

## **Chapter Two**

### **Left displacement of the abomasum in dairy cattle: recent developments in epidemiological and etiological aspects**

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## Summary

The research with respect to displacement of the abomasum (DA) in dairy cattle is reviewed. Evaluated articles describe epidemiological and experimental studies. Contributing factors to the occurrence DA are breed, gender, age, concurrent diseases, environmental aspects and production levels. Emphasis is placed on the effects of nutrition and metabolism. Reviewing the experimental work there is focussed on two topics: research of gas production in the abomasum and hypomotility of the abomasum, since both represent presumed pathways in the development of DA. Although the different fields of research have positive contributions to the understanding of the pathogenesis of DA, contradictions in the different studies are present.

**Abbreviation key:** DA = displaced abomasum, NEB = negative energy balance, VFA = volatile fatty acid.

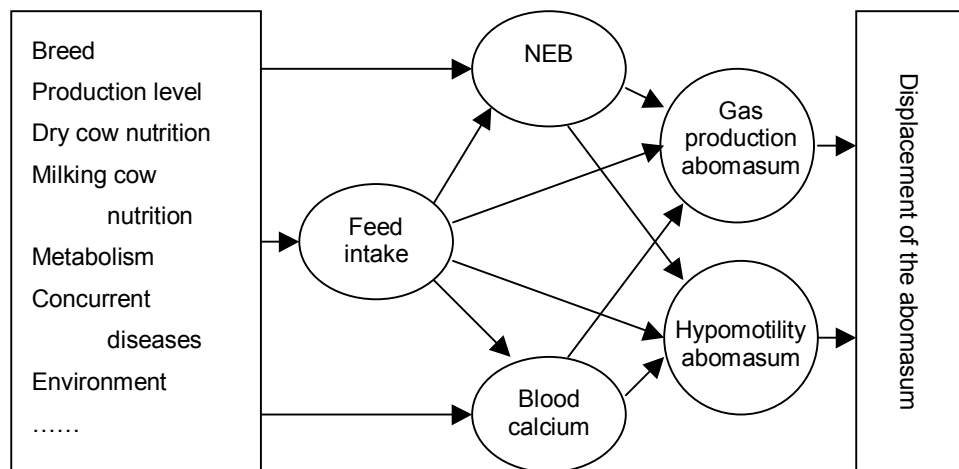
## Introduction

Since the first report of displacement of the abomasum (DA) in a cow by Begg in 1950, this disorder in dairy cattle nowadays has become more common. The DA is characterised by the abomasum filled with gas and floating in the dorsal part of the abdomen. This state can result in anorexia and signs of colic, accompanied by a drop in milk yield, discomfort of the cow and in some cases death (Dirksen, 1962). After (non-) surgical correction of the position of the abomasum the milk production can be disappointing, which may result in culling of the cow. The total estimated economic loss of a case of DA is between US \$250 to \$450 (Bartlet et al., 1995). Geishauser et al., (2000) have calculated the annual loss in North America due to DA as up to 220 million dollar. The incidence of DA varies, depending on the country, from 0 to 7 percent per year (Cameron et al., 1998 and Kelton et al., 1998). There is however a large variation at herd level within a country (Van Dorp et al., 1999 and Wolf et al., 2001). Some herds seldom have a case of DA, while in other farms the incidence can be 20% (Dawson et al., 1992, Jacobsen, 1995, and Kane, 1983). When the herd-incidence is high, DA can result in considerable economic losses.

