**INTRODUCTION**

The aims of fluid therapy are rehydration, replacement of ongoing losses, and maintenance. In sanctuaries, one of the most common causes of dehydration is diarrhoea, and, after briefly discussing other needs for fluid therapy, this is concentrated on in this booklet. The booklet is divided into 3 sections. The first looks at general principles of fluid therapy, the second on oral rehydration therapy and the third on parenteral fluid therapy. Note that treatment of malnutrition, itself another major cause of dehydration, is dealt with in a separate booklet.
GENERAL PRINCIPLES

Distribution of Body Fluids

Total Body Water = 60% body weight, half is extracellular, half is intracellular. Of the extracellular, 5% body weight is intravascular (plasma) and 15-25% body weight is interstitial fluid.

Blood volume = 7-10% body weight

Parenteral vs. oral fluids

Regulation of water and electrolytes (and thus blood volume) is a function of the kidney. If there is not enough blood flow to the kidney, this regulation breaks down. However, if the kidneys are working, and the animal is not excessively vomiting, oral administration of fluids is best – the kidney is better at working out the animal’s requirements than most vets! The commonest situation where oral fluids are used is diarrhoea.

In most other circumstances, intravenous administration (via a large bore indwelling catheter) is best. If the animal’s blood volume is low (so low pressure), a vein may be hard to catheterise. The answer is to do a sterile cut down onto the vein; this is quicker and better for the animal than proplonged poking about the region of the vein followed by the administration of fluids by an inappropriate route.

If all else fails, fluids can be given intraperitoneally. Since the peritoneal cavity is only a potential space under normal circumstances, the chances of hitting an organ with the needle are high.

Subcutaneous administration is not a good way to give fluids because if the animal has a low blood volume/ acidosis the blood vessels supplying the skin will be constricted. This is done to divert blood to vital organs but will also mean that the fluid will not be absorbed. Some fluids (dextrose 5%) will cause vasoconstriction and actually draw fluid out of circulation into the subcutaneous depot! Also, apes in particular don’t have a large subcuticular space.

Intraosseous administration has been used in puppies, kittens, birds, reptiles and baby monkeys. Injections via this route are extremely painful in man, when a neonatal animal is so sick as to be unable to fight back it is hardly sporting to subject it to excrutiating pain as well. Infection is another problem when using this route – the consequences are likely to be disastrous.
TABLE 1. WHICH FLUIDS TO USE FOR WHICH SITUATION

<table>
<thead>
<tr>
<th>Condition</th>
<th>Loss</th>
<th>Fluid Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemorrhage</td>
<td>All blood components</td>
<td>MILD – colloids (crystalloids)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SEVERE – (fresh) whole blood</td>
</tr>
<tr>
<td>Dehydration (not drinking enough)</td>
<td>Water</td>
<td>NaCl 0.18% + dextrose 4%, dextrose 5% (KCl 10-20 mmol/L added after 2 days)</td>
</tr>
<tr>
<td>Vomiting</td>
<td>Water, H+, Na+, K+, Cl-</td>
<td>NaCl 0.9%, Ringers (KCl 10-20 mmol/L added after 2 days)</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>Water, HCO3-, Na+, K+, Cl-</td>
<td>Oral fluids (see Section 2), LRS (KCl 10-20 mmol/L added after 2 days)</td>
</tr>
<tr>
<td>Severe vomiting and diarrhoea</td>
<td>Water, HCO3-, Na+, K+, Cl-</td>
<td>Colloid + LRS</td>
</tr>
<tr>
<td>Peritonitis</td>
<td>Plasma + ECF</td>
<td>Colloid + LRS</td>
</tr>
<tr>
<td>Gut Obstruction</td>
<td>Water, HCO3-, Na+, K+, Cl-</td>
<td>Colloid + LRS + NaHCO3</td>
</tr>
<tr>
<td>Urethral obstruction</td>
<td>Retention of H+, K+</td>
<td>NaCl 0.9% + dextrose 5%</td>
</tr>
</tbody>
</table>

**PRINCIPLES OF FLUID THERAPY**

Fluid therapy is based on an assessment of the degree of dehydration present. Principles are as follows:

