# Long Way To Go

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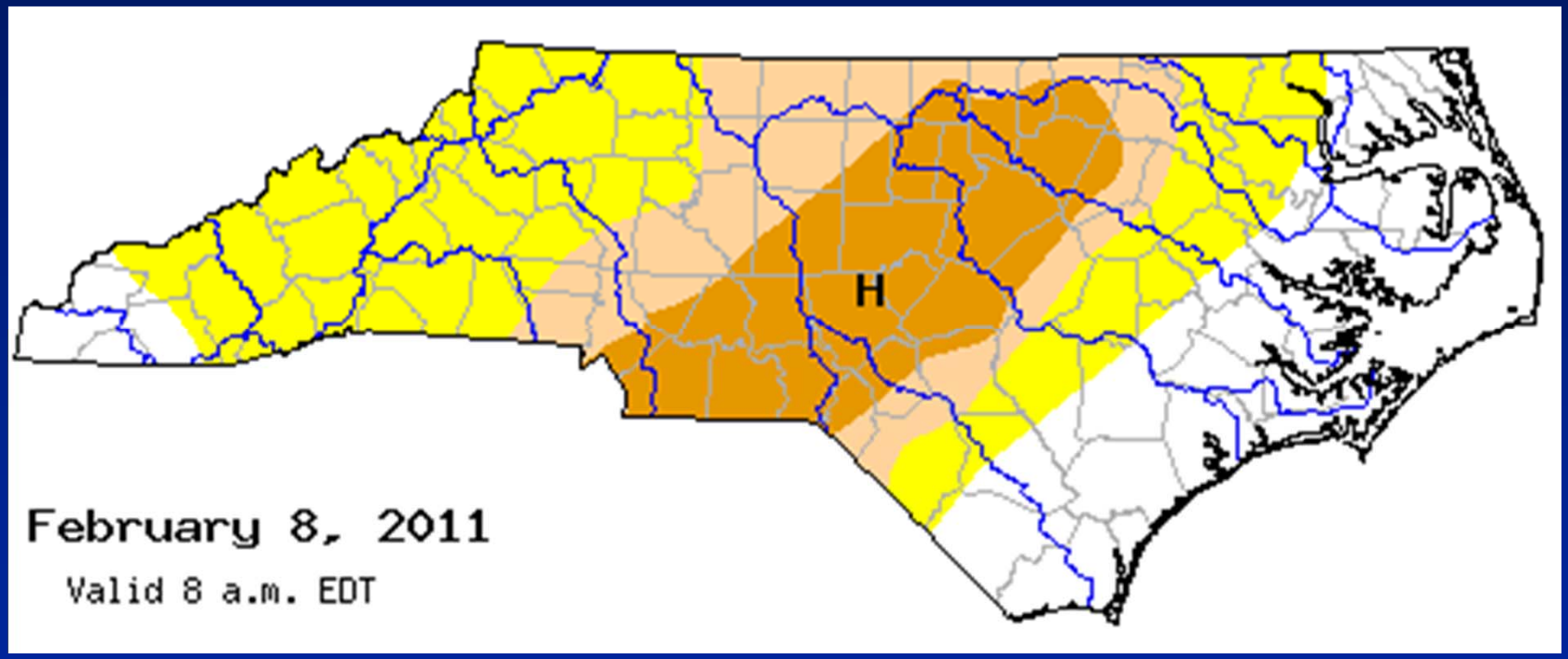
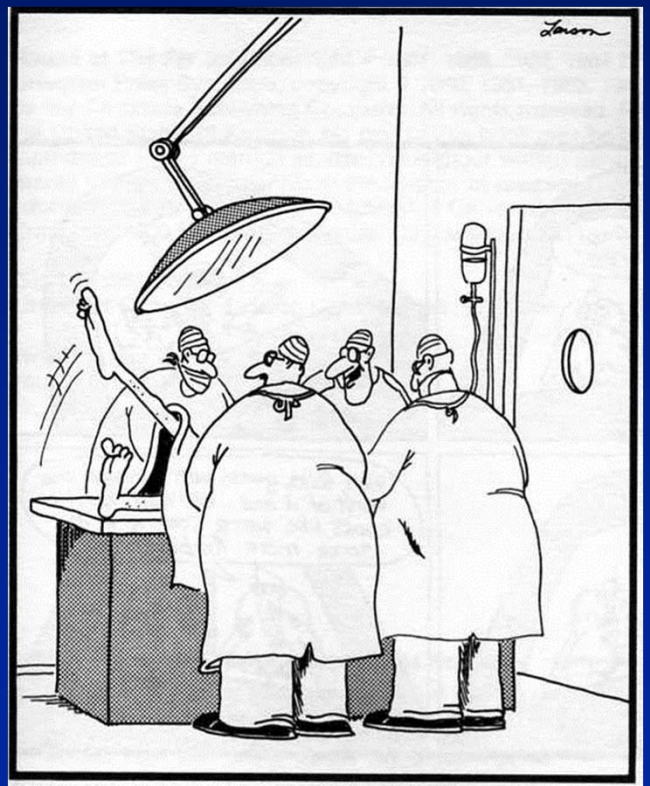


Suddenly, MURDERBUG.

# Long Way to Go

# Categories of Pathologic Processes:

- Vascular/Hemodynamic
- Inflammatory/Infectious/Immunologic
- Developmental/Genetic
- Neoplastic
- Environmental/Nutritional/Endocrine
  - Iatrogenic



"Whoa! *That* was a good one! Try it, Hobbs — just poke his brain right where my finger is."

# Objectives

- **Understand basic principles behind fluid shifts between intra- and extravascular space**
- **Understand the vascular and hemodynamic consequences of various disease processes**

# THE Objective

- **Be able to routinely apply these and all basic principles to disease processes throughout the course and in the future**



**Without prompting**

# HEMODYNAMICS

## EDEMA, HEART FAILURE, HEMORRHAGE, AND SHOCK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# Edema

- **Increased Tissue Water Content**
  - **Intracellular**
  - **Extracellular**
    - **Interstitial**
      - **within tissues**
    - **Body Cavities**
      - **Present and potential spaces**
      - **Pleural, Peritoneal, Pericardial**

swollen cells.

it will start filling in a space, or abscess, within the tissue.

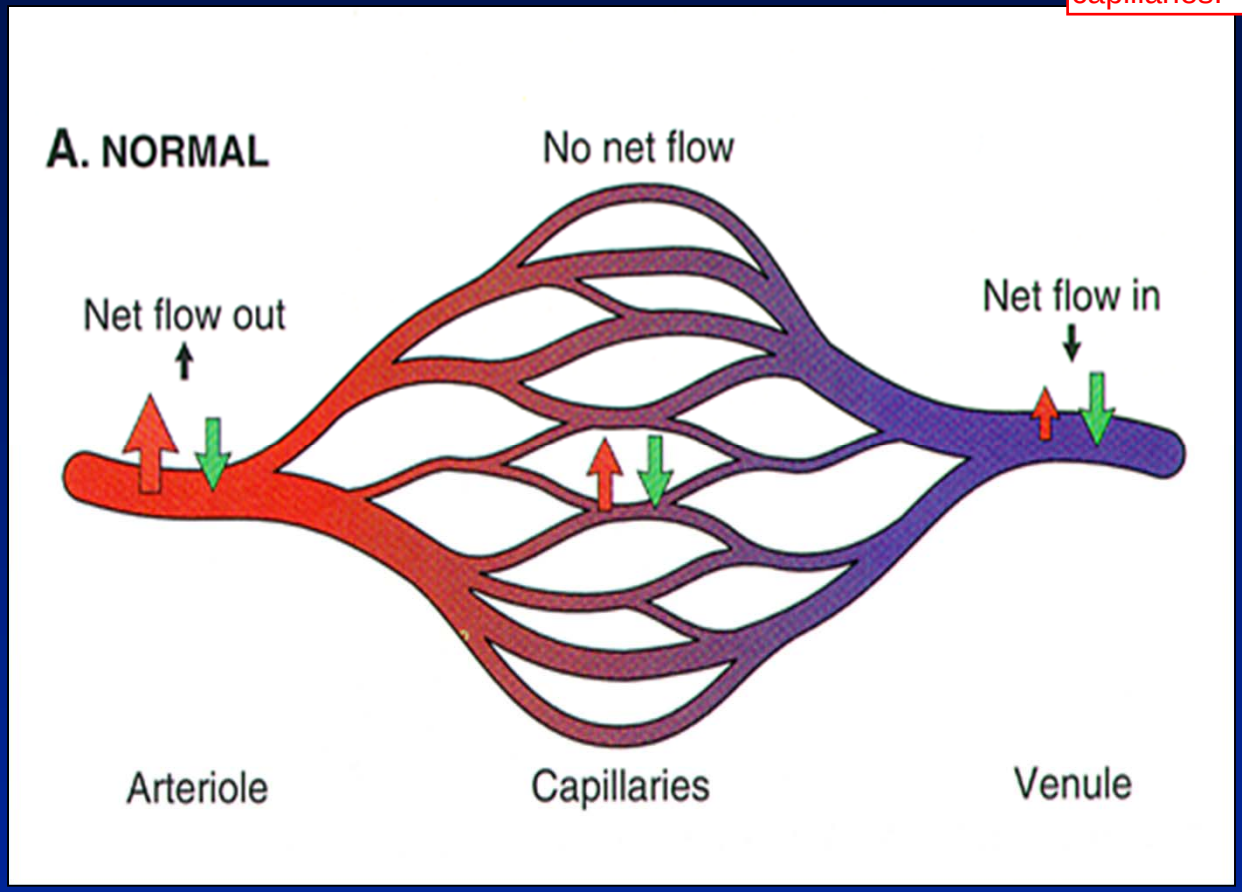
ASCITES! I remember that word, so I put it in CAPS.

# Edema


This is bad empathy. The Michelin Man is very sensitive about his weight.

# Tissue Fluid: Balance

salt balance and pressure balance causes this stuff. proteins in serum pull water in, hydrostatic pushes it out in distal arterioles/proximal capillaries.




