Chapter 97 – Renal Failure

Episode Overview:

1) Describe a general approach to the evaluation of acute kidney injury (AKI)
2) List clinical features of AKI
   a) CV / Metabolic / Neurologic / Gastrointestinal / Hematologic / Infectious
3) List the causes of prerenal azotemia
4) Compare laboratory test differences between pre-renal azotemia and ATN
5) List intrinsic renal diseases that cause AKI
6) List the RFs for contrast induced ATN
7) List causes of postrenal renal failure
8) List causes of pigment induced AKI
9) List causes of hematuria, what are the most common?
10) List complications of AKI
11) Compare and Contrast nephritic vs nephrotic syndrome
12) List the Main Causes of CKD
13) List the reversible and treatable causes of CKD
14) List the mechanisms of drug toxicity in CKD
15) List four major complications of CKD and their management
   a) Hyperkalemia
   b) Bleeding
   c) Pulmonary edema
   d) Infection
16) Compare the mechanisms of dialysis in HD and PD
17) List indications for emergency dialysis
18) List complications of hemodialysis
19) List DDx for Hypotension in the hemodialysis patients
20) List causes of altered mental status in dialysis patients
21) Describe the management of peritonitis in the PD patient
22) Describe the management of:
   a) Hyperkalemia
   b) Hypocalcemia
   c) Hyperphosphatemia
   d) Hypermagnesemia

Wisecracks

1. How do NSAIDs cause AKI?
2. Describe the likely pathophysiologic etiology of the following casts:
   Hyaline Casts; Red Cell Casts; White Cell Casts; Granular Casts; Fatty Casts

Rosen’s in Perspective

So what’s the emergency about kidney disease?

Well here’s the thought process:
1. Identify renal failure (azotemia)
   a. Rule out life threats: hyperK, pulmonary edema
   b. Is this AKI or a pre-existing CKD?
   c. ...all the rest of the steps we’ll cover in the show!

AKI can be from pre-renal, intrinsic parenchymal damage, or post renal / obstructive causes.

When you say Acute Tubular necrosis, it means the cause of intrinsic AKI can NOT be attributed to a glomerular, vascular, or interstitial cause

Quick refresher:

2. Source: https://commons.wikimedia.org/wiki/File:Kidney_nephron_molar_transport_diagram.svg
Soap Box:

Remember all you lasix happy people:

Patients w/ CHF or cirrhosis are often salt-overloaded and water-overloaded HOWEVER their effective intra-arterial volume is decreased.

Giving these patients diuretics can further decrease intravascular volume = decreased glomerular filtration and prerenal azotemia.

In the end “a state of chronic, stable, prerenal azotemia may be the best achievable compromise between symptomatic volume overload and severe renal hypoperfusion.” - Rosen’s 9th edition

1) Describe a general approach to the evaluation of acute kidney injury (AKI)

Azotemia (azot, “nitrogen” + -emia, “blood condition”) is a medical condition characterized by abnormally high levels of nitrogen-containing compounds (such as urea, creatinine, various body waste compounds, and other nitrogen-rich compounds) in the blood. - Wikipedia.

Hx: Look for pre-renal causes:

- Decreased cardiac output signs & symptoms (lightheadedness, SOB, PND, orthopnea etc)
- Bleeding
- GI fluid loss
- Abnormal polyuria

Hx: Obstructive / Post Renal:

- Nocturia / frequency / hesitancy or decreased urinary stream
- Dysuria / hematuria (infection / inflammation or neoplasm)
- Hx kidney stones or chronic urinary tract infection (UTI).

Pearl: Hx of acute anuria (<100 mL of urine/day) = high-grade urinary tract obstruction but can also include:

- Severe volume depletion
- Severe acute glomerulonephritis
- Cortical necrosis
- Bilateral renal vascular occlusion.

Intermittent anuria usually = Obstruction

Ask about med use and other toxin exposures, rash, dark urine, fever and arthritis.

