Approach to fluid therapy

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Like we said in surgical practice patients who are excepted to undergo surgery are kept NPO, so fluid replacement (IV) is necessary.

Also as you know during surgery the patient is expected to lose some degree of fluid based on the surgery.

So if the patient is kept NPO, there is no input, only output (kidney, skin, lungs, feces), the patient may enter the surgery with a preexisting deficit that will predispose to complications, like?

- Acute renal failure
- Hypovolemia
Formula

Let's keep in mind that NPO will cause fluid and electrolyte deficits not just water loss from the body.

Our maintenance fluid therapy has a simple equation; they sometime call it the 4 2 1

As you can see
It depends
On body weight
This is for water!

<table>
<thead>
<tr>
<th>Weight (kg)</th>
<th>Hourly</th>
<th>Daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10 kg</td>
<td>4 mL/kg/hr.</td>
<td>100 mL/kg/day</td>
</tr>
<tr>
<td>10 –20 kg</td>
<td>40 mL + 2 mL/kg for every kg &gt;10 kg</td>
<td>1000 mL + 50 mL/kg/day for every kg &gt;10</td>
</tr>
<tr>
<td>&gt;20 kg</td>
<td>60 mL + 1 mL/kg for every kg &gt;20 kg</td>
<td>1500 mL + 20 mL/kg/day for every kg &gt; 20</td>
</tr>
</tbody>
</table>

4-2-1 rule EXAMPLES

For a 5 kg infant, Maintenance Hourly Fluid (water) Requirements would be:
4 x 5 = 20 ml/hr.
Daily rate: 20 x (24 hr) = 480 ml/day

For a 15 kg child, Maintenance Hourly Fluid (water) Requirements would be:
4 x 10 = 40 ml + 2 x 5 = 10 ml
Total: 40 + 10 = 50 ml/hr.
Daily rate: 50 x (24 hr) = 1200 ml/day
Now like we said we lose water and electrolytes, we managed the water now we need to manage the electrolyte loss by either the type of solution of adding electrolytes to the solution.

Daily requirements for:

- Na: 1-2 mEq/Kg BW/day
- Ka: 1-2 mEq/Kg BW/day
- CL: 1.5 mEq/Kg BW/day

Just for knowledge:

- 1 mmol of sodium or potassium = 1 mEq
- 2 mmol of Ca+2 = 1 mEq
The most common maintenance fluid is D5 ½ NS with 20 or 40 mEq KCL (because as we said normal saline doesn’t have potassium).

But usually its 20 mEq because with 40 you have higher risks on the cardiac conducting system.

20 mEq of potassium = 1500 mg (daily requirement 3.5-4.6 g)

5 mEq of sodium = 100 mg (daily requirement of < 2g)

So if we have an adult male patient that weighs 70kg, what is the maintenance therapy plan for him? You tell me…

\[
\begin{align*}
\text{Na} & = 1.5 \text{ mEq} \times 70 = 105 \text{ mEq/day} \\
\text{K} & = 1 \times 70 = 70 \text{ mEq/day}
\end{align*}
\]

So our choice is D5 ½ NS + KCL.
Deficit

So clinically a patient presenting for surgery after an overnight fast without any fluid intake will have a preexisting deficit which is proportional to the duration of fast.

So lets say as a definition: it’s the fluid that has already been lost, in contrast to replacement which we will talk about in a minute which refers to both the deficit + ongoing losses + future losses

Now how can we calculate the deficit??

Same as maintenance therapy formula, it will give a rough estimate because in reality we have renal conservation so the deficit will be less
When replacing the deficit we give an infusion rate higher than the normal maintenance rate until the deficit is corrected.

It’s about 3 to 4 times the maintenance rate.

Once its corrected u go back to the same rate as before.

Now what if the duration of fasting is unknown or it is known but the patient has abnormal fluids losses (sweating, diarrhea, ascites), what will we do?

We will approximate bases on clinical data (physical exam).

This is effected by the chronicity of the condition so the longer the worse the deficit.

