Fluid Therapy In Children: A Review

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Fluid therapy restores circulation by expanding extracellular fluid. Intravenous fluid therapy for children with volume depletion should first restore extracellular volume with measured infusions of isotonic saline followed by defined, appropriate maintenance therapy to replace physiological and pathological losses according to principles established. To understand the fluid therapy in children, it is important to know the different types of deficits. Likewise, it would be optimal to have a brief understanding of the water and electrolyte distribution in children at different ages.

Introduction

The goal of fluid and electrolyte management is to replace losses of water and electrolytes so as to maintain normal balance of these essential substances during growth and recovery from disease. A subsidiary aim in the management of fluid and electrolyte balance is to proceed as per age, weight, and ways the patient is facing body losses. The principles of fluid and electrolyte management in the neonatal period are similar to those established for older children, except for some variations and specific features of body composition, insensible water loss (IWL), renal function, and neuroendocrine control of fluid and electrolyte balance. The first step in caring for the child with dehydration is to assess the degree of dehydration. This dictates both the urgency of the situation and the volume of fluid needed for rehydration. The infant with mild dehydration has few clinical signs or symptoms. The infant may be thirsty; the alert parent may notice a decline in urine output. The history is most helpful. The infant with moderate dehydration has clear physical signs and symptoms. Intravascular space depletion is evident by an increased heart rate and reduced urine output. This patient needs fairly prompt intervention. The infant with severe dehydration is gravely ill. The decrease in blood pressure indicates that vital organs may be receiving inadequate perfusion. Immediate and aggressive intervention is necessary.

Review

At birth total body water (TBW) = 75% of body weight (BW). First week of life, TBW reduces to 65% because of obligatory diuresis. At one year of age, TBW reduces to 60% of BW. TBW distribution is changed in adolescence since there is increase in fat in girls (TBW=55%), as compared to boys who are more muscular, (TBW=60%).

Electrolyte distribution:
Sodium ion (Na⁺) is the principle cation of the extracellular fluid (ECF) amounts to 140 mEq/L, and forms a reasonable estimate of total body sodium. Similarly, potassium ion (K⁺), forms the principle ion of intracellular fluid (ICF) and amounts to 150mEq/L, a 30 times more concentration than in ECF.

After the neonatal period maintenance requirements has been generalized:
A. Water (H₂O) is generated in the process of metabolism. This metabolism produces heat whose regulation requires H₂O. There is also production of solute load whose excretion requires H₂O. Metabolism/metabolic rate is related to surface area and to weight of the child. This metabolic rate (kcal/day) approximates fluid need (cc/day).
B. Holliday-Segar Method to calculate metabolic rate for “normal” patients as per their weight
1. Weight                  Caloric expenditure/24 hours
   0-10 kg                  100 kcal/kg
   >10-20 kg                1000 kcal+ 50 kcal/kg for the increment>10kgs
   >20 kgs                  1500 kcal+ 20 kcal/kg for the increment> 20kgs
2. H₂O need = 1 cc H₂O per kcal energy expended.
C. Maintenance calculation by Holliday-Segar assumes:
Fluid losses normally are estimated as 1cc/estimated 1 kcal expenditure and include, a) insensible losses: respiratory =15% of total, skin =30% of total; b) urinary losses =55%
D. Modification in “maintenance” requirement, in various conditions are as under.
   1. fever – 12% increase for each degree (Celsius)
above 38 Celsius.
2. activity – 0-30% increase
3. tachypnea, hyperpnea: 5-20 ml/100kcal
4. anuria: insensible and stool losses only
5. profuse sweating: 5-25ml/100Kcal
5. obligate polyuria: requires more urine to clear each mOsm of solute
6. VLBW infants; Decreased skin integrity and increased surface area/body kg weight.

E. Maintenance electrolyte requirements:
1. Na: 2-4 mEq/ 100cc H₂O (start with 3 mEq/100cc)
2. K : 2-3 mEq/ 100cc H₂O (start with 2 mEq/100cc)
3. Cl : 5-6 mEq/ 100cc H₂O

Estimation of fluid and electrolyte deficit:
Usually clinical criteria are used to asses the degree of dehydration and fluid deficit is calculated on weight before dehydration, which is readily available.

Dehydration is classified as:
A: As per body weight; Mild: 5% Body weight (BW) loss amount to deficit of 50ml/kg. Moderate: 10% BW loss amounts to deficit of 100ml/kg, Sever: 15% BW loss amounts to 150ml/kg.
B: As per electrolytes; Isonatremic: when S. sodium is 135-145 mEq/L. Hyponatremic: when S. sodium is <130 mEq/L. Hypernatremic: when S. sodium is >150 mEq/L
C: As per speed of fluid loss; Rapid: < 2 days duration, ECF: ICF deficit=75/25%. Moderately rapid: 2-7 days duration, ECF: ICF deficit=60/40%. Slow: > 7 days duration, ECF: ICF deficit=50/50%. Total fluids in 24 hours amount to deficit plus maintenance fluids along with concurrent losses if any.

