Oesophageal Groove Dysfunction as a Complication of Neonatal Diarrhea in the Calf*

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Introduction

Ever since the basic investigations by Wester[29] as well as by Trautmann and Schmitt[23] it has been recognized that the initiation of the oesophageal groove contraction in the bovine depends on certain prerequisites. Subsequent investigations dealt with different details of reflex induction (e.g. 6, 7, 13, 15, 18, 19, 20, 30, 31, etc.). From several communications it is evident that even in the healthy calf a small amount of the consumed milk–on average, it is thought, less than 10% of the volume taken[13,30]—almost always flows from the oesophageal groove into the reticulo-rumen. However, larger volumes of fluid may flow out, depending on the method of feeding, substance being fed, age and other influencing factors. In addition, some of the fluid consumed may reach the rumen from the abomasum by a physiological or nonphysiological reflux. If the fluid remains in the reticulo-rumen for a sufficient period of time, the nutrients it contains are subject to bacterial breakdown.

Van Bruinessen-Kapsenberg, Wensing and Breukink[5] indicated in 1982 that disorders of the reticulo-rumen (indigestions) can occur as a consequence of disturbance of the oesophageal groove reflex in initially healthy veal calves. Since then this disease complex, the so-called 'ruminal drinking,' has been intensively studied by the Dutch investigators (Utrecht).[2,3,4,5,16,25,26,27,28] Our own investigations have shown that oesophageal groove reflex dysfunction can also lead to a serious complication in calf neonatal diarrhea.

Materials and Methods

The investigations included 249 calves, aged up to two weeks, which had been hospitalized due to neonatal diarrhea. Ten healthy milk-fed calves from farms were used as controls. During the first fortnight of life and a second time at the age of 3 to 4 weeks ruminal fluid was aspirated, 3 hours post-feeding. In addition, control investigations were carried out on 12 clinic patients which had recovered; they had previously suffered from enteritis[11] or bronchopneumonia.[1] The diagnosis or suspicion of oesophageal groove dysfunction was based on the following examinations:

1. auscultation during ballottement and during percussion of the left flank to detect splashing or metallic sounds in the upper third of the abdomen (Fig. 1);
2. rumen auscultation during drinking;
3. aspiration of ruminal fluid by stomach tube about 30 minutes and also 3 hours following the fluid consumption;
4. rumen fluid examination by the following methods: gross appearance (color, odor, consistency, floccule formation, nonphysiological admixtures and quality of the sediment); centrifugation test: 10 ml of rumen fluid are centrifuged at 1500 U/min. for 10 minutes. If the sample contains entire milk then three layers are formed—from top to bottom: fat, whey and sediment.

Determination of pH value, total acidity, chloride content, methylene blue reduction as well as total content of volatile fatty acids and concentrations of acetic, propionic, butyric and (L + D) lactic acids. Statistical methods: calculation of the arithmetic median value, standard deviation, comparison of median values with the t-test, comparison of relative frequencies by means of the Chi-Square test. For further data see Dirr (1988).

Results

Findings in healthy milk-fed calves:

On clinical examination prior to the rumen fluid aspiration, splashing sounds from the rumen could be detected in half of the calves. Character and localization of the sounds, a soft, dull splashing in the lower third, differed distinctly from the auscultatory findings typical for the 'ruminal drinking' calf (see Methods).

