
بسم الله الرحمن الرحيم

ACUTE RENAL FAILURE

By

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6th stage

D*U*C*O*M

Acute Renal Failure - Definitions

- ***Renal failure*** is defined as the cessation of kidney function with or without changes in urine volume
- ***Anuria*** – UOP < 0.5 cc/kg/hour
- ***Oliguria*** – UOP "more than 1 cc/kg/hour"

Acute Renal Failure - Definitions

- 70% Non-oliguric , 30% Oliguric
- Non-oliguric associated with better prognosis and outcome
- “Overall, the critical issue is maintenance of adequate urine output and prevention of further renal injury.”

pathophysiology

1. Pre renal: in which decrease renal perfusion
2. Renal : in which there is renal paranchymal injury
3. Post renal : in which there is obstruction of renal outflow

Outcome

- 3 phases of ARF:

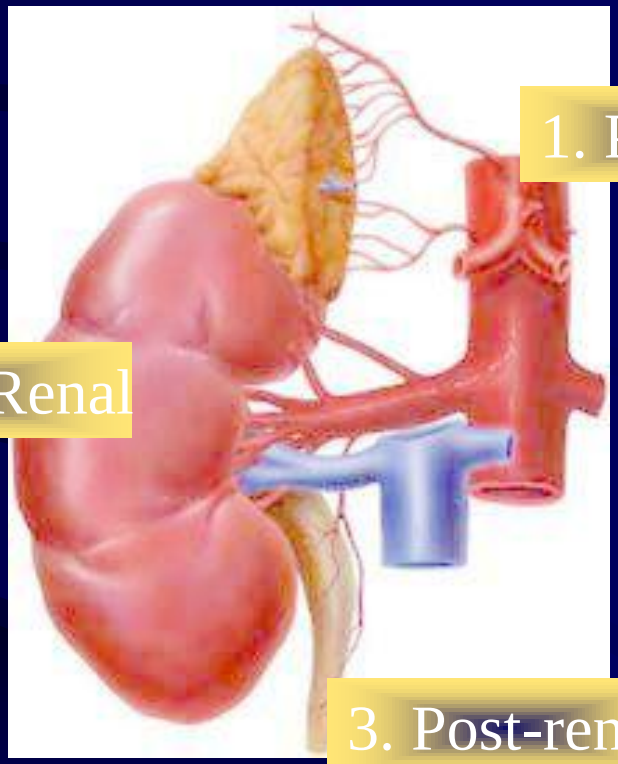
✓Oliguric.

✓Diuiretic.

✓Recovery.

- The overall survival rate is 70%.

The ARF Paradigm



1. Pre-renal

2. Intrinsic Renal

3. Post-renal

Prerenal Disease

- True volume depletion
- Advanced liver disease
- Congestive heart failure
- Renal arterial disease
- Perinatal or Neonatal hemorrhage
- Perinatal asphyxia and hyaline membrane disease
- Gastroenteritis
- Congenital and acquired heart diseases

Prerenal Disease

- A reduction in renal blood flow - the most common cause of acute renal failure.
- Occur from true volume depletion or from selective renal ischemia (as in bilateral renal artery stenosis).
- Causes of prerenal azotemia: true volume depletion, advanced liver disease, and congestive heart failure.

Prerenal ARF of Newborns and Infants

The most common cause of ARF is prerenal etiologies.

Prerenal ARF:

- Perinatal hemorrhage - Twin-twin transfusion, complications of amniocentesis, abruptio placenta, birth trauma
- Neonatal hemorrhage - Severe intraventricular hemorrhage, adrenal

Prerenal ARF of Newborns and Infants

- Perinatal asphyxia and hyaline membrane disease (newborn respiratory distress syndrome) both may result in preferential blood shunting away from kidneys (ie, prerenal) to central circulation.

Prerenal ARF of Children

The most common cause of ARF is prerenal etiologies.

Prerenal ARF:

- The most common cause of hypovolemia in children is gastroenteritis.
- Congenital and acquired heart diseases are also important causes of decreased renal perfusion in this age group.

Symptoms and Signs of Prerenal Failure

- Patients commonly present with symptoms related to hypovolemia, including thirst, decreased urine output, dizziness, and orthostatic hypotension.
- Look for a history of excessive fluid loss via hemorrhage, GI losses, sweating, or renal sources.

Intrinsic Renal Failure

- **Tubular diseases**
- **Interstitial diseases**
- **Glomerular diseases**
- **Vascula diseases**
- Nephrotoxins
- **Allergic interstitial nephritis**

Intrinsic Renal Failure

- **Glomerular diseases**: Nephritic syndrome of hematuria, edema, and HTN is synonymous with a glomerular etiology of ARF

Intrinsic Renal Failure

- **Tubular diseases**: ATN should be suspected in any patient presenting after a period of hypotension secondary to cardiac arrest, hemorrhage, sepsis, drug overdose, or surgery.

Intrinsic Renal Failure

- **Interstitial diseases** - Acute interstitial nephritis, drug reactions, autoimmune diseases (eg, systemic lupus erythematosus [SLE]), infiltrative disease (sarcoidosis, lymphoma), infectious agents (Legionnaire disease, hantavirus)
- **Vascular diseases** - Hypertensive crisis, polyarteritis nodosa, vasculitis

Intrinsic Renal Failure

- **Allergic interstitial nephritis** should be suspected with recent drug ingestion, fevers, rash, and arthralgias.

Acute Tubular Necrosis

Renal insults, including

- renal ischemia
- exposure to exogenous or endogenous nephrotoxins.

The net effect is a rapid decline in renal function that may require a period of dialysis before spontaneous resolution occurs.

Major Causes of Acute Tubular Necrosis

- ***Renal Ischemia:***

* Severe prerenal disease from any cause.

- ***Exposure to Nephrotoxins:***

* Amphotericin B

* Aminoglycosides * Heme Pigments * NSAID's (hemoglobinuria/myoglobinura)

Intrinsic ARF of Children

- Hemolytic uremic syndrome (HUS) often is cited as the most common cause of ARF in children. The most common form of the disease is associated with a diarrheal prodrome caused by *Escherichia coli* 0157:H7.
- These children usually present with microangiopathic anemia, thrombocytopenia, colitis, mental status changes, and renal failure.

