Hemodynamic Disorder and cardiovascular diseases

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(A) Hemodynamic Disorder

- **Edema**
- **hyperemia or congestion**
- **hemorrhage**
- **thrombosis**
- **embolism**
- **infarction**
- **shock**

Edema

an excess of fluid in the interstitial spaces and/or body cavity

1. localized – pitting edema :acute inflammation, allergy, venous obstruction, lymphatic edema

2 tissue or organ – periorbital area, pulmonary edema, brain edema; ascites, hydrothorax (pleural effusion), pericardial effusion

3 generalized -- anasarca: heart, kidney, starvation

- transudate, exudate(more cell and protein)

Inducing reasons of edema

A) increased hydrostatic pressure (blood vessel)

1).venous return pressure increase 2) arterial dilation

EX: deep vein thrombosis, congestive heart failure (backward heart failure)

B) decreased oncotic pressure (plasma)

1). Hypoproteinemia. 2). Hypoalbuminemia

EX: nephrotic syndrome, cirrhosis

C) obstruction of the interstitial fluid drainage (lymphedema)

EX: tumor, surgery, radiation, filariasis

D) increased tissue hydration (sodium retention)

EX: hyperaldosteronism

E) inflammation: congestion, vascular permeability increase

clinical signs of edema

- variable
- dependent on causes, rate, severity

  EX: lung and brain edema

Hyperemia

1. active (artery, capillary)→ arterial and capillary dilatation → inflammation
2. passive (congestion), vein return obstruction
   a) acute
      local – abrupt vein return obstruction, thrombosis, organ torsion
      systemic – acute heart failure, asphyxia
   b) chronic → ischemia → cell degeneration or death
      local – long term, progressive vein obstruction
      systemic – chronic heart failure

Hemorrhage – extravasation of blood

*acute or chronic;

*short term or long term;

*external or internal

1. types of hemorrhage

   a) petechia: 1-2 mm – mucosa, skin

      – vascular pressure increase, platelet decrease

   b) purpura: $\geqq$3mm – skin

      – trauma, vasculitis, increase in vascular fragility

   c) ecchymosis: $\geqq$1cm – skin

      – trauma

hemorrhage

Causes : trauma, vasculitis, tumor, hypertension, aneurysm rupture, hemorrhagic diathesis

Clinical terms:

- hemoptysis (嗀血)
- melena (瀝青性便血)
- hematemesis (吐血)
- hematochezia (便血)
- hematuria (血尿)
- metrorrhagia (陰道出血)
- menorrhagia (經血過多)
- hematoma (血腫血塊)

Thrombosis

clotting, is transformation of the fluid blood into a solid aggregate encompassing blood cells and fibrin.

1) Pathogenesis: endothelial cell injury → platelet aggregation and deposition → hemostatic plug formation → vascular statis

2) Factors of intravascular coagulation:

a) coagulation proteins b) platelets c) endothelial cells

3) Virchow's triad: three predisposing conditions for formation of pathologic thrombi

a) endothelial cell injury

b) hemodynamic change

c) hypercoagulability of the blood

Thrombosis

4) Types

a) arterial thrombosis → heart, large artery → multiple organs infarct

b) venous thrombosis → vascular stasis – leg vein → local congestion edema, lung infarct

5) Fate of the thrombi:

a) Small thrombi – lysis

b) Large thrombi :1) narrowing, occlusion

2) organization –recanalization

3) emboli – ischemic infarction

*clinical symptoms of thrombosis: 1) size 2) extent 3) rapid

a) heart, cerebral artery→death

b) pulmonary Emboli→high mortality

(often not recognized clinically)

Disseminated intravascular coagulation (DIC)

pathogenesis: activation and aggregation of intravascular fibrin protein → consumption of platelet and coagulation factor → resulting in hemorrhagic change

reason: infection, amniotic fluid, malignant tumor,
or unknown cause

clinical signs:

1) diffuse microthrombosis formation → ischemia of brain, lung, heart, kidney

2) consumption of platelet and coagulation factor → hemorrhage

* injury of red blood cell when pass through the fibrin thrombosis → lysis → microangiopathic anemia

Embolus and Embolism

– a detached intravascular solid, liquid or gaseous mass

– a procedure of an embolus is carried by blood to a distal site fixed in the vascular lumen

