

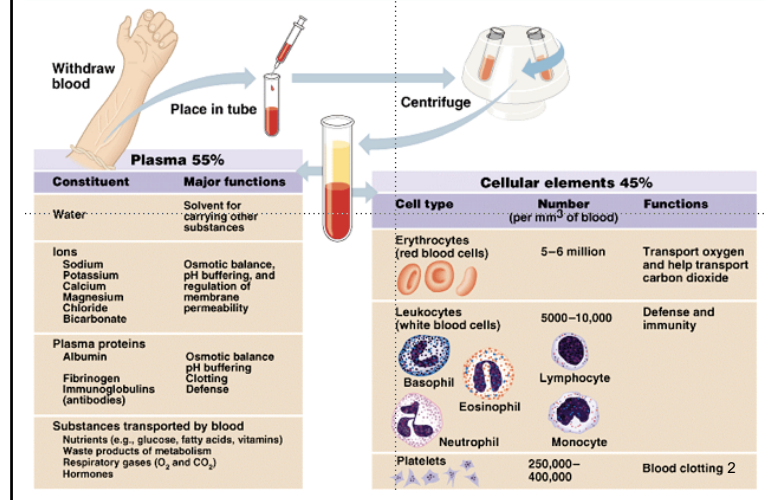
혈액의 구성 및 기능

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1

1

Components of the Blood



2

Composition of the Blood

- **Cellular component** : 45%
 - erythrocyte (red blood cell, **RBC**)
 - leucocyte (leukocyte, white blood cell, **WBC**)
 - **platelet** (thrombocyte)
- **Fluid component (plasma)** : 55%
 - water
 - inorganic substance
 - organic compound

3

3

Volume of the Blood

- 6~8% of body weight (adult)
- 8~9% of body weight (child)
- Normal adult : **4~6 liter**

4

4

Function of the Blood

- Transport of O₂ and CO₂
- Transport of nutrient & metabolite
- Transport of ions, vitamins, enzymes, hormones, water
- Regulation of body temperature
- Body defense
- Prevention of bleeding (=hemostasis)
- Regulation of pH

5

5

1. Plasma

6

6

Composition of Plasma

- 55 ml /100 ml of blood (55%)
- water > 90%
- inorganic substance (0.9%)
 - electrolyte : NaCl & etc. (K⁺, Ca²⁺, Mg²⁺)
- organic compound (7~9%)
 - plasma protein (6.5~8%)
 - others : carbohydrate, lipid, metabolite

7

7

Inorganic substance

- electrolyte (NaCl etc.)
- 96% of body osmotic pressure
- osmotic pressure
 - crystalloid osmotic pressure (96%)
 - Size < 1 nm
 - Electrolyte (NaCl)
 - colloid osmotic (=oncotic) pressure (4%)
 - Size : 1 nm ~ 1 μm
 - Plasma protein
 - physiologically more important

8

8

Plasma proteins

- albumin
- globulin
 - α_1
 - α_2 : haptoglobin (bind to hemoglobin), celuroplasmin (bind to copper)
 - β : transferrin : transport of iron
 - γ : immunoglobulin (Ig, antibody)
- fibrinogen
 - blood coagulation
- etc.

9

2. Erythrocyte (RBC)

10

Function of RBC

- transport of O_2
 - role of hemoglobin (Hb)
- transport of CO_2
 - role of carbonic anhydrase
- control of pH
 - role of Hb

11

Shape of RBC

- biconcave disc
- diameter : 7~8 μm
- width : 1~2 μm
- advantage
 - easy to go through blood capillary
 - increase in surface area & gas exchange



12

RBC Count

- male : $5,200,000 \pm 300,000 / 1 \mu\text{l} (1 \text{ mm}^3)$ of the blood
- female : $4,700,000 \pm 300,000 / 1 \mu\text{l} (1 \text{ mm}^3)$ of the blood
- total RBC number : 30×10^{12}
- total body cell number : 100×10^{12}