Acute Glomerulonephritis

- Rare in the hospitalized patient
- Most common types: acute post-infectious GN, “crescentic” RPGN
- Diagnose by history, hematuria, RBC casts, proteinuria (usually non-nephrotic range), low serum complement in post-infectious GN
- Usually will need to perform renal biopsy

Acute Glomerulonephritis (2)

- If diagnosis is post-infectious, disease is usually self-limited, and supportive care is usually all that is necessary.
- For RPGN, may need immunosuppressive therapy with steroids ± Cytoxan, plasmapheresis (if assoc. with anti-GBM)

Acute Interstitial Nephritis

- Usually drug induced
  - methicillin, rifampin, NSAIDS
- Develops 3-7 days after exposure
- Fever, Rash , and eosinophilia common
- U/A reveals WBC, WBC casts, + Hansel stain
- Often resolves spontaneously
- Steroids may be beneficial (if Scr>2.5 mg/dl)

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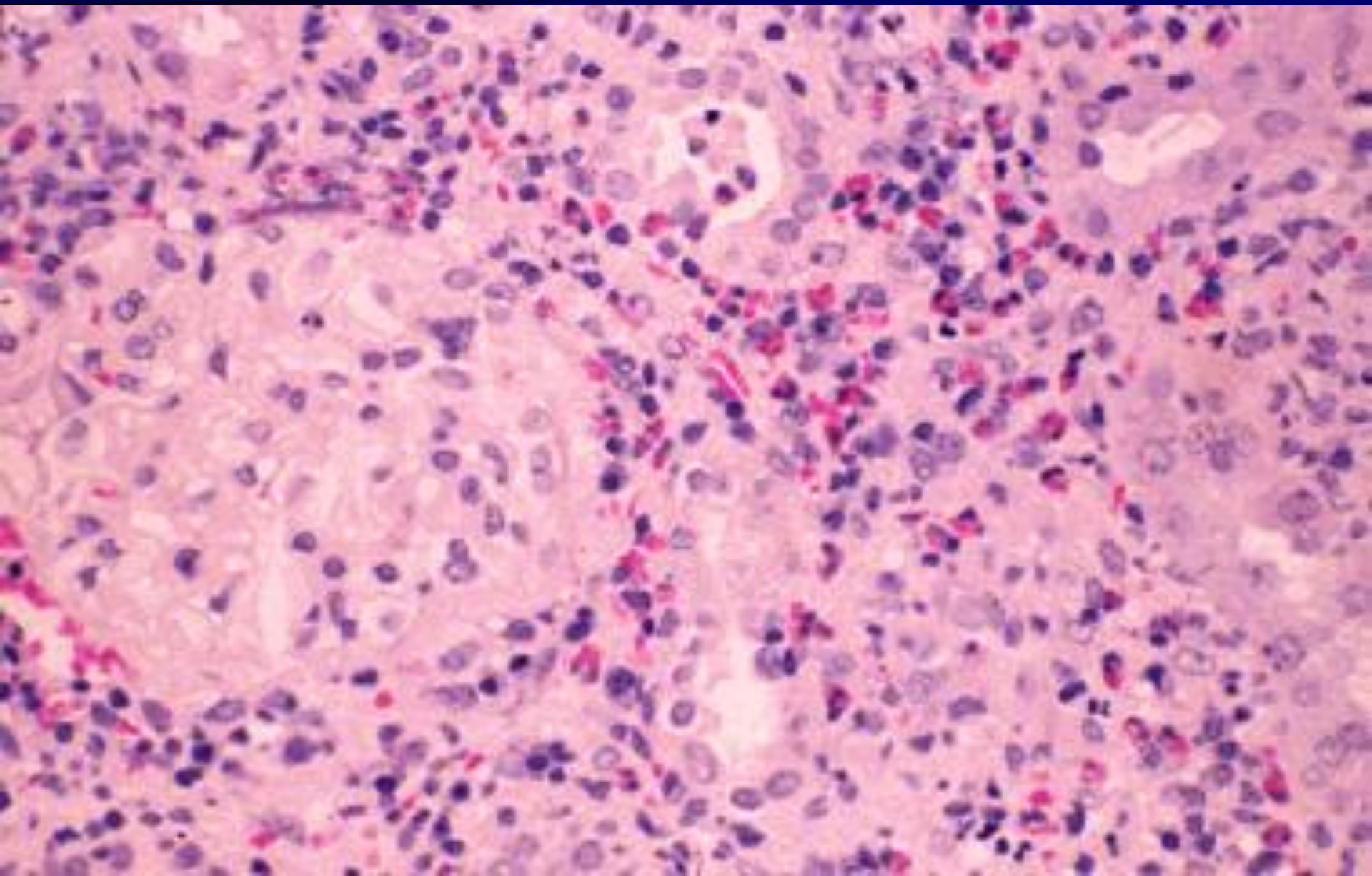


Selective Renal Ischemia

- Hepatorenal syndrome
- Nonsteroidal anti-inflammatory drugs
- Bilateral renal artery stenosis
  - Can be exacerbated by ACE inhibitors

Aminoglycoside toxicity

- Cause of ARF in 5 - 25% of hospitalized patients
- Aminoglycosides
  - Not metabolized but excreted primarily by glomerular filtration
  - Taken up by proximal tubules by a high capacity transport system
  - High levels in the proximal tubule results in tubular cell necrosis
- Nephrotoxicity usually produces a nonoliguric ARF
  - Increase in serum creatinine levels not seen until after 8 to 10 days of aminoglycoside therapy

Rhabdomyolytic ARF

- Diagnose with ↑ serum CPK (usu. > 10,000), urine dipstick (+) for blood, without RBCs on microscopy, pigmented granular casts
- Common after trauma (“crush injuries”), seizures, burns,
- Treatment is largely supportive care.
- Alkalinization of urine .

Acute Renal Failure Etiologies

- Post-Renal

  Bladder outlet obstruction

  – Posterior urethral valve

  – stricture

    - Ureteral stone
    - Tumer
    - DM with pyelonephritis
    - Sickle cell disease

Clinical Manifestations

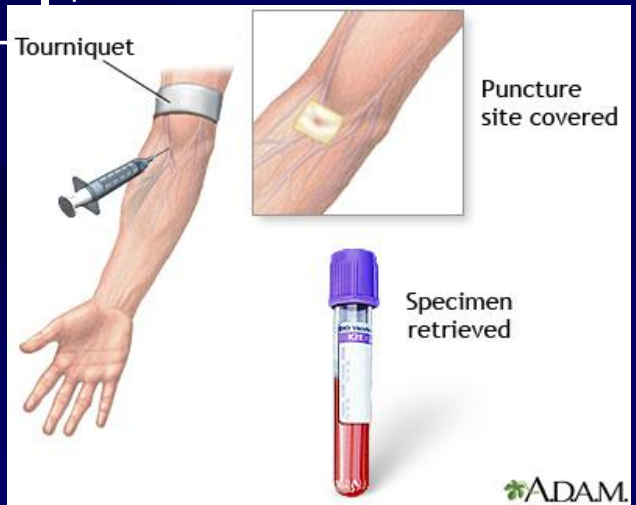
- ❖ Anuria
- ❖ Oliguria
- ✓ Vomiting
- ✓ Diarrhea
- ✓ Fever

- ❖ Sign of Collapse
- ✓ Sunken Fontanels
- ✓ Dry Tongue & Mucous Membranes
- ✓ Loss of skin turgor
- ✓ Irritability
- ✓ Feeble Pulses

- ❖ Throat or Skin Infection
- ❖ Rash
- ❖ Hx of Nephrotoxic Agents
- ❖ Frank Anuria
- ❖ Sign of uremia
- ✓ Anorexia
- ✓ Vomiting
- ✓ Nausea
- ✓ Lethargic
- ✓ Hypertension
- ✓ Uremic Encephalopathy
- ✓ Seizures

Investigations

- **Blood Counts:**
- ✓Low Hb---blood loss
- ✓Leukocytosis---infection
- ✓Platelet Counts---low in HUS, Renal Vein Thrombosis or SLE



