FLUID THERAPY IN CALVES

A practical guide to fluid therapy in calves by Dr Raffaela Marian, Resident in Bovine Health Management, School of Veterinary Medicine, UCD and Dr Eoin G Ryan, Asst. Professor in Farm Animal Clinical Studies, School of Veterinary Medicine, UCD

Neonatal calf diarrhoea remains the leading cause of neonatal calf morbidity and mortality in Irish dairy and beef herds, and has significant implications for both animal welfare and farm profitability, with an incidence rate of 25.5 per cent in dairy and 8.7 per cent in beef calves in 2022 (Teagasc, 2022). The most common causes of neonatal calf diarrhoea (NCD) in recent years were found to be rotavirus and cryptosporidiosis (Department of Agriculture, Food and the Marine, 2023). Fluid therapy remains the cornerstone of treatment for neonatal calf diarrhoea. There is a greater risk of calf mortality if calves receive inadequate volumes, inappropriate formulations, or fluid therapy via an incorrect route of administration. It is important that antibiotics are not prioritised over fluid therapy.

Successful fluid therapy requires more than simply recognising dehydration; it depends on an understanding of the underlying pathophysiology, especially the role of metabolic acidosis and electrolyte changes that are responsible for the clinical signs seen, such as recumbency or absence of menace reflex. Timely decision-making regarding the route of administration – oral versus intravenous – can significantly impact the overall outcome. This article aims to provide an evidence-based, practical guide for fluid therapy in calves, with an emphasis on clinical assessment and practical treatment protocols applicable on farm.

Pathophysiology

Some pathogens (E.coli) cause secretory diarrhoea, which leads to a net secretion of chloride (Cl), sodium (Na), and water into the intestinal lumen. Other pathogens damage the small intestinal villi resulting in malabsorption (cryptosporidiosis, rota- and coronavirus) of electrolytes and water from the intestinal lumen. Regardless of the pathogen, diarrhoea increases the loss of electrolytes and water in the faeces of calves and often also decreases milk intake. This leads to dehydration, electrolyte abnormalities, strong ion acidosis, increase in D-lactate concentrations and negative energy balance.

The primary goals of fluid therapy are:

1) to correct the free water and electrolyte abnormalities;
2) correct the acid-base deficits (acidosis); and,
3) provide nutritional support.

Clinical signs

Dehydration

The first step for successful fluid therapy is the correct assessment and interpretation of clinical signs. A key indicator for the hydration status of calves is the position of the eyeball in the socket (enophthalmos). A formula to estimate the grade of dehydration is eye recession in mm x 1.6-1.9. For example, if the eyeball is 5mm sunken the estimated dehydration is 8-10 per cent (Constable et al, 1998). Other indicators are a prolonged skin tent, tacky mucous membranes, or the temperature of extremities and ears; however, they are considered less sensitive but can still give an indication (Figure 1).

Predicting dehydration from clinical signs

Dehydration	Eyeball sunkenness	Mild cervical skin tent (seconds)	Mucous membranes	Extremities
0%	None	≤2	Moist, pink	
2%	Slight, 1mm	3	Dry	
4%	Slight, 2mm	4	Dry	
6%	Moderate, 3mm (separation of eyeball from orbit)	5	Dry	
8%	Moderate, 4mm	6	Dry	Cold
10%	Severe, 6mm	7	Dry	Cold
12%	Severe, 7mm	>8	Dry	Cold
≥14%	Severe, >8mm	>10	Dry, white	Cold

Figure 1: Guide to assess degree of dehydration in calves (Constable et al. 1998; Naylor 1987b).

How much fluids are needed?

To correct dehydration, it has to be considered that not only replacement fluids are needed but also maintenance and ongoing losses have to be covered. First, the replacement is calculated by percentage (%) of dehydration by bodyweight (BW) (kg) – this is the primary role of the veterinary practitioner when treating a dehydrated calf with intravenous fluid therapy on-farm or at the clinic. Secondly, maintenance requirements are calculated by BW (kg) x 80-100ml/kg/day; and thirdly, ongoing losses in faeces are estimated to be around 15 per cent of BW in cases of severe scour (Table 1: example for a 40kg calf with 8 per cent dehydration). Both maintenance and ongoing losses will primarily be managed using oral rehydration therapy and ongoing milk feeding.