Administration of IV fluids: it is given in three phases:
1. Phase I, during the first hour, 20ml/kg of NS/4 ie 200ml of water and 31mEq of sodium.
2. Phase II, during the next 7 hours, half of the rest of fluid, 1800/2=900ml→130ml/hour or 2.14ml/minute.
3. Phase III, during the next 16 hours, 900ml→56ml/hour ie, approximately, 1ml/minute. If the patient voids urine then add 25mEq/L of K+ as KCl.

Hyponatremic dehydration (Serum Na+ < 130mEq/L): Hyponatremia causes:

Hypernatremic dehydration (Serum Na+ > 150mEq/L): Causes are:
a), Inadequate free water intake, increased sodium intake, accidental, iatrogenic, or ORS administration or infant feeds.
b), Excessive free water loss, as in extrarenal causes including burns, sweating, tachypnea. While as renal causes include nephrogenic diabetes insipidus, craniopharyngioma, granulomatous diseases, post operative causes.

Clinical manifestations: doughy feel of the skin, woody consistency of the tongue, alteration in sensorium, seizures, and intracranial bleeds. Treatment include administration of ORS in conscious patients. Free water or breast feeds should be offered to the child. Acute hypernatremia may be treated with sodium free fluid. Correction should be made by reducing the levels just by 12 mEq/L in 24 hours to reduce the complication.

I. Methodical approach to a patient having dehydration.
a). Listen for the history; b), Examine the Patient; c); Don’t forget the ABCs: A – Airway, B – Breathing, C – Circulation – Requires fluid, d), The faster you are treating abnormalities (volume or electrolyte), the more often you need to check the patient’s progress to reassess the accuracy of your predictions. e), Use fluids which are pre-mixed commercially whenever possible. That are less expensive, less opportunity for error, quicker. f), Becoming more facile with fluid management will lead to better outcomes, this does not have to be difficult.

Goals:
1. Assess for signs of Shock, that include,
decreased alertness, urine flow, bowel sounds, capillary refill time and peripheral pulses because of poor perfusion to the respective organs

2. Estimate degree of dehydration.

Estimating volume depletion like "mild", "moderate", "severe", and rapid, moderately rapid and slow, and iso, hypo or Hypernatremic type of dehydration. Estimate deficit, maintenance and concurrent losses if any.

3. To Prescribe Fluids – once estimation about the amount to given is made then routes and type of fluid administration are important and readjustment after lab values are known, and after follow-up confirms or alters your estimates. When the patient is >3-5% dehydrated, always check electrolytes stat.

4. Choosing a rate of fluid administration:

A. If the patient is poorly perfused, i.e. there are signs of shock: give 20cc/kg of isotonic fluid as rapidly as possible, repeat as necessary to establish perfusion to a maximum of 1 liter in children is given. Next choose a rate and composition which will: replace the deficit early in the 24 hour period (4-8 hours), make use available fluids like ½ the deficit plus ½ the maintenance over 8 hours, then the remaining ½ deficit and ½ maintenance over the next 16 hours, or the whole deficit over 8 hours, then the whole day’s maintenance over 16 hours. Replacement of K+ and HCO3 may take longer than the replacement of volume. Do not start K+ replacement until urine flow is established, it is important to note that; the faster the rehydration or the more severe the fluid/electrolyte abnormality, the more often the patient needs to be reassessed.

Oral Rehydration:

A. Best used in the absence of shock. When poor perfusion is present, isotonic fluid bolus can restore perfusion, then oral rehydration can proceed. Glucose is actively absorbed and Na is co-transported across gut mucosa, hence a) it works even in most forms of diarrhea, b) optimal glucose transport at different concentrations, c) higher glucose concentration will exacerbate diarrhea and Na loss

B. Instructions for Oral Rehydration

1. Use WHO-ORS or a commercial preparation for rehydration i.e. to replace the deficit over 4-6 hours.
2. Then use breast milk or other lower sodium maintenance fluids for the rest of the day.
3. Use more ORS to continue to replace ongoing losses.
4. Restart feedings as soon as possible (if lactose-free)

D. Cautions about Oral Rehydration

1. Should not start until shock has been treated and reversed.
2. Some patients (<10%) will need some IV treatment due to vomiting or high volume stool.
3. Improper mixing of fluids can lead to iatrogenic fluid imbalance.
4. Some ORS doesn’t taste great.

Abbreviation(s)

TBW: Total body water; Na: Sodium; K: Potassium; SIADH: Syndrome of inappropriater antiidiuretic hormone; ORS: Oral rehydration solution; ECF: Extra cellular fluid; ICF: Intracellular fluid;

Authors Contribution(s)

MA Was the pricipal contributor, rest of the authors contributed equally

References

8. Nicholson J, Pesce M. Laboratory testing and
Neonatal fluid requirements (ml/kg/day):

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Approximately 70% of the maintenance fluids are given in the first 2 days and 100% requirement is given by next 4-5 days, however requirements are adjusted as per the need, like more fluid are needed in neonates who are under radiant warmers, phototherapy units, who are running fevers and have high metabolic rates. During the first 2 days of life, dextrose 10% (D 10) is used in which 1ml Potassium Chloride (KCl)/100ml of D 10 is added once neonate voids. However, in neonates who are < 1 kg 5-10% dextrose is used.
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