13

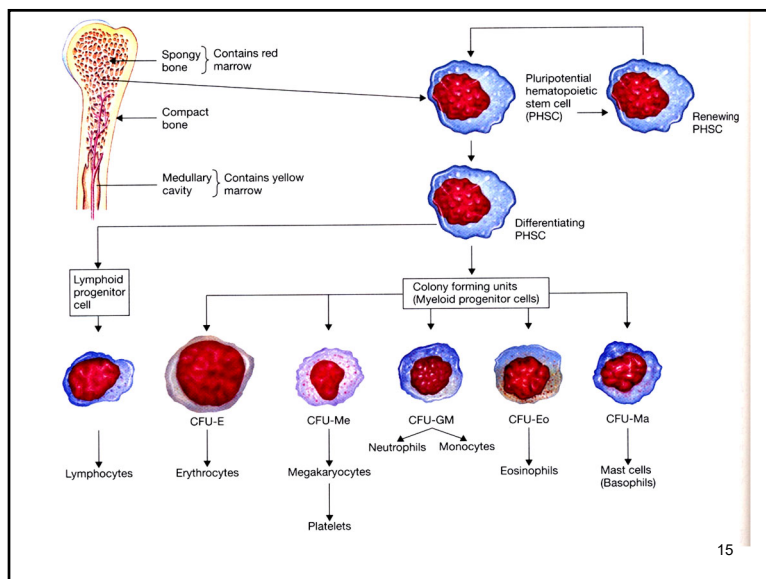
13

RBC production

- Site : **bone marrow**
 - 0 ~ 5 yr : all bone marrow
 - 5 ~ 20 yr :
 - **long bone** : inactive, **yellow marrow**
 - **membranous bone** : active, red marrow
 - 20 yr ~
 - **membranous bone marrow** & proximal parts of humerus & femur

14

14



15

15

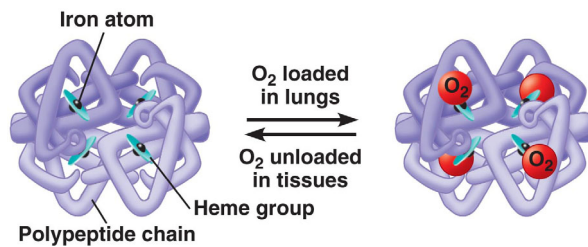
Hemoglobin

16

16

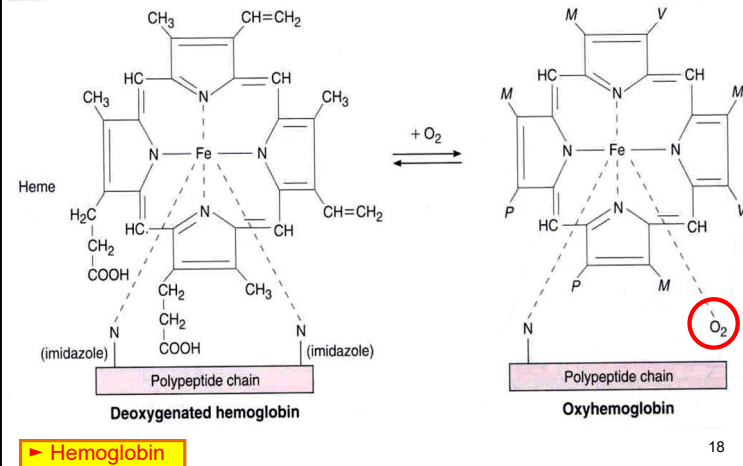
Oxygen binding to Hb

- binds to one of 6 coordination bonds in Fe^{2+} of Hb
- O_2 binding : reversible
- **deoxyhemoglobin** (dark red) vs **oxyhemoglobin** (bright red)



17

• deoxyHb & oxyHb



18

- **Energy source of RBC**
 - glucose
- **Destruction of RBC**
 - life time : **120 days**
 - mainly **spleen**
 - sinusoid diameter: $3\ \mu\text{m}$
 - **malaria**
 - RBC destruction (\uparrow) \rightarrow splenomegaly

19



20

20

Anemia

- Definition : **deficiency of functional Hb**
- Classification
 - **blood loss anemia** : **iron deficient**
 - **aplastic anemia** : bone marrow dysfunction
 - **megaloblastic anemia** : vitamin B12 deficient (**Pernicious anemia**)
 - **hemolytic anemia**
- Effect on the circulatory system
 - oxygen transport decrease → hypoxia
 - blood viscosity decrease → cardiac output increase → offsets low oxygen supply

