Inflammation, healing and cellular adaptations

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Inflammation

„Stereotypical, defensive reaction of organism that follows the tissue injury with the aim to eliminate the pathogenic insult and remove the injured tissue components“
Inflammation
The aim

• To prevent the dissemination and spreading of pathogenic factor – bordering the locus
• To dilute and eliminate the pathogenic factor
• To prepare the tissue for reparation
stages of inflammation

1. VASCULAR EVENTS
2. CELLULAR EVENTS
## Cellular components

<table>
<thead>
<tr>
<th>Cellular Component</th>
<th>Percentage</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutrophil</td>
<td>54-62%</td>
<td>Phagocytosis of bacteria and fungi</td>
</tr>
<tr>
<td>Eosinophil</td>
<td>1-6%</td>
<td>Phagocytosis of parasites in allergic reactions</td>
</tr>
<tr>
<td>Basophil</td>
<td>&lt;1%</td>
<td>Phagocytosis of parasites in allergic reactions</td>
</tr>
<tr>
<td>Monocyte</td>
<td>2-8%</td>
<td>Migrate from bloodstream to tissues and differentiate into tissue resident macrophages or dendritic cells.</td>
</tr>
<tr>
<td>Macrophage</td>
<td>12:31</td>
<td>Phagocytose cellular debris and pathogens, and stimulate lymphocytes to immune response</td>
</tr>
</tbody>
</table>
Classification

• according to:
  – duration (fulminant, acute, subacute, chronic)
  – reaction of organism to ethiological agent (norm-, hypo-, hyperergic)
  – ethiology (phys., chem., biol.)
  – localisation (superficial / deep)
  – morphologic changes in tissue
Classification of inflammation according to the main components

1. **Alterative inflammation** – predominant tissue damage (regressive changes or necrosis)

2. **Exsudative inflammation** – changes of extracellular matrix caused by liquid and cellular components from blood vessels
   - serous
   - catarrhal (mucous)
   - fibrinous
   - purulent
   - gangrenous
   - haemorrhagic

3. **Proliferative inflammation** – with increase of fibrous connective tissue
   - reparation of acute inflammation
   - chronic inflammation
Serous inflammation

- effusion of clear, protein poor, serous fluid
- healing (resorption)
  - serous membrane – virus, autoimmune inflam.
  - mucous membr. (catarrhal inflam.) + mucus
  - skin (blisters)
  - deep tissue – allergic
Catarrhal bronchitis (162) with purulent superinfection

- catarrhal (mucinous) i. - serous i. on mucous membranes

- production of serous fluid -> mucus in bronchus with desquamated epithelial cells and granulocytes
- submucosal hyperemia
- fibrin is not present
- mucosa is swollen and mucous cells are activated
- 90% viruses, 10% bacteria
Fibrinous inflammation

- fibrinous exudate (↑ permeability)
- healing (organisation with granulation tissue / fibrinolysis and resorption)

- serous membr. – microorganism, uremia
- mucous memb., skin (pseudomembranous) + pseudomembranes
- deep tissue – crupous (lobar) pneumonia
Fibrinous pericarditis (11)

- Exsudative fibrinous inflammation

- “hairy pericardium” — p. covered in fibres formed from exsudated fibrin — weak adhesions

- infections, uremia, infarction
micro:
- eosinophilic fibrin fibres on BM
- tissue under BM is swollen and PMNL are present
- vascular hyperemia
Pseudomembranous inflammation (88)

- exudative fibrinous inflammation with necrosis
- certain types of bacteria that produce strong exotoxins – cause necrosis of surface layer of mucosa
- *pseudomembranes* – fibrin, necrotic tissue and inflammatory cells

- diphteria, bacillar dysentria, staphylococcal pseudomembranous enteritis
Psedomembranous colitis

- antibiotic – associated colitis (broad spectrum ATB)
- Clostridium difficile
- diarrhea with mucus and blood, fever, abdominal pain
Purulent (suppurative) inflammation

- Leu produce enzymes that liquify affected tissues
- PUS - consists of neutrophils, dead cells and fluid

- healing (resorption/chron.inflam. – pyogennic membr.)
  - serous membr. – plaques of pus ... empyema
  - mucous membr. (purulent catarrhal inflam.)
  - skin - folliculitis
  - deep tissue - diffuse (phlegmona)
    - localised (abscess)
Appendicitis

