Pediatric Potpourri

Jaundice
Meningitis
Basic Fluid Management
Objectives

- To be able to thoroughly evaluate and treat Hyperbilirubinemia
- To be able to recognize meningitis and treat
- Understand and calculate daily maintenance fluid volume needs for a well child.
- Understand and calculate daily maintenance sodium and potassium needs for a well child
- Estimate and replace fluid and electrolytes in the dehydrated child
What is there to Know About a Yellow Baby?
Hyperbilirubinemia was more of a problem prior to Rhogam approval in 1968. Since, the use of Rhogam Hemolytic Disease of the Newborn (HDN) has dramatically decreased. We no longer see the high bilirubin levels that necessitate double volume exchange transfusion.
Kernicterus

- Unconjugated bilirubin encephalopathy
- Three Clinical Phases
  - hypotonia, lethargy, poor suck in the first day or so
  - hypertonia +/- opisthotonus towards the end of the first week when there is often also a high-pitched cry, fever and seizures
  - then a third phase when the baby again becomes hypotonic
- Survivors tend to have choreoathetoid cerebral palsy and hearing impairment.
How do we Prevent It?

ASSESS An Infant’s Risk
It’s not just the Bhutani Nomogram and Bilitool
Risk Assessment

- Family History
- Pregnancy History
- Birth History
- Feeding History
- Stooling History
- Weight Loss
- Sepsis Risk
- Time of Onset of Jaundice
- Newborn Bilirubin Results
Family History

- Family History of Jaundice
- Cystic Fibrosis
- G6PD
- Other Blood Disorders or Hemolytic Processes
- Ethnicity
Pregnancy History

- Blood Type
- Rh
- Isoimmune Antibodies
- Maternal Diabetes
- Hepatitis
Birth Hx/Feeding/ Stooling /Weight

- Gestational Age
- Birth Trauma
- In’s and Out’s and Other Vitals
- Weight Loss—Calculated as % decreased from Birth Weight
- Feeding History—Latch,Frequency,Interest
- Stool color, frequency, and passage of meconium in the first 24 hours
Pearls of Jaundice

- REMEMBER JAUNDICE IN THE FIRST 24 HOURS IS NEVER NORMAL
- Direct Hyperbilirubinemia needs further investigation

Direct Hyperbilirubinemia >2mg/dl or >10% of the total serum bili
When using this nomogram, remember that "risk" refers to the risk of a subsequent bilirubin level in that infant >95%ile for age.
Hour-specific Nomogram for Risk Stratification

<table>
<thead>
<tr>
<th>Risk zone</th>
<th>Approximate threshold at 36 hours of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants age</td>
<td>36 hours</td>
</tr>
<tr>
<td>Total bilirubin</td>
<td>12.9 mg/dl</td>
</tr>
<tr>
<td>Risk zone</td>
<td>High Risk</td>
</tr>
</tbody>
</table>

Risk zone is one of several risk factors for developing severe hyperbilirubinemia. Please see AAP Phototherapy Guidelines below. If phototherapy threshold IS exceeded, please also review AAP Guidelines for Exchange Transfusion. If phototherapy threshold IS NOT exceeded, please see recommended follow-up in sidebar to the right.


<table>
<thead>
<tr>
<th>Neurotoxicity risk zone</th>
<th>Start phototherapy?</th>
<th>Approximate threshold at 36 hours of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Risk (&gt;= 38 weeks and well)</td>
<td>No</td>
<td>13.6 mg/dl</td>
</tr>
<tr>
<td>Medium Risk (&gt;=38 weeks + neurotoxicity risk factors OR 35 to 37 6/7 weeks and well)</td>
<td>Yes</td>
<td>11.7 mg/dl</td>
</tr>
<tr>
<td>Higher Risk (35 to 37 6/7 weeks and neurotoxicity risk factors)</td>
<td>Yes</td>
<td>9.6 mg/dl</td>
</tr>
</tbody>
</table>

A follow-up bilirubin is recommended in 6–12 hours if known hemolysis by direct Coomb's or ETCO (end-tidal carbon monoxide) and otherwise recommended within 24 hours (high risk).
Rate of Rise

