ACUTE KIDNEY INJURY

DR. RAVINDRA PRABHU A. MD, DM

DEPARTMENT OF NEPHROLOGY
Kasturba Medical College, Manipal
TALK STRUCTURE

- Renal functions
- Renal response to injury
- Acute kidney injury
  - Definition
  - Etiology
  - Clinical feature
  - History, exam
  - Lab investigations
- Prevention
- Treatment
- Outcome
NORMAL RENAL FUNCTION

- Excretion of waste products
- Individual regulation of water and solute balance
- Endocrine – EPO, VITD3, Renin, PGs etc
- Glucose production, peptide catabolism
WHY KIDNEY?

- Critically dependent on endothelial vasodilation
- Undue sensitivity to vasoconstrictors
- Medulla relatively ischemic normally
Renal response to injury

Hypovolemia

Angiotensin 2 ↓ NE AVP

Vasoconstriction

EFF ART constriction, autoregulation, PG

↓ RBF, GFR

Autoregulation overwhelmed

↓ Ischemic ATN

↓ Sustained GFR → Recovery
DEFINITION

- Rapid decline in GFR – within 48 hours
- Retention of Nitrogenous waste – Uremia
- Extracellular fluid volume perturbed
- Disturbed electrolytes, acid base balance

Mostly reversible
## Incidence and Mortality of AKI in the ICU

<table>
<thead>
<tr>
<th>Setting (no. of patients)</th>
<th>AKI definition</th>
<th>Incidence (% of study group)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General ICU (26,669)</td>
<td>Need for dialysis</td>
<td>27.6</td>
<td>56 (at hospital discharge)</td>
</tr>
<tr>
<td>Cardiothoracic ICU (58)</td>
<td>Need for dialysis</td>
<td>N/A</td>
<td>67 (ARF)</td>
</tr>
<tr>
<td>CCU (2392)</td>
<td>Complex</td>
<td>4.0</td>
<td>50</td>
</tr>
<tr>
<td>Postcardiopulmonary bypass (47)</td>
<td>Need for dialysis</td>
<td>2.0</td>
<td>53.8 (at ICU discharge)</td>
</tr>
</tbody>
</table>
CAUSES

Prerenal 55%
Renal 40%
Vessels, Glomeruli, Tubules, Interstitium
Post renal 5%
PRERENAL FAILURE

- Acute decline in renal function reversed rapidly by correction of perfusion
PRERENAL

- Hypovolemia – Gastro enteritis
- Low cardiac output – CCF
- Systemic vasodilation
  - Sepsis, Anaesthesia
- Renal vasoconstriction
- Cirrhosis with ascites - hepatorenal
- Impaired autoregulation
  - NSAIDS, ACE inhibitors
RENAL

- Large vessel obstruction
- Small vessel obstruction
- HUS, TTP, Toxemia of pregnancy, DIC,
  Malignant hypertension
- Glomerulonephritis
Renal....

- **Acute tubular necrosis**
  - Ischemic
    - Prerenal, obstetric, Post surgery, Multifactorial

**Phases**
- Initiation - Hours to days
- Maintainence - 1 – 2 weeks
- Recovery phase

**Indicators** – Hypotension, sepsis, dehydration
ISCHEMIC ATN

Hypoperfusion causing acute decline in function sustained by aberrant hemodynamics, cell injury

Recovery – regeneration, repair
AKI CAUSES

- **Toxins**
  - Exo - Contrast, Antibiotics (Aminoglycosides), Chemotherapy
  - Endo - Hemolysis, Snake bite, Crush injury
  - Increased risk in elderly, renal insufficiency, hypovolemia, concomitant toxins

- **Interstitial nephritis**
  - Allergy – Antibiotics
  - Infection – Leptospirosis

**Post renal**
- Obstruction – Ureter, Bladder, Urethra
SURGICAL AKI

Pre renal
- Volume depletion, nasogastric suction, GI bleed
- 3rd space loss - burns, pancreatitis, peritonitis
- Hemorrhage
SURGICAL AKI

