Bloat in young calves

Cases of bloat in calves, including a condition found in both dairy and beef herds, have increased in recent years in both the UK and Ireland and around the world. Dr Jessica Cooke BSc PhD, Volac, Hertfordshire, UK, discusses how bloat can affect the abomasum

WHAT IS ABOMASAL BLOAT?

Abomasal bloat is caused primarily by the excess fermentation of high-energy, gastrointestinal contents in the abomasum (from milk, milk replacer, or high-energy oral electrolyte solution), along with the presence of fermentative enzymes (produced by bacteria), resulting in the production of an excess quantity of gas, which cannot be evacuated from the abomasum (Burgstaller et al, 2017). This process is exacerbated by anything that slows down the rate of abomasal emptying, since it will give the bacteria already present in the stomach additional time for fermentation of carbohydrates. The exact aetiology is unknown but it involves both bacteria that produce a gas, as well as something that slows abomasal emptying (Burgstaller et al, 2017). Abomasal emptying in the calf is potentially influenced by several factors, such as volume, osmolality and caloric content of the ingested milk feed, as well as the abomasal and duodenal pH (Sen et al, 2006).

ABOMASAL EMPTYING AND MILK VOLUME

The volume of the milk feed ingested alters the rate of abomasal emptying as a means of ensuring nutrients are presented to the small intestine at a constant rate and stabilising blood-glucose levels. The abomasal-emptying rate for an entire meal has been shown to be 40% slower when feeding a high volume of milk (4L per feed) compared to a low volume (2L per feed) (MacPherson et al, 2016). When using a computerised feeder, it is recommended to limit the milk volume to a maximum of 2-2.5L per feed. For example, if the total volume of milk offered is 6L per day, allow the calf 2L of milk per feed, to ensure all meals are of an equal size. When using a twice-daily feeding system, milk should be limited to a maximum of 3L per feed. Never feed the calf 4L or more per feed, and don't feed the calf a large volume once daily.

ABOMASAL EMPTYING AND OSMOLALITY

Next to milk volume, the osmolality (Osm) of the milk is also an important determinant of abomasal emptying. Whole milk is typically 12.5% total solids, which equates to an osmolality of about 300mOsm/L, which is optimal for absorption and digestion of nutrients. Greatly decreasing or increasing the solids concentration, as well as adding additives to milk or milk replacer, will alter the osmolality and may alter digestibility. Increasing the solids concentration (i.e. adding more powder) is likely to delay abomasal emptying since the concentrated solution must be held in the lumen of the intestinal tract until enough water can be secreted to dilute the concentrated solution down to 300mOsm/L or below, and this can take considerable time. The osmolality of whole milk has been shown to increase from 265-533mOsm/L, with increasing total solids from 13.5-20.4%, respectively; but this increase up to 500mOsm/L, did not affect the passage rate, nutrient digestibility or faecal score (Azevedo et al, 2016). Reference values for osmolality are not well established, but it has been recommended that fluids with an osmolality of more than 600mOsm/L should be offered with caution, and they should never be provided when water is not available (McGuirk 2003). The osmolality of some milk replacers mixed at 13% (150g powder plus 1L of water) has recently been estimated at around 310-330mOsm/L (Wittek et al, 2016). As a guide, good-quality milk replacers should be mixed at up to 15% (ie. 150g milk powder per litre of mixed milk) with the aim of keeping the osmolality of the mixed milk at less than 500-600mOsm/L. The total solids content can be estimated and monitored on farm using a Brix refractometer. It is important to apply a correction factor; this will vary between different milk replacers as it depends upon the ingredients, fat, protein and carbohydrate content, and has been shown to vary between a digital and optical refractometer. Estimates of the correction factor for milk replacers have been made of between 1.1% (optical) to 1.5% (digital) to be added to the Brix reading (i.e. Brix reading of 12 indicates a total solids of 13.1-13.5%), but these values are specific to the milk replacer used (Floren et al, 2016).

Mixing rate is clearly a key determinant of osmolality, but once milk is mixed at the correct concentration (normally 12.5-15% milk solids), other on-farm factors can subsequently increase osmolality. Factors that can increase the osmolality of the ingested milk feed include:

- Poor calf health (diarrheic dehydrated calves);
- The addition of water-soluble antimicrobials or coccidiostats and rehydration fluids to the milk replacer (these can be very hypertonic and raise the osmolality);
- The use of soft water (with a high-sodium content) to mix the milk replacer; and
- A low-water intake.

