PedsCases Podcast Scripts

This is a text version of a podcast from Pedscases.com on the "Approach to Pediatric Anemia and Pallor." These podcasts are designed to give medical students an overview of key topics in pediatrics. The audio versions are accessible on iTunes or at www.pedcases.com/podcasts.

Dehydration in Children

Developed by Michelle Bischoff and Dr. Melanie Lewis for PedsCases.com.
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Introduction

Hey everyone, my name is Michelle Bischoff and I'm a medical student at the University of Alberta. This podcast was reviewed by Dr. Melanie Lewis, a General Pediatrician and Associate Professor of Pediatrics at the Stollery Children's Hospital and the University of Alberta in Edmonton, Alberta, Canada.

This podcasts is on dehydration and fluid requirements in children.

The objectives of the podcast are threefold:

1. To address dehydration including hypernatremic and byponatremic dehydration states and assessment findings
2. To give an approach to correcting dehydration including oral, gastric and intravenous methods
3. To discuss maintenance fluid requirements in pediatric patients

Dehydration is a very common problem encountered in both acute and ambulatory care settings. Children suffer fluid losses from a number of conditions, including diarrhea caused by gastroenteritis (the most common cause), fever, losses post-operatively, or a high urine output due to diabetes insipidus. Water and electrolytes are lost through urine, stool and stomach secretions, and insensibly through the skin and lungs.

Whatever the cause, dehydration is a serious and potentially life-threatening condition, particularly in the pediatric population. Children's bodies have a higher percentage of water content than adolescents and adults making them more prone to water and electrolyte loss and rapid fluid shift.

Dehydration can be separated into three types: mild with about 5% loss of pre-illness body weight, moderate being 10% and severe meaning 15% or more (for children less than 2 years of age). For kids greater than 2 years, the percentages are 3, 6, and 9% for mild, moderate and sever dehydration respectfully. Determining the severity of the

child's state is important for calculating fluid resuscitation amounts, which will be explained shortly. Clinical manifestations usually do not become apparent until the child is moderately to severely dehydrated, and it is critical that you are able to identify these upon assessment.

The severity of dehydration – i.e. mild, moderate or severe dehydration - can be determined via signs and symptoms. A mildly dehydrated child with about a 5% loss in body weight will be pretty much asymptomatic except for a decrease in urine output and increased thirst. With moderate dehydration (i.e. 10% loss), heart rate increases and blood pressure may be low normal; remember vital signs changes are a relatively late findings and are very, very concerning. Other signs of moderate dehydration include: decreased urine output, dry mucous membranes, sunken anterior fontanel and eyes, decreased skin turgor, decreased tears, and a prolonged capillary refill time. If the child is severely dehydrated, all of these clinical manifestations are exacerbated and you will note decreased BP, tachycardia, poor perfusion, and decreased LOC - all the typical signs of shock. The majority of infants and children with 15% dehydration will need to be managed in an ICU setting.

Loss of body weight can be another useful indicator of dehydration, however only if combined with other clinical signs and symptoms, because weight can fluctuate and is subject to error.

Use the patient history to discern possible causes of fluid loss

If an infant is breastfeeding and recently has had poor intake, or is having diarrhea and/or emesis, expect hypernatremic dehydration. A child who is drinking a lot of free water and experiencing diarrhea would likely have hyponatremic dehydration. Most children have isotonic dehydration (around 800% and therefore normal serum sodium values.

Investigations

Labs should be drawn on a case by case basis. They are generally not helpful unless the child needs parenteral fluid replacement. Keep in mind, if you need to start an IV on a child, to avoid a second poke, think about drawing labs at that time!

Consider the following tests:

Basic Electrolyes:

Serum sodium concentration- This can indicate whether dehydration or hyponatremic or hypernatremic.

Serum K- Which may be low due to diarrheal losses or emesis.

Chloride is also clinically helpful. For instance, a significantly dehydrated baby with pyloric stenosis who is obviously having gastric losses including HCL would be expected to have hypochoremic hypokalemic metabolic alkalosis.