So we look at signs of hypovolemia......
## Degree of dehydration

<table>
<thead>
<tr>
<th>Clinical signs</th>
<th>mild</th>
<th>moderate</th>
<th>severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease in body weight</td>
<td>3-5%</td>
<td>5-10%</td>
<td>10-15%</td>
</tr>
<tr>
<td>Skin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turgor</td>
<td>normal</td>
<td>decreased</td>
<td>Markedly decreased</td>
</tr>
<tr>
<td>Color</td>
<td>normal</td>
<td>pale</td>
<td>markedly decreased</td>
</tr>
<tr>
<td>Mucous membranes</td>
<td>Dry</td>
<td></td>
<td>Mottled or gray; parched</td>
</tr>
<tr>
<td>Hemodynamic signs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>normal</td>
<td>slight increase</td>
<td>tachycardia</td>
</tr>
<tr>
<td>Capillary refill</td>
<td>2-3 s</td>
<td>3-4 s</td>
<td>&gt;4 s</td>
</tr>
<tr>
<td>blood pressure</td>
<td>normal</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>perfusion</td>
<td>normal</td>
<td></td>
<td>circulatory collapse</td>
</tr>
<tr>
<td>Fluid loss</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>urinary output</td>
<td>mild oliguria</td>
<td>oliguria</td>
<td>anuria</td>
</tr>
<tr>
<td>Tears</td>
<td>Decreased</td>
<td></td>
<td>absent</td>
</tr>
<tr>
<td>Urinary indices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>specific gravity</td>
<td>&gt;1.020</td>
<td></td>
<td>anuria</td>
</tr>
<tr>
<td>Urine [Na+]</td>
<td>&lt;20mEq/L</td>
<td></td>
<td>anuria</td>
</tr>
</tbody>
</table>
But as you can see this is not very rational or this is hard and a very rough estimate.

So a more rational approach is to diagnose that we actually have a deficit then just treat based on restoration of vital signs and maintaining a good urine output (0.5-1 ml/kg per hour) and correction of base deficit if present.

To achieve this usually the main stay is 1-2 liters of isotonic fluid, 1 liter bolus/hour followed by a continuous infusion and monitoring.

The crystalloid given depends on the particular electrolyte profile.
Replacement of fluids can be pre or intra operatively.

When replacing fluids we have to know from which compartment is the fluid lost (blood, GI, thirst space) so we can give the correct type of fluid needed.
Blood loss

Briefly because my college's will talk about blood products

Most common way to estimate blood loss during surgery is to measure blood in:

Suction container

Visually (soaked sponges (4x4, 10 ml), soaked lap (100-150ml))

And even serial hematocrit can be done in long surgeries

And like we know each ml of blood needs about 3 to 4 ml of crystalloids or 1 ml of colloid
Third space loss

What is third space?

It's a space that is neither the intra or extracellular compartments.

Like?

In ascites

bowel lumen

Thirst space loss or third spacing??

When too much fluid from the intravascular space moves into the interstitial or third space (non-functional areas) that causes serious problems; hypotension, reduced CO, edema.
The estimation of fluid loss is very hard here, if we have ascites we can do aspiration or maybe nasogastric tube in ileus mthln

Example:

70 kg patient with ileus, lost 2l of fluid in a nasogastric aspirate, aspirate has 240 mEq of sodium and 20 mEq of potassium

What is the replacement therapy and what type of fluid would u use?

Lets take it step by step
We start by the maintenance which like we calculated is approximately 2.5 L.

We add these to the 2 liters he lost so now we need 4.5 L.

Now the sodium like we said in maintenance 105 mEq add the 240 lost so we need 345 mEq.

Potassium lost is 20 so also add 105 we need 125 mEq of potassium.

So we can start with 2 bags of normal saline (has about 300 mEq of sodium).

Then 1 liter of ¼ NS about 39 mEq of sodium.

And add 1 liter of D5 with 120 kcl (6 bags each 20 mEq).
Intra-op thirdspacing

Intra op its highly dependent on type of surgery and size of incision!

Usually replaced by lactated ringer solution

Small excision: 1-3 ml/kg/hour (like hernia)

Medium excision: 3-7 ml/kg/hour (uncomplicated sigmoidectomy)

Large incisions: 9-11 ml/kg/hour (pancreatoduodenectomy)
<table>
<thead>
<tr>
<th></th>
<th>Volume</th>
<th>Na⁺</th>
<th>K⁺</th>
<th>Cl⁻</th>
<th>HCO₃⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma</td>
<td></td>
<td>140</td>
<td>5</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Gastric secretions</td>
<td>2500</td>
<td>50</td>
<td>10</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Intestinal fluid (upper)</td>
<td>3000</td>
<td>140</td>
<td>10</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Bile and pancreatic secretions</td>
<td>1500</td>
<td>140</td>
<td>5</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Mature ileostomy</td>
<td>500</td>
<td>50</td>
<td>5</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Diarrhoea (inflammatory)</td>
<td></td>
<td>110</td>
<td>40</td>
<td>100</td>
<td>40</td>
</tr>
</tbody>
</table>

*If gastrointestinal loss continues for more than 2–3 days, samples of fluid and urine should be collected regularly and sent to the laboratory for measurement of electrolyte content.*
A few words only:

Blood loss we replace with crystalloids or colloids to maintain intravascular volume.

Now if the danger of anemia outweighs the risk of transfusion, at this point further blood loss is replaced with transfusion of rbcs to maintain hemoglobin.

And like we explained before depending of type of surgery and wound and so on we replaced fluids lost during surgery.
A brief note

There is something called Allowable Blood Loss:
Which is the amount of blood lost that doesn’t need resuscitation
Which can be calculated by $EBV \times (Hi - Hf)/Hi$
Estimated blood volume (75ml/kg in males, 65ml/kg females)
Initial hemoglobin
Final hemoglobin