Renal
- Aortic dissection
- Drugs – NSAIDS, contrast, antibiotics

Post renal
- Uretero pelvic junction – stone, clots
- Ureter – Trauma, stone, papilla, clot, cancer
- RPF, tumor
- Bladder – Rupture
- Urethra – BPH, stone, FB, stricture, phimosis
INCIDENCE

- Highly prevalent
- Post operative 27%
- Trauma 20 – 40%
- Burns 15 – 30%

Risks:
- Cardiac surgery
- Jaundice
REASONS

Comorbidity – DM, HTN, CHF

- Afferent art constriction

Second hit

- Reoperation
- Sepsis
- Nephrotoxins
- Circulatory / volume deficit
- Heart failure
TRAUMA

**Early** – Hypovolemia, pigment induced
**Late** – MOD, Sepsis

Risk factors for AKI:
- Severe injury
- Hypotension at arrival
- Increased CPK
- On mechanical ventilation
- Mortality – creat < 4 – 71%
  > 4 – 93%
BURNS

3rd degree, > 10% BSA

Early – Vol. depletion
Hypotension
↑ CPK

Late – Nephrotoxin
Sepsis
MOD
AKI

Phases

- Initiation- 2 days
- Maintainence- 10 to 14 days
- Recovery- 1 week
PRESENTATION

According to cause
- Decreased urine oliguria/anuria
- Uremia
- Acidosis / Pulmonary edema

No reliable clinical indicator
- Measure renal functions in all acutely ill patients
- Record fluid intake and output
- Daily weighing
- Postural BP recording
SUSPECT AKI

- Hypertension
- Edema/ Dehydration
- Electrolyte disturbance
- Urinary abnormality
- Anemia, Hypoalbuminemia
- Abnormal RFT
Risk factors for AKI

- Diabetes mellitus
- Heart failure
- Age > 65 years
- Nephrotic syndrome
- S. creat > 2
- IV contrast > 125 ml
APPREACH

- History
- Physical exam
- Urine analysis
- RFT. Electrolytes
DIAGNOSTIC APPROACH IN AKI

- Establish whether acute or chronic
  - Look at previous records
  - Clinical features of CRF
    - Vague ill health
    - Nocturia, pruritus
    - Anemia, Neuropathy
    - Longstanding hypertension, proteinuria
    - Renal size
Diagnostic approach in AKI....

**Indicators of volume depletion**

- Low JVP
- Postural drop in BP > 10 mmHg
- Postural tachycardia > 10 /min
- Fast thready pulse
- Hypotension
- Collapsed peripheral veins
- Cool peripheries
- CVP
- Fluid challenge
Diagnostic approach in AKI….

Exclude urinary obstruction

- Readily treatable
- Urological symptoms - Flank / suprapubic pain
- Prostatism – Nocturia, frequency, hesitancy
- Anuria, alternate polyuria / anuria
- Imaging
Diagnostic approach in AKI….

- Exclude AGN / AIN / Vasculitis
  - Oliguria / edema / HTN / active urine / fever / arthralgia / rash / multisystem disorder
  - History of drug ingestion
  - Connective tissue work up

- Exclude renal vascular event
  - Flank pain / Oligoanuria / Retinal change / digital ischemia / SC nodules
**URINALYSIS**

<table>
<thead>
<tr>
<th>Prerenal</th>
<th>Acellular, Hyaline casts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postrenal</td>
<td>Pyuria, hematuria</td>
</tr>
<tr>
<td>Renal</td>
<td>Muddy brown granular casts – ATN</td>
</tr>
<tr>
<td></td>
<td>RBC casts – AGN</td>
</tr>
<tr>
<td></td>
<td>WBC / Nonpigment granular – AIN</td>
</tr>
<tr>
<td></td>
<td>Broad – CRF</td>
</tr>
<tr>
<td></td>
<td>Eosinophiluria – Allergic AIN, Atheroemboli</td>
</tr>
<tr>
<td></td>
<td>Crystals – Uric acid, Oxalate, Hippurate</td>
</tr>
</tbody>
</table>