Refer to Fig 87.1 for a structured approach to Azotemia
2) List clinical features of AKI

Box 87.1

**Cardiovascular**
- Pulmonary edema
- Arrhythmia
- Hypertension
- Pericarditis
- Pericardial effusion
- Myocardial effusion
- Pulmonary embolism
- Coma
- Seizures

**Gastrointestinal**
- Nausea
- Vomiting
- Gastritis
- Gastrooduodenal ulcer
- Gastrointestinal bleeding
- Pancreatitis
- Malnutrition

**Metabolic**
- Hyponatremia
- Hyperkalemia
- Hypocalcemia
- Hyperphosphatemia
- Hypermagnesemia
- Hyperuricemia

**Neurologic**
- Asterixis
- Neuromuscular irritability
- Mental status changes
- Somnolence

**Hematologic**
- Anemia
- Hemorrhagic diathesis

**Infectious**
- Pneumonia
- Septicemia
- UTI
- Wound infection

3) List the causes of prerenal azotemia

Box 87.2

**Volume loss**
- GI losses
- Renal (diuresis)
- Blood loss
- Insensible losses
- Third-spacing sequestration
- Pancreatitis
- Peritonitis
- Trauma
- Burns

**Cardiac causes**
- Myocardial infarction
- Valvular disease
- Cardiomyopathy
- Decreased effective arterial volume
- Antihypertensive medication
- Nitrates

**Neurogenic causes**
- Sepsis
- Anaphylaxis
- Hypoalbuminemia
- Nephrotic syndrome
- Liver disease
4) Compare laboratory test differences between pre-renal azotemia and Intrinsic AKI

<table>
<thead>
<tr>
<th></th>
<th>Pre Renal</th>
<th>Intrinsic</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUN : Cr (ratio)</td>
<td>Usually &gt;20</td>
<td>10-20</td>
<td>10-20</td>
</tr>
<tr>
<td>Urine Na (mEq/L)</td>
<td>&lt;20</td>
<td>&gt;30</td>
<td>&lt;20 early, &gt;40 late</td>
</tr>
<tr>
<td>FENa (%)</td>
<td>&lt;1</td>
<td>&gt;2-3</td>
<td>&lt;1 early, &gt;3 late</td>
</tr>
<tr>
<td>Urine Osm (mOsm/kg)</td>
<td>&gt;350</td>
<td>~300</td>
<td>&gt;400 early, 300 late</td>
</tr>
<tr>
<td>Urine Specific Gravity</td>
<td>&gt;1.020</td>
<td>~1.010</td>
<td>&gt;1.010 early, &lt;1.010 late</td>
</tr>
<tr>
<td>Urine Micro</td>
<td>Normal +/- hyaline casts</td>
<td>ATN: Hyaline casts w/ dark granular casts, renal epi cells or casts</td>
<td>Normal +/- hyaline casts or granular casts</td>
</tr>
</tbody>
</table>

5) List the intrinsic renal diseases that cause AKI

Box 87.4

**Vascular Diseases**

**Large-Vessel Diseases**
- Renal artery thrombosis or stenosis
- Renal vein thrombosis
- Atheroembolic disease

**Small- and Medium-Sized Vessel Diseases**
- Scleroderma
- Malignant hypertension
- Hemolytic uremic syndrome
- Thrombotic thrombocytopenic purpura
- HIV-associated microangiopathy

**Glomerular (Systemic) Diseases**
- Systemic lupus erythematosus
- Infective endocarditis
- Systemic vasculitis
- Henoch-Schönlein purpura
- HIV-associated nephropathy
- Essential mixed cryoglobulinemia
Primary Renal Diseases
- Poststreptococcal glomerulonephritis
- Other postinfectious glomerulonephritis
- Rapidly progressive glomerulonephritis

Tubulointerstitial Diseases and Conditions
- Drugs
- Toxins
- Infections
- Multiple myeloma

Acute Tubular Necrosis
- Ischemia -> Shock, sepsis, severe pre-renal azotemia
- Nephrotoxins -> Antibiotics, radiographic contrast agents, myoglobinuria, hemoglobinuria

Other Diseases and Conditions
- Severe liver disease
- Allergic reactions
- NSAIDs

6) List the RFs for contrast induced ATN

According to LITFL here

Top 3:

- Pre-existing renal disease (especially Cr >120)
- Diabetes mellitus
- Age >75yrs

Others:

- CHF
- Hypertension
- Hypovolemia
- Nephrotoxins (NSAIDs, cyclosporin, aminoglycosides, amphotericin)
- High dose contrast, intra-arterial worse than IV
- Cirrhosis/nephrotic syndrome
- Multiple myeloma
- PVD
- High uric acid and hypercholesterolemia
7) List the causes of postrenal renal failure

