

UBC ACC Guidelines and SOP for the Maintenance of Fluid Homeostasis in Animals

Effective Date: December 2018

Background

Approximately 60-80% of body mass is water and the majority of fluid is maintained within the within cells but fluid is also found within the circulation system and outside cells. Animals often become dehydrated after undergoing surgery, procedures, experimental drug administration or when they are anorexic (stop eating and drinking) for whatever reason. Fluid homeostasis is critical for normal physiological functioning and therefore fluid therapy (e.g. to restore intravascular volume to improve cardiac function and thus organ and tissue perfusion) must be used to rehydrate animals.

This guideline describes how to: 1) evaluate whether an animal is dehydrated, 2) how to reestablish fluid homeostasis by fluid therapy and 3) how to monitor animals with undergoing fluid therapy. Specific steps are outlined for rodents and larger species.

1) Evaluation of Fluid Homeostasis

A normal part of monitoring post-operative, post-procedure animals or animals who are showing signs of poor health is to evaluate whether or not they are dehydrated.

Is the animal dehydrated?

- 5% dehydration is not detectable.
- >5 % is defined as "clinical dehydration" and is detectable.
- 10% dehydration can result in alterations to the cardiovascular system and ultimately shock and death.

Since a mild degree of dehydration is not easily detectable clinically, it is wise to hydrate the animal when in doubt.

Clinical Assessment and Signs of Dehydration:

- Skin turgor: Hydration is identified as loss of skin turgor, which is evaluated by tenting of skin (gently lifting the skin on the animal's back). The animal is dehydrated if the skin does not snap right back (in under < 2 seconds). In pigs, test the skin on the ventral side. Typically, a skin tent of > 2 seconds is at least 5% dehydrated. In rodents, it may represent 10-15% dehydration.

Other signs:

- Sunken and dry eyes
- "Square" tail in rodents (the dorsal and ventral lateral ligaments can be easily seen)
- Sticky (tacky) mucous membranes (e.g. gums) and prolonged capillary refill time (> 2 seconds)
- No urine output for > 12 hours and there are few dry feces or no feces. In rodent cages, the bedding is dry or there is no obvious urine spot
- Listless (depressed mental state), weak and inactive
- Lack of appetite and body weight loss of more than 10% (2.5 g in a 25 g mouse or 25 g in a 250 g rat) within 24-48 hours. Dehydrated animals will limit their food intake thus

dehydration will also cause weight loss. For example, a 5% dehydrated animal will have lost 5% or more of its body weight.

2) Fluid Therapy

If an animal is dehydrated, in some cases the animal may be healthy enough to consume an adequate volume of water to sustain normal fluid balance. For example, a pig that has recovered from anesthesia from surgery and is back to normal activity levels. In contrast, for rodents, they are at risk of rapid dehydration if they stop eating or drinking, so dehydration is treated regardless.

Fluids used for Fluid Therapy

Fluids should be replaced by injecting a sterile physiological solution, typically via subcutaneous route in rodents and via intra-venous routes in larger animals. Fluids should be warmed to body temperature prior to administration.

Lactated Ringers Solution (LRS) is a recommended fluid replacement solution. It is comprised of a physiological saline solution with added electrolytes that mimic the components of the body's extracellular fluids.

Sterile Saline (0.9% NaCl) is a readily available solution for rehydration. This solution lacks electrolytes to replace any deficits that can occur with severe dehydration so should be used as a second choice if an animal is already dehydrated. If fluids are given as a preventative measure, then sterile saline is fine.

Dextrose 5 % in water (D5W) can also be given subcutaneously in a mildly dehydrated rodent and post-operatively or IV in larger species. It is used to prevent clinical signs of hypoglycemia (weakness, mental dullness and seizures). D5W is also a good partial fluid replacement for an anorexic rodent. Caution in that it increases fluid loss through the kidneys so can make rehydration challenging. Supply half of the total calculated fluid volume as D5W and half of the volume as LRS mixed in the same syringe when treating an anorexic animal.

Routes for Fluid Administration

Subcutaneous Administration (SC)

For rodents, fluids are typically administered by SC route for ease of access. If the total amount is large, then you can administer the total volume at a few different sites on the back, so that the animal's skin does not become uncomfortably stretched (See "Fluid Therapy for Rodents" below). Note that the subcutaneous route is not as effective for severely dehydrated animals because dehydration and hypothermia results in peripheral vasoconstriction and poor absorption. So, prevention is critical.

Intravenous Administration (IV)

Intravenous access is mostly used in larger species for which IV catheters can be placed (see "Fluid Therapy for Large Animals" below) but it can be used in critical cases in rodents using a tail vein IV catheter.

