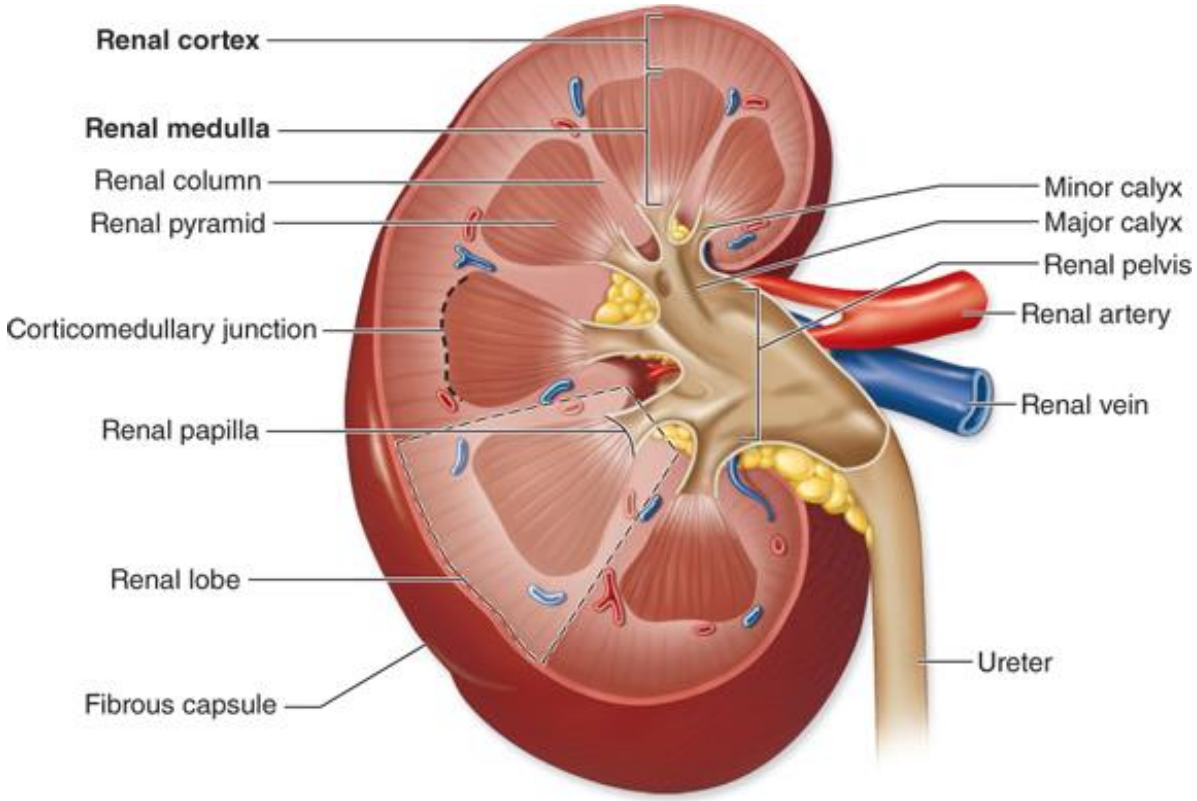
Renal block

Acute kidney injury

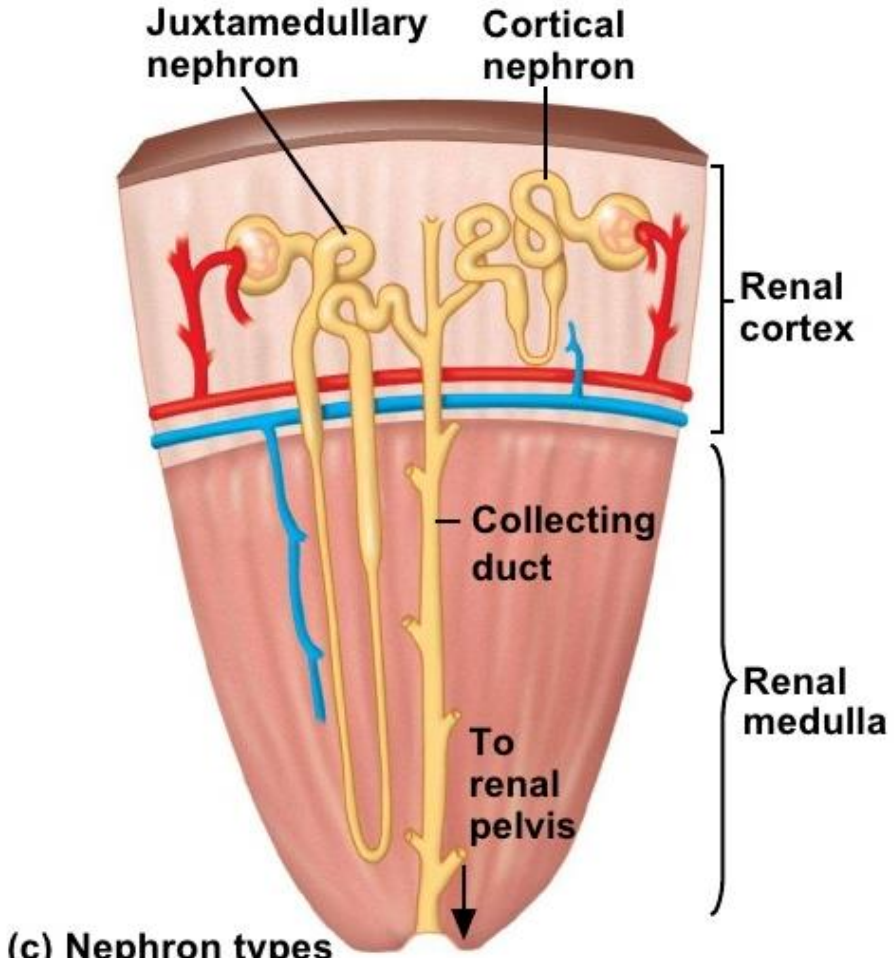
Acute kidney injury objectives

- Introduction to the renal pathology
- Acute Kidney Injury
- Definition, Types, Clinical Overview, Causes
- Pathological findings

