Chapter 133
Fluid Therapy in Medical Disorders

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Almost every third hospitalized patient needs fluid infusion. Different types of fluids are used for intravenous (IV) therapy. Inappropriate IV fluid therapy (incorrect volume or incorrect type of fluid) is a significant cause of patient morbidity and mortality. Administration of the wrong type of fluid results in derangement of serum sodium concentration, which, if severe, leads to serious neurological injury. So it is important to have a basic understanding of the different IV fluids and to choose the fluid most appropriate to the patient’s needs. Proper fluid management plays very vital role in treatment of all critical patients.

WHY PATIENTS NEED INTRAVENOUS FLUID THERAPY?
Patient needs IV fluid therapy for maintenance (to supply daily needs), replacement (to replace deficit and on-going losses) and resuscitation (to correct an intravascular or extracellular deficit).

Aims of Fluid Therapy
- Correction of shock and establish proper tissue perfusion
- Correct fluid deficit and ongoing losses
- To provide maintenance requirement of fluid electrolyte if needed
- Proper selection of fluid so as to correct electrolyte and acid base disorder simultaneously.

Planning and Preparing Prescription of Intravenous Fluids
Goal of fluid therapy is to provide the right amount of the right fluid at the right time. Basic principle of fluid therapy is that fluid replacement should be as close as possible in volume and composition to those fluids lost for given patient.

Step 1: Assessment
While planning fluid therapy it is essential to consider:
- Volume status of patient (severity of dehydration)
- Etiology of dehydration
- Presence of electrolyte disorders (Na and K)
- Presence of acid base disorders
- Associated coexisting disorders [i.e. diabetes mellitus, hypertension, congestive heart failure (CHF), renal failure, liver failure, etc].

Step 2: Calculation of Volume of Intravenous Fluids
On the basis of volume status amount of IV fluids to be infused is calculated.

Step 3: Selection of Intravenous Fluids
According to the nature of fluid deficit and presence of electrolytes and acid base disorders select appropriate IV fluids.

Step 4: Determine Rate of Fluid Administration
- How fast to give IV fluids are decided on the basis of clinical assessment. Acute losses should be replaced quickly, while chronic losses should be replaced with caution.

How Much Fluid to Give?
Proper assessment of volume status (Table 1) and in sick patients’ invasive methods (Table 2) helps to determine the volume of fluid to be infused. Add the patient’s daily maintenance requirements to the fluid needed to replace the losses to make the total daily requirement. Watch carefully for a response to IV fluids and modify volume and rate of fluid infusion, if necessary. Since fluid overload is common, monitor every patient closely and be alert for its signs (Table 3).

Every patient responds differently to fluid therapy. More important than any rule on the volume of replacement fluids is to observe the patient’s response to volume infusion. The signs that you have given adequate IV fluids and can slow the infusion are increase in hypotension, reduction in tachycardia, increase in jugular venous pressure and increase in volume of urine in oliguric patient.

Which Fluid to Give?
Intravenous fluids to be infused in a given patient is selected on the basis of
- Composition of IV fluids (Tables 4 to 7).
- Underlying etiology and presence of electrolytes and acid-base disorders.
- Selection of intravenous fluids (Considering its Composition).

TABLE 1 | Presentation of dehydration

<table>
<thead>
<tr>
<th>Type of Dehydration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild dehydration</td>
<td>Up to 5% total body water (3 L in 70 kg man)</td>
</tr>
<tr>
<td>Moderate dehydration</td>
<td>5–10% total body water (5 L in 70 kg man)</td>
</tr>
<tr>
<td>Severe dehydration</td>
<td>10–15% total body water (6 L in 70 kg man)</td>
</tr>
</tbody>
</table>

TABLE 2 | Invasive methods for assessment of body fluids

Central venous line, arterial line and pulmonary artery catheter
Nephrology

- For proper selection of IV fluid it is essential to remember basic facts about its contents.
  
  Considering above mentioned basic facts proper selection of IV fluid should be done for given patient.

