Joint Trauma System

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Hyperkalemia and Dialysis in the Deployed Setting

Part of the Joint Trauma System (JTS) Clinical Practice Guideline (CPG) Training Series

Purpose

This CPG provides evidence–based guidelines for the treatment of acute kidney injury and its complications to include hyperkalemia.

Presentation is based on the JTS Hyperkalemia and Dialysis in the Deployed Setting CPG, 24 Jan 2017 (ID:52) . It is a high-level review. Please refer to the complete CPG for detailed instructions. Information contained in this presentation is only a guideline and not a substitute for clinical judgment.

Agenda

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1. Summary
2. Background
3. Evaluation
4. Medical Management
5. Treatment
6. Performance Improvement (PI) Monitoring
7. References
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Summary

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- Patients with acute kidney injury may require renal replacement therapy for life threatening sequela such as hyperkalemia.
- Austere locations need to be prepared to use medical management in addition to renal replacement therapies.

Background

- Acute kidney injury (AKI) and its complications are associated with combat trauma.
  - 34.3% of most critically injured have AKI within 2 days.
  - Hyperkalemia associated with AKI can be life threatening.
- Robust renal replacement therapies are often available at higher roles of care, but temporizing measures may be required at lower levels of care if evacuation is not possible.
- Approximately 1/3 of patients with oliguric renal failure develop life threatening hyperkalemia.

Evaluation

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- Patients at risk for AKI and hyperkalemia should be monitored closely.
  - ❑ Hourly urine output
  - ❑ Serum creatinine checks
  - ❑ Serum potassium checks
- AKI is classified by relative changes in creatinine or a decrease in urine output.
  - ❑ Severe AKI is characterized by oliguria and doubling of serum creatinine and may require renal replacement therapy (RRT).
  - ❑ More minor AKI can generally be treated with supportive care.

Medical Management

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- Initial Medical management for hyperkalemia includes:
  - **Cardiac membrane stabilization**: IV calcium chloride or calcium carbonate
  - **Shifting Potassium intracellularly**: insulin, β-2 adrenergic agonist, or sodium bicarbonate
  - **Remove Potassium**: binding resins and diuretics
    May be limited by hemodynamic status, anuria, and bowel injuries.
- Shifting potassium intracellularly should be done when potassium is greater then 5.5 meq/L.
- Cardiac stabilization should be done if evidence of altered cardiac conduction (peaked T waves, widened QRS, flatted P waves) and empirically if potassium concentration > 6 meq/L.

Treatment: Hyperkalemia

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Initial Medical Management for Hyperkalemia

Drug/ Treatment	Dose & Route of Administration	Mechanism of Action	Time to Onset	Duration of Effect	Caution/Contraindication	Other Comments
Stabilize Cardiac Membranes						
Calcium gluconate	1000mg=one 10ml "amp" of 10% (100mg/mL) solution; infused IV over 2-3 mins	Stabilizes myocyte membrane electrical activity	Immediate	30-60 mins	Caution if pre-existing hypercalcemia	Can be administered via peripheral IV; repeat in 5 mins for persistent EKG changes
Calcium chloride	1000mg=one 10ml "amp" of 10% (100mg/mL) solution; infused IV over 2-3 mins	Stabilizes myocyte membrane electrical activity	Immediate	30-60 mins	Administration via central line preferred (can damage small vessels, cause tissue necrosis); caution if pre-existing hypercalcemia	Repeat in 5 mins for persistent EKG changes
Shift Potassium Intracellularly						
Insulin, regular	10 units by IV bolus; if blood glucose <250 mg/dL give 50 mL 50% dextrose immediately after insulin	Shifts potassium intracellularly by way of Na-K ATPase pump	10-20 mins	4-6 hr	Caution if hypoglycemia	Check blood glucose within one hour of administration
Albuterol	10 mg nebulized, over 10 mins	Shifts potassium intracellularly by way of Na-K ATPase pump	20-30 mins	1-2 hr	Can cause tachycardia	Has additive effect with insulin tx
Sodium Bicarbonate	150 meq in 1L of D5W over 2-4 hr	Shifts potassium intracellularly by increasing blood pH	~4 hr	Variable	Can decrease ionized calcium and destabilize cardiac membranes; caution in setting of volume overload	Minimally effective and should not be used unless pH<7.2

Treatment: Hyperkalemia

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Initial Medical Management for Hyperkalemia *(continued)*

