Renal

Jennifer MacDermott, MSN, RN, ACNS-BC, NP-C, CCRN
Clinical Nurse Specialist
Surgical Intensive Care Unit
The Ohio State University Medical Center

Objectives
- Identify abnormal assessment findings in a patient with renal disease.
- Describe therapeutic treatment interventions for a patient with renal disease.
- Identify clinical manifestations of electrolyte imbalance.
- Describe the standards in caring for a patient undergoing renal surgery or renal testing.

Renal Facts
- Function
  - Regulation of fluid and electrolytes
  - Excretion of metabolic waste products
  - Regulation of acid-base balance
  - Regulation of blood pressure
  - Formation of urine
  - Synthesis and maturation of red blood cells
- Approximately 25% of the cardiac output is delivered to kidneys
- Total renal blood flow in both kidneys is 1200ml/min

Glomerulus
- Site of fluid filtration from the blood
- Prevents blood cells and proteins from entering Bowman capsule

Glomerular filtration rate (GFR)
- Determined by
  - Capillary oncotic pressure (opposes filtration)
  - Capillary hydrostatic pressure (favors filtration)
  - Bowman's capsule hydrostatic pressure (opposes filtration)
- Affected by blood volume, tubule obstruction, collecting duct obstruction, low serum albumin

\[
GFR = \frac{(140 - \text{age in kg}) \times \text{weight in kg}}{72 \times \text{serum Cr in mg/dl}}
\]

Assessment of the Patient with Renal Dysfunction
- Overall appearance
- Weight
- Vital signs
  - Blood pressure
  - Temperature

Physical Assessment
**Physical Assessment**

- **Neurologically**
  - Level of responsiveness
  - Tremor
  - Weakness
  - Chvostek’s sign
  - Trousseau’s sign

- **Pulmonary**
  - Rate, rhythm, depth, and effort
  - Auscultate vesicular breath sounds and for presence of adventitious breath sounds
  - Dyspnea with exertion or orthopnea

- **Cardiovascular**
  - Heart rhythm
  - Jugular vein distention
  - Edema
    - Non-pitting
    - Pitting
      - +1 depth 2mm
      - +2 depth 4mm (<15 seconds)
      - +3 depth 6mm (15-60 seconds)
      - +4 depth 8mm (>60 seconds)
  - Auscultate heart sounds for murmur, click, and pericardial friction rub

- **Gastrointestinal**
  - Inspect for flank or abdominal ecchymosis
  - Auscultate renal arteries for presence of bruit
  - Palpate abdomen and liver border
  - Fluid wave assessment

- **Genitourinary**
  - Costovertebral angle (CVA) tenderness
  - Urine volume and color

**Urine Laboratory Studies**

- **Creatinine**
  - End-product of muscle metabolism
  - Rate of excretion determined by GFR
  - Normal: 0.7 – 1.5 mg/dL

- **Blood urea nitrogen**
  - End-product of protein metabolism
  - Normal: 10 – 20 mg/dL
  - Affected by decreased renal function, decreased fluid intake, increased catabolism, increased dietary protein intake

- **Creatinine clearance**
  - 24hr sample
  - Cr clearance = (urine Cr x urine volume)/serum Cr
  - Normal 110-120ml/min; significant renal dysfunction <50ml/min

- **Protein**
  - 24hr sample; normal = negative/no protein
  - May be indicative of glomerulonephritis, infection, trauma, or intrarenal ARF

- **Urine sediment**
  - RBCs, WBCs, and/or casts; normal = negative
  - May be indicative of prerenal ARF, kidney stones, trauma, prostatic disease, glomerulonephritis, rhabdomyolysis, infection

- **Urine specific gravity**
  - Normal 1.005-1.030
  - Increased levels occur with fluid volume deficit, DM, and glomerular membrane disease because protein/glucose are passed into urine
  - Decreased levels are the result of the kidneys inability to excrete the usual solute load
Urine Laboratory Studies

- Urine osmolarity
  - Dependent on resorption or excretion of water in the tubules
  - Normal 500-1200 mOsm/kg
  - Increased osmo levels & decreased UO → fluid volume deficit
  - Decreased osmo levels and increased UO → fluid volume overload
  - Decreased osmo levels and decreased UO → acute kidney injury

