

Quantitative measurement of udder oedema in dairy cows using ultrasound to monitor the effectiveness of diuretic treatment with furosemide[#]

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Quantitative Messung von Euterödemen bei Milchkühen mittels Ultraschall zur Kontrolle der Wirksamkeit einer diuretischen Therapie mit Furosemid

Ziel dieser Studie war, den Verlauf von peripartalen Euterödemen bei Milchkühen mittels Ultraschall zu messen und den therapeutischen Effekt des Diuretikums Furosemid zu untersuchen. Zu diesem Zweck wurde ein Aufsatz mit Drucksensor für die Ultraschallsonde entwickelt, welcher Messungen unter ähnlichen Druckverhältnissen und somit wiederholbare und vergleichbare Ergebnisse ermöglichte. Im Rahmen eines Vorversuchs wurden bei 10 Kühen täglich in einem Zeitraum von 14 Tagen ante partum bis 14 Tagen post partum Ultraschallmessungen an vier Lokalisationen pro Euterviertel durchgeführt. Der Hauptversuch fand an 50 Kühen statt. Den Tieren der Versuchsgruppe (n=25) wurde am Tag der Kalbung und am ersten und zweiten Tag post partum jeweils 500 mg Furosemid intramuskulär verabreicht. Die Tiere der Kontrollgruppe (n=25) erhielten 10 ml 0,9% Natriumchlorid-Lösung gleichermaßen. Der Versuchszeitraum erstreckte sich vom 21. Tag ante partum bis zum 21. Tag post partum. In dieser Zeit wurden 15 Ultraschallmessungen im Abstand von jeweils drei Tagen an der Zitzenbasis durchgeführt. Diese Position war im Vorversuch als beste Messlokalisation identifiziert worden. Zusätzlich wurden Viertelgemelksproben am Tag der Abkalbung, an Tag 7 und an Tag 14 genommen. Ein Zusammenhang zwischen subklinischen Mastitiden und der Ausprägung des Euterödems konnte nicht festgestellt werden. Die durchschnittliche Euterödemedicke unterschied sich nicht zwischen der Furosemid- und der Kontrollgruppe. Zusammenfassend ist zu sagen, dass eine Methode zur Messung von Euterödemen mittels Ultraschall etabliert werden konnte. Die Zitzenbasis erscheint die optimale Messlokalisation für Untersuchungen zum Verlauf von Euterödemen zu sein. In der vorliegenden Studie hatte die Behandlung mit Furosemid keinen messbaren positi-

Summary

The aim of this study was to record the course of peripartal udder oedema with ultrasonography in dairy cows and to investigate the therapeutic effects of diuretic furosemide. For this purpose, a device with a force sensor for the ultrasound probe was developed, which ensured the generation of data under similar pressure conditions and thereby repeatable and comparable results. In a pretrial with ten cows, ultrasonographic measurements were performed daily at four locations per udder quarter beginning 14 days ante partum until 14 d post partum. The main study included 50 dairy cows. The experimental group (n=25) received 500 mg furosemide intramuscularly on the day of calving, as well as on the first and second day post partum. The control group (n=25) was treated with 10 mL 0.9% sodium chloride solution (NaCl) at the same timepoints. The experimental period was extended from 21 days ante partum until 21 days post partum and included 15 ultrasonographic measurements at three-day intervals. The measurements were performed at the teat base, which turned out to be the most suitable location in the pretrial. Quarter milk samples were collected on the day of calving, 7 and 14 days post partum. The average thickness of the udder oedema between the group treated with furosemide and the control group did not differ. In conclusion, a method for the ultrasonographic measurement of udder oedema under comparable applied forces was established. The teat base turned out to be a suitable location to monitor the characteristic temporal course of udder oedema. In the present study, treatment with furosemide did not have a measurable, positive effect on the severity of the udder oedema post partum in the study animals. Finally, further studies with a higher sample size are necessary to confirm this relationship.

