CVS
PATHOLOGY

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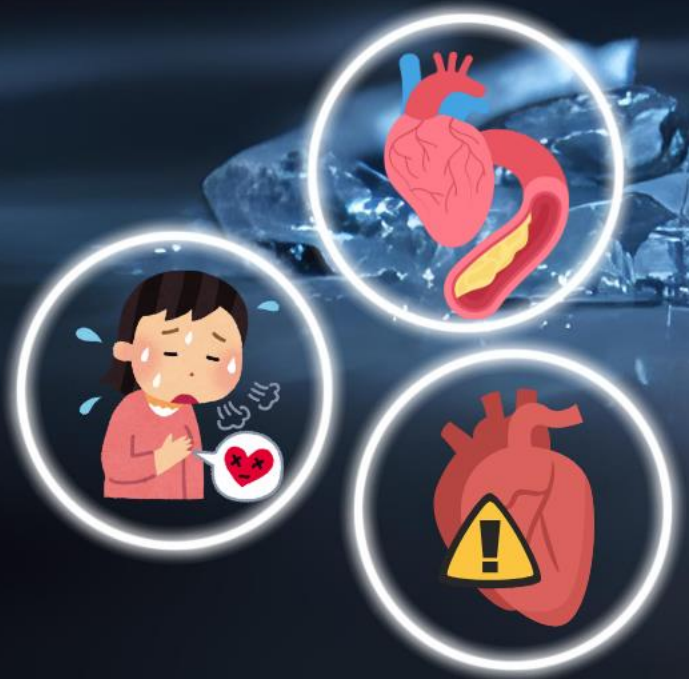

كتابة: محمود جرادات

تدقيق: خديجة ناصر

الدكتور: نسرين أبو شاهين

EMBOLISM AND INFARCTION

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Color code

Slides
Doctor
Additional info
Important

EMBOLISM:

- **An embolus is a detached intravascular solid, liquid, or gaseous mass that is carried by the blood to a site distant from its point of origin**

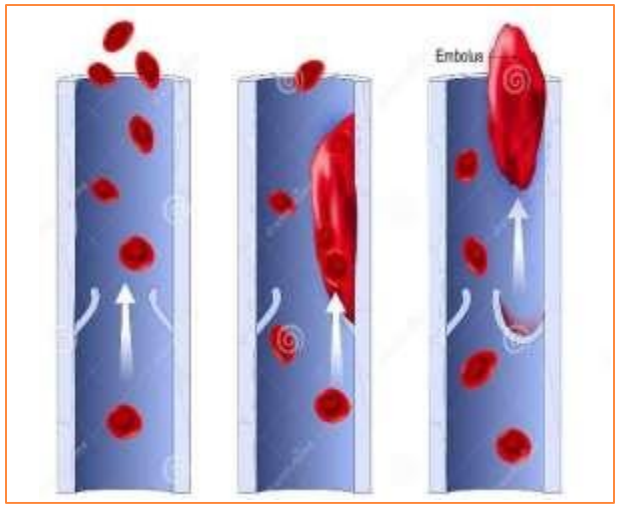
- **Types (according to composition of emboli):**

1. **Thromboembolism: 99% (from dislodged thrombus)**
2. **Fat embolism**
3. **Air /Nitrogen embolism**
4. **Amniotic fluid embolism**

1%

"An embolism is a dislodged fragment of a thrombus that moves through the bloodstream, accounting for 99% of cases. However, in 1% of cases, embolism refers to vascular obstruction caused by other substances entering the circulation.
These substances can be solid, liquid, or gas. They enter the bloodstream from a specific site (point of origin), travel in the direction of blood flow, and can reach various locations, causing mechanical obstruction of blood vessels.

Emboli Types (according to composition)



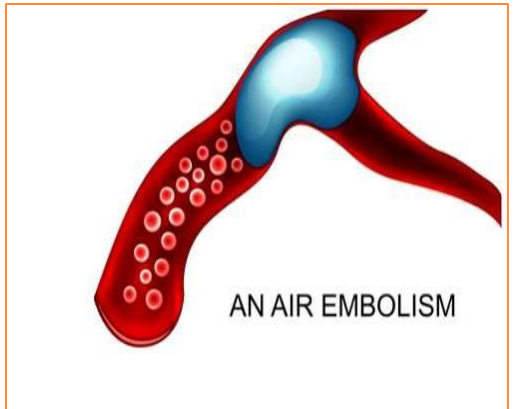
99%

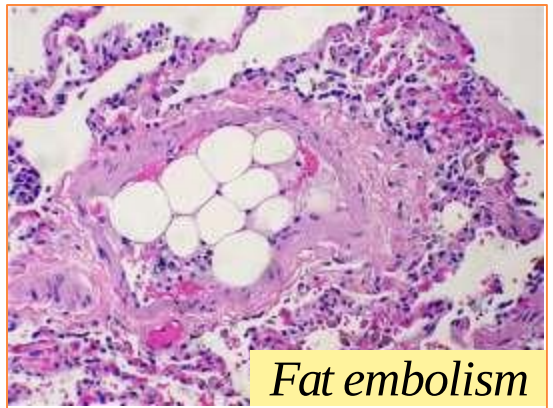
1.Thromboembolism: 99% (from dislodged thrombus)
2. Fat embolism
3. Air /Nitrogen embolism
4. Amniotic fluid embolism

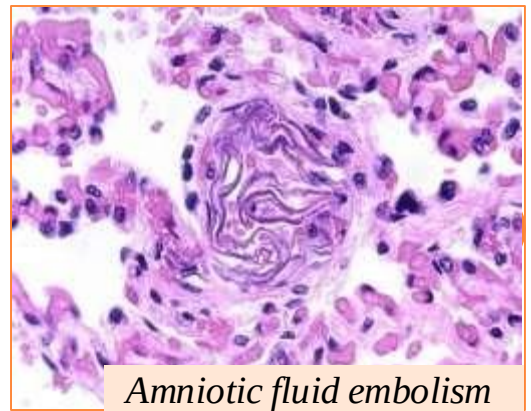
In air embolism, air bubbles are present in vessels and can cause obstruction.
While in fat embolism, fat globules block the vessels.
Amniotic fluid has its own structures that also can cause obstruction

The picture above represents 99% of cases, in which there is a thrombus (mainly a venous thrombus) and part of it (called an embolus) dislodges and moves inside the circulation.

