I. INTRODUCTION

PCCN Test Plan

Endocrine, Hematology, Renal & GI: 18%

a. Acute Renal Failure
b. Chronic Renal Failure
c. Contrast-Induced Nephropathy
d. End-Stage Renal Disease (ESRD)
e. Electrolyte Imbalances
f. Medication-Induced Renal Failure
g. Nephritic Syndrome

II. RENAL PHYSIOLOGY

Major Functions of the Kidney

a. Excretion of Metabolic Wastes
b. Urine Formation
c. Acid-Base Balance Regulation
d. Electrolyte Regulation
e. Fluid Regulation
f. Blood Pressure Regulation
g. Erythropoietin Secretion/Anemia Regulation

Renal Assessment

a. Blood Work
   • Blood Urea Nitrogen
   • Creatinine
   • Serum Electrolytes
   • Hgb & Hct
   • Serum Albumin
   • Serum Osmolality
b. Urine Assessment
   - Volume & Concentration
   - Urinalysis
   - Renal Clearance Studies

c. Other Tests
   - KUB X-ray
   - Renal Arteriography
   - IVP
   - CT
   - Ultrasound
   - Biopsy

d. Nephritic Syndrome

III. END-STAGE RENAL DISEASE (ESRD)

a. Acute renal failure affects many body systems.
b. Chronic renal failure affects EVERY body system.
c. Chronic Renal Failure (CRF) is a permanent, irreversible condition in which the kidneys cease to remove metabolic wastes and excessive water from the blood. (ESRF, ESRD, CRD, CKD).
d. Etiology - more than 100 different diseases can cause RF
   - Glomerular Disease
   - Tubular Diseases
   - Vascular Kidney Diseases
   - Urinary Tract Disease
   - Infection (kidney)
   - Systemic Vascular Diseases
   - Metabolic Diseases
   - Connective Tissue Diseases

Terms

a. Azotemia – Nitrogenous Waste Products in the Bloodstream
b. Uremic Syndrome – Systemic and Laboratory Manifestations of ESRD
c. Renal Replacement Therapy – Treatment Options

Stages of Renal Failure

a. Diminished Renal Reserve
b. Renal Insufficiency
c. End Stage Renal Disease (ESRD) – Affects every system in the body
Treatment
Renal Replacement Therapies

a. Medications
b. Hemodialysis
c. Peritoneal Dialysis
d. Renal Transplant

IV. ACUTE RENAL FAILURE

Pathophysiology

A sudden deterioration in renal function usually associated with the loss of the kidney’s ability to concentrated urine, as well as the retention and accumulation of nitrogen wastes.

a. Decreased Glomerular Filtration Rate
b. Interstitial Inflammatory Changes
c. Tubular Lumen Obstruction
d. Oliguric < 400 mL/day
e. Non-Oliguric, Large Amt of Dilute Urine

Common Etiologies

a. Severe Hypotension (all forms of shock)
b. Heart Failure
c. Dehydration
d. Nephrotoxic Agents
e. Complication of Infection
f. Severe Hypertension

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<tr>
<th>Etiologies of Acute Renal Failure</th>
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**Phases of ARF**

a. Onset Phase
   • BUN & Creatinine Rising
   • Urine Output Dropping
   • Diuretics Still Working
   • Acidosis Beginning
   • Oliguric Phase
   • Alteration in Electrolyte Balance
   • Potential for Infection
   • Alteration in acid-base Balance
   • Alteration in Nutrition Status
   • Uremic Syndrome
   • Alteration in Pulmonary Status
   • Alteration in GI Function
b. Diuretic Phase
   • Fluid Loss
   • Goal is to Maintain Adequate Fluid Balance and Regulate Electrolytes
• Alteration in Electrolytes

c. Recovery Phase
  • Goal is Supportive Care
  • Prevent Further Insults
  • Assessment of Renal Function
  • Keep Patient Well Hydrated and Free From Infection
  • Prevent Further Insults

Systemic Response to Acute Failure

a. Hypertension
b. Tachycardia
c. Decreased UO
d. Lethargy
e. Pulmonary Edema
f. Depends on Type
g. Very Similar to Chronic RF