- **No dehydration** - If diarrhea is present, but urinary output is normal, the normal diet may continue with fluid intake dictated by thirst. High osmolality fluids such as undiluted juices should be avoided, and maintenance oral electrolyte solution (Na 45-60 mmol/L) offered "ad libitum."
- **Mild** - If symptoms and signs are limited to decreased urinary output and increased thirst, mild dehydration is suspected. Assessment and treatment under close supervision are indicated. Rehydration consists of ORS or maintenance solution 10 mL/kg/hr with reassessment at 4-hour intervals. Early
refeeding is recommended. Extra ORS or maintenance solution (e.g., 5-10 mL/kg) may be given after each stool if diarrhea persists.

• **Moderate** - If at least two of the following signs, sunken eyes, loss of skin turgor ("tenting" of abdominal skin lasting less than 2 seconds), or dry buccal mucous membranes are present, moderate dehydration is diagnosed and rehydration consisting of ORS 15-20 mL/kg/hr with direct observation and reassessment at 4-hour intervals. If dehydration is corrected, therapy for ongoing losses and maintenance are continued as outlined above. If not, treatment is repeated as indicated by clinical signs or symptoms.

• **Severe** - If, in addition to signs of moderate dehydration, there is rapid breathing, lethargy, coma, a rapid thready pulse or "tenting" of the skin lasting more than 2 seconds, severe dehydration and shock are present. Blood pressure should be measured. Prompt intravenous therapy is indicated with rapid infusion of saline plasma or colloid sufficient to replete blood volume (10-20 mL/kg over 30 minutes may be necessary). Intraosseous infusion should be used if an intravenous line cannot quickly be inserted.

<table>
<thead>
<tr>
<th>% DEHYDRATION</th>
<th>CLINICAL SIGNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>None detectable. Rely on history</td>
</tr>
<tr>
<td>5-6</td>
<td>Subtle loss of skin elasticity</td>
</tr>
<tr>
<td>6-8</td>
<td>Definite delay in return of skin to normal position</td>
</tr>
<tr>
<td></td>
<td>+/- Eyes sunken into head (reduced fat content)</td>
</tr>
<tr>
<td></td>
<td>+/- Dry mucous membranes</td>
</tr>
<tr>
<td>10-12</td>
<td>Tented skin stands in place</td>
</tr>
<tr>
<td></td>
<td>Prolongation of CRT</td>
</tr>
<tr>
<td></td>
<td>Eyes sunken into orbits</td>
</tr>
<tr>
<td></td>
<td>Dry mucous membranes</td>
</tr>
<tr>
<td></td>
<td>+/- signs of shock (increased heart rate, cool extremities, weak pulse)</td>
</tr>
<tr>
<td>12-15</td>
<td>Definite signs of shock – death imminent unless rapid therapy</td>
</tr>
</tbody>
</table>

**THE PHYSIOLOGICAL PROCESS DURING DIARRHOEA.**

In the normal healthy intestine, there is a continuous exchange of water through the intestinal wall – in humans up to 20 litres of water is secreted and very nearly
as much is reabsorbed every 24 hours - this mechanism allows the absorption into the bloodstream of soluble metabolites from digested food.

In a state of diarrhoeal disease the balance is upset and much more water is secreted than is reabsorbed causing a net loss to the body which can be as high as several litres a day. In addition to water, sodium and other minerals are also lost (see table 1). The body's store of sodium (in the form of sodium ions Na+) is almost entirely in solution in body fluids and blood plasma, i.e., extra cellular (ECF)- by contrast 98% of the body's total potassium (K+) is held within cells i.e. intra-cellular (ICF).

The concentration of Na+ in the extracellular fluid has to be held to within close limits (135-150 mmol/l) for the proper functioning of the body. As mentioned above sodium concentration is normally precisely controlled by the renal function, however in a state of dehydration water is conserved by anuria (no urine production) and the sodium regulation cannot work effectively.

Thus continued diarrhoea causes rapid depletion of water and sodium, which is to say a state of dehydration. If more than 12% of the body's fluid is lost death occurs.

