FLUID AND ELECTROLYTE THERAPY
SALT SUGAR WATER AND VINEGAR
WHY A CHILD IS MORE VULNERABLE TO DEHYDRATION THAN ADULT

Increased BSA relative to body weight
Large daily turn over of fluid
An infant exchanges 1/2 of ECF every day (50%)
An adult ..................1/7  .........................(15%)
Reduced renal concentrating ability. maximum Urine osmolarity is  600 mosm in infancy and 1200 mosm in older
Infants do not express thirst effectively
Poor access to water
ADULT – DAILY TURN OVER

ECF
14 LITRE

15% of ECF

IN 2000 ML

OUT 2000 ML
INFANT – DAILY TURN OVER

ECF
1400 ml

IN
700 ml

OUT
700 ML

50% of ECF
BASICS OF WATER AND SALT
HOMEOSTASIS - STEADY STATE
HOMEOSTASIS IN FLUID ELECTROLYTE BALANCE

1. Normal Total Body Water (TBW)
2. Appropriate distribution (ICF/ECF. ECF: PV/ISF)
3. Osmolality
4. Appropriate electrolyte balance
2/3 OF EARTH AND BODY ARE MADE UP OF WATER
<table>
<thead>
<tr>
<th></th>
<th>Preterm</th>
<th>Term newborn</th>
<th>Infant child</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>ICF</td>
<td>-</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>ECF</td>
<td>-</td>
<td>30</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Total Body water</td>
<td>80</td>
<td>70</td>
<td>65</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td></td>
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</tr>
</tbody>
</table>

BODY WATER COMPARTMENT IN VARIOUS AGES (% AGE OF BODY WEIGHT)
TBW

ICF

1. Interstitial fluid:  2. Intravascular-fluid  3. Transcellular fluid:
ECF - SUBDIVISIONS

1. Intravascular-fluid: Plasma is the 1/4 of the ECF (5% of TBW)
2. Interstitial fluid: Interstitial Fluid (ISF) surrounds the cells, but does not circulate. About 3/4 of the ECF. (15%)

3. Transcellular fluid: Set of fluids that are outside of the normal Compartments. CSF, pleural, peritoneal, intraocular digestive juices, mucus, etc. (1.5%)
Insensible water loss
Lungs – 15 ml/kg
Skin – 30

Sensible water loss
Urine – 50 (40-70)
Stool – 5 ml/kg
Sweat – 0-20
INSENSIBLE WATER LOSS CALCULATION

Insensible water loss 400 ml/M2 BSA
Or 1/3 maintenance
30ml/kg in infancy
20ml/kg in children
10ml/kg in adults
<table>
<thead>
<tr>
<th></th>
<th>CATION</th>
<th>MMOL/L</th>
<th>ANION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ECF</td>
<td>ICF</td>
<td>ECF</td>
</tr>
<tr>
<td>Na</td>
<td>140</td>
<td>10</td>
<td>Cl</td>
</tr>
<tr>
<td>K</td>
<td>4</td>
<td>158</td>
<td>HCO3</td>
</tr>
</tbody>
</table>
WATER BALANCE

• Intake: Regulated by thirst decided by osmolality and volume of plasma
• Loss: Physiological control is on volume and content of urine
• ADH decreases and ANP increases urine volume
• ADH is released when plasma osm or plasma volume
SODIUM BALANCE

• Dietary intake: Cultural
• Usually water balance determines Na concentration and not Na balance
• Excretion: Amount of Na in urine is decided by plasma volume, mediated by Renin-Angiotensin-Aldosterone system
TERMINOLOGY

Osmolarity is number of osmotically active particles per one litre
Osmolality is number of osmotically active particles per one Kg
• Tonicity refers to osmolality of a solution relative to plasma
• High osmolality stimulates thirst and ADH release
• For clinical purposes both are same
• Normal 285 - 295
Formula to calculate serum osmolality:
\[ 2 \times \text{Sodium in mmol} + \frac{\text{Glucose in mg}}{18} + \frac{\text{Urea in mg}}{6} \]

E.g., Serum sodium 140; Glucose 90 mg; Urea 24;
Calculate osmolality is \[ 280 + 5 + 4 = 289 \]
ECF tonicity is regulated by water whereas ECF volume is regulated by sodium intake and excretion. They are blessed by Endocrine, neural, behavioral and paracrine systems.
PATHOLOGICAL LOSS OF WATER

