PRACTICAL FLUID THERAPY IN CATTLE – AN OVERVIEW

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LOUISE SILK MA, VetMB, MRCVS discusses two scenarios in which it is likely this form of medical treatment would be considered for cows

FLUID therapy in large animal practice is commonly undertaken, with the two most likely scenarios being in a calf with diarrhoea and a sick adult cow.

While it is possible to carry out laboratory analysis on affected individuals to determine the degree of fluid and electrolyte deficit and the acid-base status, this is often not practical in practice (Rousell, 2004).

In terms of acid-base status, if assumptions are to be made out in the field, it is generally recognised sick calves with diarrhoea tend to be acidotic. In adult cattle, conditions such as grain overload or choke (due to failure to ingest alkalinising saliva) cause an acidotic state, while gastrointestinal catastrophes such as abomasal volvulus and caecal or abomasal torsion result in a metabolic alkalosis (Rousell, 2004).

Other scenarios in adult cattle where fluid therapy is indicated include conditions where there is endotoxaemia as a result of peracute Gram-negative bacterial infections, such as *Escherichia coli* mastitis, severe endometritis and septic peritonitis (Sargison and Scott, 1996).

In these scenarios, correction of dehydration will often restore renal function sufficiently that electrolyte and acid-base imbalances will then self-correct. This is not the case in more severely affected diarrhoeic calves.

To understand how and when fluid therapy should be administered, it is important to first consider the pathophysiological changes occurring within the affected individual.

Calf diarrhoea

Pathophysiology

Two main mechanisms exist by which young calves can suffer from diarrhoea – secretory, as is the case with enterotoxigenic *E coli* infections, and osmotic, which may occur as a result of *Salmonella* or many viral infections.

In secretory diarrhoea, toxins released by the bacteria inhibit the sodium/chloride connected reabsorption, thus increasing the chloride excretion into the gut lumen, which draws fluid with it. In osmotic diarrhoea, the bacteria or virus destroys the intestinal villi, reducing the surface area for absorption of fluid and electrolytes, as well as decreasing production of digestive enzymes such as amylase and protease.

This results in an increase in partially digested food, as well as fluid and electrolytes, passing into the large intestine where it ferments, thus drawing more fluid out into the gut lumen by osmosis (Grove-White, 2007).

The end result of both types is a decrease in extracellular fluid volume with resultant decreased plasma volume and arterial pressure. This leads to a decrease in renal function, with reduced H+ excretion, and decreased tissue perfusion, with subsequent anaerobic cellular metabolism. Both result in a metabolic acidosis. Intracellular H+/K+ exchange leads to a hyperkalaemia, which can have dramatic effects on the electrophysiology of the heart and result in death (Argenzio, 1984, cited in Scott et al, 2003).

Treatment

Clinically, we see the effects of varying degrees of dehydration, metabolic acidosis and increased plasma potassium, urea and creatinine in affected calves ([Table 1]).

Practically, the clinical assessment of the calf prior to treatment, as well as ongoing monitoring of response to treatment, can provide the best indicators as to the composition and quantity of fluid replacement therapy required, as well as the most appropriate route of administration.

As a general rule, in a calf that is able to stand and suck, oral rehydration therapy (ORT) should be sufficient, whereas a depressed, recumbent calf (greater than seven per cent dehydrated) requires IV fluids. Exceptions would include calves worsening in clinical signs despite ORT or where there is evidence of intestinal hypomotility such as a dilated abomasum (Grove-White, 2007) when IV fluids would be more appropriate. SC fluids are of little value in these calves due to collapsed peripheral circulation and the sheer volumes of fluids required.

Older calves are able to compensate better and can therefore tolerate a higher base deficit before clinical signs are visible. The degree of acidosis in these animals will often be greater than in younger calves less than one week old, with similar clinical signs. The difference seems to be more pronounced in beef calves than in dairy animals (Grove-White, 1996, cited in Grove-White, 2007).

It can also be the case that pronounced acidosis in older calves is not necessarily accompanied by severe dehydration. These are important considerations to bear in mind when selecting the most appropriate fluid composition to use for rehydration and highlight the importance of ongoing clinical assessment during fluid therapy.

ORT

A number of commercial preparations are available for ORT in calves. The majority of these are formulated to be isotonic with plasma, and contain sufficient potassium and bicarbonate to replace faecal losses, and sodium and glucose in equimolar amounts (Scott et al, 2003).

Citrate is a common bicarbonate precursor that is used in ORT because bicarbonate itself would react with the acid in the abomasum to produce CO_2, thus rendering it unavailable to enter the bloodstream.

Oral rehydration preparations can often be mixed either with water or milk, but it is important to bear in mind there will be insufficient energy in these products to meet the calves’ energy requirements. Using ORT with additional glucose will not fulfil all of the calves’ energy requirements, but may, however, prove beneficial for several reasons:

• Reduced weight loss by providing some of a calf’s metabolic requirements.