Keywords: cattle Dimazon® oedema udder ultrasonography quantification

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ven Effekt auf die Ausprägung des Euterödems bei Milchkühen. Allerdings sind weitere Untersuchungen mit einer größeren Stichprobe nötig, um diesen Zusammenhang abschließend zu klären.

Schlüsselwörter: Rind Dimazon® Ödem Euter Sonographie Quantifizierung

Introduction

Udder oedema is a physiological condition in dairy cows around parturition.³² Normally, udder oedema disappears two to three weeks after calving.¹ Excessive periparturient or persisting udder oedema may be a risk factor for decreased milkability, udder tissue induration, teat and udder skin necrosis, mastitis, trauma and decreased milk yield.^{5,8,15} Despite these economically important consequences, the aetiology of pathological udder oedema still remains unknown. However, there have been numerous studies investigating risk factors related to this condition. Especially the role of oestrogens, feeding, age and genetic disposition have been evaluated.^{3,17,21,22,29} Additionally, the cranial superficial epigastric venous blood pressure has an influence on the development of udder oedema.³⁰ Periparturient udder oedema has been shown to be more severe and more common in heifers than in older dairy cows.⁷ As previous semiquantitative evaluations lacked precision and were subjective,^{4,9,28} testing possible therapeutic effects proves difficult. Ultrasonography is a sensitive method for identifying oedema. The udder oedema appears sonographically as alternating hyperechoic and hypoechoic parallel lines in the subcutaneous space at defined locations.³⁴ Recently, a sonographic udder oedema scoring system, allowing objective determination of the severity of udder oedema in show cows after a prolonged milking interval, was evaluated.² Thus, it was possible to differentiate between overbagging and other forms of oedema

in dairy show cows. It was the aim of this study to develop a method for periparturient dairy cows which can determine the thickness of udder oedema using ultrasound and to investigate the effectiveness of diuretic treatment with furosemide. By placing an ultrasound probe on the udder skin, oedematous subcutaneous tissue can be easily differentiated from the fibrous udder capsule and the remaining udder tissue. However, in order to obtain repeatable results for the thickness of udder oedema, the pressure applied with the ultrasound probe on the tissue needs to be constant. Otherwise, the udder tissue is virtually compressed, leading to inconsistent measurements. This was achieved by designing a carrier for the ultrasound probe containing a force transducer linked to a voltmeter. In the main study, the treatment success of furosemide in udder oedema should be examined with this measuring unit. We hypothesised that the injection of furosemide would reduce the mean thickness of udder oedema post injectionem in comparison to the mean udder oedema thickness in control animals which had only received 0.9 % sodium chloride solution (NaCl)-solution.

Material and methods

Force transducer unit for ultrasound probe

For this trial, the portable ultrasound device Sonovet 2000 (Medison Co., USA) with a 5 MHz linear probe was used. The development of the measuring unit was necessary to achieve constant pressure while taking the measurements to obtain repeatable results. The measuring unit was developed in cooperation with the electronics workshop of the Institute of General Radiology and Medical Physics of the University of Veterinary Medicine Hannover, Germany. The probe was connected with the measuring unit which consisted of three components: the force transducer (Type 8435, Fa. Burster Präzisionsmesstechnik GmbH & Co KG, Gensbach, Germany; Figure 1), the single channel amplifier (Type 9236, Fa. Burster Präzisionsmesstechnik GmbH & Co KG, Gensbach, Germany) and the voltmeter (VC 120, Voltcraft Hirschau, Germany; Figure 2). The force transducer recorded the force during the measurements and transduced it in a voltage. The amplifier raised the voltage and transmitted it to the voltmeter. In this way, involuntary force variations were displayed on the voltmeter in millivolts. The measuring