21

21

3. Leucocyte (WBC)

22

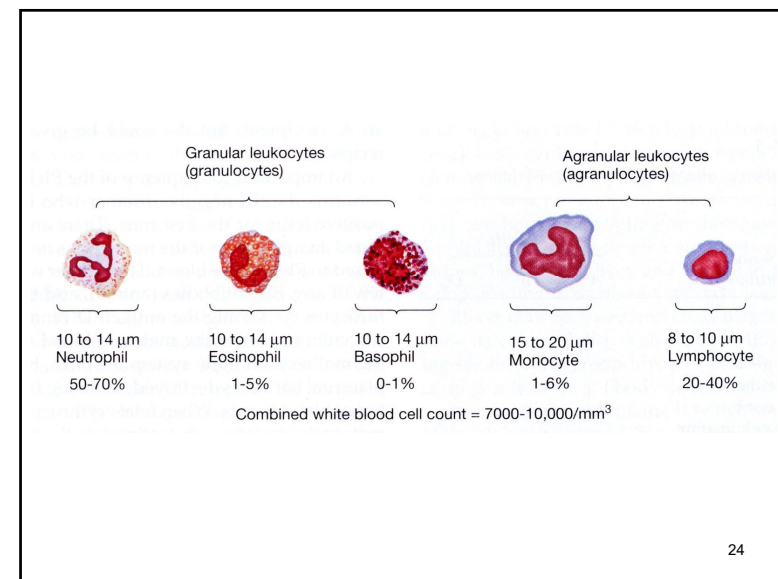
22

Types of leucocyte

- **granulocyte** : 60~70%
 - = polymorphonuclear leucocyte (PMN, polys)
 - (polymorphonuclear) **neutrophil** : **62%**
 - (polymorphonuclear) **eosinophil** : **2.3%**
 - (polymorphonuclear) **basophil** : **0.4%**
- **monocyte** : **5.3%**
 - **macrophage**
- **lymphocyte** : **30%**

23

23



24

24

Function

- body defense
 - ① phagocytosis
 - granulocyte (mainly **neutrophil**) & **macrophage**
 - ② immune response
 - antibody & sensitized lymphocyte
 - **lymphocyte** & **macrophage**

25

25

Normal value

- variable
- **4,000~10,000**/μl of blood
- **leucocytosis**
 - WBC count > 10,000/μl
- **leucocytopenia**
 - WBC count < 4,000/μl

26

26

WBC production

- site : **bone marrow**
- myelogenous
 - granulocytes
 - **monocyte**
 - 10~20 hours in the blood
 - → wander into the tissue
 - → swelling & lysosome increases
 - → **tissue macrophage**
- lymphogenous
 - **lymphocyte**
 - B lymphocyte (cell)
 - T lymphocyte (cell)

