**GASTROENTERITIS**

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**Introduction**

For most children with gastroenteritis, there are three basic principles:

1. **Manage the child in shock aggressively**
   - Isotonic fluids (normal saline or albumin)
   - Intravenous or intra-osseous
   - Boluses of multiples of 20 ml / kg

2. **Re-hydrate orally or nasogastrically the child not in shock**
   - Re-hydration (2-4 hrs): Pedialyte 5 ml/min (25ml/5 min)
   - Maintenance phase: 10 ml / kg per diarrhoeal stool
   - Review the child frequently, support and educate the family

3. **Begin feeding early**
   This management plan is outlined in the flow chart with further details and explanatory comments below.
Flow Chart for the Management of Suspected Gastroenteritis

Is the child shocked?
- Yes: Reassessate with bolus saline or colloid
- No: Is this gastroenteritis?
  - Yes: Treat primary diagnosis
  - No: Is the child dehydrated?
    - Yes: Check serum electrolytes. Is there hypokapnia ([Na+] < 130) or hyperosmolality (OsmO > 320)?
      - Yes: Admit to ward
      - No: Oral Rehydration Therapy*
        Pedialyte 50 ml per minute or 25 ml every 5 minutes. If child will not drink proceed to NG. Aim to rehydrate over 2-4 hours.
        - Review in one hour. Is child taking pedialyte?
          - Yes: Consider admission to ward
          - No: NG tube or IV fluids
            - Review in one hour. Is child taking pedialyte?
              - No: Check U&E 4-hourly to ensure [Na+] falling slowly. Liberalise fluid therapy when [Na+] < 130.
              - Yes: Oral Maintenance Therapy. Continue child’s regular diet and usual milk. Give pedialyte to replace ongoing stool losses (10 ml/kg loose stool).
        - Slow oral rehydration with pedialyte. Maximum rate = 15 ml/hr. Aim to rehydrate over 12-24 hours. Weigh all napkins and calculate fluid balance hourly.
    - No: Do you suspect hypokapnia or hyperosmolality?
      - Yes: Oral Rehydration Therapy*
      - No: Observe in Short Stay Unit

* Details about IV rehydration and oral rehydration therapy below.
Notes

1. Is the Child Shocked?

See the Guideline on Shock.
The child who is shocked may be limp, drowsy or comatose, with a rapid thready pulse, cold blue peripheries, hypotension and anuria. Less reliable signs include skin retraction and capillary refill.

Shock is an emergency. Establish IV or intra-osseous access. Take bloods (FBC, U&E, creatinine, calcium, glucose, blood cultures, arterial gas). Give a bolus of 20 ml per kg of 0.9% NaCl or 5% Albumin, and repeat as needed.

If the child does not respond well, treat as septicaemia, insert a urinary catheter and contact PICU. Notify your consultant. Lumbar puncture may be dangerous and should be deferred.

If there is a good response to bolus therapy, change to 0.45% NaCl and 2.5% Dextrose at maintenance rates while awaiting blood results.

2. Is This Gastroenteritis?

Acute gastroenteritis may be defined as diarrhoea of rapid onset, with or without vomiting, fever or abdominal pain. There is often a history of contact with another person with the same symptoms. Rotavirus is the most common infectious agent, and may also cause low grade fever, cough, coryza and neurologic symptoms.

In a child with a diagnosis of gastroenteritis who has abdominal pain that continues for more than 24 hours, alternative diagnosis need to be considered and investigated for, consultant review needs to occur, and further surgical intervention may be required.

Not all vomiting is gastroenteritis. Bile stained vomiting means bowel obstruction until proven otherwise. Surgical conditions that may present with vomiting include pyloric stenosis (typical age about 6 weeks), intussusception (typical age about 6 - 10 months), appendicitis or intestinal malrotation.

Vomiting may precede diarrhoea in Rotavirus, but you should suspect that isolated vomiting may be due to another cause. In every child with bile-stained vomiting, obtain a plain (erect/supine) abdominal x-ray and a surgical opinion.

