Fluid therapy: Tips and Tricks

Linda Barton DVM, DACVECC

An important aspect of the management of most critically and acutely ill patients is fluid therapy. Fluid therapy is used to correct life-threatening abnormalities in volume, electrolyte and acid-base status. Patients with normal kidneys, cardiovascular systems and vascular endothelium can usually adjust to a less than perfect fluid plan. Critically ill patients often have compromise of these organ systems and are therefore much less tolerant of fluid therapy miscalculations. Improper use and application of fluid therapy can create new problems for the patient. This session will cover tips and tricks for prescribing and monitoring fluid therapy in this patient population.

1. Synthetic colloids improve the management of "leaky" patients

There is a common pathophysiology found in many critically ill patients. An inciting stimulus initiates the production and release of circulating mediators that cause inflammatory changes throughout the body. The response of the body to this cascade of mediators is termed the systemic inflammatory response syndrome (SIRS). Because of the increased capillary permeability, SIRS patients tend to "leak" from their vascular space into the interstitial space. The use of synthetic colloids will help to retain fluid in the vascular space and allow adequate intravascular volume without interstitial edema. Despite the recent controversy surrounding the use of this fluid in critically ill human patients, I find the use of synthetic colloids very useful in this patient population. Hetastarch can be given at a rate of 10-20 ml/kg/day.

Following administration of synthetic colloids, measurement of serum albumin, total protein or refractometer total solids does not accurately reflect the patient's "effective" oncotic pressure. Colloid administration similarly affects the evaluation of urine and other body fluids. Colloid oncotic pressure measurements can help guide colloid therapy. Normal COP is approximately 20 mmHg. Patients with COP values <15 mmHg are at risk of the development of peripheral edema. The stimulus for hepatic production of albumin is the COP of the blood. Therefore, colloid administration producing elevated COP values may decrease endogenous albumin production.

2. Some fluid is good, more is not always better

Intravenous fluids are essential to correct fluid-responsive hypoperfusion, replace fluid deficits, replace ongoing loses, and to provide maintenance needs until the patient is willing to eat and drink enough to maintain normal fluid balance. Administration of fluid in excess of these goals serves no therapeutic purpose and may result in patient morbidity. The deleterious consequences of overzealous fluid therapy are increasingly being recognized.

Patients at greatest risk for intravascular volume overload and/or interstitial edema secondary to excessive fluid administration are those with decreased oncotic pressure, inflammatory diseases causing altered vascular permeability, oliguric renal failure and cardiac insufficiency. Clinically, edema of the subcutaneous tissues is most evident. However the edema in the brain, GI tract, heart, liver, lungs and kidneys may be responsible for the morbidity associated with excessive fluid administration. Excessive fluid administration can also cause morbidity in patients that are capable of excreting the excessive fluids. Overexpansion of the vasculature causes a pressure diuresis, resulting in a loss of electrolytes and water. The normal hyperosmotic renal medullary interstitium becomes "washed out" by the increased medullary blood flow resulting in a lack of urine concentrating ability.

3. A fluid bolus is not always the right choice for a "shocky" patient

Clinical recognition of shock is based on physical exam parameters (decreased mentation, weakness, pale/grey/white mucous membranes, changes in capillary refill time, tachycardia/bradycardia, tachypnia, changes in peripheral pulse quality, hypothermia) and hypotension. Rapid fluid administration is the mainstay of therapy for hypovemic shock and is also an important component in the treatment of other types of shock.

A study evaluating the role of fluid resuscitation in the treatment of critically ill children in sub-Saharan Africa recently published in the New England Journal of Medicine showed that fluid boluses significantly increased the 48-hour mortality. This study serves as a reminder of the definition of shock; an abnormality of the circulatory system that results in inadequate organ perfusion and tissue oxygenation. The common denominator in all shock states is a critical decrease in oxygen and nutrient delivery to cells resulting in altered cellular metabolism, cell death, organ failure and ultimately death.