Water consumption is key (see Table 1); if a calf does not drink enough water, this could increase osmolality and, in turn, delay the rate of abomasal emptying. Fresh, clean *ad libitum* water must always be provided from day one; if there are more than 20 calves per group, provide two water points. Variation in water intake and health between individual calves within a group is inevitable, therefore, mixing milk replacer at or below 15% should help to minimise the risk of 'creating' a high osmolality in calves where water consumption is low or in diarrheic, dehydrated calves.

Age	Water Intake
One to two weeks	1L per day
Three to four weeks	3L per day
Approaching weaning at eight weeks	5L per 1kg of dry feed consumed

Table 1: Expected water intake of calves up to weaning.

The rate of abomasal emptying has an important part to play in the onset of bloat, but there are also many other potential risk factors, including vagal nerve damage; bacteria; bacteria and colostrum; bacteria and milk-feeding equipment; and bacteria and water.

RISK FACTORS

VAGAL NERVE DAMAGE

Good calf health starts with excellent colostrum management, with stomach tubing often the method of choice. Abomasal motility is predominantly controlled by the ventral branch of the abdominal vagal nerve; vagal reflex is responsible for accommodation and relaxation of the abomasum while the calf is eating (Burgstaller et al, 2017). Oesophageal or pharyngeal injury resulting in oesophageal lesions can damage the intricate vagal-nerve branches responsible for eructation, swallowing and forestomach motility. The incorrect use of an oesophageal tube and/or a tube that is cold and hard, or damaged, will increase the risk of injury. A recent study has highlighted the difficulty in tubing calves; 15 Holstein Friesian calves were tubed one hour postnatum, but the tube could not be introduced directly into half of the calves (n=7) due to the inability to swallow or due to vigorous defence reactions (Kaske et al, 2005). It is recommended to always use a bottle and teat to feed colostrum. If a calf is unable to suck, and it is necessary to feed colostrum with a tube, the tube must be soft and clean, and in a good condition, and inserted by a trained individual to minimise the risk of injury. A calf should also only be tubed once.

BACTERIA

The bacterium that is suspected as the cause of abomasal bloat is a Clostridial bacteria, although other organisms may be involved. These include organisms such as *Sarcina ventriculi*, *Lactobacillus* species and *Salmonella typhimurium*; many of which are present in the calf's stomach all the time. In small amounts, these bacteria are generally harmless in the intestine, but under the right conditions they may grow and proliferate. The relatively low production of acid in the abomasum and limited production of trypsin (responsible for the digestion of the major lethal toxin, ß-toxin, produced by Clostridia) in the intestine, coupled with large amounts of milk or milk replacer increase the risk for rapid overgrowth by Clostridia. *Clostridium perfringens type A* is commonly found in many environments, including the normal bovine intestinal tract but also in water, contaminated or improperly thawed colostrum/milk, and calf-housing environments. Anything that encourages the growth of these bacteria will increase the risk of poor calf health and the onset of bloat. Excellent hygiene is, therefore, key.

BACTERIA AND COLOSTRUM

A recent study, assessing a total of 240 colostrum samples from 24 farms in Australia, reported that only 58% (n=140) of the colostrum samples met the recommendations in terms of a total plate count of <100,000cfu/ml (Phipps et al, 2016). In an earlier study, based on one farm in the US that was suffering from sporadic calf losses, it was reported that one of three samples of pooled colostrum yielded *C perfringens*, and environmental swab samples collected from the surfaces of the calving pen, the buckets for taking colostrum, and the walls of the fridge used to store the colostrum, yielded *C perfringens* type A (Van Kruiningen et al, 2009). Colostrum must be kept clean and always handled using clean and disinfected storage and feeding equipment.

BACTERIA AND MILK-FEEDING EQUIPMENT

An excellent level of cleaning and hygiene of the feeding equipment (used to feed both colostrum and milk, whether using buckets or a computerised feeder) is essential in making any system a success. A recent study, based on 38 farms in the US, highlighted the ability for bacteria to thrive on computerised feeders; 68% of samples taken from the tube end had a standard plate count of >100,000cfu/ml (recommended target for milk/milk replacer fed to calves is <100,000cfu/ml) (Jorgensen et al, 2017). But, it is important to note the health score (scored on a scale of zero to four, with a score of zero representing an apparently healthy animal) of these calves pre-weaning; the majority of calves were scored as 'zero' for attitude, ear, eye, and nasal score, and there was no report of bloat. Therefore, it suggests that despite the high levels of bacteria found, if the system is managed well, this level of bacteria may not always be an issue for poor calf health. However, due to the potential ability of bacteria to thrive on a feeder, strict adherence to the recommended cleaning protocol is essential to minimise the bacterial load, with particular attention to the teats and tubes/pipes. The teat should be swapped for a clean one daily (or even twice daily). The teat should be removed, washed, rinsed and placed in a bucket of sterilising solution, ready for the next day. Computerised feeders have both automated and manual cleaning functions; running automated cleaning functions several times a day, together with manual cleaning, has been shown to be associated with reduced bacterial contamination in milk (Dietrich, 2015). The type of detergent used is also paramount, since most feeders are set to operate at temperatures of 45-55°C, thus detergents designed to work at higher temperatures in the parlour may not be as effective.

