

Glomerulonephritis, Nephrotic and Nephritic Syndrome, and Acid-Base Disturbances

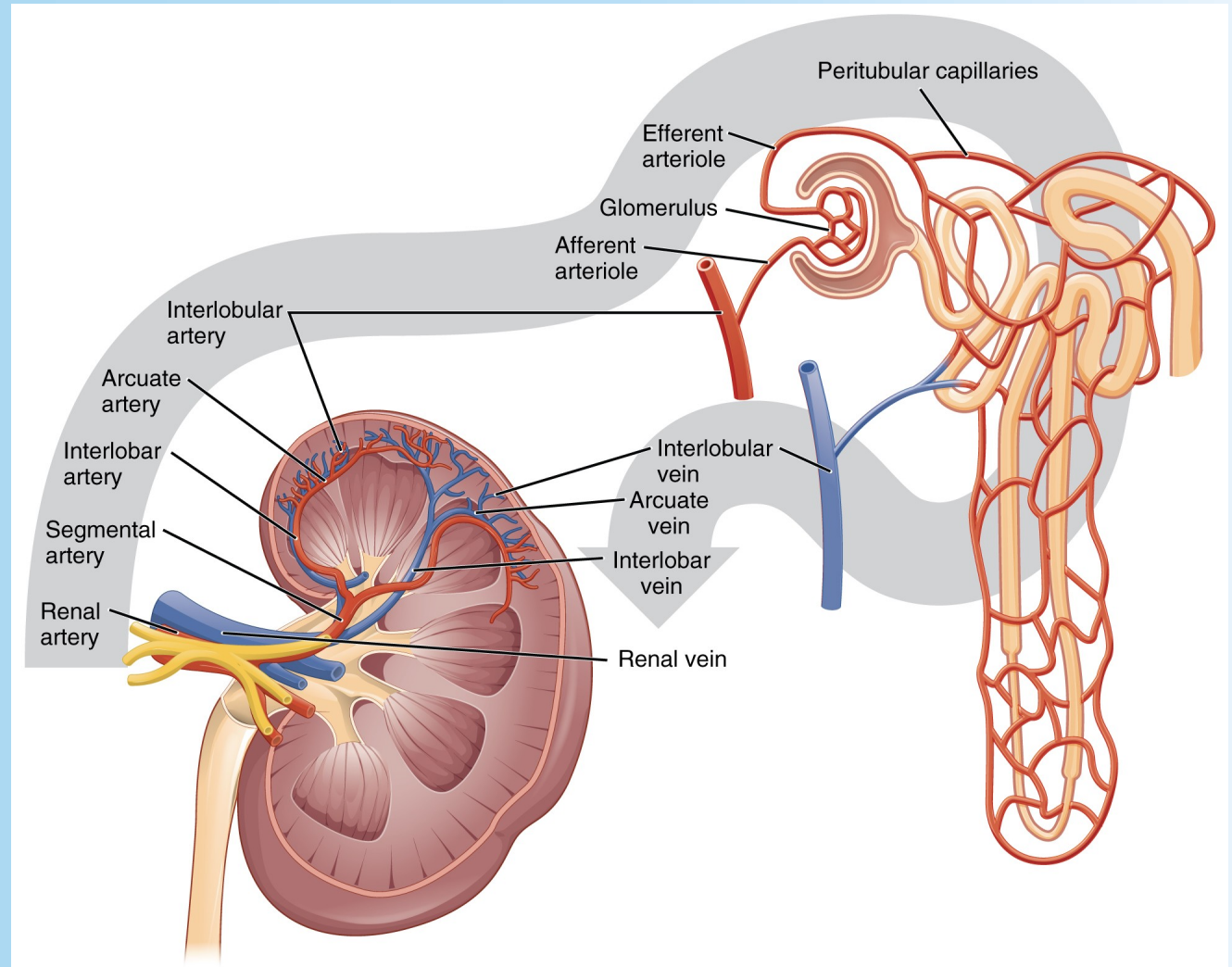
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Goals

- Clinical signs of altered kidney function
- Understand nephritic vs nephrotic syndrome
- Explain glomerulopathies and nephrolithiasis
- Understand acid/base disorders and edema

What The Kidneys Do

- Filter blood and remove waste
- Control water and electrolytes
- Regulate acid-base balance
- Produce hormones:
erythropoietin, renin, vitamin
D activation