Hydrostatic pressure

Colloid osmotic pressure

**Arteriolar Hydrostatic Pressure ~35 mm Hg**

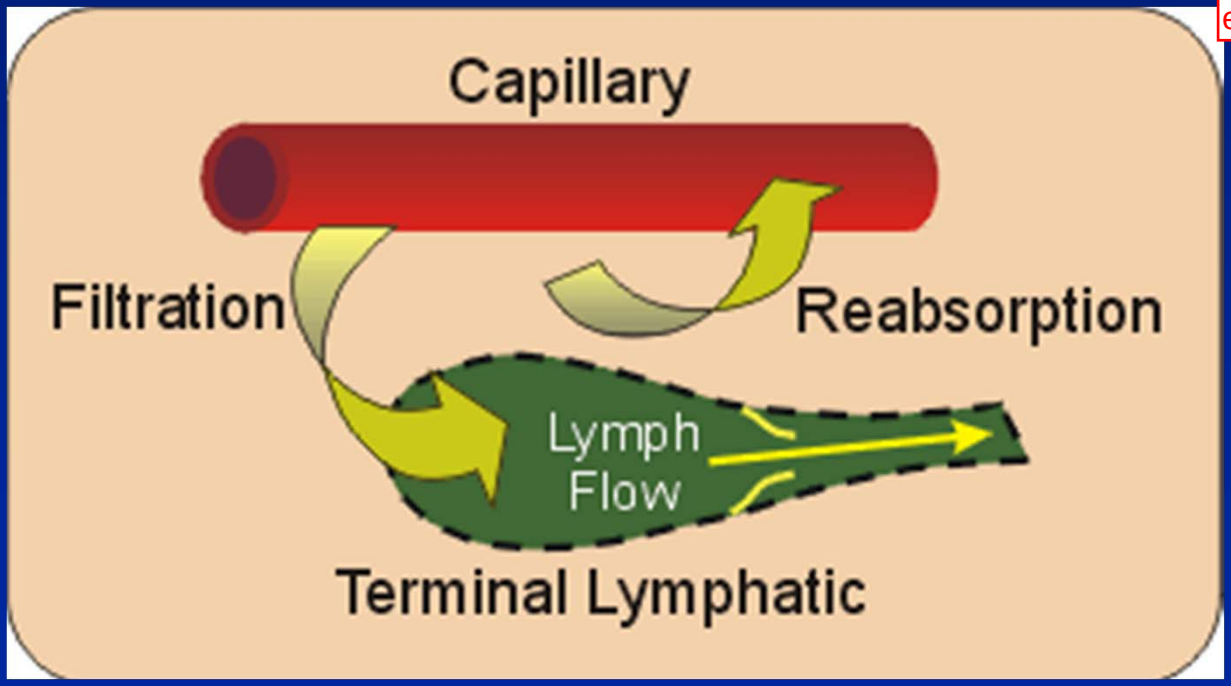
**Venular Hydrostatic Pressure ~15 mm Hg**

**Colloid Osmotic (Oncotic) Pressure ~25 mm Hg**

# Tissue Fluid: Balance

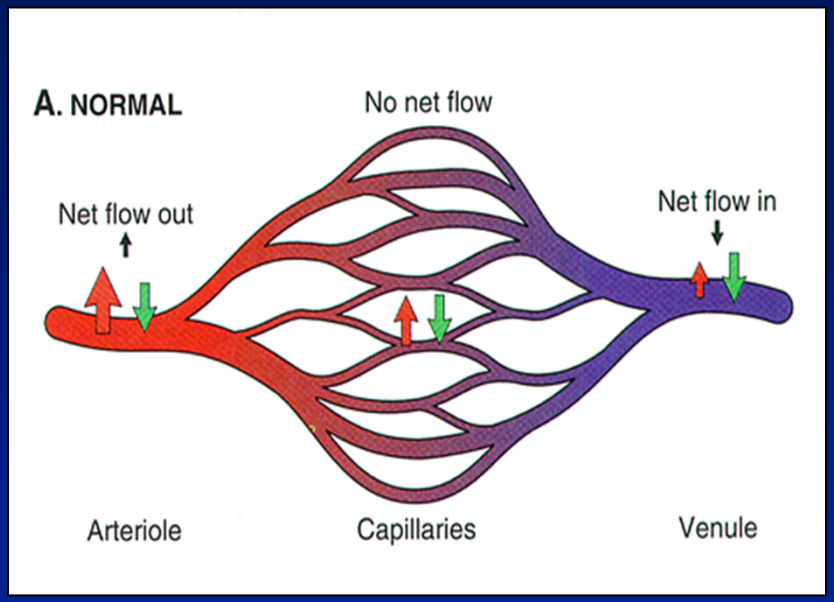
- **Generally net flow from vessels to tissue (filtration > reabsorption)**
- **Lymphatics help remove excess extracellular/interstitial fluid**

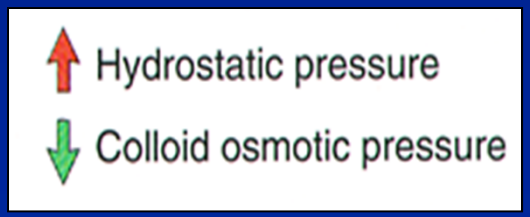
Extra fluid that doesn't come back in goes into lymph system. Occlude lymph system -> edema.




Kabunde

# Causes of Interstitial Edema




## 1) Increased Transcapillary Hydrostatic Pressure

- Pressure across the capillary bed is more affected by increases in venous pressure and resistance than arterial pressure

if you have increased venous pressure/ resistance, then you have increased capillary pressure, so you're gonna get damage due to hyperpermeability.

He made a joke that the people on the left are the people who come to lecture, the people on the right are the streamers. As a streamer, I would MUCH rather be a vein. So much less... pressure. :D

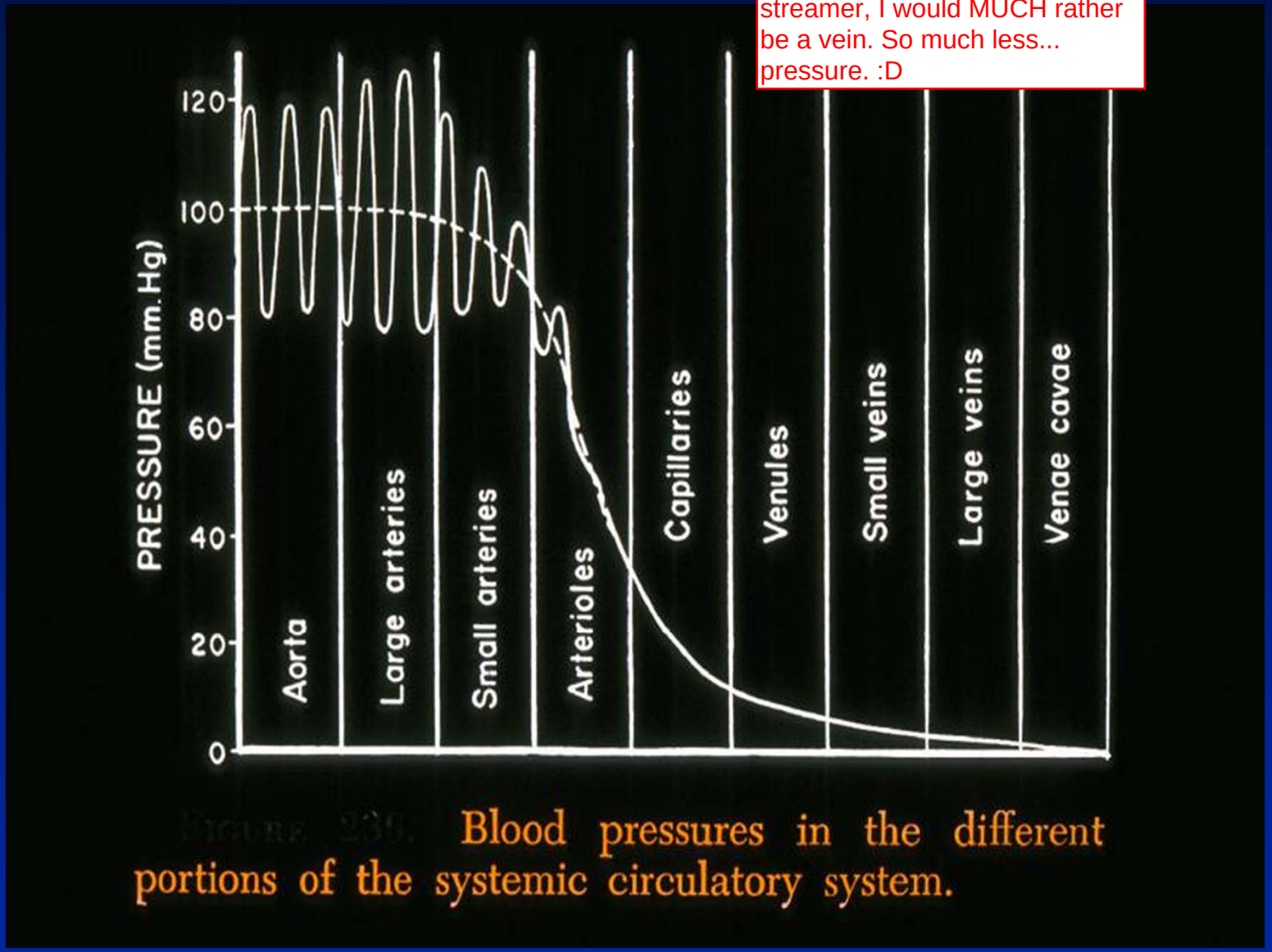



FIGURE 230. Blood pressures in the different portions of the systemic circulatory system.

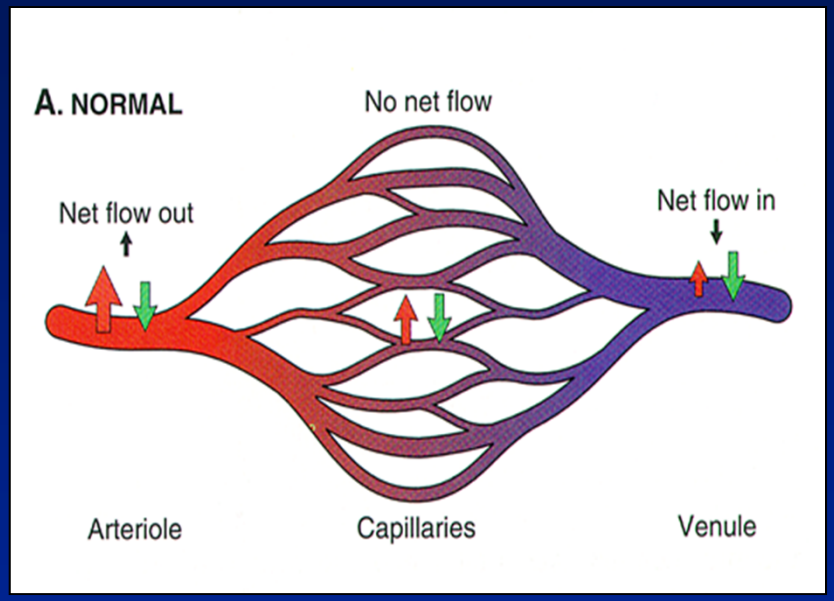
# Increased Hydrostatic Pressure Across the Capillary Bed

- Chronic Dependency/Gravity
- Congestive Heart Failure
- Venous Obstruction
  - DVT, Caval Obstruction
  - Cirrhosis
  - Constrictive Pericarditis
- Marked Arterial Vasodilation

Caval - like a tumor or something in your vena cava.

Some surgeons wear support hose, to prevent DVT (deep venous thrombosis). I would pay money to see this. Wait. I HAVE paid money to see this.

# Causes of Interstitial Edema




Hydrostatic pressure

Colloid osmotic pressure

sometimes you will give people colloids IV in order to help hold IV fluid in the vascular system.

## 2) Decreased Osmotic Pressure Gradient

- The capillary barrier is readily permeable to ions
- Osmotic pressure is determined by plasma proteins (colloids)
- **Albumin chief protein**
  - **Decreased intravascular**
  - **Increased extravascular**

# Decrease in the Osmotic Pressure Gradient between Intravascular and Extravascular/Interstitial Compartments

- **Hypoalbuminemia/Hypoproteinemia**

  **"Less Pull"**

- **Increased Vascular Permeability**
  - **Inflammation**
  - **Trauma/ Injury/Burns**

  **"More Leak"**

If you're letting proteins through, then you have a BIG problem. Even on a smaller level, it's just hard to keep ions in vascular supply.