1%



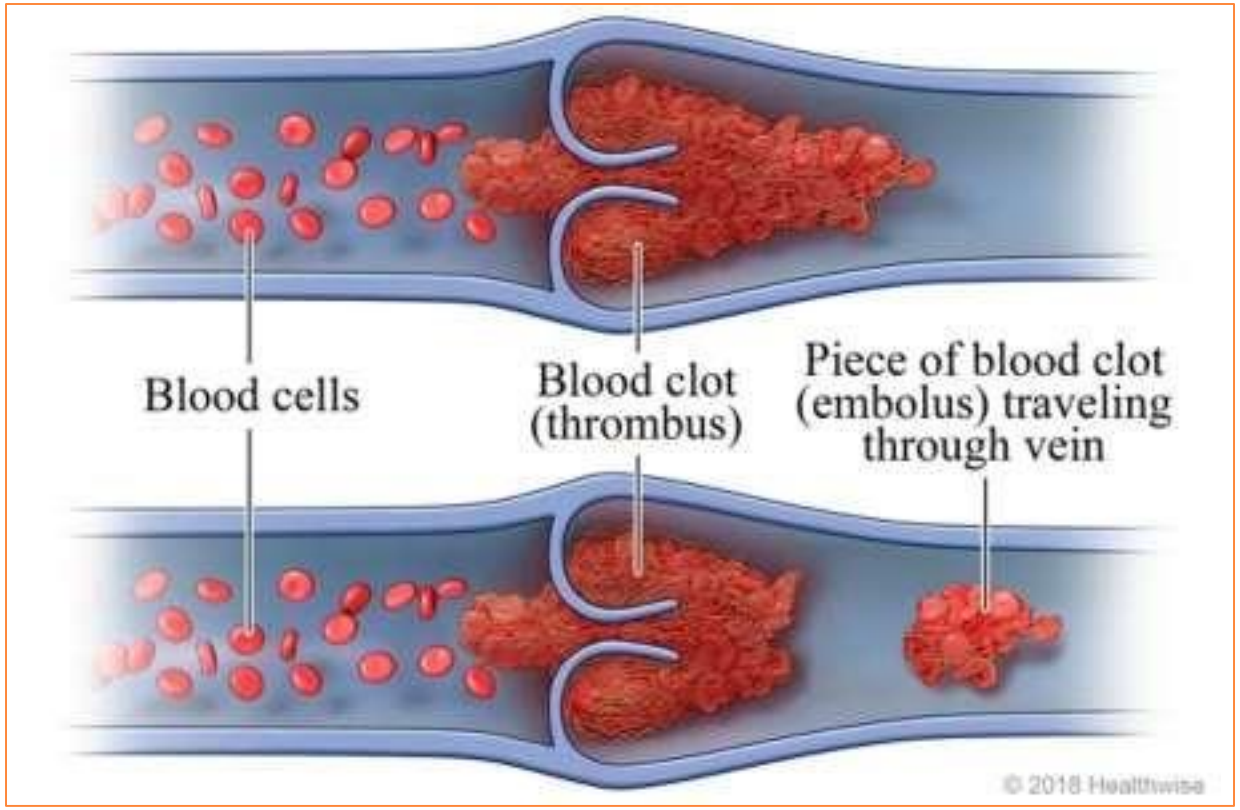

Fat embolism

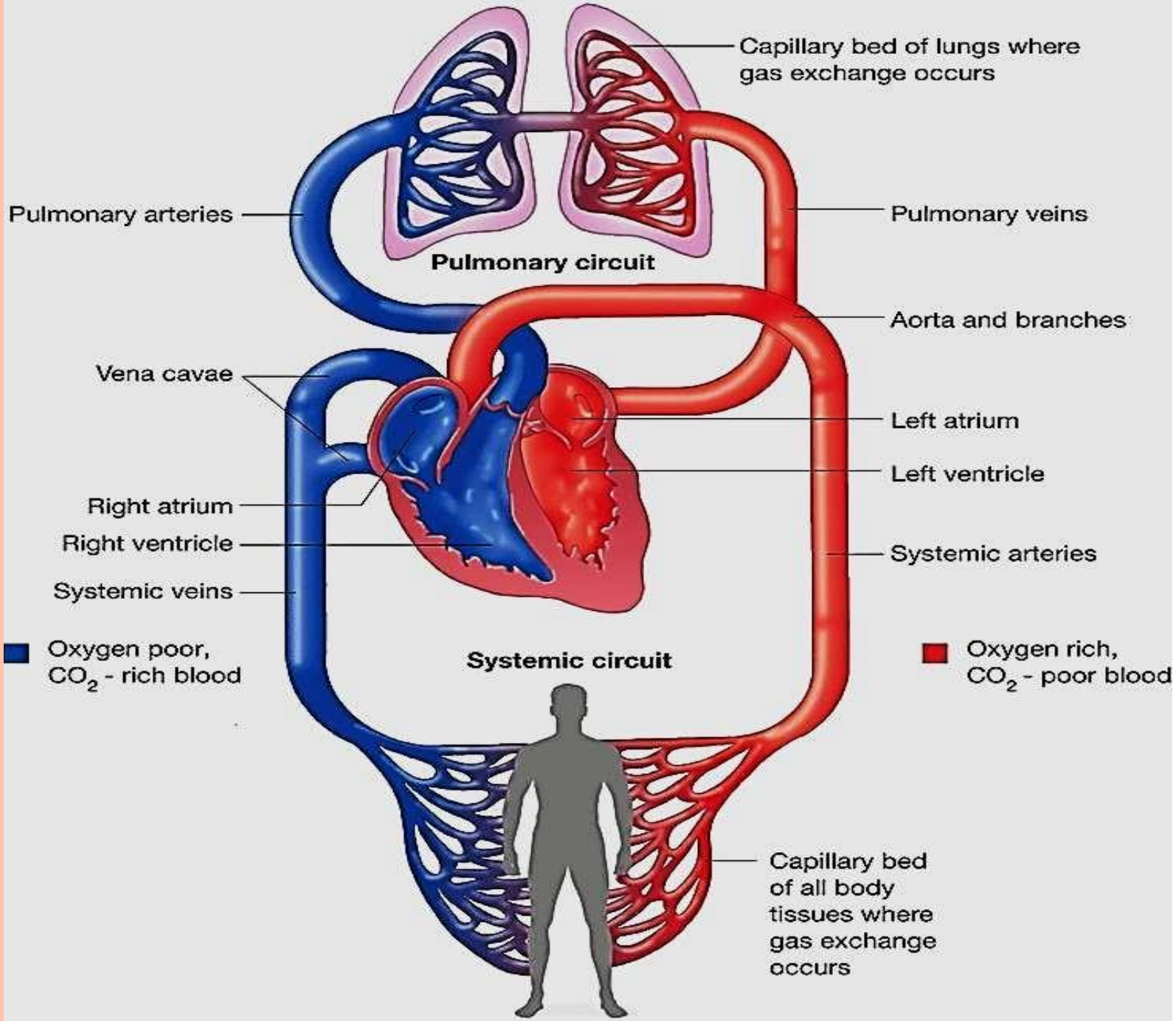

Amniotic fluid embolism

THROMBUS VS EMBOLUS ….?

THROMBOEMBOLISM

Both are blood clots
BUT embolus is movable while thrombus is not.

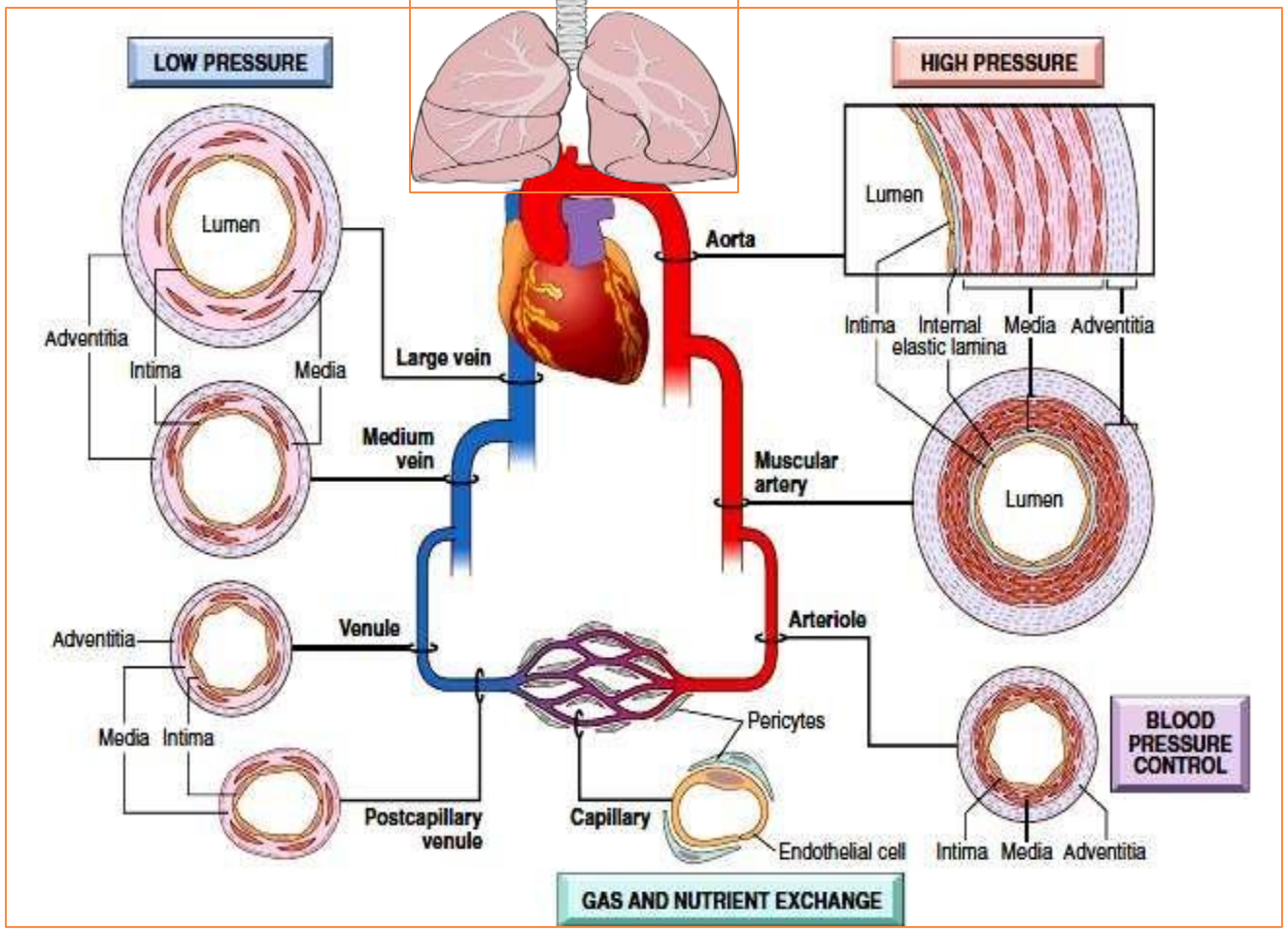




- The veins, right atrium, and right ventricle are all blue in diagrams, indicating they carry deoxygenated (venous) blood.

- Once blood reaches the right ventricle, it is pumped to the lungs via the pulmonary trunk, which bifurcates into smaller branches. These narrow branches can trap an embolus, causing a blockage.

2 TYPES /SIDES OF CIRCULATION: VENOUS & ARTERIAL (SYSTEMIC)



Emboli Types (according to site of origin):

1 **venous**

2 **arterial** *(systemic) emboli*

Classification of Emboli Based on their **Origin**:

1. Venous Emboli: Originate from veins, such as in deep vein thrombosis (DVT).
2. Arterial Emboli: Originate from arteries and can target any organ.

- Remember the Function of the Veins to return poorly oxygenated blood to the heart.
- while Arterial function: to carry oxygenated blood and nutrients to the body.

Every embolus has an origin and a target.
In case of thromboembolism (rather than air or fat embolism), the origin is the site of the original thrombus from which this embolus was detached .