**Proteinuria** –

- > 1g/day – Glomerular
- > 1g – Tubular

**Pigments** – Hb, Myoglobin
# Renal Failure Indices

<table>
<thead>
<tr>
<th></th>
<th>Prerenal</th>
<th>ATN</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_{NA}$</td>
<td>&lt; 10</td>
<td>&gt; 20</td>
</tr>
<tr>
<td>$U_{OSM}$</td>
<td>&gt; 500</td>
<td>&lt; 350</td>
</tr>
<tr>
<td>$FE_{NA}$</td>
<td>&lt; 1</td>
<td>&gt; 2</td>
</tr>
<tr>
<td>B. Urea / creat</td>
<td>&gt; 40</td>
<td>&lt; 20 – 30</td>
</tr>
<tr>
<td>Urine sediment</td>
<td>Bland</td>
<td>Pigmented granular casts</td>
</tr>
<tr>
<td>U.S.Gr</td>
<td>&gt; 1.018</td>
<td>&lt; 1.015</td>
</tr>
</tbody>
</table>
## AKI RIFLE SCORE

<table>
<thead>
<tr>
<th>Class</th>
<th>Glomerular filtration rate criteria</th>
<th>Urine output criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk</td>
<td>Serum creatinine $\times$ 1.5</td>
<td>$&lt; 0.5 \text{ ml/kg/hour} \times 6 \text{ hours}$</td>
</tr>
<tr>
<td>Injury</td>
<td>Serum creatinine $\times$ 2</td>
<td>$&lt; 0.5 \text{ ml/kg/hour} \times 12 \text{ hours}$</td>
</tr>
<tr>
<td>Failure</td>
<td>Serum creatinine $\times$ 3, or serum creatinine $\geq 4 \text{ mg/dl}$ with an acute rise $&gt; 0.5 \text{ mg/dl}$</td>
<td>$&lt; 0.3 \text{ ml/kg/hour} \times 24 \text{ hours}$, or anuria $\times 12 \text{ hours}$</td>
</tr>
<tr>
<td>Loss</td>
<td>Persistent acute renal failure = complete loss of kidney function $&gt; 4 \text{ weeks}$</td>
<td></td>
</tr>
<tr>
<td>End-stage kidney disease</td>
<td>End-stage kidney disease $&gt; 3 \text{ months}$</td>
<td></td>
</tr>
</tbody>
</table>
# MODIFIED RIFLE

<table>
<thead>
<tr>
<th>AKI stage I</th>
<th>Increase of serum creatinine by $\geq 0.3$ mg/dl or increase to $\geq 150% – 200%$ from baseline</th>
<th>Urine output $&lt; 0.5$ ml/kg/hour for $&gt; 6$ hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKI stage II</td>
<td>Increase of serum creatinine to $&gt; 200% – 300%$ from baseline</td>
<td>Urine output $&lt; 0.5$ ml/kg/hour for $&gt; 12$ hours</td>
</tr>
<tr>
<td>AKI stage III</td>
<td>Increase of serum creatinine to $&gt; 300%$ from baseline or serum creatinine $\geq 4.0$ mg/dl with an acute rise $&gt; 0.5$ mg/dl or treatment with renal replacement therapy</td>
<td>Urine output $&lt; 0.3$ ml/kg/hour for $&gt; 24$ hours or anuria for $12$ hours</td>
</tr>
</tbody>
</table>
LABORATORY FINDINGS

- Raised B. urea, S. creatininine
- Hyperkalemia – Increased in hypercatabolic states
- Metabolic acidosis
- Hypocalcemia, Hyperphosphatemia
- Hyperuricemia, CK
- Anemia, Leucocytosis
- DIC
- Non obvious causes to be considered HUS, multiple myeloma
ESTIMATE GFR