Drug/ Treatment	Dose & Route of Administration	Mechanism of Action	Time to Onset	Duration of Effect	Caution/Contraindication	Other Comments
Remove Potassium						
Sodium polystyrene sulfonate (Kayexalate®)	30 grams PO	Exchanges sodium for potassium in the large intestine	>2 hours	Variable	Case reports of colonic necrosis; avoid in setting of bowel obstruction or following bowel injury or surgery; may be of limited utility in setting of severe hyperkalemia	Can repeat every 4-6 hours; consider initial dose of 45-60 grams in body weight >80 kg
Furosemide	40mg IV	Impairs renal potassium reabsorption	5 mins	2 hours	Avoid if sulfa allergy; caution in volume depletion, hypotension	May require larger does (up to 200mg) or be ineffective in setting of acute kidney injury

Treatment: AKI

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- Patients that have a potassium greater then 6 meq/L despite medical management should have renal replacement therapy (RRT).
- NxStage System One and acute peritoneal dialysis are two current therapies in theater.

Treatment: AKI

- NxStage System One must have central venous access with a dialysis catheter, a functional machine, appropriate setup, and a prescription.
- Setup of NxStage System One should be displayed on the initial computer screen and are straightforward.
- Central Venous Hemodialysis Catheter (12-14 French size) recommendations include:
  - 1st choice location: right internal jugular vein (15 cm catheter)
  - 2nd choice location: femoral vein (20-25 cm catheter)
  - 3rd choice location: left internal jugular (20 cm catheter)
  - Avoid subclavian placement

Continuous Renal Replacement Therapy

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5 Elements of Continuous Renal Replacement Therapy (CRRT) Prescription:

1. **Mode**
   - Option of continuous venovenous hemofiltration (CVVH) or hemodialysis (CVVHD)
   - Suggest CVVH for those unfamiliar with machine, but if familiar CVVHD more efficient.
2. **Blood flow rate**
   - Minimum flow rate is 200 ml/min but rate should be 400 ml/min if possible to decrease likelihood of blood clotting filter.
   - Main reason for lack of flow is pressure required to draw blood out. To correct:
     - Manipulate catheter by spinning 180 degrees.
     - Reverse line connections on dialysis catheter.
     - Final option is placing line at new location.

Continuous Renal Replacement Therapy

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5 Elements of CRRT prescription *(continued)*

3. Replacement fluid

- Two options: 0 meq/L potassium (0K) and 4 meq/L potassium (4K)
- Use 0K fluid until potassium < 5.5 meq/L.

4. Replacement fluid rate

- Start at 3 L/hr and if no improvement in potassium concentration, increase.
- If unable to clear potassium at maximum rate, surgical re-evaluation appropriate for debridement of severe ongoing necrosis.
- Final option is setup of second CRRT circuit.

5. Ultrafiltration rate

- Rate at which volume is removed.
- Absent overt hypervolemia, initial setting should be 0 or equal to all the patient's hourly fluid input.

Treatment: AKI

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Suggested Starting Prescriptions and Dosage

	Recommendation	Notes
Mode	CVVH	If hospital personnel are familiar with the machine, CVVHD should be considered because it is more efficient per liter of volume infused.
Blood Flow Rate	200-400 ml/min	The blood flow rate should be increased as much as tolerated by the access pressures and machine alarms to avoid clotting. We suggest maintaining flows of at least 200 cc/min
Replacement Fluid Type	0K	For use with hyperkalemia. Change to 4K when potassium <5.5 meq/L. If neither of these fluids are available, CRRT can be performed using lactated ringer, Plasmalyte or the improvised solutions for peritoneal dialysis (See table on slide 20). Note that if a solution with 0 Ca is used, the ionized calcium should be closely monitored and replaced as needed.
Replacement Fluid Rate	3L per hour	Increase if needed for further clearance of potassium.
Ultrafiltrate Rate	0 ml/min	If desired, fluid can be removed via ultrafiltration. In the acute setting, barring overt hypervolemia, fluid removal should be avoided. However, consider setting the ultrafiltration rate to the patient's hourly "In's" to avoid hypervolemia.

Peritoneal Dialysis

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- If NxStage System One is not available, consider acute peritoneal dialysis (PD).
  - Use generally supplanted by CRRT, but it is an established treatment.
  - May be only option if medical management fails.
- PD relies on diffusion and convection of solutes from the blood into a fluid across the peritoneal membrane.
  - Fluid must be exchanged periodically to maintain clearance.
  - Recent laparotomy is considered a relative contraindication, but if no other option, it can be considered if recent laparotomy performed in combat casualties.

Peritoneal Dialysis

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4 Elements of Peritoneal Dialysis

1. Catheter Placement

- Specialized catheters are generally not available.
- Nasogastric tubes, pediatric chest tubes, and Jackson-Pratt drains have been used.
- Recommend tunneling of catheter to prevent peritonitis.

2. Fluid Type

- Specialized fluids often not available in deployed setting.
- For Hyperkalemia use a solution with potassium concentration of 0.