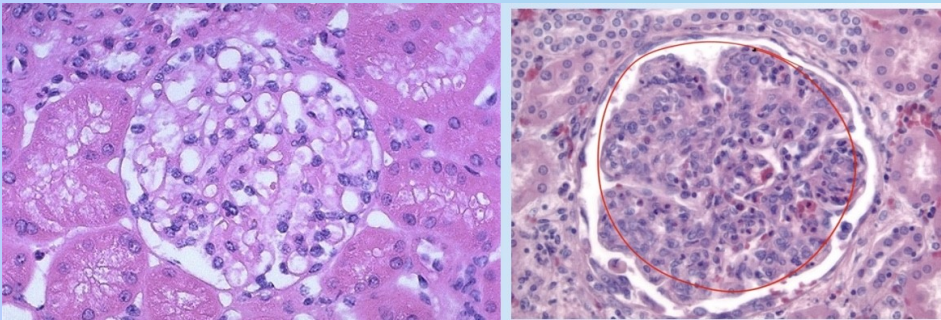
Clinical Manifestations of Kidney Dysfunction

- Reduced urine output (oliguria/anuria)
- Swelling (edema)
- Hypertension
- Hematuria and proteinuria
- Fatigue, nausea, confusion in severe disease

Nephritic vs Nephrotic Syndrome

Nephritic syndrome

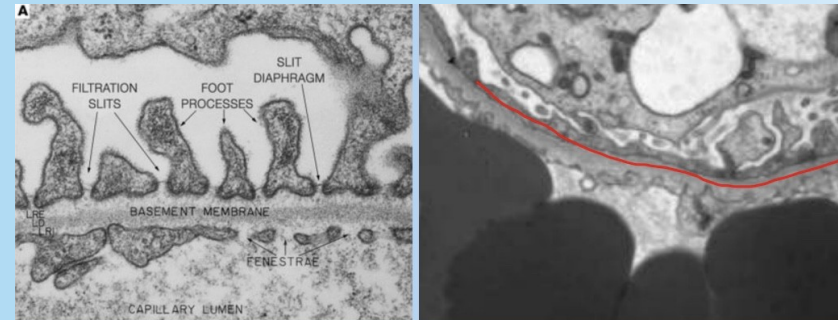
- **I** for **I**nflammation
- Signs and symptoms due to glomerular capillary damage due to inflammation



- **Hematuria**
- Mild to moderate proteinuria
- Hypertension
- Reduced GFR and oliguria
- Edema (localized, not generalized)

Nephrotic syndrome

- **O** for pr**O**tein
- Signs and symptoms that indicate damage to the glomerular filtration barrier itself



- **Massive proteinuria (>3.5 g/day)**
- Hypoalbuminemia
- Generalized edema
- Hyperlipidemia
- Increased thrombosis risk

What is the difference?

Nephritic = inflammation and blood

Nephrotic = protein loss and edema

Both can reduce kidney function

Some conditions have elements of both
where one usually dominates

Glomerulopathies

- **Glomerulopathies** are diseases that affect the **glomeruli**, the filtering units of the kidneys.
- **Glomerulonephritis (GN)** is a type of glomerulopathy characterized by **inflammation of the glomeruli**.
- Damage to the glomeruli → **proteinuria, hematuria, edema, hypertension, and reduced kidney function**.
- Glomerular diseases are commonly divided into **nephritic syndrome** and **nephrotic syndrome** patterns.
- Common causes: **post-streptococcal infections, autoimmune diseases (SLE), diabetes, and genetic disorders**.
- Persistent glomerular injury can lead to **glomerulosclerosis**, chronic kidney disease (CKD), and eventually end-stage renal disease (ESRD).

