Adult CCRN/CCRN-E/CCRN-K Certification Review Course: Renal

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Disclosures
- Nothing to disclose
Acute and Chronic Renal Problems and Life-threatening Electrolyte Disturbances

80%
20%
20%

Physiology
- Function
  - Excretion of metabolic waste
  - Urine formation
  - Acid-base balance regulation
  - Electrolyte regulation
  - Fluid regulation
  - Blood pressure regulation
  - Erythropoietin secretion/anemia regulation

Physiology (cont)
- Assessment of renal function
Laboratory and Other Tests

- Blood tests
  - Blood urea nitrogen
  - Creatinine
  - Serum electrolytes
  - Hemoglobin, hematocrit
  - Serum albumin
  - Serum osmolality

Laboratory and Other Tests (cont)

- Urine volume and concentration
- Urinalysis
- Renal clearance studies
- KUB x-ray (kidneys–ureters–bladder)
- Renal arteriography

Laboratory and Other Tests (cont)

- IVP
- CT
- Ultrasound
- Biopsy
Acute renal failure (ARF) affects many body systems

Chronic renal failure (CRF) affects every body system

Chronic Renal Failure

- CRF is defined as a permanent, irreversible condition in which the kidneys cease to remove metabolic wastes and excess water from the blood. Also called:
  - End-stage renal failure
  - End-stage renal disease
  - Chronic renal disease

- Chronic kidney disease

Chronic Renal Failure: Etiology

- Glomerular disease
- Tubular diseases
- Vascular kidney diseases
- Urinary tract disease
- Infection (kidney)
- Systemic vascular diseases
- Metabolic diseases
- Connective tissue diseases
Stages of Renal Failure
- Diminished renal reserve
- Renal insufficiency
- End-stage renal disease

System Alterations

Treatment
- Medications
- Renal replacement therapies
  - Hemodialysis
  - Peritoneal dialysis
  - Renal transplant
Renal

Acute Kidney Injury (AKI)

Pathophysiology

- A sudden deterioration in renal function usually associated with the loss of the kidney’s ability to concentrate urine and the retention and accumulation of nitrogen wastes

Pathophysiology of AKI (cont)

- Decreased glomerular filtration rate (GFR)
- Interstitial inflammatory changes
- Tubular lumen obstruction
- Oliguric: <400 mL/day of urine
- Non-oliguric: large amount of dilute urine

Common Etiologies

- Severe hypotension
- Heart failure
- Dehydration
- Nephrotoxic agents
- Complication of infection
- Severe hypertension
Common Etiologies
- Prerenal
  - Perfusion problem
    - Dehydration
    - Ischemia
    - Hypoperfusion
- Postrenal
  - Problem after the kidneys
    - Urethra
    - Bladder
    - Trauma
- Renal
  - Kidney tissue problem
    - Glomerulus
    - Tubule
    - Nephron
    - Trauma

Prerenal vs Renal

<table>
<thead>
<tr>
<th>ASSESSMENT</th>
<th>PRERENAL</th>
<th>RENAL</th>
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</thead>
<tbody>
<tr>
<td>Urinary sodium</td>
<td>&lt;20 mEq/L</td>
<td>&gt;20 mEq/L</td>
</tr>
<tr>
<td>BUN: creatinine</td>
<td>&gt;20:1</td>
<td>10–20:1</td>
</tr>
<tr>
<td>ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response to</td>
<td>Positive response</td>
<td>No response</td>
</tr>
<tr>
<td>volume or</td>
<td></td>
<td></td>
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<tr>
<td>diuretics</td>
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Acute vs Chronic
- Chronic
  - 90%–95% nonfunctioning nephrons
- Acute
  - 50% nonfunctioning nephrons
Phases of AKD

- Onset
- Oliguric
- Diuretic
- Recovery

Systemic Response

- Hypertension
- Tachycardia
- Decreased urinary output
- Lethargy
- Pulmonary edema
- Depends on type
- Very similar to CRF

Care Needs

- Ensure hydration
- Fluid challenges
- Diuretics
- Monitor fluid status
- Weigh daily, measure intake/output
- Monitor electrolyte imbalance
- Support renal function
Renal