Serum bicarbonate is also helpful in noting the degree of acidosis. A serum bicarbonate of greater than 17 meq/L is reassuring that the child is not significantly dehydrated.

Blood Urea Nitrogen and serum creatinine can be ordered – if there is volume depletion with no renal insufficiency, expect the B.U.N level to be elevated with little or no change in creatinine. Remember, you have to have muscle mass to generate an elevated creatinine. For instance, a very scrawny infant in renal failure may have an elevated urea but a normal creatinine. So don't be fooled.

Urinalysis– urine specific gravity is usually elevated if dehydration is significant Also, dehydration may cause the presence of hyaline or granular casts, a few white cells and red cells, and proteinuria.

Hematocrit and haemoglobin– both will increase in dehydration due to hemoconcentration.

Also, blood and urine cultures may be indicated if the child is febrile.

Management

Once you have established that the child is dehydrated, fluid management includes 4 steps: restoring circulating volume acutely, replacing the total deficit, maintaining hydration, and replacing ongoing losses. Fluid resuscitation methods include oral, gastric via nasogastric, orogastric or GTube, and intravenously.

Oral Rehydration

Oral rehydration solutions are electrolyte solutions such as Pedialyte and Gastrolyte. These should be your treatment of choice for children with mild dehydration for a number of reasons – oral intake is easier on the child, easier to administer, is associated with fewer major adverse events and can continue at home. The trick is to give small amounts at frequent intervals – sometimes squirting fluid into the mouth with a syringe is helpful or using a spoon. Then gradually increase volume as tolerated. Most practitioners will aim to give about 10cc/kg/hr plus replacement of ongoing losses.

Oral rehydration solutions that contain glucose and sodium in a 1:1 ratio are optimal, as glucose and sodium are cotransported across the basolateral membrane of the intestine. Glucose enhances sodium absorption, and sodium subsequently draws in water.

Contraindications to oral fluid replacement therapy are if the child has prolonged vomiting, severe dehydration or shock, an altered level of consciousness, a paralytic ileus or malabsorption.

All children with dehydration should be fed (an age-appropriate diet) as soon as they have been rehydrated. It is a myth that doing so will exacerbate symptoms of diarrhea. On the contrary, introducing solids early may decrease the duration of diarrhea. If the infant or toddler is being breastfed, breastfeeding should continue even during the initial stages of volume rehydration.

Important to note: A dehydrated child should not be given juice or soda, because these are high in carbohydrates, low in electrolytes and have a high osmolarity, not a satisfactory combination for rehydration. Also, children with acute presentations of dehydration, such as those with gastroenteritis, should not be given plain water, because this can induce hyponatremia and hypoglycaemia.

NG, OG, or GTube Replacement
The next preferred method of rehydration is via a nasogastric, orogastric or GTube. A nasogastric tube can be inserted if, for instance, the patient has a normal level of consciousness but cannot swallow. This allows continuous administration of fluids at a steady rate. Again, resume normal, age-appropriate solid foods as soon as rehydration is complete and the child tolerates.

IV Replacement Therapy
For moderate to severe dehydration or if there are contraindications to oral or gastric intake, IV resuscitation is necessary.

IV maintenance fluids normally contain water, sodium, glucose, and potassium. You should be familiar with these commonly used intravenous solutions. NS and RL are ISOTONIC solutions, meaning concentrations are approximately equal to plasma – these are used to INITIALLY stabilize patients in moderate or severe dehydration states. For children with a normal sodium level, use D5NS as your maintenance solution of choice. For neonates, consider solutions with higher glucose concentrations like D10NS. These solutions are also available with the addition of potassium chloride or dextrose.

Next, we will talk about the specifics of fluid resuscitation including calculating maintenance requirements.

Fluid resuscitation includes 4 key steps: restoring circulatory volume, correcting fluid deficit, maintaining hydration, and replacing ongoing losses.