- Maximum Rate of increase in bilirubin for an infant with a non-hemolytic process is 5mg/dl/24 hours or 0.2mg/dl/hr
- This is helpful to calculate because if you are fortunate to have a previous bili level then at a level greater than or close 0.2mg/dl/hr you will reach light level.
Additional Tests to Consider

- CBC with diff and peripheral smear
- Reticulocyte Count
- Coomb’s
- Electrolytes
- Albumin
- LFT’s
- If history warrants, sepsis work-up
So, Your Patient Needs Phototherapy

- Adequate Hydration
- Additional Labs
- Phototherapy
- Repeat Bilirubin
Signs and Symptoms

- Fever
- Irritability
- Nausea
- Vomiting
- Headache
- Myalgia
- Back Pain
- Photophobia
Differential Diagnosis
Physical Exam

- Bulging Fontanelle in Infants
- Irritable
- Stiff Neck
- Positive Kernig and Brudniski Sign
Kernig’s sign
## CSF Evaluation

<table>
<thead>
<tr>
<th>CSF finding</th>
<th>Viral</th>
<th>Bacterial</th>
<th>Partially Treated Bacterial</th>
<th>Lyme</th>
<th>Fungal</th>
<th>TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leukocytes/mm³</td>
<td>&lt; 1000</td>
<td>&gt; 1000</td>
<td>&gt; 1000</td>
<td>&lt; 500</td>
<td>&lt; 500</td>
<td>&lt; 300</td>
</tr>
<tr>
<td>Polymorphonuclear cells</td>
<td>20–40%</td>
<td>&gt; 85–90%</td>
<td>&gt; 80%</td>
<td>&lt; 10%</td>
<td>&lt; 10–20%</td>
<td>&lt; 10–20%</td>
</tr>
<tr>
<td>Protein (mg/dL)</td>
<td>N or &lt; 100</td>
<td>&gt; 100–150</td>
<td>60–&gt; 100</td>
<td>&lt; 100</td>
<td>&gt; 100–200</td>
<td>&gt; 200–300</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>N[c]</td>
<td>UD to &lt; 40</td>
<td>&lt; 40</td>
<td>N</td>
<td>&lt; 40</td>
<td>&lt; 40</td>
</tr>
<tr>
<td>Blood-to-glucose ratio</td>
<td>N</td>
<td>&lt; 0.4</td>
<td>&lt; 0.4</td>
<td>N</td>
<td>&lt; 0.4</td>
<td>&lt; 0.4</td>
</tr>
<tr>
<td>Positive smear[d]</td>
<td>–</td>
<td>&gt; 85%[e]</td>
<td>≥ 80%</td>
<td>–</td>
<td>&lt; 40%</td>
<td>&lt; 30%</td>
</tr>
<tr>
<td>Positive culture</td>
<td>Rare</td>
<td>&gt; 95%</td>
<td>&lt; 90%</td>
<td>–</td>
<td>&gt; 30%[f]</td>
<td>&lt; 30%</td>
</tr>
<tr>
<td>PCR or other methods</td>
<td>Enterovirus, herpesvirus</td>
<td>16S RNA, bacterial DNA</td>
<td>16S RNA, bacterial DNA</td>
<td>Borrelia burgdorferi antibodies</td>
<td>Histoplasma and Mycobacterium tuberculosis</td>
<td>Cryptococcus antigen, India ink for Cryptococcus</td>
</tr>
<tr>
<td>Bacteria</td>
<td>Antibiotic of Choice</td>
<td>Other Useful Antibiotics</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>--------------------------------</td>
<td>---------------------------------------------</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><em>Neisseria meningitidis</em></td>
<td>Penicillin G or ampicillin</td>
<td>Cefotaxime or ceftriaxone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Haemophilus influenzae</em></td>
<td>Cefotaxime or ceftriaxone</td>
<td>Ampicillin or ceftriaxone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Streptococcus pneumoniae</em></td>
<td>1. Penicillin–susceptible (MIC &lt; 0.1 μg/mL)</td>
<td>Cefotaxime or ceftriaxone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Penicillin–intermediate (MIC = 0.1–1.0 μg/mL)</td>
<td>Cefepime or meropenem</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Penicillin–resistant (MIC = 1.0 μg/mL)</td>
<td>Cefepime or meropenem</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Cephalosporin-nonsusceptible (MIC &gt; 0.5 μg/mL)</td>
<td>Add rifampin to antibiotics of choice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Listeria monocytogenes*          | Ampicillin ? gentamicin                     | Trimethoprim–sulfamethoxazole |