Simple giving a saline solution (water plus Na+) by mouth has no beneficial effect because the normal mechanism by which Na+ is absorbed by the healthy intestinal wall is impaired in the diarrhoeal state and if the Na+ is not absorbed neither can the water be absorbed. In fact excess Na+ in the lumen of the intestine causes increased secretion of water and the diarrhoea worsens.

If glucose (also called dextrose) is added to a saline solution a new mechanism comes into play. The glucose molecules are absorbed through the intestinal wall - unaffected by the diarrhoeal disease state - and in conjunction sodium is carried through by a co-transport coupling mechanism. This occurs in a 1:1 ratio, one molecule of glucose co-transporting one sodium ion (Na+).

It should be noted that glucose does not co-transport water - rather it is the now increased relative concentration of Na+ across the intestinal wall which pulls water through after it.

Several other molecules apart from glucose have a similar capacity to co-transport Na+ including

- aminoacids (e.g. glycine)
- dipeptides
- tripeptides

The absorption of these molecules may occur independently of each other at different sites - thus their effect can be additive. Research is currently being carried on to utilize these additive effects to develop a multi-component "Super ORS".
Starch is metabolised in the intestine to glucose and therefore it has the same properties of enhancing sodium absorption, however it has an added advantage that it has less osmotic effect, which would act to pull water back into the lumen of the intestine.

**Oral Rehydration Therapy (Ort)**

Acute diarrhea normally only lasts a few days. ORT does not stop the diarrhoea, but it replaces the lost fluids and essential salts thus preventing or treating dehydration and reducing the danger.

The glucose contained in ORS solution enables the intestine to absorb the fluid and the salts more efficiently.

ORT alone is an effective treatment for 90-95% of patients suffering from acute watery diarrhoea, regardless of cause. This makes intravenous drip therapy unnecessary in all but the most severe cases.

**The Composition of Ors, and findings in people.**

In deciding the optimal composition of an oral rehydration solution the following considerations must apply:

**Sodium** - losses of sodium in the stool range from 50-60 meg/l to well over 100 meg/l in cholera and in fact total body depletion of sodium may be higher than stool losses alone indicate. For this reason a Na+ concentration of 90 meg/l is considered an optimal figure for replenishing Na+ in dehydration from diarrhoea caused by any etiology and in all age groups from neonates to adults.

For some years there was controversy over optimum concentration of sodium in oral rehydration fluids, which stemmed from the fact that in the early days of its use, particularly in USA, causes of hypernatraemia (excess sodium) occurred fairly frequently in infants given oral rehydration therapy.

The apparently obvious answer was to assume that the sodium concentration in the oral rehydration fluid used was too high and to reduce it (even to as low as 25 or 30 meg/l). Unfortunately, the apparently obvious was not the correct answer - actually nearly all these children were being given high-solute infant formula which tended to make them hypernatraemic to start with and the oral rehydration solution used then contained excess glucose - up to 8% - which was added to provide extra nutritive calories. Unfortunately, the excess glucose cause osmotic diarrhoea which precipitated acute hypernatraemia in these children.

The less obvious but correct answer was to reduce the glucose content not the sodium - we now recognize that the sodium and glucose should be in a 1:1 ratio in terms of molarity.
Experience has now shown that even hypernatraemic neonates with dehydration can be successfully rehydrated and made normonatraemic using the standard WHO / UNICEF ORS formula (with 90 meg/l Na+) when the water intake is sufficient to ensure normal kidney function and hence physiological regulation of the sodium concentration in the plasma.

Although ORS with a sodium content of around 50 meq/l is sufficient for maintenance of hydration of a normally will-nourished child with diarrhoea it would be inadequate for rehydration of a patient with a secretary diarrhoea (e.g., cholera) losing considerable sodium in the stool.

**Glucose** should be close to equivalent with the Na+ content - it is 111 mmol/l in the WHO / UNICEF formula, which happens to be exactly 2%. It should be noted that if glucose is present in excess of 3% it will cause further losses of water through osmotic effects, this would also upset the electrolyte balance, sine increased water losses will result in hypernatraemia.