- When giving intravenous fluid therapy, assess the percentage dehydration (degree of enophthalmos [mm] x 2 approximately) and multiply by bodyweight.
- A calf in lateral recumbency with obviously sunken eyes will likely be 10 per cent dehydrated. Therefore, the calf requires 5L of fluids IV over a period of three hours through a 16G jugular catheter.
- Discuss subsequent maintenance fluid therapy with the farmer.

Replacement (L)	BW (kg) x Dehydration (per cent)	0.08 x 40 = 3.2L
Maintenance (L)	BW (kg) x 100ml/day	100 x 40 = 4L
Ongoing losses (L)	BW (kg) x Ongoing losses (per cent)	0.15 x 40 = 6L
Total amount (L)		13.2L

Table 1: Example of fluid requirements for replacement, maintenance, and ongoing losses in a 40kg calf with NCD.

Metabolic acidosis – how much bicarbonate is needed?

A second very common concurrent problem is metabolic acidosis or acidaemia in calves with diarrhoea. However, it has to be noted that there is no relationship between the severity of dehydration and acidosis. The main cause for metabolic acidosis in calves is D-lactate. In calves that experience dystocia and hypoxia, it is mainly L-lactate due to tissue hypoperfusion, whereas in older calves it is mainly caused by high D-lactate concentrations, secondary to malfermentation of carbohydrates (milk) in the abomasum and small intestines, and less commonly, to ruminal drinking from tubing of milk feeds (Lorenz, 2009). Metabolic acidosis tends to be more severe in older calves (> 1 week). Those calves usually display an increased heart and respiratory rate (an attempt to exhale CO_2 which is acidaemic), and, depending on the severity of the acidosis, varying degrees of depression of the central nervous system (CNS). Calves with severe metabolic acidosis may appear comatosed, will have obvious muscular weakness, a reduced or absent suck reflex, and a reduced or absent palpebral reflex. The palpebral reflex seems to be mostly affected by D-lactate concentrations as it has a direct toxic effect on the brain and is blocking L-lactate as an energy source in the CNS (Abeysekara et al, 2007; Lorenz, 2009).

In a hospital setting, a blood gas analysis would be performed to determine blood pH and the base deficit of plasma bicarbonate (HCO_3). However, as this is not feasible in general practice, a numerical scoring system to quantify clinical signs in calves with metabolic acidosis was developed (Figure 2) to give guidance on how to determine the severity of the acidosis (Kasari and Naylor, 1986).

Numerical scoring system to quantify clinical signs in calves with metabolic acidosis (expressed as a depression score)

Variable	Method of Assessment	Score*	Interpretation
Suckle reflex	Index finger in mouth	0	Strong organised suckle
		1	Weak coordinated suckle
		2	Disorganised chewing
		3	Absent
Menace reflex	Rapid hand movement toward eye	0	Strong instantaneous reflex
		1	Slow delayed reflex
		2	Absent
Tactile response	Skin pinched over lumbar area	0	Skin twitch, head movement toward flank
		1	Skin twitch, no head movement toward flank
		2	No skin twitch, no head movement toward flank
Ability to stand	Manually prod ribcage with pen	0	Ability to stand
		2	Inability to stand
Warmth of oral cavity	Fingers in contact with Mucosa of hard/ soft palate	0	Normal mucosa warmth
		1	Cool mucosa
		2	Cold mucosa
Warmth of extremities	Hands clasped around fetlock	0	Normal skin warmth
		1	Cool skin
		2	Cold skin

**The score for each variable is added to yield a minimum score of zero in healthy calves and a maximum possible score of 13 in severely affected calves.*

Figure 2: Further studies on the clinical features and clinicopathological findings of a syndrome of metabolic acidosis with minimal dehydration in neonatal calves (T R Kasari and J M Naylor, Can J Vet Res., 1986 Oct; 50(4): 502–508).