Other possible causes include:
- appendicitis, pelvic abscess and other surgical abdominal conditions
- acute metabolic / endocrine disease
- bacterial gastroenteritis
- diabetes
- food poisoning (e.g. a Salmonella endotoxin or Staphylococcal exotoxin)
- head injury or other trauma
- other intracranial causes
- poisoning
- sepsis (especially urinary tract infection)
3. Is the Child Dry?

The best way to find out is to measure weight loss, but a recent weight is seldom available. Clinical estimate of the degree of dehydration is unreliable. Doctors usually overestimate the deficit, and may underestimate it if there is hypernatraemia.

In the management of dehydration, it is much more important to follow a child closely over time, than it is to calculate and replace a hypothetical figure for % dehydration.

<table>
<thead>
<tr>
<th>Severity</th>
<th>Symptoms</th>
<th>Physical signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>thirsty, restless</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slightly dry buccal mucosa</td>
</tr>
<tr>
<td>Moderate</td>
<td>lethargic, irritable</td>
<td>Dry buccal mucosa, absent tears</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sunken eyes &amp; fontanelle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreased urine output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Altered skin elasticity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Signs of ketosis (rapid shallow breathing, smell of ketones)</td>
</tr>
<tr>
<td>Severe</td>
<td>limp, drowsy</td>
<td>Drowsiness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shock (tachycardia, poor volume peripheral pulses, cool peripheries)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hypotension is late/ominous sign</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skin retraction time &gt; 2 seconds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capillary refill time &gt; 3 seconds</td>
</tr>
</tbody>
</table>

As a rough guide, the child who is mildly dehydrated (“5%”) may be considered to have a 50 ml / kg deficit, and the child who is shocked (“10 - 15%”) may be considered to have at least a 100 ml / kg deficit.

4. Do You Suspect Hypernatraemia or Hyperosmolality?

Hypernatraemia is almost entirely a complication of gastroenteritis in infants under the age of 12 months, particularly in those who have been given inappropriately concentrated formula or home-made rehydration solutions.

Hypernatraemia is uncommon in the population who present to Starship CED. Suspect and check for hypernatraemia in a moderately dehydrated infant whose history or physical findings (irritability and lethargy, fever, doughy feel to the skin) seem unusual for straightforward gastroenteritis.

See below for the management of hypernatraemia or hyperosmolality. NB: a child with a high urea or glucose may be hyper-osmolar in the presence of a normal serum [Na+].
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Oral Rehydration Therapy (ORT)

This is the treatment of choice for dehydration from gastroenteritis. It is safer and more effective than IV therapy for all degrees of dehydration except shock.

ORT uses Oral Rehydration Solution, which takes advantage of glucose / sodium co-transport mechanisms in the small bowel.

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Na+ (mmol/l)</th>
<th>K+ (mmol/l)</th>
<th>Chloride (mmol/l)</th>
<th>Citrate (mmol/l)</th>
<th>Glucose (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrolyte</td>
<td>60</td>
<td>20</td>
<td>60</td>
<td>10</td>
<td>1.8</td>
</tr>
<tr>
<td>Pedialyte</td>
<td>45</td>
<td>20</td>
<td>35</td>
<td>30</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Certain principles must be remembered:

- **ORT is intensive.** It depends on a lot of input from the child’s caregiver, or the use of a nasogastric tube.
- **Pedialyte is the ORS of choice**
- **The treatment of gastroenteritis with ORS occurs in two phases:** rehydration and maintenance. Except in hypernatraemia, ORT aims for full rehydration within 4 (or at most 12) hours of admission.
- **The schedule suggested here for the rehydration phase is a standard rate of replacement for all dehydrated children who are not shocked.** The final volume given is determined by clinical assessment of when the child is rehydrated.
- **During the rehydration phase, fluid is given at a rate of 5 ml per minute,** by teaspoon or syringe. The small volumes decrease the risk of vomiting. The rate (1 teaspoon / minute) is easy to calculate and administer for a parent sitting at the bedside. 25 ml every 5 minutes can also be used.
- **This rate of replacement is already maximal, and is not supplemented for ongoing losses.** If the child’s ongoing losses exceed an intake at this rate, the child will require nasogastric or intravenous fluids. This rate will rehydrate a moderately dehydrated 1 year old in 2 to 4 hours and a 2 year old in 3 to 5 hours (estimating diarrhoea at 0 -10 ml per kg per hour).
- **An alternative rate is 25 ml / kg /hr,** in small aliquots frequently
- **There must be frequent review (at least 2 hourly) in the rehydration phase.**
- **Vomiting is not a contra-indication.** Most children with gastroenteritis who vomit, will still absorb a significant percentage of any fluid given by mouth or NG.
**Nasogastric Tube**

Delivery of ORS by constant infusion through a NG tube is very effective. If the clear diagnosis is gastroenteritis, choose NG infusion in preference to IV fluids in the child who is refusing ORS, has intractable vomiting or profuse diarrhoea, or where there is no caregiver able to give ORS by mouth. The principles are the same: to rehydrate fully within 4 hours in the iso-osmolar child, and more slowly in the moderately hypernatraemic child.

**Rate for constant infusion is 25 ml/kg/hr Pedialyte.**
Reduce rate to 15 ml/kg/hr in moderate hypernatraemia.

Medical review at least every 2 hours is mandatory during rehydration. When the child is rehydrated, remove the NG tube. If there is doubt about the child’s ability to drink to keep up with ongoing losses, then it can be left in until this is clarified.

**Intravenous Rehydration in Osmolar or Hypo-Osmolar Dehydration**

Most children with gastroenteritis do not need IV therapy. Indications for an IV are:

- Shock
- If oral fluids might be unsafe (decreased consciousness, ileus, surgical abdomen)
- Severe hyperosmolality ([Na⁺] > 170, osmolality > 350)
- The failure of oral or NG rehydration due to intractable vomiting (rare)

After correcting shock, the speed of IV rehydration varies with osmolality. If the osmolality is < 350, the child has been fully resuscitated, is fully conscious and able to drink, and has no evidence of paralytic ileus change to oral or NG fluids.

1. **Calculation of Osmolality**

   The serum osmolality can be measured directly, but is easy to calculate:

   \[ \text{Serum osmolality (mOsm / l)} = (2 \times [\text{Na}^+] + (2 \times [\text{K}^+] + [\text{Urea}] + [\text{Glucose}] \]

<table>
<thead>
<tr>
<th>Definition</th>
<th>Serum Osmolality</th>
<th>Serum [Na⁺]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypo - osmolar</td>
<td>&lt; 280</td>
<td>&lt; 130</td>
</tr>
<tr>
<td>Iso-osmolar</td>
<td>280 - 319</td>
<td>130 – 150</td>
</tr>
<tr>
<td>Hyperosmolar (Moderate)</td>
<td>320 - 350</td>
<td>&gt; 150</td>
</tr>
<tr>
<td>Hyperosmolar (Severe)</td>
<td>&gt; 350</td>
<td>&gt; 170</td>
</tr>
</tbody>
</table>

2. **Calculation of Maintenance Fluids** (requirement per 24 hours)

   Age < 1 month: 120 ml / kg / day.
   Age > 1 month: as below

<table>
<thead>
<tr>
<th>Weight</th>
<th>Hourly maintenance fluid requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10 kg</td>
<td>4 ml/kg/hr</td>
</tr>
<tr>
<td>10 - 20 kg</td>
<td>40 ml/hr + 2 ml/hr for every kg over 10</td>
</tr>
<tr>
<td>&gt; 20 kg</td>
<td>60 ml/hr + 1 ml/hr for every kg over 20</td>
</tr>
</tbody>
</table>

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Use 0.45% NaCl and 2.5% Dextrose. Replace the rest of the deficit + maintenance over 24 hours. Give 1/2 the deficit in the first 8 hours, and the other 1/2 over 16 hours.