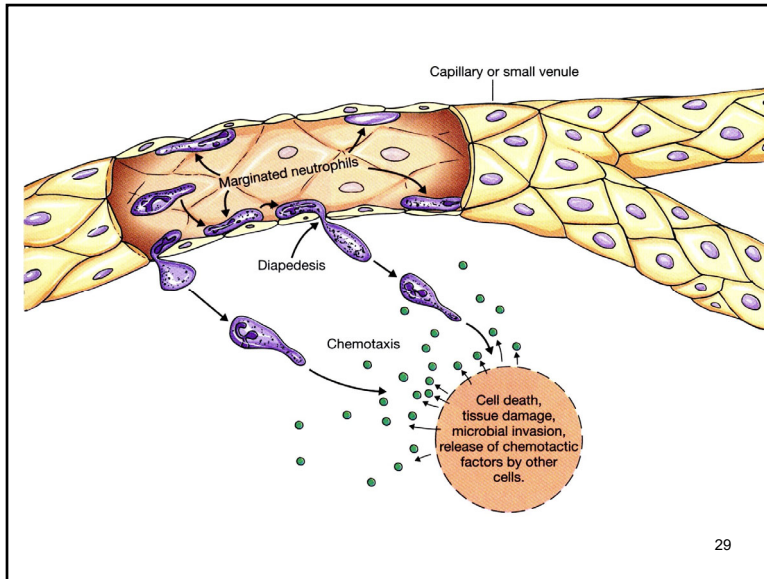
27

27

Phagocytosis

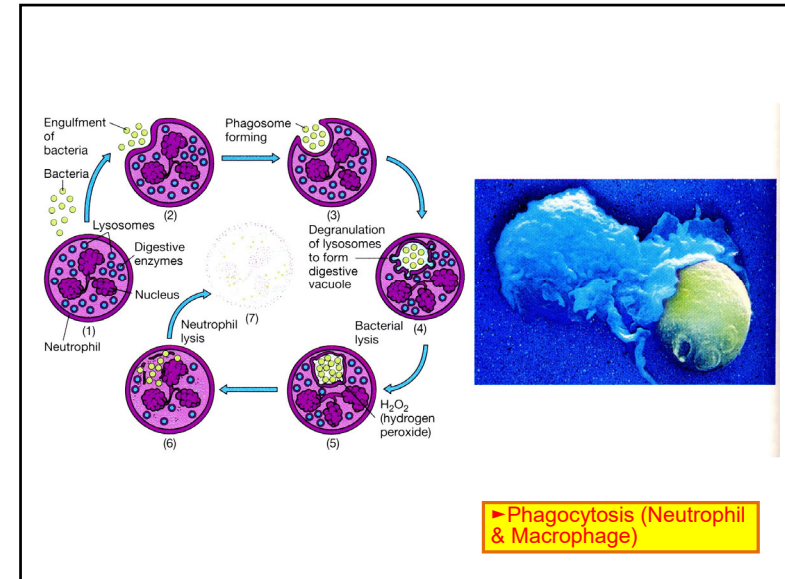
28

28

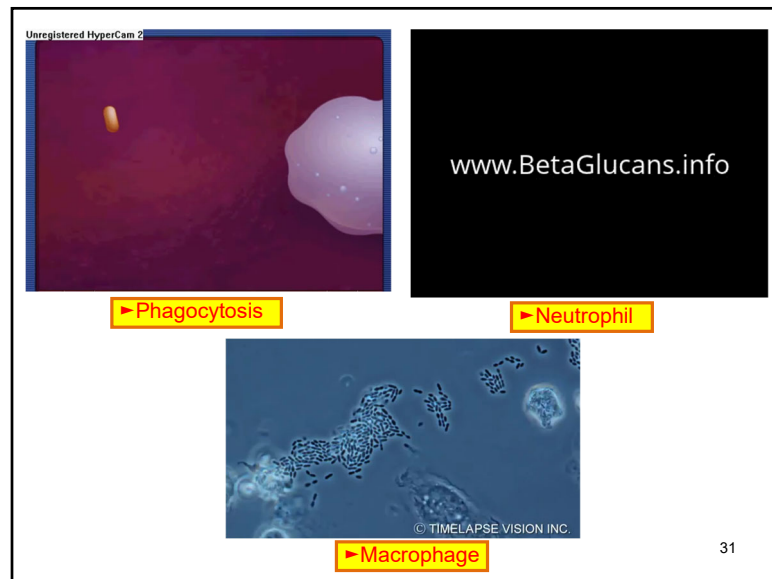


29

29



30



31

31

Leukemia

- uncontrolled production of **abnormal WBC**
- increased number of abnormal WBC
- causes : **cancerous mutation** of WBC
 - lymphocytic leukemia
 - myelogenous leukemia

32

32

Leucopenia

- causes : bone marrow aplasia
 - gamma ray irradiation : nuclear explosion
 - chemical : benzene
 - drugs : chloramphenicol, thiouracil, barbiturate

33

33

Immunity

34

34

Innate immunity

- phagocytosis
 - neutrophil & macrophage
- natural killer cell
 - cytotoxic large lymphocyte
- stomach acid & enzyme
- corneal layer of skin

► Natural killer cell

35

35

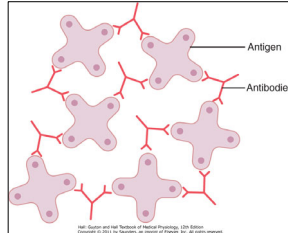
Acquired immunity

- humoral immunity
 - B lymphocyte (B cell)
 - antibody → antigen-antibody reaction
 - mainly bacteria
- cellular immunity
 - T lymphocyte (T cell)
 - activated or sensitized lymphocyte
 - virus, fungus, tubercle bacillus, tumor cell