# Causes of Hypoalbuminemia

- **Inadequate Synthesis**
  - **Liver Failure**
  - **Protein Malnutrition**
- **Excessive Loss**
  - **Albuminuria: Nephrotic Syndrome**
  - **Protein Losing Enteropathy**
- **Edema Resulting from Hypoalbuminemia is usually Generalized (Anasarca)**

Anasarca - the michelin man thing.

# Nephrotic Syndrome

## Glomerular Injury/Inflammation

### Autoimmune, infectious, toxic (incl. DM)

1. Proteinuria (esp. albumin, >3.5 gm/day)
2. Hypoalbuminemia (<3 gm/dl)
   normal = 3.5 - 5.5 gm/dl
3. Generalized Edema
4. Hyperlipidemia and Hyperlipiduria

# Extracellular Edema

- **Anasarca**
  - **Generalized tissue edema**
  - **Includes all soft tissues and viscera**

in lungs, heart, skin, EVERYWHERE. DUN DUN DUNNNNNNNNNNN.

- **Pitting Edema**
  - **Subcutaneous Edema**

**Edema due to hypoalbuminemia or increased venous hydrostatic pressure is a transudate (fluid with low protein content and low specific gravity, <1.012)**

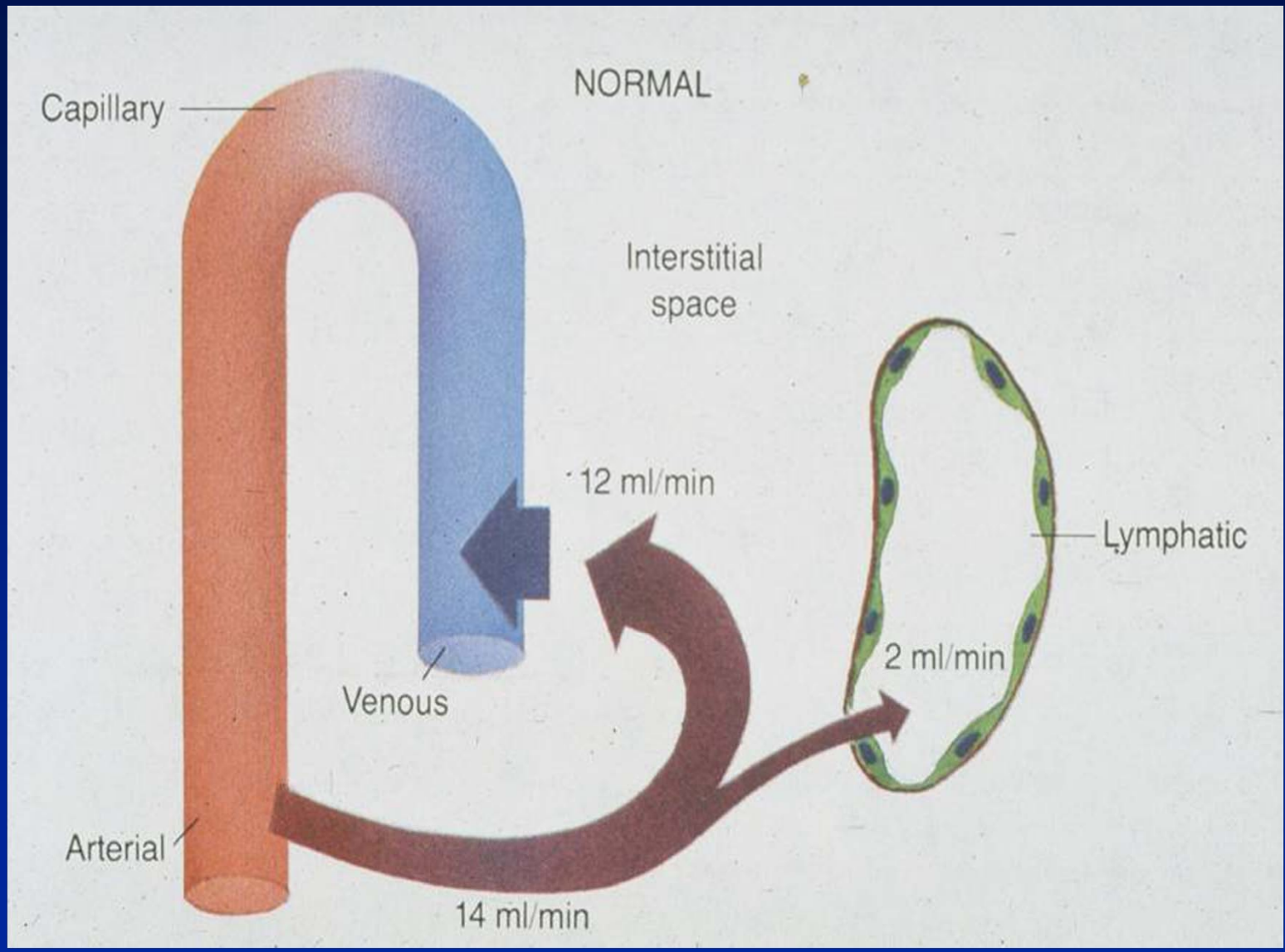
**- Unable to hold fluid in vessels; diffuses out**

this is osmotic/oncotic problem.

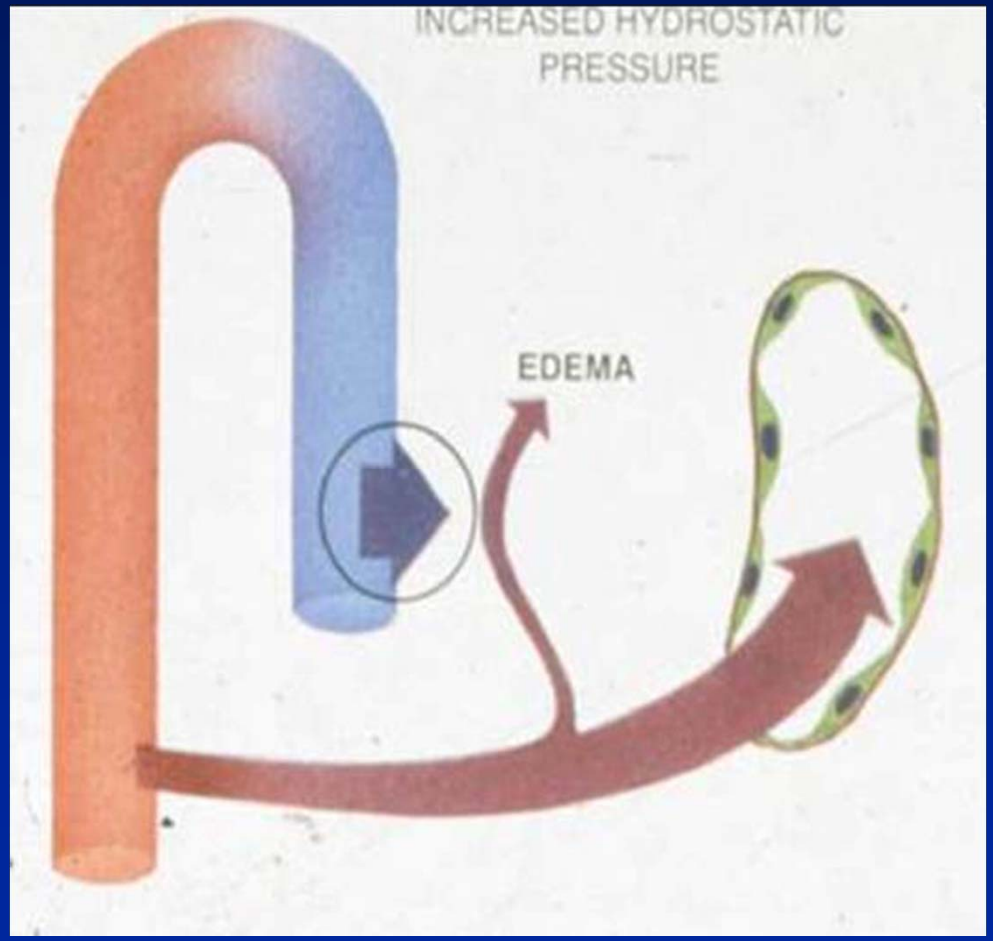
**Edema due to inflammation is an exudate (fluid with high protein content and specific gravity > 1.02)**

**- Leakage of fluid and proteins across compromised endothelium/membrane**

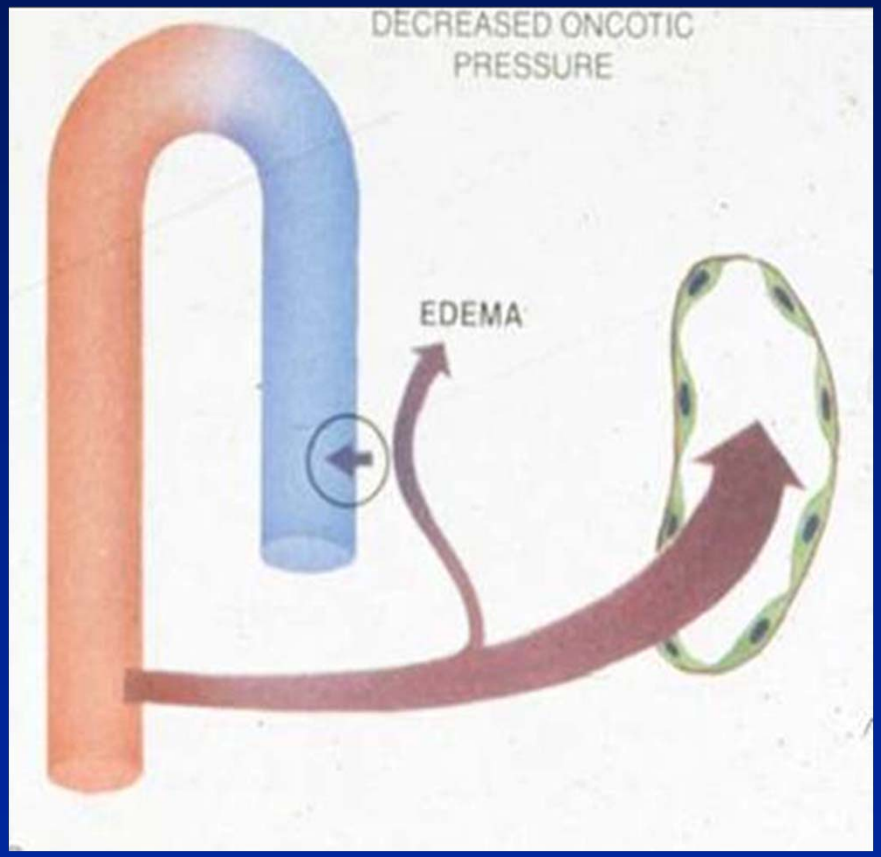
this is permeability problem. I'd guess this is worse?