Box 87.3

**Intrarenal and Ureteral Causes**
- Kidney stone
- Sloughed papilla
- Malignancy
- Retroperitoneal fibrosis
- Uric acid, oxalic acid, or phosphate crystal precipitation
- Sulfonamide, methotrexate, acyclovir, or indinavir precipitation

**Bladder**
- Kidney stone
- Blood clot
- Prostatic hypertrophy
- Bladder carcinoma
- Neurogenic bladder

**Urethra**
- Phimosis
- Stricture

8) List the causes of pigment induced AKI

Box 87.5

**Rhabdomyolysis and myoglobinuria**
- Crush injury
- Compartment syndrome
- Electrical injury
- Myonecrosis from coma or immobilization
- Acute arterial occlusion
- Vigorous exertion
- Status epilepticus
- Hyperthermia/heat stress

**Metabolic myopathy**
- Drugs/toxins
- Hypokalemia
- Hypophosphatemia

**Hemoglobinuria**
- Acute hemolysis
- Transfusion reaction
- Infections

9) List causes of hematuria, what are the most common?

Think:

- UTI
- Stones
- Exercise induced
- Trauma
- Endometriosis
- **Cancer**
- PCKD
- **Glomerular Disease**
According to UptoDate:

**RENAI**
- Benign renal mass (angiomyolipoma, necrocytoma, abscess)
- Malignant renal mass (renal cell carcinoma, transitional cell carcinoma)
- Glomerular bleeding (IgA nephropathy, thin basement membrane disease, hereditary nephritis - Alport’s syndrome)
- Structural disease (polycystic kidney disease, medullary sponge kidney)
- Pyelonephritis
- Hypercalcemia / hypercalciuria
- Malignant hypertension
- Renal vein thrombosis / renal artery embolism
- Arteriovenous malformation
- Papillary necrosis (sickle cell disease)

**MIMICS OF HEMATURIA**
- Membranoproliferative glomerulonephritis
- Drugs (pyridium, phenazopyridine, rifampin, nitrofurantoin)
- Pseudomembrane
- Bacteremia

**URETER**
- Malignancy
- Stone
- Stricture
- Fibroepithelial polyp
- Post-surgical conditions (ureteral transitional cell carcinoma)

**CENTRIFUGE RESULT**
- Sediment red
- Supernatant red

**Hematuria**
- Dipstick heme

**Negative**
- **Erythrocritia**
- Phenazopyridine
- Paraphrenia
- Other

**Positive**
- Myoglobin
- Hemoglobin

**Plasma color**
- Clear
- Red

**Myoglobinuria**
- Hemoglobinuria

**PROSTATE / URETHRA**
- Benign prostatic hyperplasia
- Prostate cancer
- Prostatic procedures (biopsy, transurethral resection of the prostate)
- Traumatic catheterization
- Urethral stricture
- Urethral diverticulum
10) List complications of AKI

Spaced repetition! Essentially the same as questions 1, but here is another way of thinking about it

Checkout the CCC at LITFL [here](http://www.canadiem.org/crackcast)

- Volume overload – CHF, HTN
- Metabolic acidosis
  - Hypercholaemia
  - accumulation of organic anions – PO4
  - decreased Alb -> decreased buffering
  - impaired insulin action -> hyperglycaemia
  - catcholamine resistance (bAR downregulation)
  - increased iNOS
- Electrolytes – increased K+ and low Na+
- Pulmonary oedema – low albumin -> decreased oncotic pressure + volume overload
- ALI – neutrophil activation and sequestration in the lung
- Uraemia (ALOC and pericarditis)
- Immune – decreased clearance of oxidant stress, tissue oedema, WCC dysfunction – increased risk of infection
- Haematological – decreased RBC synthesis and increased destruction of RBC -> anaemia, decreased EPO, platelet dysfunction secondary to uremic toxins, vWF -> bleeding
- GI – GI oedema -> compartment syndrome, decreased nutritional absorption, gut ischaemia -> peptic ulcer disease
- Pharmacology – increased Vd, decreased bioavailability, albumin, decreased elimination -> under dosing or toxicity