Introduction to the renal pathology

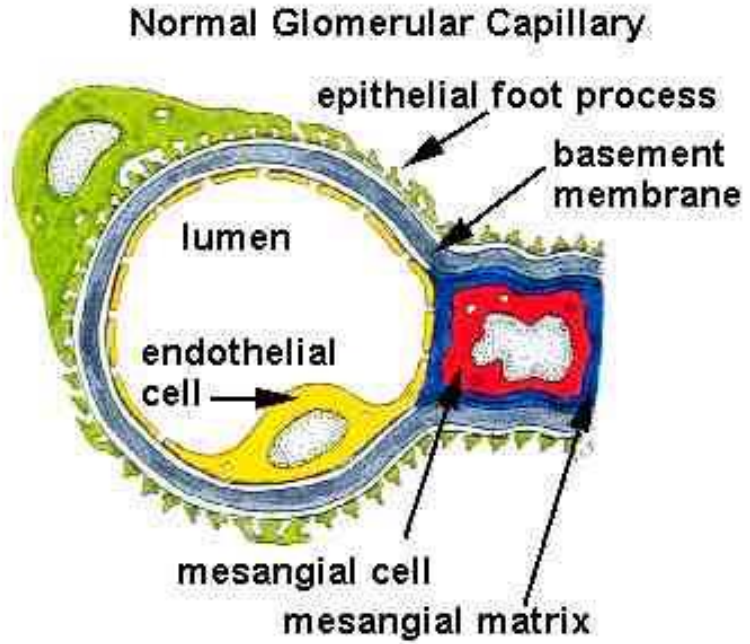


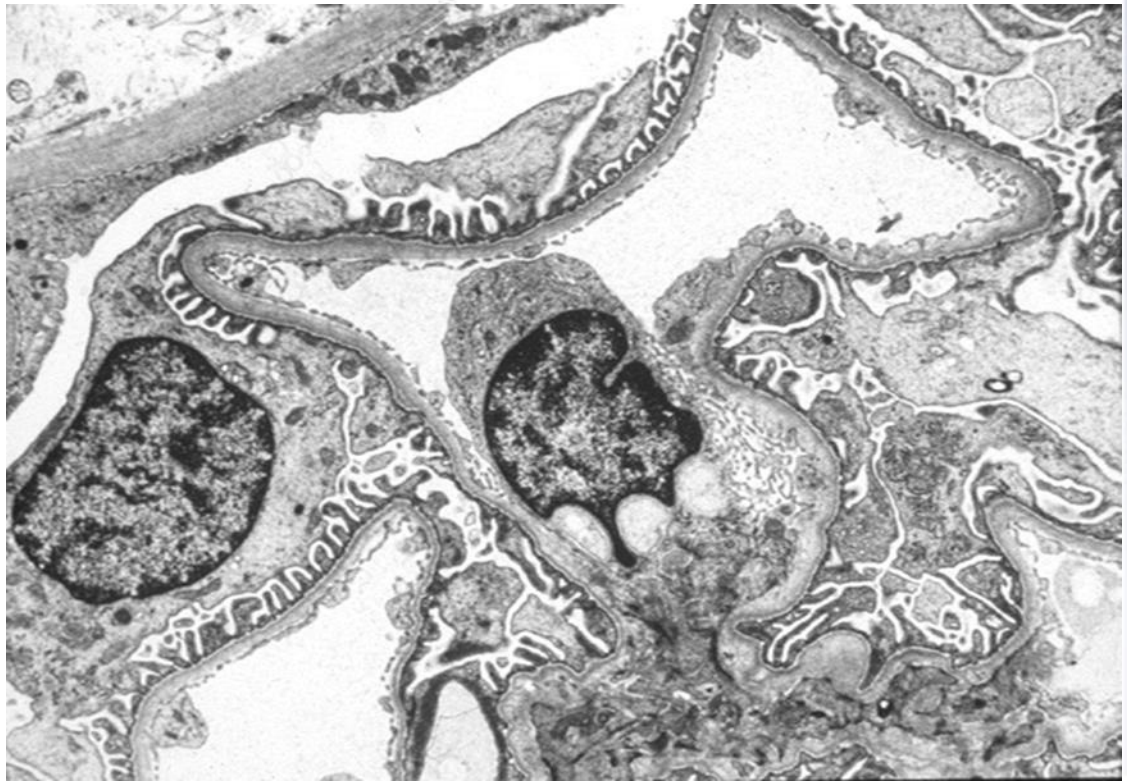
Source: Anthony L. Mescher: Junqueira's Basic Histology, 14th Edition.
www.accessmedicine.com