Renal Tests and Procedures

**Renal Ultrasound**
- Measurement of dimensions of the kidney, evaluation of mass lesions, detection and grading of fluid accumulation
- Advantages: painless, non-invasive, minimal preparation, no IV contrast or radiation exposure
- Disadvantages: minimal visualization in obese patients, less direct visualization compared to other available renal tests and procedures
- Pre-procedure: only clear fluids after midnight the day of the test

**KUB**
- Kidney-ureter-bladder (KUB)
- Determines position, structure, and size of the kidneys, urinary tract, and pelvis
- Advantages: painless, non-invasive, minimal preparation, no IV contrast exposure
- Disadvantages: radiation exposure, less direct visualization compared to other available renal tests and procedures
- Diagnostic for calculi and masses

**Computed Tomography (CT)**
- Radioscope administration: IVP is absorbed in kidneys allowing for visualization of kidney
- Spiral CT allows for visualization of vessel perfusion, tumors, cysts, stones, calculi, hemorrhage, necrosis, and trauma
- Advantages: painless, non-invasive, minimal preparation
- Disadvantages: IV contrast and radiation exposure

**Magnetic Resonance Imaging (MRI)**
- High energy radiofrequency waves penetrate tissues
- Allows for visualization of trauma, cysts, masses, malformation of vessels or tubules, stones, calculi, and necrosis
- Advantages: painless, non-invasive, minimal preparation, no IV contrast or radiation exposure

**Renal Angiography**
- Assessment of renal vasculature and precise measures of renal blood flow
- Pre-procedure
  - Informed consent
  - Clotting studies and blood typing
  - IV access; preparation of procedural sedation
- Intra-procedure
  - Percutaneous procedure involving contrast injection for radiological visualization of blood flow
  - Manual pressure application to access site following removal of catheter
- Post-procedure
  - Vital sign assessment/documentation q15min x8, q1hr x4, and q4hrs x6
  - Assessment of access site
  - Assessment of distal extremity

**Renal Biopsy**
- Histological assessment
- Contraindications: serious bleeding disorders, excessive obesity, severe hypertension
- Pre-procedure
  - Informed consent
  - Clotting studies and blood typing
  - IV access; preparation of procedural sedation
- Intra-procedure
  - Percutaneous procedure utilizing biopsy needle
  - Open biopsy under general anesthetic
- Post-procedure
  - Vital sign assessment/documentation q15min x8, q1hr x4, and q4hrs x6
  - Assessment of urine color
  - Assess for abdominal bruising
Renal Dysfunction

Acute Renal Failure
- Severe reduction in renal function that occurs suddenly
- Diagnosed with an acute increase in serum creatinine >0.5 mg/dl
- Manifestations
  - Usually associated with decrease in GFR
  - Reduced urine output
  - Retention of nitrogenous waste or azotemia (elevated BUN)
- Etiology
  - Prerenal: result of decreased kidney perfusion
  - Intrarenal: occurs when the nephron is damaged
  - Postrenal: occurs due to obstruction of urine outflow distal to the kidney

Differentiating Between Prerenal, Intrarenal, and Postrenal Failure

<table>
<thead>
<tr>
<th></th>
<th>BUN:Cr</th>
<th>Urine specific gravity</th>
<th>Urine osmolality</th>
<th>Urine Na+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>1.003 – 1.040</td>
<td>80–1300 mOsm/L</td>
<td>10 – 40 mEq/L</td>
<td></td>
</tr>
<tr>
<td>Prerenal</td>
<td>&gt;20:1</td>
<td>Increased</td>
<td>Increased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Intrarenal</td>
<td>10:1</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Increased</td>
</tr>
<tr>
<td>Postrenal</td>
<td>10:1</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
</tr>
</tbody>
</table>

Chronic Renal Failure
- Progressive loss of renal function occurring over months to years
- GFR <60 ml/min for ≥3 months
- Irreversible condition that leads to end-stage renal disease (ESRD)

Chronic Renal Failure
- Causes
  - ATN
  - Congenital conditions
  - Cystic disorders (polycystic kidney disease)
  - Neoplasms
  - Infections
  - Systemic conditions
- Results in tubular atrophy, glomerulosclerosis, interstitial fibrosis, and interstitial mononuclear cellular infiltrates → damage to nephrons