36

36

- **Antigen (Ag)**
 - protein or polysaccharide
- **Antibody (Ab)**
 - immunoglobulin (**γ -globulin**)
 - IgG, IgA, IgM, IgD, IgE
- Ag-Ab reaction
 - **agglutination**
 - precipitation
 - neutralization
 - lysis



37

37

4. Blood types

38

38

- Ag-Ab reaction
 - agglutination
- **agglutininogen**
 - antigen in RBC membrane
 - **ABO** or **Rh**
 - 30 common (hundreds rare) antigens
- **agglutinin**
 - antibody in plasma
 - IgG (or IgM)

39

39

ABO blood type

40

40

ABO blood type

phenotype	genotype	agglutinin	agglutinin	ratio
O	OO	-	α & β	45~47% (28%)
A	OA, AA	A	anti-B (β)	41% (34%)
B	OB, BB	B	anti-A (α)	9~10% (27%)
AB	AB	A & B	-	3~4% (11%)

* () : Korea, 2012 data

41

41

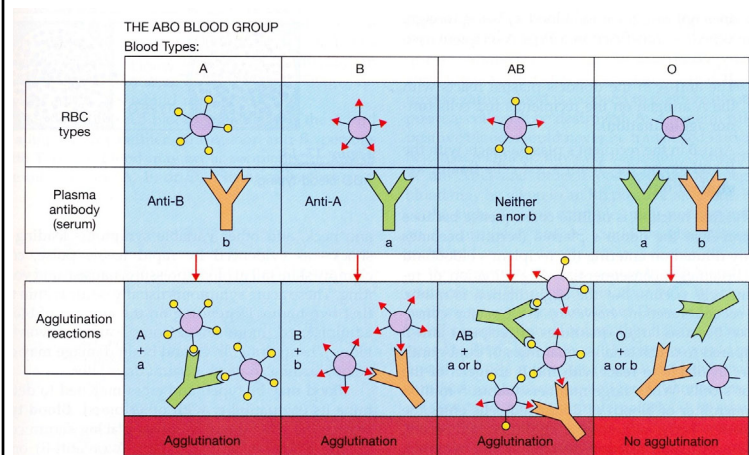
ABO antigen (agglutinin)

- present in **RBC membrane & other tissues**
 - saliva, salivary gland, testis, semen, pancreas, kidney, liver, lung, amniotic fluid
- all people : H gene \rightarrow H antigen
 - A type : enzymes converting H Ag to A antigen
 - B type : enzymes converting H Ag to B antigen
 - AB type : 2 kinds of enzymes
 - O type : no enzyme, only H antigen

42

42

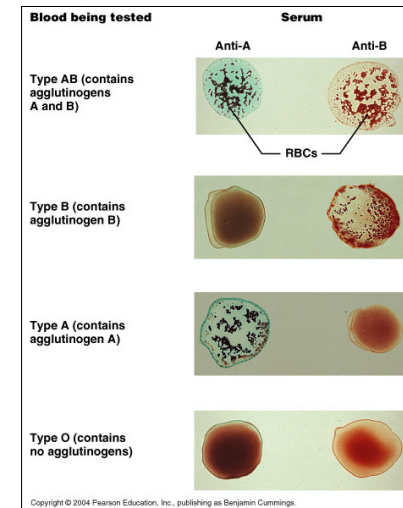
Principles of blood typing



43

43

Blood typing method



44

► Blood typing

44

Rh blood type

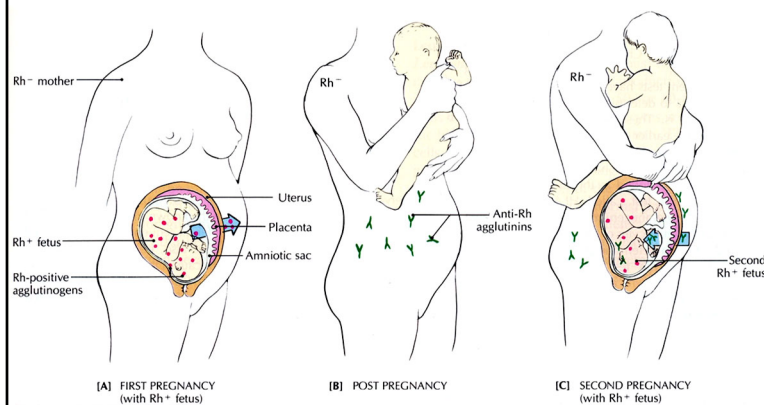
45

Rh antigen (factor)