*Streptococcus agalactiae*        | Penicillin G ? gentamicin                   | Ampicillin ? gentamicin      |

*Enterobacteriaceae*              | Cefotaxime or ceftriaxone with/without aminoglycoside | Cefepime or meropenem       |

*Pseudomonas aeruginosa*          | Ceftazidime + amikacin                      | Cefepime or meropenem       |
Treatment for Presumed Bacterial Infection

- Supportive Care with fluids (TREAT Shock!), antiemetic (Zofran)
- Cefotaxime/Ceftriaxone
- Vancomycin dosed at 60mg/kg/day/q6
- Adjunct therapy with dexamethasone at 0.6–0.8mg/kg/day/BID–TID. Needs to be administered before or during first dose of antibiotics
Duration

- *Streptococcus pneumoniae* 10–14 days
- *Neisseria meningitidis* 4–7 days
- *Haemophilus influenzae* 7–10 days
Complications

- Seizures
- Infarctions
- Septic Shock
- Subdural Effusions
- Prolonged Fevers
- Hearing Loss
Every Child Needs a Hearing Screen after Meningitis!
General Fluid Management

Water
Sugar
Salt
S.M.A.R.T. Fluid management

- **Shock or acute deficits**
  - Treat shock or dehydration first

- **Maintenance**
  - Calculate fluid and electrolytes for **normal** situations.

- **Adjustments**
  - Adjust for ↑ or ↓ fluid or electrolyte needs.

- **Reassess therapy** regularly
Shock and Acute Fluid Needs

- Isotonic Solution—Normal Saline/Lactated Ringers
- Bolus 20cc/kg
- Bolus to perfusion and clinical improvement
- If no improvement after the third bolus reassess and other fluids or pressors
Holliday–Segar Method
This method is based on the assumption that for every 100 calories metabolized 100ml of water is required. This method is based on metabolic rate.

THIS METHOD DOES NOT WORK FOR INFANTS LESS THAN 14 DAYS OLD
## Holliday–Segar

Weight = Kilocalories expended = Volume (ml) of H₂O needed

<table>
<thead>
<tr>
<th>Weight</th>
<th>kcal / 24hr</th>
<th>cc / 24 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant ≤ 10 kg (4)</td>
<td>100 kcal / kg</td>
<td>100 cc/kg</td>
</tr>
<tr>
<td>Child 10–20 kg (2)</td>
<td>1000 kcal + 50 kcal per kg over 10</td>
<td>1000cc+ 50cc/kg</td>
</tr>
<tr>
<td>For each kg 20–80 (1)</td>
<td>1500 kcal + 20 kcal per kg over 20</td>
<td>1500cc+20cc/kg</td>
</tr>
</tbody>
</table>

Max ~2400 cc/day (~100 cc/hr)***
What About Na and K?

- Sodium 3 mEq / 100 kcal (100 ml fluid) = 30 mEq NaCl / L

- Potassium 2 mEq/100 kcal (100 ml fluid) = 20 mEq KCl / L
Glucose—Why D5?

- 50 grams dextrose per 1000 ml water
- Glucose is the principle nutrition for the brain, heart and red blood cells.
- 5% Dextrose (metabolizes to glucose) provides adequate short term nutrition in the resting state (20% of caloric RDA).
We have Water (fluid rate), Electrolytes and Glucose.

So what fluid do we order?
We need Sodium 3 mEq per 100 ml = 30 mEq NaCl / L

We have:

- Normal Saline (0.9% NaCl) = 154 mEq/L
- ½ NS (0.45% NaCl) = 72 mEq/L
- ¼ NS (0.2% NaCl) = 34 mEq/L

Potassium 2 mEq/L per 100 ml = 20 mEq/L

Order: D5 ¼ NS with 20 meq KCl/L for maintenance fluid

Why then is Everyone writing for 1/2NS or NS on the Pediatric Wards?
Many sick patients need more than \( \frac{1}{4} \) NS (0.2\% NaCl).

They are at risk for hyponatremia with hypotonic fluid.