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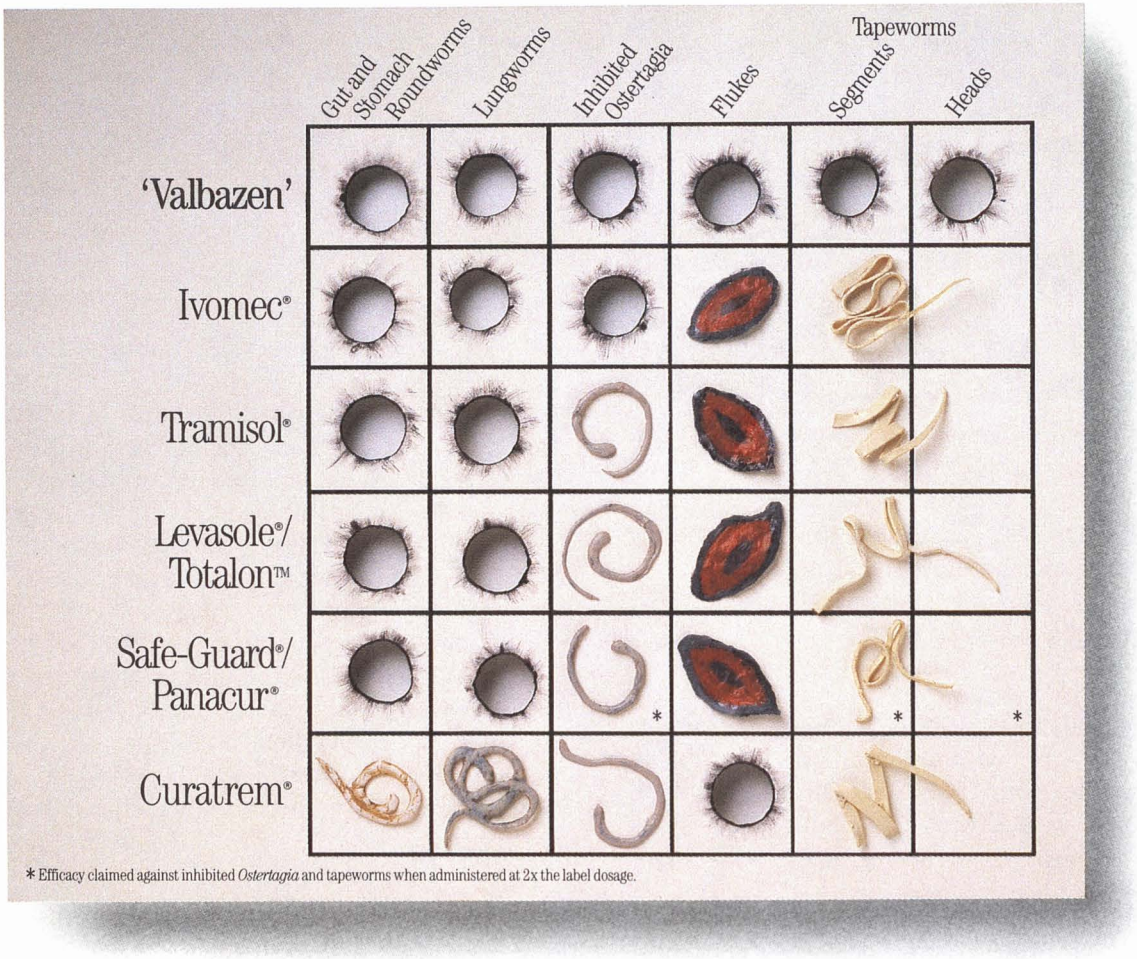

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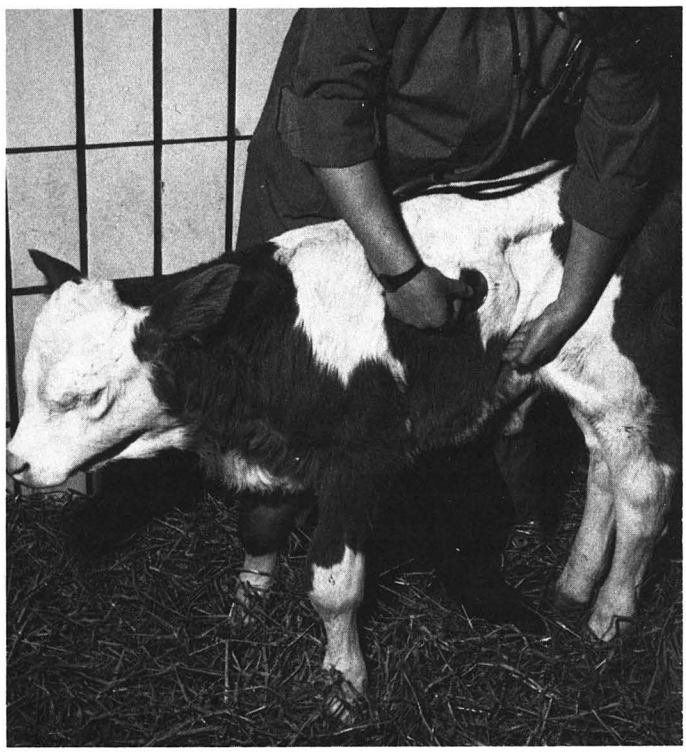

FIGURE 1. Auscultation during ballottement of the left flank to detect splashing sounds.

