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Renal Failure

Acute and Chronic



**Bowman's
Capsule**

100% filtrate produced

**Proximal
Tubule**

80% filtrate reabsorbed

**Active and passive
absorption**

**Loop of
Henle**

6% filtrate reabsorbed

H₂O and salt conservation

**Distal
Tubule**

9% Filtrate reabsorbed

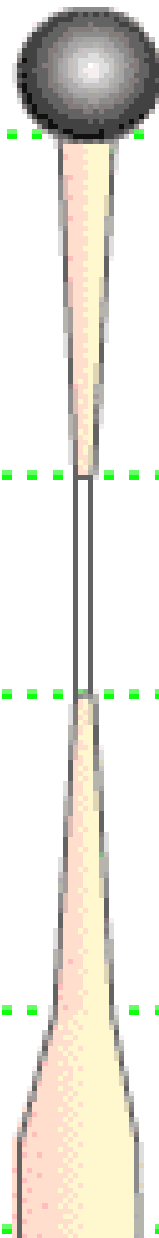
**Variable reabsorption,
active secretion**

**Collecting
Tubule**

4% Filtrate reabsorbed

**Variable salt and
H₂O reabsorption**

Urine vol. = 1% total filtrate volume



Healthy kidney

Functions:

Sodium and water removal

Waste removal

Hormone production

Unhealthy kidney

Problems:

Fluid overload

Elevated wastes such as:

- urea
- creatinine
- potassium

Changes in hormone levels controlling:

- blood pressure
- making red blood cells
- uptake of calcium

Kidney failure

Acute renal failure (ARF)

A sudden loss of kidney function caused by an illness, an injury, or a toxin that stresses the kidneys
(kidney function may recover)

Chronic kidney disease (CKD)

A long and usually slow process where the kidneys lose their ability to function

End-stage renal disease (ESRD)

When the kidneys have completely and permanently shut down

ARF



1

NORMAL



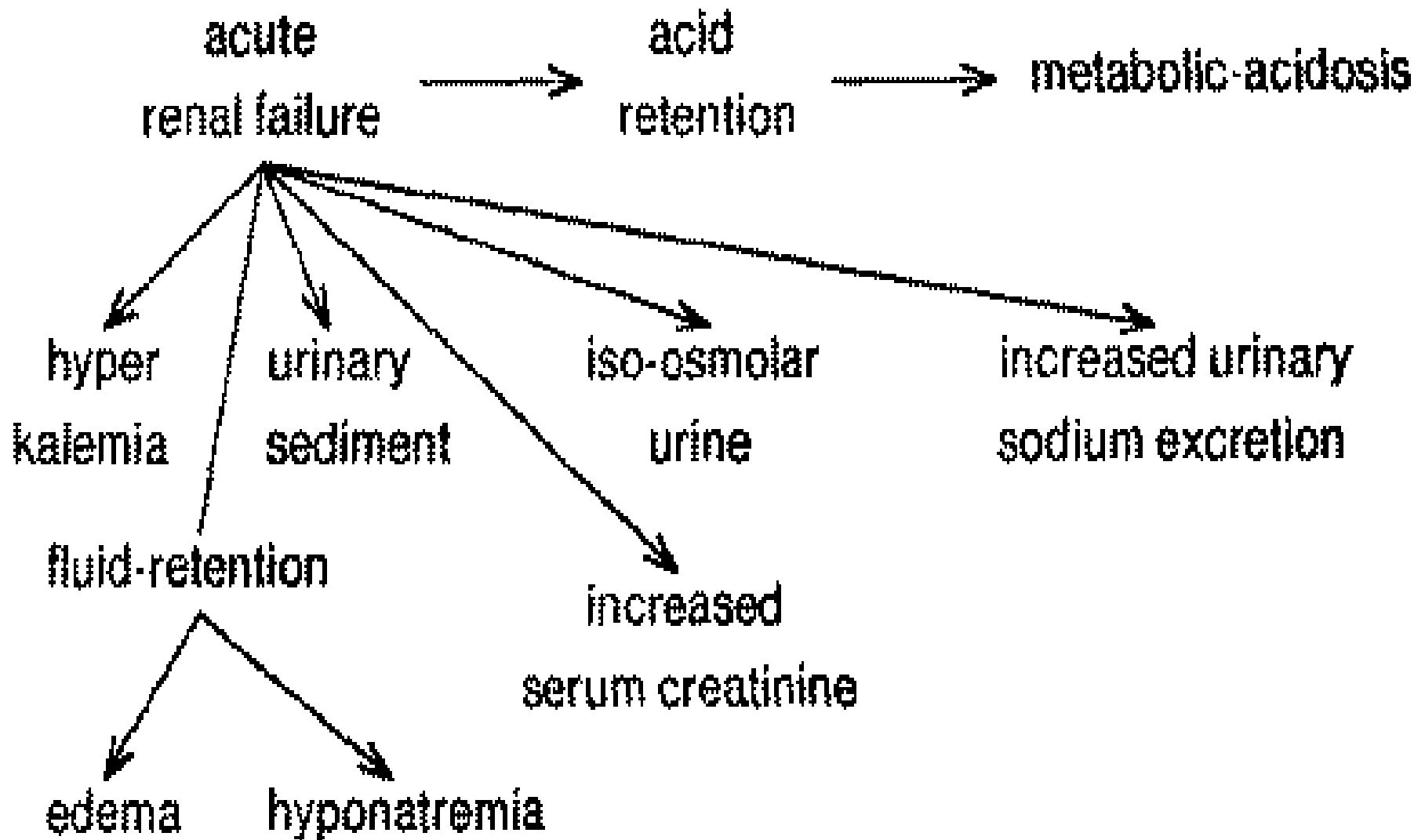
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CRF



3

ACUTE RENAL FAILURE (ARF)



Definition

- ⌈ Inability of kidney to maintain homeostasis leading to a buildup of nitrogenous wastes
- ⌈ Different to renal insufficiency where kidney function is deranged but can still support life

ARF

Υ Occurs over hours/days

Υ Lab definition

- ♣ Increase in baseline creatinine of more than 50%
- ♣ Decrease in creatinine clearance of more than 50%
- ♣ Deterioration in renal function requiring dialysis
 - Anuria – no urine output or less than 100mls/24 hours
 - Oliguria - <500mls urine output/24 hours or <20mls/hour
 - Polyuria - >2.5L/24 hours

Acute Renal Failure

Persons at Risks

- ♣ Major surgery
- ♣ Major trauma
- ♣ Receiving nephrotoxic medications
- ♣ Elderly

