Practical fluid therapy for calves

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Neonatal calf diarrhoea remains one of the main causes of calf disease and mortality world-wide. Most causative organisms involved in the pathogenesis of neonatal diarrhoea produce severe damage to the enterocytes leading to villous atrophy and malabsorption. Depending on the extent of damage to the enterocytes, it will take from a few days to two weeks for the intestinal cells to heal and be able to properly absorb water, nutrients and electrolytes again. This means that some calves might exhibit diarrhoea for two weeks or longer even though the organism that caused the damage in the first place is long gone!

Specific therapy against the main causal pathogens (enterotoxigenic *Escherichia coli*, rotaviruses, coronaviruses, cryptosporidium) is either not available or does not significantly influence the duration and severity of diarrhoea. Regardless of the organism or mechanism involved, a young calf suffering from diarrhoea will have increased losses of water, electrolytes and buffer in the faeces, which together with decreased milk consumption will lead to dehydration, hypovolaemia, electrolyte imbalances, metabolic acidosis, accumulation of L- and D-lactic acid in blood, and negative energy balance.

Effective fluid therapy is vital to provide rehydration, treat acidosis and restore electrolyte and energy balance in diarrhoeic calves. Ideally, optimal fluid therapy should be individually tailored whenever laboratory analysis is available, giving an accurate measure of the acid-base, electrolyte, free water, glucose and plasma osmolality imbalances and deficits that need treating. However, most calves suffering from diarrhoea are treated out on the farm where vets don't have easy access to laboratory analysis before initiating treatment. In these cases, as clinicians we need to determine the nature and degree of the abnormalities likely to be present based on the clinical presentation of our patients and select the most appropriate fluid therapy approach for treatment.

Clinical assessment of calves suffering from diarrhoea

When assessing diarrhoeic calves, the two main things we want to find out is their degree of dehydration and degree of acidosis.

Dehydration

Dehydration develops due to excessive fluid loss and decreased fluid absorption in intestines. A calf with severe diarrhoea can lose copious amounts of fluids very quickly (one example from teaching hospital: loss of over 21% of body mass in fluids within 24 hours).

Useful clinical parameters for estimating current dehydration in calves are:

1. Eye recession into orbit/ enophthalmos:
    - Can be used to accurately estimate dehydration in percentage of body weight in neonatal calves (not known whether similar relationship exists for adult cattle).
    - Eye recession in mm x 1.6= % dehydration.
    - Mild enophthalmos of 1mm would indicate about 2% dehydration.
2. Skin tent
    - Ideally assessed on upper eyelid (include lashes), alternatively on neck.
    - Skin tent should resolve promptly in well hydrated patients.
    - Skin tent resolution slightly delayed (~2 seconds): 5% dehydration.
    - Skin tent resolution moderately delayed (~2-6 seconds): 8% dehydration
    - Skin tent does not resolve/ remains over 6 seconds: ≥10% dehydration.
3. Urine specific gravity (measured by refractometer): dehydration present if USG >1.030
4. Mucous membranes: not moist anymore, increased degree of tackiness with dehydration

5. Temperature of extremities: result of reduced cardiac output leading to reduced peripheral perfusion; manual comparison of temperature of hindlimb fetlock area of diseased calves with fetlock area of healthy calves housed in same environment

Acidosis

Acidosis in neonatal calves with diarrhoea develops due to a combination of loss of buffer in diarrhoeic faeces, increased production and accumulation of organic acids like D-lactate, plus dehydration leading to decreased glomerular filtration rate and therefore decreased ability to excrete a systemic acid load. Calves older than one week tend to become more severely acidotic than calves under one week of age.

Clinical assessment of acidosis involves:
1. Palpebral reflex: eyelids should close promptly and completely in normal calves; palpebral reflex will be slower and more incomplete depending on severity of acidosis.
2. Posture: ability to stand securely will be reduced depending on severity of acidosis
3. Other signs of acidosis: unphysiological postures while standing or lying, somnolence.

Table 1. Clinical estimation of acidosis severity

Severity of acidosis	Clinical signs	Approximate base deficit	Required amount of bicarb (g)
Mild	Standing securely, palpebral reflex mildly delayed	10mmol/L	20g
Moderate	Standing insecurely, can be pushed over, palpebral reflex delayed and incomplete	20mmol/L	40g
Severe	Recumbent/ unable to stand, very delayed or absent palpebral reflex	30mmol/L	60g

Fluid therapy

Three questions arise when considering fluid therapy approaches for scouring calves:
- How much fluid is required (volume?)?
- What ingredients are needed (amount of buffer, electrolytes, dextrose, etc.?)?
- How will we get it into the calf (oral, intravenous, milk?)?

Volume

To determine the total fluid requirements (for 24-hour period) for diarrhoeic calves, the following equation should be used:

Fluid requirements = existing losses + ongoing losses + maintenance.