Investigations

- **Blood Urea & Creatinine:**

Raised due to diminished renal function

- **Serum Calcium, Phosphate, Alkaline Phosphates:**

✓ S.Ca low

✓ S.Phosphate raised

✓ Al.po4 normal

Investigations

- **Serum Electrolytes & Osmolality:**
  - ✓Na low & K high
  - ✓Ratio of urine Osmolality to Plasma Osmolality---
    > 1.1:1.0 show pre-renal

    < 1.1:1.0 show Intrinsic renal

Investigations

- **Urine Examination:**
- ✓Urine Na-- > 20 mEq/l show intrinsic renal

  < 10 mEq/l show pre-renal
- ✓Urine Microscopy--- Pus, RBC's, White Cell Casts

Investigations

- **C3 Complement Level:**
  - ✓ Low in AGN, SLE Nephritis
- **Plain X-ray abdomen:**

Investigations

- **X-ray Chest**

- **Abdominal USG:**

Investigations

❖Renal Biopsy

- Unexplained acute renal failure
- Acute nephritic syndromes;
- Unexplained proteinuria and hematuria
- Systemic diseases associated with kidney dysfunction, such as systemic lupus erythematosus (SLE), Goodpasture's syndrome, and Wegener's granulomatosis, to confirm the extent of renal involvement and to guide management
- Suspected transplant rejection, to differentiate it from other causes of acute renal failure

Urine output

Anuria (<100 mL/d)	Urinary tract obstruction, renal artery obstruction, rapidly progressive glomerulonephritis, bilateral diffuse renal cortical necrosis
Oliguria	(100-400 mL/d) Prerenal failure, hepatorenal syndrome
Non-oliguria	(>400 mL/d) Acute interstitial nephritis, acute glomerulonephritis, partial obstructive nephropathy, nephrotoxic and ischemic ATN, radiocontrast-induced ARF, and rhabdomyolysis

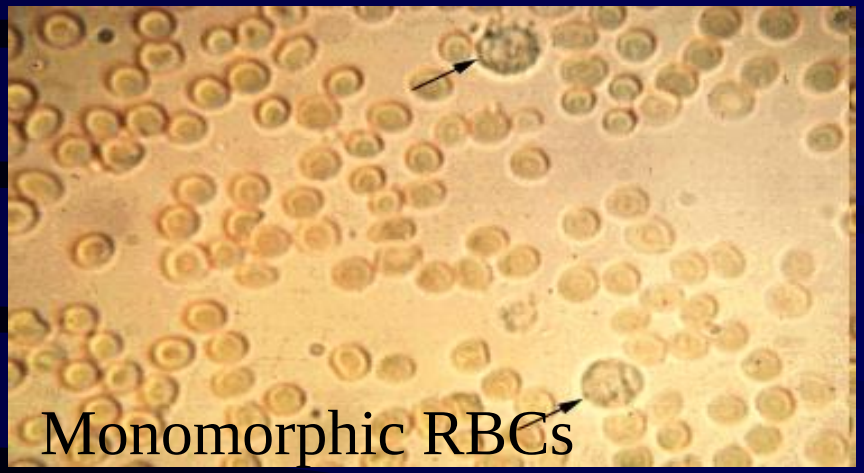
Urinalysis

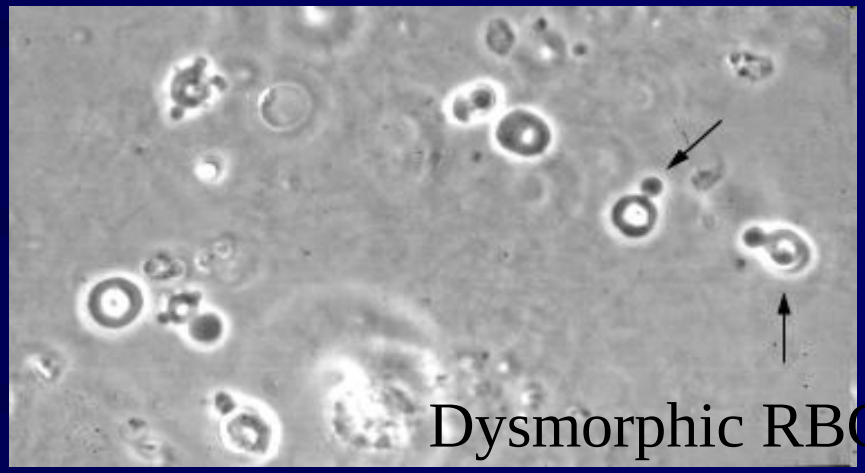
Granular casts	ATN, glomerulonephritis, interstitial nephritis
RBC casts	Glomerulonephritis, malignant HTN
WBC casts	Acute interstitial nephritis, pyelonephritis

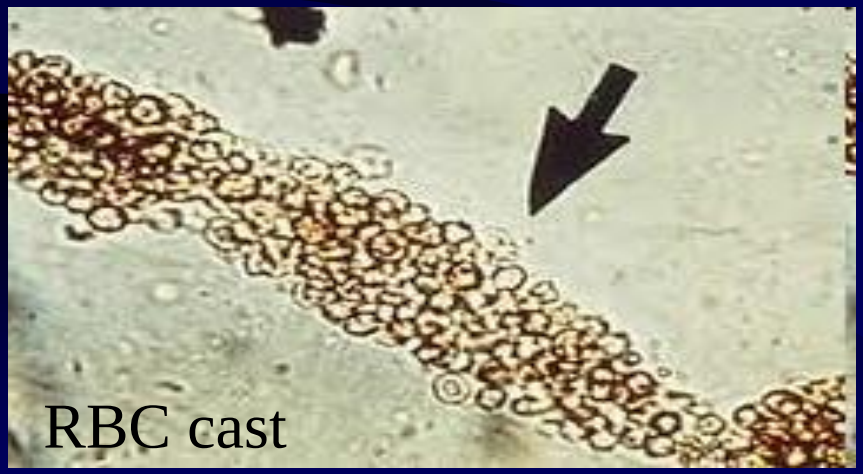
Urinalysis

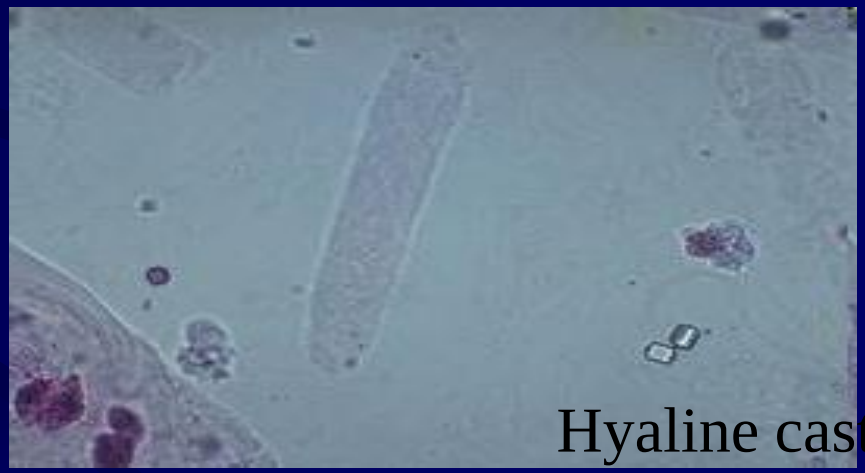
Eosino-philuria	Acute allergic interstitial nephritis, atheroembolism
Crystall-uria	Acyclovir, sulfonamides, methotrexate, ethylene glycol toxicity, radiocontrast agents
Normal	prerenal and postrenal failure, HUS/thrombotic thrombocytopenic purpura (TTP), preglomerular vasculitis, or atheroembolism