Renal insult



Advanced age



Proteinuria



Volume
depletion



Myeloma



Diuretic use



Diabetes
mellitus



Previous cardiac
or renal insufficiency



Higher probability
for ARF

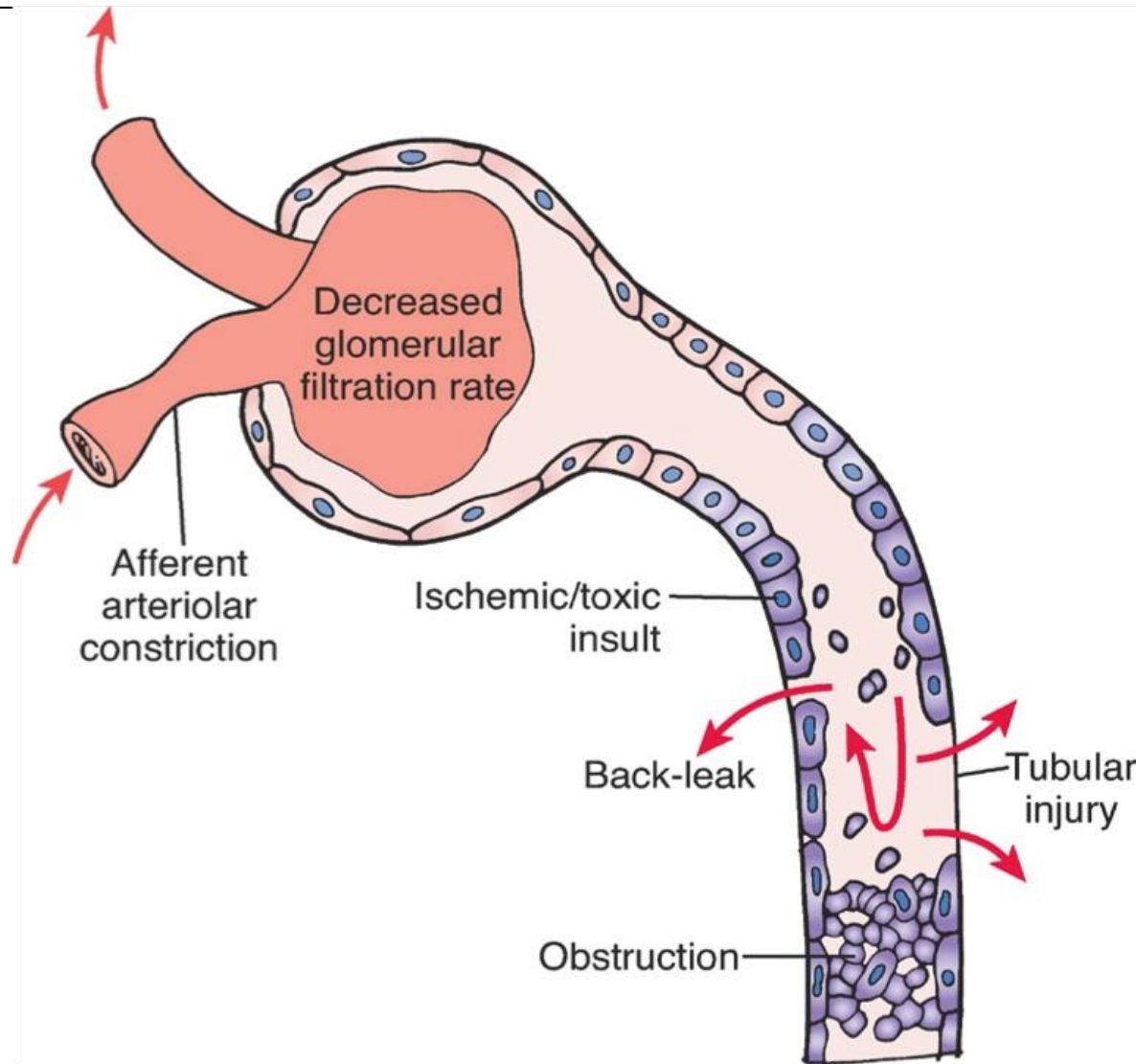


ARF

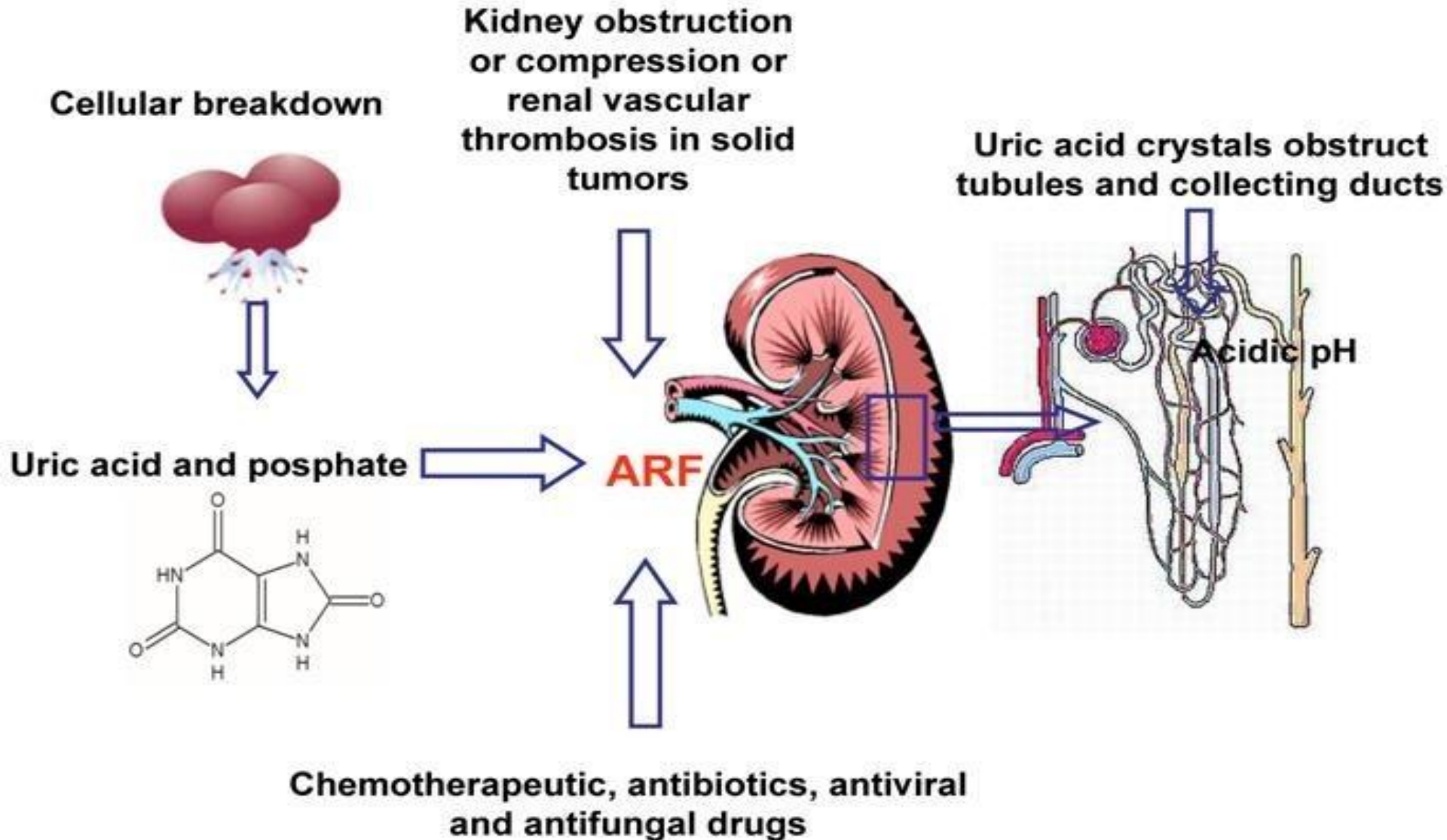
⌞ Pre renal
(functional)

⌞ Renal-intrinsic
(structural)

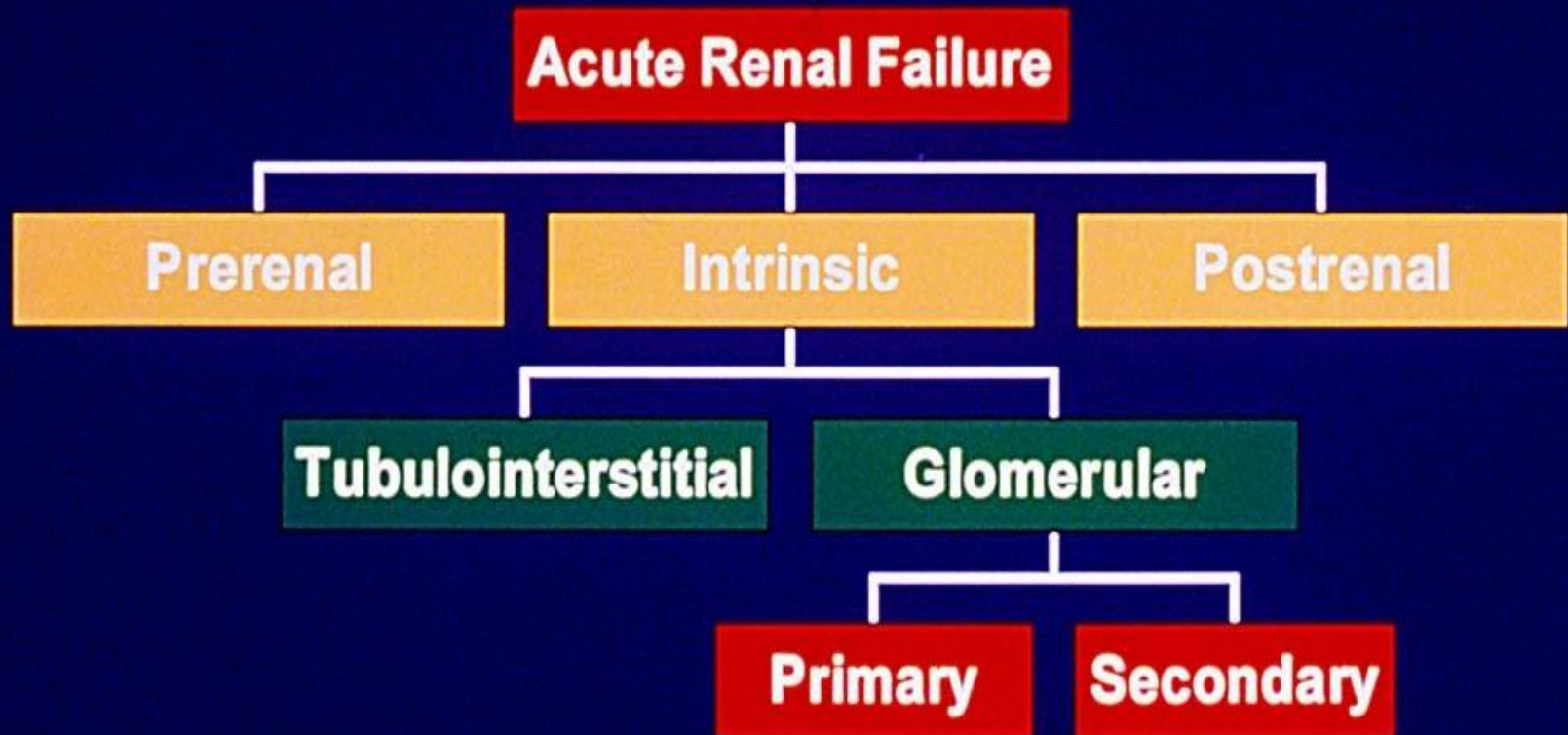
⌞ Post renal
(obstruction)