- 100 / S creat
- Cockroft gault - \( \frac{(140 - \text{age}) \times \text{wt.kg}}{72 \times \text{S. creat}} \)
- MDRD
PREVENTION

Pharmacologic
↑ ECF
↑ Urine flow
Maintain MAP
? Renal vasodilators
Pre op optimisation
PREVENTION

Aggressive restoration of volume status
Avoid / adjust dose of nephrotoxins

Aminoglycosides
- Once daily use
- Monitor S – Creat
- Avoid in liver disease, advanced age, preexisting renal insufficiency

Radiocontrast
- hydration, sodabicarb, acetylcysteine
PREVENTION

- Avoid $\geq 2$ nephrotoxins
- Consider alternatives
- Use small doses briefly
- Formulation / dose modification, monitor levels
- Measure RFT frequently
- Hydration
- Computer surveillance
PREVENTION

Minimize nosocomial infection
Hand wash
Catheter care
Antibiotics
Avoid aspiration
  - Elevate head
  - Gastric aspiration
  - ↓ sedation
MANAGEMENT

- 1\textsuperscript{st} treat life threatening complications
  \(\uparrow K^+,\) pulmonary edema
- Assess volume status and resuscitate accordingly
- Establish acute Vs chronic renal failure
- Establish cause or causes of ARF
- Prescribe treatment / refer to specialist unit
SURGERY IN AKI

- elective surgery
- Scrupulous attention to volume
- Avoid nephrotoxins
- S. creat > 2.5 – increases incidence of
  - Sepsis
  - GI bleed
  - fluid overload
COMPLICATIONS

- Hyperkalemia (N: 3.5 - 5 mEq/L)
- Tenting of T waves
- ↓ size of p waves
- ↑PR interval, widened QRS
- Disappearance of P wave
- Sine wave formation
Complications....

Increased K\(^+\) treatment
- IV 10\% Ca Gluconate 10 ml over 1 min
- IV Glucose 50\%, 50 ml over 10 min + 10 units insulin \(\downarrow K^+ 1 – 2\) mmol/L over 30 – 60 min
- Salbutamol nebuliser
- Cationic exchange resin 15G 6 hrly oral/rectal
- Hemodialysis

Pulmonary edema
- Upright position O2, Morphine
- IV frusemide
- Hemodialysis
Complications....

Bleeding: Heparin effect

Treat anemia

Antacids / H₂ blockers / sucralfate

Infection: Important cause of death

Prophylactic antibiotics not useful
TREATMENT OF AKI

- Loop diuretics: 1-4 mg/Kg/hour. Max 1G/day
  - May change oliguric to nonoliguric
  - Overall course unchanged
- Mannitol – May be helpful in crush injury
- Dopamine – 1-5 $\mu$g/kg/min
ARF, Urine <30-40 ml/h

Treat cause, avoid nephrotoxins

CVP<5 cm H2O

Yes Vol Repletion

No response

Frusemide 80 mg

No response

Frusemide infuse 2-4 mg/min + Dopamine X 4 hrly

Response

Continue

No resp

Stop
SPECIFIC THERAPY

Prerenal
- Correction of hemodynamic insult, inotropes
- Stop nephrotoxins
- Careful fluid infusion,
- Large volume paracentesis in cirrhosis

Renal
- AGN / AIN: Steroids
- Immunosuppressive
- BP control

Post renal
- Removal of obstruction
FLUID REQUIREMENTS

- According to fluid lost
  - Hemorrhage – Blood
  - GI / Urinary loss – 0.45% saline
  - Burns, pancreatitis – N saline
  - $\text{K}^+$, $\text{HCO}_3^-$ Supplement
  - Assess daily requirement
SUPPORTIVE

- Maintain fluid balance – Urine +500 ml/day
- Treat acidosis – if $\text{HCO}_3^- < 15$, $\text{pH} \leq 7.2$
  