NORMAL
Capillary
Interstitial space
12 ml/min
Lymphatic
2 ml/min
Venous
Arterial
14 ml/min

# Increased Hydrostatic Pressure



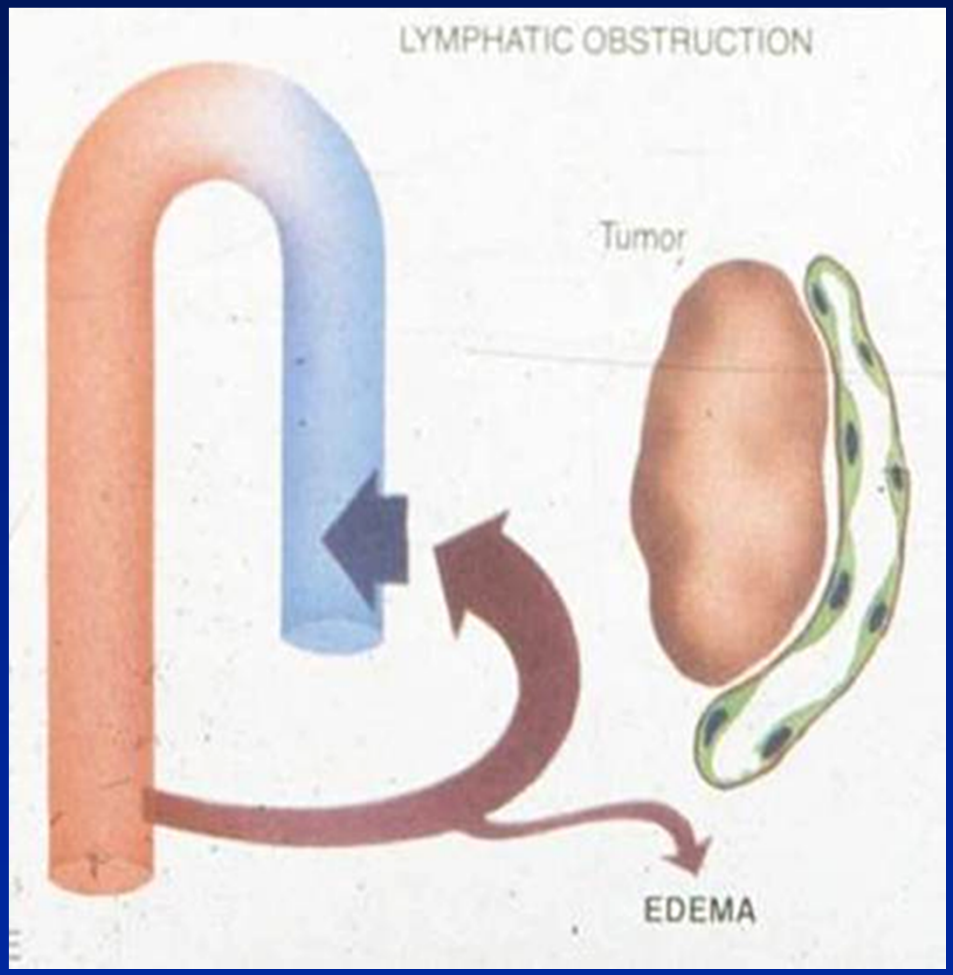
# Altered Osmotic Pressure Gradient





two different scenarios, oncotic v. permeability (left and right). know the difference.

# Lymphatic Obstruction




hey look! Another type. Doesn't have to be tumor, just lympatic blockage.

# Lymphatic Obstruction

- **Obstruction secondary to Malignancy**
  - **Mass Effect >**
  - **Hematologic (“sludging”)**
- **Iatrogenic**
  - **Surgical Interruption**
  - **Post Radiation Therapy**
- **Parasitic Invasion**

# Parasitic Obstruction

- **Filariasis (Elephantiasis)**
  - ***Wuchereria bancrofti, Brugia malayi and Brugia timori***

Obstruction from organisms, lymphatic injury and inflammatory cells clogging lymphatic flow

# Increased Venous Pressure

1. **Congestion (passive increase in blood volume in veins due to increased venous pressure)**

**Contrast with:**

if these are at higher pressure, then you need even higher pressure upstream in order to push through. Floppy blood vessels struggle to push on their own.

2. **Active Hyperemia (increase in blood volume due to increase in blood flow)**

# Manifestations of Congestive Heart Failure

**Heart failure is characterized by:**

**1) Increased atrial pressure (backward failure), causes most of the obvious symptoms**

**2) Diminished cardiac output (forward failure).**

blood backing up is more significant. It's a pump problem. Can't get pump to move fluid, so it stays static.

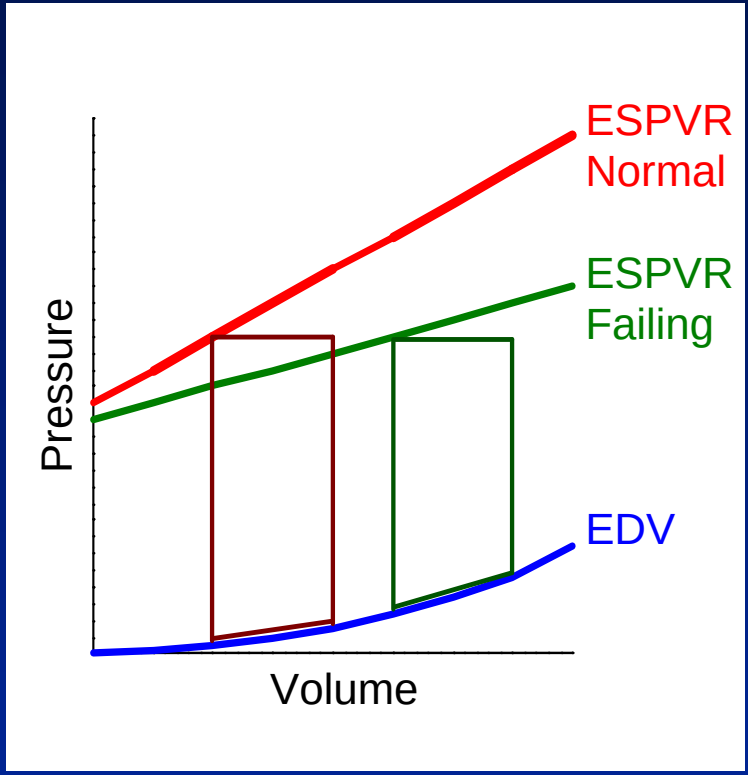
# Manifestations of Congestive Heart Failure

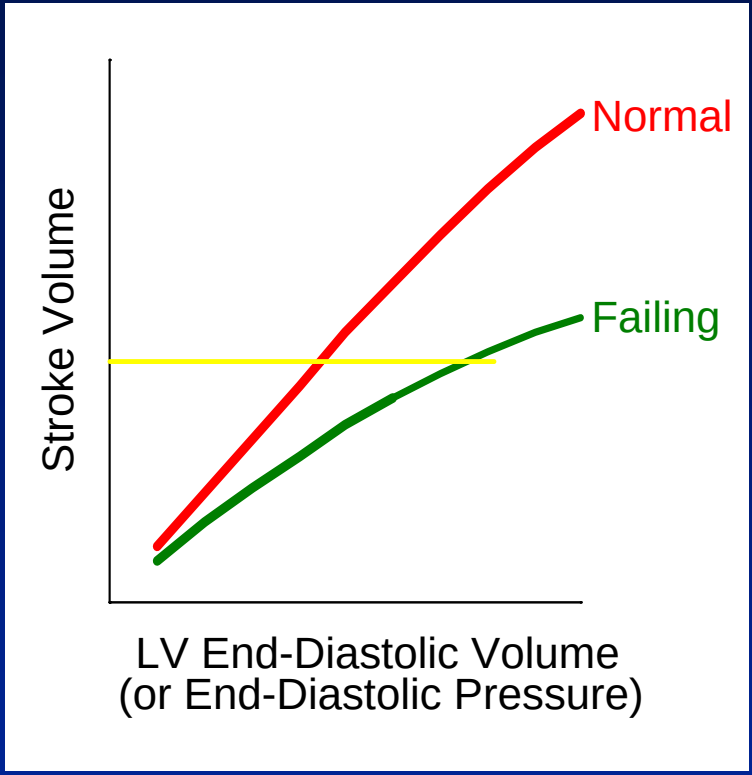
- **Diminished cardiac output results in renal hypoperfusion, which ultimately results in decreased excretion of sodium and water (Juxtaglomerular Apparatus).**
- **Likewise, accumulation of fluid in body cavities results in decreased effective blood volume and therefore decreased sodium and water excretion.**

Kidneys - "If I'm not getting enough blood, NO ONE is getting enough blood. MORE Renin Angiotensin Aldosterone!"

gotta solve edema and hypervolemia in addition to fixing the pump (heart).

# Congestive Heart Failure




Greater filling volumes, less output

Increased intravascular volume, sodium retention

3 seconds on this slide. if you get it, move on.

ESPVR: End Systolic Peripheral Vascular Resistance; EDV: End diastolic volume

# Edema in Congestive Heart Failure

## Left-sided Heart Failure:

Left atrial pressure **Increases**

Pulmonary venous pressure **Increases**

Pulmonary congestion **Key feature of left heart failure, can lead to pulmonary edema**

Right atrial pressure **No initial change**

just start with the failure, and work backwards. Everything flows DOWN a pressure gradient. If the left atrium is at high pressure, pulm. veins will start filling until the pressure is high enough to push blood into left atrium. Keep playing this game. You might anticipate this causing RHF, and you'd be right.

# Edema in Congestive Heart Failure

## Right-sided Heart Failure:

Right atrial pressure **Increases**

Systemic venous pressure **Increases**

Congestion where?

**Systemic**

again, play the backup game. Pressure/volume increases behind the traffic jam.