Rumen fluid findings: The rumen fluid was colored light-milky to beige, mainly with a stale smell and a watery viscosity. The centrifugation test was always negative. Further data are listed in Tables 1 and 2.

TABLE 1. pH-value, total acidity, chloride concentration and uration of methylene blue (MB) reduction in rumen fluid samples from 10 healthy milk-fed calves at the age of 1–2 weeks and 3–4 weeks; $\bar{x} \pm s$ (min.–max.)

Age	pH-value	Total acidity clinical units	Chloride mmol/l	MB-Reduction minutes
1. Sample 1–2 weeks	6.8±0.4 (5.8–7.1)	12.3±4.2 (6.0–18.0)	80±17 (55–102)	5.7±3.1 (2–10)
2. Sample 3–4 weeks	6.7±0.3 (6.4–7.0)	17.0±4.2 (12.0–24.0)	75±15 (42–93)	7.0±2.6 (3–10)

The findings from the recuperated clinic patients are in accordance with those described above, and will therefore not be individually listed. (Individual data from Dirr, 1989).

TABLE 2. Total concentration of volatile fatty acids (C_2–C_4) as well as concentrations of acetic (AA), propionic (PA), iso-butyric (i–BA) and butyric (BA) acids in rumen fluid samples from 10 healthy milk-fed calves at the age of 1–2 weeks and of 3–4 weeks; $\bar{x} \pm s$ (min.–max.).

Age	(C_2-C_4)	AA	PA	i-BA	BA
	mmol/l $\bar{x} \pm s$ (min.–max.)				
1. Sample 1-2 weeks	17.4±6.4 (7.9-28.4)	13.0±5.6 (4.8-24.8)	3.1±1.4 (1.9-6.7)	0.3±0.2 (0.1-0.7)	0.8±0.3 (0.2-1.1)
2. Sample 3-4 weeks	24.2±5.6 (11.8-34.0)	17.3±3.9 (8.7-23.8)	5.8±2.0 (2.0-8.7)	0.3±0.2 (0.2-0.6)	0.8±0.3 (0.7-1.1)

Findings in calves with neonatal diarrhea and oesophageal groove dysfunction:

Incidence and distribution: In 28 (11.2%) of the 249 patients with acute catarrhal enteritis, a disturbance of the oesophageal groove contraction, could be ascertained during their stay in the clinic. Out of this group eleven animals (39%) died. A further 29 calves (11.6%) were highly probably affected by such a disturbance; 12 of them died (41%).

On clinical examination of 57 of these patients, high-pitched splashing sounds could be heard in 74% on auscultation with ballottement of the left flank, up to its upper level. In a proportion of the examined animals (16%) metallic sounds ('steel band effect') were audible on auscultation with percussion of the left side of the abdomen.

Rumen fluid findings: The acid status of the rumen fluid could be checked over several days in a total of 30 diarrheic patients with an oesophageal groove disturbance, as well as in a further 7 'ruminal drinkers' suffering from other primary ailments. It was evident that intensive fermentation processes were taking place in the rumen. From the analyses of the acids and further criteria, the following types of fermentation could be distinguished:

1. predominant butyric acid fermentation;
2. predominant lactic acid fermentation;
3. biphasic type, where a predominant lactic acid fermentation changes to predominant butyric acid fermentation, or vice versa.

Consequently, the rumen fluid findings on the day of hospitalization will be presented in Tables 3, 4, and 5 according to fermentation type.

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TABLE 3. Gross findings and results of the centrifugation tests of rumen fluid samples, taken on the day of hospitalization, from 30 milk-fed calves with dysfunction of the oesophageal groove.

