Pediatric Emergencies: Part I
An Evidence-based Update
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November 9, 2006
Part I: Recent Literature Updates

- Asthma
  - MDI vs Nebulizer
  - Systemic Steroids
  - Status Asthmaticus
  - Discharge Planning From the ED
- Fever Without a Source
  - Post-Prevnar Updates
  - Viral Testing
- Corticosteroids for Meningitis
- The Dehydrated Child
  - IV vs PO hydration
  - Medications and Supplement
Case Presentation #1

- Lamotrigine, a 6 yo girl, developed a URI a few days ago, and has been coughing and having trouble breathing since last night, despite using her albuterol every 4 hours.
- PMH: Asthma since age 3, no hospitalizations, but two ER visits in the past year. She has been prescribed prednisone but always throws it up.
- VS: Afebrile, HR 120, R 45, O2 sat 97%.
- Exam: Alert and awake, tachypneic, with increased work of breathing, very little air movement bilaterally, occasional wheeze
Multiple Choice Question

You begin Lamotrigine on 3 back-to-back doses of albuterol/atrovent. Meanwhile, you decide to give an anti-inflammatory agent, but wish to avoid oral prednisone. Which of the following is the BEST option at this point?

A. Give a dose of inhaled budesonide (Pulmicort)
B. Give solumedrol IM
C. Place an IV and give solumedrol
D. Give the IV form of decadron orally
E. Give oral montelukast (singulair)
Questions

- What are the options for delivery of bronchodilators and systemic steroids?
- If initial management fails, what is the next step?
- Should she be started on a controller medicine in the ED?
Evidence: Bronchodilator Delivery by MDI/Spacer

- Bottom line: Equivalent doses of albuterol by MDI/spacer, when used correctly, are just as effective (or more effective) than nebulizer, even in the acute setting
  - Young infants and children
  - Moderate severity
- Cost-effectiveness in ED
  - Depends on availability of meds, equipment
- MDI preferred by parents
Recommendations: MDI/Spacer

- Use MDI/Spacer in ED whenever possible
  - Reinforces use for the parent
  - May be cost-effective
  - 8 puffs from MDI = 2.5mg unit neb dose

- ALL patients should learn MDI/spacer technique!!!
Infant Spacer Technique

- Good seal over nose AND mouth
- One puff at a time
- Count five breaths
Background: Systemic Steroids

- Effective and safe in children
  - Prevent hospitalization
  - Reduce duration of symptoms
  - Most effective when given early

- Oral and IV/IM routes equivalent efficacy
  - Evidence from asthma, croup

- Problem: Oral prednisone poorly tolerated, compliance variable
Evidence: Dexamethasone

- Longer half-life than prednisone (36-72 hours)
- Safety well-established
- The IV form (4mg/ml) can be given PO, very well-tolerated
- Efficacy in asthma?
  - Two doses 24 hours apart shown better tolerated and equally effective as 5 days of prednisone in one RCT
Despite your initial management, including oral dexamethasone and the initiation of continuous inhaled bronchodilators, Lamotrigine’s condition worsens.

Her O2 sat is now 88% on RA, she is breathing at 54 and starting to look tired.

What medications would be helpful at this point?
Evidence: Magnesium

- Mechanism: SM relaxation due to decreased calcium uptake
- RCT data in children has established safety and efficacy
- Most beneficial in severe asthmatics
- Single dose recommended
  - Utility of repeated doses unclear
Evidence: Theophylline

- Fallen out of favor compared to terbutaline
  - Fear of toxicity, need for monitoring
  - Initial studies failed to show improvement, but did not include severe asthmatics

- Efficacy in status asthmaticus:
  - RCT’s in children shown superior to placebo
  - Compared to terbutaline in a recent RCT
    - Equally safe and effective
    - More cost-effective
Recommendations: Status Asthmaticus

- **Magnesium**
  - A single dose is safe and effective for use in pediatric status asthmaticus
  - **Dose:**
    - 25-75mg/kg (max 2.5g) IV over 20 minutes
    - Adverse effects: flushing, nausea