Selection of Intravenous Fluid in Common Clinical Problems

Fluid therapy in hypovolemic shock: Fluid loss leading to hypovolemia, hypotension and shock can be life threatening and requires emergent medical intervention. Amount of fluid to be given is decided by clinical and other guidelines (Table 1). Most important question to be answered is that which fluid should be given and why?

Potency of various IV fluids, colloids and blood products are different in correcting hypotension and shock, depending on its ability to expand intravascular volume (Table 8).

Selection of intravenous solution for initial treatment of hypovolemic shock:

- Fluids to be avoided: 5% dextrose, all isolyte fluids.
- Most effective agents: Colloids, albumin, blood products.
- Most preferred fluids: Isotonic saline, Ringer’s lactate.

For initial treatment of hypovolemic shock: Avoid 5% dextrose: Avoid 5% dextrose because (a) it is ineffective in raising blood pressure (1,000 ml of D-5% will increase intravascular volume only by 83 ml); (b) It carries risk of hyponatremia (as it lacks sodium) and (c) It leads to urinary fluid loss. Larger and faster infusion of D-5% (> 25 g/hour) will lead to hyperglycemia and osmotic diuresis. Two distinct disadvantages of osmotic diuresis are (1) it delays correction of dehydration and (2) it misguides clinician by creating false impression that there is satisfactory correction of fluid deficit. In such setting rate of fluid replacement may be reduced, despite hypovolemia. This can be detrimental.

Avoid all isolytes: Isolyte-M, -P and -G, all should be avoided in initial treatment of hypovolemic shock because of poor sodium content (so less effective in correcting hypotension); high potassium content (risk of hyperkalemia in oliguric patient) and its dextrose content (can lead to osmotic diuresis and fluid loss).

Isotonic saline is most preferred: Because it corrects hypotension effectively (1,000 ml of saline will increase intravascular volume by 300 ml so effective in raising blood pressure) and is safe even when glycemic status is not known. Advantages of saline over colloids/ blood products are less cost, easy availability and no risk of reaction.

Ringer’s lactate (RL) is preferred fluid: Because RL corrects hypotension effectively (1,000 ml of RL will increase intravascular volume by 200 to 240 ml approximately, so effective in raising blood pressure) and it is most physiological composition of RL is similar to extracellular fluid, so large volume of RL can be infused without fear of electrolyte imbalance. If patient needs more than 3–4 liters of normal saline, it carries risk of “expansion acidosis” and therefore balanced salt solution—Ringer’s lactate should replace 0.9% saline (except in cases of hypochloremia, e.g. from vomiting or gastric drainage).

Colloids, albumin, blood products most effective agents: All these agents are distributed chiefly in intravascular compartment, so they correct hypotension most effectively with least volume. However considering its cost and possible side effects, it should be used judiciously.

Fluid Therapy in Diarrhea

As diarrheal fluid is rich in sodium, bicarbonate and potassium, diarrhea leads to hypokalemic hyperchloremic metabolic acidosis with dehydration. Most of the patients with diarrhea-induced

### Table 3 | Signs and symptoms of fluid volume excess

- Tachycardia, increased blood pressure, edema, weight gain, orthopnea, distended neck veins, gallop rhythm, pulmonary edema, ascites and pleural effusion.

### Table 4 | Sodium concentration of various intravenous fluids

<table>
<thead>
<tr>
<th>Intravenous fluids</th>
<th>Isotonic saline</th>
<th>Ringer’s lactate</th>
<th>0.45% saline</th>
<th>Isolyte-G</th>
<th>Isolyte-M</th>
<th>Isolyte-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na (mEq/L)</td>
<td>154</td>
<td>130.0</td>
<td>77</td>
<td>63</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>3% NaCl 2 ml = 1 mEq Na, 7.5% NaHCO₃ 10 ml = 9 mEq Na</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 5 | Potassium concentration of intravenous fluids

<table>
<thead>
<tr>
<th>Intravenous fluids</th>
<th>Isolyte-M</th>
<th>Isolyte-P</th>
<th>Isolyte-G</th>
<th>Ringer’s lactate</th>
<th>KCl (15%) Amp</th>
</tr>
</thead>
<tbody>
<tr>
<td>K (mEq/L)</td>
<td>35.0</td>
<td>20.0</td>
<td>17.0</td>
<td>4.0</td>
<td>20 mEq/10 ml</td>
</tr>
</tbody>
</table>

