Objectives

- Link altered electrolytes to potential life threatening complications
- Evaluate emergent treatment options for altered electrolyte disturbances

Hyperkalemia

- Serum level > 5.3
- Causes:
  - Crush injury
  - Acidosis
  - Renal failure
  - Rhabdomyolysis

Disclosures

- NONE!

The Lytes & ECG's Danger Signs!!

Potassium

- Normal:
  - 3.5 - 5.3 mEq/L

Case Studies in Electrolyte Management

Julie Miller, RN, BSN, CCRN
Hyperkalemia

- Cardiac changes
  - Greater Than 5.5
    - Peaked T waves
    - Prolonged PR Intervals

> 5.5

Hyperkalemia

- Greater Than 6.5
  - Prolonged PR and small P waves
- Greater Than 7.0
  - Widened QRS Tall T wave

> 7.5

Hyperkalemia

- Greater Than 8.0
  - Widened QRS, Sine waves
  - Varies by patient progresses to asystole

> 8.5

Hyperkalemia Treatment

- Protect the Heart
  - Calcium Chloride or gluconate
    - Stabilizes Cardiac Cell
    - Narrows the QRS

- Hide the Potassium
  - Insulin and glucose
    - Insulin Drive K⁺ Into Cell
    - Glucose prevents hypoglycemia
  - Na Bicarbonate
    - Drives K⁺ Into Cell

Hyperkalemia Treatment

- Excrete the Potassium
  - Sodium polystyrene sulfonate
    - Takes 2 – 12 Hours
  - Diuretics
    - Need Healthy Kidneys
  - Dialysis
    - Takes Time to Set-up
    - Requires hemodynamic stability

Serum level > 5.3

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Hyperkalemia Treatment

<table>
<thead>
<tr>
<th>Emergency Hyperkalemia Treatment</th>
<th>Protect the Heart</th>
<th>Hide the potassium</th>
<th>Excrete the potassium</th>
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</thead>
<tbody>
<tr>
<td>Calcium Chloride or gluconate</td>
<td>Calcium Chloride</td>
<td>Insulin and</td>
<td>Sodium polystyrene</td>
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<tr>
<td>intravenous</td>
<td>chloride or</td>
<td>dextrose and</td>
<td>sulfonate, dialysis,</td>
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<td>(CaCl) has three times more</td>
<td>gluconate</td>
<td>sodium bicarbonate.</td>
<td>diuretics</td>
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<td>available Ca than gluconate</td>
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<td>temporarily</td>
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</tbody>
</table>

Case Study

- 63 y.o. F. Diabetic, Chronic renal failure, HX of cardiac disease
- Found semi-conscious and bradycardic
- Transferred to ICU, Labs pending

Case Study

- 58 yo M
- Skipped last 2 dialysis treatments due to feeling poorly with cough and fever
- Admitted with Sepsis, Metabolic Acidosis
- Lactate 7.8
- Standard Hyperkalemia Treatment being administered during the code

Case Progression

- History obtained:
  - Patient kept bottle of Salt Substitute at bedside
  - Nursing Implications
- Case Conclusion
  - Patient Died at 0910
  - Potassium 7.3 mEq/Liter

Case Study

- 1324
- 1351
Case Progression

- 1431

Case Conclusion

- 1449

Hospital #1 in the ER 1115

Another Case!!

Hospital #2 Admit Med/Surg

- Direct Admit ECG at 1206 – “I have a concern” - Try CUSSING!!

CUS – From TeamSTEPPS

- C – “I have a Concern about....”
- U – “I am Uncomfortable because....”
- S – “This is a Safety issue and....”
- 2nd Time:
- I have a concern, this is unsafe, STOP
Hypokalemia

• Serum levels < 3.5

• Causes:
  – Diuresis
  – Gastric loss
  – Insulin
  – NaHCO3⁻

• Treatment
  • Protect the Heart!
    – Replace losses

Case Study

• At risk for PVC’s, V Tach, V Fib

Case Study

• 54 y.o. M c/o 3 day history of diarrhea and vomiting.

• Has continued Lasix tablets but stopped KCL because it upset his stomach

Guess the potassium?
Case Study

• Potassium: 1.8 mEq/Liter

• Treatment?
  – Replace the losses
  – IV: Not faster than 10 mEq/Hour

Hypokalemia

• Patient complains of feeling dizzy and palpitations....
  – See the “R on T”?