Forms of emboli:

a) Thromboemboli—the most pattern

1) **pulmonary thromboembolism** – venous embolism

- deep vein of leg and pelvis
- small emboli—lung infarct, lung hemorrhage, silent (60-80%)
- large emboli—acute lung failure, sudden death

EX: traveler syndrome

2) **systemic thromboembolism** – arterial embolism

intracardiac mural thrombi (80%), dilated left atrium, atherosclerotic plaque, valvular vegetation, unknown origin (10-15%)

→ intestine, brain, spleen, kidney infarct

Forms of emboli

b) Liquid emboli – 1) fat emboli, 2) amniotic fluid

1) long bone fracture (90%), fat tissue injury, burn

2) rare (1/50000) but deathful complication (20-40%) of labor, can't to prevent the amniotic content (amniotic fluid, fetal skin, hair, feces) into the mother vascular circulation→ lung infarct, DIC, hemorrhage and shock

c) Gaseous emboli (100cc volume)

Chest wall injury, decompression sickness, caisson disease—bone necrosis and organ infarct

d) Solid particle emboli - cholesterol crystal, tumor cells, bone marrow, foreign material

Infarction and infarct

A consequence of ischemic necrosis of distal tissue from an embolic event; an area of ischemic necrosis caused by occlusion of vessels

1) causes: thrombus or embolus (the most), vascular spasm, compression, torsion, injury

2) Morphologic change:

Gross: triangle or wedge-shape, pale or hemorrhagic

Micro: coagulative necrosis, liquefactive necrosis, abscess (septic infarction)

3) type: a) white (anemic) infarct– arterial occlusion

→ heart, spleen kidney, brain, solid organs

b) red or hemorrhagic infarct—venous obstruction or two sets blood supply → ovary, testis, intestine, lung, liver

The major factors that influence development of an infarct

1) nature of the vascular supply
2) rate of development of occlusion
3) vulnerability to hypoxia
4) oxygen content of blood

Shock (cardiovascular collapse)

Definition: a state of systemic hypoperfusion of tissue with blood

1) Type of shock:

a) cardiogenic shock --reduction in cardiac out—myocardial injury, ventricular occlusion, external compression

b) hypovolemic shock --reduction in the effective circulating blood volume—hemorrhage, trauma, burn

c) septic shock --loss of peripheral vascular tone—endotoxic shock, Gram (-), systemic infection

*neurogenic shock—loss of sympathetic and vasomotor tone → peripheral pooling of blood---pain, fear, spinal cord injury

*anaphylactic shock—allergy→IgE release, systemic vasodilation and →increased vascular permeability—drug, nuts, insect bite

Symptoms and signs of shock

a) Skin, pale and cold

b) Kidney, decreased GFR, oliguria, anuria, metabolic acidosis

c) Acidosis – potentiates heart failure

- causes vasodilatation, peripheral pooling of blood

- Left ventricular insufficiency raises the intrapulmonary venous pressure, pulmonary edema→shock lung, ARDS→respiratory acidosis
- Anoxia – cytokines release, (IL-1, TNF), vasodilatation

*anoxic endothelial cell→lose their antithrombogenic properties → revert into clot-forming cells, release clotting factors, combined with platelet, plasma clotting factors⇒DIC

Stages of shock

a) early or compensated shock: tachycardia, vasocontriction of peripheral arterioles, skin pale,

* blood pressure is normal

b) decompensated but reversible shock: tachypnea and shortness of breath (anoxia) acidosis,

arterial dilatation, oligouria, confused

* hypotension

c) irreversible shock: circulatory collapse severe tissue and organ injury

Decreased blood pressure

Compensations to main of heart and brain function

1) Stimulate sympathetic nervous system

a. thirst b.anxiety, restlessness

c. tachycardia d.vasoconstriction, pallor

2) Renin—angiotensin—aldosterone

a. vasoconstriction b. retention of Na+, and water, oliguria

3) Increased ADH secretion

a. retention of water

Direct Effects of Decreased Blood Pressure

Lethargy, weakness

Anaerobic metabolism-→ Metabolic acidosis

↓

Vasodilation and decreased cell function

↓

Slow blood flow in microcirculation → Thrombus forms

Ischemia on organ → Decreased function

→ Necrosis (eg., kidney)

↓

Decreased venous retum

↓

Further decrease in cardiac output

Severe acidosis, CNS depression,

Organ damage (eg., acute renal failure, lung damage)