  IV bicarbonate = $0.6 \times \text{B wt} \times \text{Bicarb deficit}$
  
  To be given over several hours, dialysis
- Hyperphosphatemia – Phosphate binders, restrict $\text{PO}_4^-$
- Hypocalcemia – Ca replacement
- Dose modification of drugs
- Avoid nephrotoxins
DIALYSIS

- Refractory hyperkalemia
- Refractory fluid overload
- Overt uremia
  - Encephalopathy
  - Pericarditis
- Acidosis causing circ. compromise
- B. Urea > 180 mg/dl, S. Creat > 8-10 mg/dl
- Modality depends on patient, facilities
RENAL REPLACEMENT THERAPY

Indications
- Uraemic encephalopathy
- Uraemic pericarditis
- Uraemic neuropathy/myopathy
- Severe dysnatraemia ([Na] > 160 or <115 meq/l)
- Hyperthermia
- Drug overdose with a dialysable toxin

One criteria can be an indication for the initiation of RRT. Two or more criteria make RRT mandatory. Multiple criteria are a reason for early initiation of RRT.
NON RENAL INDICATIONS

MOST

- Blood purification and renal support
- Temperature control
- Acid–base control
- Fluid balance control
- Cardiac support
- Protective lung support
- Cerebral protection
- Bone marrow protection
- Blood detoxification and liver support
- Septic therapy - immunomodulation and endothelial support
Options

- Hemodialysis
  - Intermittent
  - Continuous
  - Extended intermittent

- Peritoneal dialysis

Tailored to time, hemodynamic, metabolic requirements, molecules.
# RENAL REPLACEMENT THERAPY – Classification

<table>
<thead>
<tr>
<th>Time</th>
<th>Driving force</th>
<th>Operational characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermittent</td>
<td>Arteriovenous</td>
<td>Diffusion</td>
</tr>
<tr>
<td>Extended intermittent</td>
<td>Pumped venovenous</td>
<td>HD</td>
</tr>
<tr>
<td>Slow</td>
<td></td>
<td>Convection</td>
</tr>
<tr>
<td>Continuous</td>
<td></td>
<td>HF, UF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both – HDF, High flux</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adsorption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pheresis</td>
</tr>
</tbody>
</table>
TREATMENT NOMENCLATURE

- Hemodialysis
- Hemofiltration
- Hemodiafiltration
- High flux dialysis
- Ultrafiltration
- Plasmapheresis
- Hemoperfusion
- SLED
- Hybrid
ASSESSMENT

- Therapeutic potential
- Goals of management
- Practicality of delivery of RRT
- Likelihood of improving survival
- When to start RRT
- Costs involved
GOALS

IMMEDIATE
- Improve fluid, acid base
- Hemodynamic stability
- Temporary support till renal recovery

ONGOING
- Fluid removal
- Weaning vasopressor
- Support organ function
- Prevent further renal insult
- Promote renal recovery
NUTRITION

- Nutrition enteral preferred
- 35 Kcal/kg, 1 to 1.5 g protein / kg
- PO₄, Na, K⁺ restriction
- Water soluble vitamins
- Trace elements
FACTORS AFFECTING AKI MORTALITY

- Primary diagnosis
- Co-morbidity
- Quality of non specialist management
- Appropriate site of care
- Early referral to a nephrologist
- Intensity of intermittent dialysis
- Higher doses of CVVH
OUTCOME

Depends on systems involved

- Obstetric 15%
- Nephrotoxic 30%
- Trauma / Major surgery – 60%
- Oliguria, creat > 3mg/dl, elderly, MOF
- 5% → CRF
AKI - MORTALITY

- ATN 60%
- Prerenal 35%
- Acute on CRF 35%
- ARF+RS- 50%
- Obstructive 27%
- Other 26%
- MOF 90-100%
CONCLUSION

- AKI is common
- Preventable if attention is paid to volume,
- avoid or use nephrotoxins with care
- Once established lasts for 10 to 14 days and has no specific treatment
- Considerable mortality, morbidity, costs and requirement of specialist support
THANK YOU