Due to Elevated Anti-Diuretic Hormone (ADH).
- Infection
- Drugs
- Hypovolemia
- Neurologic disease
- Pain / anxiety
- Surgery / anesthesia
Assessing Dehydration

<table>
<thead>
<tr>
<th></th>
<th>Older Child</th>
<th>Infant</th>
</tr>
</thead>
<tbody>
<tr>
<td>3% (30 mL/kg)</td>
<td>6% (60 mL/kg)</td>
<td>9% (90 mL/kg)</td>
</tr>
<tr>
<td>5% (50 mL/kg)</td>
<td>10% (100 mL/kg)</td>
<td>5% (150 mL/kg)</td>
</tr>
</tbody>
</table>

EXAMINATION

Dehydration
- Mild
- Moderate
- Severe

Skin turgor
- Normal
- Tenting
- None

Skin (touch)
- Normal
- Dry
- Clammy

Buccal mucosa/lips
- Normal
- Dry
- Parched/cracked

Eyes
- Normal
- Deep set
- Sunken

Tears
- Present
- Reduced
- None

Fontanelle
- Flat
- Soft
- Sunken

CNS
- Consolable
- Irritable
- Lethargic/obtunded

Pulse rate
- Normal
- Slightly increased
- Increased

Pulse quality
- Normal
- Weak
- Feeble/impalpable

Capillary refill
- Normal
- ~2 sec
- >3 sec

Urine output
- Normal to Decreased
- Decreased
- Anuric

Preillness weight – illness weight/preillness weight x100% = %

Dehydrated = Necessary Fluid Replacement

### Isonatremic Dehydration

<table>
<thead>
<tr>
<th>F.#</th>
<th>First 8 hours</th>
<th>Next 16 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1</td>
<td>Replace ½ of calculated deficits divided evenly over 8 hours.</td>
<td>Replace remaining ½ of calculated deficits divided evenly over 16 hours.</td>
</tr>
<tr>
<td>F.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance To be given in addition to above calculated deficits at hourly rate.</td>
<td></td>
</tr>
</tbody>
</table>

### Hyponatremic Dehydration

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</tr>
<tr>
<td>F.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F.2</td>
<td></td>
<td></td>
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<td></td>
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### Hyponatremic Dehydration

<table>
<thead>
<tr>
<th>F.#</th>
<th>First 8 hours</th>
<th>Next 16 hours</th>
<th>Next 24 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.4</td>
<td>Replace ½ of deficit over first 24 hours.</td>
<td></td>
<td>Replace remaining ½ of calculated deficit over next 24 hours.</td>
</tr>
<tr>
<td>F.5</td>
<td>Replace ½ of calculated deficits divided evenly over 8 hours.</td>
<td>Replace remaining ½ of calculated deficits divided evenly over 16 hours.</td>
<td></td>
</tr>
<tr>
<td>F.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance To be given in addition to above calculated deficits at hourly rate.</td>
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</tbody>
</table>
Replace Ongoing Stool Loss

- Anything over 40cc/kg/day or 20cc/kg/shift needs to be replaced.
- Replacement fluid is either ½ NS or NS
- Remember to Reassess your Patient!
Method: Give 5–10 mL of oral rehydration solution (ORS) every 5–10 minutes, gradually increasing volume

Deficit replacement:
- Mild dehydration = 50 mL/kg over 4 hours
- Moderate dehydration = 100 mL/kg over 4 hours

Maintenance: Infants should resume formula/breastmilk by mouth (PO) ad lib. Children should continue with regular diet

Ongoing losses: Regardless of the degree of dehydration, give additional 10 mL/kg of ORS for each additional diarrheal stool
**Individualize Electrolyte Therapy**

**Hypotonic Saline** (0.2% NaCl)
- Hypervolemic states
  - Congestive heart failure, liver failure, nephrotic syndrome

**1/2 Normal to Isotonic Saline** (0.45–0.9% NaCl)
- Critically ill children
  - Sepsis, pneumonia, dehydration
- Children who need to maintain higher effective serum osmolality
  - Mild CNS injury, DKA, post-operative, gastroenteritis

**Hypertonic Saline** (3% NaCl)
- Significant CNS injury (ICP), CSW
- Severe, symptomatic, Hyponatremia
References

- AAP Guidelines on Hyperbilirubinemia
References

- A special thanks to Dr. John Brandt, pediatric nephrologists, for contributing to the fluids lecture.