Glomerulopathies

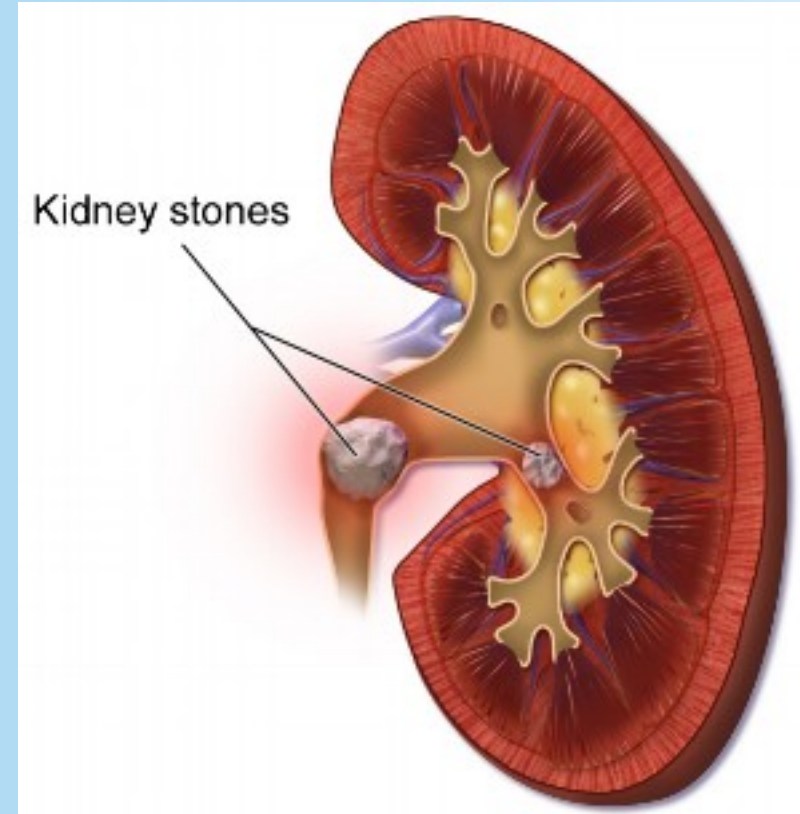
Glomerulopathy	Main Pathogenesis	Syndrome Pattern	Nephritic / Nephrotic / Mixed	Common Etiology / Associations	Can Progress to CKD?
Post-streptococcal glomerulonephritis	Immune complex deposition after streptococcal infection causing glomerular inflammation	Hematuria, edema, hypertension	Nephritic	Group A Streptococcus throat/skin infection	Usually no , especially in children; severe adult cases may progress
IgA nephropathy (Berger disease)	IgA deposition in mesangium → chronic inflammation	Episodic hematuria ± proteinuria	Nephritic	Often follows respiratory infection	Yes , common cause of CKD in young adults
Rapidly progressive GN (RPGN)	Severe immune-mediated injury with crescent formation	Rapid fall in GFR	Nephritic	ANCA vasculitis, anti-GBM disease, lupus	Yes , often rapidly progresses without treatment
Lupus nephritis	Immune complex deposition from autoimmune disease	Hematuria + proteinuria	Mixed	Systemic lupus erythematosus	Yes , major cause of CKD in SLE patients
Membranoproliferative GN (MPGN)	Complement activation + immune complex injury	Proteinuria and hematuria	Mixed	Hepatitis B/C, autoimmune disorders	Yes , many patients develop CKD
Minimal change disease	Podocyte foot process effacement	Massive proteinuria and edema	Nephrotic	Common in children; NSAIDs, Hodgkin lymphoma	Rarely , prognosis usually excellent
Focal segmental glomerulosclerosis (FSGS)	Podocyte injury with focal glomerular scarring	Severe proteinuria	Nephrotic	HIV, obesity, heroin use, idiopathic	Yes , frequently progresses to CKD/ESRD
Membranous nephropathy	Immune complex deposition on glomerular basement membrane	Heavy proteinuria	Nephrotic	Autoimmune disease, hepatitis B, malignancy	Yes , especially untreated disease
Diabetic nephropathy	Chronic hyperglycemia damages glomeruli	Progressive proteinuria	Nephrotic	Diabetes mellitus	Yes , leading cause of CKD worldwide
Amyloidosis	Amyloid protein deposition in glomeruli	Severe protein loss and edema	Nephrotic	Chronic inflammatory disease, plasma cell disorders	Yes , progressive renal dysfunction common
Alport syndrome	Genetic defect in type IV collagen	Persistent hematuria	Mainly Nephritic	Hereditary disease with hearing/eye defects	Yes , progressive renal failure common
Goodpasture syndrome	Anti-GBM antibodies attack kidneys and lungs	Hematuria and rapidly declining renal function	Nephritic	Autoimmune anti-basement membrane disease	Yes , especially if untreated
Thin basement membrane disease	Thinning of glomerular basement membrane	Mild isolated hematuria	Mild Nephritic pattern	Usually inherited	Usually no , generally benign
C3 glomerulopathy	Dysregulation of complement pathway	Hematuria + proteinuria	Mixed	Complement abnormalities	Yes , high CKD risk

Nephrolithiasis

- Solid crystals form in urinary tract
- Calcium oxalate most common
- Causes severe colicky flank pain
- May cause hematuria and obstruction

Risk factors

- Dehydration
- High salt diet
- Hypercalcemia
- Recurrent urinary tract infections
- Family history



Nephrolithiasis

Composition	Frequency	Causes	Treatment	Comments
Calcium phosphate Calcium oxalate	Most common (usually seen)		thiazide	
Ammonium magnesium phosphate (struvite)	Second most type		removal	Staghorn stone 
Uric acid	Third most c		and alkalinization of (O_3) for gout	Risk factors: - Hot, arid climates - acidic pH - Low urine volume
Cysteine	Rare; most c seen in child		and alkalinization of	Can also cause staghorn stone