Chronic Renal Failure
- Stages
  - Decreased renal reserve: <75% of nephrons non-functioning; no signs or symptoms; labs normal
  - Renal insufficiency: 75 – 90% of nephrons non-functioning; polyuria and nocturia; slight elevation BUN and Cr; may be controlled with diet and meds
  - ESRD: >90% of nephrons non-functioning; azotemia; fluid and electrolyte abnormalities; dialysis or transplant necessary
Therapeutic Management of the Patient with Renal Dysfunction

Prevention of Renal Dysfunction
- Maintain adequate hydration
- Maintain nutritional status
- Remove indwelling catheters as soon as possible
- Treat episodes of hypotension aggressively
- Monitor nephrotoxic drug administration
- Control blood glucose levels and blood pressure in diabetics to prevent renal complications
- Diuretics
- Calcium channel blockers
- Acetylcysteine

Management of Renal Dysfunction

Medications
- ARF
  - IV fluids (prerenal)
  - Diuretics
  - Albumin
- CRF
  - ACE inhibitors
  - Calcium channel blockers
  - Calcium and Vitamin D supplementation
  - Phosphate binders
  - Epogen
  - Management of electrolyte imbalances

Nutrition
- Low protein diet
- Fluid, potassium, and sodium restrictions
- Water-soluble vitamin, pyridoxine, and folic acid supplementation
- Transplantation: may be treatment option for patients with ESRD

Management of Renal Dysfunction

Dialysis
- Results in removal of waste materials and excess fluid
- Results in correction electrolyte abnormalities
- Indicated in patients with fluid overload and subsequent, pulmonary edema, HTN, HF, electrolyte imbalances, and/or acid-base imbalances
- Types
  - Peritoneal
  - Hemodialysis
  - Continuous renal replacement therapy CRRT

Peritoneal Dialysis
- Removal of solutes and fluid through instillation of a dialysate solution into the peritoneal cavity
- Exchanges occur via Tenckhoff (peritoneal) catheter
- Requires instillation every 4 – 6 hours (5 – 10 minute instillation, 30 – 45 minute dwell time, 20 minute drain)
- Nursing care
  - Warm dialyzing fluid to body temperature
  - Monitor vital signs
  - Maintain accurate I&O and weight records
  - Observe for signs of peritonitis
  - Prevent constipation
Peritoneal Dialysis

- Complications
  - Technical: incomplete recovery of fluid, leakage around catheter, blood-tinged peritoneal fluid
  - Physiologic: abdominal viscera irritation or perforation, pulmonary complications, hypovolemia and hypernatremia, disequilibrium syndrome, hyperglycemia, peritonitis, hypertension, pain/discomfort, immobility

Intravenous Access

- Arteriovenous graft or fistula
  - Patency
    - Palpate for thrill
    - Auscultate for bruit
  - Adequate circulation to distal extremity
- Do not take BP or draw blood from access limb
- Temporary dialysis catheter
  - Inspect access site for signs of inflammation or infection
  - Verify placement radiographically prior to use
  - Remove anticoagulant from line prior to flushing device
  - Do not unclamp catheter unless preparing dialysis

Hemodialysis

- Rapidly correct biochemical disturbances
- Indications
  - Chronic renal failure
  - Complications of acute renal failure, i.e. uremia, fluid overload, acidosis, hyperkalemia, drug overdose
- Contraindications
  - Low cardiac output
  - Sensitivity to abrupt changes in volume status

Hemodialysis

- Nursing care
  - Documentation of frequent vital signs
  - Monitor and document flow rates
  - Monitor lab values
  - Daily patient weights
  - Hold medications removed by dialysis until after treatment
  - Avoid administration of antihypertensive meds 4 – 6 hours before treatment

Hemodialysis

- Treatment 3 – 4 hours
- Complications: hypotension, dysrhythmias, muscle cramps, dialysis disequilibrium syndrome, vascular access infections, hemolysis, air embolism

Continuous Renal Replacement Therapy (CRRT)

- Indications
  - ARF or CRF with hemodynamic instability and/or those requiring gradual solute removal
  - Patients requiring more than a 3 – 4 hour treatment to correct metabolic imbalances of ARF
  - May absorb proinflammatory substances in patients with septic shock
Continuous Renal Replacement Therapy (CRRT)