In the pathogenesis of the DA the accumulation of gas in the abomasum is crucial. The underlying hypothetical cause of this accumulation is a combination of two pathways: an increased production of gas in the abomasum and a hypomotility of the abomasum (Dirksen, 1962). The gas accumulated in the abomasum consists mainly of methane (70%), and carbondioxide (Dirksen, 1962 and Svendsen, 1969). When gas production is present, this is equal to the clearance in oral or aboral direction. When motility of the abomasum is inadequate accumulation of gas may occur (Breukink, 1977, Dirksen, 1962, and Geishauser, 1995). The vagus nerve plays a predominant role in abomasal motility (Cottrell and Stanley, 1992, Cottrell, 1994, Geishauser 1995, Geishauser et al., 1998b, and Ruckebusch et al., 1987). Besides the effect of the vagal nerve, large amounts of volatile fatty acids (VFA) in the rumen and abomasum (Breukink and De Ruyter, 1977, Gregory and Miller, 1989, Poulsen and Jones, 1974, Svendsen, 1970, and Vlamincck et al., 1984), endotoxins (Vandeplassche et al., 1984, Vlamincck et al., 1984, and Vlamincck et al., 1985), metabolic alkalosis (Poulsen and Jones, 1974) and low blood calcium levels (Madison and Trout, 1988) are mentioned as plausible causes for a decreased motility. Kuiper and Breukink (1988) reported periodical, at night-time, inactivity of the abomasum, mainly the corpus. They related the inactivity to lying at night, or a day-night rhythm. In a postpartum cow one or both mechanisms, hypomotility and gas production or gas inflow, can play a role, resulting in accumulation of gas and buoyancy of the abomasum. In Figure 1 a flowchart is presented. In this chart epidemiological aspects relate to etiological factors. These etiological factors are linked with the two pathogenic pathways (hypomotility and gas production) that

lead to DA.

The research on abomasal displacements consists mainly of epidemiological surveys and experimental studies. The epidemiological research has generated associations, risk factors and hypotheses. The experimental work is performed to test these and other hypotheses. The aim of this paper is to evaluate these efforts, with an emphasis on the developments in the last decade, and to suggest directions for further research.



**Figure 1.** Flowchart of risk factors of DA (in left text box), related to etiological factors (ovals). The pathogenic pathway (circles) of the etiological factors

## Epidemiological factors

### Species, breed, gender, age and production level

The displacement of the abomasum as a disease has been described in ruminants of the Western Hemisphere, sheep, goat and cattle, both male and female. With respect to the incidence of DA one should conclude that DA is mainly a disorder associated with cattle, in particular Holstein-Friesian, Jersey and Guernsey cows. Geishauser et al. (1996) and Uribe et al. (1995) reported a heritability of DA of 0.24 and 0.28 respectively. Van Dorp et al. (1998) however, could not confirm this finding.

The major risk period is the first month after calving, with an increasing risk with increasing age (Constable et al., 1992). Other authors report that the first

lactation is also a period with a relative high risks for development of DA. This could be due to poor social and nutritional adaptation of the newly lactating heifer (Jubb et al., 1991). Lacasse et al. (1993) found a four times higher risk for DA in heifers that were fed ad libitum in the period of 1 to 1.5 years of age, compared with their restrictedly fed controls. DA is associated with milk production: the higher the milk yield the larger the risk of development of DA (Fleischer et al., 2001). Other authors report that this relation is not always present (Cameron et al., 1998 and Rohrbach et al., 1999). An explanation can be the findings of Dettelleux et al. (1997): DA cows have a 557-kg lower 305-day milk production than control cows and 30% of the milk loss occurred before DA diagnosis. The general opinion is that cows that develop DA are high producing cows, but due to DA the current lactation period has a poor milk yield. Constable et al. (1992) conclude that, taking milk production into account, there is still an unexplained high incidence of DA in Jersey and Guernsey dairy cows. An explanation can be that these breeds are more susceptible than Holstein-Friesian cows for the occurrence of hypocalcemia, which is discussed later.

In general could be concluded that a high producing dairy cow in the first four weeks after calving, of the HF, Jersey or Guernsey breed, are animals with high risk for DA.