- Lungs: Ventilated, Tachypnea as in bronchiolitis
- Skin: Burns, Excessive sweating (CF, Warmer)
- Urine: DM, DI, Diuretics, Mannitol
- Stool: diarrhea
DEFENCE OF TONICITY

Normal plasma osmolality is 280 – 295 mosm/L
1. ADH: even a change of 1 mosm leads to significant changes in ADH secretion
   Increase in osmolality causes ADH secretion
2. Thirst: Increase in osmolality increases thirst
DEFENSE OF TONICITY

- Osmoreceptors in hypothalamus senses the plasma osmolality
- Balanced by water intake (Thirst) and Excretion (ADH)
- Na is the principal determinant of serum osmolality
- Minimum Urine osm is 30-50 mosm/L. This places an upper limit to kidney for water excretion, hence water intoxication can cause severe hypernatremia
DEFENCE OF VOLUME

1. By plasma osmolality primarily: Amount of Na in the plasma is the main determinant of osmolality and so ECF volume

2. Control of water excretion through:
   A. ADH
   B. Angiotensin II
   C. ANP
DEFENSE OF VOLUME

If ECFV falls

1. By osmotic stimuli: Thirst and ADH both increases ECFV

2. By volume stimuli: ADH is secreted ... water retention and ECFV

2. AT II increases thirst, ADH secretion ...... the Na absorption in DCT and CT

1. ADH secretion is ... and hence water excretion leads to fall in ECFV.

2. ANP is secreted and leads to natriuresis
ADH secretion is not an all or none phenomenon, it is a graded one guided by osmolarity. Under conditions of hyperosmolality, ADH secretion is initiated prior to onset of thirst allowing for retention of ingested water.
ALDOSTERONE

Responds to fall in effective circ volume
Acts by RAA axis and enhances renal tubular reabsorption of Na
ATRIAL NATRIURETIC FACTOR (ANF)

Important role in regulating blood volume and pressure
Responds to excessive circ volume
Acts by causing natriuresis and diuresis
Inhibits AT II induced vasoconstriction and inhibit the release of ADH
# ELECTROLYTE COMPOSITION OF VARIOUS BODY FLUIDS

<table>
<thead>
<tr>
<th></th>
<th>Na mEq/L</th>
<th>K</th>
<th>HCO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea</td>
<td>10-80</td>
<td>10-80</td>
<td>40</td>
</tr>
<tr>
<td>Gastric</td>
<td>20-80</td>
<td>5-20</td>
<td>0</td>
</tr>
<tr>
<td>Small Intestine</td>
<td>100-140</td>
<td>5-20</td>
<td>40</td>
</tr>
<tr>
<td>Ileostomy</td>
<td>40-140</td>
<td>5-20</td>
<td>40</td>
</tr>
</tbody>
</table>
IVF MAINTENANCE FLUID VOLUME
HOLIDAY SEGAR FORMULA

For one day:
Upto 10 kg BW: 100ml/kg
11-20 kg BW: 1000 + 50 ml/kg for every 1 kg > 10
> 21Kg BW: 1500 + 20 ml/kg for every 1 kg > 20 kg

Hourly:
Upto 10 kg BW: 4ml/kg/hr.
11-20 kg BW: 40 + 2 ml/kg/hr. for every 1 kg > 10
> 21Kg BW: (1000 + 500) + 20 ml/kg for every 1 kg > 20 kg
# ALTERATION IN IVF MAINTENANCE REQUIREMENTS

<table>
<thead>
<tr>
<th>Factor</th>
<th>Alteration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>12% per degree C</td>
</tr>
<tr>
<td>Hyperventilation</td>
<td>10-60 ml/kg (per 100 kcal)</td>
</tr>
<tr>
<td>Sweating</td>
<td>10-60 ml/kg</td>
</tr>
<tr>
<td>Humidified ventilation</td>
<td>Reduce</td>
</tr>
<tr>
<td>GI and Renal loss</td>
<td>Monitor and adjust</td>
</tr>
</tbody>
</table>
WHAT IS THE IDEAL CONCENTRATION OF Na IN IVF?