### Table 6 | Characteristics of intravenous fluids

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Intravenous fluids</th>
<th>Characteristic</th>
<th>Intravenous fluids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most physiological</td>
<td>RL</td>
<td>Glucose free</td>
<td>Saline, RL</td>
</tr>
<tr>
<td>Rich in sodium</td>
<td>NS, DNS, RL</td>
<td>Sodium free</td>
<td>Dextrose solutions</td>
</tr>
<tr>
<td>Rich in chloride</td>
<td>NS, DNS, Iso-G</td>
<td>Potassium free</td>
<td>NS/DNS, dextrose solution</td>
</tr>
<tr>
<td>Rich in potassium</td>
<td>Iso-M, P and G</td>
<td>Avoid in liver failure</td>
<td>RL, Iso-G, 5% D</td>
</tr>
<tr>
<td>Corrects acidosis</td>
<td>RL, all isolyte</td>
<td>Avoid in renal failure</td>
<td>NS, RL, all isolyte</td>
</tr>
<tr>
<td>Corrects alkalosis</td>
<td>Isolyte-G, NS</td>
<td>Provides phosphorous</td>
<td>Isolyte-M</td>
</tr>
</tbody>
</table>

Abbreviations: RL, Ringer’s lactate; NS, Normal saline; DNS, Dextrose normal saline; Iso-G, Isolyte-G; Iso-M, Isolyte-M.
dehydration can be treated effectively with ORS. Few patients with severe dehydration and shock need IV fluid therapy. Ringer’s lactate is most preferred IV fluid to correct dehydration. Lactate content of RL gets converted in to bicarbonate by liver. As RL additionally provides bicarbonate it is preferred fluid in diarrhea. In severe form of diarrhea with acidosis and hypokalemia, treatment of both disorders needs to be done simultaneously and meticulously. If only metabolic acidosis is corrected rapid, potassium will be shifted intracellularly. If patient is hypokalemic, only correction of acidosis can precipitate dangerous hypokalemia. Common complain in such situation is weakness, uneasiness and difficulty in breathing with fall in SPO2.

On the contrary, without correction of acidosis, potassium supplementation can cause dangerous hyperkalemia. This is due to failure of potassium shift into the intracellular compartment (due to acidosis), even in state of potassium deficit of the body.

**Fluid Therapy in Vomiting**

Vomiting leads to hypokalemic hypochloremic metabolic alkalosis with dehydration. Most preferred IV fluid to correct dehydration due to vomiting is isotonic saline. Saline prevents further loss of potassium and effectively corrects rest of all electrolytes and acid-base disorders due to vomiting. To restore previous and ongoing potassium losses, 30–40 mEq/l potassium is added to saline (after correction of shock and in absence of oliguria or renal failure).

Isolyte-G is the specific fluid used for the replacement of upper GI loss, as it corrects all electrolyte abnormalities. This is the only fluid which corrects metabolic alkalosis directly. However this fluid should not be used:

- In presence of shock, oliguria and renal failure (because of 17 mEq/l potassium)
- In patients with liver disorder (because of its content ammonium chloride, which can precipitate or aggravate hepatic encephalopathy)
- In presence of associated diarrhea leading to acidosis (because Isolyte-G by providing H ion aggravates acidosis caused by diarrhea).

**Fluid Therapy in Combined Loss: Diarrhea and Vomiting**

Most preferred IV fluid to correct combined loss due to diarrhea and vomitting is isotonic saline with potassium supplementation. Ringer’s lactate preferred to correct deficit due to diarrhea, is detrimental in vomitting, as it aggravates metabolic alkalosis. Similarly Isolyte-G preferred to correct deficit due to diarrhea, is detrimental in diarrhoea as it aggravates metabolic acidosis.