Origin of most venous emboli = lower limbs

Target (where it causes the vascular block) **of most venous emboli = lungs**

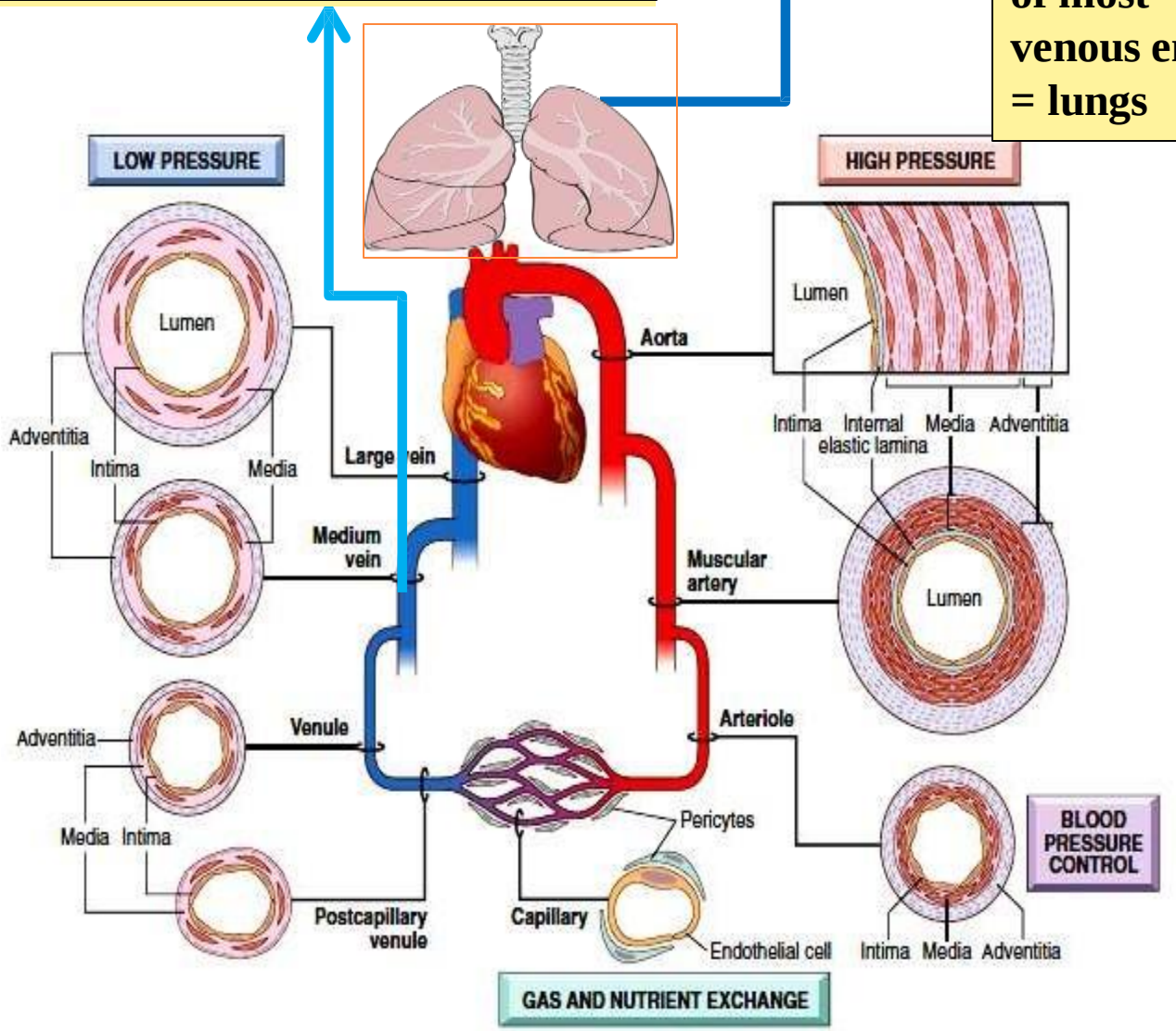


Figure 9–1 Regional vascular specializations. Although all vessels share the same general constituents, the thickness and composition of the various layers differ as a function of hemodynamic forces and tissue requirements.

Emboli move with the blood & flow with its direction

Blood coming from the lower limb will go through a series of veins to finally reach the IVC and then enter the heart from the right atrium, the blood then goes to the rt ventricle and gets ejected through the pulmonary artery to reach the lungs

So an embolus from the lower limb (venous embolus) will eventually reach the lungs causing a possible obstruction (as a result of the gradual narrowing in the lumen as the vessels branch in the lungs)

Deep Vein Thrombosis (DVT):

- DVT is a critical concept as it is a common cause of pulmonary embolism.
- For example, if a thrombus forms in the left popliteal vein (a vein in the lower limb), the embolus fragments travel through:
- Left popliteal vein → Femoral vein → External iliac vein → Common iliac vein → Inferior vena cava → Right atrium → right ventricle → pulmonary artery →lungs

Origin of most arterial emboli = heart chambers (left side of the heart).

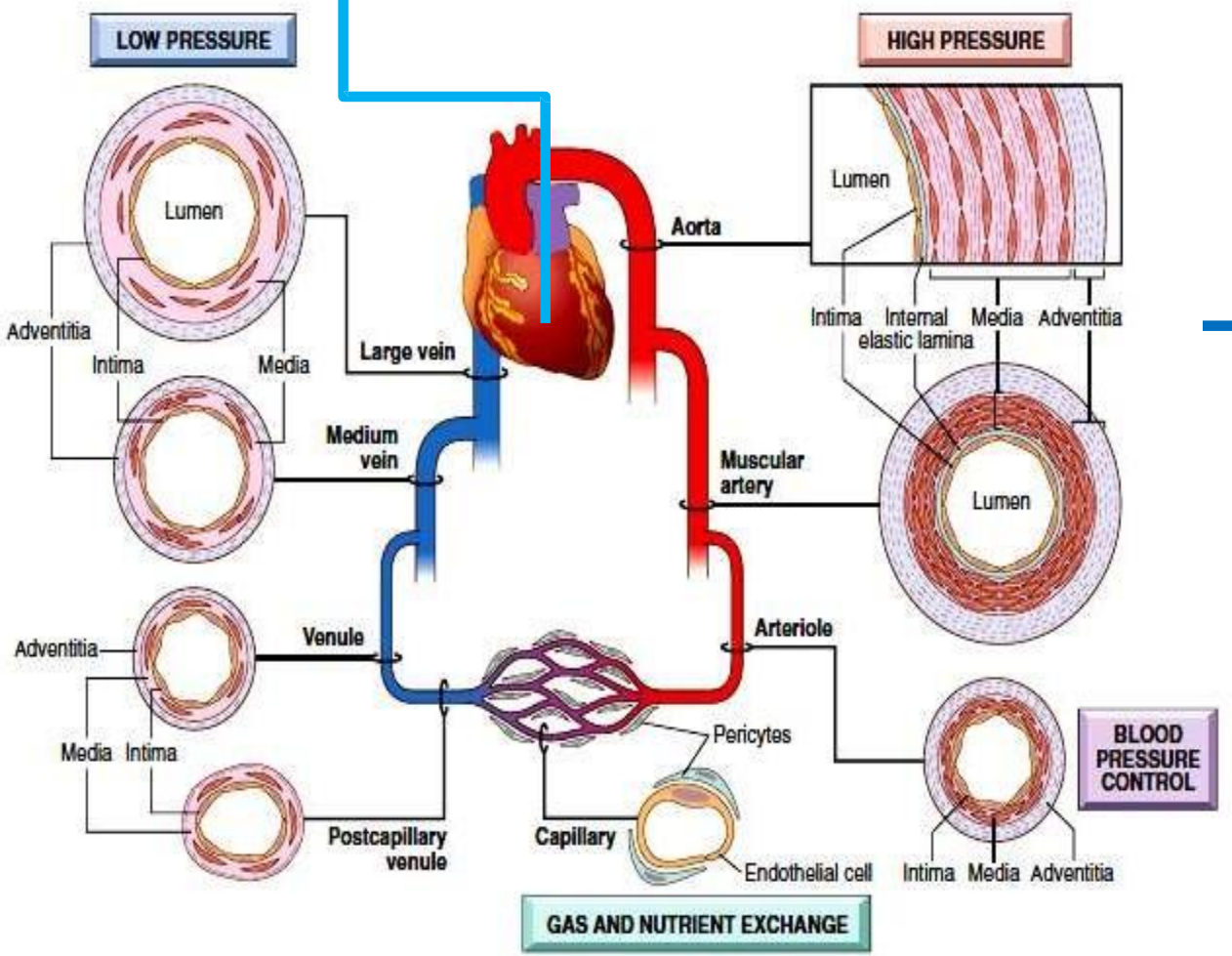


Figure 9–1 Regional vascular specializations. Although all vessels share the same general constituents, the thickness and composition of the various layers differ as a function of hemodynamic forces and tissue requirements.

Target of most arterial emboli = lower limbs (75%)

All organs can be targeted by arterial emboli, **including the lungs!**, but the lower limbs are most commonly affected.

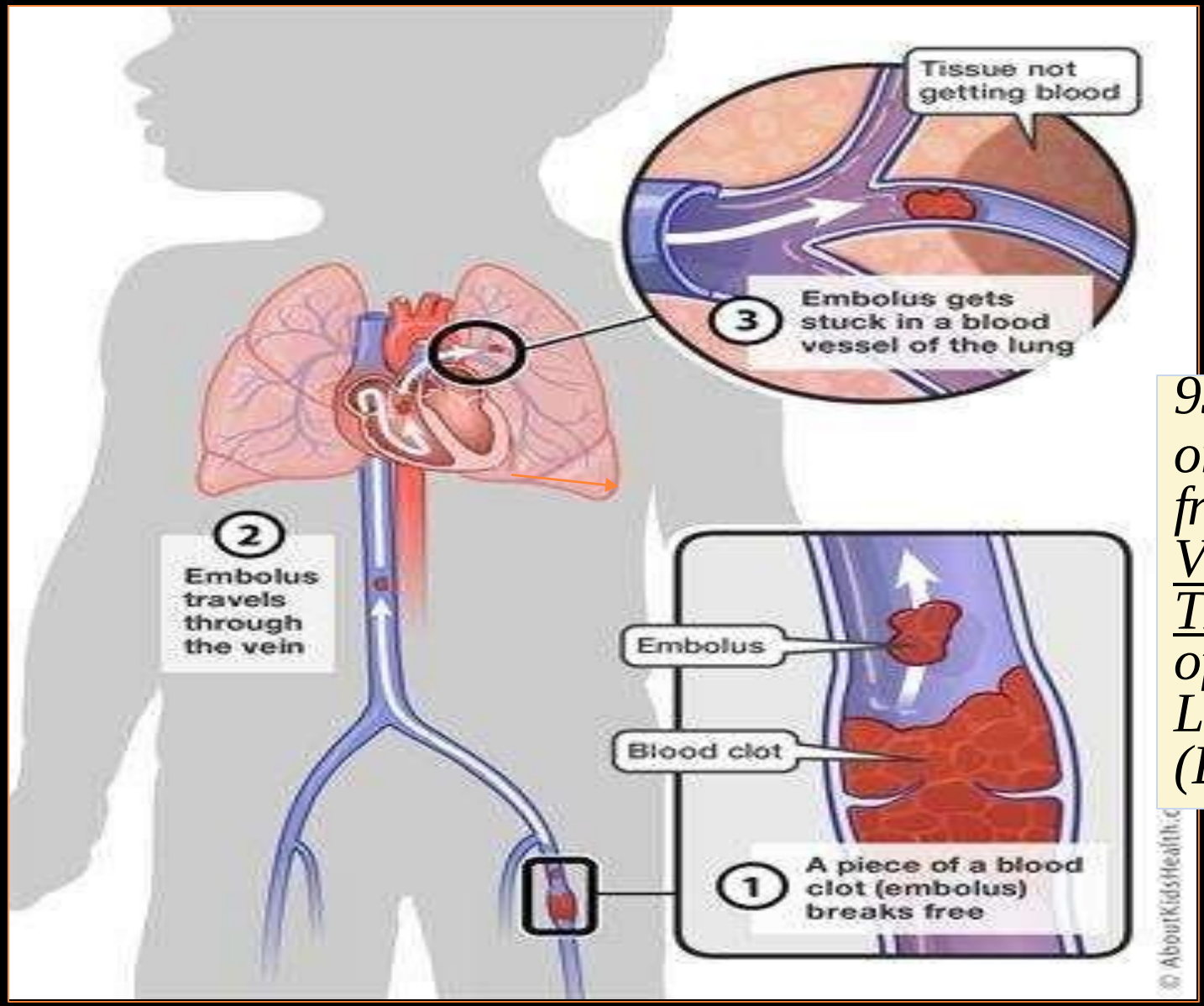
- Example: Atrial fibrillation causes left atrial dilatation and blood stasis, leading to thrombus formation in the left atrium. The embolus then travels through:
- Left atrium → Left ventricle → Aorta → Arterial system, targeting any organ such as the brain and causing conditions like **stroke**.