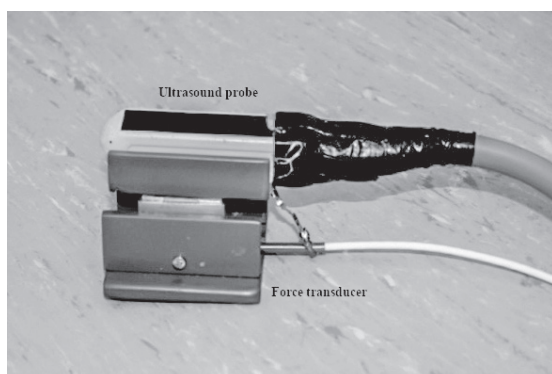


Figure 1: Measuring unit Part I: Ultrasound probe (5 MHz, Sonovet 2000® (Medison Co., USA) connected with the force transducer (Type 8435, Burster Präzisionsmesstechnik GmbH & Co KG, Gensbach, Germany).

system was calibrated with reference weights before and after the measurements were taken.

Pre-trial

The pre-trial for establishing the method took place at the Clinic for Cattle of the University of Veterinary Medicine Hannover. One healthy cow with a marked non-inflammatory udder oedema post partum was used for a serial measurement to test the repeatability of the results. Five healthy cows with a marked non-inflammatory udder oedema post partum were needed to find the optimal measuring pressure.

Farm and feeding of the animals

The preliminary experiment and the main study were performed on a commercial dairy farm in the region of Hannover (80 cows, German Holstein, milk yield: 9,900 kg). The lactating cows were housed in a freestall barn (high boxes, rubber mats, sawdust) and the dry cows were housed on a straw bedding. The lactating cows received a total mixed ration (TMR) in two levels (level 1: 40 L milk per day, level 2: 25 L milk per day) based on corn silage, grass silage, barley, rye, corn, protein mix (soy/rapeseed) and minerals. The dry cows were fed a TMR based on 50 % corn- and grass silage and minerals. The transition cows received the TMR level 1 of the lactating cows and hay ad libitum from two weeks ante partum until one week post partum.

Preliminary experiment part 1: Finding the optimal measuring location

Ten healthy cows with a marked non-inflammatory udder oedema post partum were used to find the optimal mea-

suring location. Calving did not take place earlier than three days before the expected calving date. Ultrasonographic measurements were performed daily at four locations per udder quarter (1. teat, 2. teat base, 3. udder middle, 4. udder base) beginning 14 days ante partum until 14 days post partum. At the udder, the distance between udder skin and the udder capsule was measured in mm and identified as oedema thickness. At the teat, the distance measured in mm between skin and teat lumen was identified as oedema. Per location, the mean value of three measurements was documented as the daily udder oedema thickness. Figure 3 is an example of such an ultrasound image with three measuring points.

Preliminary experiment part 2: other factors possibly affecting the severity of the udder oedema

During the same time period and in the same ten healthy cows, the concentration of total free oestrogens in blood plasma (ten samples every third day) and the concentration of sodium and potassium in saliva (14 days ante partum, day of calving, 14 days post partum) were measured. The measurements were performed in the Clinical Chemistry Laboratory and the Endocrinology Laboratory of the Clinic for Cattle, University of Veterinary Medicine Hannover. Sodium and potassium concentrations were measured using quantitative flame photometry.¹³ The intraassay coefficients of variation for sodium and potassium were 0.19 % and 4.5 %, respectively. Concentration of total free oestrogens was measured using a competitive double antibody enzyme immunoassay.²³ The intraassay and interassay coefficients of variation were below 10 %. Additionally, sterile