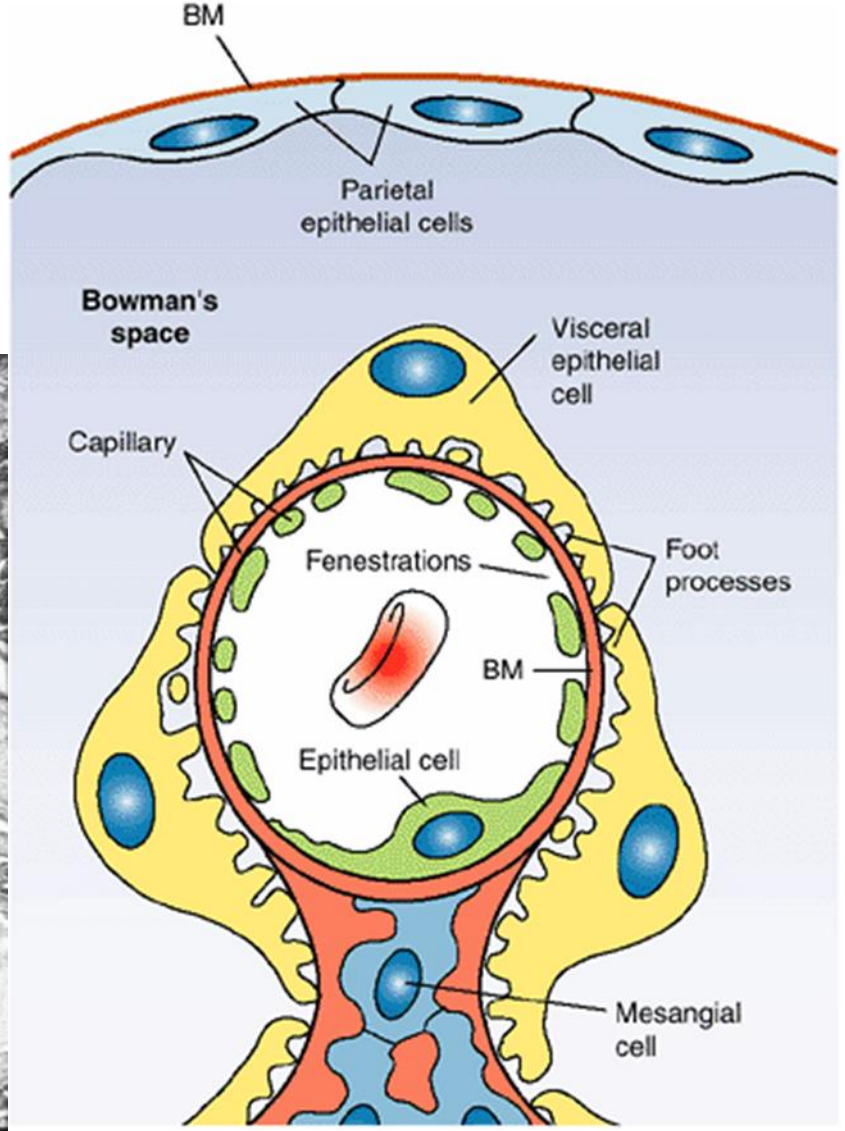


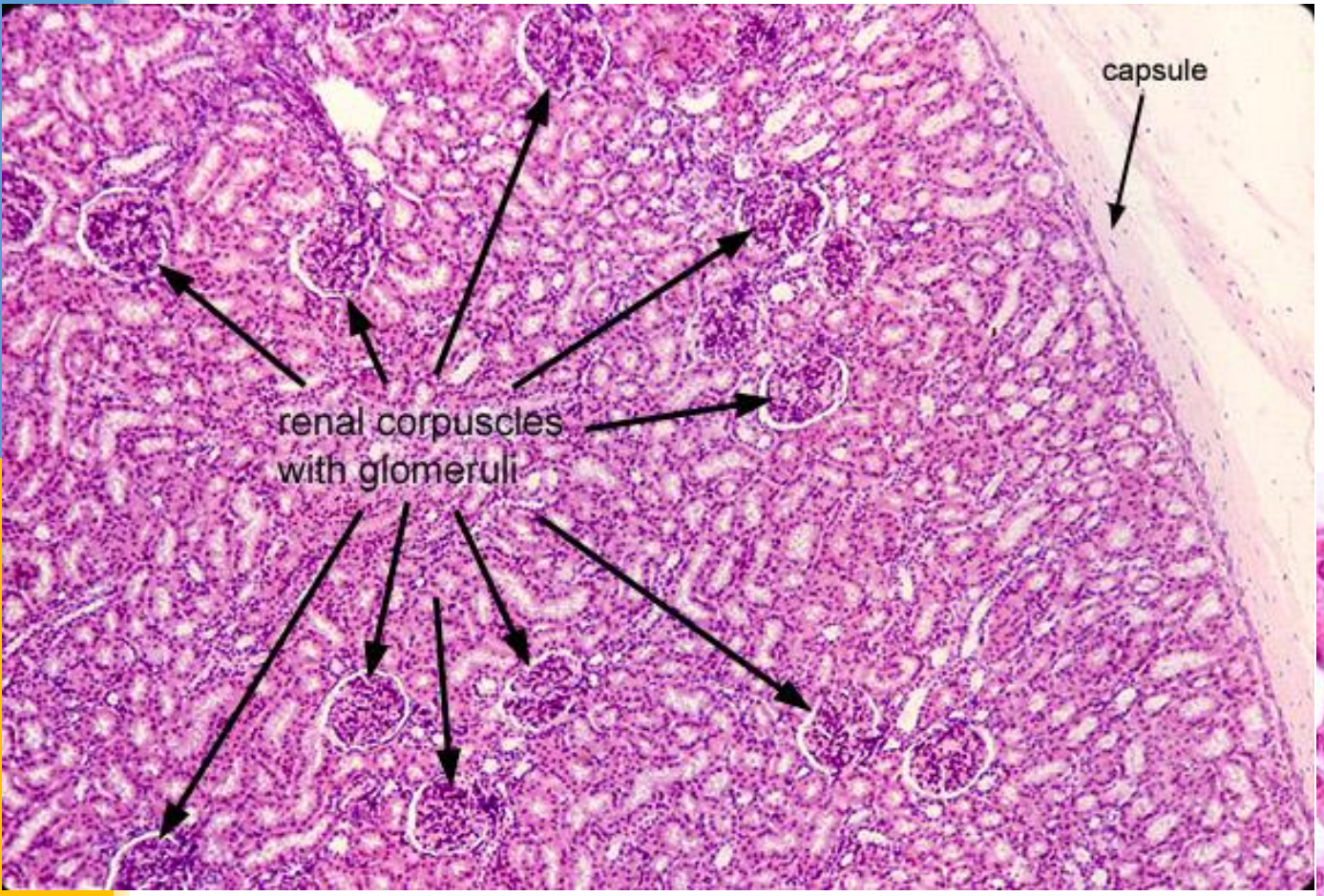
(c) Nephron types

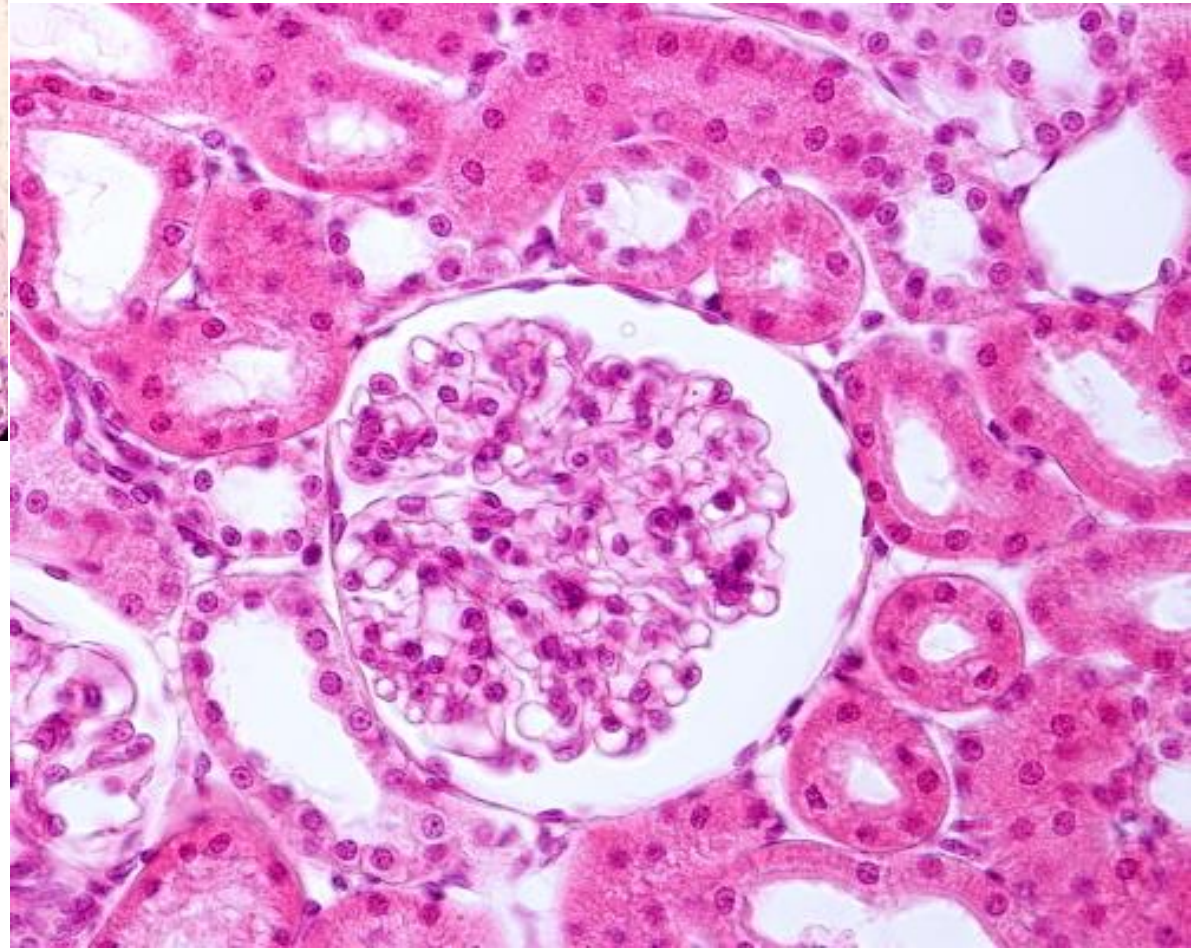
Kidney ultrastructure on EM








capsule
renal corpuscles
with glomeruli



Acute Kidney Injury

Definition, Types, Clinical Overview, Causes, Pathological findings

DEFINITION

Acute kidney injury (*AKI*) is also called as *acute renal* failure (ARF). It is an abrupt decrease in renal function resulting in the accumulation of nitrogenous compounds such as urea and creatinine. It is a syndrome defined by a sudden loss of renal function over several hours to days. Lab results show a **rapid rise in serum creatinine** or **decrease in urine output**.

Background information

- Creatinine clearance or filtration is dependent on the glomerular filtration rate (GFR).
  - GFR = Glomerular hydrostatic pressure – Bowman capsule hydrostatic pressure – glomerular oncotic pressure
  - Glomerular pressure is primarily dependent on renal blood flow.
  - In AKI → there is reduction in RBF → leads to decreasing GFR (this is the common pathologic pathway for AKI regardless of the cause).
- Uremia is a clinical syndrome associated with fluid, electrolyte, and hormone imbalances and metabolic abnormalities, which develop with deterioration of renal function. The term uremia, which literally means urine in the blood. Uremic illness is due largely to the accumulation of organic waste products, that are normally cleared by the kidneys. Uremia develops in chronic kidney disease and also in acute kidney injury.
- Azotemia: is an elevation of blood urea nitrogen (BUN) and serum creatinine levels. The reference range for BUN is 8-20 mg/dL, and the normal range for serum creatinine is 0.7-1.4 mg/dL.

In AKI/ARF there is:

- Accumulation of nitrogenous waste products.
- Increased Serum creatinine.
- Derangement of extracellular fluid balance.
- Acid-base disturbance.
- Electrolyte and mineral disorders.

Clinical features of acute kidney failure may include:

- Oliguria: Decreased urine output (occasionally urine output remains normal)
- Hypotension
- Tachycardia
- Fluid retention, causing swelling in your legs, ankles or feet
- Nephritic syndrome
- Nausea, vomiting, flank pain
- Fatigue
- Uremic encephalopathy, confusion, seizures or coma, pericarditis, bleeding in severe cases
- Sometimes acute kidney failure causes no signs or symptoms and is detected through lab tests done for another reason.

ACUTE RENAL FAILURE
CLASSIFICATION BY URINE VOLUME

OLIGURIC: urine output less than 500cc/24hr.