First 8 hours Volume (ml) = \( \text{maintenance (ml/24 hr)} + \text{remaining deficit (ml)} \)

Rate (ml/hr) = \( \frac{\text{Volume}}{8} \)

Next 16 hours Volume (ml) = \( \text{maintenance (ml/24 hr)} \times 2 + \text{remaining deficit (ml)} \)

Rate (ml/hr) = \( \frac{\text{Volume}}{16} \)

4. **Hypo-osmolar Dehydration ([Na+] < 130 mmol/l, Osmolality < 280)**

Replace the water deficit as for iso-osmolar dehydration. If [Na+] is < 120, admit to PICU. A slow infusion of 3% NaCl (517 mmol/l Na+, @ 0.5 mmol/ml) at 1.2 ml/kg/hr (0.6 mmol/kg/hr) will raise [Na+] by 1 mmol/hr. Once [Na+] is \( \geq \) 120, if necessary replace the remaining Na+ deficit over 24 hrs by adding extra Na+ to the IV fluids.

Note: the total Na+ deficit (mmol) = \( [135 - \text{serum [Na+]}(\text{mmol/l})] \times 0.6 \times \text{weight (kg)} \)

5. **Acidosis**

Acidosis may be due to bicarbonate loss or tissue hypoxia. If the latter, it usually corrects itself as hypovolaemia is corrected. If severe acidosis persists (arterial pH <7.1) always reconsider the diagnosis and consider adding bicarbonate to the IV fluids in consultation with senior colleagues.

6. **Potassium**

If the child passes urine, and is not hyperkalaemic, add 10 mmol KCl to 500 ml IV fluid. If there is acidosis or profuse diarrhoea, more KCl than this may be needed.

**Note:** correction of the acidosis may cause a rapid fall in the serum [K+].

7. **Calcium**

If the serum [Ca++] is low, add 10 ml Calcium Gluconate / 500 ml IV fluid. Do not add Calcium Gluconate to a solution containing bicarbonate.
8. Ongoing Losses While on Intravenous Rehydration

Ideally, weigh the stools and replace every 1 gm of stool with 1 ml of fluid. Alternatively, approximate ongoing losses by giving 10 ml/kg per loose stool, and 2 ml/kg per vomit. In the child with profuse losses, calculate the fluid balance hourly.

If the child cannot drink, measure ongoing losses hourly and replace ml for ml by IV infusion over the following hour. Or, estimate ongoing losses and add the estimate to the IV infusion rate. If you do this, review the child often and adjust the infusion rate as losses change. If the child can drink, estimate ongoing losses as above, and replace them orally in frequent small aliquots.

There is no substitute for frequent clinical re-assessment. Weigh the child daily, and if in doubt, 12 or even 8 hourly.

Management of Hypernatraemia or Hyperosmolality

This is defined as a serum Na > 150 mmol / l, or a serum osmolality > 320 mOsm / l. Note that a child with a high urea or glucose may be hyper-osmolar in the presence of a normal serum [Na⁺].

In the hyper-osmolar child, rapid correction of osmolality may cause cerebral oedema, convulsions and permanent brain damage. Severe hyperosmolar dehydration should be managed very cautiously with IV rehydration. Moderate hyperosmolar dehydration can be managed with IV rehydration, or with cautious modified ORT (see below).

1. Intravenous Rehydration of Hyperosmolar Dehydration

Moderate hyperosmolar dehydration  [Na⁺] > 150  osmolality ≥ 320
Severe hyperosmolar dehydration  [Na⁺] > 170  osmolality ≥ 350

Admit children with severe hyperosmolar dehydration to PICU.

In order to reduce the risk of cerebral oedema and brain damage during intravenous rehydration in hyperosmolality, aim to lower the serum [Na⁺] slowly at a rate of 10 - 15 mEq in 24 hours, and the osmolality by no more than 0.5 - 1 mmol/hr.