If an absolute or relative hypovolemia contributes to the shock state, fluid therapy is indicated. Most veterinary patients present in shock caused by loss of blood or non-hemorrhagic fluid loss from decreased intake, vomiting, diarrhea, renal loss and/or fluid loss into a body cavity. However, if the decreased oxygen delivery to the tissues is caused by myocardial dysfunction or decreased oxygen carrying capacity (anemia, dysfunctional hemoglobin, hypoxia), other therapeutic interventions may be more critical.

4. Don't use a replacement fluid when a maintenance fluid is indicated

Replacement fluids (0.9% NaCl, LRS, Normosol-R, Plasma-lyte-A) contain high concentrations of sodium, ranging from 130 meq/l to 154 meq/l). These fluids are indicated for the replacement of fluid lost from the extracellular fluid compartment. After the initial phase of the fluid plan designed to replace intravascular fluid deficits (resuscitation) and interstitial fluid deficits (rehydration), subsequent fluid therapy is needed only to provide maintenance needs and to match any ongoing losses, until the patient is able to meet its fluid needs by ingestion. Administration of a replacement fluid to provide a patient's maintenance water needs, results in the delivery of 16 times the National Research Council's recommended daily dose of sodium. This can lead to the development of hypernatremia and/or the development of edema or congestion in patients prone to fluid retention (cardiac disease, renal insufficiency, portal hypertension, and systemic inflammation).

5. Hypovolemic shock resuscitation should be completed within minutes (not hours), and customized to the needs of your patient.

When hypovolemic shock has been identified in a patient, the goal should be to restore normal perfusion as rapidly as possible. Decreased oxygen delivery to tissues continues to occur until the hypoperfusion is corrected. The typical fluid prescription for shock is to administer ¼ of a shock dose over a short period and then re-evaluate perfusion parameters. This dose can be repeated as indicated by the response of the patient. End point(s) of fluid resuscitation include restoration of normotension (systolic blood pressure>90mmHg or a MAP>60-70mmHg) and normalization of abnormal physical exam perfusion parameters.

A balanced, isotonic crystalloid fluid is often the first choice to commence fluid resuscitation but there are other options depending on the situation. Rapid volume expansion with crystalloids is based on the estimation of an animal's blood volume (dogs 80-90ml/kg, cats 40-60ml/kg). Crystalloid treatment provides a large volume expansion in a short time, however, ~75% of the fluid will redistribute to the interstitium in about 30 minutes. Inappropriate or excessive administration of crystalloid fluids can lead to (worsening) pulmonary edema, increased intracranial pressure, abdominal compartment syndrome, and dilution of plasma elements.

Another choice of fluid would be a synthetic colloid. These fluids are isotonic crystalloids which have larger molecules added. These larger molecules contribute to an increased colloid oncotic pressure that will help pull interstitial fluid into the vascular space. The result is vascular volume expansion with less interstitial expansion. The total shock dose of colloidal fluids is much lower than crystalloids due to these oncotic pull effects (dogs 10-20ml/kg, cats 5-10ml/kg). Synthetic colloids have the potential to prolong clotting times at higher volumes administered. Dilution of plasma elements and potential for rare allergic reactions are other adverse effects to be aware of.

Hypertonic crystalloids (typically 7.2%-7.5% NaCl) create a strong osmotic gradient from the interstitial to the intravascular fluid space drawing fluid into the vasculature. As little as 4-6ml/kg in dogs and 3-4ml/kg in cats can provide an effective intravascular fluid expansion in shock situations. This dose may be combined with a ¼ shock dose of a synthetic colloid (so called "TurboStarch") to prolong the volume expanding effects. Due to the hyperosmotic characteristics, hypertonic saline (or "TurboStarch") has shown benefit in traumatic brain injury as a treatment for both cerebral edema and circulatory shock. Other proposed benefits include immunomodulation and arterioloar dilation with improved microvascular circulation. Hypertonic saline has the potential to cause clinical hypernatremia leading to neurologic effects in patients with dehydration, pre-existing sodium imbalance, or if delivered too rapidly.

Perhaps more important than the choice of resuscitation fluids, is the need to customize the resuscitation to the patient. There is morbidity associated with both under resuscitation and excessive administration of fluids. If resuscitation endpoints have not been achieved following administration of a full shock dose of fluids, the resuscitation plan should be re-evaluated. The filling of the vascular compartment should be evaluated via inspection of jugular size and filling, central venous pressure measurement, and/or evaluation of vascular fill on thoracic radiographs. If the vascular space remains unfilled, additional fluids are indicated. If the vascular space is adequately filled other therapies such as vasopressors or iontropes should be considered as additional fluid administration will lead to overhydration, peripheral edema formation, and pulmonary edema.