Fermentation Type	Color	Smell	Viscosity	Centrifugation Test
Butyric acid fermentation (n = 10)	milky 8 beige 3	rancid 9 stale 1	watery 7 thick 3	+ 5 - 5
Lactic acid fermentation (n = 20)	milky15 beige 5	sour 15 rancid 2 stale 2	creamy13 watery 7	+ 18 - 2

TABLE 4. pH-value, total acidity (TA), chloride concentration and duration of methylene blue (MB) reduction of rumen fluid samples, taken on the day of hospitalization, from 30 milk-fed calves with dysfunction of the oesophageal groove; $\bar{x} \pm s$ (min.–max.).

Fermentation Type	pH	TA clinical units	chloride mmol/l	MB-reduction minutes
Lactic acid fermentation (n=20)	4.6±0.6 (4.0-5.2)	53±13.8 (23-80)	48±16 (28-71)	9±3 (3- > 10)
Butyric acid fermentation (n=10)	5.7±0.4 (5.0-6.2)	32±14.7 (18-60)	58±20 (26-84)	3±2 (1-6)

Figures 2 to 7 show examples of changes in the acid status of rumen fluid, over a number of days, from milk-fed calves with oesophageal groove dysfunction and different initial findings.

Discussion

The study of rumen fluid from healthy milk-fed calves showed that even in the first few weeks of life fermentation or break-down processes were taking place in the reticulo-rumen. It became apparent that the fermented substrates originated from that milk which had flowed out from the oesophageal groove and/or flowed back from the abomasum. The measured total concentrations of volatile fatty acids (TVFA) at average levels of 17 (1./2. weeks) to 24 (3./4. weeks) mmol/l (Table 2) correlate to those of Anderson et al., 1987, also derived from milk-fed calves. During the first two weeks of life the greater proportion consisted of acetic acid; at about the third week of age the level of propionic acid also began to rise markedly. The

TABLE 5. Concentrations of volatile fatty acids and of lactic acid in rumen fluid samples of 37 calves with oesophageal groove dysfunction. Samples of group A and B were taken on the day of hospitalization, those of group C during the course of the disease. TVFA—total concentration of volatile fatty acids; AA/PA/BA—acetic, propionic, butyric acid; L-La/D-La/TLA - L-, D-, total lactic acid; $\bar{x} \pm s$ (min.–max.).

	Fermentation Type	TVFA	AA	PA	BA	L-LA	D-LA	TLA
		mmol/l $\bar{x} \pm s$ (min.–max.)						
A	Lactic acid fermentation (n=20)	9±7.3 (1-22)	6±4.9 (1-20)	2±2.2 0-7)	1±1 (0-4)	31±13 11-58)	10±10 0-37)	41±20 (14-79)
B	Butyric acid fermentation (n=10)	42±11.7 (27-53)	21±5.8 (13-31)	5±3.5 (2-14)	16±5.7 (8-31)	-	-	-
C	Lactic acid phase (n=7)	10±4.7 (3-17)	7±4 (3-15)	1±1 (0-3)	2±2 (0-3)	22±10 (11-35)	6±4 (2-12)	29±11 (18-47)
	Butyric acid phase (n=7)	54±19 (30-76)	28±13 (14-44)	5±3 (2-9)	20±6 (10-32)	(2.3)*	(2.4)*	(4.7)*

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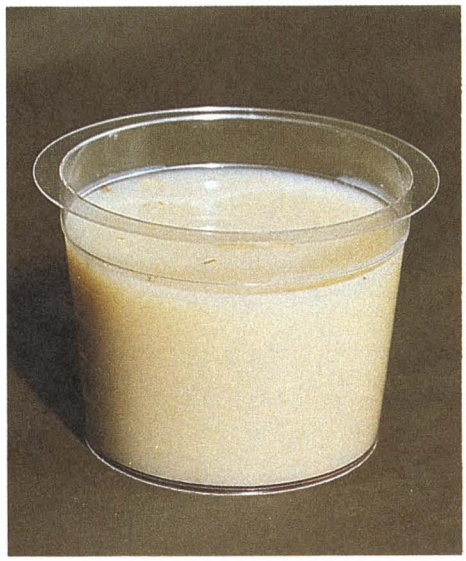

FIGURE 2. Rumen fluid sample, taken about 30 minutes after milk intake, from a calf with dysfunction of the oesophageal groove. The sample still has a milk-like character.