### **Nutrition and metabolism**

Cows developing a DA show depressed feed intake prior to DA diagnosis (Østergaard and Gröhn, 2000). This is in accordance with the remarks of Dirksen (1962), who suggests that a decreased rumen filling enables the abomasum to move to the left, even before clinical presence. This is reflected in the findings of Cameron et al. (1998). They report restricted supply of energy dense feed in late gestation as a risk factor for DA. There is an association between the amount as well as the quality of the roughage fed and DA (Dawson et al., 1992, Jacobsen, 1995, and Shaver, 1997). Roughage of poor quality and bad tastiness leads to a lowered feed intake with DA as a result (Jacobsen, 1995). Some authors recommended a fibre length of the roughage of minimal 1.3 to 2.5 centimetres (Dawson et al., 1992 and Shaver, 1997). The fibre length is needed for rumination and saliva production. There is also an association between the kind of roughage fed and the occurrence of DA; feeding a large proportion of maize of the total roughage is associated with a higher risk of DA (Van Winden et al., 2002a). Parallel to these findings Cammack (1997) describes more frequent abomasal displacements and other disorders of the abomasum in herds that are fed a large proportion of maize silage. The roughage component of the ration should not be

looked at without paying attention to the concentrate part of the ration, since the combination of both will result in the fermentation processes in the rumen. A proportion of at least 25% of roughage in the ration on dry matter basis is a rule of thumb from nutritionists' point of view, whereas concentrates should be supplied three or four times daily (Centraal Veevoeder Bureau, 2001, Shaver, 1997, and Van Winden et al., 2002a). Østergaard and Gröhn (2000) suggest that feeding concentrates together with roughage in a Total Mixed Ration (TMR) reduces the odds for DA. They report that rumen fill, ration physical form (fibre length) and the amount of volatile fatty acid produced in the rumen are considered as the major causes for hypomotility of the abomasum resulting in the development of DA.

Nutrition as well as milk production and breed confound metabolism. The high producing dairy cow has certain nutritional requirements to maintain the equilibrium of its metabolism. There are three factors concerning metabolism associated with the phenomenon of DA: hypocalcemia, metabolic alkalosis and negative energy balance (NEB). Several authors describe clinical hypocalcemia in postpartum dairy cows as a risk factor for DA (Correa et al., 1993, Massey et al., 1993, Oetzel, 1996, Rohrbach et al., 1999, and Van Dorp et al., 1999). Lowered calcium levels also in the second week of lactation are found in cows prior to DA (Geishauser et al., 1998a). A decreased contractility of the abomasal wall during hypocalcemia is the hypothesised cause of abomasal hypomotility.

Metabolic alkalosis is mentioned as a risk factor for DA (Poulsen, 1974). Metabolic alkalosis is a risk factor for hypocalcemia via a reduced sensibility of the receptors for parathyroid hormone (PTH). In Jersey and Guernsey cows there is a decreased sensibility of the PTH-receptors (Horst et al., 1997). This can explain the relatively high incidence of DA in these breeds (Constable et al., 1992). It seems likely that both the metabolic alkalosis as well as the Jersey- and Guernsey breed's susceptibility are based on the increased risk for hypocalcemia leading to an increased risk for DA. Hypocalcemia is the probable pathway for the risk factors "breed" and "metabolic alkalosis".

Another disturbance in metabolism is a severe NEB. Every postpartum dairy cow develops a NEB. However, not every cow experiences problems with it. Disease depends mostly on the depth and the duration of the NEB. A severe NEB has been regarded to result in an increased risk for DA (Cameron et al., 1998, Correa et al., 1993, Geishauser et al., 1998a, Heuer et al., 1999 and Rohrbach et al., 1999). Pathways mentioned are hypo- or hyperglycemic status, hyper-, or hypoinsulinemia in these cows (Holtenius et al., 2000).

There could be concluded that a reduced feed intake in both dry cows and lactating cows is a risk factor for DA. As a result the cow experiences hypocalcaemia and a more severe NEB, which could be the pathway of development of DA.