Existing losses are calculated by multiplying % dehydration according to clinical assessment by body weight of the calf. *Ongoing losses* are estimated by evaluating the severity of diarrhoea/ faecal consistency that is currently present (4% of body weight/24hr for mild diarrhoea = pasty faeces; about 8% of body weight/24hr for moderate diarrhoea = soupy faeces; over 10% (up to 20%) of body weight/24hr for severe diarrhoea = watery faeces). *Maintenance fluid requirements* for calves are usually stated as 5-10% of body weight/24hr and it is recommended to stick closer to the 10% mark in young calves. For 40kg of body weight, these volumes will add up to total 24hr fluid requirements of 8–9L for calves with mild diarrhoea, and up to 13–15L for calves with severe diarrhoea.

However, based on experience, clinical improvement can be achieved with smaller than calculated volumes, especially once calves regain their ability to stand and suckle.

Fluid components

Buffer: sodium bicarbonate is the preferred (most economical and readily available) intravenous alkalinising agent. Alternative products, i.e. metabolisable sodium salts such as acetate and L-lactate are more expensive and result in a delayed increase in plasma bicarbonate. However, sodium bicarbonate cannot be heat sterilised and

should not be used in solutions containing calcium because an insoluble compound will form. Mildly hypertonic sodium bicarbonate solution (1.4%) is ideal but hypertonic solutions (up to 8.4%) can be used, with 1.4% solutions achieving faster rehydration, and 8.4% solutions achieving faster acidosis correction. Estimated amount of required sodium bicarbonate for acidotic calves (Table 1):

- 0.6 x base deficit x body weight = base requirement in mEq, OR
- Base deficit x 2 = amount of bicarbonate in g (for 40kg calf).

Glucose / dextrose: in calves with acute hypoglycaemia an IV bolus of 0.3g/kg BW can be given (30ml of 40% dextrose in a 40kg calf). 10g of dextrose (25ml of 40% dextrose) should be added to every litre of IV fluid for first day of treatment, however beyond that IV dextrose is not recommended since it will reduce voluntary milk intake.

Electrolytes: isotonic (0.9%) saline solution is acidifying, especially if large quantities are administered quickly. It also contains too much chloride (154mmol/L). Its use in large quantities (relative to volume of initial extracellular space) is therefore not recommended. In calves suffering mainly from dehydration without marked acidosis, rapid infusion of hypertonic (7.2%) saline (18g needle at 4–5ml/kg BW over 4–5 min) immediately after the administration of 2–3L of an isotonic oral electrolyte solution (OES) by oesophageal intubation immediately before hypertonic saline is administered has proven to be a successful approach.

Ringers: Lactated Ringer's solution is not recommended in diarrhoeic calves, because it effectively acts as a mildly acidifying solution rather than producing the expected alkalinising effect (Constable *et al.* 2021). Furthermore, although L-lactate can be metabolised to bicarbonate by neonatal calves, severely dehydrated calves often have already increased blood L-lactate concentrations and a significant decrease in the rate of L-lactate metabolism, making the addition of L-lactate to improve acid-base status clinically irrational. In addition, commercial formulations usually are racemic DL-lactate solutions and therefore contain D-lactate which is not metabolised in calves and thus just adds to the D-lactate load.

Fluid application

Oral electrolyte solutions (OES): offer as extra feed! Ideally 4–6L per day depending on severity of scours. OES can be offered *ad libitum* overnight for calves that are able to stand and drink. There is a variety of products available, read the label and make sure the product has sufficient alkalinising capacity (ideally 60–80mEq/L). The EU regulations for oral electrolytes used to treat calves with diarrhoea state they should have at least 60mEq/L! In mild to moderately acidotic calves, oral application of 50g sodium bicarbonate in 500ml water has been proven effective, especially for independently drinking calves or as repeated dosage for already treated and rehydrated calves. Avoid simultaneous feeding of bicarbonate and milk.

IV fluids: indicated if any of the following criteria are met: calf is severely acidotic, severely dehydrated (>8%), not able to stand, anorexic >24 hours, not drinking/too weak to drink. Ear catheters in calves work well, are more easily maintained on farm by the farmer, and are preferred over jugular catheters in severely dehydrated calves (concurrent hyperkalaemia makes them very vulnerable to stress). Provide between 250-750mmol sodium bicarbonate depending on severity of acidosis. Rehydration speed can be fast for calves for the first hour (80ml/kg BW over the first hour of infusion), drop to 50ml/kg BW/hr after that. Improved mentation and urination in calves that can stand are positive signs of rehydration that occur within 30-60min.

Milk: continue milk feeding if suckle reflex present! Milk withdrawal doesn't improve clinical outcome and leads to malnourishment and weight loss. Even 'high-energy' OES can't prevent negative energy balance in calves. Never drench or force feed milk (other than first colostrum).

Other recommendations

Warm up IV fluids as much as possible. Provide heat lamps and other means of warming up dehydrated calves (IV fluids <38°C will cool the calf).

A new vaccine against *Cryptosporidium parvum* has recently been launched in Europe, watch this space!

References

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