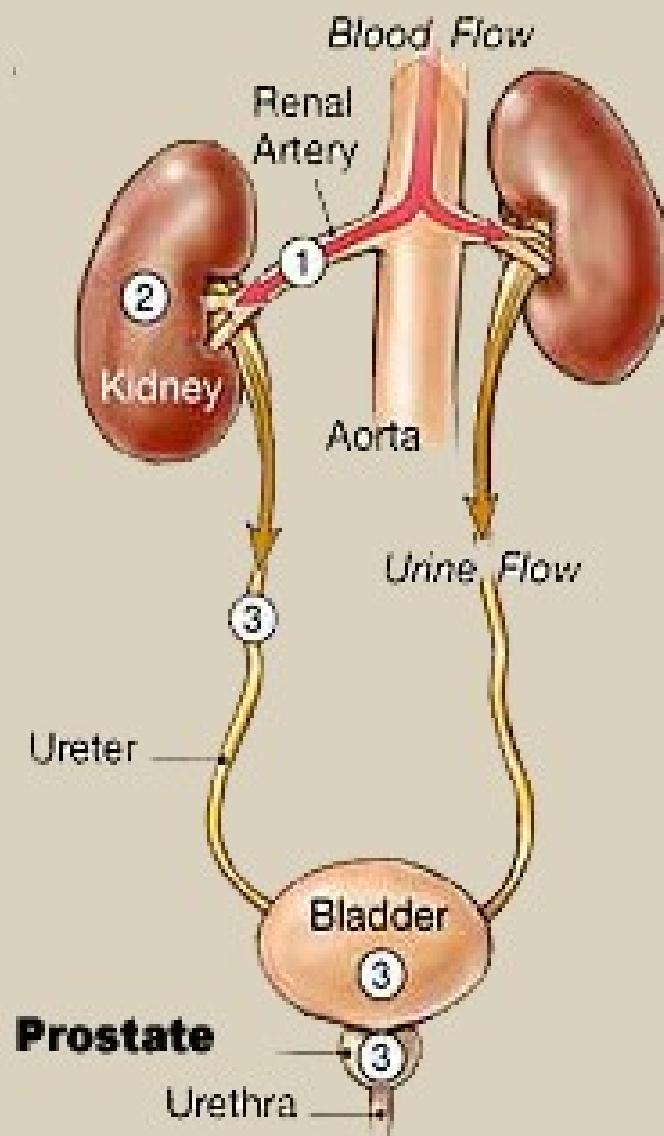
Multifactorial



Work-up of Acute Renal Failure



Causes of Acute Renal Failure

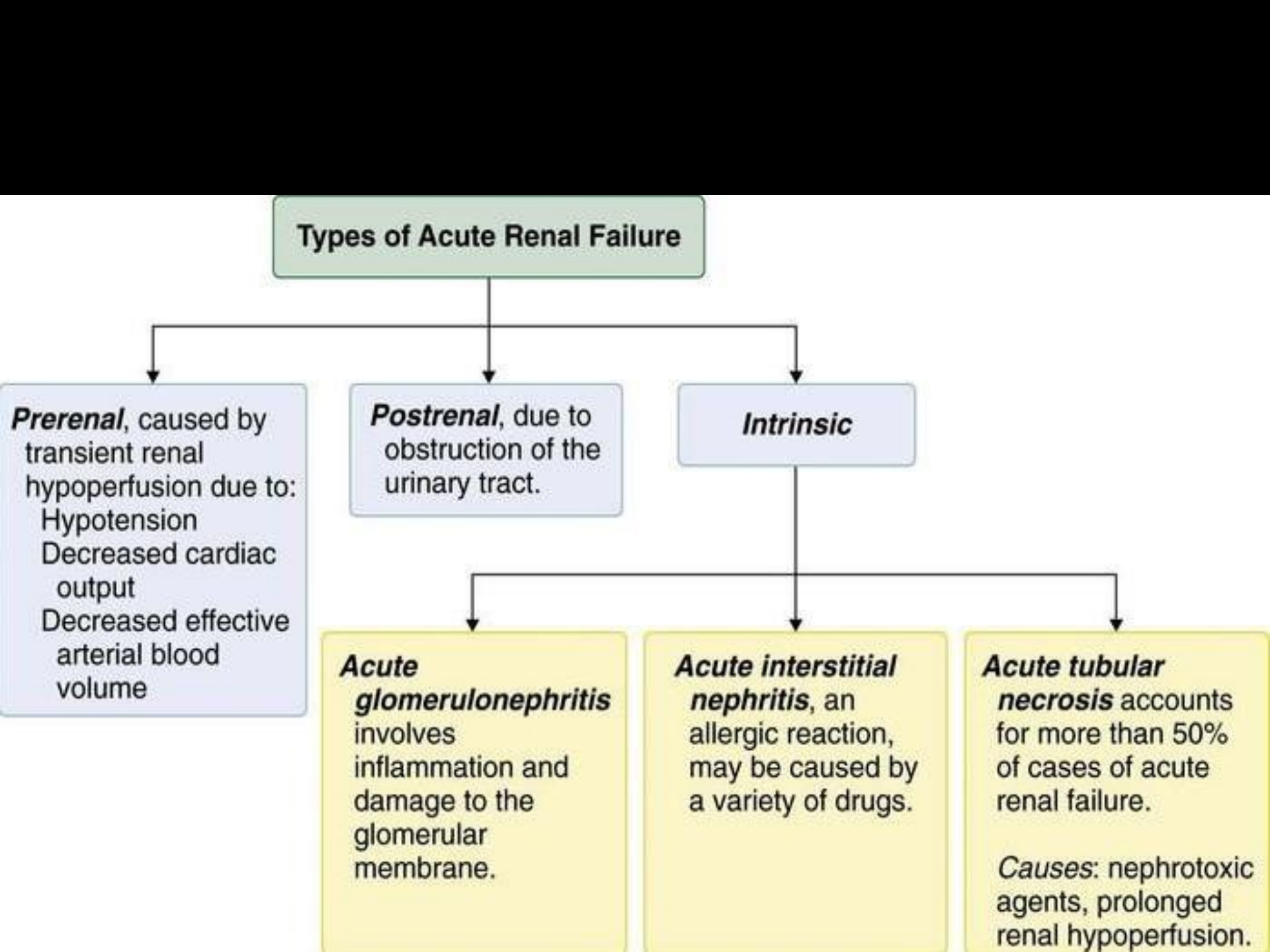


① Prerenal
Sudden and severe drop in blood pressure (shock) or interruption of blood flow to the kidneys from severe injury or illness

② Intrarenal
Direct damage to the kidneys by inflammation, toxins, drugs, infection, or reduced blood supply

③ Postrenal
Sudden obstruction of urine flow due to enlarged prostate, kidney stones, bladder tumor, or injury

Types of Acute Renal Failure



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graph TD; A[Types of Acute Renal Failure] --> B[Prerenal, caused by transient renal hypoperfusion due to: Hypotension, Decreased cardiac output, Decreased effective arterial blood volume]; A --> C[Postrenal, due to obstruction of the urinary tract.]; A --> D[Intrinsic]; D --> E[Acute glomerulonephritis involves inflammation and damage to the glomerular membrane.]; D --> F[Acute interstitial nephritis, an allergic reaction, may be caused by a variety of drugs.]; D --> G[Acute tubular necrosis accounts for more than 50% of cases of acute renal failure. Causes: nephrotoxic agents, prolonged renal hypoperfusion.];
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Prerenal, caused by transient renal hypoperfusion due to:
Hypotension
Decreased cardiac output
Decreased effective arterial blood volume

Postrenal, due to obstruction of the urinary tract.

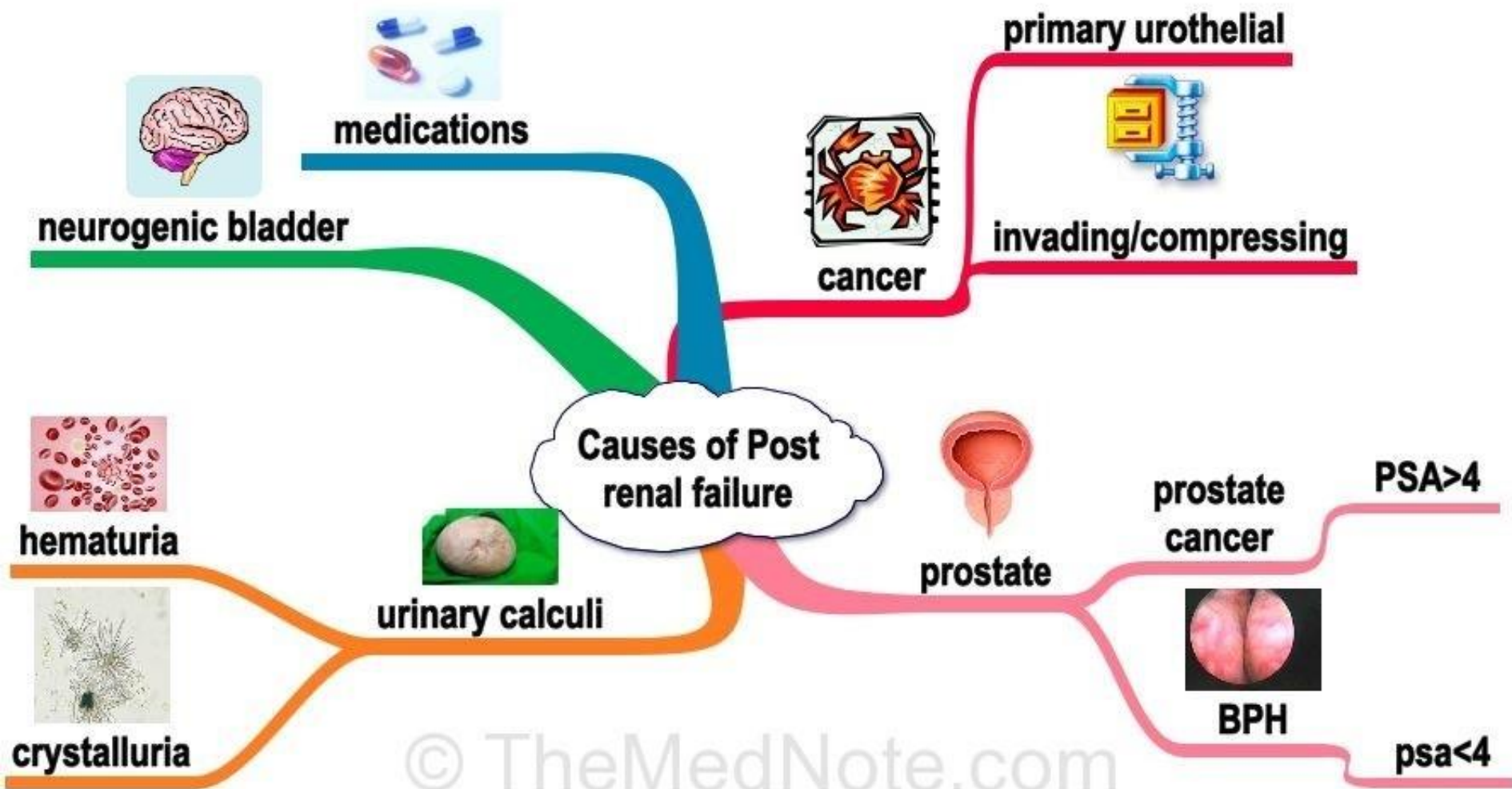
Intrinsic

Acute glomerulonephritis involves inflammation and damage to the glomerular membrane.