↓

Decompensation

pathologic changes of shock

- brain→ischemic neuropathy
- heart→coagulation necrosis, subendocardial hemorrhage
- kidney→acute tubular necrosis
- lung→diffuse alveolar damage (shock lung)
- G-I system→hemorrhagic gastroenteropathy
- Liver→ fatty change
- Adrenal→ hemorrhagic necrosis

(B) Disease of cardiovascular system

1) **Acquired heart disease**:

Heart failure, Ischemical heart disease, Hypertensive heart disease, Cor pulmonale, Rheumatic heart disease, Infective endocarditis, Nonbacterial thrombotic endocarditis, Valvular heart disease, Myocardial disease,

2) **Congenital heart disease**,

3) **Vascular diseases**:

Arteriosclerosis, Varicose vein

Heart failure

A) right-sided heart failure:

Cause: pulmonary artery occlusion, lung parenchyma disease, chronic inflammatory disease, lung tumor, chest wall deformity or exercise disturance

Clinical signs: central venous pressure increase, hepatosplenomegaly, organ congestion, ascites, peripheral edema, nutmeg liver

B) Left-sided Heart Failure:

Causes: hypofunction of left ventricle, aortic or mitral valve pathologic change

Clinical signs: lung edema, pleural effusion, cardiogenic asthma, hemoptysis, dyspnea

Ischemic heart disease

1) causes: coronary arterial occlusion or spasm, vasculitis, tumor, hypovolemic shock, ventricular fibrillation → coronary artery blood flow decreased or interruption
2) clinical signs: angina pectoris, acute myocardial infarct, chronic ischemia heart disease, cardiogenic sudden death
3) gross and microscopic changes: myocardial necrosis, hemorrhage and fibrosis
4) complications: arrhythmia, left-sided heart failure, papillary muscle rupture, mural thrombus formation, heart rupture, ventricular aneurysm, pericarditis
5) death: arrhythmia, cardiogenic shock, thromboemboli

Hypertensive heart disease

1) definition : blood pressure ＞140/90mmHg
2) gross: left ventricle hypertrophy, dilatation, heart failure
3) side effects: pathological change in central nervous system and kidneys

Cor pulmonale

1) cause: pulmonary hypertension, pulmonary thromboemboli, chronic obstructive lung disease, lung tumor, chest wall deformity or exercise disturbance

2) gross:

acute form – right ventricle dilatation, right-sided heart failure

chronic form – right ventricle hypertrophy, right-sided heart failure

Rheumatic heart disease

1) acute rheumatic fever – Group A beta, hemolytic streptococcus → pharyngitis

clinical signs:

* myocarditis – Aschoff's nodule (diagnostic characteristic),
* migratory polyarthritis,
* subcutaneous nodule,
* erythema marginatum,
* Sydenham's chores

#ASLO (antistreptolysin O) antibody elevation, fever

Endocardium – vegetation, heart failure

Rheumatic heart disease

2) chronic rheumatic heart disease

gross: valve deformity – mitral & aortic valve

→ atrophy, hypertrophy, fibrosis, calcification

clinical signs: stenosis or insufficiency

⇒ blood flow stasis, left ventricle dilatation, mural thrombus formation, atrial fibrillation, lung congestion, heart failure

Infective endocarditis

a) acute: present in healthy heart

*pathogen – staphylococcus, pneumococcus – sepsis

bacterial vegetation – infective emboili, pyemia abscess

b) subacute: present in heart with congenital deformity or valvular abnormality

*pathogen – streptococcus viridans

bacterial vegetation, anemia, multiple emboli, splenomegaly

Nonbacterial thrombotic endocarditis

patient with chronic disease, or malignant tumor

gross: small nonbacterial vegetation over the leaflets of mitral valve or tricuspid valve

valvular heart disease

1) mitral valve stenosis

cause: congenital, rheumatic heart disease

clinical signs: progressive left heart failure, heart murmurs, lung congestion and edema, pleural effusion