- most common abdominal surgical emergency (peak incidence 10-30y)
  - obstruction of its orifice (feaces, parasites, Tu, foreign bodies...)
  - exsudation of granulocytes into the lumen, interstitium and on the peritoneum
  - lymphatic tissue activation

- perforation – diffuse peritonitis
Cerebral abscess (14)

- **Exudative purulent inflammation**
- **Intensive tissue injury by pathological agent without propagation and spreading** (Staphylococcus)

- **ways of spreading:**
  1. local extension from adj. foci
  2. hematogenous spread
  3. direct implantation
Cerebral abscess (14)

- Leu lyse the tissue (proteolytical enzymes) -> liquefactive necrosis
- Abscess cavity is formed

- in other organs and tissues it is bordered by granulation tissue and pyogenous membrane is formed
Influenza – trachea, lungs (213)

• Nonspecific, nonpurulent viral inflammation

• Trachea and bronchi
  – necrosis of epithelium (dry cough at first)
  – hyperaemia
  – endotelium function impairment
  – exudation of plasma and Ery
  – infiltration with Ly, Ma and plasma cells
  – squamous epithelial metaplasia in bronchi
  – mucin production (productive cough later)
  – good soil for bacterial growth – bacterial superinfection – inf.inf. becomes mixed (Neu)
Influenza – trachea, lungs (213)

- **Lungs**
  - **interstitial pneumonia**
  - lymphocytic infiltration
  - edema and hyperemia of interstitium
  - alveolar oedema
  - alveolar bleeding
  - hyaline membranes
Enterobius vermicularis (Pinworm)

- **ingestion** of pinworm eggs (hands, food, water)
- **hatch** in duodenum, larvae **migrate** towards colon
- adults **mate** in ileum
- females settle in i, c, a, ca and **attach** to the mucosa, their body becomes filled with eggs
- migrate through colon, **emerge** from the anus and lays eggs
- these are **transmitted** to other surfaces
Granulomatous inflammation

• chronic specific inflammation
• **ethiology**: mycobacteria, foreign bodies, rheumatoid nodules...
• **formation of granulomas**:
  - macrophages
  - epitheloid cells
  - multinucleated giant cells
    (Langhans type, foreign body giant cells)
  - lymphocytes
  - fibrosis at the periphery of granuloma
TUBERCULOSIS

- **causative agent**: *M. tuberculosis hominis / bovis / avium*... (acid fast mo, strict aerobe – thrives best in tissues with high oxygen tension)
- specific inflammation: A/E/P
- **miliary TBC** = chronic granulomatous i. (P)
- formation of specific granulomas = **TUBERCULES**
- epitheloid cells, Langhans cells(Ly, plasma cells, fibrobl.)(HARD)
- caseous necrosis (SOFT)

- lungs are most commonly affected by TBC
- **2 types**:  
  1. **PRIMARY TBC** – in patients not previously infected / immunised  
  2. **SECONDARY TBC** – in patients previously infected / immunised
PRIMARY TBC

• mo enter the organism (aeroin., inn.)
• form **PRIMARY COMPLEX**:

1. **pulmonary component** (tbc pneu)
2. **ly vessel comp.** (Ma with bacilli)
3. affected **mediastinal lymph node**

• lesion **heals** by **fibrosis** (calc.) or
• lesion **progresses** into **PPT** – spread by bronchi or
• bacilli enter vessels and **spread** to organs = **PMT**
SECONDARY TBC

• occurs in reinfection / reactivation of PC (in lowered resistance...)