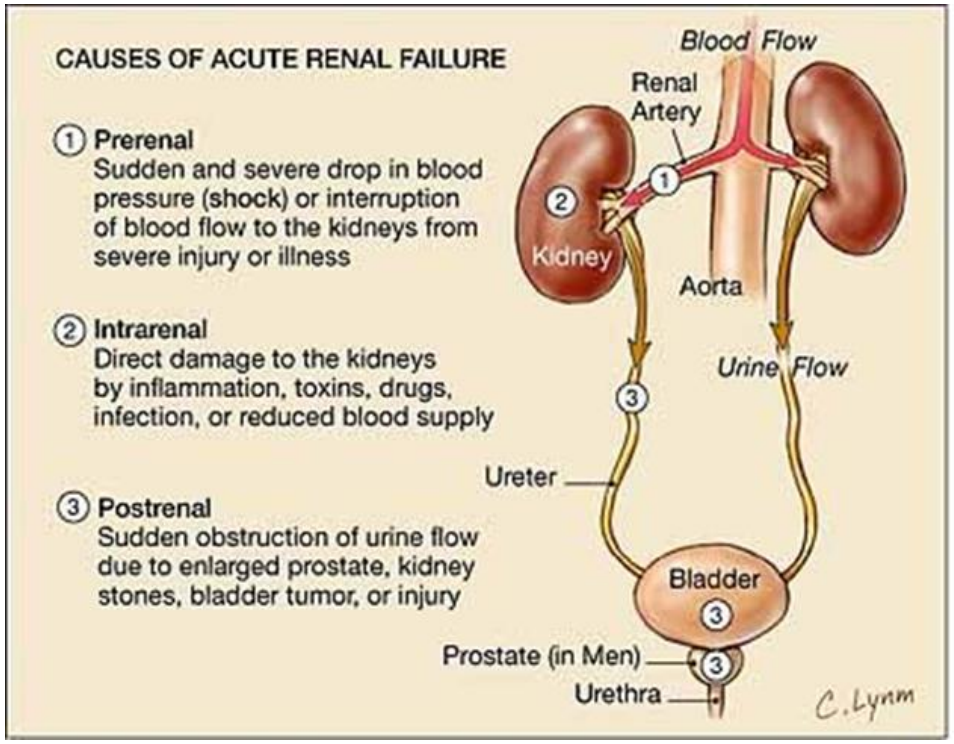
NON-OLIGURIC: urine output greater than 500cc/24hr.

ANURIC: urine output less than 50cc/24hr.

ETIOLOGY OF ACUTE RENAL FAILURE

AKI can be divided into pre-renal, renal or post-renal etiology.

- **Pre-renal (55-60%)** : the renal tubular and glomerular functions are normal. Here the GFR is decreased due to reduced renal perfusion.
- **Renal/ intrarenal/ intrinsic (35-40%)**: is due to diseases of the kidney itself (which is associated with release of renal afferent vasoconstrictors)
- **Post-renal (35-40%)**:



Pre-renal ARF (decreased renal blood flow)

- Most common cause of ARF
- Results from decreased renal perfusion
- Treatment of the cause restores renal function tubular function intact
- Prolonged pre-renal failure may lead to acute tubular necrosis.

Table 1. Causes of Acute Renal Failure

Prerenal
Hypovolemia
Hemorrhage
Fluid loss
Hypoalbuminemia
Third-space losses
Cardiac failure: myocardial dysfunction, valvular dysfunction, cardiac tamponade, pulmonary hypertension
Systemic vasodilatation: sepsis, cirrhosis, anaphylaxis, anesthesia, pharmacologic vasodilation
Afferent arteriolar vasoconstriction: sepsis, hypercalcemia, hepatorenal syndrome, drugs
Efferent arteriolar vasoconstriction: angiotensin-converting enzyme inhibitors, angiotensin-receptor blockers

RENAL ARF

Renal causes of ARF are divided into glomerular, tubular, vascular and interstitial causes. They are as follow:

<table>
<tr><th>GLOMERULAR</th><th colspan="2">TUBULAR</th><th>VASCULAR</th><th>INTERSTITIAL</th></tr>
<tr><td rowspan="2">The destruction of some glomeruli leave less total filtration area, reducing the GFR.
Acute glomerulonephritis (GN)
• Post infectious GN
• Rapid progressive crescentic GN
Thrombotic microangiopathies
Atheroembolic disease</td><td colspan="2">Acute Tubular Injury/ Necrosis (Ischemic & nephrotoxic)</td><td rowspan="2">Various forms of vasculitis and emboli lead to reduced renal blood flow due to vascular obstruction or destruction, thus lowering the GFR
e.g.
• Vasculitis
• Thromboembolic disease
• Malignant hypertension</td><td rowspan="2">Acute Interstitial Nephritis (AIN)
e.g.
• drug induced/allergic (NSAIDs)
• Autoimmune
• Infections (pyelonephritis)
• Malignant infiltration</td></tr>
<tr><td>Ischemic:
Prolonged ischemia of the nephrons leads → tubular injury and necrosis</td><td>Toxic
I) Endogenous toxins
Pigments:
• Myoglobinuria (Rhabdomyolysis)
• Hemeglobinuria
II) Exogenous toxins
Drugs:
• Aminoglycosides(antibiotic).
• Amphotericin B
• Etc.
Radiograph contrast medium - induced:

Toxicity to the nephrons leads → tubular injury and necrosis</td></tr>
</table>

Post renal ARF

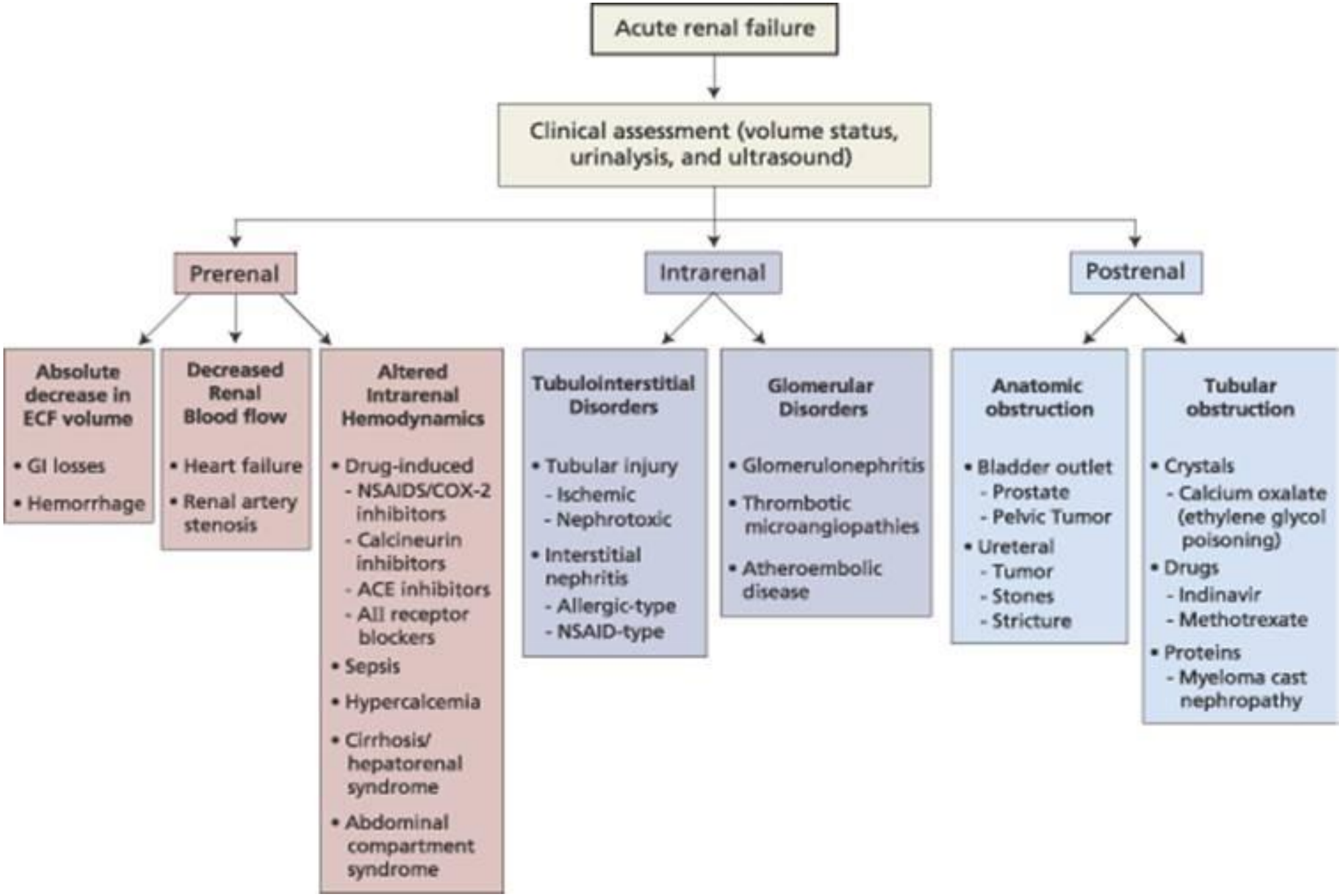
Any obstruction to the outflow of urine:

I) Anatomical obstruction

- In young = congenital or structural abnormality
- Older male = prostatic enlargement (prostatic hyperplasia)
- Any tumor in the bladder, prostate or urethra
- Stones in the urinary tract

II) Tubular obstruction

- Crystals (oxalate)in tubules
- Casts (myeloma casts nephropathy) in tubules


Acute renal failure
Clinical assessment (volume status, urinalysis, and ultrasound)
Prerenal
Intrarenal
Postrenal
Absolute decrease in ECF volume
• GI losses
• Hemorrhage
Decreased Renal Blood flow
• Heart failure
• Renal artery stenosis
Altered Intrarenal Hemodynamics
• Drug-induced
- NSAIDS/COX-2 inhibitors
- Calcineurin inhibitors
- ACE inhibitors
- AII receptor blockers
• Sepsis
• Hypercalcemia
• Cirrhosis/ hepatorenal syndrome
• Abdominal compartment syndrome
Tubulointerstitial Disorders
• Tubular injury
- Ischemic
- Nephrotoxic
• Interstitial nephritis
- Allergic-type
- NSAID-type
Glomerular Disorders
• Glomerulonephritis
• Thrombotic microangiopathies
• Atheroembolic disease
Anatomic obstruction
• Bladder outlet
- Prostate
- Pelvic Tumor
• Ureteral
- Tumor
- Stones
- Stricture
Tubular obstruction
• Crystals
- Calcium oxalate (ethylene glycol poisoning)
• Drugs
- Indinavir
- Methotrexate
• Proteins
- Myeloma cast nephropathy

Acute tubular injury/necrosis

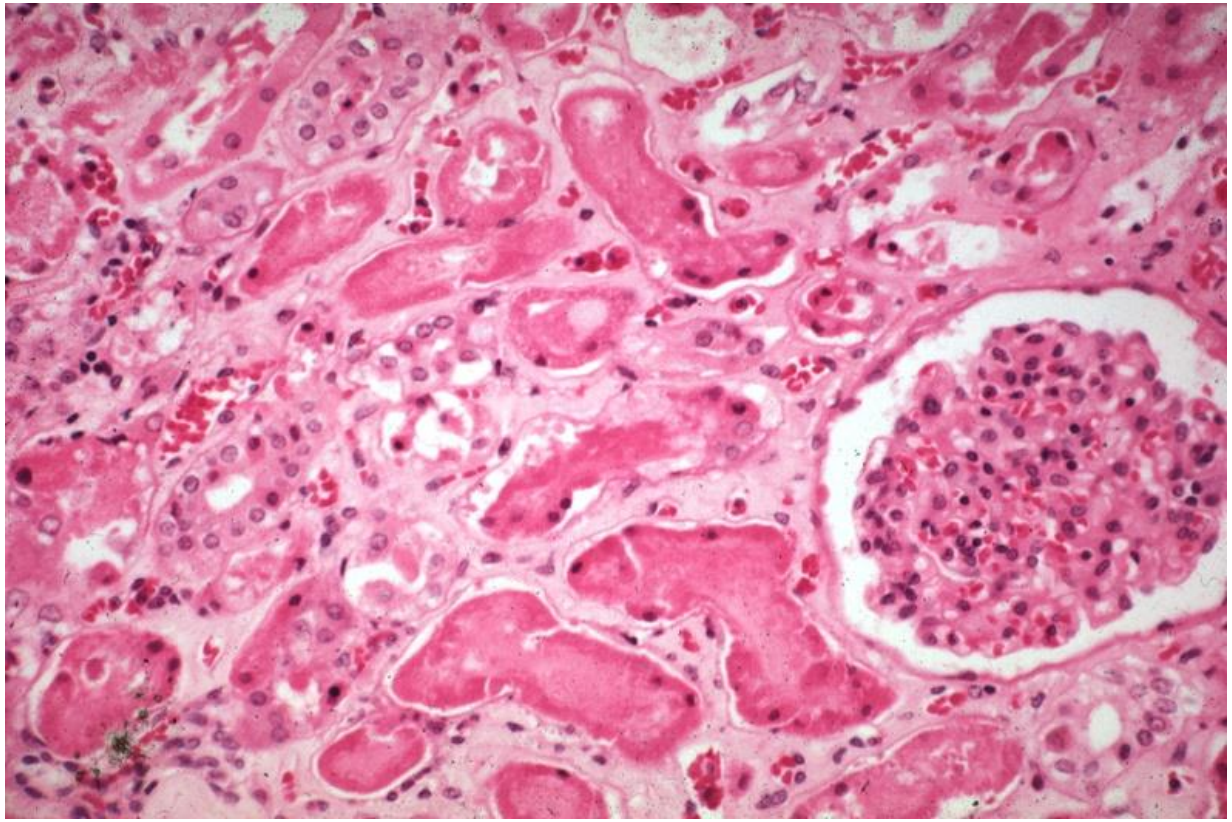
Histology:

Early:

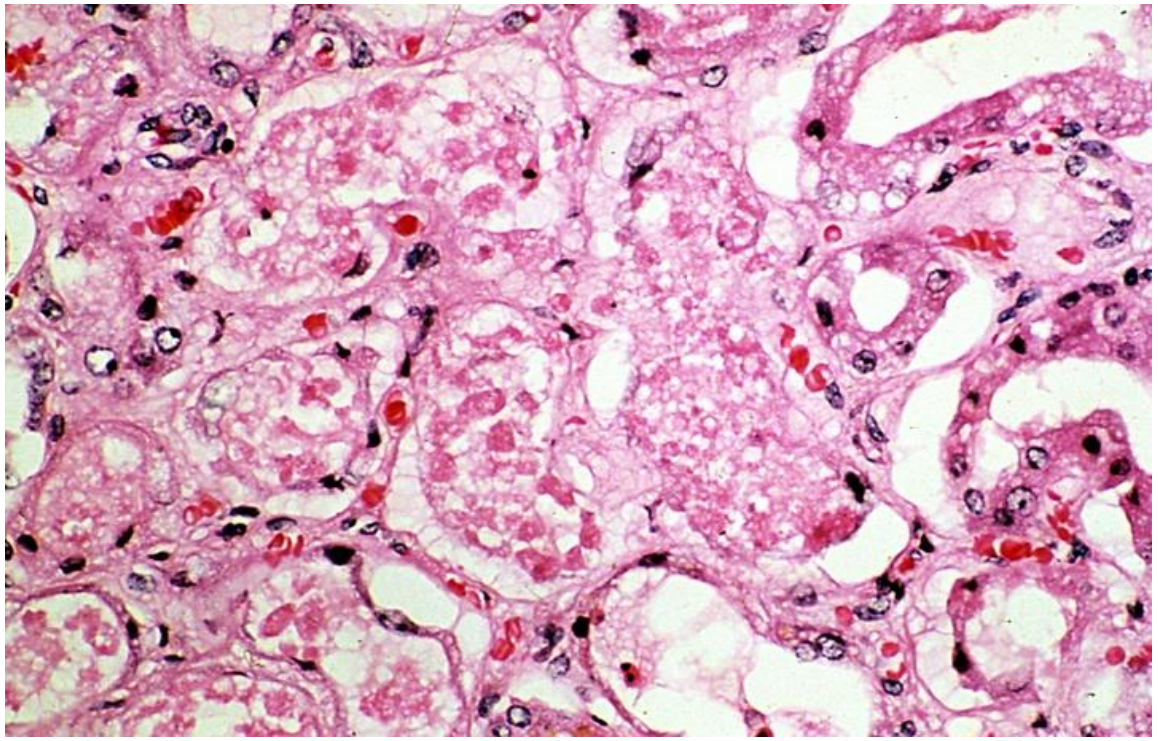
- varies from cell swelling to tubular epithelial necrosis
- dilated proximal tubules with thinning of tubular wall and loss of brush border
- hyaline, granular and pigmented cases, particularly in distal and collecting ducts
- interstitial edema