Nursing Care Needs

a. Ensure Hydration
b. Fluid Challenges
c. Diuretics
d. Monitor Fluid Status
e. Weigh Daily & I & O
f. Monitor Electrolyte Imbalance
g. Support Renal Function

Treatment Options/Alternatives

a. Drug Therapy
b. Diet Therapy
c. Renal Replacement Therapies (Hemodialysis, Peritoneal Dialysis)
d. Renal Transplant
Support Therapy for Renal Failure

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<td>• Restrict NaCl and H₂O</td>
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<td>Hyponatremia</td>
<td>• Restrict Oral H₂O</td>
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<td>• Restrict Hypotonic IV Solutions</td>
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<td>• Restrict K intake</td>
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<td>• Eliminate K Supplements</td>
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<td>• NaBicarb</td>
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<td>• Ca Gluconate</td>
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<td>• Phosphate Binding Agents</td>
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<td>Hypermagnesemia</td>
<td>• D/C Mg Containing Antacids</td>
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<td>Nutrition</td>
<td>• High Protein</td>
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<td>• Enteral or Parental Nutrition</td>
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<td>Drug Dosage</td>
<td>• Adjust Doses Around GFR</td>
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<td>• Avoid NSAIDS, ACE I, Dye, Nephrotoxic Abx</td>
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V. RENAL REPLACEMENT THERAPIES

Goal
To remove body waste and fluids in the presence of acute or chronic renal failure

Hemodialysis

Goal
Involves shunting the patient’s blood from the body through a dialyzer in which diffusion and ultrafiltration occur and then back into the patient’s circulation.
Access
Five different types of access can be used
a. Arteriovenous Fistula
b. Arteriovenous Graft
c. External Arteriovenous Shunt
d. Femoral Vein Catheterization
e. Subclavian Vein Catheterization

Contraindications
Causes rapid fluid shifts
a. Labile Cardiovascular States
b. Recent MI
c. Hypotension

Complications
a. Hypotension
b. Air Embolism
c. Arrhythmias
d. Infection
e. Disequilibrium Syndrome - Rapid shifts in osmolality between cerebral spinal fluid and blood can lead to cerebral edema
f. Coagulopathies - Heparin used during dialysis to prevent clotting of blood outside of body

Chronic Care Needs
a. Patients are typically hemodialyzed 2-3 times a week for 2-4 hours
b. Require many medications
c. Encounter multiple acute and chronic health risks as a result of the renal failure and dialysis
d. Have dietary and fluid restrictions
e. Safety concerns regarding access sites
f. Assessment requirements for access sites

Peritoneal Dialysis (PD)

Goal
The goal is the same as above but a machine is not used to perform the “cleaning of the blood.”
The dialyzing fluid is instilled into the peritoneal cavity, and the peritoneum becomes the dialyzing membrane. PD is used for acute and chronic renal failure and can be done in the hospital or at home.

Access
An abdominal catheter is inserted into the peritoneal space.
Procedure
A sterile dialysate is instilled into the peritoneal cavity and allowed to dwell for a period of time. During this time osmosis and diffusion of particles takes place. The fluid is drained from the patient. This process is done repeatedly during a 24 hr period or just during the night.

Contraindications
a. Peritonitis  
b. Abdominal Surgery  
c. Abdominal Adhesions  
d. Pregnancy

Complications
a. Peritonitis  
b. Respiratory Distress

Chronic Care Needs
Not as many risks as HD. Most common problem is infection of catheter.

Fluids & Electrolytes

I. INTRODUCTION
Fluid and electrolyte monitoring are an essential component of patient assessment. These factors regulate most physiological functions and the acid base balance.

II. PHYSIOLOGIC FLUID BALANCE

Total Body Water
60% of body weight (approximately 40L)

a. Intracellular – 67% of total body H2O
   • Primarily made up of intracellular electrolytes  
b. Extracellular – 33% of total body H2O
   • Plasma Water – 8%, Water, proteins and lipids  
   • Interstitial Fluid & Lymph – 20%, Fluid bathing the cells  
   • Transcellular Fluid – 7%, Pleural, pericardial, peritoneal, synovial and fluids in secretions (GI, respiratory, salivary)
Osmolarity