• dormant bacilli are activated
• spread hematogenously to apex of the lungs
• form lesions with caseous n.
• mo can be spread also to other organs = SMT
Healing

- Body response to injury – to restore normal structure and function

- **Regeneration**
  - Replacement of damaged tissue by *equivalent tissue*, proliferation of parenchymal cells

- **Repair**
  - Replacement of damaged tissue by *second rate tissue*, proliferation of connective tissue elements → fibrosis, scarring

  - mostly combination of both
Regeneration

– replacement of damaged tissue by equivalent tissue
Regeneration

- According to regeneration capacity the cells are classified:
  - **Unstable** – regularly replaced: hematopoiesis, epithelia (GIT, resp.), axon
  - **Stable** – renewed only if tissue is damaged: glandular epithelium, proximal canaliculi, vascular smooth muscle
  - **Permanent** – ganglion cells, crosstried muscle, cmc
Repair

- replacement of damaged tissue by second rate tissue (fibrous)
Repair

1. Granulation tissue formation
2. Contraction of wounds

- Wound healing
  - primary (per primam intentionem)
  - secondary (per secundam intentionem)
- Organisation of hematoma and thrombus
- Healing of bone fracture
- Healing of foreign bodies
- Organisation of fibrinous exudates
1. GRANULATION TISSUE FORMATION

3 phases:

- **PHASE OF INFLAMMATION** – exsudation of plasma and Leu
- **PHASE OF CLEARANCE** – cell debris, Ery and necrotic tissue is cleared by Ma
- **PHASE OF G. TISSUE INGROWTH**
  - **ANGIOGENESIS** – formation of new blood vessels from margins of injured ones
  - **FIBROGENESIS** – production of fibrous tissue by fibroblasts that migrate to previously injured area

2. WOUND CONTRACTION
- size of the wound is reduced by 80% of it’s original size
- results in rapid healing
Wound healing

• Combination of regeneration and repair

1. **H. BY PRIMARY UNION** (w. clean, uninfected, surgically treated, without much loss of tissue)

2. **H. BY SECONDARY UNION** (w. opened, infected, with large tissue defect -> healing is slow, scars are bigger)
<table>
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<th>Details</th>
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<tbody>
<tr>
<td>initial hemorrhage</td>
<td></td>
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<tr>
<td>blood clots</td>
<td></td>
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<tr>
<td>acute inflammatory response (Neu form the edges of the wound, later replaced by macrophages)</td>
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<tr>
<td>basal cells of epidermis proliferate and later cover the wound (separation)</td>
<td></td>
</tr>
<tr>
<td>angiogenesis</td>
<td></td>
</tr>
<tr>
<td>fibrogenesis</td>
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</table>
- Leu infiltration diminishes
- epidermal cells proliferate
- scab is getting smaller in size

- vascularisation and fibroblasts diminish
- fibrous tissue predominates
- scab is removed
- wound contracts
Healing of fractured bone

- fractured bone
Healing of fractured bone

- bleeding from injured vessels -> hematoma
- local inflammatory response (exs. of fibrin, Leu)
- clearance (osteoclasts) -> organisation of hematoma (from periost) -> fr. connected
Healing of fractured bone

- formation of woven bone and cartilage = PROCALLUS / FIBROUS CALLUS
Healing of fractured bone

- procallus is a framework for ossification
- OSSEUS CALLUS (from lamellar bone) is formed
Healing of fractured bone

- osseus callus is remodeled by osteoblasts and osteoclasts = **DEFINITIVE CALLUS** is formed
Cellular adaptations

• **Physiologic adaptation** – to the physiologic needs
• **Pathologic adaptation** – to non-lethal pathologic injury

• Adaptations:
  1. **atrophy** – reduction of the number and size of cells
  2. **hypertrophy** – increase in size of cells
  3. **hyperplasia** – increase in number of cells
  4. **metaplasia** – reversible change of one type of mature cells to another type of mature cells
  5. **dysplasia** – disordered cellular development
Hypertrophy

- enlargement of cell volume
Hypertrophy

- **Physiologic** (enlarged size of the uterus in pregnancy, also hyperplasia)

- **Pathologic:**
  1. hypertrophy of cardiac muscle
  2. hypertrophy of smooth muscle
  3. hypertrophy of skeletal muscle
  4. compensatory hypertrophy
Myocardial hypertrophy

- **Hypertension in PC**
  - *acute* — RV dilatation (cor pulmonale acutum)
  - *chronic* — RV hypertrophy (cor pulm.chron.)

- **Hypertension in SC**
- *essential / secondary* hypertension
- LV hypertrophy (cor hypertensivum)

  → *cor bovinum*

- **Hypertrophy**
  - *concentric* — pressure overload
  - *eccentric* — volume overload
Hyperplasia

- increase of cell number
Metaplasia

replacement of one differentiated tissue by another differentiated tissue