- **Consider Theophylline, when available**
  - A safe and effective as terbutaline, and more cost-effective
  - See handout for dosing and monitoring guidelines
Case Continued

- Lamotrigine responds to theophylline and magnesium, is admitted to the PICU and discharged after 3 days.
- 2 wks later, she returns to your ED with a much milder exacerbation, brought on by a rabbit at school, which responds well to initial management
- What can be done in the ED to improve her asthma control?
Background: Traditional Model of Asthma Care

- Stabilization in ED, referral to PCP for long-term plan and education

- **The current model is failing**
  - High risk children are also *most likely to use the ED for episodic care*
  - Many providers not aware of guidelines, history

- Potential role of ED:
  - Initiation of Long-Term Treatment
  - Education
Evidence: Chronic Asthma Management from the ED

- Current NHLBI guidelines:
  - Inhaled corticosteroids (ICS) are 1st-line medication for persistent asthma in children

- Cochrane review of RCT’s with adults and children:
  - Initiating ICS at discharge reduces relapses and hospitalizations
  - Benefit less significant when receiving systemic steroids

- Expert consensus:
  - Supports initiation of ICS for children in the ED
Evidence: Effective ED-based Education

- Action plan
- Education which is simple, visual and culturally appropriate
  - Chronic
  - Anti-inflammatory
  - Rescue
  - Techniques
- Follow up educational intervention to high risk patients
- Referrals to PCP or specialty clinic
Recommendations: Chronic Asthma Management from the ED

- Classify asthma severity in all patients
  - If persistent asthma, begin ICS
- Give all patients an Action Plan
- Provide appropriate asthma education
- Arrange follow-up, and perform visit/call if possible
Quick and Dirty Asthma Classification

RULE OF TWO’S:

More than 2 daytime symptoms/week or
More than 2 night symptoms /month or
More than 2 ER visits/ hospitalizations/yr
= PERSISTENT ASTHMA
Case Presentation #2

- Cherimoya, a 5 mo boy, is brought in to the ED with 2 days of fever
- Exam:
  - Well appearing, well-hydrated, febrile to 39.2
- No source can be found on exam or history
- He is fully immunized for age, including his 2nd dose of PCV-7 3 weeks ago
Multiple Choice Question

What is the best strategy regarding blood tests in this infant?

Answers
A. Obtain a CBC/blood cx and LP; treat with ceftriaxone
B. Obtain a CBC/blood cx; treat with ceftriaxone if WBC >15
C. Obtain a CBC/blood cx; treat with ceftriaxone if WBC >15 or <5
D. Obtain a nasal RSV and flu test; obtain a CBC only if this is negative
E. Do not obtain any blood tests, as risk for SBI is very low
FWS: What’s the Deal?

- Nearly 20% of febrile children have FWS.
- A small proportion, although well-appearing, will have an occult serious bacterial infection (SBI) or urinary tract infection (UTI).
- Guidelines help physicians identify and treat those children at highest risk.
Before the Pneumococcal Vaccine...

- Infants 3-24 mo with FWS are known to have a small but significant risk (2-6%) of SBI, even when well-appearing.
- Guidelines developed before PCV-7 recommended use of WBC in this age group to stratify risk:
  - WBC>15 = high (6-10%)
  - WBC<15 = low (1%)
Background: The Pneumococcal Vaccine

- **S. Pneumoniae**
  - Most common cause of occult SBI in infants >3 mo

- **Prevnar: 7-valent pneumococcal conjugate vaccine**
  - 2, 4, and 6 mo + 12-15 mo
  - Contains isolates that cause 85-97% of invasive pneumococcal disease (IPD)
Evidence: Vaccine Efficacy

- Tested in pre-licensure NC Kaiser-based RCT of 37,868 children
- Efficacy for IPD from vaccine serotypes
  - Fully vaccinated children (4 doses): 97.4%
  - In children receiving one or more doses of vaccine: 94%
- Efficacy for IPD from any pneumococcal serotype, in children receiving one or more doses: 89.1%
Multiple post-licensure studies have supported the expected reduction in IPD, in both vaccinated and unvaccinated populations.