- Treatment administered continuously, 24hr/day
- Treatment may be interrupted for transportation of patient for a diagnostic test or procedure or to change the circuit
- Nursing care
  - Monitor hemodynamic status
  - Assess flow rates, hemofilter, and ultrafiltrate hourly
  - Monitor lab values

Complications
- Technical: clotting of filter, vascular access failure, clots or kinks in the catheter, rupture or leakage of filter, air in the circuit
- Physiologic: hypothermia, air embolism, hypotension

Electrolyte Emergencies

Potassium Balance

<table>
<thead>
<tr>
<th>Imbalance</th>
<th>Etiology</th>
<th>Clinical Presentation</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypokalemia</td>
<td>Decreased K⁺ intake</td>
<td>Orthostatic hypotension</td>
<td>Replace K⁺</td>
</tr>
<tr>
<td>Hypokalemia</td>
<td>Shift from K⁺ from serum to cell</td>
<td>Muscle weakness → paralysis</td>
<td>Correct alkalosis</td>
</tr>
<tr>
<td></td>
<td>Increased K⁺ excretion</td>
<td>Dysrhythmias</td>
<td></td>
</tr>
</tbody>
</table>

Management:
- Replace K⁺
- Correct alkalosis

Hyperkalemia

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<tr>
<td>Hyperkalemia</td>
<td>Acidosis</td>
<td>Orthostatic hypotension</td>
<td>Replace K⁺</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td>Renal dysfunction</td>
<td>Na/VO2M</td>
<td>Correct alkalosis</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td>Drugs</td>
<td>Muscle weakness → paralysis</td>
<td>Correct alkalosis</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td>Cell death</td>
<td>Dysrhythmias</td>
<td>Correct alkalosis</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td>Excessive intake</td>
<td></td>
<td>Correct alkalosis</td>
</tr>
</tbody>
</table>

- Kayexalate
- Loop diuretics
- Insulin/glucose
- Na bicarbonate
- High dose intrahospital beta-2 agonists
- CaO or Ca gluconate
- Dialysis

Hyperkalemia Induced EKG Changes
Potassium and pH Balance

- Potassium concentration will fluctuate 0.6mEq/L for every 0.1 unit change in extracellular pH
- Acidosis → potassium moves out of cell
- Alkalosis → potassium moves into cell

Potassium and pH Balance

Example

<table>
<thead>
<tr>
<th></th>
<th>Na</th>
<th></th>
<th>K</th>
<th></th>
<th>Cl</th>
<th>pH Correction</th>
<th>Cr</th>
<th></th>
<th>BUN</th>
<th>Phos</th>
<th>Mg</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>136</td>
<td></td>
<td>4.3</td>
<td></td>
<td>99</td>
<td>100</td>
<td>1.2</td>
<td></td>
<td>14</td>
<td>3.1</td>
<td>2.2</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Sodium Balance

<table>
<thead>
<tr>
<th>Imbalance</th>
<th>Etiology</th>
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</tr>
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<tbody>
<tr>
<td>Hyponatremia (&lt;135mmol/L)</td>
<td>-Excessive ADH</td>
<td>-Disorientation</td>
<td>-Correction of underlying cause</td>
</tr>
<tr>
<td></td>
<td>-Excessive infusion</td>
<td>-Decreased mental status</td>
<td>-Restrict free water intake</td>
</tr>
<tr>
<td></td>
<td>-IV D5W</td>
<td>-Lethargy/coma</td>
<td>-&lt;0.9% NS or hypertonic 3% saline</td>
</tr>
<tr>
<td></td>
<td>-Barturic overdose</td>
<td>-Seizures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Excessive beer ingestion</td>
<td>-N/V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Diuretics</td>
<td>-Weakness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Replacement of water but not salt loss</td>
<td></td>
<td></td>
</tr>
</tbody>
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<tbody>
<tr>
<td>Hypernatremia (&gt;145mmol/L)</td>
<td>-IV infusion hypertonic saline</td>
<td>-Reduced fluid intake</td>
<td>-Free water administration</td>
</tr>
<tr>
<td></td>
<td>-Na bicarb administration</td>
<td>-Diabetes</td>
<td>-Hypertonic fluid administration</td>
</tr>
<tr>
<td></td>
<td>-DI</td>
<td>-Diarrhea, vomiting, diuresis</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Thirst</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Polyuria</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Agitation/ restlessness/ decreased LOC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Hypertension/ tachycardia/ pitting edema</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Dyspnea/ respiratory arrest</td>
<td></td>
</tr>
</tbody>
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Calcium Balance