Treatment Options/Alternatives

- Drug therapy
- Diet therapy
- Renal replacement therapy
- Renal transplant

Review Questions

Question 1

Three days after blunt abdominal trauma with hemorrhagic shock from spleen rupture, a patient develops azotemia, oliguria, and electrolyte imbalance. The most probable cause of the acute kidney disease is:

A. Prerenal
B. Intrarenal
C. Postrenal
D. Blunt trauma to the flank
Question 1—Rationale

Three days after blunt abdominal trauma with hemorrhagic shock from spleen rupture, a patient develops azotemia, oliguria, and electrolyte imbalance. The most probable cause of the acute kidney disease is:

A. Prerenal—The hemorrhagic shock caused a decreased renal perfusion and ischemia
   - Intrarenal—There was no injury to the kidney
   - Postrenal—There was no obstruction or trauma below the kidney
   - Blunt trauma to the flank—Possible with abdominal trauma, but typically presents immediately with trauma

Renal Replacement Therapies

- Hemodialysis
- Peritoneal dialysis
- Continuous renal replacement therapy (CRRT)
- Renal transplantation

Renal Replacement Therapies (cont)

- Hemodialysis
  
  Goal
  Access procedure
  Contraindications
  Complications
  Care needs
Renal Replacement Therapies (cont)

- Peritoneal

- Goal
- Access procedure
- Contraindications
- Complications
- Care needs

Renal Replacement Therapies (cont)

- CRRT

- Goal
- Access procedure
- Contraindications
- Complications
- Care needs

Review Questions
Question 2

Three days after blunt abdominal trauma with hemorrhagic shock from spleen rupture, a patient develops azotemia, oliguria, and electrolyte imbalance. Five days after injury/surgery, it is determined that dialysis will be necessary. The decision between hemodialysis and continuous venovenous hemofiltration will be based on which set of assessment data?

A. Electrolyte imbalance, high CVP, MAP >70
B. K = 6.8, low pulmonary artery occlusion pressure, BUN: creatinine ratio = 38:4
C. Volume overload, hemodynamic instability, azotemia
D. Acute lung injury, electrolyte imbalance, hemodynamically stable

Question 2—Rationale

Three days after blunt abdominal trauma with hemorrhagic shock from spleen rupture, a patient develops azotemia, oliguria, and electrolyte imbalance. Five days after injury/surgery, it is determined that dialysis will be necessary. The decision between hemodialysis and continuous venovenous hemofiltration will be based on which set of assessment data?

C. Volume overload, hemodynamic instability, azotemia—Renal insufficiency and hemodynamic instability are the criteria for CRRT over hemodialysis
   - Electrolyte imbalance, high CVP, MAP >70—Not hemodynamically unstable
   - K = 6.8, low pulmonary artery occlusion pressure, BUN: creatinine ratio = 38:4—Renal insufficiency, but not hemodynamically unstable
   - Acute lung injury, electrolyte imbalance, hemodynamically stable—Could have hemodialysis

Question 3

While caring for a patient receiving peritoneal dialysis, the nurse notices that the drainage in the bag is yellow and cloudy with a slight pink tint. The appropriate management would be to:

A. Stop draining, turn patient on left side, call the physician immediately
B. Finish draining, send the bag to the lab for analysis
C. Assess the insertion site, contact the physician while the draining is finishing
D. Prepare for the next dialysate infusion, remembering to warm the fluid this time
While caring for a patient receiving peritoneal dialysis, the nurse notices that the drainage in the bag is yellow and cloudy with a slight pink tint. The appropriate management would be to:

C. Assess the insertion site, contact the physician while the draining is finishing—Complete assessment prior to contacting MD
   • Stop draining, turn patient on left side, call the physician immediately—Might indicate infection, continue draining
   • Finish draining, send the bag to the lab for analysis—Both appropriate steps, but the MD should be notified and the one to call for testing
   • Prepare for the next dialysate infusion, remembering to warm the fluid this time—Might be a valid choice, but does not answer the question asked