- ~78-85% drop in rates of IPD in children <2 years of age.
FIGURE 1. Rate* of vaccine-type (VT) invasive pneumococcal disease (IPD) before and after introduction of pneumococcal conjugate vaccine (PCV7), by age group and year — Active Bacterial Core surveillance, United States, 1998–2003

* Per 100,000 population.
† For each age group, the decrease in VT IPD rate for 2003 compared with the 1998–1999 baseline is statistically significant (p<0.05).
Evidence: Post-Licensure Efficacy

- Rates of invasive disease from non-vaccine serotypes has not increased since the vaccine was introduced.
  - However, the percentage of IPD due to non-vaccine serotypes increased slightly.
- **SBI from IPD and other causes are still possible, even in vaccinated children.**
Evidence: Partial Vaccination

- Precise efficacy of 1,2,3 doses still unclear
- Studies suggest that protection against IPD good after 2 doses
  - Kaiser study: high efficacy in partially vaccinated children
  - Goldblatt, 2006: Similar immune response in infants after receiving 2 vs 3 doses of vaccine
  - Huebner, 2002: In a study of a different conjugate vaccine, 95% of infants had serotype-specific antibody after 2 doses
Should PCV-7 Change Management of FWS?

- Since IPD is responsible for the majority of SBI in infants >3 months of age, and the vaccine is at least 90% effective against IPD...
- The risk of SBI in vaccinated children >3 mo of age is <0.5% regardless of WBC count.
  - *CBC is unlikely to significantly impact assessment or management*
  - Empiric CBC/blood cx NOT cost effective if rates of SBI <0.5% (Lee, 2001)
Recommendations: Fever without a Source

- Immediately stabilize any ill- or toxic-appearing febrile child, *of any age*

- Unvaccinated children: Infant <4 mo OR < 2 doses of Prevnar
  - WBC count may help identify those at higher risk for SBI
  - Screen for UTI in those at risk, based on age and circumcision status
  - Consider age, other historical factors (length/height of fever, presence of likely source, quality of follow up) in decision for additional workup
Recommendations: Vaccinated Children with FWS

- Well-appearing, vaccinated children >4 mo of age are at low risk for IPD
  - Effectively vaccinated =
    - At least two doses
    - At least 2 weeks from 2nd dose
- Screening blood tests unlikely to change management
- Screen for UTI as for the unvaccinated child
- Good follow up is essential!
My Silly Mnemonic…

- If the baby’s smiling at me
- Has had 2 doses of PCV
- And the parents can contact me
- Skip the CBC
- But don’t forget to collect the pee!
Additional Question:

Would viral testing change your management of Cherimoya?
A named viral diagnosis makes SBI/UTI less likely in a febrile infant.
- However, in young infants symptoms of viral infection may be subtle or absent.

Rapid viral testing (RVT) has added a new option for identifying infants at low risk for SBI.
- RSV, adeno, paraflu, influenza, entero and rotaviruses.

These tests are more specific than they are sensitive: false positives are extremely rare.
Evidence: Viral Testing

1. Infants with FWS with a positive viral test are much less likely to have a concurrent SBI or UTI than those without a viral dx.
   - Exact risk of SBI/UTI in infants with + viral test unknown

2. Viral testing impacts ED management
   - Reduced testing, hospitalization and antibiotics
   - Have not resulted in missed SBI.
Prospective trial (Byington, et al) of 1385 febrile infants <90 days, all underwent RVT

Results:
- LR infants:
  - Risk of SBI low (1-3%) with +/- RVT
- HR infants:
  - Risk of SBI significantly reduced with + RVT (16.7% -> 5.5)
  - *UTI accounted for majority of SBI in these infants, 4% of total*
Recommendations: Viral Testing

- A positive RVT significantly reduces probability of SBI/UTI
  - Negative predictive value for ruling out SBI best in infants with a low/mod probability of SBI
- RVT is recommended when the results will change management
- Infants at high risk for UTI should be tested for UTI regardless of viral diagnosis
Borborygmi is a 4 mo old boy whose parents do not believe in immunizations.