Edema

- Excess fluid in interstitial tissues
- Can be localized or generalized
- Important sign of systemic disease

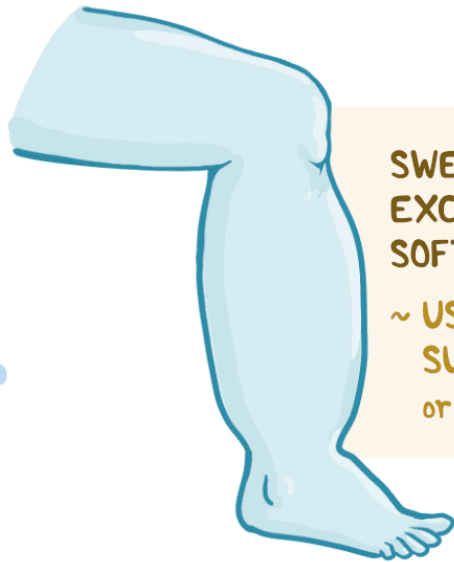


- Localized: inflammation, DVT
- Generalized: heart, kidney, liver disease
- Pitting vs non-pitting edema



Edema

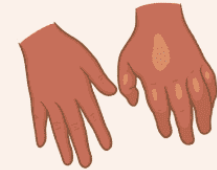
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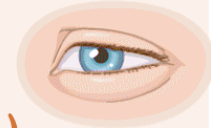
SWELLING CAUSED by
EXCESS FLUID in
SOFT TISSUES
~ USUALLY LOCALIZED,
SUCH as in UPPER
or LOWER LIMBS

CAUSES

CONDITIONS that AFFECT THYROID or
LYMPHATIC SYSTEM



- * LYMPHADEMA
~ BUILT-UP LYMPHATIC FLUID
- * MYXEDEMA
~ PRETIBIAL EDEMA (swelling in lower legs)
~ PERIORBITAL EDEMA (swelling around eyes)
- * ANGIOEDEMA
~ USUALLY RESULT of ALLERGIC REACTION
~ SWELLING in FACE, TONGUE, LARYNX,
ABDOMEN, ARMS, or LEGS
- * LIPEDEMA
~ ACCUMULATION of FAT UNDER SKIN

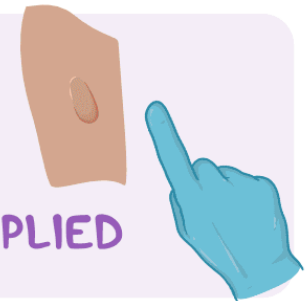


NON-PITTING EDEMA vs.