Acute interstitial nephritis, an allergic reaction, may be caused by a variety of drugs.

Acute tubular necrosis accounts for more than 50% of cases of acute renal failure.

Causes: nephrotoxic agents, prolonged renal hypoperfusion.



Ischemic or toxic insult

Hemodynamic changes

Afferent arteriolar
vasoconstriction

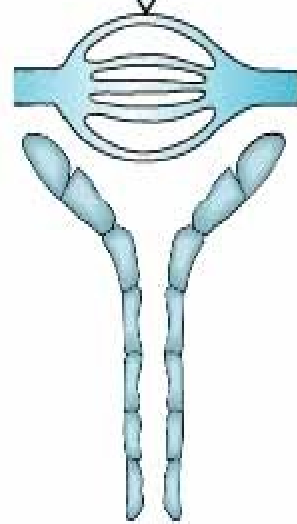
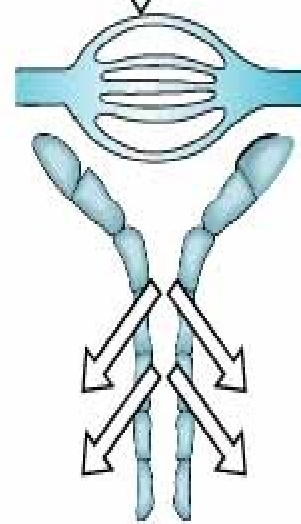
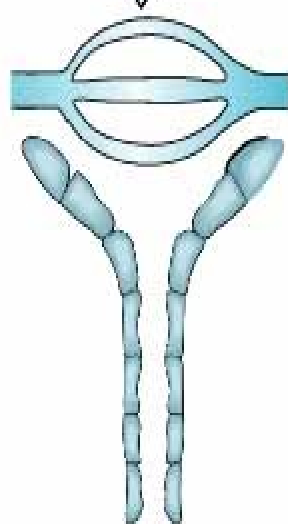
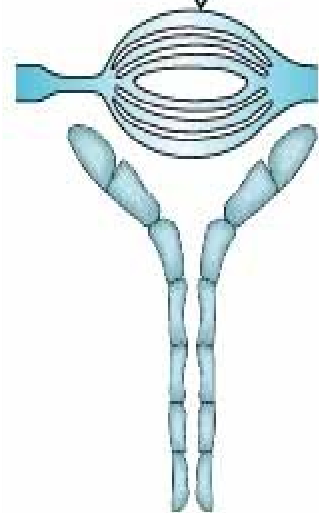
Mesangial
contraction

Reduced tubular
reabsorption of NaCl

Tubular injury and
dysfunction

Backleak of
glomerular filtrate

Tubular obstruction



Reduced GPF and P
Reduced glomerular
filtration surface area
available for filtration
and a fall in K_f

Increased delivery of
NaCl to distal nephron
(macula densa) and
activation of TG feedback

Backleak of urea,
creatinine,
and reduction in
"effective GFR"

Compromises patency
of renal tubules and
prevents the recovery
of renal function

Acute Renal Failure

Υ Stages

- ♣ **Onset** – 1-3 days with $\wedge$ BUN and creatinine and possible decreased UOP
- ♣ **Oliguric** – UOP $< 400/d$, $\wedge$ BUN, Crest, Phos, K, may last up to 14 d
- ♣ **Diuretic** – UOP $\wedge$ to as much as 4000 mL/d but no waste products, at end of this stage may begin to see improvement
- ♣ **Recovery** – things go back to normal or may remain insufficient and become chronic

ONSET PHASE

γ Subjective symptoms

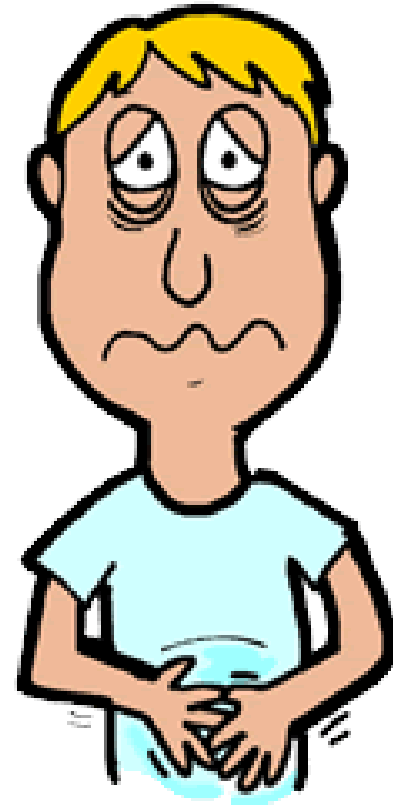
- ♣ Nausea
- ♣ Loss of appetite
- ♣ Headache
- ♣ Lethargy
- ♣ Tingling in extremities

OLIGURIC PHASE

- ♣ vomiting
- ♣ disorientation,
- ♣ edema,
- ♣ $\uparrow K^+$
- ♣ decrease Na
- ♣ $\uparrow$ BUN and creatinine
- ♣ Acidosis
- ♣ uremic breath
- γ CHF and pulmonary edema
- γ hypertension caused by hypovolemia, anorexia
- γ sudden drop in UOP
- γ convulsions, coma
- γ changes in bowels

DIURETIC PHASE

- Υ Increased UOP
- Υ Gradual decline in BUN and creatinine
- Υ Hypokalemia
- Υ Hyponatremia
- Υ Tachycardia
- Υ Improved LOC



Lab findings

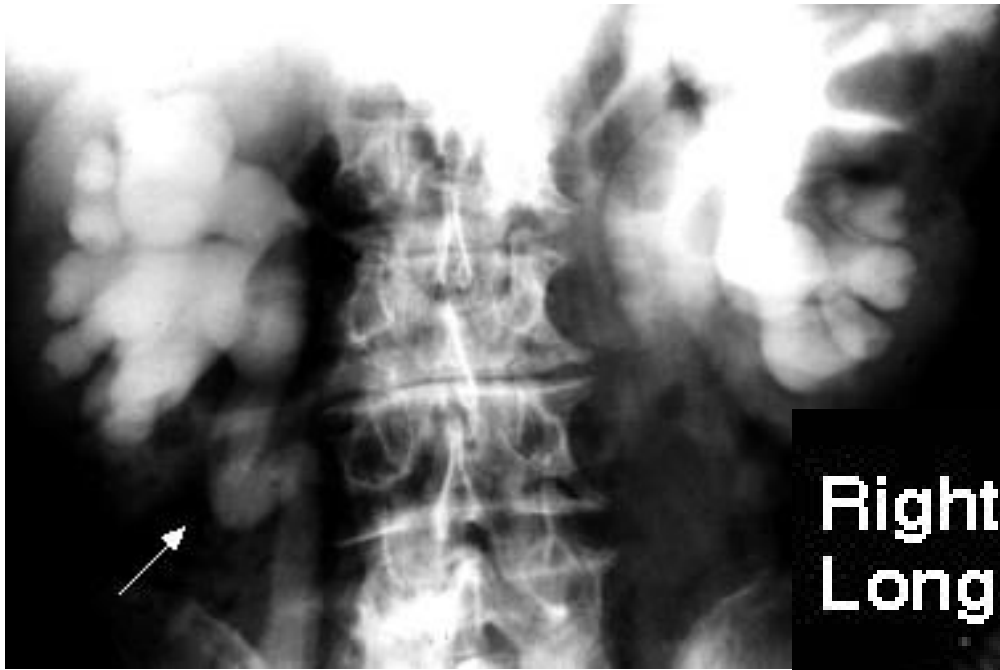
- Υ Rising creatinine and urea
- Υ Rising potassium
- Υ Decreasing Hb
- Υ Acidosis
- Υ Hyponatraemia
- Υ Hypocalcaemia