**- Centrilobular Liver Congestion (venous)**

**- Lower Extremity Edema**

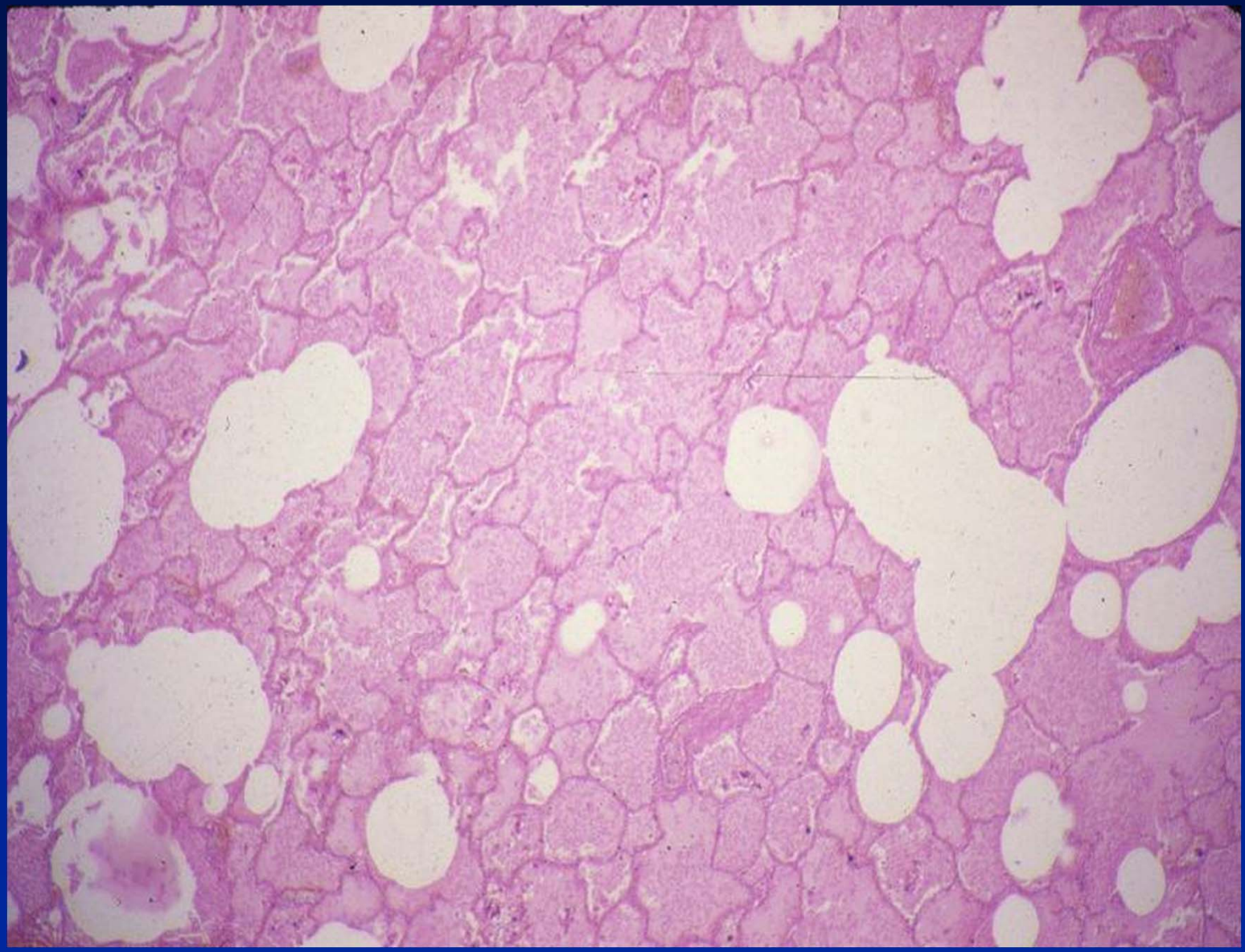
# Fluid Accumulation in Body Cavities

1. Ascites - hydroperitoneum
2. Pleural effusion - hydrothorax
3. Pericardial effusion

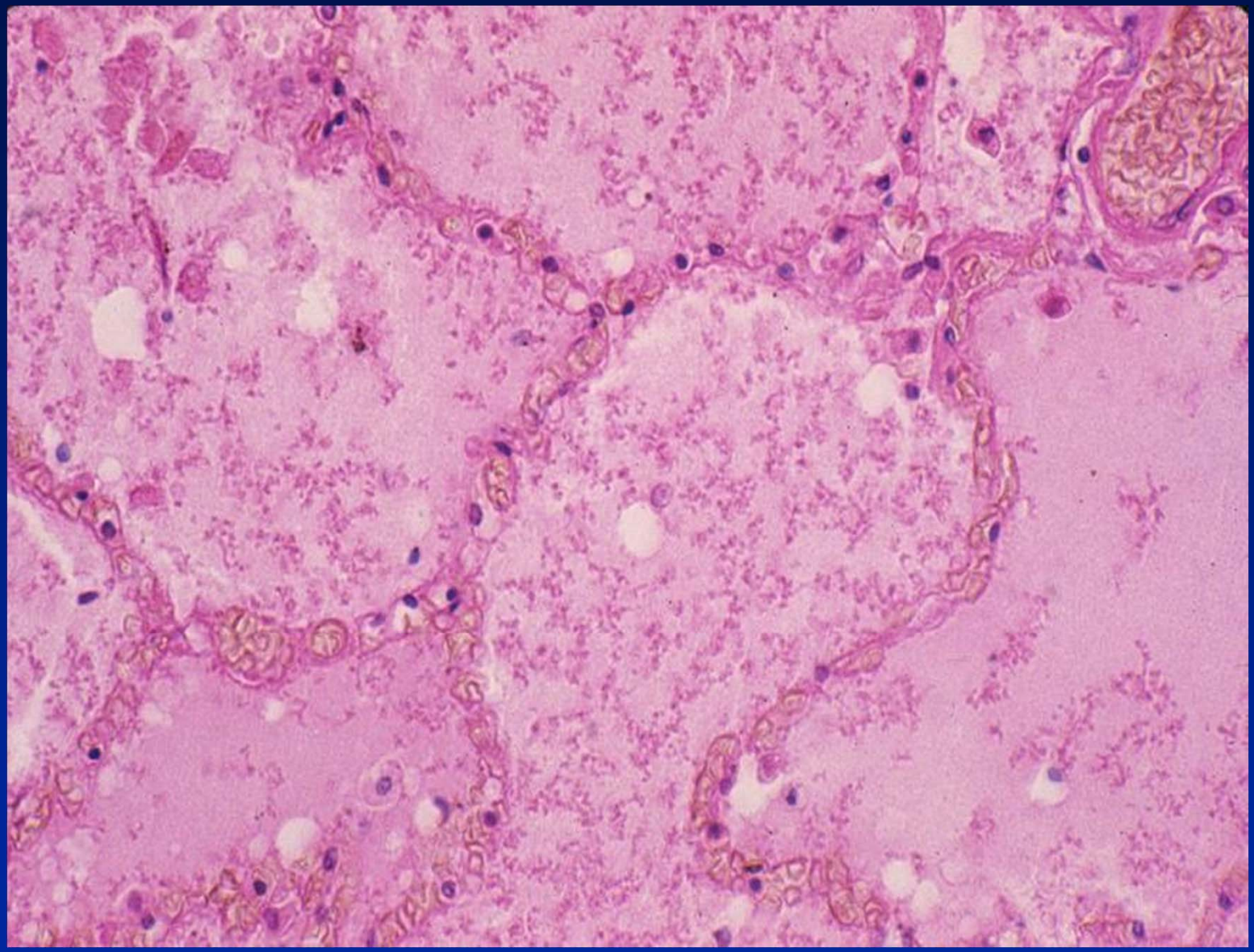
# Illustrations of Congestion and Edema

1. Pulmonary edema
2. Chronic pulmonary congestion
3. Centrilobular hepatic congestion

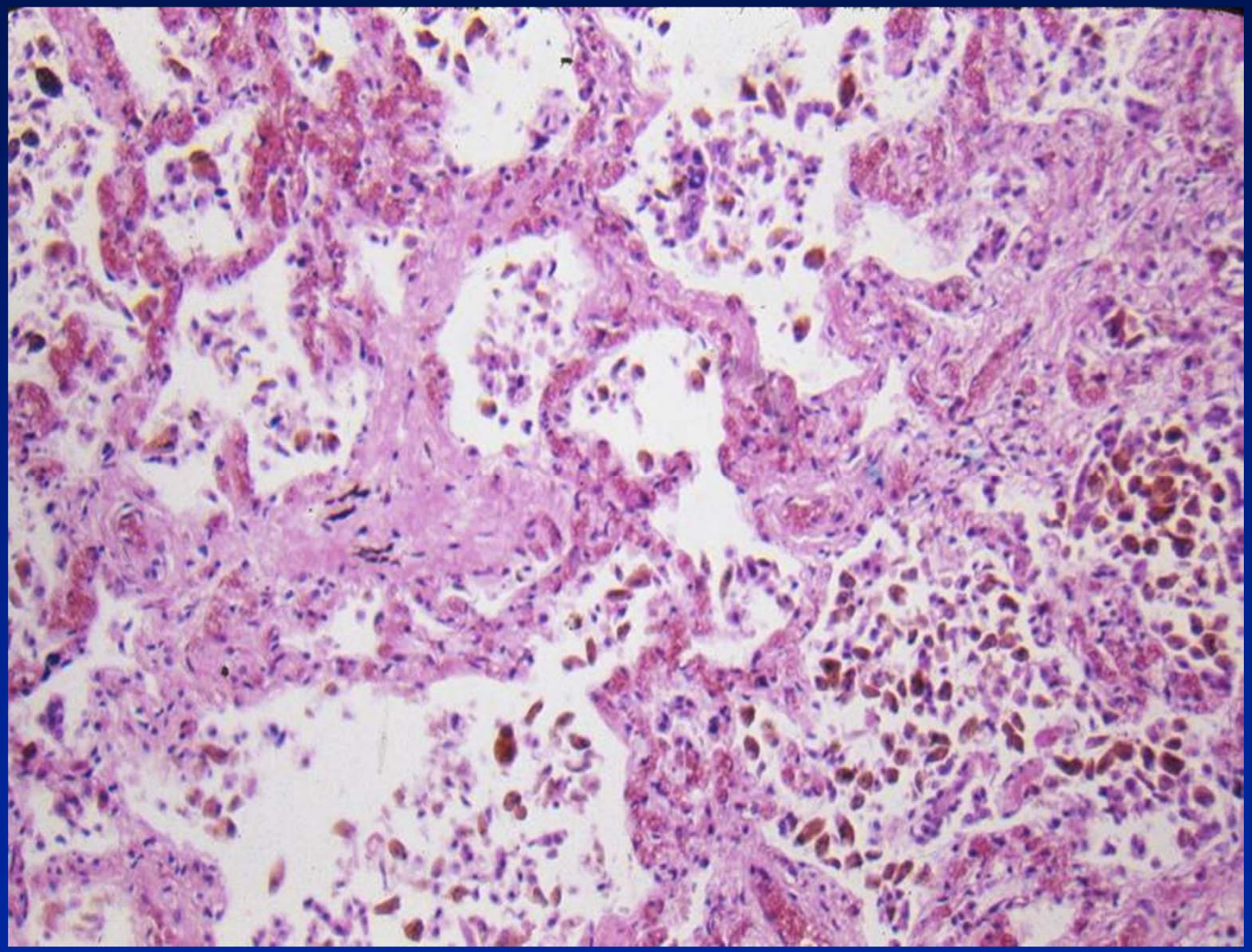
lung. fluid where air should be.