- *Emboli result in partial or complete vascular occlusion.*

- *consequences of embolism: ischemic necrosis (***infarction***) of downstream tissue*

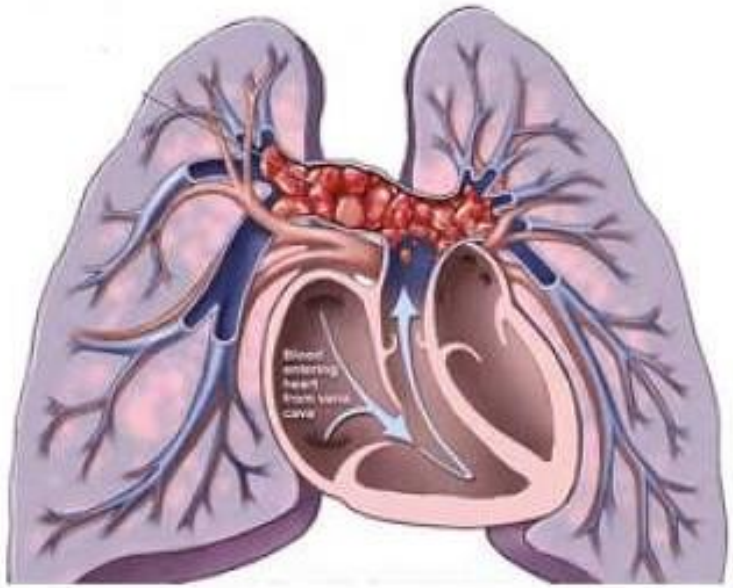
Look at the picture carefully

VENOUS THROMBI



95% originate from <u>DEEP VEINS THROMBI</u> of Lower Limbs (DVT)

Pulmonary Thromboembolism- Special terms



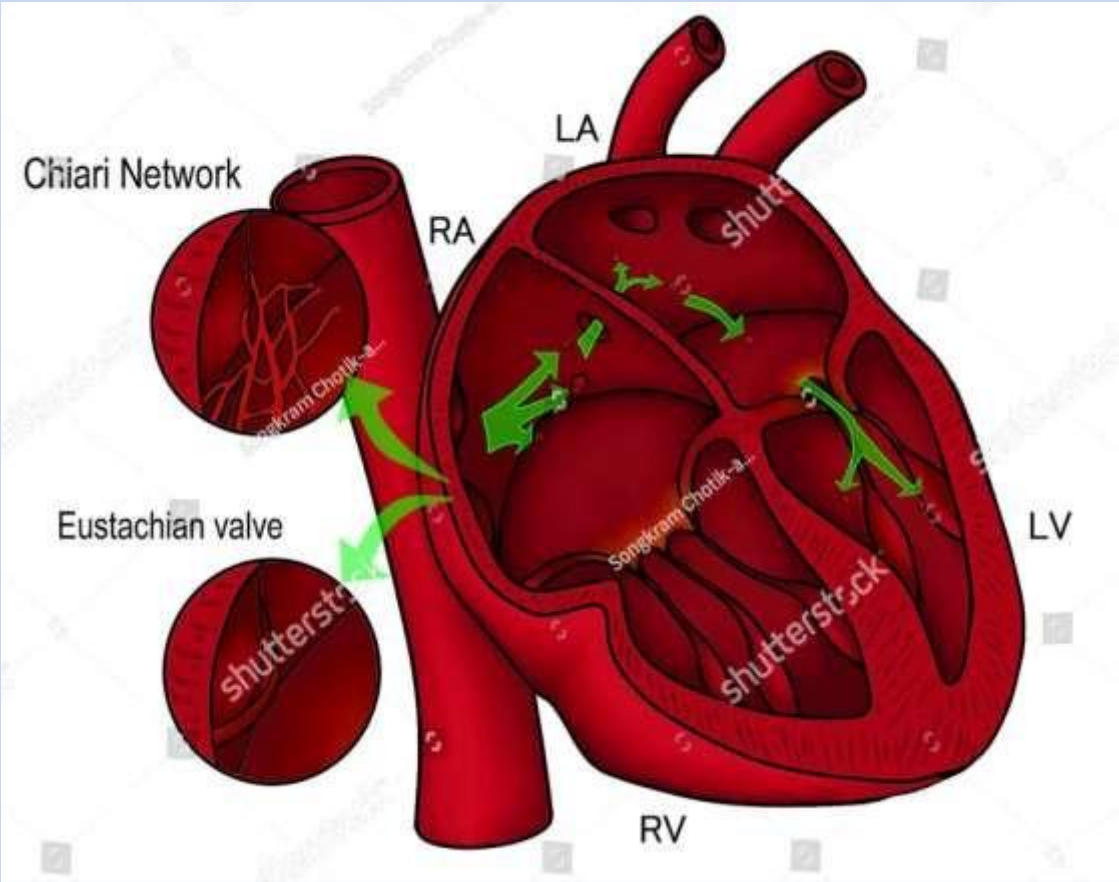
SADDLE EMBOLUS

(describing the shape of the embolus)

LARGE EMBOLUS OCCLUDING THE BIFURCATION OF PULMONARY ARTERY TRUNK (FATAL)

Embolus derived from a lower extremity deep venous thrombosis (DVT)and now impacted in a pulmonary artery branch

Paradoxical embolus: *Passage of embolus from venous to systemic circulation through PFO, ASD or VSD*



• A **paradoxical embolus** (showing paradox/ فيها تناقض) is a venous embolus that bypasses the pulmonary circuit and enters the arterial system, acting like an arterial embolus (and can now target any organ in the body).

- ASD: atrial septal defect.
- VSD: ventricular septal defect.
- PFO: patent foramen ovale.

CLINICAL CONSEQUENCE OF PULMONARY THROMBOEMBOLISM :

- **Asymptomatic** *(60%- 80%; small)*
- *Pulmonary infarction (large)*
- *Pulmonary hemorrhage* (if the embolus caused rupture in the vessel)
- *Pulmonary Hypertension and right ventricular failure: (showers of emboli over a long time)*
- *Sudden death (RVF, CV collapse): > 60 % of pulmonary vessels are obstructed*

- RVF:Right ventricular failure.
- CV:cardio vascular collapse.

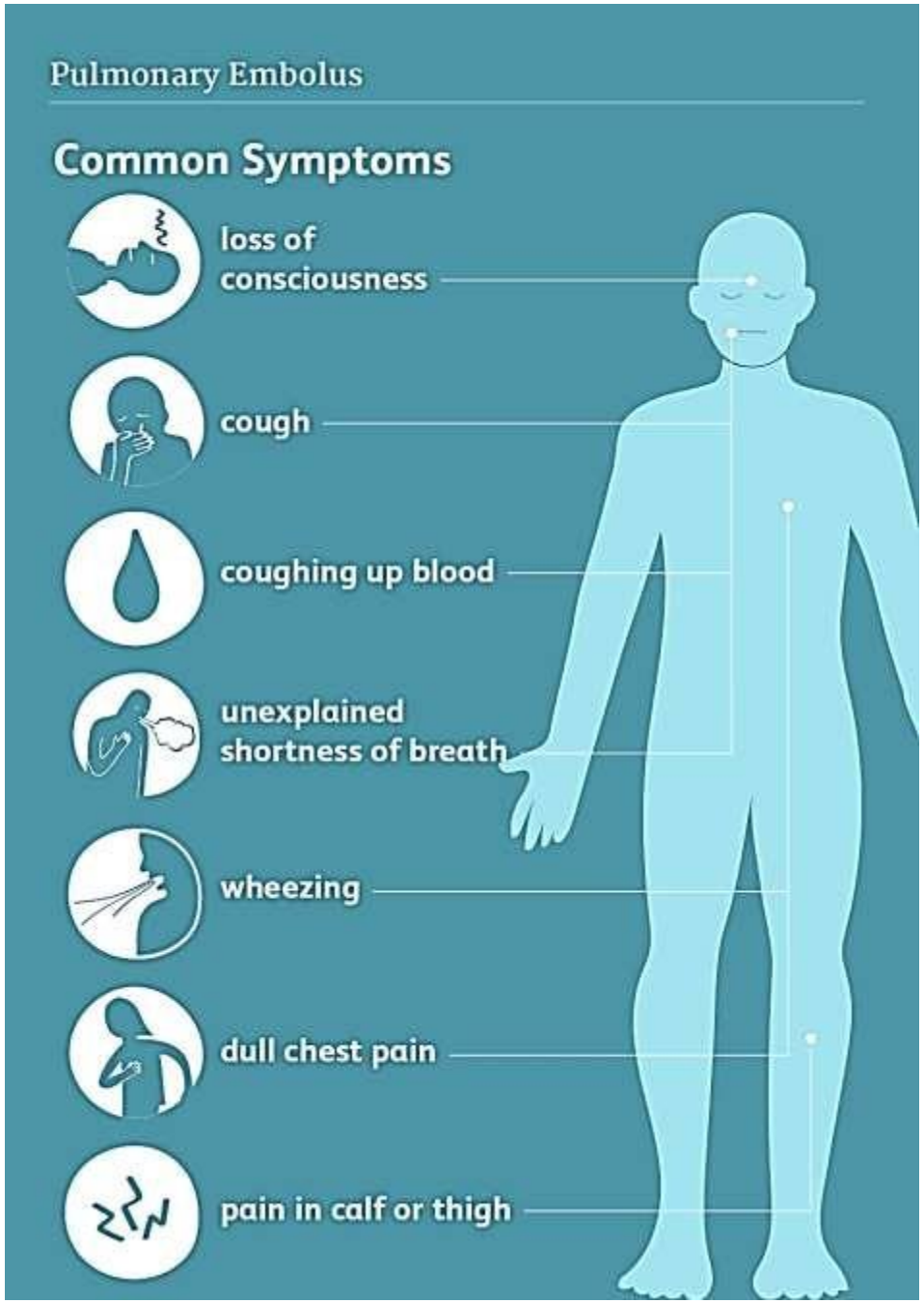
The clinical spectrum of embolism ranges widely, depending on factors such as:

- The size of the embolus which indicates the location of the occlusion, the number of emboli and the underlying vascular conditions.