(See ‘Intravenous Rehydration’ above for how to calculate osmolality and maintenance fluid requirements).

In moderate hyperosmolar dehydration, after initial resuscitation, replace the remaining deficit plus maintenance slowly at a uniform rate over 48 hours, using 0.45% NaCl and 2.5% Dextrose.

Daily volume (ml) = maintenance (ml/24hr) + remaining deficit (ml) / 2
Rate (ml/hr) = Volume / 24

In severe hyperosmolar dehydration, after initial resuscitation, aim to replace the remainder of the deficit and maintenance over a period of 72 - 96 hours.
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Never give a total IV volume of more than 200 ml/kg/day - usually give 100 -150 ml/kg/day. Calculate the osmolality at least 4 hourly, and measure it at least 12 hourly. If it is falling too quickly, reduce the rate of infusion by 20% and reassess in 4 hours.

2. Acidosis, Potassium and Calcium

As per sections in ‘Intravenous Rehydration’ above.

3. Ongoing Losses While on Intravenous Rehydration

As per sections in ‘Intravenous Rehydration’ above.

4. Changing From IV Rehydration to Oral Rehydration

When the osmolality has fallen below 350 and the serum [Na+] has fallen below 170, change to ORT (provided the child has been fully resuscitated, is fully conscious and able to drink, and has no evidence of paralytic ileus or a surgical abdomen).

Aim to continue to rehydrate the child slowly, at a rate of 15 ml / kg / hour of pedialyte. DO not give plain water or juice until the serum [Na+] is < 150. When the [Na+] is <150 fluids can be liberalised - manage as iso-osmolar dehydration.

5. Oral Rehydration In The Presence of Moderate Hypernatraemia

Moderately hypernatraemic children can be safely rehydrated orally, giving fluids at a maximum rate of 15 ml/kg/hr. Rehydralyte (a rehydration fluid with a higher [Na+] content) is no longer available in Starship so pedialyte should be used, being cautious not to allow a rapid drop in osmolality or serum [Na+].

The rate of rehydration is about half that used in iso-osmolar dehydration. It is based on the assumption that most hypernatraemic children are severely dehydrated (“10%” or more), and allows for ongoing losses. If ongoing losses exceed this rate of replacement, the child may need nasogastric or intravenous rehydration. Electrolytes must be checked 4 hourly, and the rate of replacement slowed if the serum [Na+] is falling at a rate faster than 1 mmol/hour.

Oral Maintenance Therapy

During the intensive acute rehydration phase of ORT ongoing losses are included in the standard rate of fluid replacement. After the acute phase, give both maintenance fluids and extra Pedialyte to replace the fluid in every loose stool, or the child will slip back into dehydration.

In children who are very unwell or have profuse losses, measure and replace stool loss as for children on IV therapy. In rehydrated children whose losses are not unusually profuse, advise parents to give both maintenance fluids and roughly 10 ml/kg for a diarrhoeal stool. As with ORT itself, this volume should be given in small aliquots rather than as a single large bolus.
Children who are not dehydrated often refuse Pedialyte. The following table analyses some of the alternative fluids often given by parents. Note that undiluted juice or fizzy drink contains 5 - 15% sugar, and must be diluted to bring the sugar content down to 2% or less. **In most cases, this means a dilution of 1 part juice to 5 (or more) parts water to avoid the risk of osmotic diarrhoea.** If the parents have the container of juice or fizzy drink with them, you may be able to work out the dilution needed from the information on the packet.