Urine Sediment

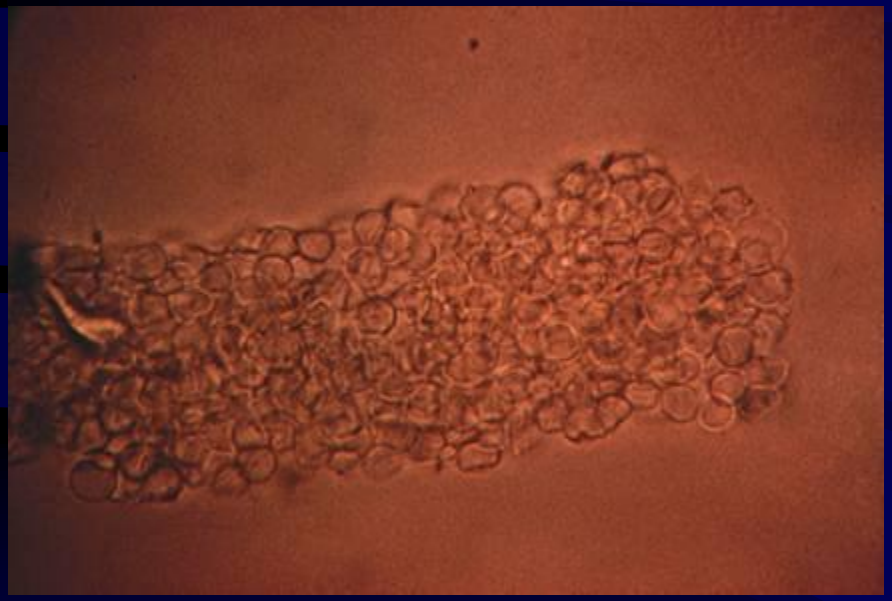

Monomorphic RBCs

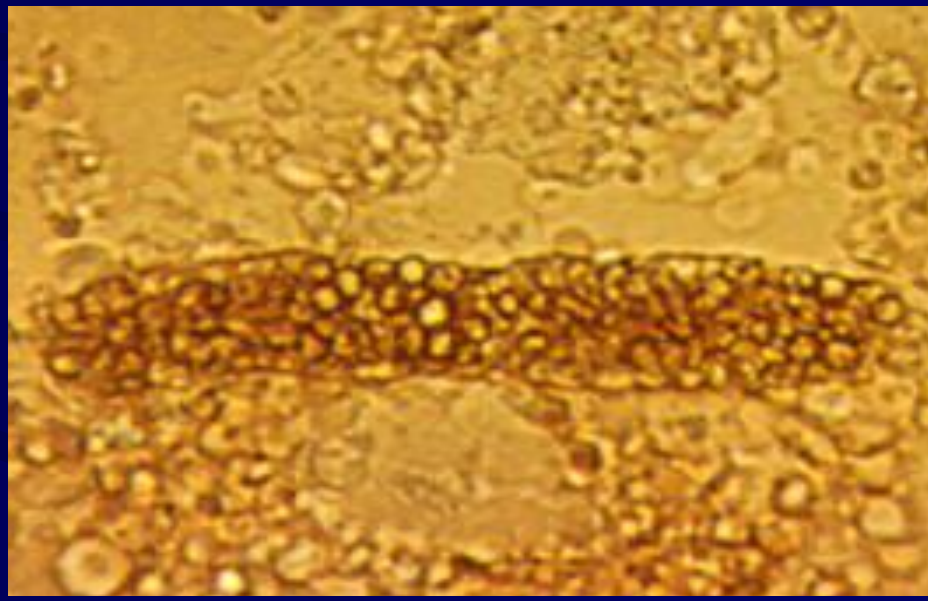

Dysmorphic RBCs


RBC cast


Hyaline cast

Red Blood Cell Cast



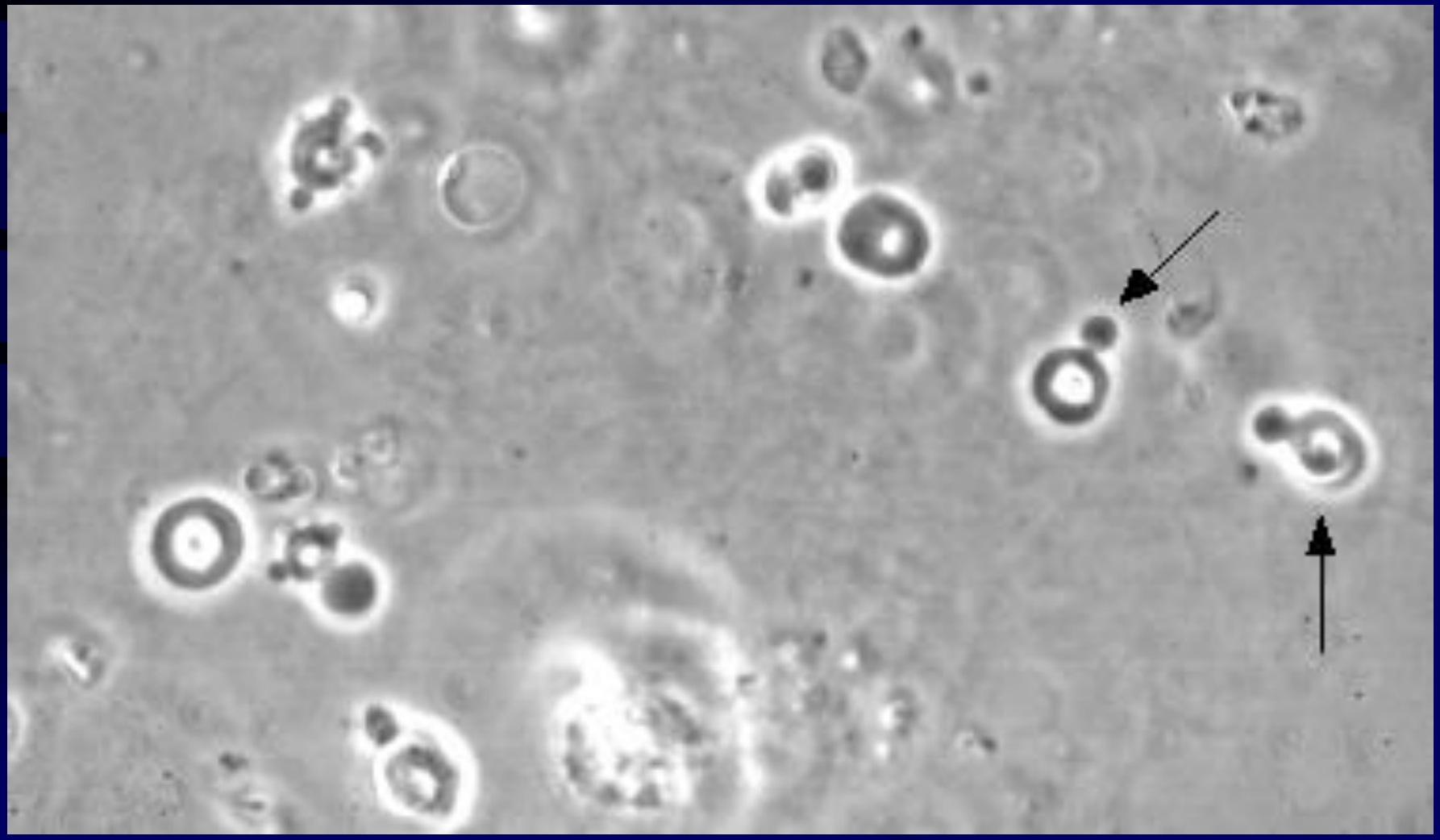


Red Blood Cells

Monomorphic

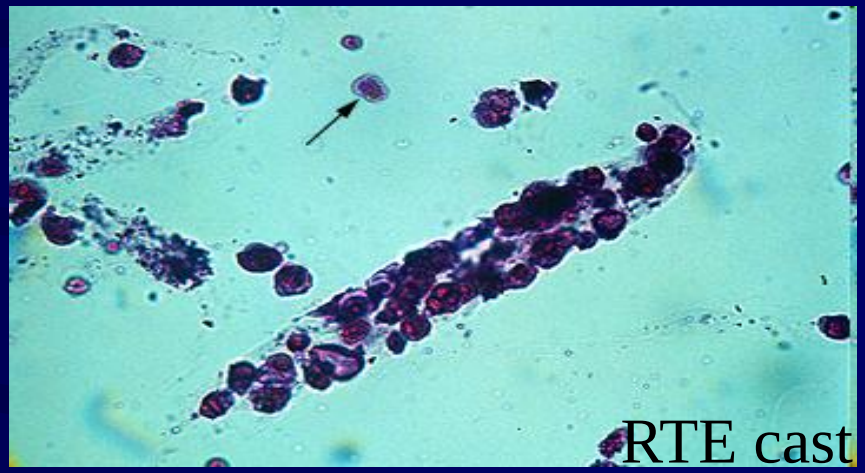
Dysmorphic

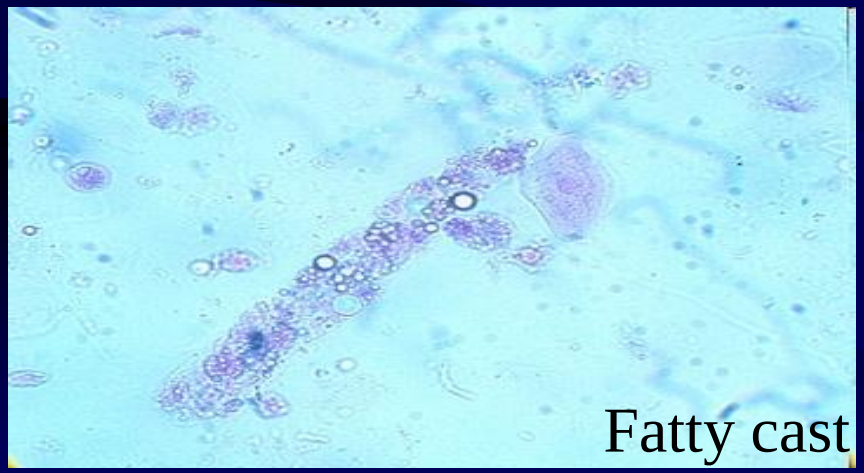
Dysmorphic Red Blood Cells

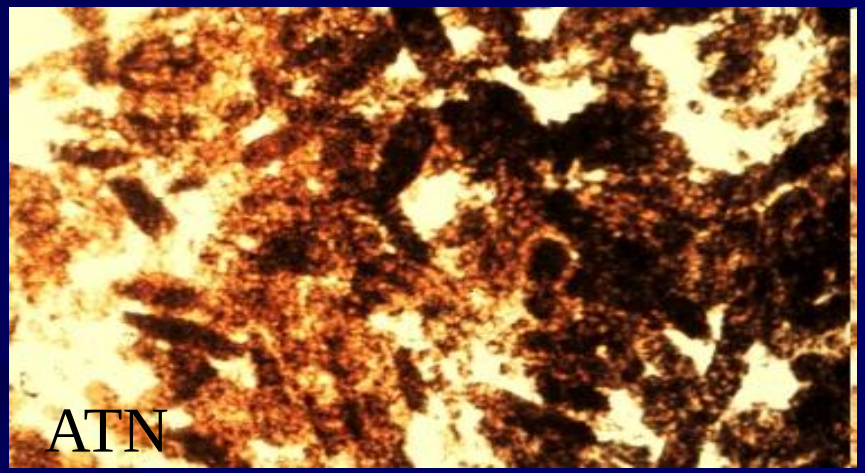


Urine Sediment

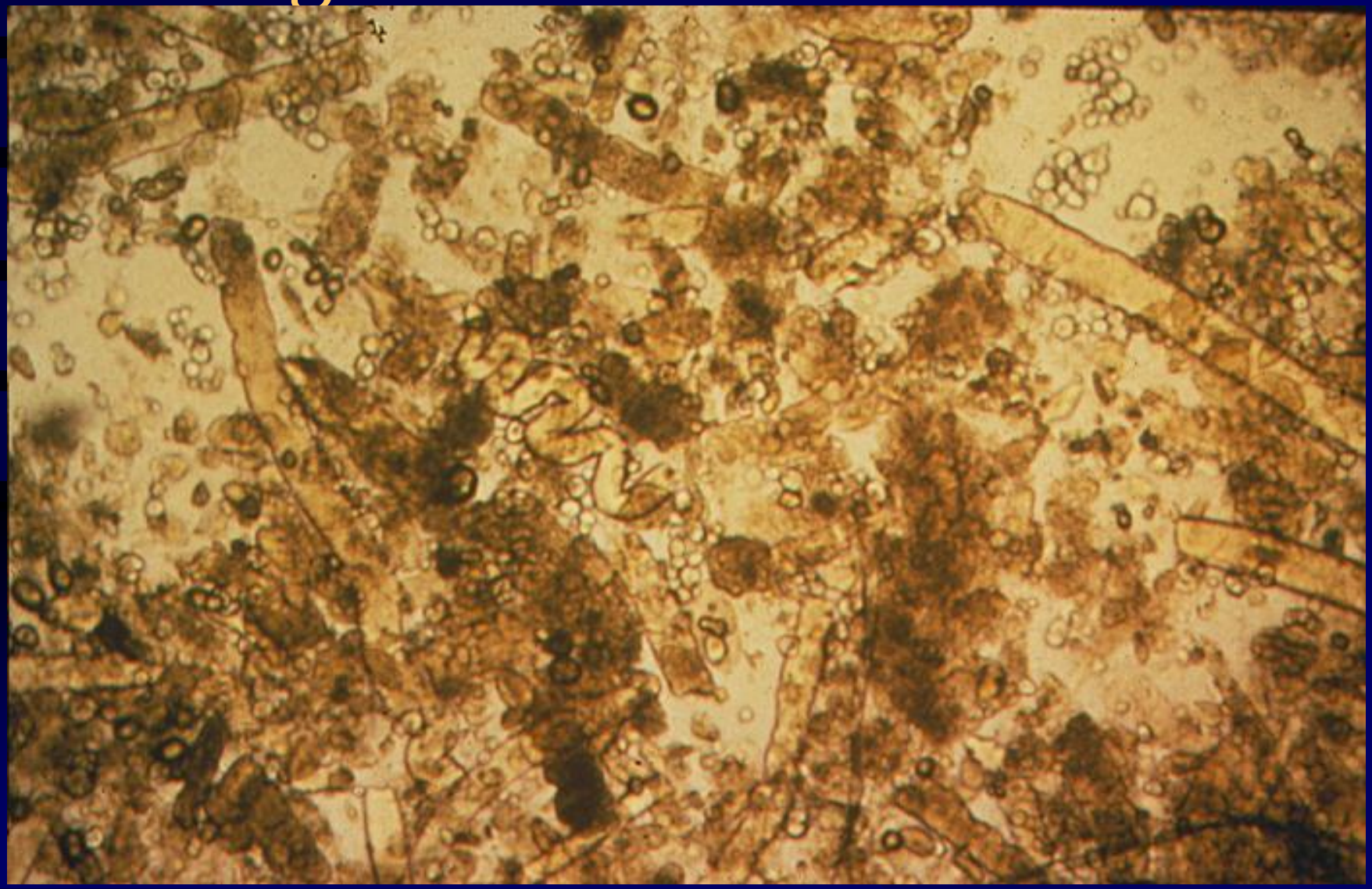

WBC cast


RTE cast


Fatty cast


ATN