Acute Renal Failure

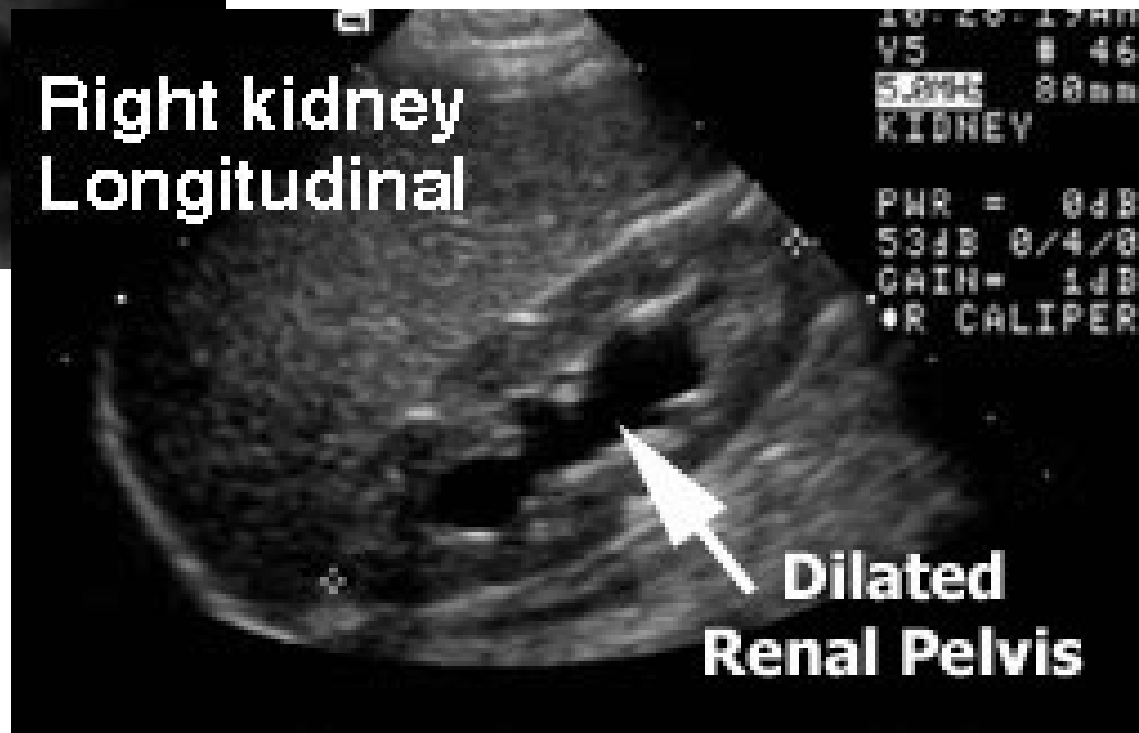
Diagnostic Tools

- Υ Urinary sediment
- Υ Urinary indices
 - ♣ Urine volume
 - ♣ Urine electrolytes
- Υ Radiologic studies

Hydronephrosis

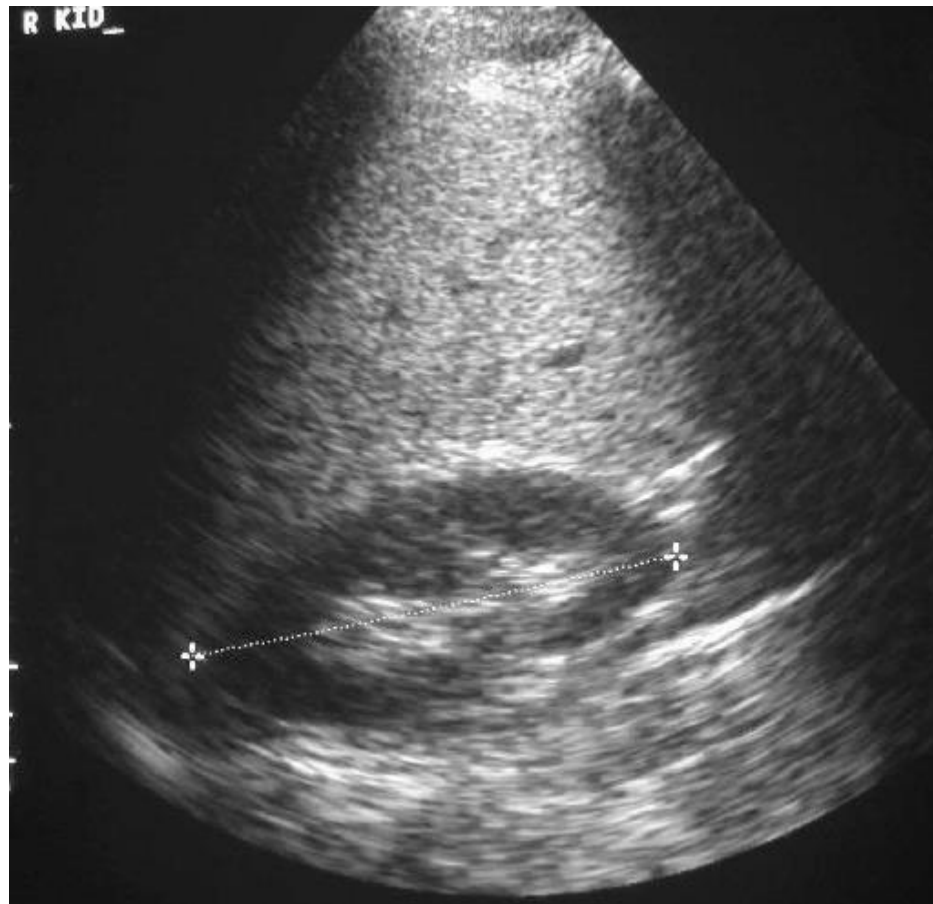


Right kidney
Longitudinal



Dilated
Renal Pelvis

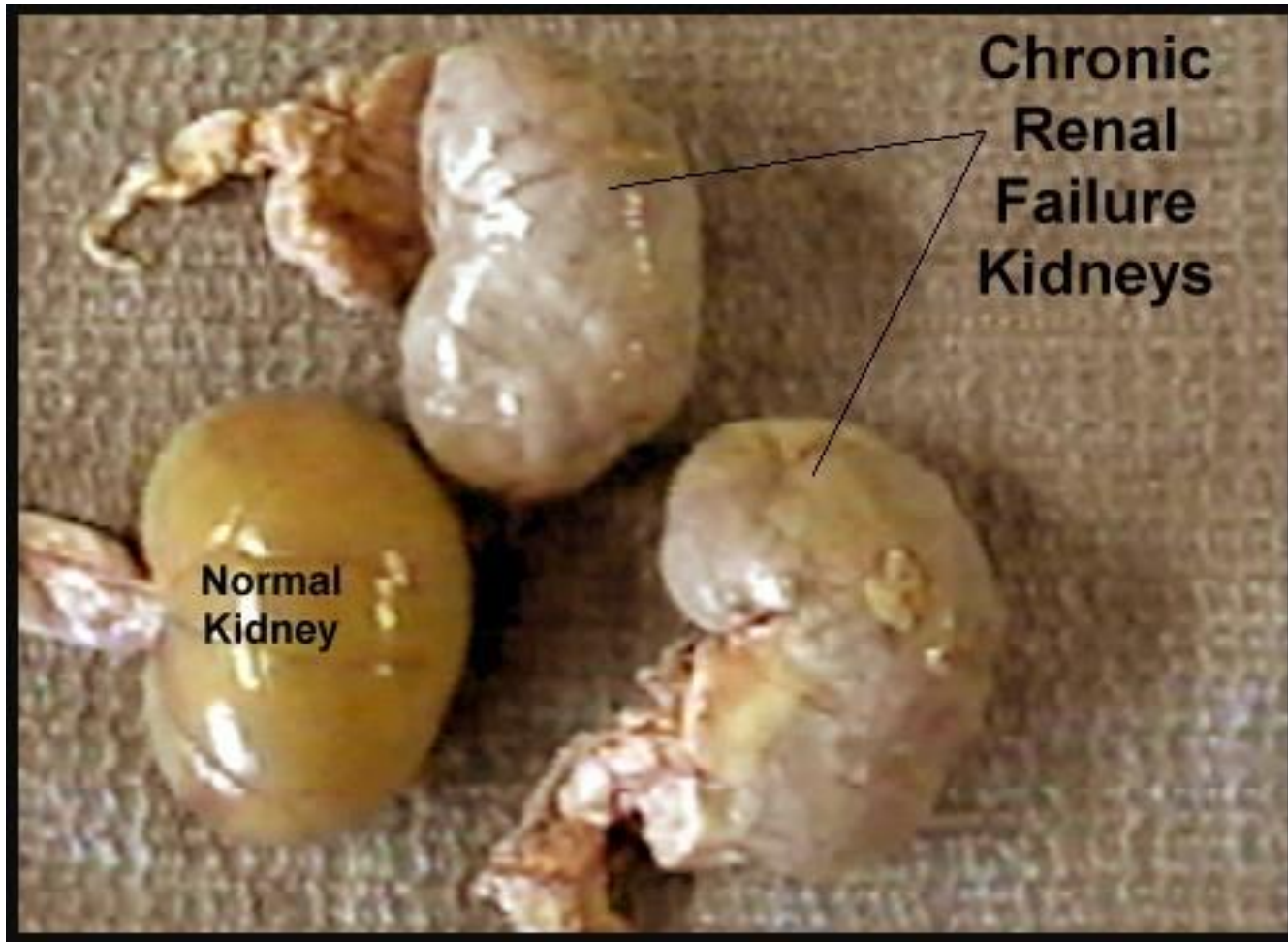
Normal Renal Ultrasound



		RIFLE criteria	
		sCreatinine	Urine output criteria
Increasing severity Outcome	Risk	$\uparrow$ sCrea $\times 1.5$	< 0.5 ml/kg per h $\times 6$ h
	Injury	$\uparrow$ sCrea $\times 2$	< 0.5 ml/kg per h $\times 12$ h
	Failure	$\uparrow$ sCrea $\times 3$ or ≥ 0.5 mg/dl if baseline sCrea $\uparrow > 4.0$ mg/dl	< 0.3 ml/kg per h $\times 24$ h or anuria $\times 12$ h
	Loss	Complete loss of renal function > 4 weeks	
	End-stage	End-stage renal disease	