### **Concurrent diseases and environmental aspects**

Concurrent diseases, other than hypocalcemia and the NEB, consist of inflammatory processes and lameness. It is mentioned that endometritis can have a risk attributive effect on the development of DA (Correa et al., 1990, Rohrbach et al., 1999). Endotoxins and mediators of inflammation can be a direct cause of DA via motility disorders. Induction of hypocalcemia can be an effect of endotoxins and a direct reason for DA. Lameness as a herd problem is more often seen in herds with DA (Lotthammer, 1992). The explanation is reduced feed intake by lame cows, resulting in DA.

Environmental aspects comprise season, weather, and housing system and housing quality. Reports of occurrence of DA in different seasons are not concise; in general most cases occur in winter (Cameron et al, 1998, Constable et al., 1992, and Correa et al., 1990). The hypothesised reason for this high incidence is the declining quality of the stored roughage over winter, with possibly poor intake of roughage as a result. There is evidence that besides season weather conditions influence the incidence of DA. Rainfall, low temperature and strong wind increase the incidence of DA cases when cows are at pasture, probably via a reduced intake of roughage (Van der Post, 1999). No recent epidemiological reports are available about the effect of housing systems and –quality, nor about the effects of walking exercise of the cows.

### **Etiological factors**

Recent epidemiological studies have three main subjects, which generated hypotheses: feed intake, negative energy balance and calcium related effects on the abomasal functioning, with respect to motility and production of gas.

#### **Feed intake**

Epidemiological research revealed a decreased feed intake prior to the development of DA. Okine and Mathison (1991) report that in cows with high dry matter intake (DMI) the size particles in the gastrointestinal tract were increased compared to cows with low DMI. This increase in large particles was combined with an increased digestive flow. Diets low in fibre caused low rumen fill and result in a decreased digestive flow in lactating cows (Feng et al., 1993). Beside a change in amount of feed, the postpartum dairy cow experiences a change in the composition of the ration. In the dry period the diet consists mainly of roughage, while after calving the ration is rich in concentrates. A diet containing concentrates compared

with a ration of only roughage resulted in a reduced myoelectrical activity of the abomasum in sheep (Lester and Bolton, 1994). In cattle a change from a roughage rich diet to a concentrate rich ration however, had no influence on abomasal myoelectrical activity or abomasal emptying (Madison et al., 1993).

Fermentation of digested feed stuffs lead to production of volatile fatty acids in the rumen (VFA). Rapid fermentation results in high levels of VFA. The VFA in the rumen fluid are either absorbed, with a limited capacity, or enter the abomasum. The inhibiting effects of VFA on the activity of the abomasum are controversial (Breukink and De Ruyter, 1977 and Svendsen, 1970). Gregory and Miller (1989) showed a reduced activity of the abomasum when infused with VFA concentrations of more than 100 mmol/l. One should consider that concentrations used are fivefold the normal abomasal contents (Breukink and De Ruyter, 1977). According to Forbes and Barrio (1992) the inhibitory effect of VFA on the activity of the abomasum occurs through the osmotic pressure. A high osmotic pressure of abomasal fluid results in a decreased motility of the abomasum and a reduced feed intake (Forbes and Barrio, 1992). Whether interaction of the vagus nerve is the case is uncertain. Martens (2000) postulated that osmotic pressure has its effect through an overload of the abomasum with fluid. An osmotic pressure higher than 341 mmol/kg in rumen contents results in a flux of water into the rumen. Also an increased osmotic pressure resulted in a decreased absorption of VFA by the rumen wall (López et al., 1994). The only pathway of diminishing rumen volume is via a drain towards the abomasum, which leads to a distension of the abomasal wall (Martens, 2000). When the abomasal wall is stretched too much, this can lead to decrease of motility via the vagus nerve or the nonadrenergic noncholinergic (NANC) system (Geishauser et al., 1998b). An impaired response of the abomasal muscles to acetylcholine was noticed in DA patients as a result of an inhibitory effect of nitric oxide (NO). Nitric oxide is synthesised by the abomasal smooth muscle and is part of the NANC system and has a relaxing effect of smooth muscles (Geishauser 1995, Salzman, 1995).