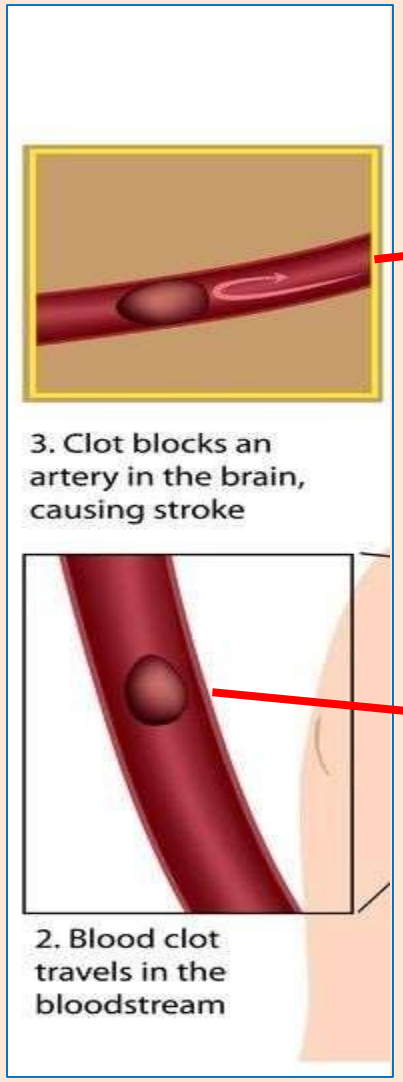
- If a large embolus is occluding the pulmonary bifurcation it can result in sudden death.
- but if a small embolus blocking a peripheral pulmonary artery it may be asymptomatic.
- Intermediate conditions such as pulmonary infarction, occur with bigger occlusions than the asymptomatic conditions and so on.

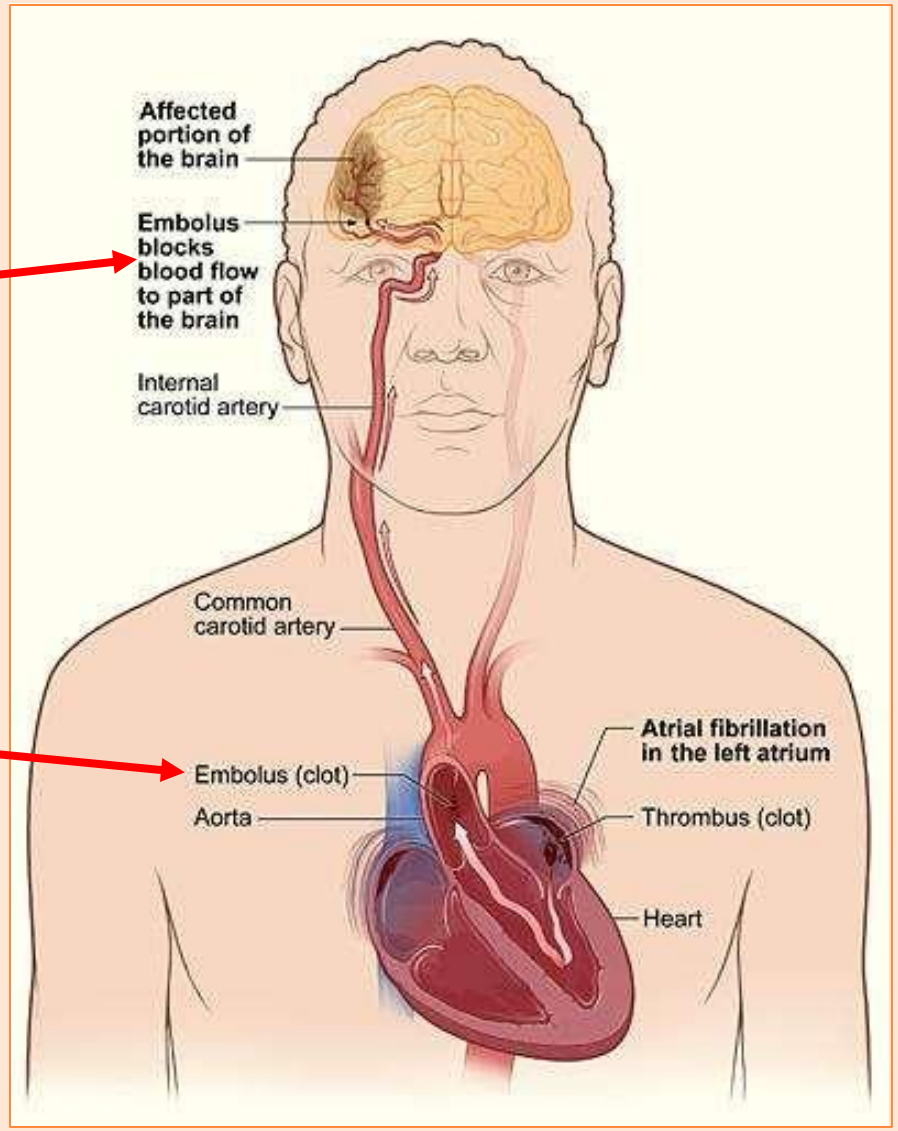
Patients with **hypercoagulability** (e.g., Factor V mutation) are at higher risk for recurrent thrombosis and embolism. These patients may experience “showers of emboli,” where multiple emboli form simultaneously.

Pain in calf or thigh because of the origin of the embolus which can be DVT



ARTERIAL EMBOLI





A patient with atrial fibrillation forms a thrombus in the left atrium. The embolus then travels to the (in this picture):

- Common carotid artery → Internal carotid artery → Brain → Causing a **stroke**.

Systemic (arterial) thromboembolism

- *Emboli traveling within the arterial circulation*
- *80% due* **to intracardiac mural thrombi (origin)**

causes: -2/3 Lt. ventricular failure

- ¼ Lt. atrial dilatation

- Ulcerated atherosclerotic plaque

- Aortic aneurysm

- valve vegetation ….etc

- *The major* **targets** *are:*

Lower limbs ; Brain ; Intestine; Kidneys; Spleen; etc…

(any organ that has arterial supply!)

Fat embolism

Different than atherosclerosis!

- *Causes:*

1. *Skeletal injury: (long bones fractures)* remember the medullary cavity (BM) of these bones contains fats
2. *Adipose tissue Injury :(e.g. fat necrosis in acute pancreatitis)*

Results:

1 *Mechanical obstruction of vessels*

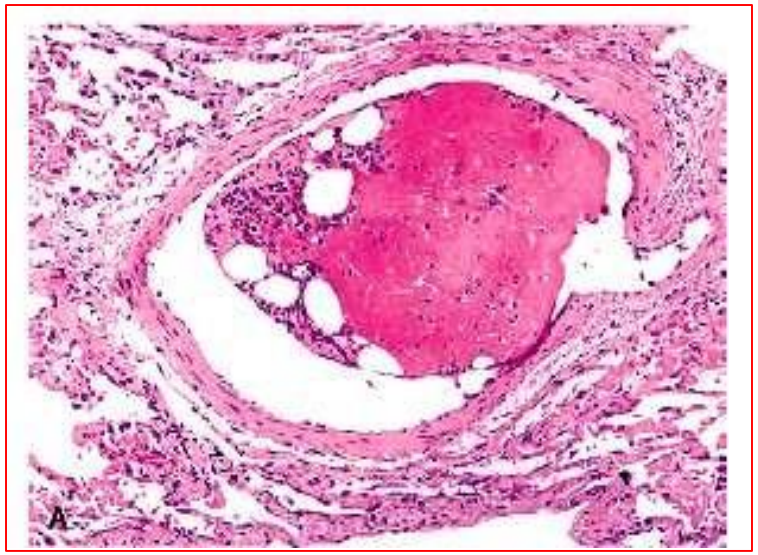
2 *Free fatty acid release: toxic injury to endothelium + systemic immune response* so the body will react with these fats as foreign bodies.

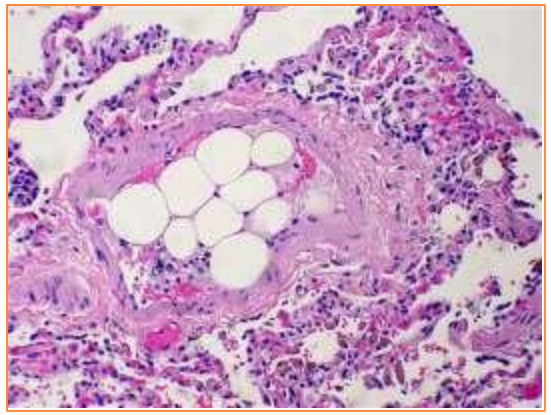
- *In skeletal injury, fat embolism occurs in 90% of cases, but only 10% or less have clinical findings*
  = **Fat embolism syndrome**

Fat globules enter the bloodstream, usually following trauma or fractures of large bones.

- Rarely, fat necrosis can occur after liposuction.