Pigmented Granular Casts



Complete blood count

Leukocytosis	common in ARF
Leukopenia and thrombocytopenia	SLE or TTP
Anemia and rouleaux formation	multiple myeloma

Complete blood count

Microangiopathic anemia	TTP or atheroemboli
Eosinophilia	allergic interstitial nephritis, polyarteritis nodosa, or atheroemboli
Coagulation disturbances	liver disease or hepatorenal syndrome.

Blood chemistry

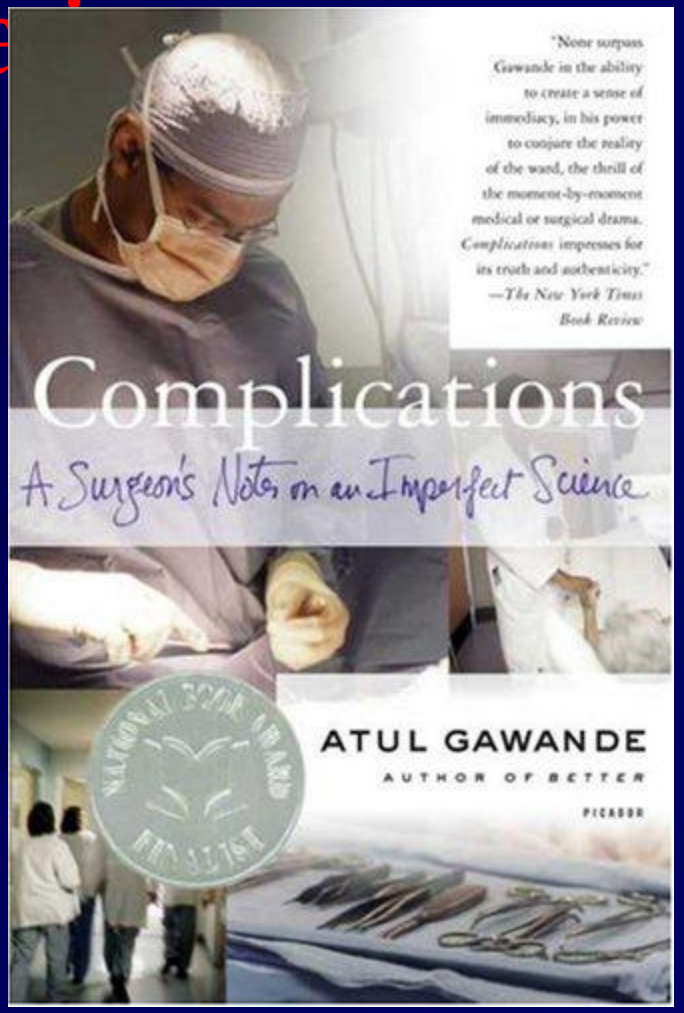
Creatine phosphokinase (CPK) elevations	rhabdomyolysis and myocardial infarction