1. First, restore circulating blood volume if dehydration is moderate to severe. Give a bolus of 20 ml/kg quickly over 5-15 min using an isotonic solution -usually NS. Then reassess. The child may need subsequent boluses until heart rate,

perfusion and mental status are once again normal. Do not wait for the blood work results to come back before beginning fluid resuscitation.

2. Calculate the child's fluid loss. This depends on the degree of dehydration, determined by clinical signs and symptoms. If the child is *5%* dehydrated, meaning mildly dehydrated, the replacement = 50ml/kg. For moderate or 10% dehydration, give 100 ml/kg and for severe, give 150 ml/kg. For kids greater than 2, remember the percentages are 3/6/9, therefore for 3% loss, give 30ml/kg; 6% loss, give 60mVkg; 9% give 90ml/kg.

If the child's serum sodium is greater than 150 mEq/L and less than 130, replace over 48 hours or so to prevent cerebral complications. For children with significant hypo or hyper natremia the goal is correct the sodium very slowly, about 0.5mEq/hr; replacement of greater than 2mEq/L is associated with cerebral complication.

If the child is voiding (i.e. if kidney function is adequate), potassium may be added to the replacement – so usually D5NS with 20 meq KCl/L for children with normal serum sodium on presentation.

3. Maintain hydration. You now need to calculate maintenance fluid requirements using the 4-2-1 rule I am about to describe. **You must add maintenance requirements to the replacement amount you just calculated. Then, subtract the amount of fluid you gave with bolusing from this new total, and infuse over about 24 hours.**

Maintenance fluid requirements can be calculated using the 4-2-1 rule. This means the child requires:
4 ml/kg/hr for the first 10 kg
2 ml/kg/hr for the next 10 kg and
1 ml/kg/hr thereafter

For instance, if you have a child weighing 15 kg – 4 ml for the first 10 kg gives you 40 ml, then 2 ml for the next *5* kg gives you 10....for a total of 50 ml/hr.

Please note that this rule only applies to children with normal cardiac and renal functions.

Remember, if the patient begins taking fluids orally, decrease the rate as necessary.

Again, add maintenance requirements to the fluid deficit, subtract any boluses, and infuse this total amount over about 24 hours.

4. Replace continuing losses. It is important consider the need for ongoing replacements. For instance, does the patient have an NG tube that is

suctioning secretions? Or an ostomy that is putting out considerable amounts of watery stool? These losses are typically replaced 1:1 with an IV solution with comparable electrolytes to stool (1/2 NS with 20 mEq K per L).

To Summarize
Bolus the child 20 ml/kg quickly to restore circulation. Calculate the total volume deficit, 50, 100, or 150 ml/kg for kids less than 2, and 30ml, 60 ml or 90 ml/kg if greater than 2 years, for mild, moderate and severe respectfully and subtract the boluses. Add the maintenance to the volume deficit for a grand total to be given over 24 hours. Last, continue to replace ongoing losses.

These guidelines are not set in stone. Continue to assess the patient's urine output and specific gravity, fluid balance, daily weights and electrolytes. Lytes should be assessed about every 2-4 hours during the first 12 hours of fluid resuscitation. Then adjust your fluid management plan as needed. There is no way to know exactly how ADH is influencing the child's fluid status, and therefore calculations may not be as precise as you think…

Special Considerations

Now onto some special considerations. Dehydration can occur with hypernatremia and hyponatremia.

Hypernatremia
Hypernatremia occurs with dehydration when serum sodium levels exceed 145 mEq per L and indicates more water is lost than sodium. Remember that sodium is present in the extracellular fluid space. Therefore, signs and symptoms of dehydration may not be present until the condition is profound. In hypernatremia, water moves from the intracellular space to the extracellular space. This causes brain cell shrinkage and possible tearing of blood vessels within the brain. Clinical manifestations include periods of lethargy and irritability, "doughy" rather than brisk skin turgor, increased muscle tone, a high-pitched cry, and altered level of consciousness.