**Potassium.** Although 98% of the body's potassium is held within the cells, repeated diarrhoeal attacks over a period of time will cause a chronic loss of potassium - this results in muscular weakness, lethargy and anorexia. The typical distended abdomen of a chronically malnourished child is caused by loss of muscle tone in the abdominal wall largely due to chronic depletion of potassium. The kidneys are unable to conserve potassium as they do sodium, and there is a continuous obligatory loss of potassium of about 10 mmol daily in the urine, in addition to the larger losses in the stool.

Potassium is not involved in any way in the sodium/glucose co-transport mechanism and is absorbed passively. Restoration of potassium levels is therefore achieved more slowly than sodium and water restoration. A potassium concentration of 20 mmol/l is considered optimal for the purpose.

Simple mixtures of sugar, salt and water or starch, salt and water contain no potassium and cannot restore potassium depletion - hence these mixtures are an "incomplete" formula and further potassium supplementation is definitely necessary for a child who suffers repeated attacks of diarrhoea.

A potassium-rich diet including e.g. bananas or coconut water can be helpful but an ORS solution containing potassium is therapeutically more effective - in order to produce a significant effect it is necessary to provide potassium-rich foods in reasonable large quantities over a period of time.

Restoring a potassium deficit will stimulate the appetite and activity of the patient. If additional food is provided over several weeks an increase in weight gain will occur and the status of the animal's health will improve markedly.

**Correcting Acidosis**
Electrolyte imbalance and fluid loss also causes metabolic acidosis. These effects are more critical in the case of infants, as their renal function is not fully developed and they have a large surface area in ratio to body weight and a higher metabolic rate. Acidosis is corrected by the addition of bicarbonate (or another base such as citrate) to the ORS formula.

**How Does Ort Work?**

The causative pathogens of diarrhoeal disease (which are very numerous) in some cases not only produce the secretion of water and sodium but also damage the intestinal wall. The normal healthy intestine is covered on its inner surface with very numerous tiny hairs, or villi, the surface cells of which are involved in the absorption of metabolites from ingested food. There is a difference between the cells of the tips of the villi and the cells of the base in their absorptive functions.

Pathogens, e.g., rotavirus, may strip the tips of the villi from large patches of the intestinal wall thus decreasing the surface area and decreasing by more than 50% the specific absorptive capacities of the intestine. The result is malabsorption which can cause malnutrition - most especially in an infant already nutritionally compromised by repeated previous attacks of diarrhoea.

Withholding food, even for one or two days, greatly exacerbates the malnutrition; this coupled with anorexia, caused partly by chronic potassium depletion, causes a vicious circle, i.e. diarrhoea causing malnutrition and malnutrition causing ever more frequent and severe diarrhoea. It is this diarrhoea/malnutrition cycle rather than acute dehydration that causes almost half of the five million deaths a year in under five year old children that are associated with diarrhoeal disease. Oral rehydration therapy (ORT), using a simple, inexpensive, glucose and electrolyte solution promoted by the World Health Organization (WHO) has reduced the number of deaths from dehydration due to diarrhea in the human population by about a million per year.

Oral rehydration takes advantage of glucose-coupled sodium transport, a process for sodium absorption which remains relatively intact in infective diarrheas due to viruses or to enteropathogenic bacteria, whether invasive or enterotoxigenic. Glucose enhances sodium, and secondarily, water transport across the mucosa of the upper intestine. For optimal absorption, the composition of the rehydration solution is critical. The amount of fluid absorbed depends on three factors: the concentration of sodium, the concentration of glucose and the osmolality of the luminal fluid. Maximal water uptake occurs with a sodium concentration from 40 to 90 mmol/L, a glucose concentration from 110 to 140 mmol/L (2.0 to 2.5 g/100 mL) and an osmolality of about 290 mOsm/L, the osmolality of body fluids. Increasing the sodium beyond 90 mmol/L may result in hypernatremia; increasing the glucose concentration beyond 200 mOsm/L, by increasing the osmolality of the solution, may result in a net loss of water. CHO to Na ratio should not exceed 2:1 in these solutions. Rehydration can be accomplished using solutions with higher sodium, i.e., 75-90 mmol/L. These are termed rehydration solutions (ORS).
Prophylaxis of dehydration and maintenance involve solutions with 45-60 mmol/L of sodium. These are termed **maintenance solutions**. High sodium rehydrating solutions used to treat acute dehydration may be used for maintenance by giving the solution alternately on a 1-to-1 basis with a no-sodium or low-sodium fluid such as water, low CHO fluids, or breast milk. The high sodium ORS should not be used as the sole fluid intake for maintenance of hydration. Fruit juices and pop are not efficacious because of their high carbohydrate concentration, osmolality and the inadequate sodium concentration. Individualized dietary management of the patient during acute diarrhoea is the key and should be emphasised.