FAT EMBOLUS = *FAT GLOBULES + HEMATOPOIETIC CELLS*





- **Fat embolism 'syndrome'** *is characterized by:*
- *Pulmonary Insufficiency (rapid breathing; shortness of breath)*
- *Neurologic symptoms (mental confusion; lethargy; coma)*
- *petechial rash (pinpoint rash, found on chest, head, and neck area due to bleeding under skin)*
- *Fever*
- *Anemia*
- *Thrombocytopenia*
- *Death in 10% of cases*

Note: Symptoms appear 1-3 days after injury

THERAPY FOR FAT EMBOLISM SYNDROME

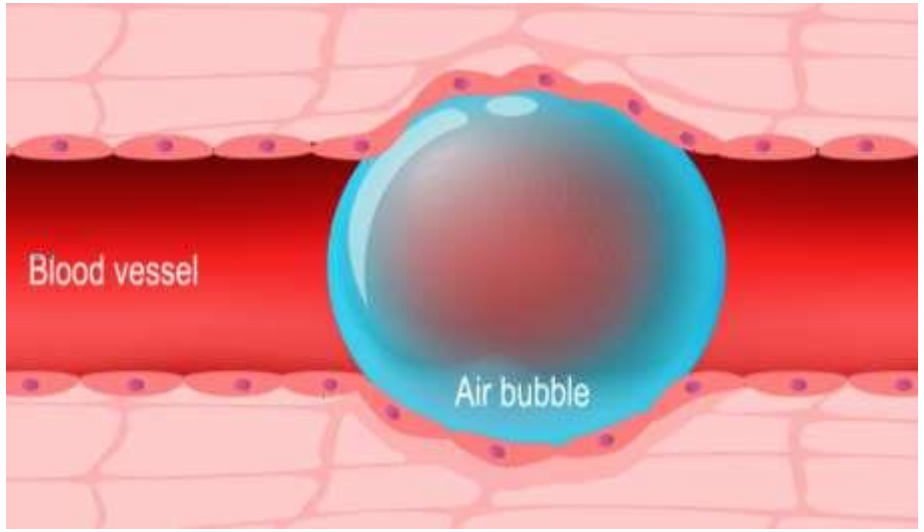
- *no specific treatment*
- *prevention, early diagnosis, and adequate symptomatic treatment are of paramount importance.*
- Supportive care *is the mainstay of therapy*
- *Includes: maintenance of adequate oxygenation and ventilation, stable haemodynamics, blood products as clinically indicated, hydration, prophylaxis of deep venous thrombosis and stress-related gastrointestinal bleeding, and nutrition.*

Air Embolism It's very rare

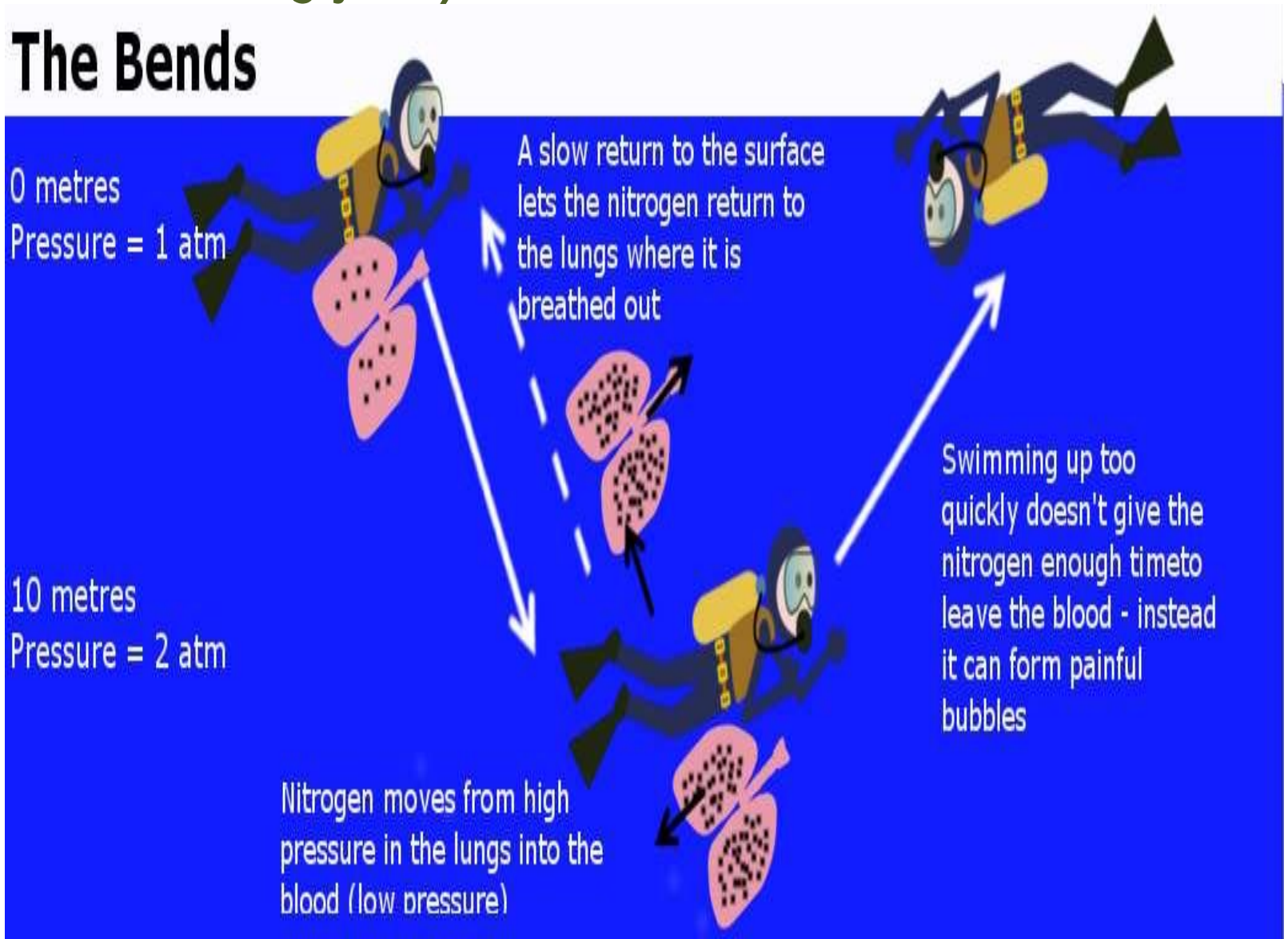
If the air enters the circulation when we put a syringe on a patient, it will cause air embolism, this depends on the **volume** of air and the **location** of the injection (the volume of air should be high and the injection should be in a large or critical vessel in order to develop air embolism)

- *Causes:*

1. *Surgical & obstetric procedures*
2. *Traumatic chest wall injury*
3. *Decompression sickness: in Scuba deep-sea divers ((nitrogen)).*

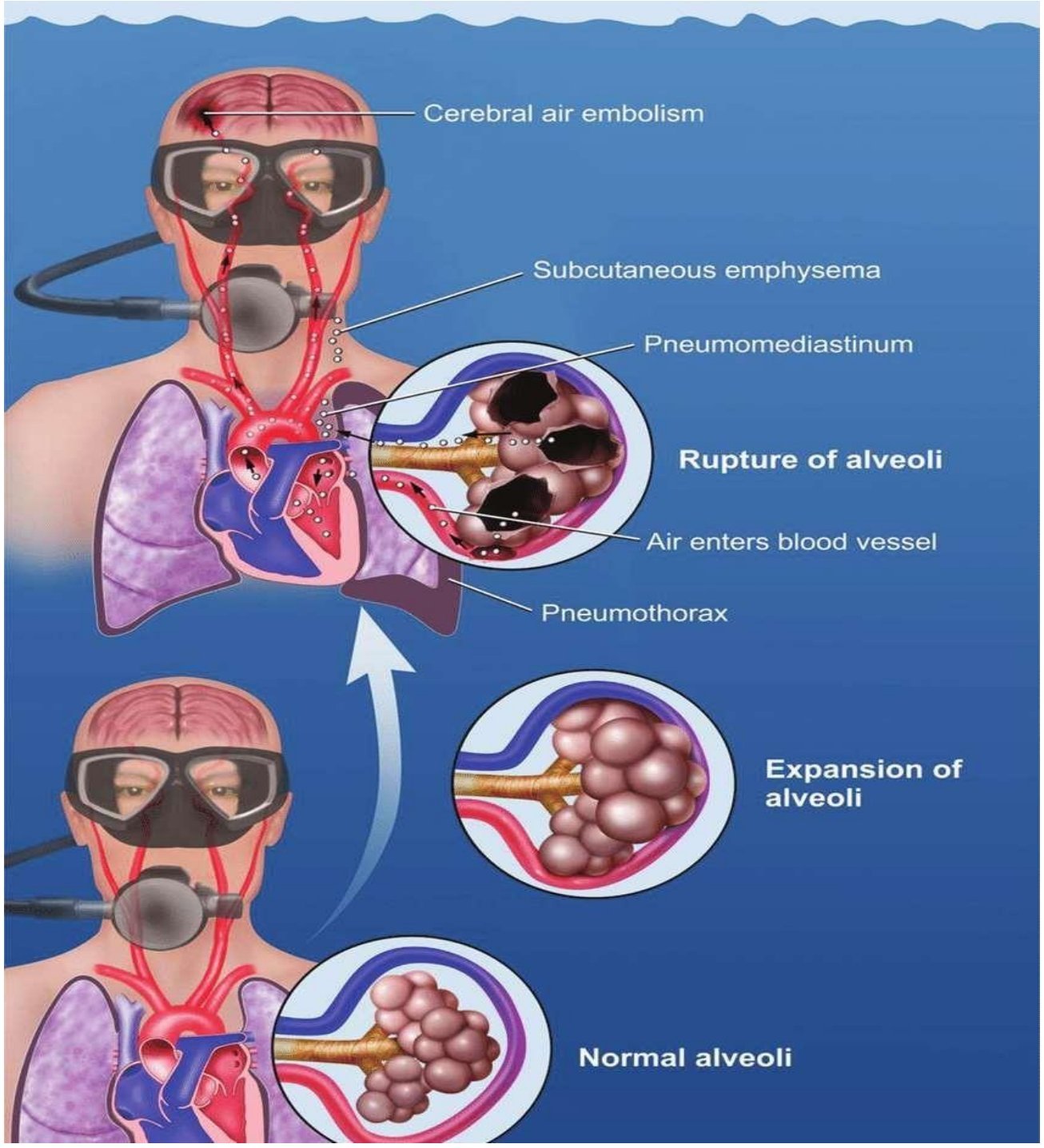


Decompression sickness (the bends because most symptoms are related to painfull and swallowing joint)



- The “bends” occurs mostly in scuba diving.
- At the sea surface, the pressure is 1 atm, which is equivalent to the pressure on the skin and lungs.
- Remember air is composed of nitrogen,oxygen and CO2…
- 70% of air is Nitrogen
- As divers descend, the pressure increases, causing nitrogen to travel from the lungs to the blood, where it gets dissolved (liquefies)

- The divers should be trained to protect themselves from decompression by avoiding rapid and quick swimming up which doesn’t give the nitrogen enough time to leave the blood leading to bubbles formation (as pressure decreases while ascending, nitrogen will return back to its normal physical state –a gas)
- The divers gradual ascending would decrease the pressure gradually, so small amount of nitrogen will return to its original state (gas) and no bubbles are formed.



