

Pehmeäntienen
Higasuss

5 mmHg/0,7 kPa

20 mmHg/3 kPa

14 mmHg/2 kPa

5 mmHg/0,8 kPa
Normal
Typical day-night fluctuation

Slightly Hypertensive
day-night fluctuation remains, blood pressure rises during the night as well.

Advanced autonomic nervous system malfunction
reversed day-night alternation pressure drops when the person is in standing position

Assignments
1. Blood pressure measurement of the arm using the auscultatory method.
2. Confirming the measurement by taking another one 2 minutes after the first measurement.
3. Blood pressure measurement using the automatic instrument.
4. Coffee test!
Assignment

1. Palpate lower body arterial pressures
   - a. dorsalis pedis
   - a. tibialis posterior
   - a. poplitea
   - a. femoralis
2. Palpate upper body arterial pressures
   - a. radialis
   - a. brachialis
3. Palpate stomach-aorta (a. abdominalis)
4. Palpate neck arteries (a. carotis)
5. Palpate superficial temporal artery (a. temporalis superficialis)

Check pulsewave changes and side differences

Common carotid

Resistance in the artery relatively large, systolic flow emphasized
Inner carotid
Resistance is less, a lot of diastolic flow as well.

Outer Carotid
Resistance in the artery relatively large, systolic flow emphasized.
CAROTIS COMMUNIS

Healthy

Stenosis

Resistance in the artery relatively large, systolic flow emphasized

CAROTIS EXTERNA

TERVE

TYVIOSAN TIUKKA AHTAUMA

Resistance in the artery relatively large, systolic flow emphasized
Resistance is less, a lot of diastolic flow as well.
Heart Sounds

- The opening and closing of valves is accompanied by heart sounds.
- Website animation: http://www.blaufuss.org/
S1. Heart Sound

- Beginning of ventricle systole
- Closing of the mitral and triscuspid valves
- It's not the actual closing that makes the sound
- Instead vibrations resulting from the sudden tension in the AV valves and the adjacent ventricular walls

S2. Heart Sound

- End of ventricle systole
- Closing of the aortic and pulmonary valves
- Vibrations of the large vessel walls and columns of blood produce S2 following closure of the semilunar valves.
- The aortic valve usually closes just before the pulmonary valve.
- These two components can be heard in the inhaling phase of breathing in children and young adults.
S3. Heart Sound

- during early diastole
- rapid filling of the ventricles results in recoil of the ventricular walls
- very low sound
- < 30-years physiological (not over 40)
- for older ages indicator of increased filling pressure
- "protodiastolic gallop" S1-S2-S3

S4. Heart Sound

- Ventricular diastole: end of it
- when present coincides with atrial contraction.
- Usually heard in pathological conditions in which an unusually strong atrial contraction occurs in combination with low compliance of the left ventricle.
- not usually heard with auscultation
- indicates elevated filling pressure
- "presystolic gallop" S4-S1-S2