Saliva composition and functions
SALIVA FUNCTIONS

- The most important component to keep homeostasis in oral cavity
- Keeps proper properties of many processes responsible for eco balance in oral cavity (due to organic and inorganic components)
- Wets cells in oral cavity allowing articulation, digestion, and swallowing
- Determines protection of teethes surface and oral mucosa against biological, mechanical and chemical
- Participates in temperature, taste and touch perception.
Saliva is secreted by:
- Salivary glands
- Parotid gland
- Sublingual gland
- Submandibular gland
- Small glands are scattered in mucous tunic in lips, palate, tongue, and cheeks
How saliva is created?
How saliva is created?

I stage:

**PRIMARY SALIVA:**
- secretion generated in cystic duct ends
- similar to extracellular fluid concentration in respect to the amount of Na\(^+\), K\(^+\), Cl\(^-\) ions
- contains most of the components of final saliva
How saliva is created?

I STAGE:
During saliva flow through lamella duct there is:

- **active** absorption of Na\(^+\), Ca\(^{2+}\) cations and Cl\(^-\), HPO\(_4^{2-}\) anions
- **passive** secretion of HCO\(_3^-\) anions and K\(^+\) cations to the lumen of the ducts

Osmotic gradient is created and is causing **passive transport of water.**
How saliva is created?

II STAGE:

In excretory glands **final saliva** is created in which:

- Na\(^+\) ions are actively absorbed,
- Cl\(^-\) ions are transported passively,
- K\(^+\) ions are actively secreted with help of Na+/K+ ATP
- HCO\(_3^-\) is actively secreted

Increased concentration of HCO\(_3^-\) determines increase of saliva pH present in ducts
How saliva is created?

II STAGE:

Because:
1. ion’s resorption in gland duct is faster than secretion and
2. penetration of water is small

therefore, saliva is hypotonic.

During very fast flow, composition of final saliva is similar to composition of primary saliva.
How saliva is created?

Big saliva glands can secrete serum saliva or mixture of saliva. *Saliva from parotid and sublingual glands* – (about 26% of total volume) *is generated by serous cells* and is:

- More watery
- Light
- Transparent

*Saliva secreted by palate mumps and tongue (69%) is:*

- thick
- mucinoid
- viscous

Rest of salivary glands are making serum–mucinoid saliva. (5%)
How saliva is created?

Saliva secretion is a continuous process.

- Without outside stimulation, it is called “resting saliva”, and its amount is in the range of **0.3 – 0.5 mL/min**

- During intensive mechanical-chemical stimulation (during the eating) amount of saliva increases and its amount is up to **1.5 – 2.3 mL/min**

- During 8-hours sleep secretion is the smallest, up to **0.05 mL/min**

- Adult is generating about **from 1 to 1.5 liters of saliva** per day.
SALIVA COMPOSITION

In 99% saliva is consisting of water. Rest of the volume are inorganic and organic components which are determining saliva properties.

pH of fresh saliva is about 6.6.

Organic components of saliva:

- **proteins** – immunoglobulins, albumins, glycoprotein, enzymes
- **non-proteins nitrate compounds** – urea, urea acid, amino acids, creatinine
- **lipids** – unsaturated fatty acids, cholesterol, lecithin, phospholipids
- **hormones** – steroids.
ORGANIC COMPONENTS OF SALIVA

PROTEINS

Glycoproteins (mucines) – one of the more important proteins of oral cavity.

- in non-stimulated saliva glycoproteins are about 20–30% of total amount of proteins
- they contain big amount of carbohydrate chains, connected by polypeptide skeleton with covalent bonds
- with increased amount of mucines in saliva volume, density and viscosity increases as well

On the surface of the tooth acquired cuticle is formed which is the first layer of tartar

Glycoproteins in saliva allow forming and swallowing of food and protection of soft tissues against mechanical irritation
ORGANIC COMPONENTS OF SALIVA

PROTEINS

Glycoproteins (MUCINES)

**AGGLUTININ**- glycoproteins with high molecular weight to be able to agglutinate (glue, combine) streptococcus carious.

**Acidic** glycoproteins:
- Phosphoproteins – have large amount of negative charge (up to 29) and asymmetric structure.
- Prevents increase of calcium phosphates crystals in saturated saliva.
- Due to negative charge, Ca$^{2+}$ ions are absorbed by hydroxyapatite which leads to decrease in its growth.
ORGANIC COMPONENTS OF SALIVA

PROTEINS

Histatins

- Small basic proteins with small molecular weight containing significant amount of amino acids: histidine, lysine, arginine

- Histatin molecule contains positive charge in amino acid side chain and bonds with negative charge of phospholipids from cell membrane of bacteria or fungus
  - that leads to integrity lost of cell membrane
  - from microorganism cell different ions and organic compounds are “escaping” (e.g.: ATP)
  - that leads to damages and finally to the death of the microorganism’s cell.