6. The scale is your best (and most cost effective) fluid monitoring tool:

The ill patient requires continuous serial monitoring of many parameters/laboratory values. A simple body weight provides a straightforward means to monitor endpoints of fluid administration and interstitial (over)hydration. With any fluid therapy plan body weight should be monitored every 6-24 hours depending on illness and fluid prescription to assess fluid losses/gains. Trends are more informative than isolated measurements and using a consistent scale is important. An anorexic animal may lose 0.1/0.3 kg/day/1000 kcal energy requirement. Losses in excess of this amount indicate fluid loss. Remember 1kg=1liter.

7. Fluid therapy is helpful only when delivered safely to your patient

The placement of catheters to facilitate IV administration of fluids and drugs is a cornerstone of fluid therapy. IV catheter placement into peripheral or jugular veins should always be performed using aseptic technique. Critically ill patients are less tolerant of breaks in aseptic technique. While large diameter, short peripheral IV catheters are more beneficial for delivering shock rate fluids, in compromised or hypovolemic patients in shock, vascular access may be a challenge and ultimately IV access with any gauge IVC is critical. Don't be afraid to perform a cut down if needed or to access the larger jugular vein in a crisis situation. Preparedness and appropriate training are critical for when these situations arise.

Peripheral IV catheters require serial inspection for signs of inflammation, phlebitis, distal edema, and integrity of the connections. Low rates of administrations may predispose the catheter to occlusion/clotting if the flow is too low. The recommendation to routinely change catheters based on time has recently been challenged. Development of a fever in a patient with an "old" IV catheter may be related to inflammation/infection originating at the insertion site.

Central venous catheters should be considered in critically ill patients instead of or in addition to peripheral lines. They can typically be left in place for longer periods but do require advanced training to place and demand close attention to their care while in the patient. The jugular is typically the first place that comes to mind but saphenous veins can also be used to place a peripherally inserted central catheter (PICC) into the caudal vena cava. It is important to remember in potential hemodialysis patients, the jugular veins should not be accessed and venipuncture should be avoided in these veins. Central venous catheters may be single lumen or multiple lumen type catheters depending on the needs of your patient. Multilumen central lines facilitate administration of multiple fluid and drug types that are incompatible with each other as well as partial/total parenteral nutrition. Central venous catheters facilitate ease of serial blood sampling without multiple venipunctures in compromised patients and without taking large volumes of blood. They are required for the administration of hyperosmolar/hypertonic (>600mOsm/L) fluids such as a constant infusions of valium, mannitol, parenteral nutrition and dextrose supplementation >5%. Delivered through a peripheral IVC, these drugs would cause severe phlebitis and other damaging effects.

We often need to administer multiple types of additives to the IV fluids. Additives such as potassium can be life threatening if inadvertently bolused and many additives/drugs have incompatibilities. Using a burette to administer fluids with additives or fluids in smaller patients can be safer for avoiding accidental overdosage or unintentional fluid overadministration. It is important to cross reference compatibility of all drugs (including antibiotics) and additives being administered through the same line or IV catheter to prevent potential catastrophic interactions in the patient.

8. Evaluation of hydration: art or science?

An important component of both the initial fluid plan and ongoing evaluation of a patient receiving fluid therapy is an assessment of their hydration status. The degree of dehydration/overhydration is estimated from physical exam parameters (moisture of oral mucus membranes, skin turgor and the moisture and position of the eye) and laboratory values such as PCV/TS and urine specific gravity. There are several clinical situations in which these guidelines will be misleading. Animals with chronic emaciation will have lost the intraorbital fat and may have catabolized the collagen in the skin, causing an overestimation of their dehydration. Assessment of oral mucus membranes can be difficult in nauseous/drooling patients or in patients that are panting. Animals with rapid fluid loss will require more fluids than estimated by standard guidelines.