**TABLE 3: Some commonly available Oral rehydration solutions and their components**

<table>
<thead>
<tr>
<th>Component</th>
<th>Rehydration</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WHO</td>
<td>Rapolyte</td>
</tr>
<tr>
<td>Sodium (mmol/L)</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Potassium (mmol/L)</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Chloride (mmol/L)</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Bicarbonate (mmol/L)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Glucose (g/L)</td>
<td>50</td>
<td>25</td>
</tr>
</tbody>
</table>

Oral rehydration and maintenance solutions presently in use, although effective in rehydration, do not decrease stool volume because of the relatively high osmolality of the glucose which they contain. The challenge, therefore, is to provide adequate glucose to the sodium pump without increasing the osmolality of the rehydration solution.

This has been done successfully by substituting short chain glucose polymers (starch) from rice and other cereals for glucose in the oral rehydration mixture. In field trials in developing countries, ORS containing glucose polymers, primarily from rice and corn, were found not only to be as effective in correcting dehydration as glucose-based ORS, but also to offer the additional advantage of reducing the amount and duration of diarrhea by 30%, thereby reducing morbidity and costs of treatment and increasing acceptability. Defined short-chained glucose polymers from rice may also be safe and effective in the treatment of acute diarrhea. Wapnir et al found that a solution containing 30 g/L of rice...
syrup solids (180 mOsm/L) resulted in 40% more water absorption than a similar solution which contained 20 g/L of glucose (230 mOsm/L). A clinical study with solutions containing rice-syrup solids confirmed their efficacy in the rehydration of infants with acute diarrhea. Further, such solutions decreased stool output, and promoted greater absorption and retention of fluid and electrolytes than did a glucose-based solution.

Amino acids have also been suggested as additives to ORS. The addition of alanine alone to the WHO oral rehydration solution (ORS) was not found to give additional benefits. However, Khin-Maung-U and Greenough found that alanine, added to a glucose polymer-based ORS, decreased the amounts of stool by a further 10% to 40%. Nevertheless, these are not currently recommended by WHO. Rice-based corn and lentil-based oral rehydration solutions have been extensively tested and may eventually be made available.

Along with improved oral rehydration solutions have come advances in the field of early refeeding. Fasting has been shown to prolong diarrhoea. This may be due to undernutrition of the bowel mucosa which delays the replacement of mucosal cells destroyed by the infection. Early refeeding with a lactose-containing formula is usually well tolerated and should commence 6-12 hours into therapy.

**General Comments, Ort Protocol and Recommendations**

Vomiting is not a contraindication to ORT. ORS should be given slowly but steadily to minimize vomiting. Fluids may be administered by nasogastric tube if required. The animal’s clinical condition should be frequently assessed. An infant should never be kept on ORS fluid alone for more than 24 hours. Early refeeding should begin within 6 hours. A full diet should be reinstated within 24 to 48 hours, if possible.

**There are certain contraindications to the use of ORT**

- Protracted vomiting despite small, frequent feedings
- Worsening diarrhea and an inability to keep up with losses
- Stupor or coma
- Intestinal ileus.
TABLE 4: Simplified ORT protocol in mild to moderate rehydration