The concentration of particles within a solution
a. Plasma osmolarity avg. 290 ± 5 mOsm/kg
b. Na⁺ is the primary regulator of extracellular osmolarity
c. K⁺ is the primary regulator of intracellular osmolarity
d. Calculated osmolarity = \[2(\text{Na}^+) + \frac{\text{BG} + \text{BUN}}{18} \times 2.8\]

IV Fluids
The most common IV solution used in Med/Surg is D5.45NS with 20mEq KCL because it is most “like” normal fluid in the human body. Typically at 125ml/hr – 3L a day

a. Isotonic Fluids
   - Normal Saline & Lactated Ringers
   - 275 -295 mOsm/L
   - Volume Expanders
   - Tend to stay in intravascular space
b. Hypotonic Fluids
   - .45% NS or less
   - Less than 275mOsm/L
   - Severe Dehydration with Dry Tissues
   - Leak out of vascular space into tissues
c. Hypertonic Fluids
   - 3% NS and above
   - D5WLR
   - D5 .9%NS
   - Greater than 290 mOsm/L
   - Volume Expanders
   - Stay in intravascular space
   - PULL fluid from interstitial space and tissues

III. ELECTROLYTE BALANCE

Physiology
Electrolytes are particles or solutes found throughout the body in fluids. They carry an electrical charge and are essential for fluid and acid base balance within the body. The cations (positively charged ions) are sodium (Na⁺), potassium (K⁺), magnesium (Mg²⁺), and calcium (Ca²⁺). The anions (negatively charged ions) are chloride (Cl⁻), bicarbonate (HCO₃⁻), sulfate (SO₄²⁻), and phosphate (PO₄³⁻).
The four major functions of electrolytes
a. Regulate Acid Base Balance
b. Maintain Fluid Balance and Osmolarity
c. Distribute the Body Fluid and H2O between the Compartments
d. Promote Neuromuscular Function/Irritability

Distribution
Electrolytes are found in the intracellular and extracellular fluid. They are concentrated in one of these two compartments and exert osmotic properties within that compartment. Electrolytes help to maintain total body fluid balance and also help to regulate fluid movement in and out of the cell. For example K⁺ is the major intracellular ion and Na⁺ is the major extracellular ion and they each play a significant role in maintaining homeostasis within each of their compartments. Each electrolyte serves a unique physiologic function and concentrations above or below the “normal” range can affect homeostasis or specific organ function detrimentally.

<table>
<thead>
<tr>
<th>Electrolyte or Compound</th>
<th>Primary Compartment</th>
<th>Extracellular Concentration (plasma or intravascular)</th>
<th>Intracellular Concentration</th>
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<tbody>
<tr>
<td>Sodium (Na⁺)</td>
<td>Extracellular</td>
<td>135 – 146 mEq/L</td>
<td>10 – 15 mEq/L</td>
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<tr>
<td>Potassium (K⁺)</td>
<td>Intracellular</td>
<td>3.5 – 5.5 mEq/L</td>
<td>140 - 150 mEq/L</td>
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<tr>
<td>Calcium (Ca²⁺)</td>
<td>Extracellular</td>
<td>T 8.5 – 10.5 mg/dL</td>
<td>0 - 2 mg/dL</td>
</tr>
<tr>
<td>Magnesium (Mg²⁺)</td>
<td>Intracellular</td>
<td>1.5 – 2.5 mEq/L</td>
<td>30 – 40 mEq/L</td>
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<tr>
<td>Phosphate (PH₄⁺)</td>
<td>Intracellular</td>
<td>2.5 – 4.5 mg/dL</td>
<td>100 mEq/L</td>
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<tr>
<td>Chloride (Cl⁻)</td>
<td>Extracellular</td>
<td>96 – 109 mEq/L</td>
<td>1 – 4 mEq/L</td>
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<tr>
<td>Bicarbonate (HCO₃⁻) or Serum CO₂</td>
<td>Extracellular</td>
<td>22 – 26 mEq/L</td>
<td>4 – 10 mEq/L</td>
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### Sodium