- Natural inhibitors of metalloproteinases have ability of combaining Zn$^{2+}$ and Cu$^{2+}$ ions - metalloproteinases activators
ORGANIC COMPONENTS OF SALIVA
PROTEINS

- **Staterine** –
  - Acidic proteins containing big amount of proline, tyrosine, and phosphoserine
  - Show inhibition properties of hydroxyapatite growth and creating of tartar,
  - Participate in remineralization of enamel and protect it from physical factors.

- **Cystatin** –
  - Softens process of inflammation in oral cavity,
  - Inhibits precipitation of calcium phosphates from saliva.
  - Plays important role in prevention of parodontium diseases,
  - Present mainly in saliva from submundibular gland.

- **Lactoferrin** - glycoprotein able to combine Fe$^{3+}$ ions. Some bacteria of oral cavity need those ions, so their attachment to lactoferrin limits their development.
ORGANIC COMPONENTS OF SALIVA

PROTEINS

Immunoglobulins

In saliva there are: **IgA, IgM, IgG** described as secretory Ig. Highest concentration is reached by Ig A.

<table>
<thead>
<tr>
<th>Body fluid/gland</th>
<th>IgG  mg/100cm³</th>
<th>IgA  mg/100cm³</th>
<th>IgM  mg/100cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum</td>
<td>1250</td>
<td>220</td>
<td>80</td>
</tr>
<tr>
<td>Non-stimulated saliva</td>
<td>1.4</td>
<td>19.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Saliva glands</td>
<td>0.04</td>
<td>4</td>
<td>0.04</td>
</tr>
<tr>
<td>Gingival fluid</td>
<td>350</td>
<td>110</td>
<td>25</td>
</tr>
</tbody>
</table>
ORGANIC COMPONENTS OF SALIVA

PROTEINS

α-amylase

- hydrolizate α – 1,4 –glycosidic bond in starch
- participates in preliminary food digestion
- helpful in removing of carbohydrates fibers located between teethes
- responsible for creating glycoprotein complex of layer on the surface of the tooth just after teethes brushing. Tartar is created on these layer which leads to the most of the oral cavity diseases (caries).
- has high affinity to the bacteria and combines with them
Non-protein nitrate compounds

Urea
- product of salivary glands metabolism
- Has significant role in buffer system of saliva – from its decomposition ammonia is generated which combines with excess of $\text{H}^+$ ions

Urea acid
- Present in concentration of 40-240 µMoles
- Exhibit an oxidative effect,
- It has about 70-80% of oxidative properties of saliva

Creatinine, amino acids
- They can be originated from blood and are transported to saliva through salivary glands.
Non- nitrate organic compounds

**Carbohydrates**
- Present in saliva in trace amount,
- Most of saliva carbohydrates combine with proteins creating glycoproteins,
- Elevated concentration are in diabetics

**Lipids**
- Neutral and phospholipids, cholesterol – are in small quantities in saliva,

**Hormones – steroids**
- Presence and concentration in saliva depends on concentration in blood.
INORGANIC COMPONENTS OF SALIVA

- Content in saliva is not constant.
- Origin mainly from blood (except $\text{HCO}_3^-$)
- Occur in ionic form.
INORGANIC COMPONENTS OF SALIVACATIONS

Na⁺
- Low concentration in saliva
- Increased concentration in stimulated saliva
- Participate in active compounds’ transport through cell membrane
- Presence of Na⁺ in hydroxyapatite influences increased solubility of enamel in acid
- Na⁺ is osmo-regulator

K⁺
- Content in saliva is constant
- Transports active compounds through cell membrane
INORGANIC COMPONENTS OF SALIVA

CATIONS

Ca$^{2+}$
- constant amount in stimulated saliva is
- has the same form as in apatite
- building material for hard tissues
- participate in enamel growth and remineralization of primary damages
- activator of some saliva’s enzymes

Mg$^{2+}$
- Participate in tooth structure creation
- Activator of some saliva’s enzymes
- Mg$^{2+}$ content in hydroxyapatite increases solubility of enamel in acids
INORGANIC COMPONENTS OF SALIVA

ANIONS

Cl$^-$
- Osmo-regulator
- $\alpha$-amylase activator

F$^-$
- Influences structure and mineralization process of enamel,
- Antibacterial action

I$^-$
- Plays role in defensive mechanism

HCO$_3^-$
- Creates in saliva the strongest hydroxycarbonate/ carbonic acid buffer system
INORGANIC COMPONENTS OF SALIVA

ANIONS

\[ \text{PO}_4^{3-}, \text{HPO}_4^{2-}, \text{H}_2\text{PO}_4^- \]

