Pediatric Fluid and Electrolyte Emergencies

Key : chapter 15
Ma, Cline : chap 80

Objectives

- Discuss some of the pediatric fluid and electrolyte disorders that may present to the paramedic
- Review the principals of treatments of :
  - Gastroenteritis
  - Dehydration
  - Early intervention for potentially life threatening fluid and electrolyte disturbances in pediatric patients
    - Including the ED treatment with ORS (oral rehydration solution)

Case 1

- Bobby is a 10 YO with insulin-dependent diabetes. He has a history of having been was eating Easter candy with his brother and their friends. Bobby began complaining with abdominal pain, then he began vomiting.
- His father called 911 when Bobby became confused.
- Upon your arrival, Bobby's father reports to you that he has thinks he smells ketones and that he has performed a home glucometer - with result of blood sugar of 430mg/dl

Case 1

Treatment

- IV NS WO -- or 20mL/kg
- Controversy among pediatric diabetologists as to best protocol
  - Cerebral edema
    - serious complication may occur with excessive fluid administration
    - may be associated with fluids greater than **50 ml/kg** over the first 4 hours of treatment

Case 1 - DKA

- Most protocols include a 10 – 20 cc/kg bolus of saline and then maintenance
- Fluids can include differing amounts of Na, K, Phosphorous
- Insulin usually given in bolus and drip depending on serum glucose level

Case 2

- 9 year old male now presents to the paramedics with with a history of severe leg pains.
- He has a history of flu-like symptoms for 3 days and has had dark brown colored urine and severe bilateral calf pain
- He is unable to ambulate and his calves are markedly tender
- Later, in the ED, his CK is 131,000;
  BUN 41 meq/L; Cr 1.1 meq/L;
  K 5.3 meq/L; Ca 9.0 meq/L; bicarb 18meq/L

Case 2 - Differential of Rhabdomyolysis

- Trauma
- Exercise
- Infection – bacterial or viral
- Medications
- Heat stroke
- Metabolic myopathies
- Severe electrolyte distrubances (chronic hypokalemia, hypophospatemia; hyponatremia)
- Alcohol abuse

Case 2 - Rhabdomyolysis

Increase renal excretion

- Volume expansion To point of good output (2mL/kg/hr)
  - NS 20mL/kg
  - Furosemide
- Alkalinize urine
  - Bicarbonate 1mEq/kg
- Dialysis if renal failure occurs
- Anticipate electrolyte disturbances
  - Hyperkalemia
  - Hypocalcemia
  - Acidosis
- Dialysis
  - may be required for correction of electrolyte abnormalities

Case 3

- 5 month old female with 6 day history of green watery stools
- Infant had her breast milk switched to formula 2 days ago. Then for the past 24 hr., the infant has has only gatoraide and Jello-water
- Lethargic for 1 day
- EMS toned out for: seizures

Case 3

- Upon arrival
  - Afebrile
  - Heart Rate = 135/min
  - Blood Pressure = 85/50
  - Accucheck in transit = 100 mg/dl
  - No Longer Seizing

Case 3

- Fontanelle and eyes are sunken
- Respirations: 64
- Dry mucous membranes; no tears
- Slight tenting of pinched skin fold
- Capillary refill : 4 sec
- Weak cry


"A sunken fontanelle — an important sign of dehydration."

Case 3 - Hyponatremic Dehydration

- Have ready diazepam 0.1 mg/kg IV while assessing for shock
- Rapidly restore intravascular volume
  - 10-20 cc/kg bolus of NS or LR for volume expansion acutely
- Estimate degree of dehydration
- Calculate fluid resuscitation rate and fluid content

Calculating Rehydration Fluid

A comprehensive calculation ***would*** include
- Deficits
- Maintenance, and
- Extra ongoing losses

An emergency clinician will rarely use a comprehensive calculation

Calculating Fluid Deficits

- Fluid loss
  - Can use actual weights to calculate or estimated percentage of dehydration based on clinical signs - most emergency clinicians don't have a baseline wt.
  - 1 cc of fluid for every 1 gram of weight lost
    (1 liter for every 1 kg of weight)
  - Can use a clinical judgment or estimate
- So far, so good

Calculating Maintenance

- Maintenance Fluid
  - 100 / 50 / 20 Rule for fluid for 24 hours
    100cc/kg for first 10kg of child's weight
    50cc/kg for next 10kg
    20cc/kg for any additional wt over 20 kg
  - This assumes normal kidney function
  - For abnormal renal function: replace insensible losses plus urine output

Calculating Rehydration Fluid

- In order to replace excessive ongoing losses
  - Replace lost volume : cc/cc
  - Replace lost electrolytes : use measured electrolytes (serum) to determine the exact type of replacement fluid