The second part of this study by Kasari and Naylor (1986) focused on relating the depression score with the base deficit, e.g., the amount of bicarbonate in mmol/L to correct the acidosis. The amount of HCO_3 (mmol/L) needed is calculated as follows: Base deficit (mmol/L) x BW (kg) x 0.7; in order to convert mmol/L to grammes of bicarbonate required, divide by 12.5 as 1g of HCO_3 = 12.5mmol. Therefore, for a 40kg calf with severe acidosis and a base deficit of 25mmol/L, the formula would be: 25 x 40 x 0.7 = 700mmol/12.5 = 56g of bicarbonate required. This would be equivalent to 600ml of an 8.4 per cent hypertonic bicarbonate solution. However, the simpler option in practice is to spike a 5L bag of 0.9 per cent saline (NaCl) with 56g of bicarbonate (bread soda). Caution should be exercised with Hartmann's solution/compound sodium lactate; it contains calcium which commonly precipitates with the bicarbonate and can lead to blockage of the fluid line or IV catheter.

- In general practice, a calf with significant muscle weakness, inability to stand, poor or absent suck, and palpebral reflexes should be considered to have severe metabolic acidosis from a clinical point of view.
- A rule of thumb for managing cases of severe metabolic acidosis is to administer 1g of sodium bicarbonate per kg bodyweight, usually by spiking sterile fluids being used to correct concurrent dehydration.
- If a bicarbonate solution is administered too quickly, it can induce a hypocalcaemia with severe muscle tremors and potential cardiac arrythmia requiring treatment with calcium borogluconate.

Route of administration

Depending on the calf's demeanour, and its ability to stand and suck, the decision has to be made whether to administer fluids orally or intravenously. If a suck reflex is still present and the calf is only mildly dehydrated, oral rehydration therapy is indicated. An oral solution must satisfy four main requirements:

1) supply sufficient sodium (90-130mmol/L) to normalise the extracellular fluid volume (strong ion difference; SID);
2) provide agents (glucose, citrate, acetate, propionate, or glycine) that facilitate absorption of sodium and water from the intestine;
3) provide an alkalinising agent (acetate, propionate, or bicarbonate) which will not interfere with clotting of milk in the abomasum to correct the acidosis usually present in calves with diarrhoea; and,
4) provide energy, because most calves with diarrhoea are in a state of negative energy balance.

The SID (sodium [mmol] + potassium [mmol] – chloride [mmol]) should be between 60-80mmol/L to be effective (Smith, 2009). There are multiple suitable products on the market that can be given, although many do not have the concentrations of electrolytes in mmol on the labels making it impossible to accurately determine SID. The most important points when giving instructions to a farmer for oral fluid therapy are:

- to continue feeding milk to provide energy (if a calf has a reasonable suck reflex, they should be encouraged to suck from a bottle and teat); and,
- to not feed the oral electrolytes mixed into the milk or at the same time.

The two feeds should be separated at least two to three hours apart. The minimum amount of fluids a calf should

Figure 3: Intravenous fluid therapy in calves: (A) calf with dehydration, severe metabolic acidosis, and ruminal acidosis from tubing of milk; (B) calves receiving IV fluid therapy.

receive on a daily basis is 15 per cent of bodyweight, with 20 per cent of bodyweight more ideal if severe watery diarrhoea is ongoing. A calf with around 40kg BW should receive 6-8L of oral fluids in 24h divided into at least four feeds!

If a calf is severely dehydrated, unable to suck or stand, intravenous fluid therapy is indicated (Figure 3). A catheter can be placed, e.g., in the jugular or auricular vein. The ear veins may be easier to access in severely dehydrated calves. A common approach, if the dehydration is moderate and no acidosis is present, is to administer hypertonic saline 7.2 per cent NaCl and give oral fluids after. Another more preferable option, indicated in severely dehydrated and acidotic calves, is to give larger amounts of isotonic NaCl (0.9 per cent) spiked with bicarbonate, or isotonic $NaHCO_3$ (1.3 per cent). In practice, for example, 5l of saline (or CSL if saline is unavailable) spiked with 250-750ml of 8.4 per cent sodium bicarbonate solution (30-50g of bread soda). Additionally, 25 to 50g of dextrose can be added per litre of fluid to provide energy. This is of most importance in calves that show signs of septicaemia and are very likely hypoglycaemic.

The flow rate is important as, if fluids are administered too fast, it can lead to pulmonary oedema. A rate of 50-80ml/kg BW in the first hour is safe and can then be reduced to 30-40ml/kg/hour if the calf is left on the drip (Doré et al, 2019). The calf should be monitored for a moist cough, tachypnoea, and urination (no urine = acute renal failure). It can take a few hours to correct the initial fluid losses. Additionally, monitoring for improvement of the mental state, urination with 30-60 minutes after IV fluids, the restoration of suckle reflex, and the ability to stand are important and should be considered when planning further fluid administration (IV or oral). A guide for practice is shown in Figure 4 (Berchtold, 2009).