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<tbody>
<tr>
<td>Hypocalcemia (ionized Ca &lt;4.0mg/dl)</td>
<td>-Sepsis</td>
<td>-Hypotension</td>
<td>-Control/correct underlying cause</td>
</tr>
<tr>
<td></td>
<td>-Burns</td>
<td>-Dysrhythmias/ cardiac arrest</td>
<td>-Replace calcium</td>
</tr>
<tr>
<td></td>
<td>-Rhabdomyolysis</td>
<td>-Muscle spasm/ tetany</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Pancreatitis</td>
<td>-Seizures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Malabsorption</td>
<td>-Anxiety/ iritability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Liver/renal disease</td>
<td>-Chvostek's sign</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Hyperparathyroidism</td>
<td>-Trousseau's sign</td>
<td></td>
</tr>
</tbody>
</table>

Calcium Balance

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</tr>
</thead>
<tbody>
<tr>
<td>Hypercalcemia (ionized Ca &gt;5.0mg/dl)</td>
<td>-Malignancy</td>
<td>-N/V, flank pain</td>
<td>-Control/correct underlying cause</td>
</tr>
<tr>
<td></td>
<td>-Immobilization</td>
<td>-Weakness</td>
<td>-0.9% NS</td>
</tr>
<tr>
<td></td>
<td>-Excessive intake vitamin A or D</td>
<td>-Depressed mental status/ confusion/coma/ irritability</td>
<td>-Diuretics</td>
</tr>
<tr>
<td></td>
<td>-Thyrotoxicosis</td>
<td>-Hypertension or hypotension</td>
<td>-Dialysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Conduction abnormalities/heart blocks</td>
<td></td>
</tr>
</tbody>
</table>
### Phosphate Balance

<table>
<thead>
<tr>
<th>Imbalance</th>
<th>Etiology</th>
<th>Clinical Presentation</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hypophosphatemia</strong> (&lt;2.5mg/dl)</td>
<td>Acute alkalosis, Drugs, Hypokalemia, hypomagnesemia, Malabsorption, malnutrition, Diarrhea</td>
<td>Muscle weakness, Respiratory failure, Rhabdomyolysis, Disorientation/coma/seizures, Hepatic/immune dysfunction, Hemolysis/impaired platelet function</td>
<td>Control/correct underlying cause, Replace phosphate</td>
</tr>
</tbody>
</table>

### Hyperphosphatemia (>4.5mg/dl)

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Clinical Presentation</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive phosphate intake</td>
<td>Symptoms of hypocalcemia, Aching/stiff joints, itching, Conjunctivitis</td>
<td>Correct hypocalcemia, Glucose/insulin, Dialysis</td>
</tr>
</tbody>
</table>

### Magnesium Balance

<table>
<thead>
<tr>
<th>Imbalance</th>
<th>Etiology</th>
<th>Clinical Presentation</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hypomagnesemia</strong> (&lt;1.8mg/dl)</td>
<td>Renal tubular dysfunction, Diuresis, Hypokalemia, Drugs, Diarrhea, Recovery from hypothermia, Alcoholism</td>
<td>Hypokalemia/hypocalcemia, Hypokalemia/insufficiency, Hypokalemia, Hypocalcemia, Delirium, Disorientation/coma, Tremor/seizure</td>
<td>Control/correct underlying disease, Replace magnesium</td>
</tr>
</tbody>
</table>

### Hypermagnesemia (>2.5mg/dl)

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Clinical Presentation</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingestion seawater, Excessive Mg ingestions, Oliguric renal failure, Adrenal insufficiency</td>
<td>Bradycardia/arrhythmias/cardiac arrest, Hypokalemia, Hypoglycemia, Lethargy, Respiratory depression, Paralysis</td>
<td>Diuretics, Dialysis</td>
</tr>
</tbody>
</table>