The Most Common Pediatric Fluid and Electrolyte Problems

- Most common problem:
  - Dehydration
- Most common cause of dehydration :
  - Diarrhea (Gastroenteritis)

Pediatric Gastroenteritis

- Definition: Acute inflammation of the lining of stomach and intestines
- Presentation:
  - Anorexia, nausea, diarrhea
  - Colicky abdominal pain
- The hallmark of gastroenteritis is
  - ***Not*** vomiting
  - Diarrhea
- Should only apply the Dx "gastroenteritis" to children with nausea or vomiting ***AND*** diarrhea

Epidemiology of Diarrheal Disease

In the US
- more than 1.5 million pediatric ED visits annually
- 200,000 hospitalizations and
- approximately 300 deaths

Worldwide
- one-third of all deaths of infants and children under 5 yrs
- mortality rate: 2-3 million deaths annually.
- Although these numbers remain high, they have been reduced almost by half over past 20 years largely due to
  - the widespread use of *oral rehydration* therapy

Epidemiology of Diarrheal Disease

The common gastroenteritis etiologic agents:
- Highly transmissible (via the fecal-oral route)
- Ease of transmission explains why cases sweep through groups
  - day cares
  - schools
  - families
  - co-workers

Etiology

- Viral (80%)
  - Rotavirus; adenovirus
- Bacterial and parasitic (20%)
  - Less ccommon
    - *Salmonella,*
    - *Shigella,*
    - *Escherichia coli*
    - *Staph*

Pathophysiology

Fluid loss
- significant shifts, with the potential for:
  - dehydration
  - hypovolemic shock, and even
  - death

Pathophysiology

In order to maintain adequate intravascular *volume*:
- Glucose and sodium have to be transported through intestinal villi membrane
- Inflammation results in damage to intestinal villi
  - Impaired absorption of glucose and sodium :
    - greater output of diarrheal fluid and
    - worsening dehydration

Pathophysiology

Continuing feedings
- Slows the progression of dehydration
- Promotes mucosal recovery and
- Improves fluid absorption

Oral rehydration
- Promotes improvement in bowel mucosa
  - By promoting transport of glucose and sodium

Clinical Features

Physical findings
- *Highest predictive* value for estimating dehydration

Historical findings
- Little or no value for estimating dehydration

But used to rule out:
- Bloody diarrhea (*Shigella* and *E. coli* 0157 : H7)
- Non-gastroenteritis causes (appendicitis, meningitis,…)
- Severe pain and altered LOC not seen in typical gastroenteritis

History

Gastroenteritis
- Clinical diagnosis
  - Nausea, vomiting, and diarrhea, with or without signs of dehydration
  - Fever may be present
  - Associated with an illness that sweeps through a community
- Alternative diagnoses :
  - just as we say "Not all that wheezes is asthma"
  - so too we say "Not all that vomits and has diarrhea is gastroenteritis"

Clinical Features of Gastroenteritis

Physical Examination
- First note any signs that are ***NOT*** typical of gastroenteritis:
  - Peritoneal signs
  - Abdominal distention
  - Altered mental status

Assessing Degree of Dehydration

Physical findings
- May signal potentially life threatening status
- Failure to recognize or adequately treat dehydration
  - may result in increased morbidity and mortality
- Highest predictive value for dehydration estimate
  - Selected findings:
    - general appearance
    - capillary refill, skin turgor / recoil
    - respiratory pattern

Physical Findings of Dehydration

Other Physical Findings
- VS: tachycardia
  - out of proportion to fever : dehydration
- HEENT:
  - anterior fontanel may be sunken
  - eyes may appear sunken
  - dry mucous membranes
  - lack of tears

Assessing Dehydration

- No one finding can accurately determine degree of dehydration
- Combination of signs is more helpful
- Most useful signs for predicting dehydration (highest confidence interval) (4):
  - Respiratory pattern (observed at least 1 full minute)
    - Kussmaul (acidemia ; inadequate tissue perfusion)
  - Skin turgor / recoil
    - normal [instant], delayed [1- 2 sec.], or prolonged [greater 2 sec.]
  - Capillary refill time
    - delayed: cold or dehydration or shock
  - Mental status

Estimating Dehydration Degree

Moderate dehydration
- 3 or more signs (sensitivity 87%)

Severe dehydration
- 6 or more signs

Clinical Criteria for Classifying Dehydration Severity

	Mild (3-5%)	Moderate (6-9%)	Severe (>10%)
Mental status	well	ill non-toxic	lethargic toxic
Capillary refill	< 2 sec	2-4 sec	very prolonged
Skin turgor (recoil)	instant	2 sec	very prolonged
Breathing	normal	increased	increased, deep