Case Study

• Treatment
  – Continue to replace potassium
  – Antidysrhythmics
    • Amiodarone
      – Dosing?
    • Lidocaine
    • Procainamide

Magnesium

• Normal:
  – Text book 1.2 - 2.9 mEq/L
  – 1.8 – 2.3 mEq/L

K+ K+ Mg++ K+
K+ Mg++

Hypomagnesemia

• Serum level < 1.2 mEq/L (< 1.8)

• Symptoms:
  – Muscle tremors
  – Nausea
  – Cardiac dysrhythmias?
    • Prolonged QT interval
Hypomagnesemia

VT & Torsades – Prolonged QT Causes

- Conditions & Medications that Prolong QT
  - Antidysrhythmics: amiodarone, procainamide, sotalol, ibutilide
  - Tricyclic Anti-Depressants
  - Haldol, Geodon

- Phenothiazines (Compazine, Thorazine)
- Hypomagnesemia, Hypocalcemia, Hypokalemia
- Hypothyroidism
- Liquid Protein Diets
- Antibiotics - Levaquin

Measuring the QT Interval

- QTc = QT measured / Square Root of the R-R interval
  - Should be Less 0.45 seconds

- Simplified Formula
  - QTc = Less than ½ the preceding R-R interval
  - Works with Regular Rhythms

Prolonged QT & Torsades

- History:
  - 40 yo admitted with Hx. of Methamphetamine Addiction
  - Placed on Telemetry
  - Haldol 10 mg IV prn for agitation
  - Doses given at 0330, 0430, 0610
  - AM Labs – Potassium and Magnesium
    - Potassium 2.7 mEq/Liter
    - Magnesium 1.7 mEq/Liter
  - Low levels of both of these put patient’s at risk for prolonged QT interval

Measure the patient’s QT Interval

- Actual measured QT interval is in PINK – It should be less than ½ the preceding R-R interval;
  - If you just measured the QT interval in pink it measures as “normal” at 0.44 sec. You need to compare the QT to the preceding R-R interval to correct it for the heart rate.
- Measured R-R interval is in BLUE – R-R interval is 0.62 sec – the measured QT should be less than ½ the preceding R-R interval

Measure QT Interval

- When you compare the measured QT to the preceding R-R interval, the QT of 0.44 seconds is prolonged as it is greater than ½ the preceding R-R interval
- RR interval is 0.62 sec – The QT should have been less than 0.31 sec.
10 minutes after 4th Dose of prn Haldol

Nursing Implications
• Be AWARE of the numerous medications which prolong the QT
• Amiodarone, Levaquin, Haldol, Geodon, anti-depressants, etc. see table below
• When giving a medication that may prolong the QT interval
  – Measure the QT and correct it for the HR = QTc
  – QT calculated or QTc = QT (measured) ÷ √R-R interval (seconds)
  – Evaluate your electrolytes and correct

Update your knowledge with the latest AHA Scientific statement found at:
http://circ.ahajournals.org/content/121/8/1047.full.pdf+
http://ajcc.aacnjournals.org/content/17/1/77.full.pdf+

Table Medications that Prolong the QT interval

<table>
<thead>
<tr>
<th>Medications implicated in torsades de pointes</th>
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<tbody>
<tr>
<td>Proocainamide</td>
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<tr>
<td>Chlorpromazine</td>
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<tr>
<td>Disopyramide</td>
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<tr>
<td>Quinidine</td>
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<tr>
<td>Class III antiarrhythmics</td>
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<tr>
<td>Sotalol</td>
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<tr>
<td>Dofetilide</td>
</tr>
<tr>
<td>Amiodarone &amp; Geodon</td>
</tr>
</tbody>
</table>

Antimicrobials
Antiprotozoals
Pentamidine
Macrolides
Clarithromycin
Erythromycin
Antimalarials
Chloroquine
Halofantrine

Adapted from AJCC
AMERICAN JOURNAL OF CRITICAL CARE, January 2008, Volume 17, No. 1

Antipsychotics
Phenothiazine neuroleptics
Mesoridazine
Thioridazine
Droperidol
Pimozide
Haloperidol
Diphenylpiperidine neuroleptics
Butyrophenone neuroleptics
Others
Methadone
Arsenic trioxide

Amiodarone & Geodon should not be used together

Potassium and Magnesium
• Electrolytes – Rule of Thumb
  – Potassium > 4.0
  – Magnesium > 2.0

Hypermagnesemia
• Serum level
  – > 2.9 mEq/L
• Symptoms:
  – Respiratory depression
  – ECG is similar to hyperkalemia

Calcium
• Normal:
  – Total: 8.6 – 10 mEq/Liter
  – Ionized: 1.16 – 1.32 mEq/Liter
**Calcium**

- Total Calcium
  - 8.6 - 10.0 mg/dl
  - 40% bound to albumin
    - Must correct for low albumin
  - Normal albumin = 3.5 – 5.0