Fluid Therapy for Dehydration Prevention

Fluid therapy is used to prevent dehydration in the following special circumstances:

For animals undergoing surgery: rodents 20 ml/kg SQ; rabbits 3 ml/kg/hr; pigs and sheep 3-5 ml/kg/hr. Contact veterinarians for other species.

For rodents that undergo frequent anesthesia sessions: rodents 10 ml/kg SQ

For debilitated rodents or where procedures might cause animals to become debilitated, an easily accessible oral water supplement should be given such as ClearH₂O products (e.g. Hydrogel, DietGel 76A) and soaked rodent chow on the cage bottom.

Fluid Therapy for Dehydrated Animals

For animals that are clinically dehydrated a fluid therapy plan must be established (see species specific therapy plans below). Since rodents are at risk of rapid dehydration if they stop eating or drinking, dehydration is treated regardless.

3) Monitoring Animals Undergoing Fluid Therapy

When to Stop?

After therapy is started, reassess hydration status before each additional fluid treatment. Fluid therapy can be stopped when the animal is hydrated and can maintain that hydration status on their own.

Monitoring Criteria for Assessing Hydration Status:

- **Weight:** Weigh animals using the same scale, at least 2 times per day (frequency will depend on severity of dehydration). The weight should increase to reflect the fluid therapy. E.g. if an animal is 10% dehydrated, then their weight should increase by 10% once rehydrated.
- **Skin turgor:** Turgor should return to normal (i.e. no skin tent).
 - In rodents, if the location where the original injection was given is not visible or palpable after a few hours, the animal needed the fluid and therefore continue with plan. If a pocket of fluid remains after a few hours, then it is likely the animal is no longer dehydrated and another dose of fluid can be omitted but continue monitoring for dehydration in the following days. However note that in severely dehydrated rodents peripheral vasoconstriction can result in poor absorption of fluid.
- **Respiratory Distress:** Over-hydration may cause pulmonary edema and respiratory distress. This can be seen as rapid and labored breathing, coughing or “clicking respiratory” sounds (rodents only) or crackles in the lung on auscultation with a stethoscope. If seen, then stop fluid therapy and contact your clinical veterinarian.
- Serous (clear) nasal discharge
- Chemosis (swelling of eyelids)
- Shivering
- Tachycardia
- Ascites (enlarged abdomen)
- **Urination:** Ensure the animal is urinating. If kidney failure is present (due to severe dehydration or drug effect) the animal will not be able to compensate for over-hydration.

- Stop fluid therapy and contact your clinical veterinarian.
- For larger animals, urine output should be monitored every 4 hours (calculate ins and outs to assess response to therapy)

Fluid Therapy for Rodents

Fluid is typically administered via the subcutaneous route in rodents. Note that subcutaneous route is not as effective for severely dehydrated animals because dehydration and hypothermia results in peripheral vasoconstriction and poor absorption. Fluid therapy is broken down into 2 phases.

Phase 1 - Emergency Correction of Dehydration in Clinically Dehydrated Rodents

Formula to determine volume of warmed fluid to be replaced:

Body weight (grams) X % dehydration (as a decimal value) = Fluid volume (ml)

Example: A 300 g rat who is estimated to be 5% dehydrated (skin tent of >2 seconds)

$300 \text{ g} \times 0.05 = 15 \text{ ml}$ of fluids needs to be replaced

How fast should fluids be administered?

Replace 50% of the calculated volume immediately by the administration of a warmed fluid replacement solution (i.e. to body temperature, 37°C). Replace the remaining 50% after 2-3 hours. Re-evaluate animal's hydration status (see above).

Phase 2 - 24-hour Maintenance or Post-Emergency Fluid Requirements

If an animal is not drinking on its own, its daily maintenance requirement will have to be replaced in order to prevent dehydration.

Rat: 100 ml/kg/day¹

Mouse: 150 ml/kg/day¹

Example: A 300 g rat would require $100 \text{ ml} \times 0.3 \text{ kg} = 30 \text{ ml}$ per 24 hours

How fast should fluids be administered?

24-hour fluid volume replacements should be divided into 2 or 3 treatments over the 24-hour period

Example: The 300 g rat (above) is administered 10 ml three times or 15 ml twice over a 24-hour period.

Animals undergoing fluid therapy **MUST** be monitored as above "Monitoring Animals Undergoing Fluid Therapy". Stop when animal can maintain normal hydration status on their own.

Considerations: Contact veterinarian for assistance with animals that have cardiovascular, kidney or respiratory disease or compromise. These animals are at greater risk of over-hydration.

¹ Hankenson F.C. 2014. Critical Care Management for Laboratory Mice and Rats. CRC Press.

Fluid Therapy for Large Animals

Intravenous catheters are typically used in large animals that require fluid therapy. Fluid therapy is broken down into 3 phases.