At the initial assessment, dehydration should be estimated and replaced over 8-24 hours. The rate of replacement should mirror the rate of fluid loss. Physical examination, including an evaluation of perfusion and hydration status should be performed at least twice daily. This will help in determining if the patient requires a higher or lower fluid rate, or even if an additional fluid bolus should be given. Signs of persistent dehydration may include inappropriate tachycardia, tacky/dry mucous membranes (in the absence of panting), prolonged CRT, skin turgor, doughy feel to the abdomen, lack of urination in 10-12 hours, or abnormal hair "quality". Physical exam findings which can indicate early fluid overload or overhydration include increase in respiratory rate and/or effort, "jiggly" subcutaneous tissues, clear nasal discharge, frequent urination, or consistent and unexpected weight gain while hospitalized.

9. Large and overweight patients are not well served by linear equations to calculate maintenance fluid requirements

Maintenance fluid requirement is the volume needed to keep a patient in neutral fluid balance. Daily fluid requirements parallel energy requirements. Many of us were likely taught to calculate maintenance fluid rates based upon 60 ml/kg/day, or some other similar linear equation. However, energy and fluid requirements are not a linear function of body weight but rather related to body surface area. Linear equations will overestimate the fluid needs of larger patients. A more accurate estimate of maintenance

fluid requirements should be based on a curvilinear equation which adjusts for body surface area. Estimates based on basal, resting and maintenance energy requirements have been recommended.

What about fat cats? Not all patients handle fluids equally. It is extremely important to evaluate your patient's body condition and not just their measured weight when choosing a fluid therapy plan. Overweight patients are very easy to overload on fluids. Remember - a 10 kg cat who is 40% overweight still has the cardiovascular system of a 7 kg cat. This will hold true even for cats receiving subcutaneous fluids. Calculate your dose appropriately based upon your estimated lean body weight of the patient. In contrast, occasionally a very lean patient may actually need a higher fluid rate than measured with scale body weight. These patients could be at risk of uncorrected dehydration. For these reasons, overweight and underweight patients may actually benefit from even more frequent body weight measurements, physical exams, and re-evaluation of the fluid therapy plan.

10. Normosol-R is not the best choice for every patient

In most of our patients needing fluid resuscitation and/or rehydration, we can select any high sodium, isotonic crystalloid (0.9% NaCl, LRS, Normosol-R, Plasmalyte-A). However, there are a few specific disease states in which we may want to think twice before just grabbing a bag of fluids.

Patients presenting for repeated episodes of vomiting (possibly projectile) or chronic anorexia with large, fluid distended stomachs, will many times have blood gas changes consistent with a hypochloremic metabolic alkalosis. Remember that as large volumes of HCl are lost from the stomach, the body will have a total body deficit of chloride and thus anions. To replace this loss, the kidney will retain HCO3- leading to a metabolic alkalosis. These patients are inevitably dehydrated as well. This acid-base abnormality is best corrected by the administration of normal saline, higher chloride containing fluid. Because there is no potassium in normal saline, it should also be considered in patients with hyperkalemia that is not rapidly correctable. In the absence of a chloride responsive condition, infusion of large volumes creates a hyperchloremic metabolic acidosis. Recent human studies have shown worse outcomes in patients treated with 0.9% saline versus a balanced electrolyte solution.

Lactated Ringers contains lactate as a bicarbonate precursor. Lactate requires hepatic metabolism, making this fluid NOT a good choice for patients with severe hepatic dysfunction. LRS should also be avoided in patients which lymphosarcoma due to their abnormal metabolism of lactate. Lymphosarcoma cells undergo more anaerobic metabolism than other cells and therefore have an increased amount of lactate present initially. Lactated Ringers should not be administered via the same catheter with a blood product. The calcium present in this fluid will compete with the anticoagulants present in the stored product, resulting in microscopic clot formation. LRS may be the fluid choice for sick neonates because of their ability to utilize lactate as energy in the presence of hypoglycemia. LRS should be used in preference to magnesium containing fluids in patients with lower motor neuron disease such as botulism or other neuromuscular blockade agents. LRS contains calcium which is essential for the release of acetylcholine and lacks magnesium which would compete for this receptor and therefore block the release of acetylcholine.