Sarashina and others (1990) concluded that the gas in the abomasum originates from rumen fluid. CO<sub>2</sub>: CH<sub>4</sub> ratio in gas of the rumen is on average 2, whereas the ratio in abomasal gas is 0.4. Absorption of CO<sub>2</sub> via the abomasal wall can explain the shift in CO<sub>2</sub>: CH<sub>4</sub> ratio (Kolkman et al., 1998). In cows with a higher amount of concentrates in the ration the CO<sub>2</sub>: CH<sub>4</sub> ratio in both rumen and abomasal fluid increased due to a shift in metabolic products of the microbial flora (Mackie et al., 1992 and Sarashina et al., 1990). Besides the CO<sub>2</sub>: CH<sub>4</sub> ratio, the amount of gas escaping from the abomasum in cows increased in cows that were fed a concentrate rich ration (Svendsen, 1969). He reported an In this report a control diet of hay resulted in a production of 0.5 litre gas in the abomasum, whereas the concentrate rich diet resulted in more than 2 litres of gas. Another possible route of gas production is fermentation of contents in the abomasum. This



is only possible in conditions of an elevated pH of the abomasal contents above 5.5. Van Winden et al. (2002b) reported a rise in abomasal pH in postpartum cows. Besides a rise in pH, there was a large variation in pH of abomasal contents in these cows in the second and third week after calving.

### **Negative energy balance**

Dairy cows postpartum undergo a negative energy balance due to the fact that energy loss (milk) exceeds energy intake. During the early lactation glucose and insulin blood levels decrease, whereas ketone bodies and non-esterified fatty acid level in the blood increase (Smith et al., 1997 and Herdt, 2000). Patients with a displaced abomasum however, often have an elevated glucose and insulin level in the blood circulation (DeCupere et al., 1991, Itoh et al., 1998 and Muylle et al., 1990,). Holtenius et al. (1998 and 2000) report decreased abomasal motility in cows with elevated insulin, glucose, and glucagon levels as well as in cows with high insulin combined with low glucose levels. The hypomotility of the abomasum could be mediated by a decreased vagal tonus (Forbes and Barrio, 1992 and Holtenius et al, 2000). The authors mention difficulties in interpreting the results since the levels of glucagon, glucose and insulin are dependent on each other and the blood levels exceed normal conditions. Van Winden (Chapter Six) found low levels of insulin and glucose in cows that later on developed DA. The latter situation reflects the general metabolic characteristic of a cow in postpartum NEB. The elevated glucose and insulin levels found in DA cows are probably secondary to the disorder due to stress, whereas low glucose and insulin levels precede DA.

### **Calcium**

Calcium is present in the blood circulation both in ionised form and bound to proteins. The sum of both is the total calcium concentration in the blood. This is used in the following text. Although, in general, rumen motility declines during a moderate hypocalcemia of 2 mmol per litre (Jorgensen et al., 1998), Madison and Troutt (1988) found that a calcium level below 1.2 mmol/l had a reducing effect on the abomasal motility. These levels are similar with reported cows with milk fever (hypocalcaemia postpartum). They conclude that these levels are too low for cows several weeks in milk and thus hypocalcemia cannot be an etiological (causative) factor for decreased abomasal motility with respect to the development of DA. Another etiological role for calcium can be the fact that calcium is a second messenger in the parietal cell of the abomasum. In man a reduced acid secretion in the stomach is reported during hypocalcemia (Puscas et al. 2001).

## Final remarks

One can, in general, agree that epidemiological and experimental research both have contributed to the insight of the pathogenesis of DA. However, there is little co-operation between both fields of research. Epidemiological studies generate hypotheses, which are seldom evaluated by experimental work. When experimental work does evaluate epidemiological findings, these epidemiological findings sometimes can not be explained (low calcium levels prior to DA) and even contradictions do occur, e.g. concerning the effect of glucose levels on abomasal functioning. Further research is preferably performed on cows in sufficient numbers in order to prevent lack of power of the experiment. Emphasis should be on the transition period of the postpartum dairy cow, since this is the period at risk for DA.

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