11) Compare and Contrast nephritic vs nephrotic syndrome

Check out this link for a more in-depth video: [here](http://www.canadiem.org/crackcast)
# Nephrotic Syndrome vs Nephritic Syndrome

<table>
<thead>
<tr>
<th><strong>Nephrotic Syndrome</strong></th>
<th><strong>POC</strong></th>
<th><strong>Nephritic Syndrome</strong></th>
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</thead>
<tbody>
<tr>
<td>Urea/Creatinine</td>
<td>Low</td>
<td>Elevated in severe cases</td>
</tr>
<tr>
<td>Proteinuria</td>
<td>Present</td>
<td>a Sure Diagnostic Sign</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>High</td>
<td>(Tamm-Horsfall Protein)</td>
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<tr>
<td>RBCs and RC</td>
<td>Present</td>
<td></td>
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<tr>
<td>Hyaline Cast and THP</td>
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<td></td>
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<tr>
<td>Weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood</td>
<td></td>
<td></td>
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<tr>
<td>Serum Protein</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
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<td></td>
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<tr>
<td>Urea/Creatinine</td>
<td>Normal</td>
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<tr>
<td>Other</td>
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<tr>
<td><strong>Treatment</strong></td>
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<tr>
<td>Water</td>
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<td>High Protein</td>
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<td>High Calcium</td>
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<td>Salt Restriction</td>
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<tr>
<td>Potassium</td>
<td></td>
<td></td>
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<tr>
<td>Look for the underlying cause</td>
<td></td>
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<tr>
<td>Diuretics: Spirotonolactone - mannitol</td>
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<td>Albumin infusion - Calcium</td>
<td></td>
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<td>Antibiotics: corticosteroids</td>
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<tr>
<td>Empirical Steroids</td>
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</tbody>
</table>

**Source:** Professor Dr. Hossam Mokary Textbook and Lecture

**By:** Hatem Refaat El-Sheeny

Undergraduate MBCH – MUST – College of Medicine
12) List the Main Causes of CKD

Box 87.6

Vascular causes
- Renal artery disease
- Hypertensive nephrosclerosis

Glomerularopathies – Primary
- Focal sclerosing glomerulonephritis (GN)
- Membranoproliferative GN
- Membranous GN
- Crescentic GN
- IgA nephropathy

Glomerularopathies – Secondary
- Diabetic nephropathy
- Collagen vascular disease
- Amyloidosis
- Post-infectious
- HIV nephropathy

Tubulointerstitial causes
- Nephrotoxins
- Analgesic nephropathy
- Hypercalcemia or nephrocalcinosis
- Multiple myeloma
- Reflux nephropathy
- Sickle cell nephropathy
- Chronic pyelonephritis
- Tuberculosis

Obstructive Causes
- Nephrolithiasis
- Ureteral tuberculosis
- Retroperitoneal fibrosis
- Retroperitoneal tumor
- Prostatic obstruction
- Congenital abnormalities

Hereditary Causes
- Polycystic kidney disease
- Alport’s syndrome
- Medullary cystic disease
13) List the reversible and treatable causes of CKD

Box 87.7

**Reversible Factors**
- Hypovolemia
- CHF
- Pericardial tamponade
- Severe hypertension
- Catabolic state, protein loads
- Nephrotoxic agents
- Obstructive disease
- Reflux disease

**Treatable Causes**
- Renal artery stenosis
- Malignant hypertension
- Acute interstitial nephritis
- Hypercalcemic nephropathy
- Multiple myeloma
- Vasculitis
- Obstructive nephropathy
- Reflux nephropathy

14) List the mechanisms of drug toxicity in CKD

Box 87.8

- Excessive drug level
- Impaired renal excretion of drug
- Impaired renal excretion of metabolite
- Impaired hepatic metabolism
- Increased sensitivity to drug
- Changes in protein binding
- Changes in volume of distribution
- Changes in target organ sensitivity
- Metabolic loads administered with drug
- Misinterpretation of measured serum drug level
15) List four major complications of CKD and their management

A) **Hyperkalemia** (see Table 87.1 for dose/moa/details)
   - Calcium gluconate
   - Albuterol
   - Glucose & insulin
   - Sodium bicarbonate
   - Dialysis
   - IV diuretics