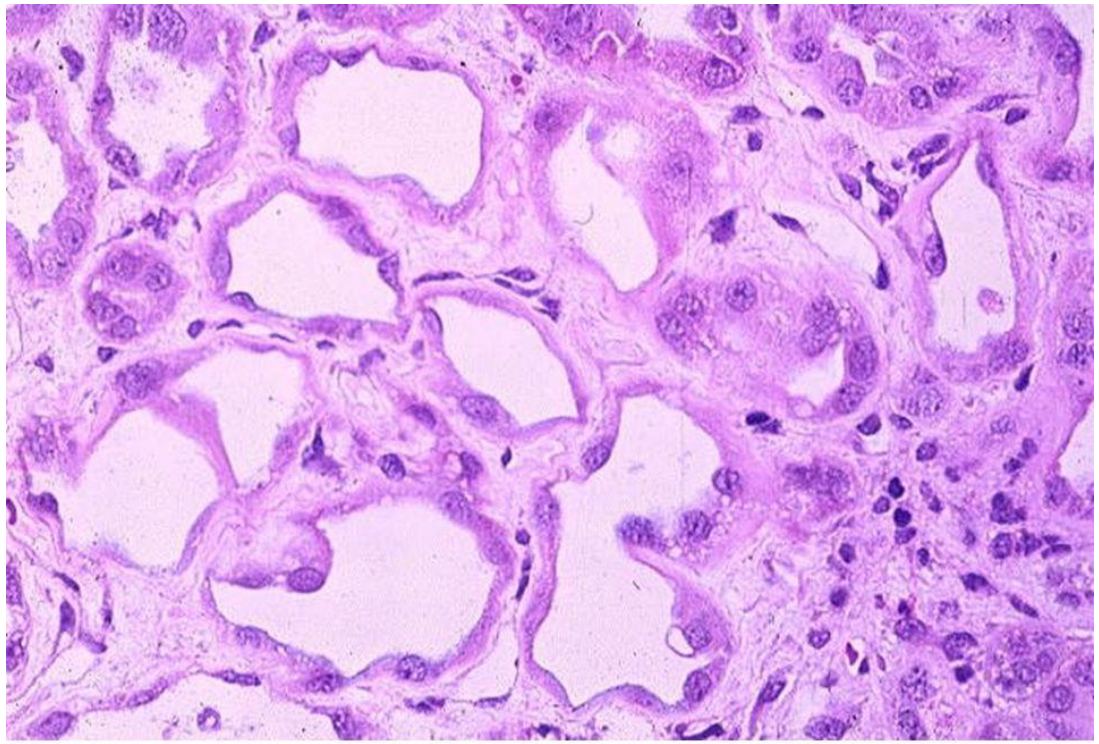
Later:

- epithelial regeneration

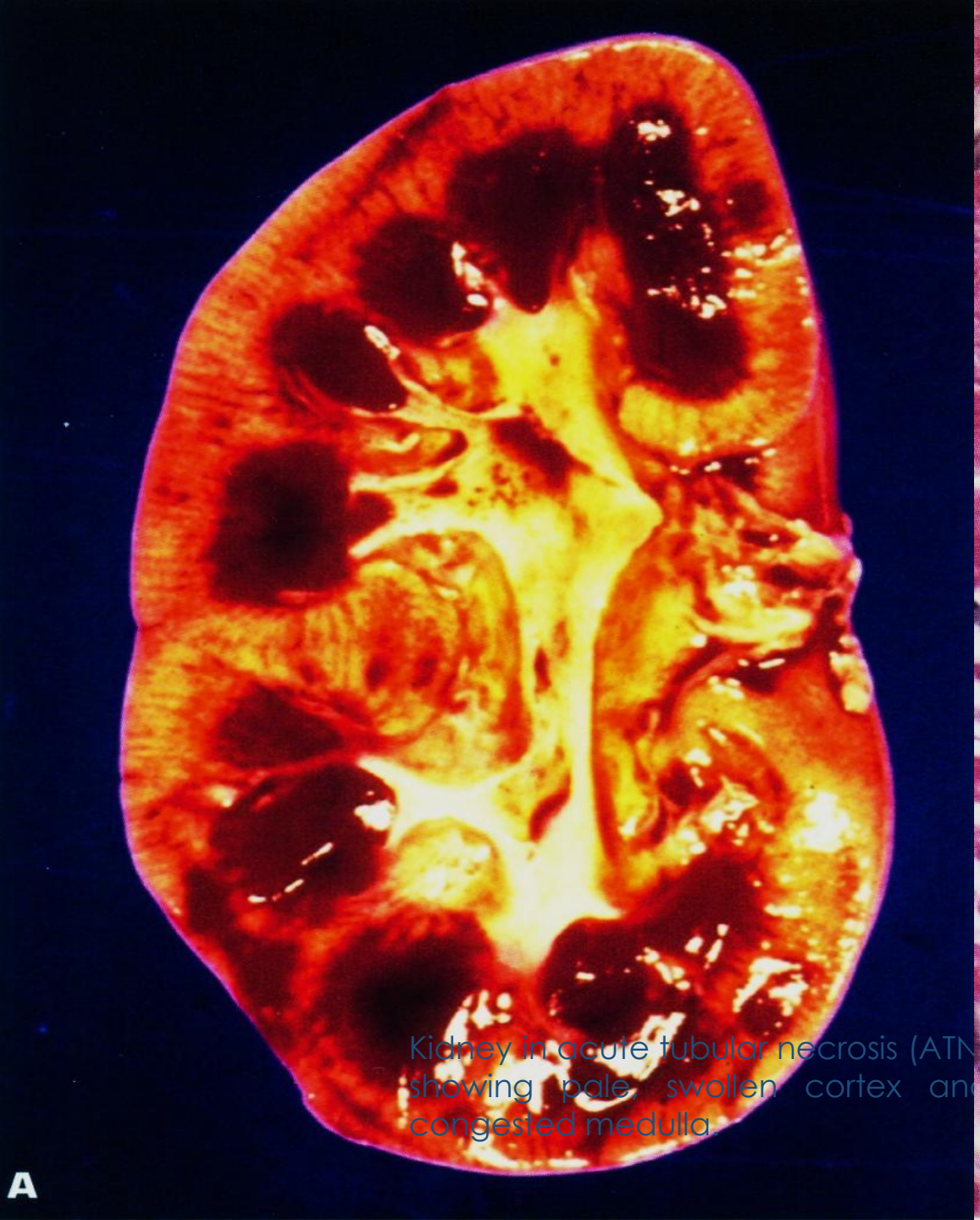


Acute tubular necrosis



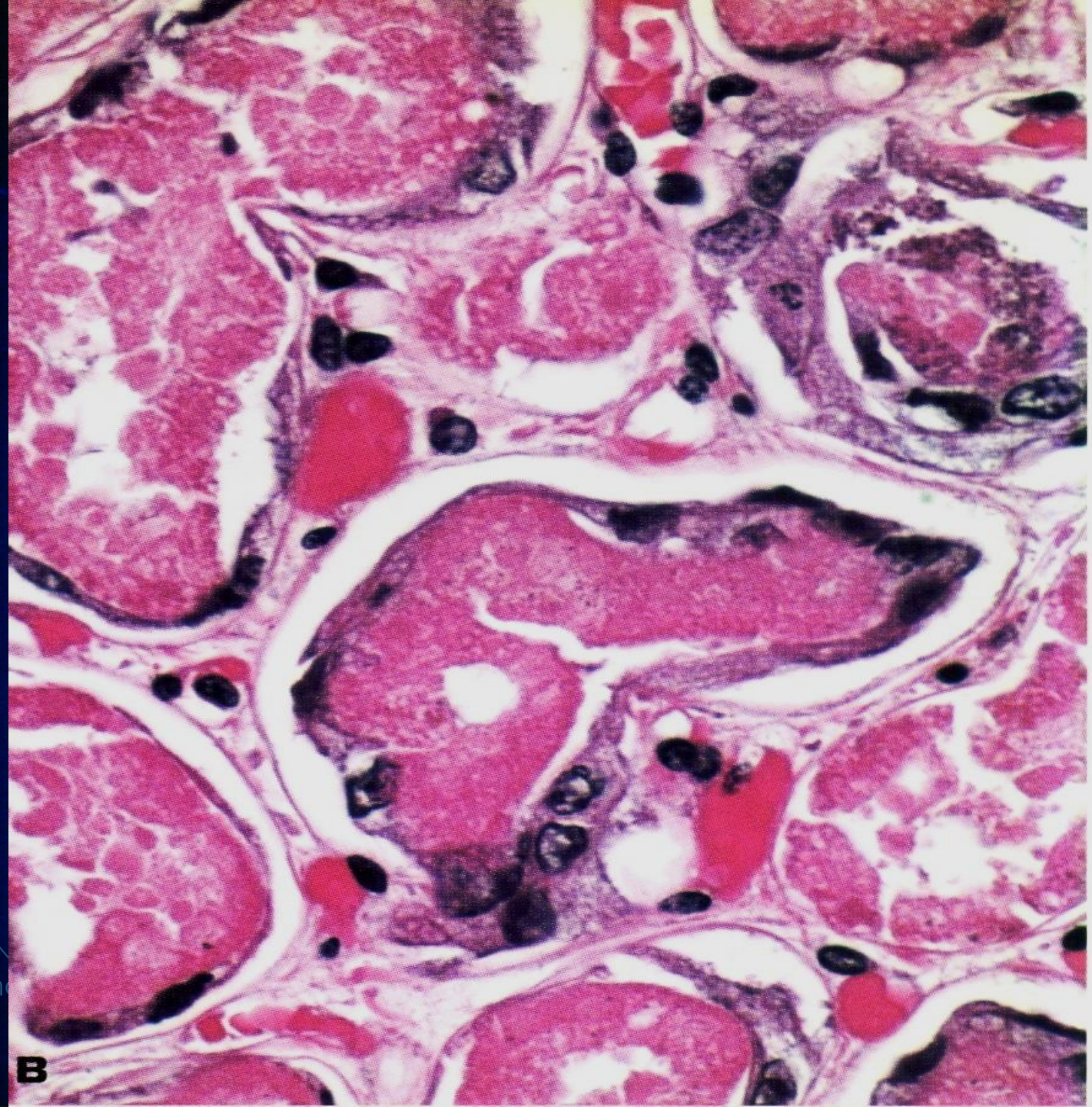


Acute tubular necrosis



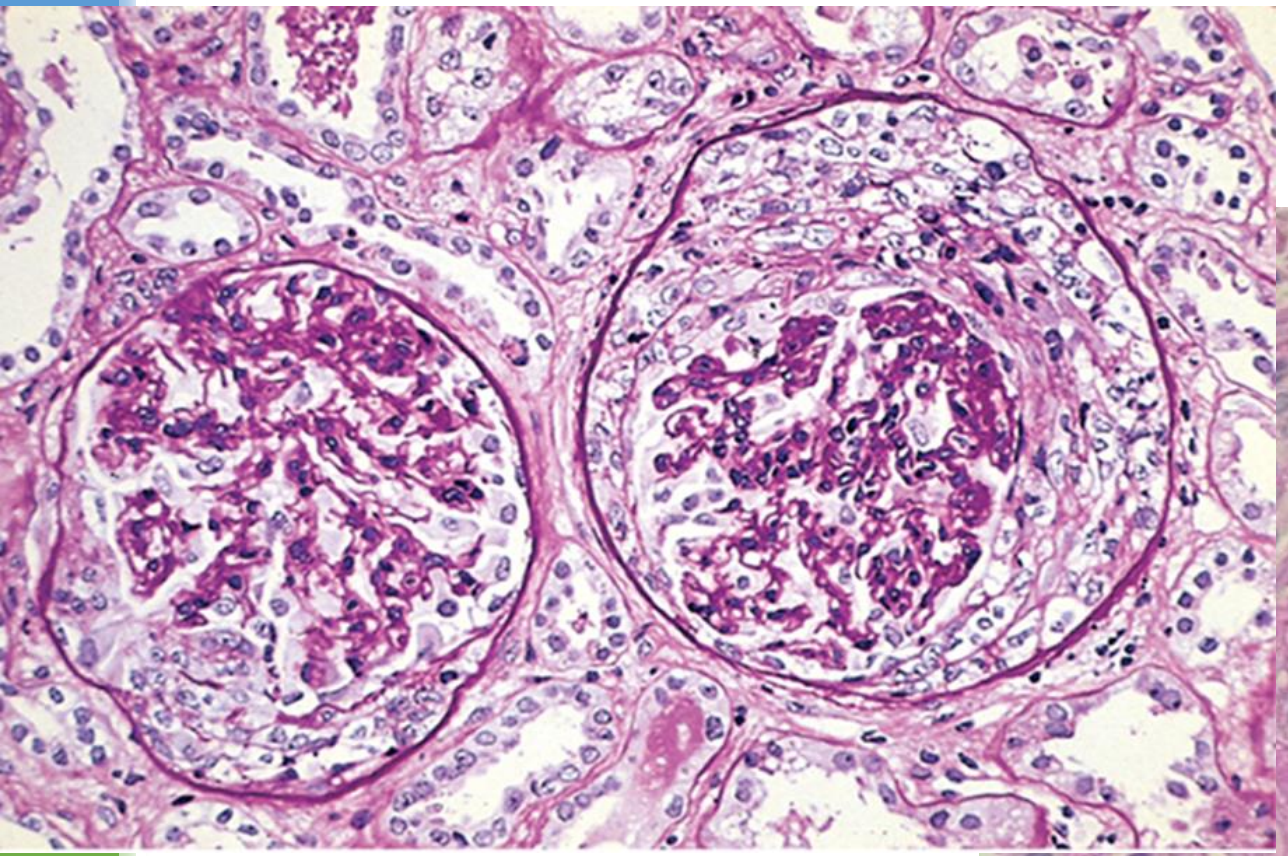
Kidney in acute tubular necrosis (ATN
showing pale, swollen cortex an
congested medulla.