<table>
<thead>
<tr>
<th>Assessment of dehydration</th>
<th>0-5%</th>
<th>5-10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st hour</td>
<td>20 mL/kg/hr</td>
<td>20 mL/kg/hr</td>
</tr>
<tr>
<td>For next 6-8 hours</td>
<td>10 mL/kg/hr administered evenly</td>
<td>15-20 mL/kg/hr</td>
</tr>
<tr>
<td>Reassessment at 4-hour intervals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-24 hrs</td>
<td><em>Ad libitum</em> ORT solution</td>
<td>idem</td>
</tr>
<tr>
<td></td>
<td>Early refeeding</td>
<td>idem</td>
</tr>
<tr>
<td>&gt; 24 hrs</td>
<td>Delayed refeeding only if severe vomiting</td>
<td>idem</td>
</tr>
</tbody>
</table>

There are many different equations for calculating administration rates in oral rehydration. ORT may be given in amounts equal to fluids calculated for intravenous administration. Alternately, fluids may be delivered by nasogastric tube.

RECOMMENDATIONS

- Dehydration accompanying infantile gastroenteritis should be treated with early oral rehydration and early refeeding strategies.
- Infants with gastroenteritis should be offered maintenance solution to prevent dehydration.
- Antidiarrheal drugs, antibiotics and antiemetic therapy are rarely indicated in gastroenteritis in juveniles and should be discouraged.
- Home-made oral rehydration solutions are discouraged since serious errors in formulation have occurred.
- Infants with mild to moderate dehydration should be treated under medical supervision with ORT in preference to intravenous rehydration.
- Infants with severe dehydration should initially be treated with intravenous or intraosseous rehydration.
- Early refeeding should commence as soon as vomiting has resolved, approximately 6-12 hours.
- Non-lactose containing formulae or milks may be used if diarrhea and abdominal cramps persist beyond expected 5- to 7-day course suggesting clinical lactose intolerance.
- Further initiatives to encourage ORT use by patients and professionals should be developed.

PARENTERAL FLUID THERAPY

Parenteral Fluid Therapy Routes (Also See Section 1)

Subcutaneous

This is convenient for MAINTENANCE fluids. However it is inefficient in extreme dehydration because the intense vasoconstriction reduces absorption of the administered fluid. Only isotonic solutions should be given. SC.
administration of 5% dextrose should be avoided because equilibration of ECF with a pool of electrolyte free solution may result in aggravation of electrolyte imbalance.

**Intraperitoneal**

An easy method of fluid administration with a large reservoir for fluid introduction. However, fluid uptake is uncontrolled. The pH of the fluid administered may cause a chemical peritonitis and a peritoneal sepsis may result from a defective aseptic technique. If solutions are too cold, emesis or shock may develop.

**Intraosseous**

Can be used in any animal where a bone marrow needle can be placed and venous access is compromised. **This should only be conducted under anaesthesia, as it is extremely painful.**

**Intravenous**

When fluid loss is sudden (haemorrhage) or extensive, the IV route must be used. Catheters increase the efficiency and ease of IV fluid administration, (and blood sample collection), and reduce stress and pain to the animal. The saphenous vein provides an excellent, easily accessible site to place a catheter in monkeys, and this or the cephalic vein can be used in baby chimps.

Under visual guidance, or by palpating the vein with a gloved fingertip, the needle should be inserted about 1mm medial to the vein at an acute angle to penetrate it. To avoid haemolytic reactions and rapid coagulation, the use of wide lumen needles (0.9mm) and regular heparin flushes are recommended to maintain patency.

**FORMULATING A PARENTERAL FLUID THERAPY PLAN**

**Replacement**

Fluid and electrolyte deficit is most commonly due to vomiting, diarrhoea, haemorrhage or urinary loss. Fluid for replacement should therefore contain electrolytes that are approximately the same concentration as that lost. This is usually LACTATED RINGERS SOLUTION (HARTMANN’S). This will often need supplementation with 20mEq/L of KCl to add the required potassium.

Exceptions to LRS administration include

- Pulmonary and cerebral oedema
- Ruptured bladder (use 0% saline)
Congestive heart failure (use 0.45% saline + 2.5% dextrose OR ½ strength LRS + 2.5% dextrose.

Maintenance

Insensible losses of fluids and electrolytes (GIT, UT, lungs, skin) contain roughly half the salt concentration found in serum or LRS, and about 4-5 times the potassium – that is – potassium MUST be added to fluids to replace this loss – thus

LRS + 5% dextrose + KCl = ½ strength LRS + 2.5% dextrose and 20mEq/L KCl is an adequate maintenance solution.