There are three major mechanisms of hypernatremic dehydration. Number 1: Pure water depletion – i.e. Diabetes insipidus. Number 2: Water losses exceeding sodium depletion - from, for instance, diarrhea or vomiting, and Thirdly: Sodium excess or sodium poisoning . i.e. a caregiver may incorrectly mix a formula so that it is much more concentrated than it should be.

Initial treatment includes administration of normal saline. Aim to decrease sodium by 0.5 mEq/hr) over 48-72 hours to prevent cerebral edema. The reason is that when a person is hypernatremic, water is leaving the cells. To compensate, these cells generate osmotically active particles to draw water back into the cell. Then, if the patient is rehydrated too quickly, these cells may be overloaded with water,

causing swelling and rupture. Rapid correction is even more dangerous in cases of prolonged dehydration.

Hyponatremia

Hyponatremia, more common than hypernatremia, is defined as a serum sodium concentration less than 135 meQ per L which results from a decrease in the body's sodium content and/or a rise in extracellular fluid. Causes of hyponatremia include giving too much fluid low in sodium, like water, juice, and carbonated drinks, excessive sodium losses or retention of free water, either renally or otherwise, or insufficient sodium intake – the last being rare.

Factors that may contribute to the development of hyponatremia include increased excretion of Antidiuretic Hormone in response to pain, nausea, vomiting and certain medications like narcotics. Also, SIADH causes hyponatremia and may be due to a CNS infection like meningitis and encephalitis, a brain tumour, stroke or head trauma, or respiratory failure. Certain conditions also lead to increased total body water retention such as heart failure, nephritic syndrome, and cirrhosis. As well, gastroenteritis can cause more loss of sodium than free water through the GI tract and lead to hyponatremia, especially in kids only drinking free water as oral replacement.

Regardless of the cause, signs and symptoms are the same. As the extracellular concentration of sodium decreases, water will move into cells, including brain cells, causing cerebral edema and irritability, headache, seizures, nausea, and vomiting. Also, decreased muscle tone. These manifestations tend to occur when the drop in extracellular sodium concentration is fast i.e. within hours.

Again, rehydrate slowly - aim to increase by 0.5 mEq/hr over 48-72 hours to prevent pontine myelinolysis.

<u>Take-home Points</u>

1. Dehydration is a common condition encountered in both acute and ambulatory care; pay close attention to clinical signs and symptoms to accurately assess dehydration.
2. Oral rehydration therapy is best for mild dehydration unless there are contraindications to oral ingestion (the goal being about 10 ml/kg/hr while keeping up with ongoing losses). Remember when orally hydrating to give small amounts frequently and to encourage ongoing breastfeeding. Intravenous fluid resuscitation is indicated in moderate to severe cases.
3. Fluid resuscitation includes 4 key steps: restoring circulatory volume, correcting fluid deficit, maintaining hydration, and replacing ongoing losses.
4. Hyponatremic and hypernatremic dehydration states need to be corrected slowly, over 48-72 hours to prevent cerebral complications which may lead to death.

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5. Monitor level of consciousness and electrolytes frequently during the initial 12 hours of management. Check electrolytes every 2-4 hours to ensure sodium levels are not changing too rapidly.
6. Hyper and hyponatremic dehydration cases are challenging with potentially deadly consequences. Don't hesitate to ask for help if you are not comfortable calculating the appropriate replacement.

Taken from Toronto Notes:

	Mild	**Moderate**	**Severe**
Heart rate	Normal, full	Rapid	Rapid, weak
Blood pressure	Normal	Normal-low	Shock- decreased BP
Urine output	Decreased	Markedly decreased	Anuria
Oral mucosa	Slightly dry	Dry	Parched
Anterior fontanel	Normal	Sunken	Markedly sunken
Eyes	Normal	Sunken	Markedly sunken
Skin turgor	Normal	Decreased	Tenting
Capillary refill	Normal (<3 sec)	Normal to increased	Increased (>3 sec)
% loss of pre-illness weight			
<2 years	5%	10%	15%
> 2 years	3%	6%	9%

References

References available upon request.

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