- Ionized Calcium
  - 1.16 - 1.32 mmol/L
  - Levels change based on pH
    - Decrease in pH causes increase in Ca
  - Relationship to Phosphorous?
    - Inverse

**Calcium**

- Needed
  - Bones
  - Muscles
    - Skeletal and Cardiac
    - Cardiac Conduction
      - Especially SA - AV conduction
  - Clotting

**Hypercalcemia**

- Causes
  - Immobility, Multiple Myeloma, Alkalosis, Hyperparathyroidism
  - Thiazide diuretics

**Hypercalcemia**

- Signs and Symptoms
  - N/V, Constipation, Confusion, AV Blocks, Shortened Q-T interval

**Hypocalcemia**

- Causes
  - Blood transfusions, GI Loss, CRF, Acute Pancreatitis, Hypoparathyroidism
- Banked Blood
  - Citrate to prevent Clots
  - Binds with Calcium

- Treatment
  - NS, Loop Diuretics, Mithramycin, Oral Phosphates

- Blood transfusions, GI Loss, CRF, Acute Pancreatitis, Hypoparathyroidism
- Banked Blood
  - Citrate to prevent Clots
  - Binds with Calcium
Hypocalcemia

• Signs and Symptoms
  – Tremors, Cramps, Lethargy, Labored Shallow Respirations
  – Prolonged QT
  – Irritable Heart

• Treatment
  – Monitor and Replace

Case Study

• 68 yo M admitted for multiple myeloma
  – Confused, restless, weak
  – Monitor:

  Sinus Brady with First Degree Heart Block

Case Study

• 68 yo M admitted for multiple myeloma
  – Monitors shows Sinus brady with 1st degree AV block
  – PR Interval – 0.24 – 0.26
  – Guess the calcium level?

  12.1

Case Study – What rhythm?

Case Study

• 65 yo F Hx. Hyperparathyroidism admitted for nausea and vomiting
  – Medications include Digoxin – Not sure why she takes this medication
  – Attached to monitor
  – 12 Lead ECG ordered and Labs sent

Case Study

• Treatment?
  – DC Digoxin
  – NS at 150 ml/hour – Watch out for pulmonary edema
  – Lasix 20 mg IVP every 6 hours
**Phosphate**

- **Intracellular**
  - 15% total body
  - 85% bound with Calcium in bone
  - Muscle, Nervous System
  - RBC
  - Glucose Metabolism

- **Normals**
  - Adults
    - 2.5 – 4.5 mg/dl
  - Child
    - 4.5 – 5.5 mg/dl
  - Newborn
    - 4.5 – 9 mg/dl

- **Hyperphosphatemia**
  - Kidney dysfunction
  - Hypoparathyroidism
  - Hypocalcemia
  - Excessive Vit. D
  - Bone tumors and metastases

- **Hypophosphatemia**
  - Hyperparathyroidism
  - Diabetic coma (Increased CHO metabolism)
  - Increased Insulin
  - Malnutrition
  - Hypercalcemia

**Osmolality**

- **Osmolality**
  - Amount or number of dissolved particles in solution - Solutes
    - 275 – 295 mOsm/kg H₂O
  - Movement of fluid occurs due to osmosis
    - Movement of fluid from lesser concentration to higher concentration
  - Sodium, BUN and Glucose are Solutes

**Case Study**

- 73 yo M Hx. CVA
  - Receiving tube feedings at 60 ml/hour
  - Na 145, K⁺ 4.8, BUN 36 Cr. 1.2
  - Serum Osmolarity = 297
    - Quick Reference – Estimate Osmolality
      - 2 Times Na = Osmolality Estimate
      - 2 X 145 = 290
    - Osmo = 297 = Lot’s of Particles
      - Not Enough Water
      - Needs Fluids

**Sodium**

- **Normal Serum Levels:**
  - 135 -145 mEq/L

**Hypernatremia**

- **Causes:**
  - DI – Neurogenic or Nephrogenic
  - Dehydration – Water loss
  - Drugs: ie Na Bicarbonate

- **S & Sx:**
  - Confusion to coma
  - Febrile, Tachycardic
**Hypernatremia**

- **Dehydration**
  - Almost Always
- **Serum Labs**
  - Hypernatremia
  - Osmolality elevated
  - Hypokalemia
- **Urine Labs**
  - Hyponatremia
  - Low osmolality

**Hypernatremia**

- Sodium stays in body with massive fluid loss
- Clues
  - Urine Sodium Low with Volume losses – DI
  - Urine Sodium HIGH with renal Na loss with osmotic diuresis ie with DKA