A chronic dialysis patient is admitted for pericardial effusion and drainage. Dialysis is scheduled for noon today. All of the patient’s daily medications are scheduled for 10 AM. The day shift nurse should:

A. Hold all medications until after dialysis
B. Determine which medications are affected by dialysis and change the medication schedule accordingly
C. Give all medications as scheduled
D. Send the medications with the patient to dialysis and tell the patient to take them mid-dialysis

B. Determine which medications are affected by dialysis and change the medication schedule accordingly
   • Hold all medications until after dialysis—No need to disrupt the schedule for all medications
   • Give all medications as scheduled—Some of the medications might be dialyzed out
   • Send the medications with the patient to dialysis and tell the patient to take them mid-dialysis—Cannot delegate medication administration to the patient
Renal Transplantation

Renal System Infections
- Kidney Infection
  - Flank Pain
- Bladder Infection
  - Pain on Urination and Cloudy Urine
- Urinary Tract Infection

Incontinence
- The Involuntary Loss of Urine
- Present in 30% of Home Elderly
- 50% of Institutionalized Elderly
- 2X More Prevalent in Women
Types of Incontinence
- Stress
- Urgency
- Overflow
- Neurogenic
- Functional
- Mixed

Electrolyte Imbalances
- The chemical building blocks of the body

Sodium
Na⁺ 135–146 mEq/L
- Major extracellular cation
- Osmotic properties
- Acid–base balance
- Close relationship between water and sodium
- Physiologic activities
- Active/passive transport across cell membrane
- Intracellular metabolism
Renal

Fluid excess
Sodium deficit

Neurologic
Headache, fatigue, apathy, seizures, confusion → coma

Pulmonary
Respiratory distress

Cardiovascular
Orthostatic hypotension, decreased CVP

Gastrointestinal
Anorexia, weight loss, nausea, vomiting, abdominal cramps, muscle weakness

Hyponatremia
Sodium 135–146 mEq/L

Treatment—Sodium <135 mEq/L
- Oral or IV replacement
- 0.9% NaCl or lactated Ringer’s solution
- Hypertonic saline for emergency situations

Hypernatremia
Sodium 135–146 mEq/L

Neurologic
Restlessness, irritability, lethargy, seizures, confusion → coma

Pulmonary
Dyspnea

Cardiovascular
Tachycardia, orthostatic hypotension, dry mucous membranes, dehydration, flushed skin

Genitourinary
Decreased urine output

Musculoskeletal
Muscle weakness
### Hypernatremia

<table>
<thead>
<tr>
<th>Treatment: sodium</th>
<th>Replacement volume and treat underlying cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium &gt;146 mEq/L</td>
<td>Replace volume and treat underlying cause</td>
</tr>
</tbody>
</table>

**Free H$_2$O deficit (L) = (0.6 x kg) x Na$-140/140$**

**Example**

- 70 kg patient, Na$^+ = 160$ mEq/L
- $(0.6 \times 70) \times \frac{160-140}{140} = 42 \times 0.14 = 5.88$ L H$_2$O deficit

### Potassium: K+ 3.5–5.5 mEq/L

<table>
<thead>
<tr>
<th>Major intracellular cation</th>
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<tbody>
<tr>
<td>Cell homeostasis and function</td>
</tr>
<tr>
<td>Maintains cellular osmolarity</td>
</tr>
<tr>
<td>Electrical neutrality and conductivity</td>
</tr>
<tr>
<td>Nerve impulses and cardiac contractility</td>
</tr>
<tr>
<td>Acid-base balance</td>
</tr>
<tr>
<td>Normal kidney function</td>
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</tbody>
</table>