PITTING EDEMA

FEELS FIRM;
INDENTATION doesn't FORM

INDENTATION APPEARS and
PERSISTS when PRESSURE is APPLIED



Studyaid



Cerebral Edema

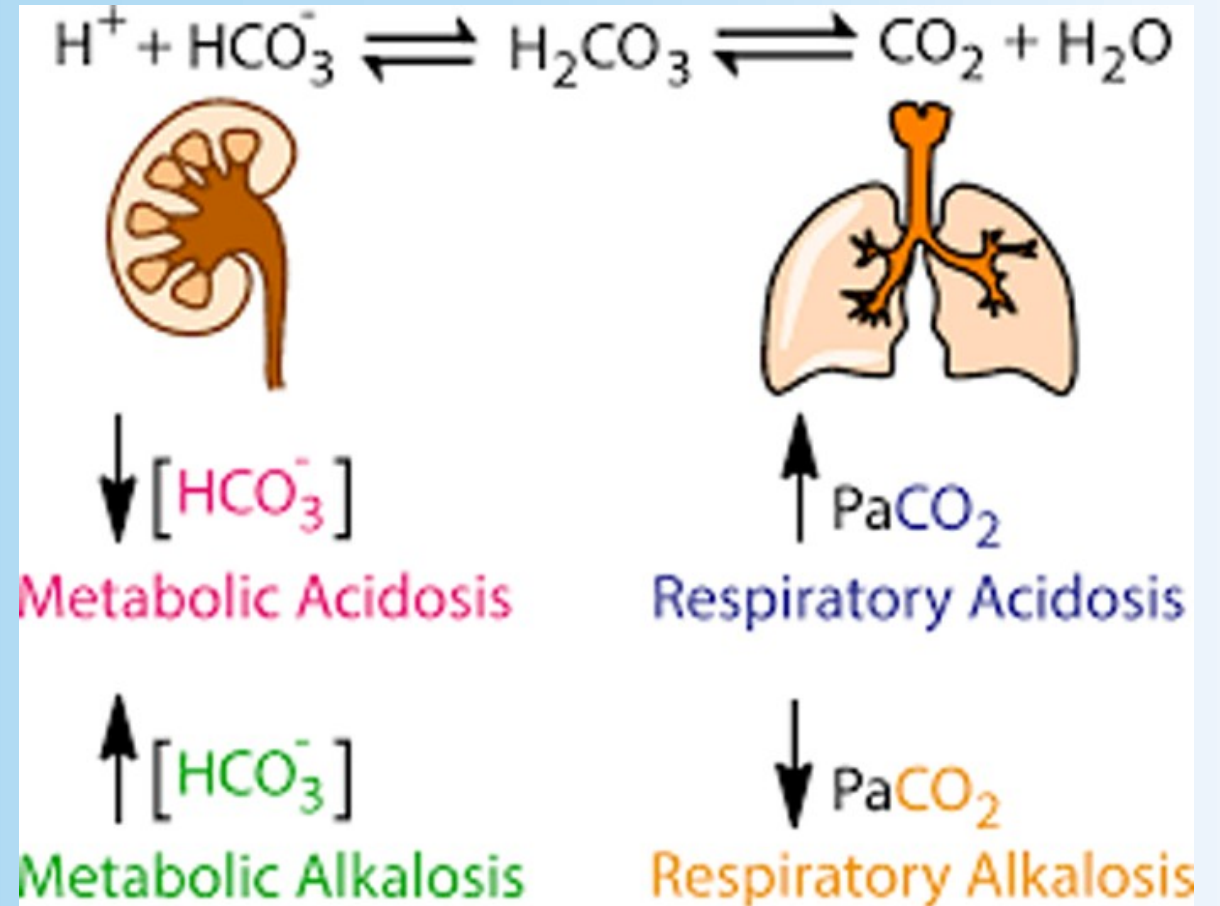
- **Cerebral edema:** excess fluid accumulates in the brain tissue, increasing intracranial pressure (ICP).
- Skull cannot expand, so swelling compresses brain structures and reduces cerebral blood flow.
- **Vasogenic edema: blood-brain barrier is disrupted** → plasma fluid and proteins to leak into the extracellular space.
 - Commonly seen in **brain tumors, trauma, inflammation, and abscesses**.
- **Cytotoxic edema: cellular injury and ATP depletion**, causing failure of Na^+/K^+ pumps and intracellular water accumulation.
 - Common in **ischemic stroke, hypoxia, and severe metabolic disturbances**.
- **Interstitial edema:** cerebrospinal fluid (CSF) crosses the ventricular lining into brain tissue, usually due to **hydrocephalus**.
 - Inflammation and injury can increase release of cytokines and mediators that worsen vascular permeability and swelling.
- Progressive cerebral edema can cause **brain herniation**, a life-threatening displacement of brain tissue.
- Clinical manifestations: **headache, vomiting, confusion, seizures, decreased consciousness, and papilledema**.

Acid-base balance

- pH maintained between 7.35 and 7.45
- Lungs regulate CO_2
- Kidneys regulate bicarbonate (HCO_3^-)
- Disturbances cause acidosis (low pH) or alkalosis (high pH)

Arterial blood gas analysis (simplest interpretation)