2) mitral valve insufficiency

cause: congenital, rheumatic heart disease, myocardial infarct

clinical signs: left ventricular hypertrophy, heart murmur

valvular heart disease

3) aortic valve stenosis

cause: congenital, rheumatic heart disease, myocardial hypertrophy, calcification

clinical signs: left ventricle hypertrophy, heart murmur

4) aortic valve: insufficiency

cause: congenital, syphilic aortitis

5) pulmonary valve stenosis

cause: congenital

Myocardial disease: myocarditis

Inflammation with myocardial necrosis
(not induce by ischemia)

a) cause: virus, bacterial, parasite,
fungus, drug, alcohol, radiation

b) clinical signs: abrupt or
progressive heart failure

c) gross or micro changes:
cardiomegaly, myocardial
necrosis

d) complication: acute heart failure,
arrhythmia, death

cardiomyopathy

unknown cause, (not by coronary artery disease, hypertension, valvular disease)

a) dilated cardiomyopathy

cause: unknown, may be associated with myocarditis or mutation of gene of myocardial contraction protein

clinical signs: progressive heart failure

gross: heart enlarged and weight, dilatation of the four chambers, mitral and tricuspid insufficiency

micro: cardial cell hypertrophy, hyperchromatic nucleus, interstitial fibrosis

cardiomyopathy

b) hypertrophic cardiomyopathy

- cause unknown: but 25% associated with abnormal gene in cardial contractile protein
- clinical signs: progressive heart failure
- gross and micro changes: ventricle and septum hypertrophy, cardial cell hypertrophy and disarrayed distribution

cardiomyopathy

3) restrictive cardiomyopathy

- ventricular space decrease
- cause unknown
- amyloidosis, glycogen storage disease, hemochromatosis, endocardial fibrosis, endocardial fibroelastosis

Congenital heart disease

a) cyanotic

1) tetralogy of Fallot (TOF)

2) transition of great vessel (TFA)

3) truncus arteriosus

Tetralogy of Fallot

- Complex congenital defect of heart and major vessel
- Cyanosis in newborn, 10% of CHD
- Four typical lesions

a) valvular stenosis (narrowing)
   of the pulmonary artery

b) ventricular septal defect

c) dextroposition of the aorta

d) hypertrophy of the right ventricle

- Blue baby
- Treat: surgical correction

Congenital heart disease

b) non-cyanotic

1) ventricular septal defect (VSD) – the most
2) patent ductus arteriosus (PDA)
3) atrial septal defect (ASD)
4) coarctation of aorta
5) pulmonary stenosis (PA)
6) aortic stenosis (AS)

Septal defects: 30~40%

a) Atrial – foramen ovale

b) Ventricle – 1) foramen ovale (upper part)

2) muscular septa (lower part)

VSD – the most common CHD

- L to R shunt
- R ventricular hypertrophy
- pulmonary hypertension
- R to L shunt, cyanosis

*easy detection by heart murmurs

*defect – small one, close spontaneous

large one, surgery

vascular disease

Arteriosclerosis

1) arteriolosclerosis

- muscular wall thickened, fibrinoid degeneration
- benign or malignant hypertension
- hypertensive heart disease, hemorrhagic stroke, hypertensive renopathy

2) atherosclerosis

a) high risk factors: hyperlipiemia, hypertension, diabetes mellitus (DM), smoking

- factors can not be changed: age, sex, hereditary
- factors can be changed:

  1) lipid metabolism-related factors

     diet, hyperlipidemia, obesity, D.M.

  2) hypertension

  3) clotting factors

  4) cigarette smoking

  5) behavior

2) atherosclerosis

b) muscular wall thick, lipid aggregation, fibrosis, calcification, hemorrhage, ulceration, thrombus formation, lumen narrowing, chronic ischemia

c) aorta, coronary artery, cerebral artery, femoral artery, popliteal artery, radial artery

d) complications: thromboemboli formation, aneurysm, myocardial infarct, ischemic stroke, peripheral infarct and necrosis

Arteritis

1) infective arteritis
2) syphilitic arteritis – ascending aorta
3) thromboangiitis obliterans
4) giant cell arteritis

Aneurysm

abnormal vascular dilatation due to vascular wall destruction

- cause: atherosclerosis, trauma, inflammation, vascular degeneration, congenital
- gross change: compression, thrombus formation, hemorrhage
- type: atherosclerostic aneurysm, aortic dissection, mycotic aneurysm

diseases of vein

1) varicose vein

- cause: intraluminal pressure increase, extraluminal supporting decrease, vascular wall weakness
- common site: lower leg, esophagus, anus, umbilicus area
- complications: ulceration, hemorrhage, pigment deposition, abscess, fistula, thromboemboli formation

2) thrombophlebitis – thrombotic occlusion of vein