<table>
<thead>
<tr>
<th>Fluid</th>
<th>[Na+]</th>
<th>[K+]</th>
<th>[HCO3-]</th>
<th>Glucose (g/l)</th>
<th>Osmolality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cola</td>
<td>2</td>
<td>0.1</td>
<td>13</td>
<td>50-150 including fructose</td>
<td>550</td>
</tr>
<tr>
<td>Ginger-Ale</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>50-150 including fructose</td>
<td>540</td>
</tr>
<tr>
<td>Apple juice</td>
<td>3</td>
<td>20</td>
<td>0</td>
<td>100-150</td>
<td>700</td>
</tr>
<tr>
<td>Chicken Broth</td>
<td>250</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>450</td>
</tr>
<tr>
<td>Tea</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Lucozade</td>
<td>13</td>
<td>0.5</td>
<td>-</td>
<td>185</td>
<td>695</td>
</tr>
</tbody>
</table>

Note that many commercially available fruit juices are largely based on apple juice.

**Feeding**

Children with diarrhoea who are fed throughout the illness lose less weight and recover more quickly. During the acute phase (2 - 4 hours) of oral rehydration, it is reasonable to give oral rehydration fluids only, unless the child indicates a strong desire for milk or food as well. After this brief period however, feeding should be re-introduced. In the hypernatraemic child, milk may need to be introduced gradually to avoid a sudden fall in serum [Na⁺].

Breast-feeding should never be discontinued. Formula can be given at full-strength. Solids can be given if the child is interested in them.

**Lactose Malabsorption**

This is not common. It is a clinical diagnosis based on symptoms of carbohydrate malabsorption (profuse stooling on lactose challenge and re-challenge), together with a positive stool fluid Clinitest for reducing substances. Anything more than a trace is positive (i.e. + ½% or more). A positive test is clinically irrelevant if not accompanied by diarrhoea. The test is meaningless in breastfed babies.

If lactose intolerance is confirmed, a lactose-free formula will need to be used until the intestine has recovered. This is usually no more than 4 - 8 weeks.

**References**


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Appendix

Is there bloody diarrhoea?

If there is blood or mucous in the stools, abdominal pain or systemic toxicity consider the diagnosis of bacillary dysentery. Treat with empiric antibiotics only if the child is immunocompromised or systemically unwell. If the child does not meet these criteria, you can afford to wait until culture results and specific sensitivities are available. In this situation, antibiotic therapy is almost never indicated.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Possible complications</th>
<th>Antibiotic therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacter</td>
<td>Neonatal septicaemia, convulsions, Guillain-Barre syndrome, Reiter’s syndrome. May mimic appendicitis</td>
<td>• In uncomplicated gastroenteritis, some benefit of therapy if given early. Usually the diagnosis is made too late for useful therapy (Erythromycin PO for 5 - 7 days)</td>
</tr>
<tr>
<td>Entero-invasive Escherichia coli</td>
<td>Bacteraemia, meningitis, osteomyelitis, typhoid fever</td>
<td>• Bacteraemia is rare. Discuss with senior</td>
</tr>
<tr>
<td>Salmonella (non-typhoid)</td>
<td>Bacteraemia, meningitis, osteomyelitis, typhoid fever</td>
<td>• Not indicated in uncomplicated gastroenteritis (may prolong duration of excretion of organism).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In bacteraemic infants &lt; 3 months, or children with complications, IV Ceftriaxone (there are other options, discuss with senior)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Duration of therapy is 14 days, or up to 6 weeks for meningitis or focal sepsis.</td>
</tr>
<tr>
<td>Shigella</td>
<td>Bacteraemia, colonic perforation, convulsions, haemolytic-uraemic syndrome, Reiter’s syndrome, fulminant toxicencephalopathy</td>
<td>• In bacteraemic infants &lt; 3 months, or children with complications, IV Ceftriaxone (discuss with senior)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In some cases treatment may be required for mild disease for reasons of public health. In this case, choose antibiotic by sensitivities</td>
</tr>
<tr>
<td>Yersinia</td>
<td>Bacteraemia, conjunctivitis, glomerulonephritis, hepatic or splenic abscess, meningitis, osteomyelitis, pharyngitis, pneumonia, reactive arthritis, pseudoappendicitis</td>
<td>• No evidence for antibacterial use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In a sick child, discuss with senior</td>
</tr>
</tbody>
</table>

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