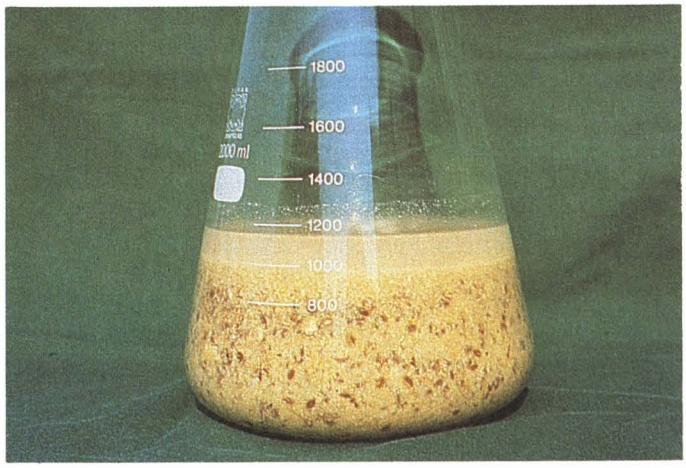

FIGURE 3. Rumen fluid sample of a milk-fed calf with continuous oesophageal groove dysfunction. The sample shows changes as with predominant lactic acid fermentation.

butyric acid concentration, in contrast, remained low and rarely rose above 1 mmol/l. The pH value of the samples varied between 5.9 and 7.2; however, the average values, at 6.8 (first sample) and 6.7 (second sample) were very similar (Table 1). Of note (in comparison to those of adult cattle) were the high chloride levels of the samples. They can be explained in part by the fact that cow milk has a high chloride level of 45 mmol/l on average; the chloride concentrations of the milk substitutes ranged from 40 to 60 mmol/l. To some extent the physiological reflux of milk from the abomasum, as described by Trautmann and Schmitt,[13] may also have played a part. Other influences, such as salivary influx or selective absorption processes appear unlikely. A direct comparison of the results with those of other authors is not possible due to different experimental conditions (older calves, other feeding regimes, etc.;[12, 21, 22]).

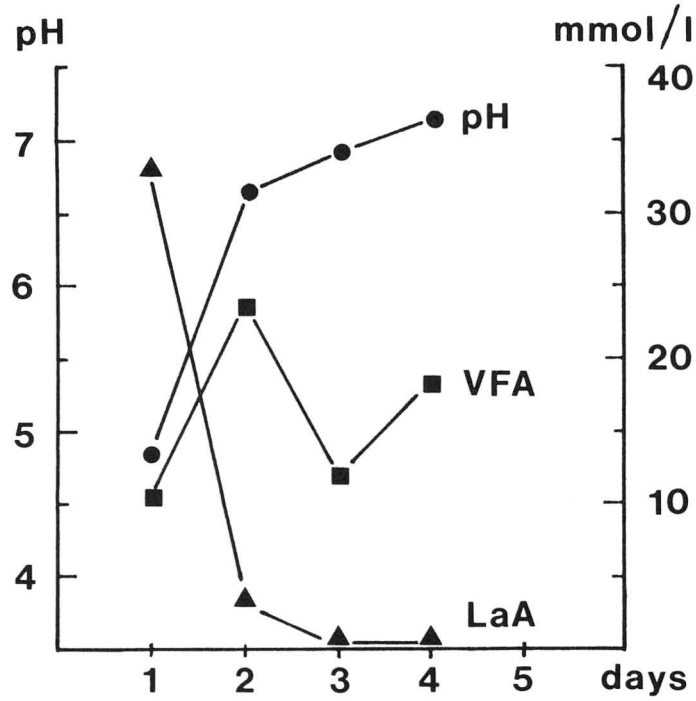

FIGURE 4. Example of initial predominant lactic acid fermentation, with subsequent normalization (recovery); calf 1298/87, age 7 days, acute catarrhal enteritis.