Also if the divers ascend very quickly the air in their alveoli expand rapidly.

This Sudden expansion can cause the pulmonary alveoli to rupture, allowing the air to enter the circulation leading to air embolism.

AIR EMBOLISM- CLINICAL CONSEQUENCE

1. **Painful joints**: *rapid formation of gas bubbles within Skeletal Muscles and supporting tissues* (tendons and joints).

2. **Focal ischemia in brain** *and* **heart**

3. **Respiratory distress** *(chokes)*→ *Lung edema, hemorrhage, atelectasis, emphysema*

4. **Caisson disease**: *in scuba divers; gas emboli in the* **bones** *leads to multiple foci of ischemic necrosis, usually the heads of the femurs, tibias, and humeri*

Amniotic fluid embolism

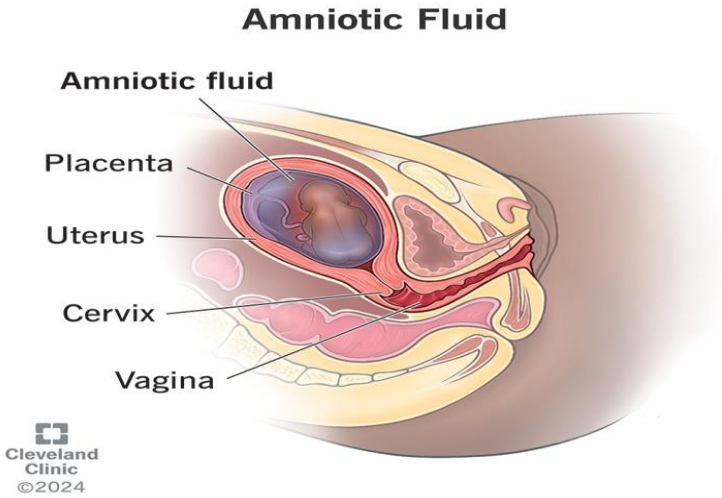
- *High* **Mortality** *Rate = 20%-40%*
- *Very* **rare** *complication of labor*
- *infusion of amniotic fluid into* **maternal** *circulation via tears in placental membranes and rupture of uterine veins,* this can happen due to complicated labour or complicated cesarean section.
- **Symptoms**: **sudden severe dyspnea, cyanosis, ARDS, and hypotensive shock, followed by seizures, DIC and coma**

- **Microscopic** *Findings upon autopsy:*

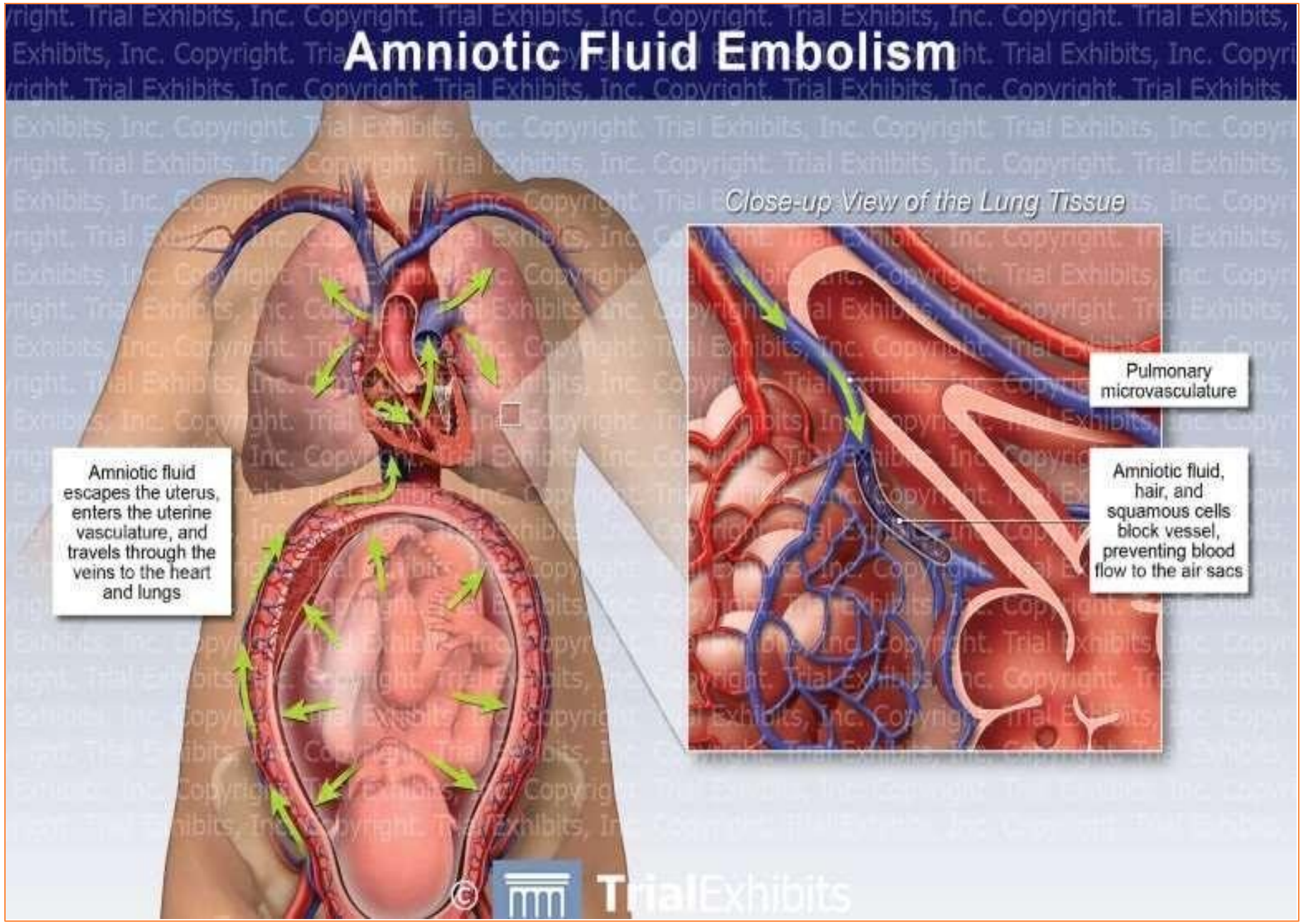
  fetal squamous cells, lanugo hair, fat, mucin

  .....et

  c within the maternal pulmonary microcirculation

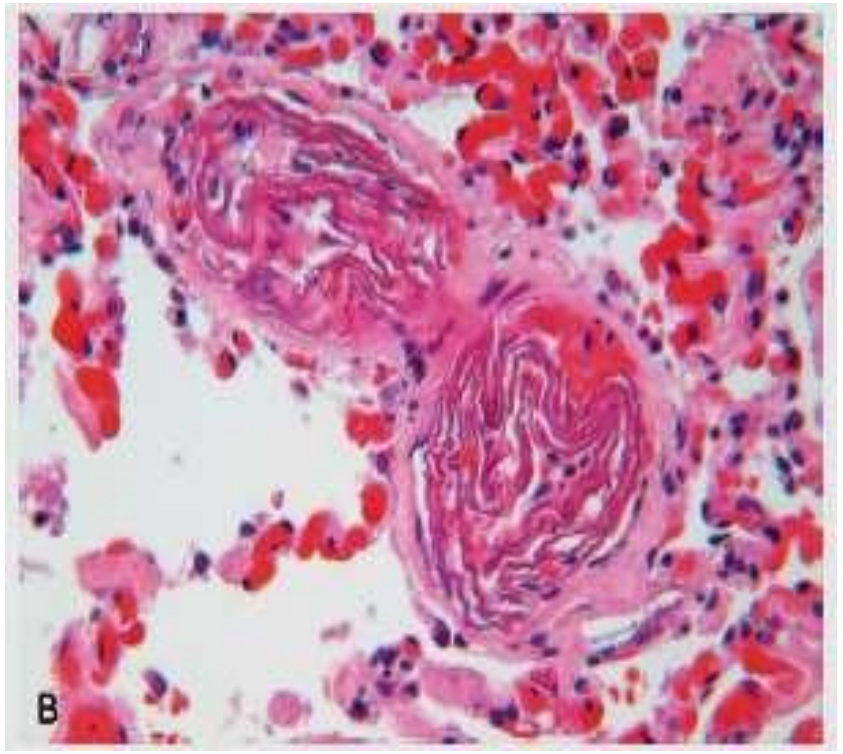


- Amniotic fluid is formed inside the amniotic sac and surrounds the fetus
- This case is associated with pregnant women (due to injury in both the amniotic sac and the maternal vasculature)
- It's extremely rare but is still important due to its high mortality rate


Amniotic Fluid Embolism
Close-up View of the Lung Tissue
Amniotic fluid escapes the uterus, enters the uterine vasculature, and travels through the veins to the heart and lungs
Pulmonary microvasculature
Amniotic fluid, hair, and squamous cells block vessel, preventing blood flow to the air sacs
TrialExhibits

AMNIOTIC FLUID EMBOLUS. KERATIN AND FETAL SQUAMOUS CELLS IN PULMONARY ARTERIOLES (the smallest arteries).