Rate of Fluid Administration

The rate of fluid administration is determined by the rate and magnitude of the fluid loss. Rapid or extensive fluid loss requires rapid replacement. Provided congestive heart failure or anuric renal failure are not present fluid can be given as rapidly as 60-90mL/kg/hr. When fluid is administered this rapidly, ALWAYS assess the patient at 15 minute intervals to determine if the rate is too fast and fluid overload is occurring (see monitoring section below).

In chronic disease, fluid does not need to be replaced as rapidly. The replacement volume can be added to the daily fluid requirement and administered to the patient over 24 hours.

Fluid administration (LRS) at 5-10mL/kg/hr should be considered in any patient undergoing anaesthesia and surgery for periods of greater than 30 minutes. This is to help reduce the effect of cardiovascular compromise that occurs with all anaesthetic techniques and to counteract the major evaporative losses that occur when the chest or abdomen is open during surgery.

Amount of Fluid to Administer

Replacement volume

The replacement volume is determined by the estimated degree of dehydration (ie the amount of fluid lost by the patient).

Eg. 10kg chimp juvenile 10% dehydrated = 10 x 0.1 = 1. ie, 1L of LRS is required for the replacement volume.

Maintenance fluids

A maintenance volume of fluid must be administered during any period that a patient is not taking in oral fluids. This accounts for obligatory fluid loss through
the urinary tract, GIT, skin and lungs. Maintenance fluid requirements are 50-70mL/kg/24hrs. This fluid must be administered in addition to the replacement volume.

**Ongoing Losses**

Account of continued loss through vomiting, diarrhoea, urinary tract, large wounds, drains or peritoneal loss must be taken. An estimate is made of the volume lost and this is added to the replacement and maintenance volumes of fluid administered over a 24 hour period. During surgery, 3mL of LRS should be administered for every mL of blood lost.

**Monitoring Fluid Therapy**

When fluid is administered rapidly (30-90 mL/kg/hr) the patient should be monitored every 15 minutes to ensure that volume overload or haemodilution has not occurred. Examination should include auscultation of the chest, paying particular attention to the lungs for an increase in interstitial/ alveolar sounds that may indicate the onset of pulmonary oedema. PCV and TP should be monitored to assess haemodilution.

During more chronic administration of fluid a physical examination should be carried out twice daily. This should include assessment of skin turgor, thoracic auscultation, PCV, TP and weight. An estimate of urine output should be made. Normal output is about 1-2mL/kg/hr.

Signs of fluid overload include serous nasal discharge, restlessness, cough, dyspnoea, pulmonary oedema, ascities, polyuria, exophthalmos, vomiting, diarrhoea.

If an IV catheter is in place, the catheter site should be checked daily for signs of redness and swelling. Other signs of sepsis eg, increase in temperature should also be monitored. The catheter site should be changed every 72 hours even if there is no sign of infection present. When not in use the catheter should be flushed with 5 units/mL of 0.9% saline (heperanised saline). The catheter should be removed as soon as fluid therapy is no longer necessary to reduce the potential for sepsis.

**A Theoretical Example**

1. **CALCULATE VOLUME OF FLUID REPLACEMENT REQUIRED**
   - Weigh and/or estimate weight of patient prior to illness
   - Estimate degree of dehydration
   - Calculate replacement volume required.
20kg chimpanzee that appears 8% dehydrated due to 10 days diarrhoea, unresponsive to ORT.

20 x 0.08 = 1.6 = 1.6L of LRS to replace the deficit

2. DECIDE UPON ANY ADDITIONAL POTASSIUM

If serum potassium concentration cannot be determined, use 20mEq/L of LRS

3. DECIDE UPON REPLACEMENT FLUID ADMINISTRATION RATE

- Decide over what time period you wish to give the LRS
- Calculate the rate of fluid administration from this
- Determine if potassium administration will be too fast (ie MUST be less than 0.5mEq/kg/hr to prevent hyperkalaemia.