Elevations in liver transaminases	rapidly progressive liver failure and hepatorenal syndrome
Hypocalcemia (moderate) Hyperkalemia	common complication of ARF

Urine indices

	prerenal ARF	ATN
Urine specific gravity	>1.018	<1.012
Urine osmolality (mOsm/kg H_2O)	>500	<500
Urine sodium (mEq/L)	<15-20	>40
Plasma BUN/creatinine ratio	>20	<10-15
Urine/plasma creatinine ratio	>40	<20

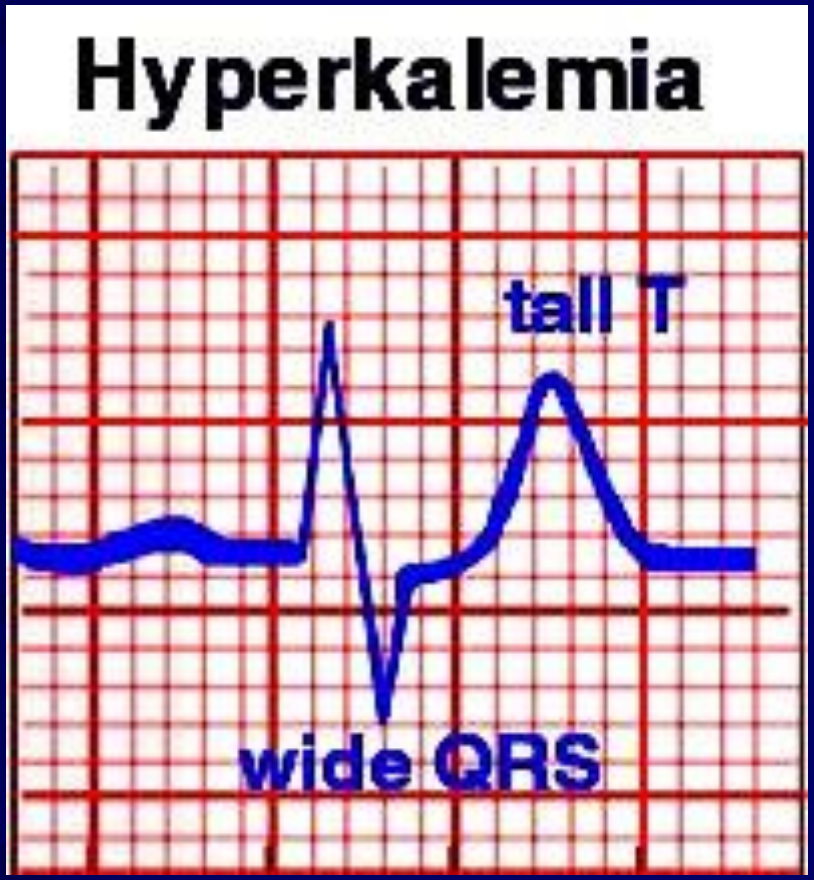
Complica

- Hyperkalemia.
- Acidosis
- Hypocalcemia
- Hyponatremia.
- Hypertension
- Seizures.
- Infections.
- Anemia