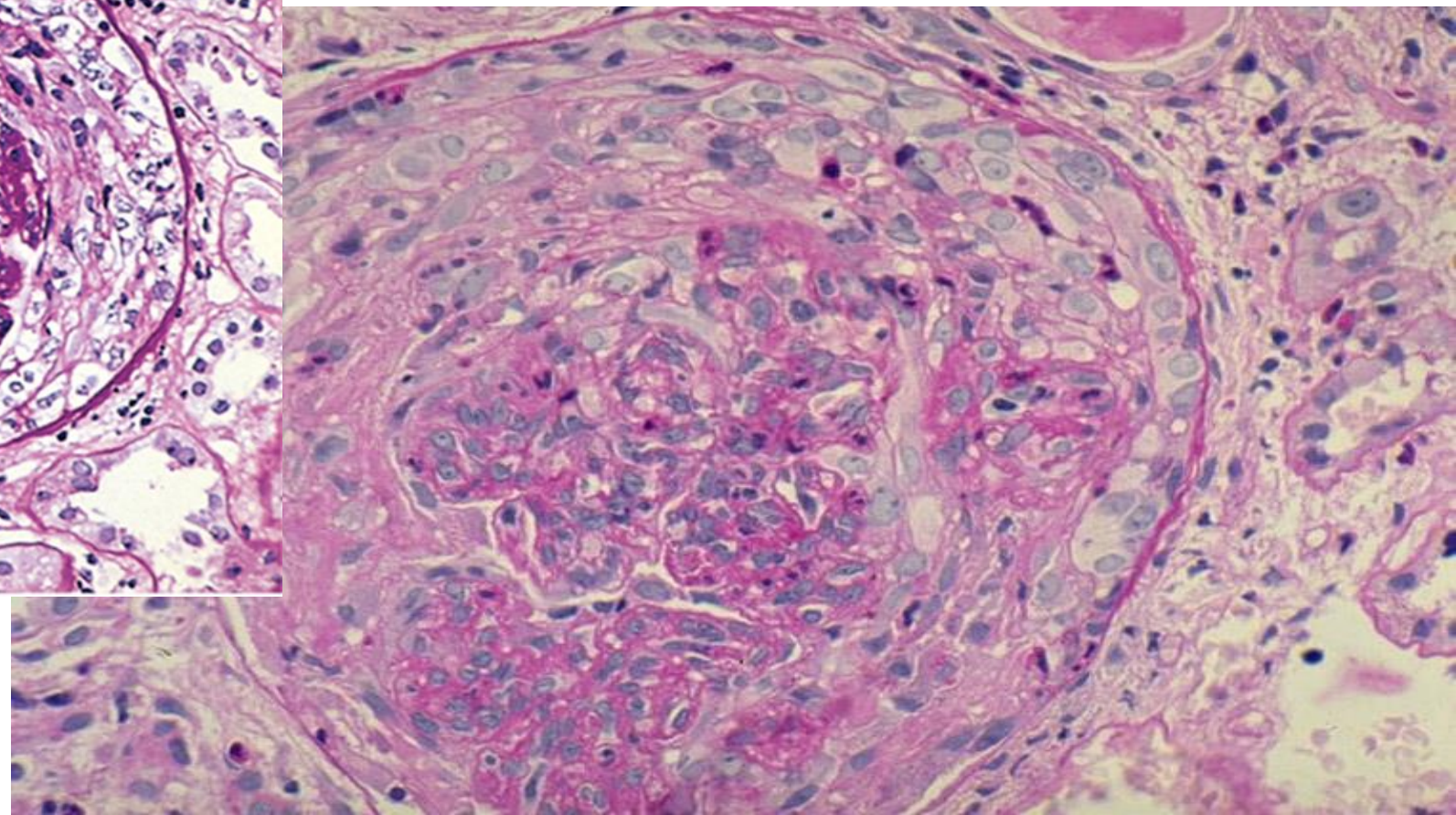
A



B

Crescentric GN

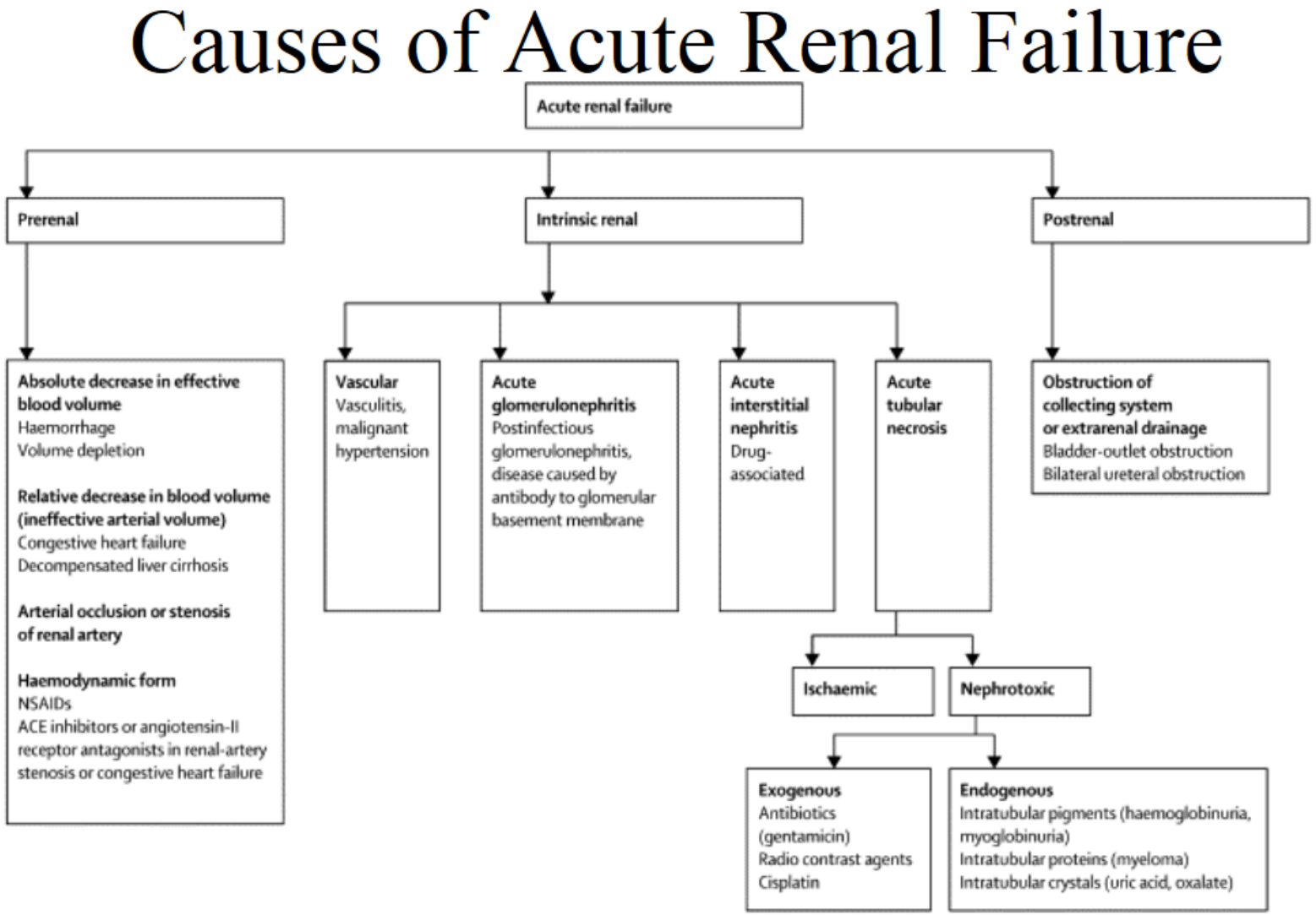




Treatment

- Treat underlying etiology.
- Indications of dialysis
  - Metabolic acidosis, hyperkalemia and fluid overload refractory to medical therapy
  - Toxins and uremic complications.
- Correction of fluid overload:
- Correction of acidosis:
- Correction of electrolyte imbalance e.g. hyperkalemia:

Summary


Causes of Acute Renal Failure
Acute renal failure
Prerenal
Intrinsic renal
Postrenal
Absolute decrease in effective blood volume
Haemorrhage
Volume depletion
Relative decrease in blood volume (ineffective arterial volume)
Congestive heart failure
Decompensated liver cirrhosis
Arterial occlusion or stenosis of renal artery
Haemodynamic form
NSAIDs
ACE inhibitors or angiotensin-II receptor antagonists in renal-artery stenosis or congestive heart failure
Vascular
Vasculitis, malignant hypertension
Acute glomerulonephritis
Postinfectious glomerulonephritis, disease caused by antibody to glomerular basement membrane
Acute interstitial nephritis
Drug-associated
Acute tubular necrosis
Ischaemic
Nephrotoxic
Exogenous
Antibiotics (gentamicin)
Radio contrast agents
Cisplatin
Endogenous
Intratubular pigments (haemoglobinuria, myoglobinuria)
Intratubular proteins (myeloma)
Intratubular crystals (uric acid, oxalate)
Obstruction of collecting system or extrarenal drainage
Bladder-outlet obstruction
Bilateral ureteral obstruction