Peritoneal Dialysis

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4 Components to Peritoneal Dialysis *(continued)*

3. Exchange Volume

- The volume of fluid infused into the peritoneal space is “exchange volume” and removing and replacing the fluid after the dwell is the “exchange.”
- Recommend starting with 1 L per exchange and increasing to 2 L if tolerated
- Patients must be kept supine and there may be leakage around the surgical site.

4. Dwell Time

- The length of time the fluid is allowed to sit in the peritoneal space.
- Initial dwell time of 2 hours and exchanges should be done every 2 hours until therapeutic goal has been achieved.
- After therapeutic goal is achieved, dwell time can be extended to 4 hours with close monitoring.

Fluid Solutions

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Examples of improvised fluid solutions

Further guidance in Appendix C.

Starting Fluid	Addition(s)	Ending Concentrations
Potassium Free Solutions		
1 Liter ½ Normal Saline Na 77, Cl 77	40ml of 8.4% Bicarbonate 35ml of 50% Dextrose 60ml of 3% Saline	Na 130, K 0, Ca 0, Cl 95, bicarbonate 35, Osm 338, Dextrose 1.54%
1 Liter ½ Normal Saline Na 77, Cl 77	40ml of 8.4% Bicarbonate 60ml of 50% Dextrose 65ml of 3% Saline	Na 129, K 0, Ca 0, Cl 95, bicarbonate 34, Osm 388, Dextrose 2.57%
1 Liter ½ Normal Saline Na 77, Cl 77	43ml of 8.4% Bicarbonate 105ml of 50% Dextrose 75ml of 3% Saline	Na 130, K 0, Ca 0, Cl 94, bicarbonate 35, Osm 476, Dextrose 4.29%
Potassium Containing Solutions		
1Liter Lactated Ringers Na 130, K 4, Ca 2.7, Cl 109, Lactate 28, Osm 273	30ml 50% Dextrose	Na 126, K 3.9, Ca 2.6, Cl 106, Lactate 27, Osm 339, Dextrose 1.46%
1Liter Lactated Ringers Na 130, K 4, Ca 2.7, Cl 109, Lactate 28, Osm 273	53ml of 50% Dextrose 10ml of 3% Saline	Na 127, K 3.8, Ca 2.5, Cl 107, Lactate 26, Osm 392, Dextrose 2.49%
1Liter Lactated Ringers Na 130, K 4, Ca 2.7, Cl 109, Lactate 28, Osm 273	95ml of 50% Dextrose 25ml of 3% Saline	Na 128, K 3.6, Ca 2.4, Cl 109, Lactate 25, Osm 481, Dextrose 4.24%

**1L fluid bags may contain extra fluid (40-60ml), this additional volume is not included in these calculations as it will not make a significant clinical difference.*

Treatment: Risks

Use of PD can be complicated by fluid leakage, especially if abdomen has to be left open and development of abdominal compartment syndrome.

- Complicating factors limit the amount of fluid that can be infused and allowed to dwell.
- The fluid can be continuously exchanged to mitigate this by instilling fluid from one site and removing from another.
- Ports for continuous exchange should be as physically distant as possible.

Treatment: Miscellaneous

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- Improvised PD can improve hyperkalemia, acidemia, and hypervolemia, but does not significantly improve azotemia or uremia.
- Additional reasons for renal replacement therapy (RRT) include acidemia and fluid overload and these can be temporized the same as with hyperkalemia.

PI Monitoring

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- **Population of Interest**

Patients with acute kidney injury or hyperkalemia (potassium > 5.5 or hyperkalemia diagnosis code or documentation of EKG changes consistent with hyperkalemia).

- **Intent (Expected Outcomes)**
  - ❑ All patients with K > 5.5 and/or EKG changes consistent with hyperkalemia receive recommended medical treatment at the same level of care where diagnosed.
  - ❑ All patients with persistent hyperkalemia despite medical management receive RRT (CRRT or peritoneal dialysis) or documentation why RRT is not implemented.
  - ❑ Indication for initiation RRT is documented.
- **Performance/Adherence Measures**
  - ❑ Number and percentage of patients who receive medical treatment for hyperkalemia at the same level of care where diagnosed.
  - ❑ Number and percentage of patients who receive RRT who have the indication for RRT documented.
- **Data Source**
  - ❑ Patient Record
  - ❑ Department of Defense Trauma Registry

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Appendices

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- **Appendix A**: Initial Medical Management for Hyperkalemia
- **Appendix B**: Continuous Renal Replacement Therapy Using the NxStage System One
- **Appendix C**: Improvised Solutions for Peritoneal Dialysis
- **Appendix D**: Additional Information Regarding Off-label Uses in CPGs

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