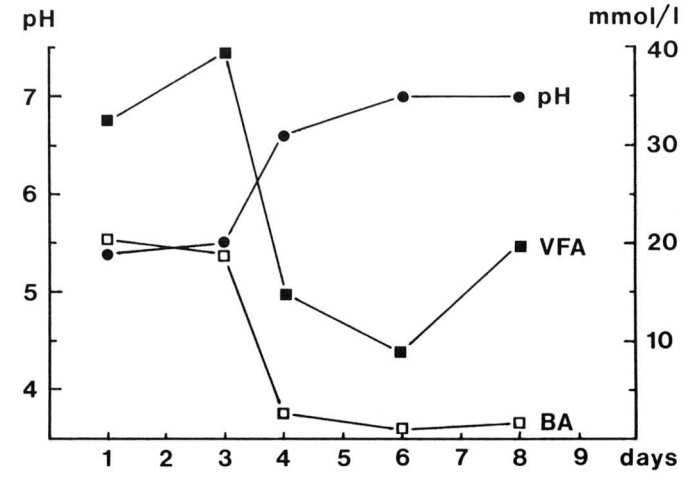

FIGURE 5. Example of initial predominant butyric acid fermentation, with subsequent normalization (recovery); calf 109/88, age 14 days, acute catarrhal enteritis.

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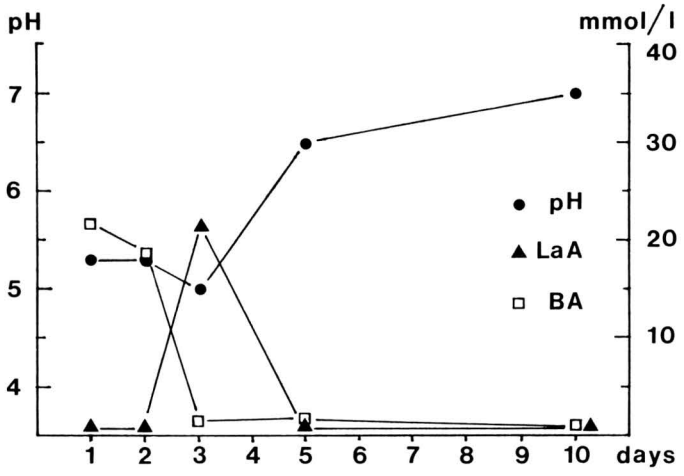

FIGURE 6. Example of biphasic fermentation type (butyric acid→lactic acid), with subsequent normalization (recovery); calf 965/88, age 5 days, acute catarrhal enteritis.

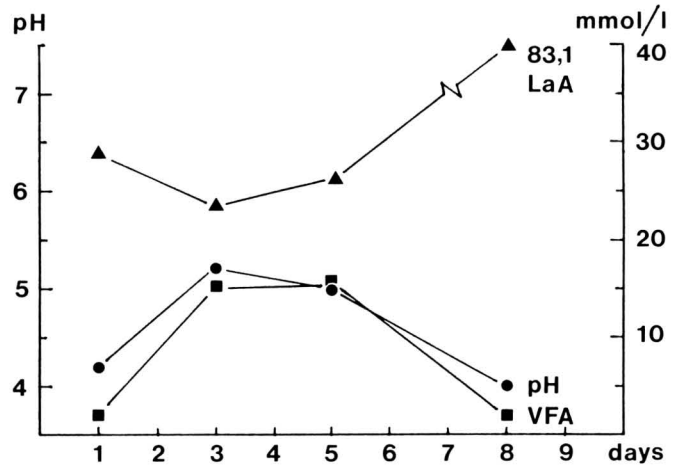

FIGURE 7. Example of persistent predominant lactic acid fermentation without normalization (lethal outcome); calf 1212/87, age 9 days, acute catarrhal enteritis.

The rumen fluid findings from the diarrhea patients with disturbed oesophageal groove function differed, as can be seen from the data in Tables 3, 4 and 5, quite considerably from those of healthy milk-fed calves in regard to gross appearance and particularly to the acid status. Total concentrations of volatile fatty acids of up to 70 mmol/l (with a high butyric acid proportion) and (L- and D-) lactic acid concentrations up to 83 mmol/l were measured. That is to say, the lactic acid concentrations almost reached the levels found in adult ruminants with an acute lactic acidosis.