Below 10 kg BW:
D5 ¼ NS + 20 mmol/L of KCl

Above 11 kg BW:
D5 1/2 NS + 20 mmol/L of KCl

Ref: Nelson text book of pediatrics. 18th edition P.310
INDICATION OF ISOTONIC FLUIDS

- Isotonic fluids are Normal saline and Ringer Lactate
- They are indicated in any child with shock.
- Hypotonic fluids such as half normal saline, Isolyte P or dextrose containing solutions such as Dextrose saline are not to be given as boluses in the presence of shock
IVF MAINTENANCE IN CNS DISORDERS

• Isotonic saline (NS) alone or with appropriate Dextrose and K.
• Maintain serum Na 145 – 150
• Normal volume, unless SIADH occurs
• Frequent monitoring of Na
COMMON IV FLUIDS

- 5 % Dextrose (D5)
- 10 % Dextrose (D10)
- Normal Saline (NS)
- Ringer Lactate (RL)
- 5% Dextrose Normal Saline (DNS)
- 5% Dextrose ½ Normal Saline (½ DNS)
- Isolyte P
- 3% Saline (Hypertonic Saline)
## COMPOSITION OF VARIOUS IV SOLUTIONS MEQ/L

<table>
<thead>
<tr>
<th>Solution</th>
<th>Na</th>
<th>K</th>
<th>Cl</th>
<th>HCO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Saline 0.9%</td>
<td>154</td>
<td>-</td>
<td>154</td>
<td>-</td>
</tr>
<tr>
<td>Dextrose saline</td>
<td>154</td>
<td>-</td>
<td>154</td>
<td>-</td>
</tr>
<tr>
<td>½ saline (0.45%)</td>
<td>77</td>
<td>-</td>
<td>77</td>
<td>-</td>
</tr>
<tr>
<td>Lactated Ringer’s solution</td>
<td>131</td>
<td>4</td>
<td>109</td>
<td>28</td>
</tr>
<tr>
<td>5% Dextrose</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Isolyte – P</td>
<td>30</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CLINICAL EVALUATION

1. Is there is dehydration
2. If so type and degree
3. Any electrolyte disturbances?
4. Acid Base disturbances?
5. How is the renal function?
## DEGREE OF DEHYDRATION

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Child: 3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant:</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>Child:</td>
<td>3%</td>
<td>6%</td>
<td>9%</td>
</tr>
</tbody>
</table>

### Type of dehydration

<table>
<thead>
<tr>
<th>Hypotonic</th>
<th>Isotonic</th>
<th>Hypertonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osm: &lt; 270</td>
<td>270-300</td>
<td>&gt;300</td>
</tr>
<tr>
<td>Sodium:</td>
<td>&lt;130</td>
<td>130-150</td>
</tr>
</tbody>
</table>
OVERHYDRATION

- Intravascular: Hypertension, respiratory distress, Pulmonary edema
- Interstitial: Edema. Puffiness, pedal, sacral
- Third spacing: Ascites, Pleural fluid,
• Degree of dehydration refer to Change in ECF volume: Mild
• Plasma sodium decides the type of dehydration.
• Isotonic (Isonatremic), hypotonic or hypertonic
# ELECTROLYTE CONCENTRATION OF STOCK SOLUTION FOR EVERY ONE ML

<table>
<thead>
<tr>
<th>IV Preparations - One ml</th>
<th>Electrolyte content</th>
</tr>
</thead>
<tbody>
<tr>
<td>3% saline</td>
<td>0.5mEq of sodium</td>
</tr>
<tr>
<td>8.4% Sodium bicarbonate</td>
<td>1 mEq of Na and HCO$_3$</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td>2 mEq of potassium</td>
</tr>
<tr>
<td>10% Calcium gluconate</td>
<td>9.3 mg of Elemental ca</td>
</tr>
<tr>
<td>10% Calcium chloride</td>
<td>27.3 mg of Elemental ca</td>
</tr>
</tbody>
</table>
WHEN TO ORDER ELECTROLYTE ESTIMATION?