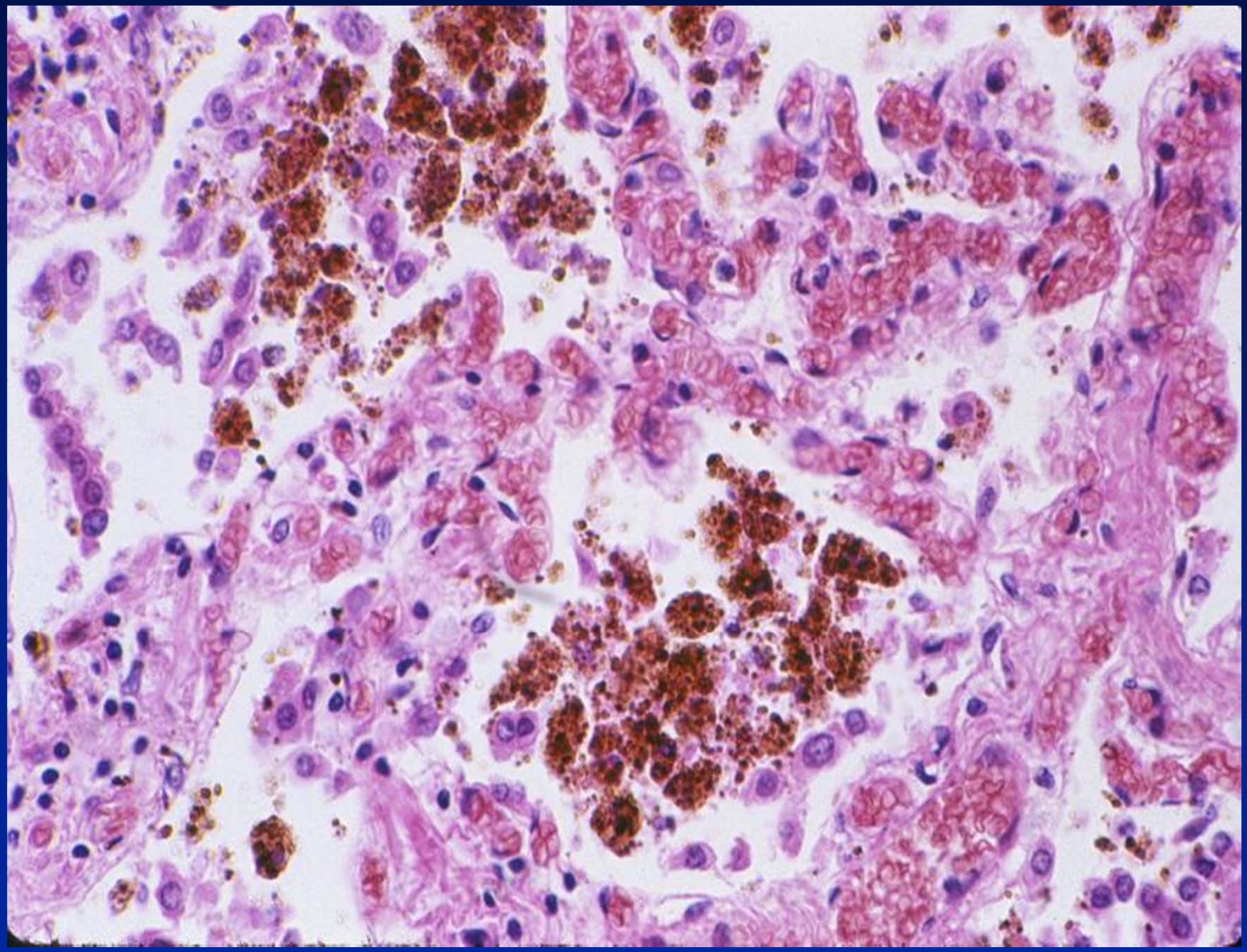
intra-alveolar edema, as opposed to interstitial edema inside the tissue space.



# Chronic Pulmonary Congestion



brown = hemosiderin. macrophage breakdown of RBCs. These are indicative of chronic heart failure.



# Centrilobular Hepatic Congestion

HOORAY KILL BILL REFERENCE!

# Hemorrhage

He asked for precision. Some people use interchangeably, you should be as careful as possible.

# Hemorrhage

**In skin, mucous membranes, or serosal surfaces:**

- **Petechiae - tiny (1-2 mm)**
- **Purpura - medium-sized ($\geq$ 3 mm & $\leq$ 1 cm)**
- **Ecchymoses- bruises (> 1 cm)**

**Hematoma - collection of blood in an organ or tissue**

# SHOCK!

HAMMER TIME.

**Syndrome resulting from generalized <u>decrease in tissue perfusion</u>**

stuff goes down because we're losing ability to have tissue function due to loss of blood

# Shock

military developed alot of this. Wonder why?

# Causes of Shock

1. Cardiogenic Shock — pump fail
2. Hypovolemic Shock — losing blood volume (bleed)
3. Shock due to Venous Pooling

   Neurogenic — massive dilation of vessels. TSS?

# Cardiogenic Shock

**Cardiac output is markedly decreased due to inadequate cardiac function**

**Myocardial Infarct**

"Come here, Gladys! It's the big one! Errk!"

**Myocarditis**

**Toxic Injury**

# Hypovolemic Shock

**Blood Loss (Hemorrhagic shock)**

**Loss of Plasma (severe thermal burns)**

Due to increased evaporation, burn also directly injures vessels which allows exudation of fluid. BAAAAD.

**Severe Diarrhea or Dehydration**

children can be susceptible to this.

# Shock due to Vasodilation

**Septic Shock - endotoxin causes increased vascular permeability (generalized edema) and cardiac depressant factors**

**Anaphylactic shock - massive histamine release and marked vasodilation**

YAY TSS! Told you so. That's what active anticipation does for you, cats and kittens.

how we deal with this.

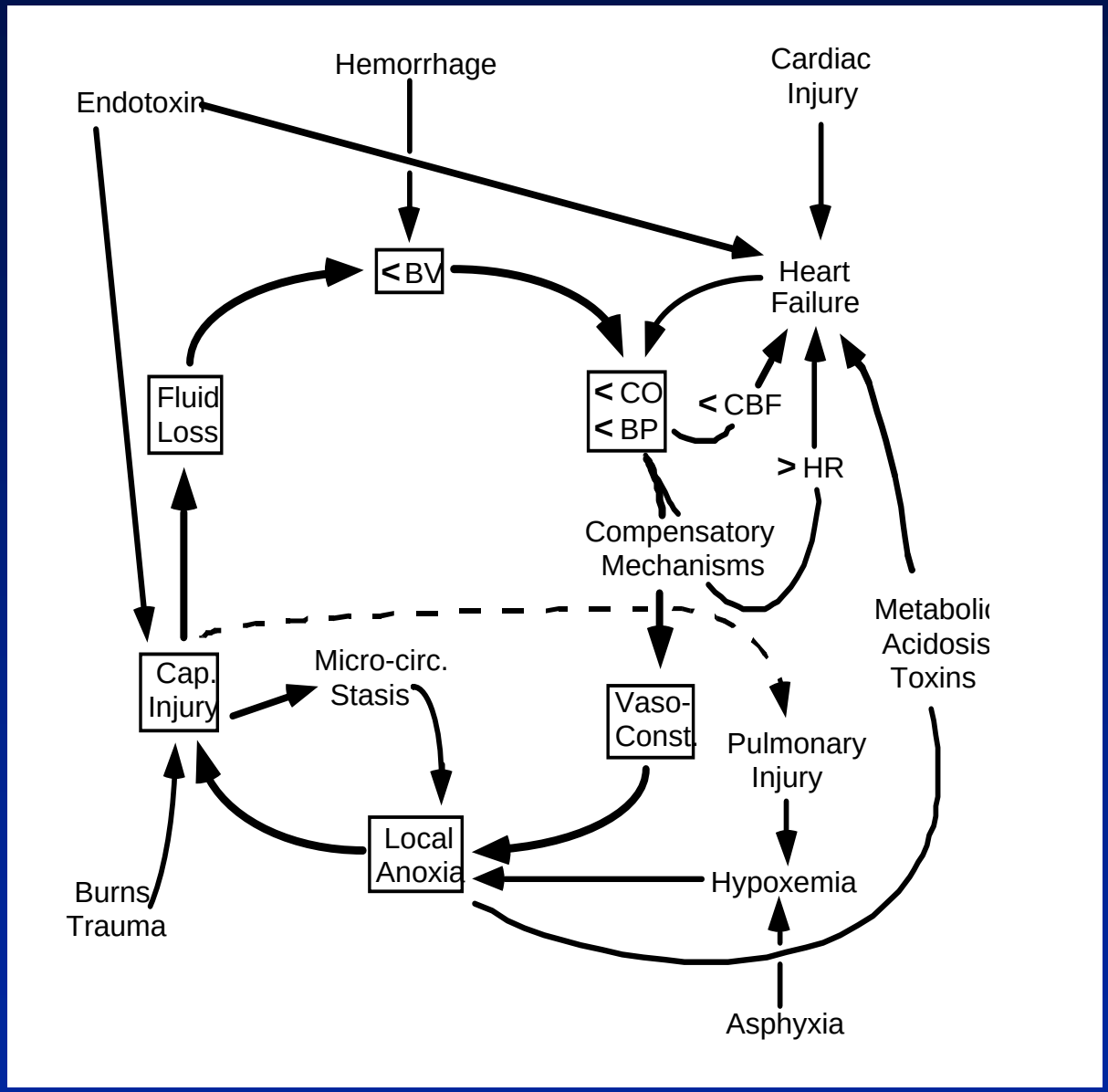
# Compensatory Mechanisms

1. Vascular autoregulation to maintain blood flow to heart & brain

gotta maintain the most important ones. This is the "world is ending, save the VIPs" complex.

2. Sympathetic activation
   - ↑ Cardiac contractility & heart rate
   - Vasoconstriction (skin, muscle, GI, renal)
3. Shift water from interstitial to intravascular space (hemodilution)
4. ↑ Renal sodium and water reabsorption

Sometimes these mechanisms help the problem, sometimes they confound it. Pumping more MIGHT bring you more blood, or it might make you squirt blood out of the bleed you have. Depends on the situation.


Hemorrhage
Endotoxin
Cardiac Injury
< BV
Heart Failure
Fluid Loss
< CO
< BP
< CBF
> HR
Compensatory Mechanisms
Metaboli
Acidosis
Toxins
Cap. Injury
Micro-circ. Stasis
Vaso-Const.
Pulmonary Injury
Local Anoxia
Hypoxemia
Burns
Trauma
Asphyxia