		AKIN criteria	
		sCreatinine	Urine output criteria
Increasing severity	Stage 1	$\uparrow$ sCrea $\times 1.5$ or $\uparrow \geq 0.3$ mg/dl in sCrea	< 0.5 ml/kg per h $\times 6$ h
	Stage 2	$\uparrow$ sCrea $\times 2$	< 0.5 ml/kg per h $\times 12$ h
	Stage 3	$\uparrow$ sCrea $\times 3$ or $\uparrow \geq 0.5$ mg/dl if baseline sCrea > 4.0 mg/dl	< 0.3 ml/kg per h $\times 24$ h or anuria $\times 12$ h
	Patients who receive RRT are considered to have met stage 3 criteria, irrespective of the stage they are in at the time of RRT		

CHRONIC RENAL FAILURE



Definition

Υ Involves progressive, irreversible loss of kidney function

Υ Defined as either presence of

- ♣ Kidney damage

- Pathological abnormalities

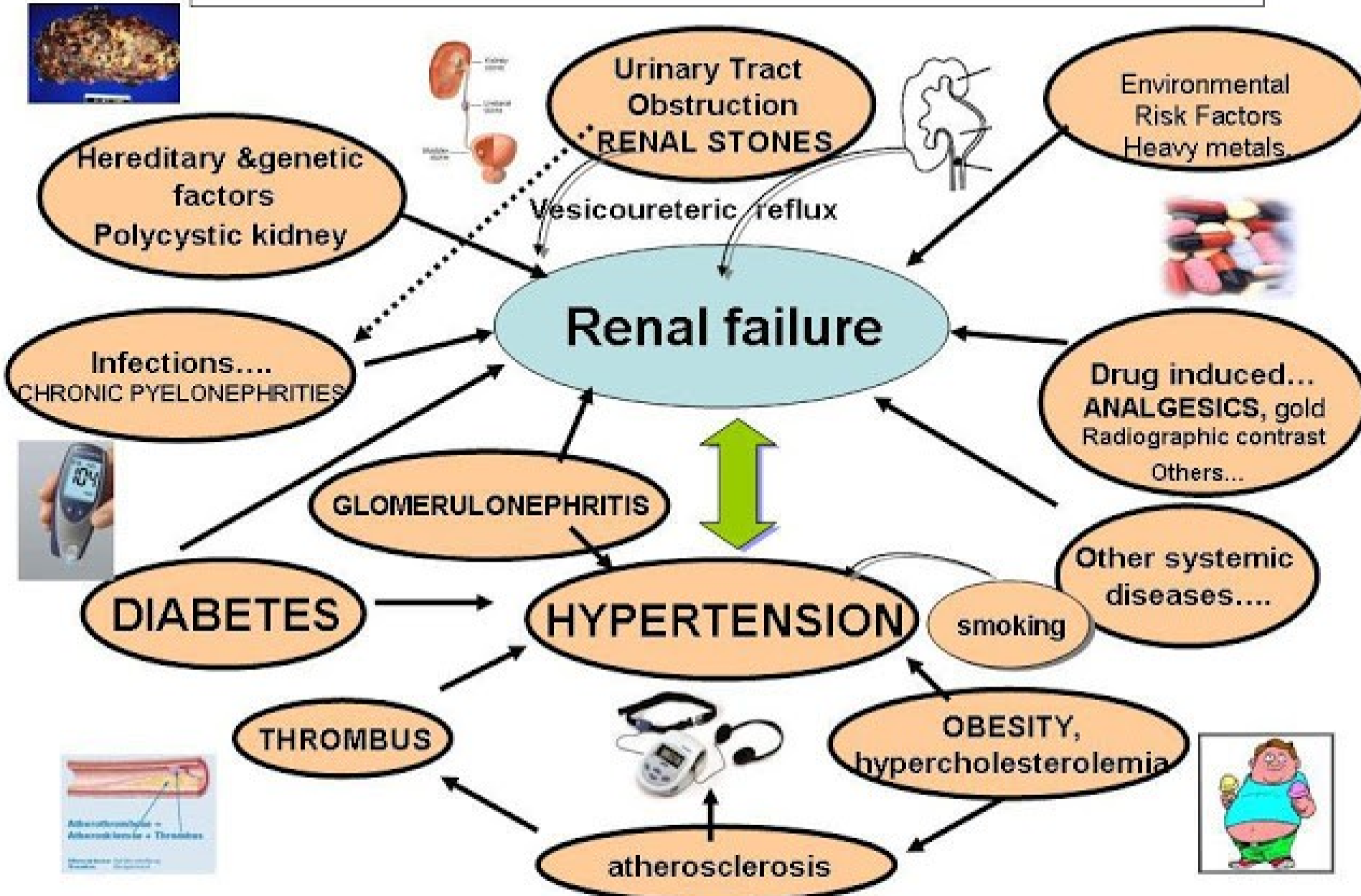
- ♣ Glomerular filtration rate (GFR)

- <60 ml/min for 3 months or longer

The Five Stages of Chronic Kidney Disease

Stage	Description	Glomerular Filtration Rate (GFR)	Kidney Function Deterioration*
1	Kidney damage (protein in urine) and normal GFR	More than 90	50% - 60%
2	Kidney damage and mild decrease in GFR	60 - 88	60% - 70%
3	Moderate decrease in GFR	30 - 59	70% - 77.5%
4	Severe decrease in GFR	15 - 29	77.5% - 85%
5	Kidney failure—End Stage Renal Disease (dialysis or kidney transplant needed)	Less than 15	85% and above

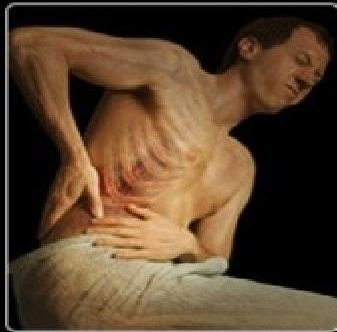
Risk factor for Chronic Renal Failure



CRF - causes

- Υ Glomerulonephritis – the most common cause in the past
- Υ Diabetes mellitus
- Υ Hypertension
- Υ Tubulointerstitial nephritis
 - ♣ are now the leading causes of CRF

- BACK PAIN
- IRREGULAR HEARTBEAT
- KIDNEY STONES
- EXCESSIVE THIRST
- HIGH BLOOD PRESSURE

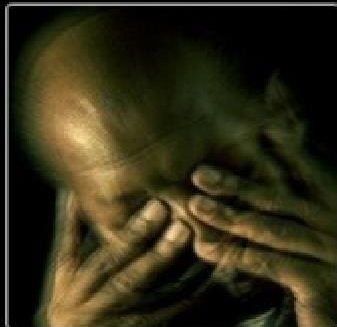


CALCIUM (EXCESS)

+
EXCESS

-
DEFICIENCY

CALCIUM (DEFICIENCY)



- MUSCLE SPAZMS
- TINGLING FINGERS
- MENTAL CONFUSION
- WEAK HEARTBEAT

- DRY MUCOUS MEMBRANES
- EXCESSIVE THIRST
- HIGH BLOOD PRESSURE
- WEAKNESS



SODIUM

SODIUM



- MUSCLE CRAMPS
- FATIGUE
- ABDOMINAL DISCOMFORT AND CRAMPS
- HEADACHE AND NAUSEA
- SEIZURES



HYPERTENSIVE
KIDNEY

- IRREGULAR HEARTBEAT
- MUSCLE WEAKNESS
(POSSIBLE PARALYSIS)
- FATIGUE
- NAUSEA



POTASSIUM

POTASSIUM



- IRREGULAR HEARTBEAT
- MUSCLE WEAKNESS
- FEELING OF PINS AND NEEDLES IN EXTREMITIES
- DECREASED APPETITE
- FREQUENT URINATION

- HIGH BLOOD PRESSURE
- EDEMA



RENIN



CALCITRIOL

- DEFORMED BONES
- WEAKENED BONES

Chronic Renal Failure

Υ Subjective symptoms are relatively same as acute

Υ Renal

- ♣ Hyponatremia
- ♣ Dry mouth
- ♣ Poor skin turgor
- ♣ Confusion, salt overload, accumulation of K with muscle weakness
- ♣ Fluid overload and metabolic acidosis
- ♣ Proteinuria, glycosuria
- ♣ Urine = RBC's, WBC's, and casts