- In the presence of dehydration or shock
- Any child with convulsions or neurological disturbances like weakness
- Any child with not gaining weight or fast breathing with normal respiratory examination
- In the presence of features of renal failure
Hyponatremia

Pseudo hyponatremia

True hyponatremia

1. Hypovolemic
2. Isovolemic
3. Hypervolemic
PSEUDOHYPONATREMIA

Hypernatremia is usually associated with low serum osmolarity. If normal or high, suspect pseudo.

1. Improper sampling: Vein proximal to IV site
2. Pseudohyponatremia: (Normal osm) Hyperlipidaemia, Hyperproteininaemia
3. Fictitious hypernatremia: (High Osm) Hyperglycaemia, Mannitol
<table>
<thead>
<tr>
<th>Hypovolemic Hyponatremia</th>
<th>Euvolemic Hyponatremia</th>
<th>Hypervolemic Hyponatremia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water ( ) and Na deficit( )</td>
<td>Water excess( )</td>
<td>Water ( ) and Na excess( )</td>
</tr>
</tbody>
</table>

**Causes**

1. Extrarenal loss (U Na < 20mmol/L) - Vomiting, diarrhea, 3rd spacing
2. Renal Loss (U Na > 20mmol/L) -
   - RTA
   - Cerebral salt wasting
   - Osmotic diuresis, DKA
   - Diuretic therapy,
   - Adrenal insufficiency
   - Pseudohypoaldoster

**Causes**

1. Water intoxication
   - Use of 5% Dextrose in post operative Period,
   - Psychogenic water drinking,
   - Tap water enema
2. SIADH

**Causes**

1. Renal failure (U Na > 40 mmol/L)
   - All others (U Na < 20 mmol/L)
2. Nephrotic syndrome
3. Congestive heart failure
4. Protein energy malnutrition
5. Cirrhosis liver
CASE SCENARIO: 8 Mo OLD WITH DIARRHEA, VOMITING AND CONVULSION

• In ER. Dehydrated, Irritable, weak peripheral pulses, HR 180 BP: 80/50. Not voided last 8 hrs., SpO2 93% with O2
• Serum Na-162 K-3.5 HCO3-20. Urea-50 Creatinine 1.0
• Diarrheal disease with shock and hypernatremic dehydration
HYPERNATREMIA - CAUSES

With dehydration: Diarrhea, DI

With normal hydration or Edema: Sodium excess (ORS, HCO3 therapy, Hypertonic saline)

Hyperaldosteronism, Cushing's syndrome
HYPERNATREMIC MANGO
CAUSES OF HYPOKALEMIA

1. Renal loss: Renal tubular acidosis, diuretic therapy and Bartter’s syndrome (Alkalosis)
2. G.I. Loss: Vomiting, diarrhea and laxative abuse
4. Limited intake: as in a child with malnutrition receiving potassium free I.V. fluid
HYPOKALEMIA-CLINICAL FEATURES

- Muscle weakness - head lag, hypotonia, weakness of limbs, phantom hernia, paralytic ileus,
- Arrhythmia, (particularly when the child is on digitalis).
- Features of primary disease
- ECG changes - depressed T wave, appearance of U wave and ST segment depression.
HYPERKALEMIA - CAUSES

- Defective excretion: Renal failure, Hypoadrenalism, Hyporeninemic hypoaldosteronism.
- Drugs: Spiranolactone, ACE inhibitors
- Shift from ICF to ECF: Acute intravascular hemolysis, trauma, tumor lysis syndrome and acidosis.
- Adrenal insufficiency
ECG CHANGES

Hyperkalemia
• Peaked T wave
• Prolonged P-R interval
• ST segment depression
• Wide QRS complex

Hypokalemia
■ Flat or inverted T
■ Appearance of U
■ ST depression.
MONITORING

- History: Vomiting, diarrhea, urine output and any other loss, sensorium
- Examination: Edema, hepatomegaly, neck veins in older children, HR, BP, lung fields
- Bedside: Body weight, Intake-Output chart, Urine color and sp gravity
- Lab: Electrolyte, urea, creatinine, Hematocrit, serum osmolarity, urine Sp. Gravity,
WHO’S WATCHING THE PATIENT?

Pierson, IN: Tobin, Principles and Practice of Critical Care Monitoring
“Internal environment” – those mechanisms by which the several organs within the body are coordinated to permit higher animals to enjoy functional stability

Nineteenth-century physiologist Claude Bernard
THANK YOU