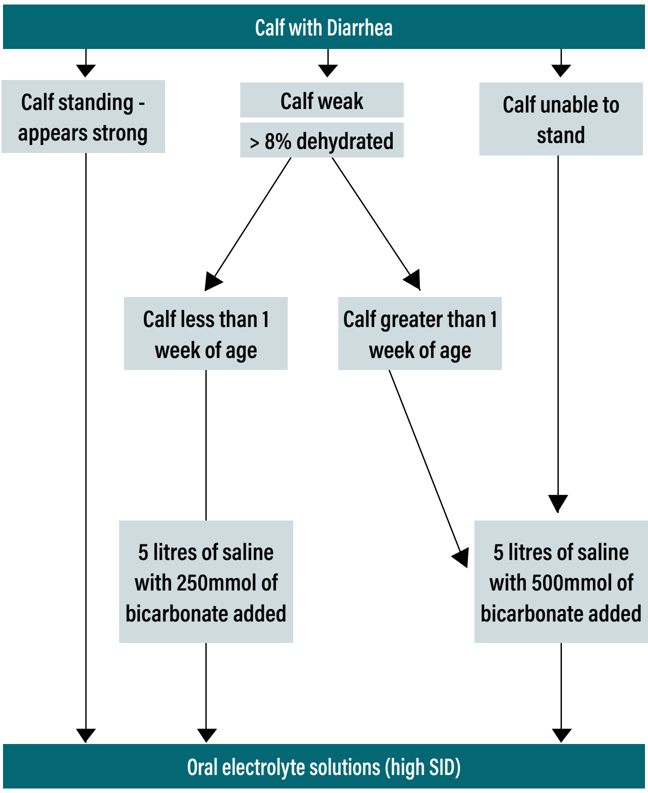

Figure 4: Treatment guide for a calf with diarrhoea by Brechtold (2009). This is a simplified algorithm for fluid therapy for dehydrated calves. This approach requires that the practitioner carry only 5-L bags of 0.9 per cent saline to which 8.4 per cent hypertonic sodium bicarbonate (HSB) can be added. 8.4 per cent HSB contains 1mmol of bicarbonate per millilitre (thus, a 100-mL bottle equals 100mmol of bicarbonate = 8.4 grammes).

Figure 5: Calf receiving a plasma transfusion: (A) taking blood from the recipient dam; (B) blood bags containing anticoagulant; (C) plasma separated into another bag after centrifugation; (D) administration of plasma to the calf with FPT; (E) calf post-transfusion under a red lamp for warmth.

Additional therapy

As diarrhoea is usually accompanied by inflammation of the intestinal tract, cramping and abdominal pain, analgesic and non-steroidal anti-inflammatory drugs (NSAIDs) are indicated, e.g., meloxicam or flunixin meglumine (Constable, 2009). The main goal is to reduce the inflammation and pain in the gastrointestinal tract. The administration of corticosteroids is not recommended as many of these calves have failure of passive transfer and are already immunosuppressed with subsequent septicaemia (Lopez et al, 1975). If the calf is showing signs of septicaemia and systemic illness, such as pyrexia, blood or mucosal shreds in the faeces, reddened mucous membranes, injected scleral vessels, and no improvement after initial fluid therapy, then antimicrobial therapy is indicated (Garcia et al, 2022). Parenteral administration of a bactericidal antibiotic with good efficacy against the gram-negative spectrum, e.g., amoxicillin or ampicillin is indicated. Alternatively, potentiated sulphonamides are also antibiotics of choice due to their good efficacy in the gastrointestinal tract.

Clean and dry bedding should be provided, as well as a heat lamp or calf jacket to keep the calf warm, and nursing care should also be be provided.

Failure of passive transfer (FPT) of colostral antibodies

Many calves with clinical signs of septicaemia and NCD have an underlying predisposing problem of failure of passive transfer of colostral antibodies. FPT can be identified in a simple way by measuring total protein (TP), with FPT associated with TP≤5.5g/dL. Alternatively, immunoglobulins can be measured, gamma glutamyl transferase (GGT) concentrations quantified, or the zinc sulphate turbidity (ZST) test carried out.