### Hypokalemia

<table>
<thead>
<tr>
<th>Neurologic</th>
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</thead>
<tbody>
<tr>
<td>Lethargy, decreased reflexes, confusion, depression</td>
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<table>
<thead>
<tr>
<th>Cardiovascular</th>
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</thead>
<tbody>
<tr>
<td>Decreased blood pressure, dysrhythmias, cardiac arrest</td>
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<table>
<thead>
<tr>
<th>Gastrointestinal</th>
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</thead>
<tbody>
<tr>
<td>Anorexia, nausea, vomiting, distension, ileus</td>
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<table>
<thead>
<tr>
<th>Genitourinary</th>
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</thead>
<tbody>
<tr>
<td>Dilute urine, water loss, thirst</td>
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<table>
<thead>
<tr>
<th>Musculoskeletal</th>
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<tbody>
<tr>
<td>Weak, flaccid, respiratory arrest</td>
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</tbody>
</table>
**Hypokalemia**

Treatment—potassium <3.5 mEq/L
- Oral replacement
- IV replacement

**Hyperkalemia**

Excess intake
- Decreased loss
- Shift of K⁺ out of cells

**Neurologic**
- Numbness, paresthesias, hyporeflexia

**Cardiovascular**
- Conduction disturbances, ventricular fibrillation, asystole

**Gastrointestinal**
- Nausea, vomiting, diarrhea

**Genitourinary**
- Oliguria, anuria

**Musculoskeletal**
- Early → irritability
- Late → weakness
- Flaccid paralysis

**Treatment 1**—potassium >5.5 mEq/L
- Three-part therapy
- Protect cardiovascular function
  - Administer 10 mL calcium chloride or calcium gluconate slow IV push
  - Renders the myocardium less excitable by decreasing the effects of excess extracellular potassium
Hyperkalemia

Treatment 2—potassium >5.5 mEq/L
- Shift potassium into the cells
  - 1 ampule sodium bicarbonate
  - 5–10 units regular insulin
  - 50 mL 50% dextrose
  - 10–20 mg albuterol IV or by inhalation

Hyperkalemia

Treatment 3—potassium >5.5 mEq/L
Remove potassium
- Loop diuretics
- Sodium polystyrene sulfonate (Kayexalate)
  - 1 g orally K+ 1 mEq, rectally K+ 0.5 mEq
  - Sorbitol
- Hemodialysis

Calcium

- Total Ca++: 8.5–10.5 mg/dL; ionized Ca++: 4.0–5.0 mg/dL
- Total calcium: 45% ionized + 40% protein-bound + 15% complexed
- Corrected calcium: Total calcium + 0.8
  (4.0 – serum albumin)
**Calcium**

Total Ca\(^{++}\): 8.5–10.5 mg/dL; ionized Ca\(^{++}\): 4.0–5.0 mg/dL

- Many physiologic and metabolic processes
- Nerve impulse transmission
- Cardiac muscle contractility
- Important role in action potential and pacemaker function
- Needed to activate clotting mechanisms
- Teeth and bone formation
- Smooth muscle contraction and vasodynamics

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**Calcium Regulation**

- Organ regulation: bone, intestines, kidney
- Parathyroid hormone
- Vitamin D
  - Calcitriol
  - Calcitonin
- Alkalosis → ↓ calcium; acidosis → ↑ calcium
- Hyperphosphatemia = hypocalcemia
- Hypomagnesemia = hypocalcemia

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**Hypocalcemia**

- Causes:
  - Excessive loss
  - Inadequate intake
  - Decreased intestinal absorption
  - Increased loss
- Neurologic:
  - Tingling → convulsions, hyperreflexia
- Cardiovascular:
  - Dysrhythmias, cardiac arrest, bruising, bleeding
- Pulmonary:
  - Increased secretions, nausea, vomiting, diarrhea
- Gastrointestinal:
  - Increased peristalsis, nausea, vomiting, diarrhea
- Musculoskeletal:
  - Osteoporosis → fractures, abnormal deposits of calcium in body tissues, muscle spasm, tetany

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**Calcium**

Total: 8.5–10.5 mg/dL
Ionized: 4.0–5.0 mg/dL
Hypocalcemia—Signs and Symptoms

Total Ca++: <8.5 mg/dL; ionized Ca++: <4.0 mg/dL
- Chvostek’s sign
- Trousseau's sign