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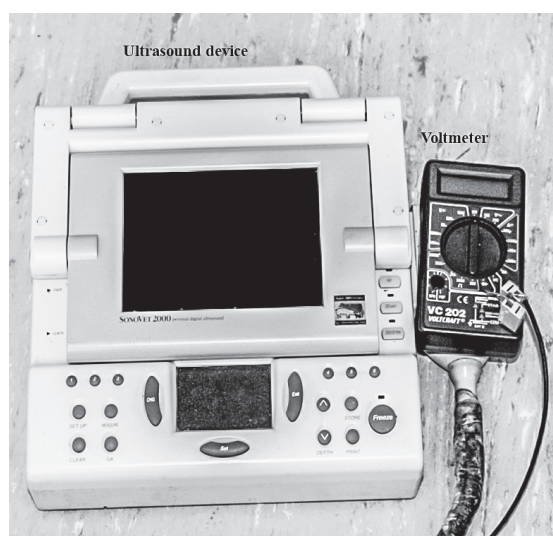


Figure 2: Measuring unit Part II: Voltmeter (VC 120, Voltcraft, Hirschau, Germany) fixed to the plug of the ultrasound probe of the Sonovet 2000® (Medison Co., USA) for better handling.

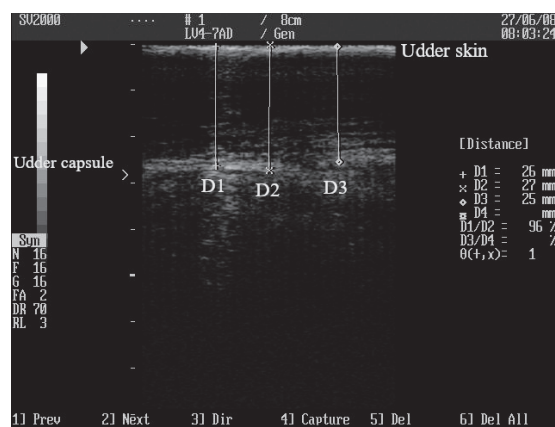


Figure 3: Ultrasound image of the left front quarter of cow 44; measuring location: teat base; timepoint: day of calving; markings showing three distance measurements (D1, D2, D3 in mm) from udder skin (upper white line near the ultrasound probe) to the udder capsule (lower line). The mean oedema thickness of this udder quarter was recorded as the mean of these three distance measurements. The mean oedema thickness of this measuring day was the mean of measurements of all four quarters.

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quarter milk samples of these cows were taken at the day of calving, 7 days post partum and 14 days post partum. The bacteriological examination took place in the Milk Laboratory of the Institute for Food Quality and Food Safety, University of Veterinary Medicine Hannover. The cytological examination of the milk samples was performed with Fossomatic® Firma Voss Elektrik, DK-3400 Hillerod (Production Medicine Unit of the Clinic for Cattle). The findings of the quarter milk samples were categorised in accordance with the DVG guidelines 2002 modified by Potrafki, 2005.^{12,26} These four categories were normal secretion, latent infection, unspecific mastitis and subclinical mastitis. All parameters were checked for a possible influence on the severity of the oedema.

Main study: Testing the treatment effectiveness of furosemide
The main study included 50 dairy cows (14 heifers, 36 cows). The animals for the study groups were selected by a lottery procedure. There was a separate lottery procedure for cows and heifers. The experimental group (n=25, seven heifers, 18 cows) received 500 mg furosemide (Dimazon®, Intervet Deutschland GmbH, Unter-

schleissheim, Germany) intramuscularly on the day of calving, as well as on the first and second day postpartum. The control group (n=25, seven heifers, 18 cows) was treated with 10 mL 0.9 % NaCl solution at the same timepoints. The experimental period was extended from 21 days ante partum until 21 days post partum and included 15 ultrasonographic measurements at three day intervals localised at the teat base. Furthermore, quarter milk samples were collected on the day of calving, 7 and 14 days post partum.