In order to optimise outcomes in calves with septicaemia and FPT, it is recommended to administer a plasma transfusion (10ml/kg) or a whole blood transfusion from the cow (Figure 5). Typically, in a hospital environment, a 50kg calf would receive 500-600ml of plasma after spinning down 1L of blood from the dam. In practice, administration of 1L of whole blood to a 50kg calf can result in similar and very beneficial improvements to demeanour and immunity with resultant improvements in cure rates.

Common mistakes to avoid

Several common mistakes encountered in field conditions can limit treatment success. Often clinical signs are misinterpreted, and metabolic acidosis is not recognised correctly. Calves with metabolic acidosis will try to compensate by increasing respiratory rate to blow off carbon dioxide (CO2) – this can be mistaken for respiratory disease. The therapy may then focus more on treatment of respiratory disease and correction of dehydration despite acidosis being the principal determinant of clinical severity.

Unfortunately, on other occasions, delay in calling the veterinary practitioner can result frequently in calves that require intravenous therapy being managed with oral fluids alone, resulting in appropriate treatment being delayed. In addition, the importance of dealing with ongoing fluid losses is frequently forgotten. Unfortunately, there is also still a misconception among some farmers that milk needs to be withheld, despite clear evidence showing that continued milk feeding supports energy balance and intestinal recovery (Barry et al, 2020).

The inappropriate and overuse of antibiotics in otherwise uncomplicated diarrhoea cases is decreasing and must be reduced due to subsequent problems with dysbiosis and antimicrobial resistance. Antibiotic use can also divert attention from the importance of rehydration and correction of acid-base disturbances. Collectively, these issues highlight the need for clearer clinical decision-making and improved communication with farmers to optimise treatment outcomes.

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Key take-home messages

- Fluid therapy is the cornerstone of treatment for neonatal calf diarrhoea.
- Metabolic acidosis, rather than dehydration alone, drives many clinical signs.
- The presence or absence of a suck reflex is a key indicator when selecting oral versus intravenous therapy.
- For a 50kg calf with severe dehydration and severe metabolic acidosis, 5L of IV fluids spiked with 50g sodium bicarbonate will usually rehydrate and correct most of the metabolic and acid-base disturbances.
- Milk feeding should be continued during diarrhoeal episodes.
- Early intervention and correct dosing of fluids significantly improve outcomes.
- Calves with clinical signs of septicaemia should be assessed for FPT and the administration of plasma or whole blood considered.

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READER QUESTIONS AND ANSWERS

1. WHAT OTHER PATHOLOGY IS USUALLY NOT ASSOCIATED WITH DEHYDRATION AND NCD?

A. Negative energy balance
B. Strong ion alkalosis
C. Strong ion acidosis
D. Increase in D-lactate

2. WHAT CLINICAL SIGN IS THE MOST SENSITIVE TO ASSESS THE GRADE OF DEHYDRATION?

A. Prolonged skin tent
B. Temperature of extremities
C. Moistness of mucous membranes
D. Enophthalmos

3. WHICH STATEMENT IS CORRECT?

A. Acidosis is more severe in calves less than one week of age
B. Calves with metabolic acidosis usually have an increased heart and respiratory rate
C. Calves with severe acidosis show presence of the palpebral reflex
D. L-lactate is caused by malfermentation of carbohydrates in the small intestines

4. WHAT REQUIREMENTS SHOULD AN ORAL REHYDRATION SOLUTION FULFIL?

A. It should provide an alkalinising agent like acetate, propionate, or bicarbonate to correct the acidosis
B. It should be low in sodium (20-40mmol/L)
C. The strong ion difference should be between 90-130mmol/L
D. It should not provide energy, as most calves with diarrhoea are in a state of negative energy balance

5. WHAT OTHER ADDITIONAL THERAPIES ARE RECOMMENDED?

A. Always administer antibiotics as most of the calves have septicaemia
B. Corticosteroids
C. Non-steroidal anti-inflammatory drugs (NSAIDs)
D. To feed milk and oral rehydration solutions at the same time

ANSWERS: 1B; 2D; 3B; 4A; 5C.