# Shock - Complications

**Hypoperfusion**

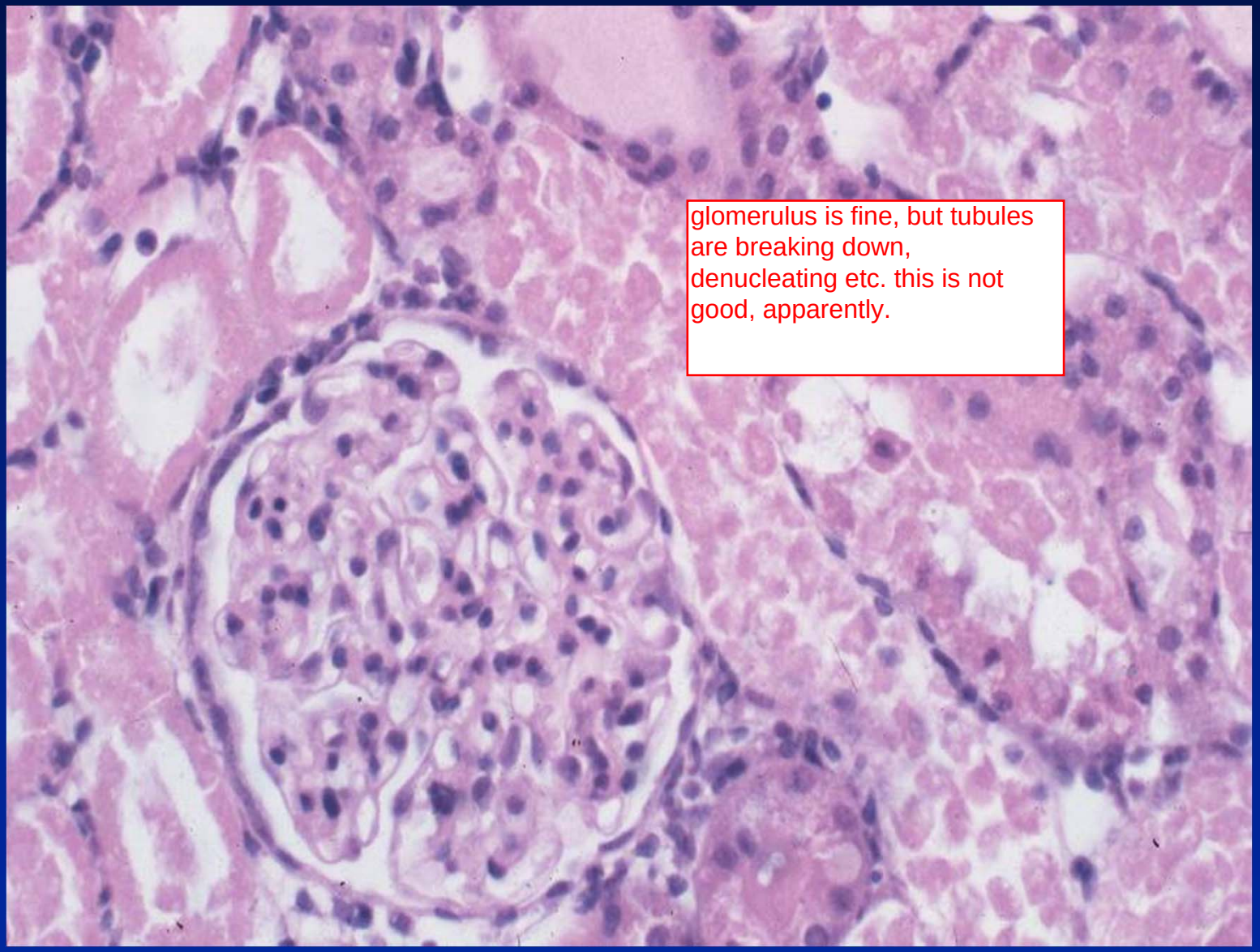
everything can shut down. Multi system organ failure. Expect this with heart attacks.

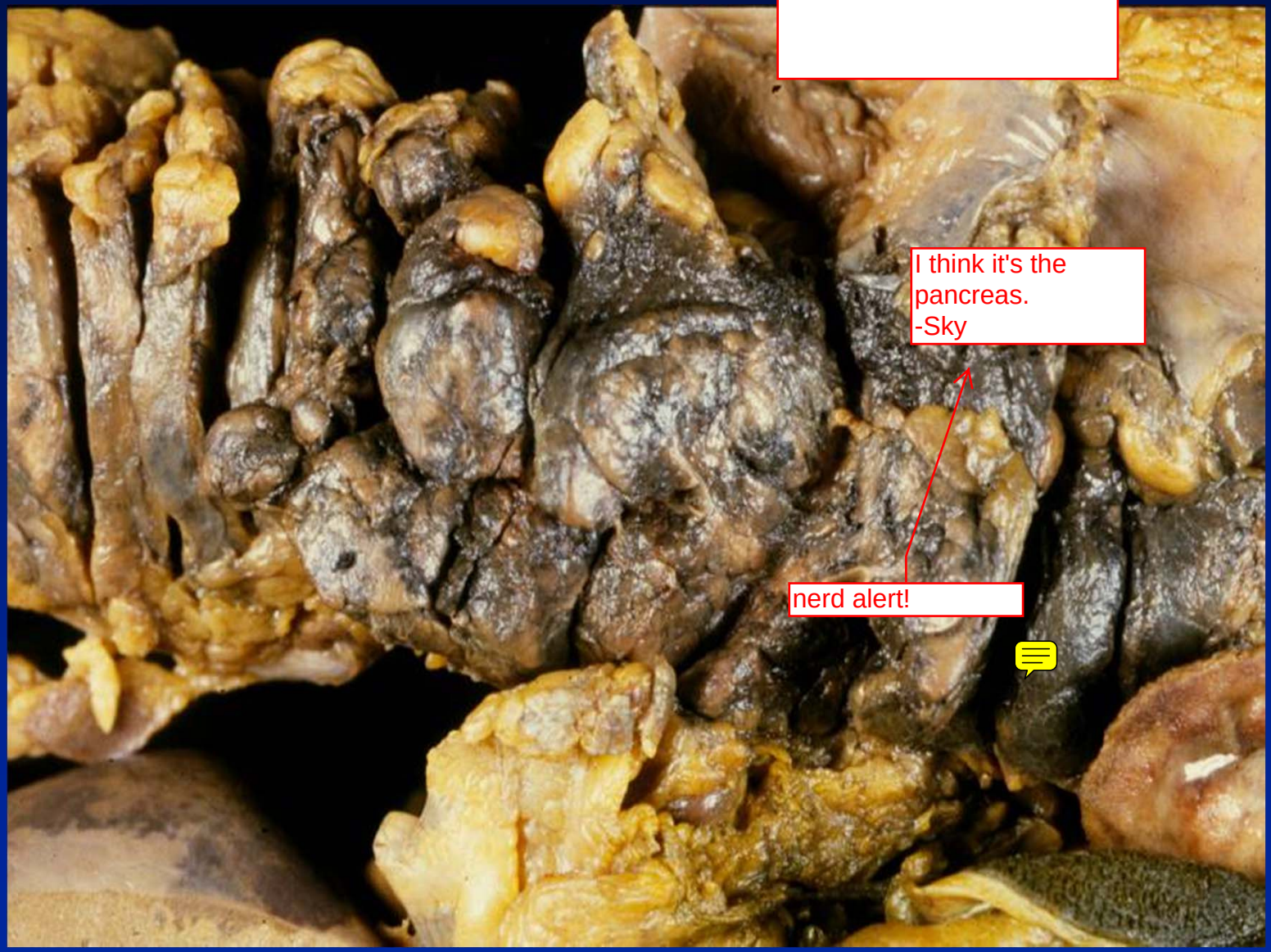
- **Acute Tubular Necrosis (ATN) - acute renal failure**
- **Pancreatitis**
- **GI Mucosal Hemorrhage and Necrosis**
- **Centrilobular Necrosis in Liver**

nearest to central vein get last dibs on blood, so they die first (lowest O2 tension)

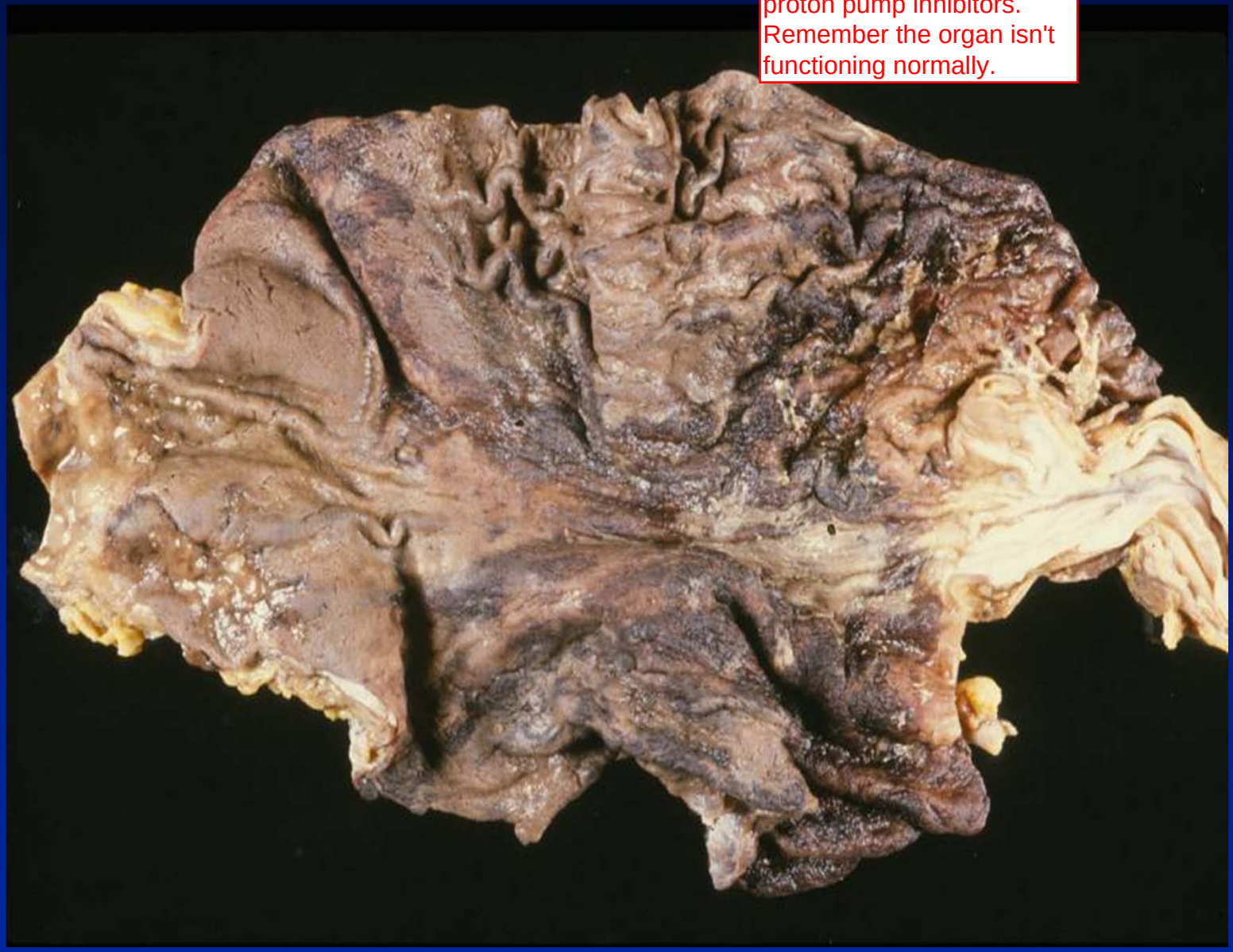
- **Watershed Infarcts in Brain**
- **Hemorrhagic necrosis of adrenal glands**