**Case Study**

- 52 y.o, s/p subarachnoid hemorrhage
- 800 ml of urine over last hour - Clear Pale Yellow
- Serum Sodium 148
- Serum Osmolality is 302
- Urine Osmolality 200 mOsm/kg
- What is this?
  - Diabetes Insipidus

**Hyponatremia**

- **Causes:**
  - Dilutional
    - SIADH, CRF, DM, Water intoxication
  - Salt Wasting Syndromes
    - DKA, Water Intoxication
    - Atrial Natriuretic Peptide
    - ACE Inhibition

**Hyponatremia**

- SIADH – Syndrome of Inappropriate ADH
  - “Swimming In” ADH
    - Excess Secretion from Post. Pituitary
  - Excess ADH
    - Decreased UOP
    - Water Retention – Volume Overload
    - Dilutional Hyponatremia
Hyponatremia

- Salt wasting
  - Atrial Natriuretic Factor
    - Hormone produces sodium excretion
    - Associated with Neurologic damage
  - Results in:
    - High urine output
    - Low serum sodium
    - Water loss = Dehydration
      - Decreased CVP & PAOP

- Hyponatremia
  - S & Sx
    - Headache, muscle cramps, confusion, Tachycardia, Seizures
  - Dilutional
    - Increased CVP & PAOP
  - Saline Loss
    - Volume Loss
    - Decreased CVP & PAOP

- Treat Underlying Cause
  - SIADH
  - Fluid Restrict, Diuretics, Hypertonic Saline
  - Salt Wasting
  - Isotonic Fluid Replacement
  - Hypertonic Saline

Case Study

- 56 y.o. F Bronchogenic Oat Cell Carcinoma, Ventilator Dependent – Trach, Confused.
- Decreased urine output
  - Urine Osmolality HIGH
- Serum Na: 132
- What is this?
  - SIADH due to Positive Pressure Ventilation &/or Lung Cancer

Differentiating

<table>
<thead>
<tr>
<th>SIADH</th>
<th>Salt Wasting</th>
<th>DI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too Much ADH</td>
<td>ANP related to HHH</td>
<td>Too Little ADH</td>
</tr>
<tr>
<td>Low Serum Na</td>
<td>Low Serum Na</td>
<td>High Serum Na</td>
</tr>
<tr>
<td>Low UOP</td>
<td>High UOP</td>
<td>High UOP</td>
</tr>
</tbody>
</table>

Electrolyte Review

- Hyperkalemia and Hypermagnesemia
  - Tall tented T Waves
  - Widen the QRS
  - Flatten the P wave
  - Prolong the PR Interval
  - Bradycardia progressing to ASYSTOLE
Electrolyte Review

• Hypokalemia and Hypomagnesemia
  – Irritate the Heart
  – PVC’S
  – V Tach
  – V Fib
  – Torsades des Pointes due to prolonged QT interval

• Hypercalcemia
  – Prolong the PR Interval
  – Brady and Blocks
  – Shortens the Q-T
  – Slows muscle contraction
  – Slows electrical conduction

Electrolyte Review

• Hypocalcemia
  – Irritable Ventricle
  – Decreased Contractility
  – Prolonged QT – May lead to Torsades!
  – Alters the clotting cascade – at risk for bleeding
  – Irritable muscles – Tremors
  • Positive Chvostek’s and Trosseau’s

• Hypernatremia
  – Almost always associated with dehydration

• Hyponatremia
  – Correct Sodium levels slowly

Questions

• 28 yo pt. Admitted for 4 days N/V and diarrhea, unable to keep any food or liquid down. The electrolyte disturbance you might expect is:
  a. Hyperkalemia
  b. Hypercalcemia
  c. Hypokalemia
  d. Hyponatremia

Questions

• 48 yo pt admitted with renal insufficiency. Has been recently diagnosed with hyperparathyroidism. The electrolyte disturbance you might expect is:
  a. Hypercalcemia
  b. Hypokalemia
  c. Hypocalcemia
  d. Hypernatremia
Questions

• You are caring for a patient with renal failure who is receiving antacids. Telemetry tech calls to report your patient is displaying a prolonged PR interval, widened QRS and tall peaked T-Wave. Labs are drawn and you expect to find:
  a. Hypernatremia & Hyperkalemia
  b. Hypokalemia & Hypomagnesemia
  c. Hyperkalemia & Hypermagnesemia
  d. Hyponatremia & Hypokalemia

Questions

• You are caring for a patient with acute pancreatitis. Neurologic assessment shows confusion and short term memory loss. Patient c/o of “Jittery” muscles. You expect the labs to show:
  a. Hypocalcemia
  b. Hypercalcemia
  c. Hypermagnesemia
  d. Hypophosphatemia

Speaker Contact

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