Thus – You decide to give the fluid over 4 hours = 1.6L given over 4 hours = 400mL LRS/hr = 8 mEq potassium/hr. The maximum potassium is 0.5mEq/kg/hr (so in this case 10). Therefore the replacement LRS can be given this rapidly without hyperkalaemia occurring.

4. CALCULATE MAINTENANCE FLUID VOLUME AND RATE OF ADMINISTRATION

- Calculate maintenance fluid volume
  - 20kg x 50mL/kg/24h = 1000mL/24hr.
- Calculate maintenance fluid rate – over the first 4 hours we are administering the replacement fluid therefore we have 20 hours remaining over which to give the maintenance volume = 1000mL/20 hours = 50mL/hr.

We could, for example, administer the fluid over a 10 hour period then flush the catheter with heperanized saline until the next day to continue the next 24hr maintenance fluid requirements. Thus: 1000mL/10hr = 100mL/hr.

5. ESTIMATE ONGOING LOSSES

Record estimated amount of ongoing losses through vomiting, diarrhoea etc and add this to today’s fluid as the patient loses the fluid or add the “extra” losses up over a 24 hour period and add them to the maintenance fluids for the next day.

6. DECIDE UPON DURATION OF PARENTERAL FLUID THERAPY.

Parenteral administration of fluid should continue until the patient can take in sufficient fluid orally to cover maintenance requirements. If a young primate is
strong enough to remove an IV line, it can imply that it’s strong enough to begin accepting ORT, if dehydration is still a problem.

**PARENTERAL FLUIDS AND ADDITIVES OF USE IN PRIMATES**

**Blood and Blood Substitutes**

Blood is of course the first choice for major blood loss, but unless a large healthy adult and proper facilities exists, this is unlikely to be used in the sanctuary setting. A blood substitute product is on sale in Japan but worries about long term effects means that it hasn’t been licensed anywhere else.

**Colloids**

- These stay in the blood vessels where they maintain blood volume
- **Fresh frozen plasma** – unlikely to be available
- **Hydroxyethyl starch solutions** – Stable, long plasma half life (about 8 hours), long shelf life – ideal but VERY expensive.

**Crystalloids**

- These move rapidly out of the blood vessels into the extracellular fluid (ECF), but can still be useful to expand the blood volume in an emergency.
- **Sodium Chloride 0.9% solution (normal saline)** – Distributed throughout the ECF. Its lack of bicarbonate or a precursor tends to lower the pH, but in acidosis, increased blood volume may improve kidney blood flow and thus kidney regulation of pH leading to a reduced acidosis. Long term use will require extra potassium
- **Dextrose 5% solution** – Used as a means of supplying water (the dextrose is quickly metabolised). Distributed throughout the body water. DO NOT give subcutaneously.
- **Ringer solution** – Similar to normal saline but with some potassium. Also tends to lower the pH
- **Lactated Ringers Solution – LRS (Hartmann’s solution)** – Commonly used for ECF replacement as it contains lactate (metabolised to bicarbonate). Will tend to raise the pH

**Electrolyte additives**

**Potassium chloride solution** – Comes in several strengths which **must be diluted before use**. They are usually mixed into a bag of crystalloid. Note that injecting potassium into a bag is NOT the same thing as mixing it with the bag’s contents – a bolus of potassium will rapidly stop the heart. Longer term fluid therapy (> 12 hours) usually requires potassium supplementation.
Hyperkalaemia can be treated by

- Correcting acidosis
- Giving insulin in 5% dextrose to promote uptake of potassium by cells
- Giving calcium borogluconate to oppose the effects of the potassium

Sodium bicarbonate 8.4% solution – **Used to correct blood acidosis.** This concentration is used because it contains 1mmol/mL which makes the sums easier. It must be mixed with other solutions before use. **Normal saline is the fluid usually used – it is incompatible with many other solutions and most drugs.** Bicarbonate administration is calculated to replace the circulating deficit only, since correcting the acidosis entirely will lower plasma potassium levels. A blood gas sample (arterial sample) is taken and the amount of bicarbonate required is obtained by multiplying the base excess (a negative number in acidosis!) by the blood volume. Once this amount of bicarbonate has been infused, the base excess is checked again.