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<th>Hyponatremia</th>
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<td>Sodium Deficit</td>
<td>Sodium Excess</td>
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<td>• Headache</td>
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<td>• Fatigue</td>
<td>• Irritability</td>
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<td>• Apathy</td>
<td>• Lethargy</td>
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<td>• Seizures</td>
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<td>• Confusion → Coma</td>
<td>• Confusion → Coma</td>
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<td>Pulmonary</td>
<td>• Respiratory Distress</td>
<td>• Dyspnea</td>
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<td>Cardiovascular</td>
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<td>• Orthostatic Hypotension</td>
<td>• Tachycardia</td>
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<td>• Drop in CVP</td>
<td>• Orthostatic Hypotension</td>
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<td>• Dry Mucous Membranes</td>
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<td>GI</td>
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<td>GU</td>
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<td>• Muscle Weakness</td>
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Potassium

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<td>Decreased Intake</td>
<td>Excess Intake</td>
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<td>Increased Loss</td>
<td>Decreased Loss</td>
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<tr>
<td>Shift of K⁺ into Cells</td>
<td>Shift K⁺ out of Cells</td>
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**Neurological**
- Lethargy
- Decreased Reflexes
- Confusion
- Depression
- Numbness
- Paresthesias
- Hyporeflexia

**Cardiovascular**
- Drop BP
- Dysrhythmias
- Cardiac Arrest
- Conduction Disturbances
- V-Fib
- Asystole

**GI**
- Anorexia
- N/V
- Distension Ileus
- N/V/D

**GU**
- Dilute Urine
- Water Loss
- Thirst
- Oliguria
- Anuria

**Muscular/Skeletal**
- Weak
- Flaccid
- Respiratory Arrest
- Early → Irritability
- Late → Weakness
- Flaccid Paralysis

**EKG Changes**
- Depressed ST segments
- Flat or inverted T wave,
- Presence of U waves
- Dysrhythmias, ventricular
- Cardiac arrest
- Tall, peaked, tented T waves
- Flattened or absent P waves
- Widening QRS
- Asystole

**HyperKalemia Treatment**
Three-Part Therapy

a. Cardiac Protect: 10ml of Calcium Chloride or Calcium Gluconate slow IV push. Renders the myocardium less excitable by decreasing the effects of excess extracellular K⁺.

b. Shift K⁺ into the Cell:
   - 1 amp Sodium Bicarbonate
   - 5-10U Regular Insulin
   - 50ml Bolus 50% Dextrose
   - Albuterol 10 – 20mg inhalation or intravenous (beta₂ adrenergic agent – stimulates B₂ receptor in the pancreas to release more insulin).
c. Removal of $K^+$:
   - **Loop Diuretic**
   - **Sodium Polystyrene Sulfonate (Kayexalate)**
     - A cation exchange resin given orally or by retention enema.
     - Oral administration is more effective.
     - Each 1gm will lower the $K^+$ 1mEq with oral administration, and 0.5mEq with rectal administration.
     - Sorbitol prevents constipation.
   - **Dialysis** can also be utilized to remove $K^+$ from the body

### Calcium

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<tr>
<th>Hypocalcemia</th>
<th>Hypercalcemia</th>
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<td><strong>Excess Loss</strong></td>
<td><strong>Excess Intake</strong></td>
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<td><strong>Inadequate Intake</strong></td>
<td><strong>Loss from Bones</strong></td>
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<td><strong>Decreased Ionized</strong></td>
<td><strong>Mobilization from Bones</strong></td>
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<td><strong>GI/Bone Absorption</strong></td>
<td><strong>Acidosis</strong></td>
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#### Neurological
- Tingling $\rightarrow$ Convulsions
- Hyperreflexia
- Dec Reflexes
- Lethargy $\rightarrow$ Coma
- Seizures

#### Pulmonary
- Larynogospasm
- Bronchospasm

#### Cardiovascular
- Dysrhythmias
- Cardiac Arrest
- Depressed Activity
- Dysrhythmias
- Cardiac Arrest

#### GI
- Increased Peristalsis
- N/V/D
- Decreased GI Tract Motility
- N/V
- Constipation

#### GU
- Kidney Stones
- Flank Pain

#### Muscular/Skeletal
- Osteoporosis $\rightarrow$ Fractures
- Abnormal Deposits of Ca in Body Tissues
- Muscle Spasm
- Muscle Fatigue
- Hypotonia
- Bone Pain
- Osteoporosis
- Fractures

#### ECG Changes
- Prolonged ST segment
- Prolonged QT interval, torsades de pointes
- Short ST/QT
- Heart Blocks
# Magnesium

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