• Hyperosmolar gradients between the small intestinal lumen and body fluids are beneficial to nutrient absorption.

• Sodium and glucose are co-transported within the gut mucosa and, therefore, the addition of glucose will aid sodium absorption.

• Increased gastric and intestinal osmolarity delays gastric emptying, thus potentially facilitating prolonged release of fluid and nutrients into the intestines (Holmes, 2004).

IV fluid therapy

In more severely affected calves, IV fluid therapy may be necessary. The target of treatment is to correct the dehydration/hypovolaemia, restore renal function and resolve the metabolic acidosis and hyperkalaemia. While these calves are hyponatraemic, once renal function is restored the kidney will self-correct sodium levels so there is no need for extra supplementation and fluids should be isotonic with plasma in respect to sodium.

The same is true for potassium as the hyperkalaemia will be corrected through H+/K+ exchange once the acidosis has been addressed. The improved renal function will also help to partially correct the acidosis and, therefore, the amount of extra bicarbonate required will depend on the degree of acidosis present (Grove-White, 2007).

In mildly to moderately acidotic calves, isotonic fluids should be used with only small amounts of extra bicarbonate added. However, in calves with severe acidosis additional bicarbonate is required. Sterile preparations of isotonic saline can be used, but with the addition of bicarbonate as described in **Panel 1**.

When attempting to correct the acid-base status of a calf, it is essential this is carried out slowly and with caution. Over-correction through excessive or rapid administration of bicarbonate can lead to increased binding of oxygen to haemoglobin, as well as a reduction in ionised calcium or alkalosis. Half correction of the acidosis over six to 12 hours, as well as restoration of the circulatory volume and, hence, renal function, will allow self-correction of the remaining acidosis and avoid these problems (Grove-White, 2007).

Hypertonic fluid administration is rarely recommended in calves with diarrhoea as it is more appropriate in the treatment of shock, rather than the correction of dehydration. It may be useful, however, in severely collapsed calves.

In a small-scale study, Leal et al (2012) found both administering IV hypertonic saline alongside ORT and just giving ORT alone produced improvements in physiological and biological parameters (hypovolaemia and acidosis) of diarrhoeic calves, although the recovery when using ORT alone was slower.

Generally, it is hard to overload adult cattle with IV fluids, but not calves. Clinical effects of over-administra tion include CNS oedema, congestive heart failure or severe respiratory disease.

Endotoxaemia in adult cattle

Pathophysiology

In adult cattle, bacterial endotoxins cause vasoconstriction and an increased permeability of capillaries to albumin. This allows movement of fluid from vessels into interstitial space with subsequent hypovolaemia and reduced cardiac output. This is followed by vasodilation, pooling of blood in capillaries and inadequate tissue perfusion.

As described earlier, it is the reduced tissue perfusion that results in a metabolic acidosis, with further effects on cardiac output (Sargison and Scott, 1996).

Biochemical analysis of these cases is rarely carried out as it is often necessary to treat the animal immediately out in the field. It is, therefore, important to attempt to assess the approximate fluid deficit based on clinical signs (Table 2; Hallowell et al, 2012).

In conditions such as acute toxic mastitis, abdominal catastrophes or severe endometritis, gastrointestinal motility is substantially reduced, making oral fluid therapy less effective (Green, 1998; Hallowell et al, 2012). For this reason, IV fluids are often indicated once moderate to severe signs of hypovolaemia are seen – despite little evidence as to the actual effectiveness of the fluid therapy in addition to other treatments.

There have been very few useful studies carried out in the field of fluid therapy in cattle and Green et al (1997) found no statistical difference in recovery rates in cows with toxic mastitis that were treated with either isotonic IV fluid therapy or flunixin meglumine, or both, alongside other standard treatments.

Oral fluid therapy

It is the author's experience that administration of oral fluid therapy by stomach pump (20 litres to 40 litres), alongside treatments appropriate for the condition, might aid in the recovery of mild to moderately sick adult cattle, which, while not yet showing obvious clinical signs of dehydration, are known to have a reduced appetite and may later become dehydrated if remedial action is not taken. Many commercial preparations are also available to be mixed into oral fluids that provide oral sources of energy and calcium, which can be useful in treatment of conditions such as ketosis and recurrent hypocalcaemia.

IV fluid therapy

The two options for IV fluid therapy in adult cattle are:

• **Isotonic fluid –** 0.9 per cent sodium chloride administered at 50ml/kg to 100ml/kg bodyweight over 24 hours (600kg cow = 24L to 60L). Practically, this is often delivered in the form of 8L to 16L of non-sterile isotonic saline pumped in using an adapted weed-killer spray over 20 minutes. This can then be repeated every six to eight hours.