The whiteish lumen is not present because it's obstructed by keratin and fetal squamous epithelial cells.



INFARCTION

- *infarct = an area of* **ischemic necrosis** *caused by occlusion of arterial supply or venous drainage*

- *99% result from thrombotic/ embolic events*

- *other mechanisms: local* **vasospasm**, *expansion of atheroma*, **extrinsic compression** *of vessel (e.g., by tumor); vessel* **twisting** *(e.g. testicular torsion; bowel volvulus); and traumatic vessel* **rupture**

MORPHOLOGY OF INFARCTS

- *infarcts may be either* **red** *(***hemorrhagic** "there is blood in the site of infarcts"*) or* **white** *(***anemic**"no blood"*) and may be either septic or bland* (Red and white are used to describe the shape of the infarcts only).

- *wedge-shaped (occluded vessel at the apex and periphery of organ forming the base)*

- *margins of infarcts become defined with time*

- *histologic hallmark :* **ischemic coagulative necrosis (***ultimately replaced by scar)*

[note: The brain is an **exception** *(liquefactive necrosis,* rather than coagulative necrosis because of the high content of water in the brain*)].*

RED INFARCTS:

- **occur in any of the following scenarios:**

(1) **venous** *occlusions (e.g. ovarian torsion).*

(2) **Loose** *tissues (e.g. lung).*

(3) *Tissues with* **dual** *circulations (e.g. lung and small intestine).*

(4) *Previously congested tissues because of* **sluggish venous** *outflow.*

(5) *when flow is* **re-established** *to a site of previous arterial occlusion and necrosis.*

WHITE INFARCTS

- *occur with:* **arterial** *occlusions in* **solid** *organs (such as heart, spleen, and kidney).*

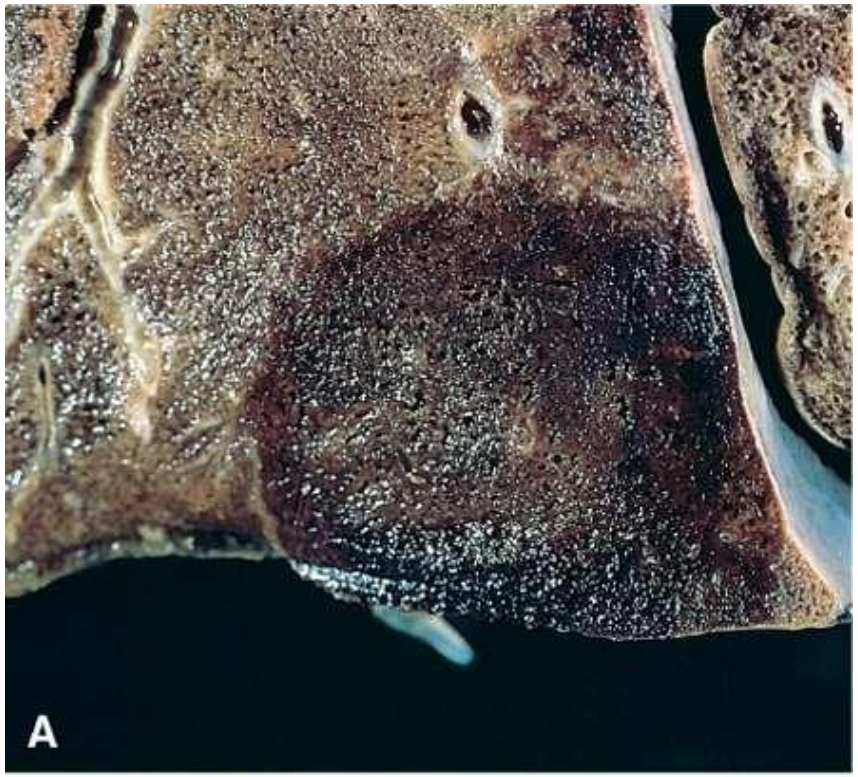
Septic(infection) **infarctions:** there are infection + necrosis in the site of injury

- *occur when infarct is superimposed by infection;*
- *examples:*

1 infected vegetations

2 microbes seed an area of necrotic tissue

- *infarct is converted into* **abscess** *with a greater inflammatory response*



Red and white infarcts respectively.

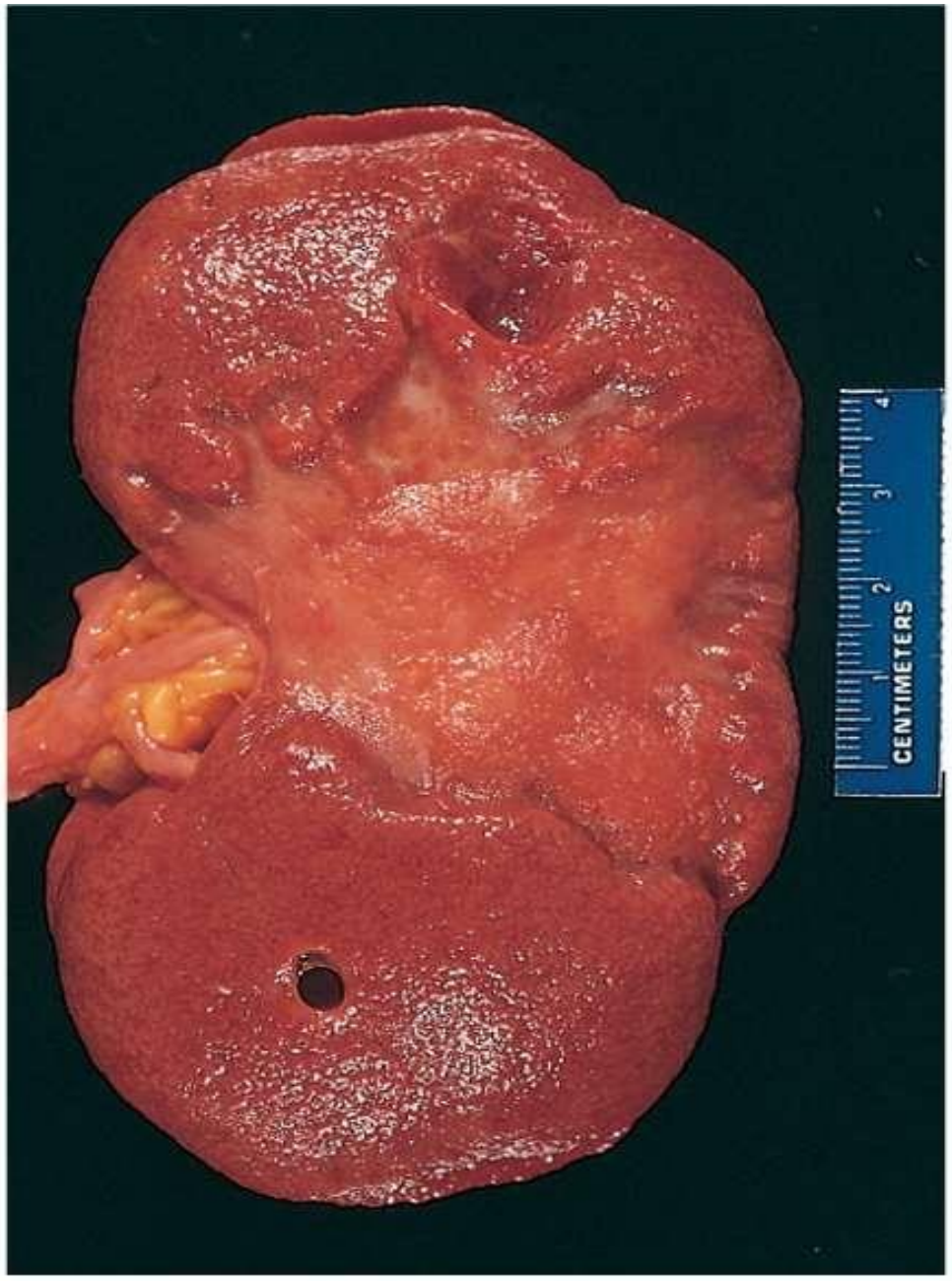
A→lung

B→spleen

Remember!
The terms “Red” and “white” don’t necessarily indicate the color of the infarct, they only describe if the infarct is involving hemorrhage or not

Some organs always have red infarcts and other organs depend on the type of occlusion whether it is arterial or venous occlusion

KIDNEY WHITE INFARCT



kidney infarct replaced by a large fibrotic scar

(White and wedge shaped infarct).

Factors That Influence Development of an Infarct

- **nature of vascular supply.**

- **rate of occlusion development (***collateral circulation).*

- **tissue vulnerability to hypoxia** and *irreversible damage*

- *Neurons →only 3 minutes*

- *Myocardial cells →20 to 30 minutes*

- **oxygen content of blood.**

Q: If we have an embolus in the pulmonary artery will the embolus be considered of venous or arterial origin and will its final target be the lungs ?

A: Embolism in the pulmonary arteries belongs to venous embolism and the main target is the lung itself .
It is a bit confusing but remember that pulmonary artery carries venous blood from the right side of the heart to the lungs, so it’s quite the opposite to what do arteries do.

- *Q: Can pulmonary embolism be of an arterial origin?*
- *A: Yes , the lung can be a target of both venous and arterial embolism types. It depends on the side of the circulation it originated from. So if the embolus is coming from venous circulation and is reaching the lung through the right side of the heart it is a venous embolus. On the other hand, if the embolus is coming out of the left side of the heart and reaching the lung through bronchial circulation, then it is an arterial embolus.*

Additional sources

قال صلى الله عليه وسلم لرجلٍ وهو يعظه: "اغتنمْ خمسًا قبل خمس: شبابك قبل هرمك.."

اعقد نيتك خالصةً لربك في سعيك، وأصلح من نفسك بقدر ما تحب أن ترى عليه غدًا أمتك!

VERSIONS	SLIDE #	BEFORE CORRECTION	AFTER CORRECTION
V1→ V2			
V2→V3			

امسح الرمز و شاركنا بأفكارك لتحسين أدائنا!!