Point-of-care Lab Testing

- Not used to diagnose or confirm dehydration
- Used to R/O hypoglycemia, especially if:
  - Altered mental status;
  - Ill appearing;
  - Early infancy (diminished fat reserves)

Intravenous Rehydration

- Enteral (po) rehydration is safe and effective and the preferred treatment
- Not all patients are good candidates for oral rehydration; and they require IV fluids :
  - Shock
  - Severe dehydration
  - Failing oral rehydration attempts
    - repeatedly vomiting

Fluid for IV Replacement Therapy

More recent developments include a "rapid" rehydration approach
- rapidly over a matter of a few hours ;
- switching to oral fluids as soon as possible

An alternative, "very rapid" approach gaining favor,
in the absence of any other complicating factors : safe and effective:

20-60 ml/kg over 1-3 hours

Fluid for IV Replacement Therapy

- Initial fluid choice for rehydration should be isotonic and ***dextrose-free***
- Normal saline (or LR) at 40 mL/kg over 1-2 hrs
- Followed by ORS and realimentation as tolerated
- Avoid hypotonic IV fluids (eg, 0.45% saline or 0.2% saline)
  - have higher rates of adverse events,
  - including fatal outcomes

Oral Replacement Therapy

Realimentation:

- Early initiation of feeding
  - Hastens intestinal recovery
  - Associated with reduced duration of illness
- Breast-fed infants with diarrhea should continue nursing

Oral Rehydration

Unlike most innovations created in wealthy countries and then implemented in the third world

- ORT is example of *"reverse technology"* : an innovation first implemented in poor third world countries has been translated into use in more wealthy countries
- With the use of ORT, morbidity and mortality can be greatly reduced

Oral Replacement Therapy (ORT)

Oral Therapy

- At least as effective as IV rehydration.
- Associated with fewer major adverse events.
- Results in shorter hospital stays

Oral Replacement Therapy (ORT)

- Underutilized for the treatment of dehydration in both at home and in the ED
  - despite clinical trials verifying ORT efficacy and safety
- Underuse of ORT
  - associated with *unnecessary* ED visits and hospitalizations, resulting in direct medical costs of greater than **$1 billion per year**

(Santosham, et al *Pediatrics* 1997;100-5)

Underuse of ORT

- Formulations readily available in any grocery or convenience store
- Prepackaged bottles cost between $2 and $9 / L
  - Pedialyte [Abbott] : $0.005 / 1mL (5 cents / 10cc) [Food Lion, Jan.'05)]
  - Gatoraide : $0.001 / 1mL (1 cent / 10cc) [Food Lion]

Underuse of ORT

Commercial formulations:

- Significantly more costly than the WHO packets
- The relatively high cost may deter parents from obtaining appropriate ORS
  - At least 1 report, lack of access as specific cause for hypernatremia

Underuse of ORT

- UN WHO has formulated, endorsed, and perfected
  the exact composition for pre-made packets of ORS
  - Packets inexpensive
    - approx. $0.55 per packet [per liter]
    - instead of a cost of between $2 and $9 / L (Abbot)
  - Powdered packets safe and effective

Oral Rehydration Solutions

	Osmolality	Glucose	Na+	K+	Recommendation
WHO	245	75	75	20	for all ages
Pedialyte®	250	130 (25 g/L)	45	20	for all ages
Gatorade®	330	255 (49 g/L)	20	3	Not recommended for younger than 2
Cola	500	700	2	0.1	Not recommended

Medications

Antiemetics

- Phenergan
  - Unacceptably high rates of side-effects
    - sedation
    - extrapyramidal effects
    - seizures
- Newer agent: ondansetron [Zofran®]
  - highly safe and effective at decreasing vomiting (and therefore effective at decreasing need for admission)

Ondansetron

- Ped Emergency use of ondansetron is off-label
- Available as oral dissolving tablets in 4-mg and 8-mg
- Reasonable to dose as:
  - age 2 and under : 2 mg (1/2 of a 4-mg tab)
  - age 4 - 8 : 4 mg tablet
  - age over 8 : 8 mg tablet

Summary

- Gastroenteritis is a common pediatric complaint; dehydration does not always occur
- Dehydration, by itself, is not an indication for IV rehydration or hospitalization.
- IV therapy is best reserved for refractory moderate or severe dehydration
- Life threatening fluid and electrolyte disturbances are common in the pediatric emergency room setting
- Oral rehydration solutions (ORS) are underutilized for the treatment of dehydration in both at home and in the ED
- New antiemetic: ondansetron [Zofran®] may be used in the prehospital setting