He comes in with a fever of 40.1, irritability, vomiting and poor feeding.

You note a full fontanelle on exam, and an inconsolable infant with nuchal rigidity.

You suspect meningitis.
After assessing and stabilizing ABC’s, and drawing blood cultures, the most appropriate NEXT step is:

- A. Obtain a lumbar puncture
- B. Administer ampicillin, gentamicin and acyclovir IV
- C. Administer dexamethasone 0.15mg/kg IV
- D. Administer ceftriaxone IV
- E. Administer ceftriaxone and vancomycin IV
Severity of inflammation is the principal predictor of outcome in experimental models of meningitis

- Neuronal injury caused by inflammation rather than bacterial invasion

Adjunctive anti-inflammatory agents could improve outcomes

- Corticosteroids in use since the 1960’s
- The only adjunctive treatment adequately assessed in clinical trials.
Evidence: Steroids for Meningitis

- Meta-analysis of trials since 1988 (post-Hib)
  - Reduction in long-term sequelae in children with H. influenza or S. pneumo when given *before or with* antibiotics (McIntyre, 1997)

- Recent trials: Benefit greatest when
  - H influenza or S. pneumo
  - Prompt diagnosis and treatment
  - Steroids are given before first dose of antibiotics
Evidence: Steroids for Meningitis

- No studies have shown worse outcomes or serious adverse events in patients receiving dexamethasone.
- There is no data to support the safety or efficacy of corticosteroids in neonates or for use in other types of meningitis.
Recommendations: Steroids for Meningitis

- Neonates (<6 weeks of age):
  - Insufficient evidence to recommend steroids in presumed or proven bacterial meningitis

- Infants/children >6 weeks of age:
  - Steroids recommended as adjunct to antibiotic therapy in suspected or proven meningitis due to S. pneumo or H. influenza
  - Initiate steroid therapy as soon as possible – preferable prior to antibiotics
Recommendations: Steroids for Meningitis

- **Recommended dose**
  - Dexamethasone: 0.15mg/kg every 6 hours
- **Continue steroid therapy for 4 days**
- **Discontinue prior to 4 days for patients with**
  - Significant steroid-induced side-effects
  - Culture-proven bacteriologic diagnosis other than S. pneumo or H. influenza
Pneumococcus still the major cause of meningitis in children in U.S.
- Recommended regimen: 3° cephalosporin and vancomycin

Optimal therapy of meningitis must balance the need for adequate sterilization of the CSF with the need to minimize inflammatory damage in the host
- Combination of vanco and ceftriaxone induces more rapid bacteriolysis than with either agent alone
Evidence: Antibiotics for Pediatric Meningitis

- **Non-bacteriolytic antibiotics**
  - Associated with decreased inflammation and mortality in animal studies

- **Delayed administration of vancomycin**
  - One RCT showed decreased risk of hearing loss in patients receiving vancomycin >2 hours after administration of a cephalosporin,
    - No additional adverse outcomes due to delay
    - NOT controlled for administration of steroids
Recommendations: Antibiotics for Meningitis

- Combined treatment with a 3° cephalosporin and vancomycin still recommended
- Delay in administration of vancomycin for 2 hours may reduce risk of hearing loss without adverse effects.
  - Additional data is needed for a strong recommendation
Case Presentation #4

- Kohlrabi, a 3 yo boy, presents to the ED with vomiting and diarrhea for 24 hours.
- Parents report he is vomiting “everything he eats”. He had 3 loose stools yesterday, and 3 today. He has had slightly decreased urine output, but had a wet diaper that morning.
- On exam, HR is 120, skin cool but well-perfused, CR of 3 sec, mouth slightly tacky, pt appears tired but is alert and responsive. Belly is soft and non-distended, with diffuse mild discomfort to palpation, good bowel sounds.
- 7 yo sister was sick last week with “stomach flu”
The most appropriate next step in assessment and management of this moderately dehydrated child is:

A. Obtain electrolytes to assess level of dehydration
B. Start an IV and give a bolus of NS
C. Start an IV and start D5 ½ NS at maintenance
D. Give a dose of oral ondansetron, then start oral hydration
E. Start oral hydration in small quantities
Background: Oral Hydration

- AAP and CDC recommend oral hydration first line for children with mild to moderate dehydration due to acute gastroenteritis.
- ER physicians and pediatricians reluctant to use oral rehydration. 
  - Ineffective?
  - Time-consuming?
  - IV therapy is preferred by parents?
Evidence: Oral vs IV Hydration

- IV vs Oral rehydration in moderately dehydrated kids evaluated in several RCT’s

- Infants 3-36 months (Nager et al):
  - IV vs NG/po hydration: equivalent in all clinical outcomes
  - PO/NG superior in cost-effectiveness, complications
  - Labs: did not alter treatment, or help with dx

- Older kids: (Atherly-John, et al):
  - IV vs oral hydration equivalent success rate
  - Decreased time in ED with oral hydration
Recommendations: Assessment and Management of Dehydration

- Minimize blood draws/IV’s in the mild/ mod dehydrated child
  - Routine labs unlikely to help with diagnosis or management

- Consider PO or NG hydration
  - Cost- and time-effective, fewer complications
  - NG better tolerated in young infants
  - Also depends on personnel, equipment and experience
Anti-emetics and antimotility agents are commonly used for adults with gastroenteritis.

Side effects well-known:
- Include drowsiness, dystonia and ileus

Nutritional supplements, including zinc and probiotics, have also received recent attention.
Evidence: Pharmacologic Therapy

- Overall, data is limited regarding safety and efficacy of anti-motility and anti-emetic agents in children
- Ondansetron
  - RCT’s have varying results
  - In general, reduces vomiting in the ED, may facilitate oral hydration, but *does not* reduce hospitalizations or prevent relapse
- Loperamide:
  - Associated with increased morbidity and mortality
- Newer drugs:
  - Racecadotril (an enkephalinase inhibitor) shown effective and safe in initial studies
**Evidence: Nutritional Supplements**

- **Zinc supplementation (15-30mg/day)**
  - Trials in developing countries suggest improved intestinal permeability and decreased severity of diarrhea.
  - Role in developed countries, and optimal mode of delivery remains unknown.

- **Probiotics (live microorganisms)**
  - Reduction in severity or duration of infectious and antibiotic-associated diarrhea.
  - However, studies vary in sample size, type and dose of supplementation, and population studied.
Recommendations: Meds and Supplements

- Mainstays of therapy: oral rehydration and restoration of proper nutrition.
- Drugs:
  - Some may be safe
  - May add to cost and risk
- Nutritional supplementation:
  - Parents may be educated on safe use of zinc and probiotics (ie: yogurt) if desired
Recommendations: Diet

- Restore age-appropriate diet as soon as possible
  - Nutrition, gut motility and healing
- Breast milk ALWAYS acceptable
- Formula does not need to be diluted
- Foods to avoid
  - Full strength juices
  - Milk in some patients
Key Points: Asthma

- Teach MDI/spacer use for all children
- Consider oral dexamethasone as an alternative to prednisone
- Use magnesium and consider theophylline for status asthmaticus
- Initiate inhaled corticosteroids in the ED for patients with persistent asthma
Well-appearing, vaccinated children (≥2 doses) are at low risk of invasive pneumococcal disease
- Routine CBC not recommended
- Vaccinated children still at risk for UTI

A positive viral test reduces chance of SBI and UTI
- Most useful in low/mod risk group
Key Points: Meningitis

- Steroids should be given as early as possible before antibiotics for suspected meningitis in infant >6 weeks
- Ceftriaxone/cefotaxime and vancomycin recommended
  - Consider delay in vancomycin for 2 hours
Key Points: Hydration for AGE

- Minimize labs and IV’s
- Oral rehydration appropriate for most children
  - Consider NG in young infants
- Routine use of medication and supplements not recommended
  - May be safe and effective for some children