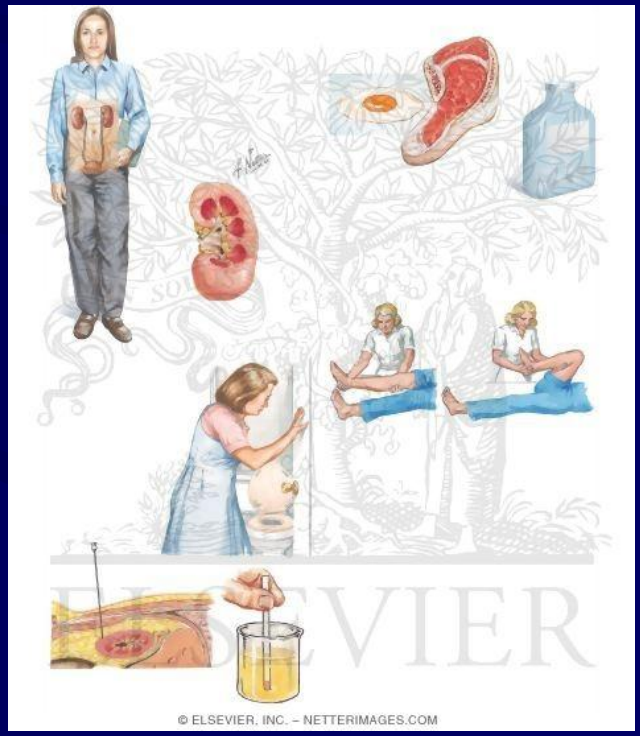
Hyperkalemia Symptoms

- Weakness
- Lethargy
- Muscle cramps
- Paresthesias
- Dysrhythmias



Management

1. General measures.
2. Fluid therapy.
3. Management of complications.



General Measures

- IV secure.
- Take blood samples.
- Collect urine sample.
- Catheterize if bladder is palpable.

- Record blood pressure.
- Careful intake and output record.
- Daily weight measurement.
- Daily investigations.
  - ✓ Urea
  - ✓ Creatinine
  - ✓ Serum electrolytes
  - ✓ Blood gases
  - ✓ ECG(to detect Hyperkalemia).

Acute Renal Failure Treatment

- Water and sodium restriction
- Protein restriction
- Potassium and phosphate restriction
- Adjust medication dosages
- Avoidance of further insults
  - BP support
  - Nephrotoxins

- Calculation of fluid in renal failure.
  - 400ml/meter square/day (insensible loss) + output(urine, vomiting, stool)
  - in infants 15ml/kg fluid + output

- 300 calories/meter square/day are given to reduce catabolism.

- Protein should be restricted to 0.5g/kg/day.

- Avoidance or careful monitoring of blood levels of drugs excreted by kidney.

Fluid Therapy

❖IN RENAL FAILURE WITH DEHYDRATION.

If pt severely dehydrated or in shock.

- Give IV push of N/S 20 ml/kg in ½ hr.
- Observe hydration status and after ½ hr passage of urine.

If hydration & Shock improved

- Give 90 ml/kg of N/S or ringer lactate slow in 3 hrs.
- Again observe hydration status and urine output.

If there in no urine output after 3 hrs and hydration is improved.

- Give frusemide 2 mg/kg/dose IV stat
- Observe for 2-3 hrs.

If urine output is not increased.

- Repeat frusemide.

If still there is no urinary out

- Peritoneal dialysis.

❖RENAL FAILURE WITH FLUID OVERLOAD (Pulmonary edema)

- No IV fluids given.
- Give frusemide 2 mg/kg/dose IV stat.
- Assess after 2-3 hrs.
- Dose may repeat.

If no diuresis after 2 doses of frusemide.

- Single IV dose of 0.5-1.0g/kg Mannitol in 30 min.
- Dopamine 5 ug/kg/min may given if there is no hypertension.
- Peritoneal dialysis is indicated if no response to above treatment.

Management of Complications

1. HYPERKALEMIA

- Calcium gluconate:

0.5-0.1ml/kg IV diluted slowly over 10 min under cardiac monitoring

S/E Bradycardia

cardiac arrest when given rapidly.

If heart rate falls 20beats/min stop the infusion until heart rate returns to normal.

- Sodium bicarbonate

- 1-2mEq/kg slow IV diluted in normal saline.
- Shifts potassium into cells.

❖Glucose solution (50%)

- 1ml/kg with regular insulin,0.1u/kg IV in 1 hr .

❖Kayexalate

- Given orally or per rectum at dose of 1g/kg mixed with sorbitol.

❖Beta adrenergic receptor agonist

- Salbutamol given by nebulization also acutely lowers potassium levels.

❖Dialysis

- Definite therapy for removal of potassium.

2. ACIDOSIS:

❖Correct acidosis by following formula;

NaHCO3 mEq/l = 0.3* W.T.* Base Deficit

(24 – serum NaHCO3)

Total calculated dose divide in 3 doses;

✓One part given stat

✓2nd part after 8 hrs

✓3rd part discard

3. HYPOCALCEMIA

Can present as tetany or convulsions.

- 0.1-0.5 mg\kg iv calcium gluconate slow and diluted in 5 to 10 mints under cardiac monitoring.

Treatment primarily involves efforts to lower the serum phosphorous level.

- Calcium Carbonate (phosphate binder) help to decrease the absorption of phosphorous & help its excretion.

4. Hyponatremia:

Due to fluid overload or hypotonic fluid administration.