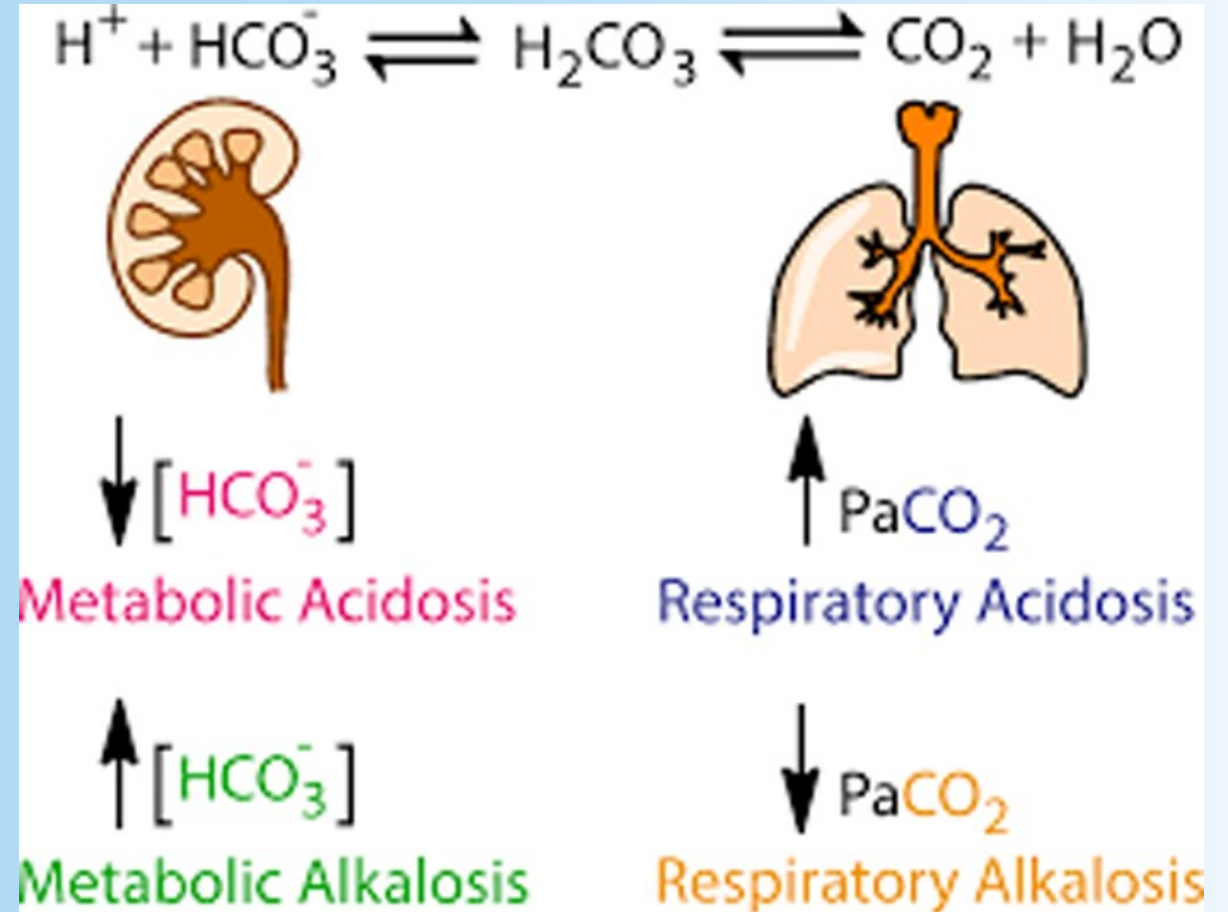
1. Look at pH
2. Look at PaCO_2
3. Look at HCO_3^-
4. Determine compensation



Acid-base disorders

Respiratory

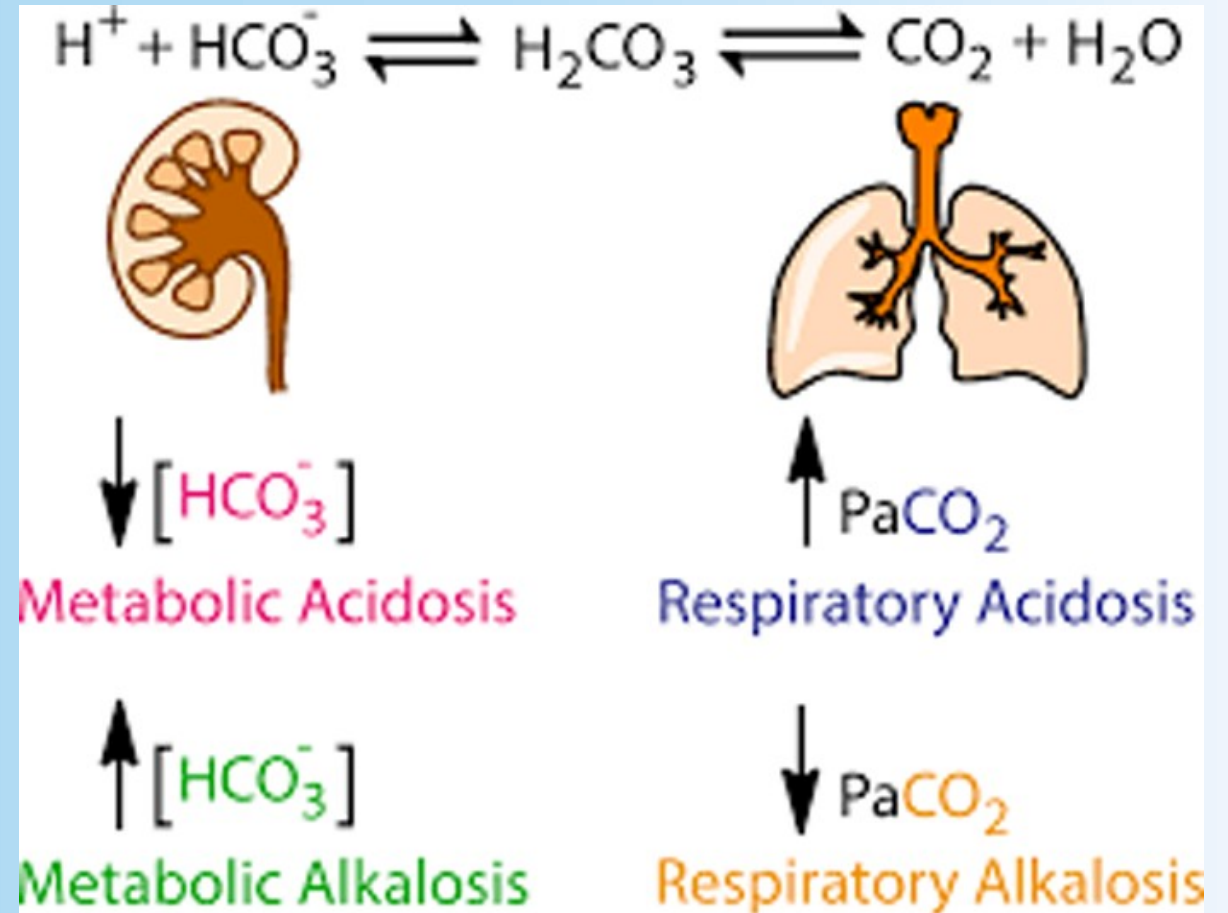
- Respiratory acidosis
 - Can't get rid of CO_2
 - CO_2 is acidic in water (forms H_2CO_3)
 - High pCO_2 in blood $\rightarrow$ $\downarrow$ pH
- Respiratory alkalosis
 - Got rid of too much CO_2
 - Example: hyperventilation
 - $\rightarrow$ $\uparrow$ pH



