ACUTE RENAL FAILURE

By
Fatima Ali Ibrahim
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 parenchymal injury

3. Post renal: in which there is obstruction of renal outflow
Outcome

- 3 phases of ARF:
  - Oliguric.
  - Diuretic.
  - 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 (e.g., 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/myoglobinuria)
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)
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.
- Alkalization of urine.
Acute Renal Failure
Etiologies

• Post-Renal

  Bladder outlet obstruction
  – Posterior urethral valve
  – stricture
    • Ureteral stone
    • Tumor
    • 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
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
Investigations

- **Urine Examination:**
  - **Urine Na** -
    - $> 20 \text{ mEq/l}$
      - show *intrinsic renal*
    - $< 10 \text{ mEq/l}$
      - 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

- 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

<table>
<thead>
<tr>
<th>Anuria (&lt;100 mL/d)</th>
<th>Urinary tract obstruction, renal artery obstruction, rapidly progressive glomerulonephritis, bilateral diffuse renal cortical necrosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oliguria (100-400 mL/d)</td>
<td>Prerenal failure, hepatorenal syndrome</td>
</tr>
<tr>
<td>Non-oliguria (&gt;400 mL/d)</td>
<td>Acute interstitial nephritis, acute glomerulonephritis, partial obstructive nephropathy, nephrotoxic and ischemic ATN, radiocontrast-induced ARF, and rhabdomyolysis</td>
</tr>
</tbody>
</table>
# Urinalysis

<table>
<thead>
<tr>
<th>Type of Casts</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granular casts</td>
<td>ATN, glomerulonephritis, interstitial nephritis</td>
</tr>
<tr>
<td>RBC casts</td>
<td>Glomerulonephritis, malignant HTN</td>
</tr>
<tr>
<td>WBC casts</td>
<td>Acute interstitial nephritis, pyelonephritis</td>
</tr>
</tbody>
</table>
## Urinalysis

<table>
<thead>
<tr>
<th>Condition</th>
<th>Possible Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eosinophiluria</td>
<td>Acute allergic interstitial nephritis, atheroembolism</td>
</tr>
<tr>
<td>Crystalluria</td>
<td>Acyclovir, sulfonamides, methotrexate, ethylene glycol toxicity, radiocontrast agents</td>
</tr>
<tr>
<td>Normal</td>
<td>Prerenal and postrenal failure, HUS/thrombotic thrombocytopenic purpura (TTP), preglomerular vasculitis, or atheroembolism</td>
</tr>
</tbody>
</table>
Urine Sediment

Monomorphic RBCs

Dysmorphic RBCs

RBC cast

Hyaline cast
Red Blood Cell Cast
Red Blood Cells

Monomorphomic

Dysmorphic
Dysmorphic Red Blood Cells
Urine Sediment

- WBC cast
- RTE cast
- Fatty cast
- ATN
Pigmented Granular Casts
### Complete blood count

<table>
<thead>
<tr>
<th>Leukocytosis</th>
<th>common in ARF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leukopenia and thrombocytopenia</td>
<td>SLE or TTP</td>
</tr>
<tr>
<td>Anemia and rouleaux formation</td>
<td>multiple myeloma</td>
</tr>
</tbody>
</table>
## Complete blood count

<table>
<thead>
<tr>
<th>Microangiopathic anemia</th>
<th>TTP or atheroemboli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eosinophilia</td>
<td>allergic interstitial nephritis, polyarteritis nodosa, or atheroemboli</td>
</tr>
<tr>
<td>Coagulation disturbances</td>
<td>liver disease or hepatorenal syndrome.</td>
</tr>
</tbody>
</table>
## Blood chemistry

<table>
<thead>
<tr>
<th>Condition</th>
<th>Clinical consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creatine phosphokinase (CPK) elevations</td>
<td>rhabdomyolysis and myocardial infarction</td>
</tr>
<tr>
<td>Elevations in liver transaminases</td>
<td>rapidly progressive liver failure and hepatorenal syndrome</td>
</tr>
<tr>
<td>Hypocalcemia (moderate)</td>
<td>common complication of ARF</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td></td>
</tr>
</tbody>
</table>
# Urine indices

<table>
<thead>
<tr>
<th></th>
<th>Prerenal ARF</th>
<th>ATN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urine specific gravity</strong></td>
<td>&gt;1.018</td>
<td>&lt;1.012</td>
</tr>
<tr>
<td><strong>Urine osmolality (mOsm/kg H₂O)</strong></td>
<td>&gt;500</td>
<td>&lt;500</td>
</tr>
<tr>
<td><strong>Urine sodium (mEq/L)</strong></td>
<td>&lt;15-20</td>
<td>&gt;40</td>
</tr>
<tr>
<td><strong>Plasma BUN/creatinine ratio</strong></td>
<td>&gt;20</td>
<td>&lt;10-15</td>
</tr>
<tr>
<td><strong>Urine/plasma creatinine ratio</strong></td>
<td>&gt;40</td>
<td>&lt;20</td>
</tr>
</tbody>
</table>
Complications

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

- Weakness
- Lethargy
- Muscle cramps
- Paresthesias
- Dysrhythmias
Management

1. General measures.

2. Fluid therapy.

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 is 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 output.

- 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 20 beats/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:
  \[ \text{NaHCO}_3 \text{ mEq/l} = 0.3 \times \text{W.T.} \times \text{Base Deficit} \]
  \[ (24 - \text{serum NaHCO}_3) \]

- Total calculated dose divide in 3 doses;
  - One part given stat
  - 2\text{nd} part after 8 hrs
  - 3\text{rd} 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 overload, 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

Baxter HomeChoice
PD

Gambro Prisma: Peds CRRT
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

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
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<tbody>
<tr>
<td>Simple to set up &amp; perform</td>
<td>Unreliable ultrafiltration</td>
</tr>
<tr>
<td>Easy to use in infants</td>
<td>Slow fluid &amp; solute removal</td>
</tr>
<tr>
<td>Hemodynamic stability</td>
<td>Drainage failure &amp; leakage</td>
</tr>
<tr>
<td>No anti-coagulation</td>
<td>Catheter obstruction</td>
</tr>
<tr>
<td>Bedside peritoneal access</td>
<td>Respiratory compromise</td>
</tr>
<tr>
<td>Treat severe hypothermia or hyperthermia</td>
<td>Hyperglycemia</td>
</tr>
<tr>
<td></td>
<td>Peritonitis</td>
</tr>
<tr>
<td></td>
<td>Not good for hyperammononemia or intoxication with dialyzable poisons</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Easy to use in PICU</td>
<td>• Systemic anticoagulation (except citrate)</td>
</tr>
<tr>
<td>• Rapid electrolyte correction</td>
<td>• Frequent filter clotting</td>
</tr>
<tr>
<td>• Excellent solute clearances</td>
<td>• Vascular access in infants</td>
</tr>
<tr>
<td>• Rapid acid/base correction</td>
<td></td>
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<tr>
<td>• Controllable fluid balance</td>
<td></td>
</tr>
<tr>
<td>• Tolerated by unstable pts.</td>
<td></td>
</tr>
<tr>
<td>• Early use of TPN</td>
<td></td>
</tr>
<tr>
<td>• Bedside vascular access routine</td>
<td></td>
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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)
  - ≥ 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
### References

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<tr>
<td>8</td>
<td>Renal Failure, Acute September 17, 2002 eMedicine.com, Inc.</td>
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Thanks!