Fluid Therapy Phases:

- 1) Resuscitation if animal is unstable
 - Emergency stabilization
 - Fluid volume replacement
 - Acid/Base management
- 2) Rehydration
 - Correction of dehydration, impaired intake and electrolyte management
- 3) Maintenance
 - Supplementation for continued impaired intake

Animals undergoing fluid therapy **MUST** be monitored as above “Monitoring Animals Undergoing Fluid Therapy”. Stop when animal can maintain normal hydration status on their own.

Complicating Factors

- Age – skin turgor decreases with age
- Weight – obese animals may appear well hydrated
- Vomiting – may mask tacky mucous membranes

What type of fluid?

Crystalloids

- Have their effects on the interstitial and intracellular compartments
- Only 25% of the volume administered remains in the vascular space 30 minutes to 1 hour later, which is good for rehydrating the body
- Replacement Crystalloids are used for rehydration e.g. 0.9% NaCl or LRS (composition resembles extra-cellular fluid)
- Electrolyte content is designed to match normal daily loss (less sodium and more potassium) than replacement solutions.

Colloids

- Pulls fluid from extravascular space into the intravascular space to help in volume expansion. Used in cases of blood loss and low blood pressure.
- 100% volume remains in intravascular space 1-hour post administration
- **DO NOT USE FOR REHYDRATION**

Carrying out Hydration Plan

Useful Information:

- Bodyweight: serial measurements are valuable to assess fluid gains and losses
- Laboratory findings:
 - Packed Cell Volume (PCV) and Total Protein (TP): Typically increase in dehydration
 - Urine Specific Gravity (USG): Often increased in a dehydrated patient

- Be aware that animals on replacement fluids and that are not eating may need potassium supplementation (see SOP for Supplementation of Potassium in IV Fluids in Large Animals).

3 Components of a fluid plan that need to be calculated and combined in total rehydration plan:

- 1) Hydration Deficit
- 2) Maintenance Requirement
- 3) Ongoing Losses
- 4) Rate of Administration

1) *Hydration Deficit*

Body weight (kg) X % dehydration (as a decimal place) = Deficit in liters

Replacement of deficit is done in stages over 24 hours:

50% deficit given over 4-6 hours

Next 50% is given over the following 18-20 hours

2) *Maintenance Requirement*

Maintenance Fluid = $1.2 \times \text{body weight (kg)}^{0.75} + 70$

Or use the average values for species:

Pigs: 50 ml/kg/day

Rabbits: 100 ml/kg/day

Sheep: 50 ml/kg/day

Rhesus Macaque: 80 ml/kg/day

3) *Ongoing Losses*

Estimate for continued vomiting, diarrhea, polyuria. Typically start with 1-2 x maintenance rate.

4) *Rate of Administration*

Total volume of fluid is given in stages over 24 hours where a larger amount of the deficit is given in the first 6 hours:

First 6 hours: 50% of deficit + daily rate for maintenance + ongoing losses.

Next 18 hours: 50% of deficit + daily rate maintenance + ongoing losses

Example of 24-hour fluid therapy plan for pig that is dehydrated due to diarrhea (see Table 1 for example).

Pig weight = 25 kg

Dehydration Assessment = 7%

Maintenance Requirement = 50 ml/kg/day

1. Hydration deficit of 7% dehydration = $25 \text{ kg} \times 0.07 = 1.75 \text{ L}$ or 1750 ml

2. Daily Maintenance Rate = 25 kg x 50 ml/kg/day = 1250 ml per 24 hours or **52 ml/hr**

3. Ongoing losses = 1 x maintenance rate = **52 ml/hr**

4. Rate of administration

Hydration deficit:

Replace 50% of hydration deficit in first 6 hours: $1750 \text{ ml} / 2 = 875 \text{ ml}$ or **145 ml/hr** and 50% in next 18 hours: $875 \text{ ml} / 18 \text{ hrs}$ or **49 ml/hr**

Total fluid administration (over 24 hours):

Rate 1st 6 hours = $145 + 52 + 52 = \mathbf{249 \text{ ml/hr}}$

Rate Next 18 hours = $49 + 52 + 52 = \mathbf{153 \text{ ml/hr}}$

Table 1: Example of fluid therapy plan for a pig that is estimated to be 7% dehydrated.

	Total Volume Needed over 24 hours (ml)	Volume (ml/hr)	1st 6 hours (ml/hr)	Next 18 hours or 6-24 hours (ml/hr)
Deficit	1750 (50% = 875)	n/a	145 (875/6)	49 (875/18)
Maintenance	1250	52	52	52
Ongoing Loss (1 x maintenance)	1250	52	52	52
Total Rate per hour			249	153

Considerations: Contact veterinarian for assistance with animals that have cardiovascular, kidney or respiratory disease or compromise. These animals are at greater risk of over-hydration.