Hypocalcemia Treatment

Total Ca++: <8.5 mg/dL; ionized Ca++: <4.0 mg/dL
- Oral replacement
- IV replacement
- Vitamin D
- Aluminum hydroxide gel for hyperphosphatemia
- Magnesium for hypomagnesemia
- Monitor very carefully

Hypercalcemia

- Total: 8.5–10.5 mg/dL
- Ionized: 4.0–5.0 mg/dL

Neurologic
- Decreased reflexes, lethargy → coma, seizures

Cardiovascular
- Depressed activity, dysrhythmias, cardiac arrest

Gastrointestinal
- Decreased motility of gastrointestinal tract, increased peristalsis, nausea, vomiting, constipation

Genitourinary
- Kidney stones, flank pain

Musculoskeletal
- Muscle fatigue, hypotonia, bone pain, osteoporosis, fractures
Hypercalcemia—Treatment

Total Ca++: >10.5 mg/dL; ionized Ca++: >5.0 mg/dL
- Volume expansion with normal saline
- Loop diuretics
- Corticosteroids
- Calcitonin or mithramycin
- Treat the underlying cause

Magnesium

Mg++ 1.5–2.5 mEq/L
- Essential for production of energy
- Sodium-potassium ATPase pump
- Cell membrane stabilization
- Vasodilating effects
- Influences neurotransmitter release

Hypomagnesemia

Neurologic
Agitation, depression, confusion, convulsions, paresthesias, ataxia, hyperreflexia, vertigo, seizures

Cardiovascular
Dysrhythmias, tachycardia, hypertension, increased systemic vascular resistance

Gastrointestinal
Nausea, vomiting

Musculoskeletal
Cramps, spasticity, tetany
Hypomagnesemia Treatment

Magnesium <1.5 mEq/L
- IV administration of magnesium
  - 1–4 g magnesium sulfate over 2 minutes to 6 hours
- Common side effects
  - Flushed feeling, sweating
  - Hypotension
  - Bradycardia
  - IV site burning

Hypermagnesemia Treatment

Magnesium >2.5 mEq/L
- Volume administration
- Diuretics
- Decrease magnesium intake
- IV insulin and glucose
- Treat acidosis
- Hemodialysis or continuous ambulatory peritoneal dialysis

Hypermagnesemia

Excess intake
Renal insufficiency
Acidosis

Neurologic
Hyporeflexia, lethargy → coma

Cardiovascular
Dysrhythmia, hypotension, flushed/warm skin

Pulmonary
Respiratory depression, apnea

Musculoskeletal
Muscle fatigue, hypotonia, bone pain, osteoporosis, fractures

Magnesium
1.5–2.5 mEq/L

Renal
Question 5

A chronic dialysis patient missed three dialysis treatments. Admission laboratory tests report calcium 7.1 mg/dL, potassium 6.5 mg/dL. ECG monitor shows tall T waves and occasional PVCs. While preparing for dialysis, the nurse would anticipate:

A. Administering oral aluminum hydroxide and hanging a lidocaine infusion at 2 mg/min
B. Connecting the patient to the external pacemaker and administering 10 units of regular insulin IV push
C. Preparing for arterial line and central line insertion
D. Administering 1 ampule sodium bicarbonate and recording a 12-lead ECG

Question 5—Rationale

A chronic dialysis patient missed three dialysis treatments. Admission laboratory tests report calcium 7.1 mg/dL, potassium 6.5 mg/dL. ECG monitor shows tall T waves and occasional PVCs. While preparing for dialysis, the nurse would anticipate:

D. Administering 1 ampule sodium bicarbonate and recording a 12-lead ECG—NaHCO₃ will raise pH and lower K and decrease PVCs. 12-lead will help to identify other potential problems:

- Administering oral aluminum hydroxide and hanging a lidocaine infusion at 2 mg/min—Ca⁺ is low and Pho₄ probably high; ventricular ectopy from acidosis and K
- Connecting the patient to the external pacemaker and administering 10 units of regular insulin IV push—No indication for pacing at this time. IV insulin will drive some K into the cell
- Preparing for arterial line and central line insertion—No indication at this time