Acid-base disorders

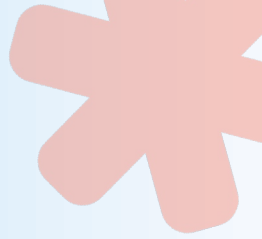
Metabolic

- Metabolic acidosis
 - Loss of HCO_3^- or buildup of other acidic substances in the blood
 - $\rightarrow \downarrow \text{pH}$
- Metabolic alkalosis
 - Kidneys retain too much HCO_3^-
 - $\rightarrow \uparrow \text{pH}$



Acid-base compensatory mechanisms

Respiratory



A. Metabolic Acidosis → Respiratory Compensation

Primary problem

There is too little bicarbonate (HCO_3^-) or too much acid.

Examples:

- Diabetic ketoacidosis (DKA)
- Renal failure
- Severe diarrhea
- Lactic acidosis

What happens to pH?

pH decreases → acidosis

How do the lungs compensate?

The lungs try to remove acid by **blowing off CO_2** .



Less CO_2 = less acid.

Mechanism

- Patient **hyperventilates**
- Faster/deeper breathing lowers CO_2
- Lower CO_2 helps raise pH toward normal

Clinical example

Kussmaul breathing in Diabetic Ketoacidosis (DKA):

Deep, rapid respirations



Acid-base compensatory mechanisms

Respiratory

B. Metabolic Alkalosis → Respiratory Compensation

What is the primary problem?

Too much bicarbonate or loss of acid.

Examples:

- Vomiting
- Diuretic use

What happens to pH?

pH increases → alkalosis

How do the lungs compensate?

The lungs try to retain acid by keeping more CO_2 .

Mechanism

- Patient **hypoventilates**
- Slower breathing retains CO_2
- Increased CO_2 lowers pH toward normal

Important limitation

Respiratory compensation is usually mild because severe hypoventilation would reduce oxygen levels.

Acid-base compensatory mechanisms

Metabolic

C. Respiratory Acidosis → Metabolic Compensation

What is the primary problem?

Too much CO_2 due to hypoventilation.

Examples:

- COPD
- Opioid overdose
- Severe asthma
- CNS depression

What happens to pH?

CO_2 increases → more acid → pH decreases

How do the kidneys compensate?

Kidneys try to retain bicarbonate and excrete H^+ .

Mechanism

- Increased H^+ secretion
- Increased HCO_3^- reabsorption
- More bicarbonate enters blood

Important point

Renal compensation takes **hours to days**.

Acid-Base Compensatory Mechanisms

D. Respiratory Alkalosis → Metabolic Compensation

What is the primary problem?

Too little CO_2 due to hyperventilation.