BACTERIA AND WATER

About 1% of the UK population obtains water from a private supply (well, borehole or spring), which may include no treatment (Barrell et al, 2000). In 1999, it was estimated that there were 200,000 or more private wells in Ireland. Of 75 boreholes tested in Cork, 24% were positive for thermotolerant coliforms (Bacci and Chapman, 2011). Wet-weather conditions are thought to have a significant impact on the microbiological water quality. Using water with a high-bacterial load to mix milk replacer and/or as a source of drinking water will clearly pose an increased risk for poor calf health. If a private water supply is used, consider testing for bacterial content.

Other possible risk factors of abomasal bloat include stress, disease and there may also be a genetic link. Minimising stress is important for all aspects of calf health; milk volume offered per day and group size are key. During the first two weeks, the calf experiences significant health and environmental stresses – the energy available to the calf during this time is directly proportionate to the supply of milk or milk replacer. The best way to increase the amount of energy provided is to simply feed a bigger volume of milk. Although milk replacers only contain 16-20% fat, the lactose content in milk replacer also provides energy. In total, the proportion of energy supplied by the fat and lactose is similar for milk replacers (whey or skim based) and whole milk. In fact, increasing the oil content of the milk replacer from 16-20% has a negligible effect compared with simply feeding more of the same (see Table 2). As a guide, following the colostrum-feeding period (approximately one to three days), feed 5L of milk until one week of age, then from one week onwards offer a minimum of 6L of milk per day. Ensure calves reach their peak milk allowance by two weeks of age at the latest. The aim is to feed calves more from the start when they need the energy provided in milk, and allow a longer weaning period (of about three weeks) to encourage starter intake in these high milk-fed calves.

Milk volume and mixing rate (12.5%)	Energy supplied/calf per day (MJ) 16% oil, 22% protein	Energy supplied/calf per day (MJ) 20% oil, 22% protein
4L- 12.5%	7.5	7.8
5L - 12.5%	11.7	12.2
6L - 12.5%	14.0	14.6

Table 2: Daily energy intake and the effect of feeding a low vs. high oil milk replacer, or feeding different volumes.

Bigger groups are associated with more competition, more stress, more disease, and poor health. Calves in larger groups (n=24) tend to drink their milk feed faster and in fewer visits than calves housed in smaller groups (n=12) (Dietrich, 2015). The ideal group size for young calves is 12 to 15 calves per group (maximum of 20 calves per group). Many computerised feeders are designed to feed 30 to 35 calves per feed station. Therefore, if calves are housed in larger groups of up to 30 to 35, minimise the age range between the calves within the group (ideally, seven days, maximum 21 days range), ensure calves have enough access to resources (ie. feed calves more milk to reduce the competition at the feeder), and ensure there are enough water points (as a guide, allow two-water points per 20 calves).

The onset of abomasal bloat is a complex multifactorial issue; the exact cause remains unknown. It is likely to involve a combination of both management and nutritional factors – when several of these risk factors come together at one time, they likely overload the calf resulting in bloat. During an outbreak of abomasal bloat, it is important to consider all the potential risk factors, and make appropriate changes in an attempt to alleviate the combination of causative factors.

KEY RECOMMENDATIONS:

- Colostrum management – remember the four Qs (quickly, quantity, quality, squeaky clean);
- Colostrum-feeding method – use a bottle and teat;
- Milk volume per feed – feed 2-2.5L per feed (3L maximum for twice-daily feeding systems);
- Milk curve – provide calves with at least 6L of milk per day from one week of age;
- Mixing rate – mix at or below 15% (ie. 150g per litre of mixed milk).
- Make sure the correct amount of milk powder is being mixed with the water (use weigh scales) and always mix consistently;
- Do not add anything to the milk replacer;
- Water intake – make sure calves are drinking enough water;
- Water source – ideally use mains water to ensure good water quality;
- Clean feeding equipment is essential – change and clean the teat daily;
- Group size – the ideal group size is 12 to 15 calves per group (with a maximum of 20 calves per group).

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