- mineral parts of saliva,
- are present in the same form in enamel
- participate in enamel growth and remineralization of primary damages
- part of phosphate/phosphoric acid
- phosphate is one of the main component responsible for plaque creation.
SALIVA FUNCTION

PROTECTIVE FUNCTION

EXCRETION of:

- harmful products of bacteria metabolism,
- bacteria
- food residue from oral cavity and teeth surface

- Speed of cleaning might be from 0.8 to 8 ml/min

- Cleaning is slower from the surfaces which are more difficult to be reach because there are more cariogenic tartar, which increases affinity of these regions for caries.
SALIVA FUNCTION

PROTECTIVE FUNCTION

Wetting of mucous tunic and teethes:
- Saliva’s proteins coats teethes layer and mucous with thin layer called *acquired cuticle*, which is consisting of:
  - amino acids and proteins selectively absorbed on the teethes surface as a result of interaction between saliva amino acids and hydroxyapatite from enamel.
  - lactoferrin (protein), lysosyme (enzyme), amylase.
- Wetting
  - helps formation and swallowing of food pieces
  - limits negative influence of damages from trauma such as:
    - mechanical
    - chemical
    - thermal and biological of mucos tunic.
SALIVA FUNCTION

PROTECTIVE FUNCTION:

- Participation in process of remineralization and slowing down demineralization. At pH 6,8 – 7,2 saliva is over saturated with calcium phosphosparate solution therefore after slight demineralization lost mineral components can return from saliva to hard tissues of tooth.

- Equilibrium between saliva and enamel

\[
\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2 \rightleftharpoons 10 \text{Ca}^{2+} + 6 \text{PO}_4^{3-} + 2 \text{OH}^- 
\]

- Acidifying of environment (e.g.: as a result of carbohydrates’ fermentation by enzymes) increases solubility, and decreases saturation of saliva with calcium phosphosparates and saliva become unsaturated solution.
SALIVA FUNCTION
BUFFERING FUNCTION

- Buffer system maintains acid-base equilibrium through neutralization of organic acids:
  - present in food
  - in product from carries bacteria

- Buffers maintain resting saliva pH in the range of 5.7 and 6.2.
- After salivary gland stimulation pH can increase to 8.
- The most important role plays bicarbonate buffer (mostly at large quantities of saliva), according to the reaction:

\[
CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+
\]
SALIVA FUNCTION

BUFFERING FUNCTION
Phosphate buffer acts according to the reaction:

\[ \text{H}_2\text{PO}_4^- \rightleftharpoons \text{HPO}_4^{2-} + \text{H}^+ \]

- Phosphate buffer has low importance in buffering of stimulated saliva because of low concentration of phosphates.
- For non-stimulating saliva phosphate concentration reaches 10 mmol/L, which is important because of low concentration of HCO$_3^-$.
- At high flow of saliva concentration of H$_2$PO$_4^-$ and HPO$_4^{2-}$ decreases which is not beneficial for teethes because it decreases saliva saturation and increases demineralizations of teethes.

This phenomena leads to increase concentration of PO$_4^{3-}$ during saliva stimulation and remineralization of teethes.
SALIVA FUNCTION

BUFFERING FUNCTION

- Albuminate buffer because it has smaller concentration of proteins and also smaller significance
  - Buffer capacity of saliva is related mostly to bicarbonate buffer
  - Not sufficient buffer activities of acids can lead to caries development and dissolving of hydroxyapatite.
  - Over-saturation of saliva with Ca$^{2+}$ and HPO$_4^{2-}$ ions leads to remineralization of enamel
  - Saliva proteins are combined with Ca$^{2+}$ ions which are used for repairing preliminary damages of enamel
  - On the other hand Ca$^{2+}$ ions combined through saliva peptides are maintaining equilibrium between hydroxyapatite and Ca$^{2+}$ from saliva.
SALIVA AS A DIAGNOSTIC MATERIAL

- Amount, buffering capabilities and bacteria content are indicators of teeth carries.
- Investigating of these parameters called „saliva tests” allows to have state of oral cavity.
- Saliva tests include:
  - Investigation of the amount of resting and stimulating saliva
  - Investigation of the buffer capacity
  - Investigation of the amount of microorganisms.
- Saliva can be used instead of serum to investigate different compounds content.
  For example: compounds which can be found in saliva as a result of diffusion.
SALIVA AS A DIAGNOSTIC MATERIAL

Saliva is used to determine concentration of:

- Steroid hormones (cortyzol, progesteron, estriol, estradiol, testosteron)
- Medicines (benzodiazepine, teofilne, cyclosporine)
- In toxicology for determining concentration of: lithium, cadmium, gallium

As a diagnostic tool in determining alcohol content and.
As a diagnostic tool in determining some carcinogens markers for cancer of oral cavity.

THE END