B) **Bleeding**

   Likely platelet dysfunction secondary to uremia:

   Desmopressin 0.3-0.4mcg/kg (max dose 20mcg)

C) **Pulmonary edema**

   IV nitro glycerin and NIPPV
   Dialysis

D) **Infection**

   Sepsis workup including blood cultures (peripheral and off any lines)
   Consider advanced imaging of fistulae (especially in Prosthetic bridge fistula)
   Big guns for antibiotics (Cipro and Septra for UTI, or Ceft and vanco for unwell)

E) **Hypocalcemia**

   Asymptomatic = Not urgent

   Tetany: IV Calcium (gluconate peripheral or chloride central)

F) **Hyperphosphatemia**

   Calcium-based antacids that bind ingested phosphate in the gut
   Dialysis

G) **Hypermagnesemia**

   Stop laxatives and Mg replacement.
   Dialysis
16) Compare the mechanisms of dialysis in HD and PD

The basis of all dialysis is having the patient's blood come in contact with a semi-permeable membrane.

In IHD, that membrane is external to the patient and thus via venous access, we remove their blood and return it post filtration.

In peritoneal dialysis the patient's peritoneum acts as the membrane. The dialysate is pumped into the patient's abdomen via a Silastic catheter.

17) List indications for emergency dialysis

Box 87.9

- Pulmonary edema
- Severe uncontrollable hypertension
- Hyperkalemia
- Other severe electrolyte or acid-base disturbances
- Some overdoses
- Pericarditis (possibly)

18) List complications of hemodialysis

_Vascular Access–Related Complications_

Occlusion
Bleeding
Infection

_Non–Vascular Access–Related Complications_

Hypotension (see next question)
Bleeding (pericardial, pleural, GI, ICH, abdominal, retroperitoneal)
VTE
CAD
Neurologic Dysfunction (disequilibrium syndrome)
19) List DDx for Hypotension in the hemodialysis patients

Box 87.10

- Hypovolemia
- Excessive fluid removal
- Hemorrhage
- Septicemia
- Cardiogenic shock
- Dysrhythmia
- Pericardial tamponade
- Myocardial infarction
- Myocardial or valvular dysfunction
- Electrolyte disorders
- Hyperkalemia or hypokalemia
- Hypercalcemia or hypocalcemia
- Hypermagnesemia
- Vascular instability
- Drug-related
- Dialysate-related
- Autonomic neuropathy
- Excessive access arteriovenous flow
- Anaphylactoid reaction
- Air embolism

20) List causes of altered mental status in dialysis patients

Box 87.11

Structural Conditions
- Cerebrovascular accident
- Subdural hematoma
- Intracerebral abscess
- Brain tumor

Metabolic Conditions
- Disequilibrium syndrome
- Uremia
- Drug effects
- Meningitis
- Hypertensive encephalopathy
- Hypotension
- Postictal state
- Hyponatremia or hyponatremia
- Hypercalcemia
- Hypermagnesemia
- Hypoglycemia
- Severe hyperglycemia
- Hypoxemia
- Dialysis dementia

21) Describe the management of peritonitis in the PD patient

Likely SBP

Send dialysate of catheter (sterile technique) if:

- >100 WBCs/mm³ peritoneal fluid
- >50% neutrophils
- Positive Gram staining

If fluid is normal then consider ruling out surgical cause

IP antibiotics: Vanco and ceftazidime or cefepime

Consider adding Heparin 500 to 1000 units to dialysate bag to decrease fibrin formation and subsequent obstruction of catheter

Wisecracks

1) How do NSAIDs cause AKI?

- Blocking prostaglandin = decreased glomerular perfusion = decreased GFR
  - This can happen in patients with normal intravascular volume and normal glomerular perfusion! (includes all NSAIDs, and Aspirin)
- Direct interstitial nephritis
- Direct papillary necrosis.

2) Describe the likely pathophysiologic etiology of the following casts

a. Hyaline Casts: Acellular think pre or post renal
b. Red Cell Casts: Glomerular disease (ie nephritic syndrome)
c. White Cell Casts: Interstitial disease (ie pyelonephritis or AIN)
d. Granular Casts: Tubular disease (ie ATN)
e. Fatty Casts: nephrotic syndrome