Chronic Renal Failure

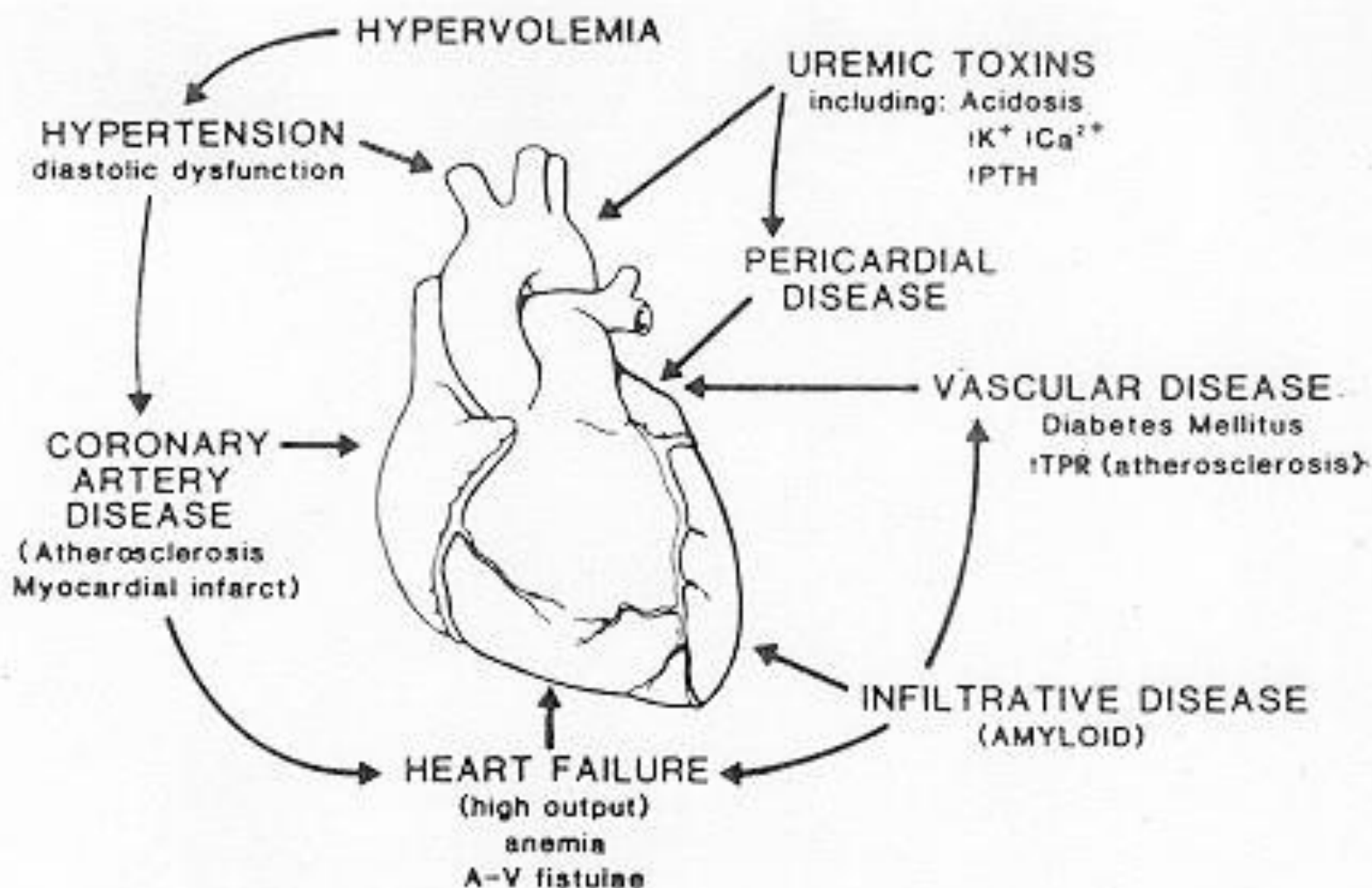
Υ Cardiovascular

- ♣ Hypertension
- ♣ Arrhythmias
- ♣ Pericardial effusion
- ♣ CHF
- ♣ Peripheral edema

Υ Neurological

- ♣ Burning, pain, and itching, paresthesia
- ♣ Motor nerve dysfunction
- ♣ Muscle cramping
- ♣ Shortened memory span
- ♣ Apathy
- ♣ Drowsy, confused, seizures, coma, EEG changes

Cardiovascular manifestations



Chronic Renal Failure

Y GI

- ♣ Stomatitis
- ♣ Ulcers
- ♣ Pancreatitis
- ♣ Uremic fetor
- ♣ Vomiting
- ♣ constipation

Y Respiratory

- ♣ ^ chance of infection
- ♣ Pulmonary edema
- ♣ Pleural friction rub and effusion
- ♣ Dyspnea
- ♣ Kussmaul's respirations from acidosis

Chronic Renal Failure

Υ Endocrine

- ♣ Stunted growth in children
- ♣ Amenorrhea
- ♣ Male impotence
- ♣ ^ aldosterone secretion
- ♣ Impaired glucose levels
R/T impaired CHO metabolism
- ♣ Thyroid and parathyroid abnormalities

Υ Hemopoietic

- ♣ Anemia
- ♣ Decrease in RBC survival time
- ♣ Blood loss from dialysis and GI bleed
- ♣ Platelet deficits
- ♣ Bleeding and clotting disorders – purpura and hemorrhage from body orifices , ecchymoses

Chronic Renal Failure

⌘Skeletal

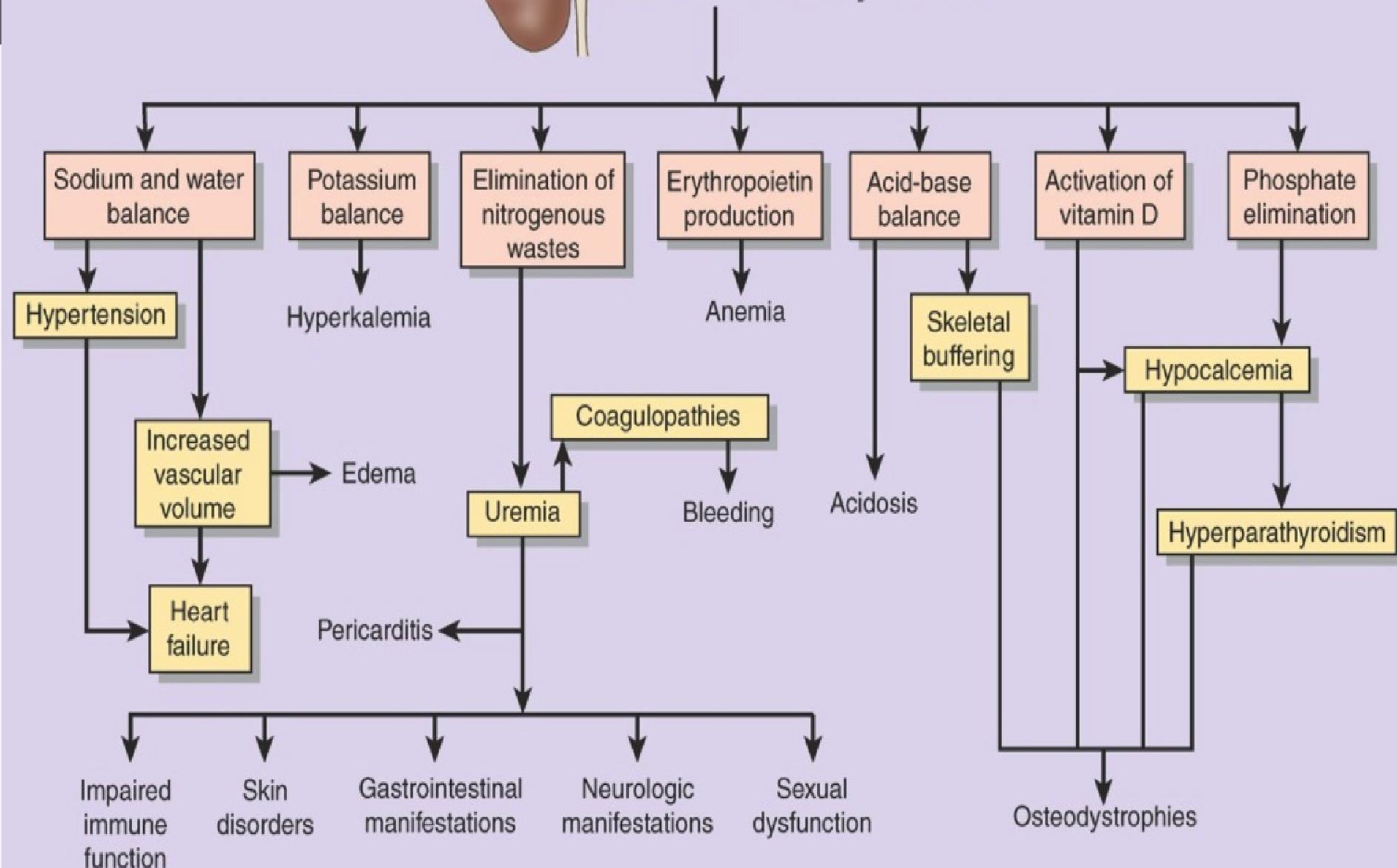
- ♣ Muscle and bone pain
- ♣ Bone demineralization
- ♣ Pathological fractures
- ♣ Blood vessel calcifications in myocardium, joints, eyes, and brain

⌘Skin

- ♣ Yellow-bronze skin with pallor
- ♣ Puritus
- ♣ Purpura
- ♣ Uremic frost
- ♣ Thin, brittle nails
- ♣ Dry, brittle hair, and may have color changes and alopecia



Chronic kidney disease



Uremia

- is clinical syndrome that results from profound loss of renal function
- cause(s) of it remains unknown
- refers generally to the constellation of signs and symptoms associated with CRF, regardless of cause
- presentations and severity of signs and symptoms of uremia vary and depend on
 - the magnitude of reduction in functioning renal mass
 - rapidity with which renal function is lost

Uremia

Υ the most likely candidates as toxins in uremia are the by-products of protein and amino acid metabolism

- ♣ Urea – represents some 80% of the total nitrogen excreted into the urine
- ♣ Guanidino compounds: guanidine, creatinine, creatin, guanidin-succinic acid)
- ♣ Urates and other end products of nucleic acid metabolism
- ♣ Aliphatic amines
- ♣ Peptides
- ♣ Derivates of the aromatic amino acids: tryptophan, tyrosine, and phenylalanine

Metabolic acidosis

Metabolic acidosis of CRF is not due to overproduction of endogenous acids but is largely a reflection of the **reduction in renal mass**, which limits the amount of NH_3 (and therefore HCO_3^-) that can be generated

The 10 A's of CKD

- Anemia
- Atherosclerosis
- Anti-angiotensin therapy
- Albumin
- Anions and Cations
- Arterial blood pressure
- Arterial Calcification
- Access
- Avoidance of nephrotoxic drugs
- Allograft

INVESTIGATIONS

- Υ **BUN** – indicator of glomerular filtration rate and is affected by the breakdown of protein. Normal is 10-20mg/dL. When reaches 70 = dialysis
- Υ **Serum creatinine** – waste product of skeletal muscle breakdown and is a better indicator of kidney function. Normal is 0.5-1.5 mg/dL. When reaches 10 x normal, it is time for dialysis
- Υ **Creatinine clearance** is best determinant of kidney function. Must be a 12-24 hour urine collection. Normal is > 100 ml/min

Υ K⁺ -

- ♣ The kidneys are means which K⁺ is excreted. Normal is 3.5-5.0 ,mEq/L. maintains muscle contraction and is essential for cardiac function.
- ♣ Both elevated and decreased can cause problems with cardiac rhythm
- ♣ Hyperkalemia is treated with IV glucose and Na Bicarb which pushes K⁺ back into the cell.