- **Pulmonary Edema (cardiogenic, septic)**

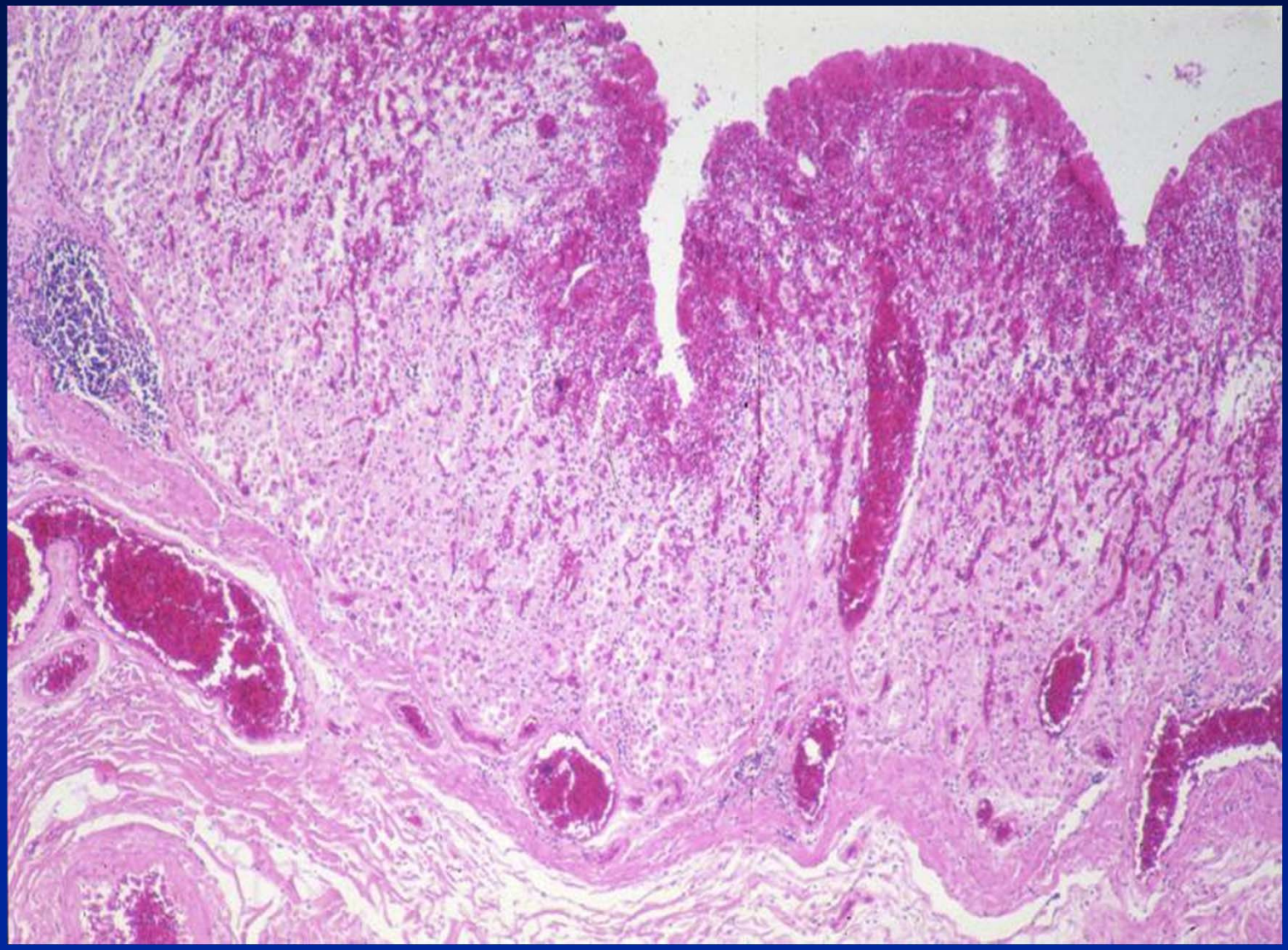

glomerulus is fine, but tubules are breaking down, denucleating etc. this is not good, apparently.

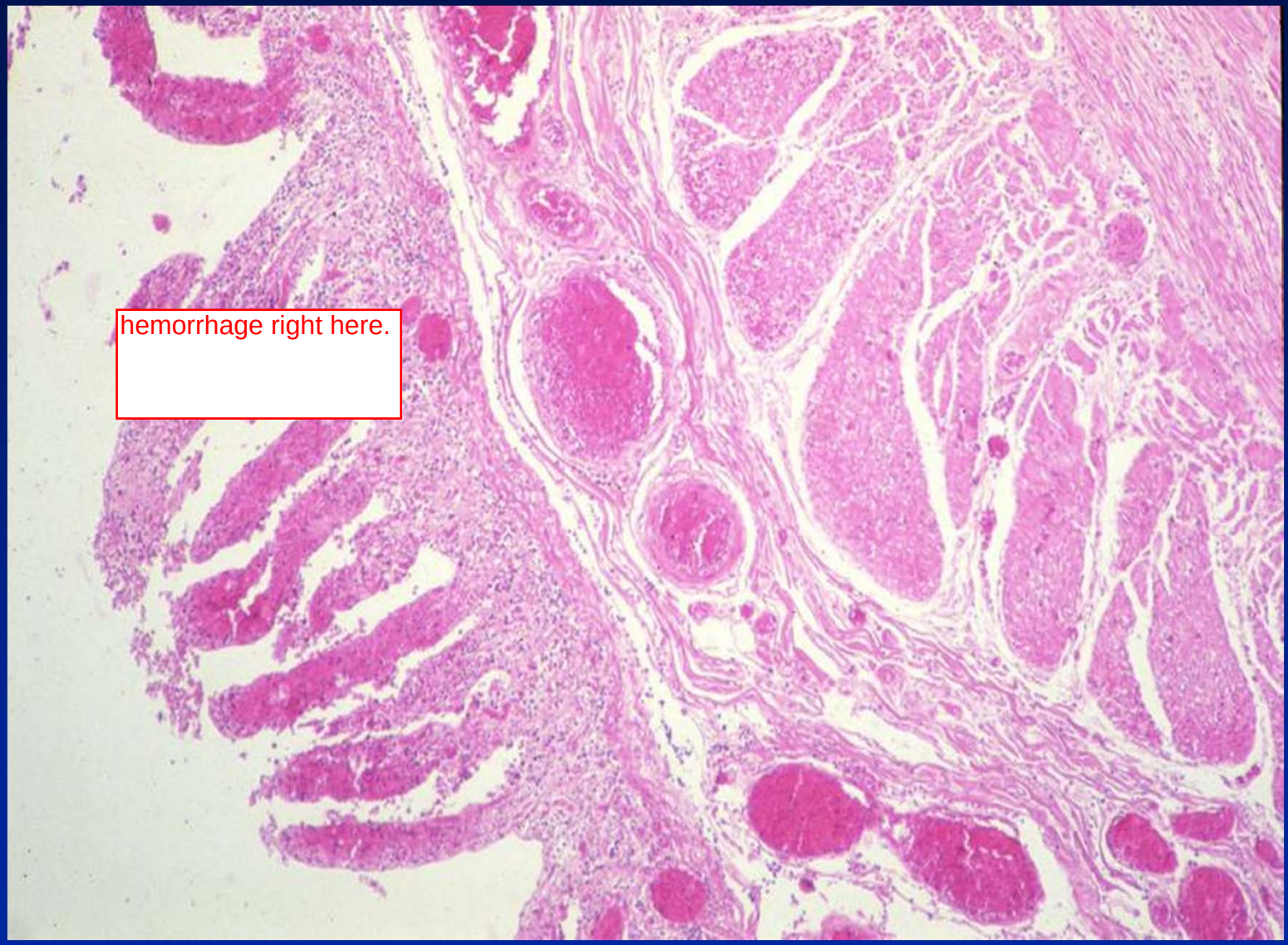

Ewwwwwwwwww. Sorry, don't know what organ this is.
I think it's the pancreas.
-Sky
nerd alert!

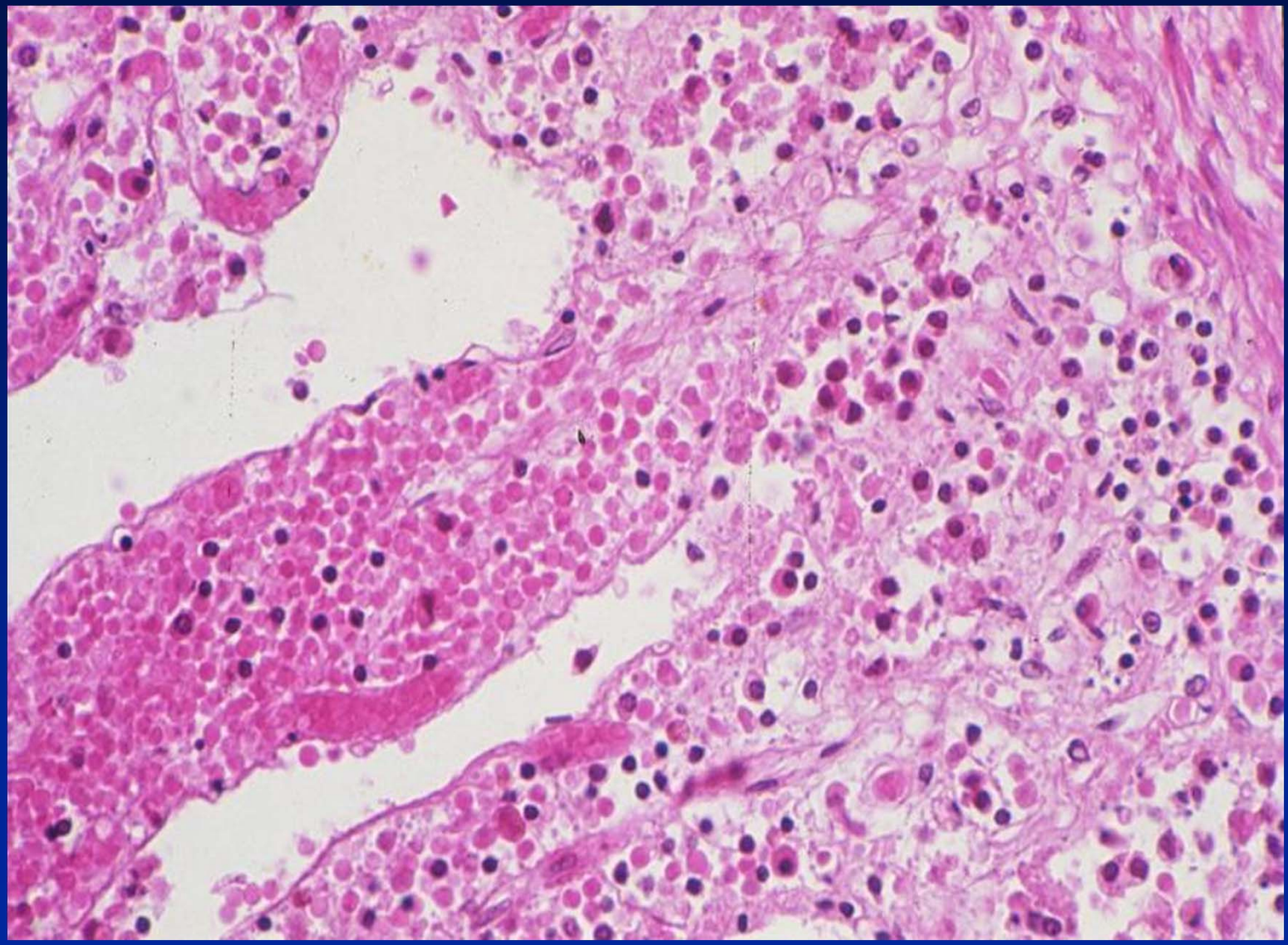
Stomach. Because of this, you need to treat them gingerly, and give them proton pump inhibitors. Remember the organ isn't functioning normally.



upper part: mucosa replaced by hemorrhage.




hemorrhage right here.




Q: what do epi-pens do for you?
A: Hypovolemic shock, solves by increasing your sympathetic tone, so greater contractility and bronchodilation. More O2 for your heartbeat buck.

# Questions?