- found in Rhesus monkey
- **only in the RBC membrane**
 - antibodies do not spontaneously produced
- antigen types : C, D, E, c, d, e
 - **D antigen** : widely prevalent & more antigenic
 - Rh(+) : DD or Dd, Rh(-) : dd
- antibody : **IgG (readily cross placenta)**
- distribution
 - African black : 100% Rh(+)
 - Asian : **99% Rh(+)**
 - American black : 95% Rh(+)
 - Caucasian : 85% Rh(+)

46

- Rh(-) mother & Rh(+) baby



47

Transfusion

48

- universal recipient : type AB
- universal donor : type O
- **Cross matching test**
 - **major** : donor RBC + recipient serum
 - RBC membrane antigen → not diluted
 - **minor** : donor serum + recipient RBC
 - serum antibody → diluted
- autologous transfusion
 - for 3 weeks, 1~1.5 liter
 - prevention of AIDS, hepatitis, transfusion reaction

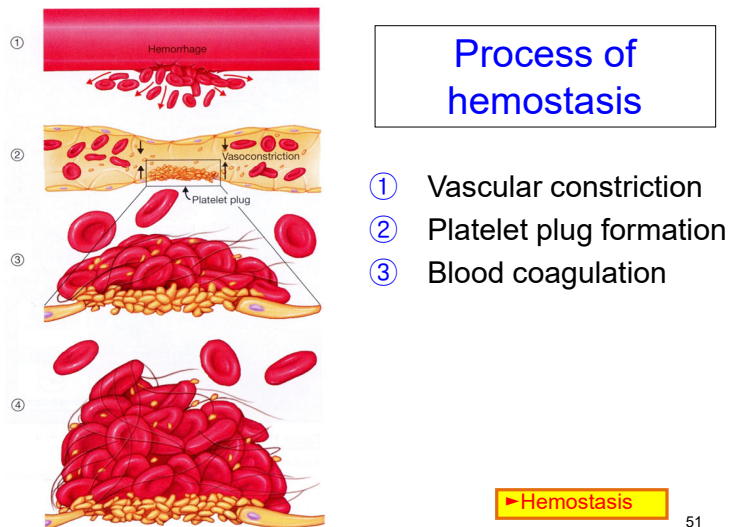
49

49

5. Hemostasis

50

50



51

51

Platelet

- stem cell → **megakaryocyte** → (fragmentation) → 1,000 platelet
- diameter : 2~4 μm , **no nucleus**
- normal value
 - 200,000~400,000/ μl of blood
 - 50,000/ μl : severe thrombocytopenia
- life-time : 10 days
- regulation : thrombopoietin (\leftarrow kidney)

52

52

Significance of platelet mechanism

- control of spontaneous bleeding in the capillary & small venule
- aspirin
 - block the formation thromboxane A_2
 - → prostacyclin (PGI_2) : increase
 - → decrease platelet Ca^{2+}
 - → inhibit platelet activation
 - → prevent cerebral & coronary vascular disease

53

53

- Normal condition,
 - Anticoagulants → inhibit blood coagulation
- Blood vessel injury,
 - Procoagulants → activate blood coagulation
 - severe injury : begins in 15~20 s
 - weak injury : begins in 1~2 min
 - completed within 3~6 min

54

54

Fate of Blood clot

- Formation of fibrous tissue
 - within 1 h after clot formation : fibroblasts grow
 - 1~2 weeks : complete fibrous tissue
 - catalyzed by platelet-derived growth factor (PDGF)
- Lysis of fibrin (fibrinolysis)
 - specific substances → lysis of clot

55

55

Plasmin (Fibrinolysin)

- plasminogen (profibrinolysin) → plasmin
- activated by tissue plasminogen activator (tPA)
 - released by injured tissue & endothelial cell
 - 1 day after coagulation complete
- lysis of clot
 - fibrin fiber & clotting factors (fibrinogen, factor II, V, VIII, XII)

56

56

Abnormality of Hemostasis

57

57

Thrombosis & Embolism

- cause
 - rough or injured endothelium
 - atherosclerosis (arteriosclerosis) or trauma
 - cerebral or coronary thrombosis
 - slow blood flow
 - → high procoagulant concentration
 - economy class syndrome

58

58