γ Ca

- ♣ With disease in the kidney, the enzyme for utilization of Vit D is absent
- ♣ Ca absorption depends upon Vit D
- ♣ Body moves Ca out of the bone to compensate and with that Ca comes phosphate bound to it.
- ♣ Normal Ca level is 4.5-5.5 mEq/L
- ♣ Hypocalcemia = tetany
 - Treat with calcium with Vit D and phosphate
 - Avoid antacids with magnesium

OTHER ABNORMAL FINDINGS

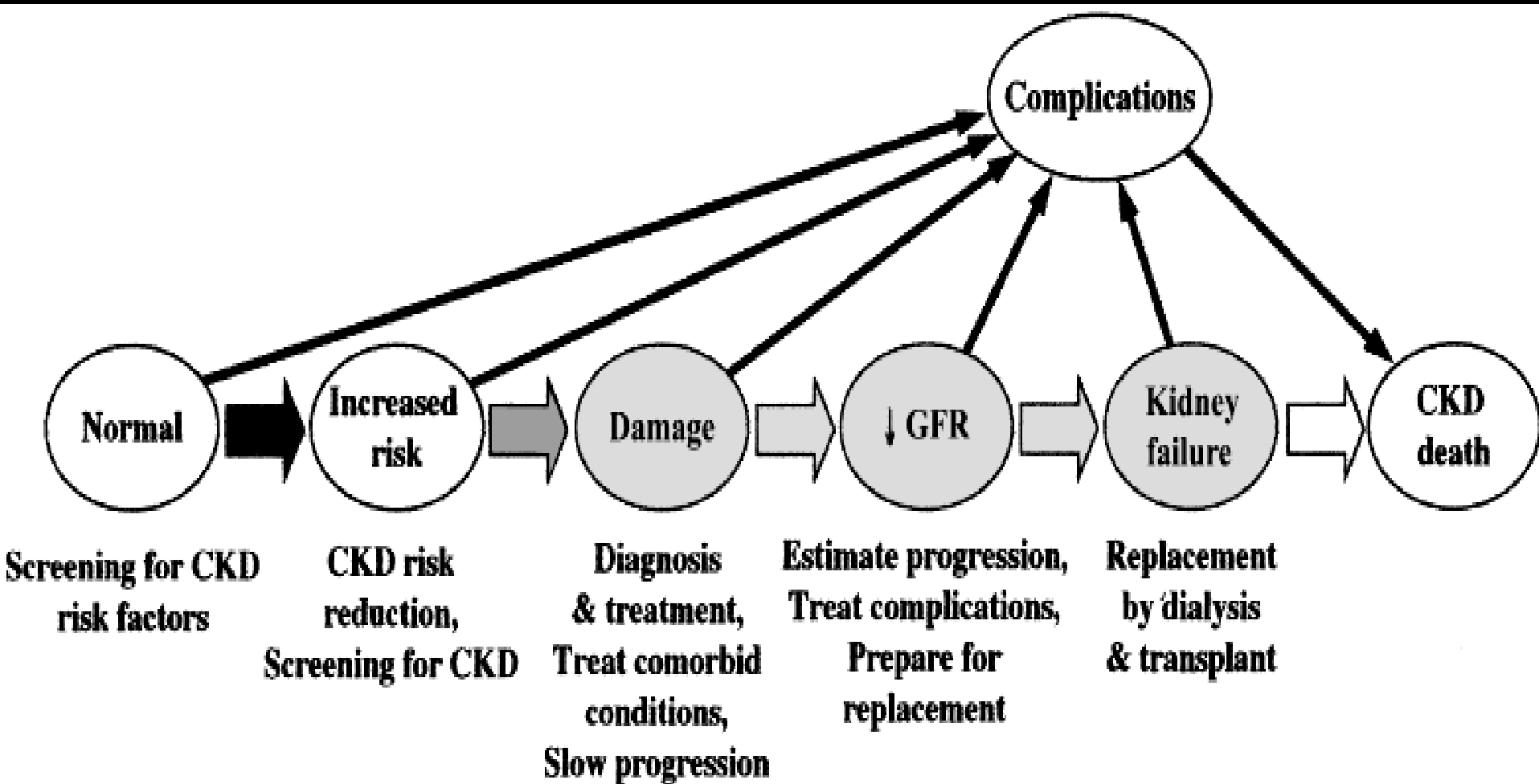
- Υ Metabolic acidosis
- Υ Fluid imbalance
- Υ Insulin resistance
- Υ Anemia
- Υ Immunological problems

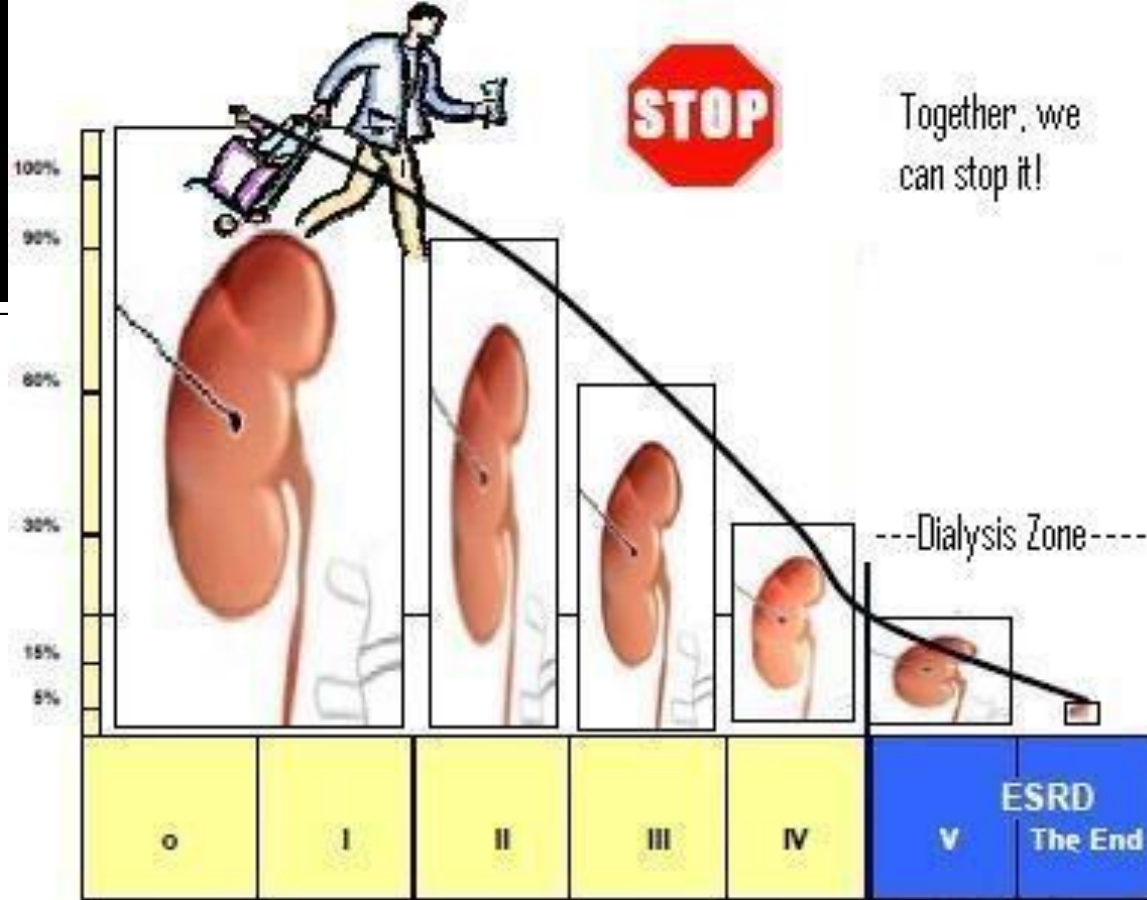
Transplant

- ♣ Must find donor
- ♣ Waiting period long
- ♣ Good survival rate – 1 year 95-97%
- ♣ Must take immunosuppressant's for life
- ♣ Decreased resistance to infections.
- ♣ Rejection
 - Watch for fever, elevated B/P, and pain over site of new kidney

What we can do at home

- **Potassium restriction**
 - 2 to 4 g
 - High-potassium foods should be avoided
 - Oranges
 - Bananas
 - Tomatoes
 - Green vegetables
- **Phosphate restriction**
 - 1000 mg/day
 - Foods high in phosphate
 - Dairy products
 - Most foods high in phosphate are also high in calcium





The progression of the kidney disease is different between patients

Most of the Patients could stay in the same stage for years!

Anemia, Renal bone disease, malnutrition, high blood pressure, fluid retention, heart failure, or weakness resulted from reduced kidney function could be prevented and treated.