Examples:

- Anxiety/panic attack
- Sepsis
- High altitude
- Pregnancy

What happens to pH?

CO_2 decreases → less acid → pH increases

How do the kidneys compensate?

Kidneys excrete bicarbonate and retain H^+ .

Mechanism

- Reduced H^+ secretion
- Increased HCO_3^- excretion

Acid-base disorders

ABG analysis

- ROME Rule for Primary Disturbance Determination:

Compare pH with abnormal value

- Respiratory → Opposite
- Metabolic → Equal

ABG	pH	PaCO ₂	HCO ₃
Respiratory Acidosis	↓	↑	normal
Respiratory Alkalosis	↑	↓	normal
Metabolic Acidosis	↓	normal	↓
Metabolic Alkalosis	↑	normal	↑

Acid-base disorders

ABG analysis

Uncompensated

- Respiratory:
 - pH below (acidosis) or above (alkalosis) normal
 - PaCO₂ above (acidosis) or below (alkalosis) normal
 - HCO₃⁻ normal
- Metabolic:
 - pH below (acidosis) or above (alkalosis) normal
 - HCO₃⁻ below (acidosis) or above (alkalosis) normal
 - PaCO₂ normal

Partial compensation

- Respiratory:
 - pH below (acidosis) or above (alkalosis) normal
 - PaCO₂ above (acidosis) or below (alkalosis) normal
 - HCO₃⁻ above (base comp.) or below (acid comp.) normal
- Metabolic:
 - pH below (acidosis) or above (alkalosis) normal
 - HCO₃⁻ below (acidosis) or above (alkalosis) normal
 - PaCO₂ below (base comp.) or above (acid comp.) normal

Full compensation

- Respiratory:
 - pH in bottom (acidosis) or in top (alkalosis) of normal range
 - PaCO₂ above (acidosis) or below (alkalosis) normal
 - HCO₃⁻ above (base comp.) or below (acid comp.) normal
- Metabolic:
 - pH in bottom (acidosis) or in top (alkalosis) of normal range
 - HCO₃⁻ below (acidosis) or above (alkalosis) normal
 - PaCO₂ below (base comp.) or above (acid comp.) normal

Example Question

You do an arterial blood gas on a man resulting in the following values:

pH: 7.53

PaCO₂: 40 mm Hg (35-45 mm Hg)

PaO₂: 88 mm Hg (80-100 mm Hg)

[HCO₃]: 36 mEq/ L (22- 26 mEq/L)

What is the acid-base disturbance?

Solution

1. Check pH for acidosis, alkalosis or compensated state:

Alkalosis

2. Check for abnormalities in the ABG:

High $[\text{HCO}_3^-]$

3. Apply ROME rule:

pH is high, $[\text{HCO}_3^-]$ is high $\rightarrow$ metabolic

Therefore, this is a uncompensated metabolic alkalosis

Example Question

- You do an ABG on a man and observe the following values:

pH: 7.30 (7.35-7.45)

PaCO₂: 60 mm Hg (35 - 45 mm Hg)

PaO₂: 66 mm Hg (80 -100 mm Hg)

HCO₃: 30 mEq/L (22 - 26 mEq/L)

What is the acid-base disturbance?

Solution

1. Check pH for acidosis, alkalosis or compensated state:

Acidosis

2. Check for abnormalities in the ABG:

PaCO₂ is high, [HCO₃] is high.

3. Apply ROME rule:

“ I think its respiratory” : pH=low and PaCO₂= high. Follows rule for respiratory primary disturbance.

“I think its metabolic” : pH=low and [HCO₃]= high. Does not follow Rule! This must be compensation

Therefore, this is a partially compensated respiratory acidosis

Example Question

54 year old Roman Jendruš presents to the emergency room for increasing shortness of breath. You decide to do an arterial blood gas and the results are shown below. What acid-base disturbance is observed?

pH: 7.37

PaCO₂: 28 mm Hg (35-45 mm Hg)

PaO₂: 88 mm Hg (80-100 mm Hg)

[HCO₃]: 18 mEq/ L (22- 26 mEq/L)

Solution

1. Check pH for acidosis, alkalosis or compensated state:

Fully Compensated in the acidic range ($7.37 < 7.40$)

2. Check for abnormalities in the ABG:

PaCO₂ is low, [HCO₃] is low

3. Apply ROME rule:

“I think its respiratory” : pH is low, PaCO₂ is low = Doesn’t follow rule! This must be compensation

“I think its metabolic” : pH is low, [HCO₃] is low= Follows rule of metabolic primary disturbance

Therefore, this is a fully compensated metabolic acidosis

Thank You for Listening. Let's try Wooclap!