< 120 mEq/l require correction with hypertonic sodium chloride

Required Sodium mEq/l = 0.6 * W.T * (125-serum Na)

- In CCF & Hypertension due to fluid over load, contraindicated to give Hypertonic Saline

Do Dialysis to correct hyponatremia

- HT
- Nifedipine=0-25---1mg\kg\dose\po
- Diazoxide=2---5mg\kg\dose\iv
- Labetalol=0-2---1mg\kg\dose\iv
- Hydralazine=0-1---0-5mg\kg\iv
- Na nitroprusside=0-5---10mcg\kg\minute\iv
- Enalapril=5---10mcg\kg\dose\iv\each 8—24hr

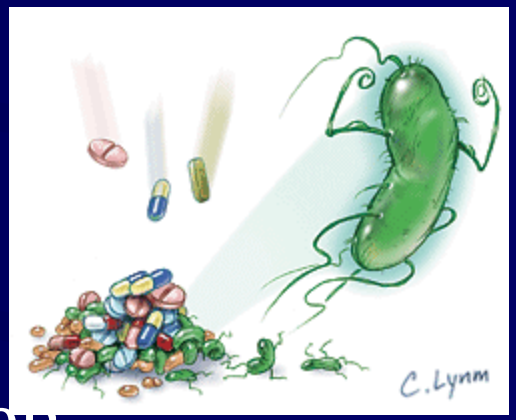
6. Seizures:

Due to primary renal disease, uremia, hyponatremia, hypocalcaemia & hypertension

Inj.Diazepam 0.03 mg/kg/dose

7. Infections:

Due to bladder catheterization or peritoneal dialysis



- Broad Spectrum Antibiotics

(B.Pencillin or Ceftrixone) given.

- Nephrotoxic

(Amikacin, Erythromycin) drugs avoided.

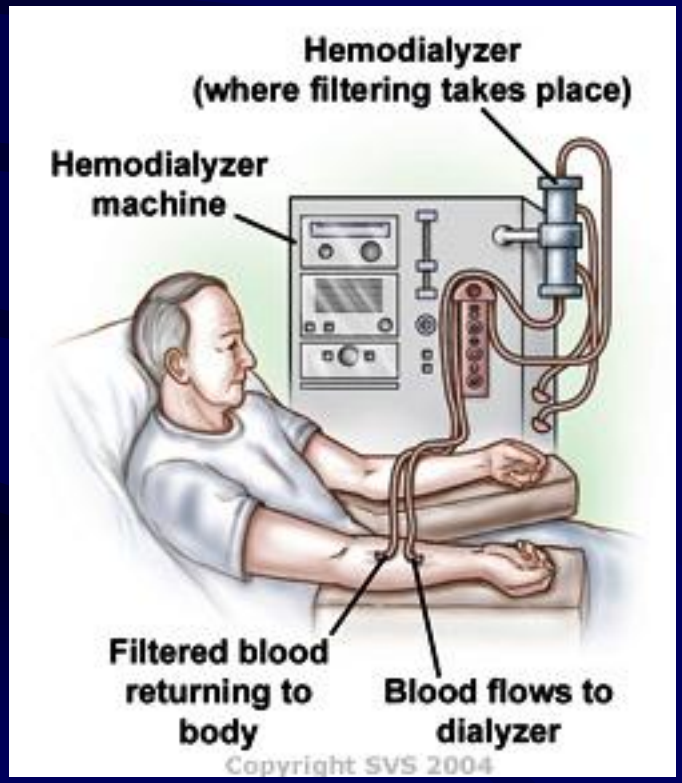
8. Anemia:

Due to volume expansion

- If Hb < 7 g/dl, blood (pack cells 10 ml/kg) should be given very slowly in 4 to 6 hrs.

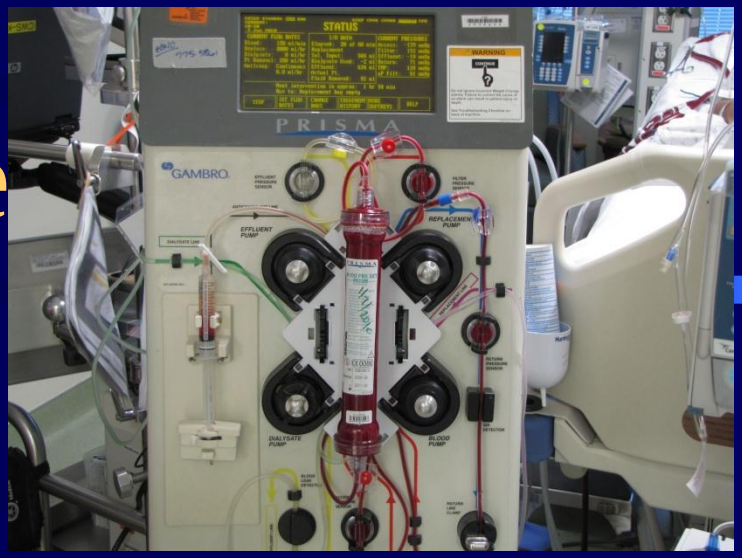
10. Dialysis:

Peritoneal dialysis & Hemo dialysis



Gambro Phoenix
Intermit HD

Gambro PrismaFlex
Adult CRRT



Gambro Prisma: Peds CRR

Baxter HomeChoice
PD

❖Indications for dialysis;

- Hyperkalemia unresponsive to medical therapy.
- Acidosis unresponsive to medical therapy.
- Fluid overload unresponsive to fluid restriction or to diuretics.
- Symptoms & Signs of uremia.
- Hypertension & CCF not responding to medical therapy.
- Blood urea N greater than 100-150mg/dl
- Mental status change

Peritoneal dialysis

Advantages

- Simple to set up & perform
- Easy to use in infants
- Hemodynamic stability
- No anti-coagulation
- Bedside peritoneal access
- Treat severe hypothermia or hyperthermia

Disadvantages

- Unreliable ultrafiltration
- Slow fluid & solute removal
- Drainage failure & leakage
- Catheter obstruction
- Respiratory compromise
- Hyperglycemia
- Peritonitis
- Not good for hyperammonemia or intoxication with dialyzable poisons

Intermittent Hemodialysis

Advantages

- Maximum solute clearance of 3 modalities
- Best therapy for severe hyperkalemia
- Limited anti-coagulation time
- Bedside vascular access can be used

Disadvantages

- Hemodynamic instability
- Hypoxemia
- Rapid fluid and electrolyte shifts
- Complex equipment
- Specialized personnel
- Difficult in small infants

Continuous Hemofiltration

Advantages

- Easy to use in PICU
- Rapid electrolyte correction
- Excellent solute clearances
- Rapid acid/base correction
- Controllable fluid balance
- Tolerated by unstable pts.
- Early use of TPN
- Bedside vascular access routine

Disadvantages

- Systemic anticoagulation (except citrate)
- Frequent filter clotting
- Vascular access in infants

Prognosis

Depends upon cause.

- 90 % complete remission in;
  - ✓ ATN
  - ✓ HUS
  - ✓ Other Causes of pre-renal failure
- Poor Prognosis when renal failure due to;
  - ✓ RPGN
  - ✓ Bilateral Renal Vein Thrombosis
  - ✓ Bilateral Cortical Necrosis

Prognosis

- Highly dependent on underlying etiology, age of patient, and clinical presentation
- AKI neonates (review)
  - Oliguric AKI mortality as high as 60%
  - CHD & Uro abnml mortality up to 86%
- Children (retrospective)
  - $\geq$ 3 system organ failure assoc with more than 50% mortality

Distinguishing ARF from CRF

Helpful clues…

- Previous creatinine values
- Hb – anemia suggests chronic problem
- Renal ultrasound – small, echogenic kidneys suggest a chronic problem
- X-rays – renal osteodystrophy suggests chronic problem
- Renal biopsy

Exceptions to the "small kidneys = CRF" rule:

early DM, amyloid, HIV nephropathy, PCKD

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Thanks!