**Fluid Therapy in Hyponatremia**

Hyponatremia is the most common and frequently missed electrolyte disorder. In all patients receiving maintenance fluids, measure serum sodium concentration daily to prevent hyponatremia. Completely avoid all hypotonic fluids in patients whose serum sodium concentration is low or falling rapidly (by > 8 mmol/L per day). Acute decreases in serum sodium concentration below 125 mmol/L with neurological symptoms is a medical emergency, and needs prompt, controlled correction of serum sodium concentration. Remember, rapid correction of chronic or asymptomatic hyponatremia can be detrimental.

- **Ruled out pseudohyponatremia**
- **Hyponatremia with dehydration** (combined loss of both salt and water, i.e. cholera): Supplement both fluid and water, i.e. isotonic saline or Ringer’s lactate
- **Hyponatremia with hypervolemia/anasarca** (retention of both, but retention of water greater than retention of salt, i.e. CHF, cirrhosis of liver): Restrict both fluid and water with loop diuretics.
- **Hyponatremia with euvoemila** (retention of water and loss of salt, i.e. Syndrome of inappropriate antiuretic hormone secretion): 3% NaCl-hypertonic saline in symptomatic patients, with strict fluid restriction and loop diuretics. Newer treatment modality in euvoemila and hypervolemica hyponatremia is vaptan (Vasopressin receptor antagonists). Advantages of vaptans are that they excrete only free water, without loss of sodium and potassium and raise serum sodium concentration.

**Fluid Therapy in Hepatic Encephalopathy**

**Basic Principles of Fluid Selection**

- Avoid hypoglycemia (high-risk due to hepatic failure leading to decreased glycogen storage).
- Avoid hypokalemia and metabolic alkalosis (high-risk due to vomitting and diuretics). These abnormalities may precipitate or aggravate hepatic encephalopathy.
Nephrology

• Avoid hyponatremia (high-risk due to vomiting and improper sodium deficit fluid infusion). These abnormalities may aggravate cerebral edema.
• Avoid hypotonic fluid (like 5% dextrose, which can aggravate cerebral edema).

Selection of Fluids

• 20% dextrose is preferred as it provides greater calories in lesser fluid volume.
• Provide adequate sodium rich fluids to correct deficit due to vomiting and diuretics and to provide maintenance need (about 100 mEq sodium per day). Similarly provide adequate potassium supplementation to correct deficit and to provide maintenance need.
• Avoid Ringer’s lactate. Due to hepatic dysfunction lactate may not get converted into bicarbonate by liver and its accumulation may lead to lactic acidosis.
• Avoid Isolyte-G. Due to hepatic dysfunction ammonia may not get converted into H ion and urea by liver and its accumulation may lead to hepatic encephalopathy.
• Edematous cirrhotic patients need fluid and salt restriction.

Fluid Therapy in Initial Phase of Stroke

Basic Principles of Fluid Selection

In initial treatment of patients with stroke,8

• Maintain euvoolemia. Avoid hypovolemic shock.
• Avoid hypotonic fluid and hypo-osmolality (which can aggravate cerebral edema).
• Avoid hyperglycemia (which can enhance brain injury and breakdown of BBB)

Selection of Fluid

• Avoid 5% dextrose, as it is hypotonic and it leads to hyperglycemia.
• Ringer’s lactate is appropriate fluid if volume of infusion is small. But avoid if large fluid volume is required because of its slightly low osmolality (Plasma 285 mOsm/L versus RL 274 mOsm/L) and presence of calcium in same, which may promote reperfusion injury.
• Isotonic saline is the ideal IV fluid.

SUMMARY

• Select appropriate fluids considering etiology and associated electrolytes/acid base disorders.
• In correction of hypovolemic shock isotonic saline is the most preferred–fluid and colloid or blood products are most potent agents.
• In diarrhea RL, in vomiting isotonic saline and in combined loss isotonic saline with potassium supplementation are most preferred IV fluids.
• In hyponatremia, principles of fluid and salt supplementation are totally different hydration status.
• In hepatic encephalopathy goal of fluid therapy is to prevent and correct dehydration, hypoglycemia, hypokalemia, hyponatremia and metabolic alkalosis to avoid hypotonic fluids.

REFERENCES