• **Hypertonic fluid –** 7.5 per cent sodium chloride administered at a rate of 4ml/kg to 5ml/kg IV fluids (3L bag for 600kg cow) over approximately five minutes, with water offered ad libitum immediately afterwards or, if the cow doesn't drink, 20 to 40 litres of oral fluids given by stomach pump. This can be repeated after eight hours as necessary. This will only be successful if there is sufficient gastrointestinal perfusion for the orally administered fluids to be absorbed (Green, 1998;

Sargison, 1996).

Isotonic fluid administration will clearly expand the circulating blood volume more slowly where hypertonic fluids cause fluid to be drawn out of the extracellular space into the circulation with a rapid, but transient improvement in blood pressure and tissue perfusion. Administration of oral fluid in this situation will help to replace the lost extracellular fluid volume and provide a more long lasting effect.

Sickinger et al (2014) found treatment for abomasal volvulus in cattle with IV hypertonic saline followed by isotonic saline, resulted in a more rapid restoration of the central venous pressure than treatment with isotonic fluids alone, although there was no difference in the recovery rates of the cattle in the two treatment groups.

In most adult cattle, effectively restoring the circulating blood volume, which in turn will cause reperfusion of the kidneys, will allow self-correction of any acid-base imbalances. It is thought in adult cattle any attempt to artificially correct the acid-base balance will have more negative effects than positive (Hallowell et al, 2012). Calcium should always be supplemented in dairy cattle undergoing fluid therapy.

Other types of fluid therapy, such as whole blood transfusion, are rarely used in large animal practice, but can be relatively simple to perform and clinically rewarding in carefully selected cases.

Infection with *Babesia* divergens, or following severe blood loss as a result of abomasal ulceration or severe trauma, may provide a suitable opportunity.

Detailed description of the procedure is beyond the scope of this article, but more information can be found in further reading (Soldan, 1999).

Summary

Direct measurements of hydration status, electrolyte levels and acid-base status are often impractical and, therefore, when treating animals in the field it is often necessary to take treatment decisions based on well-informed assumptions.

In most cases, restoration of the circulatory volume and reperfusion of the kidneys will allow self-correction of any acid-base imbalances. In more severe cases of calf diarrhoea, however, additional bicarbonate may be required.

References and further reading

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PANEL 1

There is considerable variation in the literature over the rate at which acid-base deficits should be corrected in diarrhoeic calves, with some suggesting a rapid correction of acidosis followed by volume expansion (Scott et al, 2003). Others have recommended a more measured approach, particularly when the acid-base status of the calf is unknown (Grove-White, 2007).

An example treatment strategy for a moderate to severely dehydrated calf could be to set up, with the calf to receive five litres of sterile isotonic saline with 15g sodium bicarbonate added, which will provide approximately 36mmol/litre bicarbonate (1g sodium bicarbonate provides 12mmol of bicarbonate) to improve circulation and renal function and begin to correct the acidosis. An initial fluid administration rate could be up to 80ml/kg/hour for the first one to two litres, the rate should then be slowed so the calf receives the total daily fluid volume required (see below) over 24 hours.

A separate bag of 500ml isotonic saline containing 17.5g bicarbonate (200mmol bicarbonate) could then be more slowly administered as necessary to further correct the acidosis in accordance with clinical response to the initial fluid therapy. There will be considerable variation between affected individuals and this addition may not be necessary, depending on the severity of acidosis. Ongoing monitoring of treatment response is essential with regard not only to the degree of acid base correction, but also the rate of fluid administration.

Example of overall fluid requirements for 50kg calf:

10 per cent dehydration will result in a deficit of 50 × 0.10 = 5 litres fluid

Maintenance fluids for a calf = 50ml/kg/day = 2.5 litres

Ongoing losses approximately = 80mls/kg/day = 4 litres

Total fluid volume required over 24 hours = 5 + 2.5 + 4 = 11.5 litres

Potassium should ideally be supplemented orally to calves (5g to 10g of potassium chloride for a 50kg calf) given IV fluids and fresh drinking water readily available to avoid hypernatraemia.

Fluid loss (% of BW)	Clinical signs
0%-5%	Increased thirst
5%-7%	Reduced skin elasticity; some sinking of eye; dry, cold nose
7%-10%	Very sunken eye; cold extremities; weak or collapsed with weak pulse
10+%	Progressive shock
	(Grove-White, 2007)

Table 1. Clinical picture of calves suffering from varying degrees of dehydration

Fluid deficit	Clinical signs
5%-7%	Mild depression; slightly increased capillary refill tie (CRT) and heart rate
10%	Depression; extremities may be cold; dry mucous membranes; CRT>3 secs; heart rate>50% above normal
12%-15%	Profound depression; cold extremities; dry mucous membranes; CRT>4 secs; heart rate>100% above normal
(Adapted from Hallowell et al, 2012)	

Table 2. Clinical signs associated with varying degrees of dehydration in adult cattle