Such fermentation processes in the still undeveloped rumen of young calves result in an additional worsening of their general condition, as revealed during our practical observations, and may result in a fatal outcome. In this way the absorption of nutrients from the intestines is inhibited, and the acid-base balance, in many cases already disturbed by the diarrhea, receives an additional burden in the form of lactic acid (and possibly also the relatively large quantities of butyric acid) reaching the abomasum and intestine to be resorbed. Acid flowing into the intestine raises the osmotic pressure, causes irritation of the mucosa and can thus initiate diarrhea by itself or prolong an infectious diarrhea. Eventually the ruminal acidosis reduces the animal's appetite and becomes a possible reason for the maintenance of the oesophageal groove dysfunction, and a vicious circle is created. If the abnormal fermentation continues for one to two weeks, morphological changes of the forestomach mucosa ranging from dyskeratosis to ruminitis can be expected. There is probably an association with the relatively frequent moderate ruminal tympany. All these observations indicate that an oesophageal groove dysfunction arising in a young calf with diarrhea is a complication which must always be taken seriously. This is emphasized by the high death rate of the calves studied (approximately 40%) compared to that of uncomplicated cases (less than 20%).

First indications of the diagnosis of 'ruminal drinking' are the high-pitched splashing and metallic sounds which can be heard on auscultation of the left flank during ballottment and percussion.

Confirmation of the diagnosis can be achieved by the aspiration of rumen fluid via a stomach tube. Whereas the samples which are taken about 30 minutes after feeding still retain a milk-like character, verified on centrifugation, further samples siphoned-off around three hours later show signs of completed acid formation. Precise information regarding the type of fermentation is provided by an appropriately equipped laboratory, but gross examination may provide some initial information. A predominant lactic acid fermentation is characterized by milky-white color, watery consistency (frequently with floccules), a sour odor, low pH-value (4.0 – 5.5) and a very high total acidity (50 to 100 clinical units). On the other hand, predominant butyric acid fermentation results in ruminal fluid with a pronounced rancid odor, thick in consistency, yellow in color and with not such a low pH-value (5.5 – 6.5) as with prevailing lactic acid fermentation.

On the basis of the observations on veal calves from the Dutch research group mentioned previously, as well as on our own experiences with young calves, it can be concluded that during the clinical examination of a diseased milk-fed calf, one should always check for the presence of oesophageal groove dysfunction.

Summary

It is well documented that the induction of the oesophageal groove reflex in the milk-fed calf depends on

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certain prerequisites: The fluid the calf drinks must come into contact with the receptors located in the pharynx, it must be consumed voluntarily by the animal without undue disturbances, it should have no offensive smell or taste, and the general status of the calf should not be disturbed. When those conditions are not met, the oesophageal groove closes incompletely or not at all and the milk flows into the reticulo-rumen. If the milk or any other nutrient solution remains there for a sufficient period of time, the nutrients it contains are subjected to bacterial breakdown.

In a study including 249 calves (age < 14 days) suffering from *Enteritis catarrhalis acuta*, it could be demonstrated that no closure of the oesophageal groove occurred in 11.2% of the patients; 11 calves of that group died. The same was probably true for a further 11.8% of the diarrheic calves; 12 of them died.

In 37 ruminal drinkers suffering from neonatal diarrhea (n = 30) or another primary disease (n = 7), the acid status of the rumen fluid could be examined several times. According to the analyses, the following types of fermentation could be distinguished:

1. predominant butyric acid fermentation;
2. predominant lactic acid fermentation;
3. "biphasic type": predominant lactic acid fermentation changes to predominant butyric acid fermentation, or vice versa.

In the milk fed calf suffering from neonatal diarrhea dysfunction of the oesophageal groove reflex (ruminal drinking) with its consequences (rumen acidosis, dyskeratosis of the ruminal mucosa) can be the cause of a fatal outcome of the disease.

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