Statistical analysis
Statistical analyses were carried out using the Statistical Analysis System (Version 9.1, SAS Institute, Cary, NC, USA). Normality of data points was tested using the Shapiro–Wilk test (proc univariate). All data points of the preliminary experiments and the main study were not normally distributed. Values were shown as median with first (Q25) and third quartile (Q75) or as boxplots, respectively. In the preliminary experiment (finding the optimal measuring position), differences were calculated in SAS and proc univariate was used to examine the differences in udder oedema thickness between the measuring timepoints. Wilcoxon’s signed rank test (proc univariate) was used to compare the differences in mean udder oedema thickness between the front and hind udder quarters. In the preliminary experiment concerning associations between total free oestrogens in plasma or sodium and potassium in saliva and the mean udder oedema thickness a correlation analysis was performed (Spearman, proc corr). In the preliminary experiment (relationship between subclinical/unspecific mastitis on mean udder oedema thickness) and in the main study (evaluation on treatment success of furosemide and relationship between subclinical/unspecific mastitis on mean udder oedema thickness), Wilcoxon’s two-sample test was used (proc npar1way). For the time point analysis, Wilcoxon’s signed rank test (proc univariate) was used. Differences were considered significant at $p \leq 0.05$.

Table 1: Test for repeatability of the ultrasound measurements: first quartile (Q25), median, third quartile (Q75) and coefficient of variation (CV) of repeated measurements (n=15) of udder oedema thickness (mm) at the teat base of one primigravid cow with pronounced udder oedema.

Localisation	Front quarter		Hind quarter	
	Left	Right	Left	Right
Q 25	14.3	7.6	18.3	21.0
Median	15.3	8.3	19.3	21.3
Q 75	16.3	9.0	21.0	22.6
CV (%)	8.6	12.2	8.3	5.2

Table 2: Udder oedema thickness (mm) at various measuring pressures expressed in mV; single values, first quartile (Q25), median and third quartile (Q75) in mm of five cows with pronounced udder oedema and without signs of clinical mastitis. Grey marking: selected pressure range for udder oedema measurements in this study due to minor variation in the measured oedema thickness.

Pressure (mV)	Udder oedema thickness (mm)						
	150	200	250	300	350	400	500
Cow 1	30.3	26.3	23.3	23.3	23.3	23.0	21.3
Cow 2	24.0	24.6	22.3	20.6	18.0	14.6	14.0
Cow 3	16.0	13.6	12.6	11.0	9.3	8.6	8.0
Cow 4	30.6	32.0	29.0	28.3	27.6	23.3	23.3
Cow 5	25.3	24.3	26.0	22.3	21.3	18.0	17.0
Q 25	24.0	24.3	22.3	20.6	18.0	14.6	14.0
Median	25.3	24.6	23.3	22.3	21.3	18.0	17.0
Q 75	30.3	26.3	26.0	23.3	23.3	23.0	21.3

Ethical statement

The study protocol was approved by the Lower Saxony State Office for Consumer Protection and Food Safety, Oldenburg, Germany (registration number: 33-42502-06/1149).

Results

Repeatability of the results
In order to test the repeatability of the results at the teat base, one primigravid cow with a pronounced udder oedema was used. Per udder quarter, 15 measure-

ments were performed, these showing satisfactory repeatability (Table 1). Another five healthy cows with marked non-inflammatory udder oedema post partum were used to find the optimal measuring pressure. The following forces were tested: 150, 200, 250, 300, 350, 400 und 450 mV (Table 2). The voltage range from 250 to 350 mV proved adequate and was therefore applied to all measurements. It corresponded to an average force of 4.88 ± 1.44 Newton. A force variation in one Newton affects a change in the oedema diameter of one millimetre.

Finding the optimal measuring location

In order to find the optimal measuring location to be used in the main study, the udder oedema thickness at the four measuring points (teat wall, teat base, udder middle, udder base) was evaluated. It was postulated that the optimal measuring location should provide a marked oedema development and also a marked oedema regression. Therefore, the course of udder oedema thickness of all four udder quarters (Figure 4) and the differences between the front and hind udder quarters were

evaluated (Figure 5). The location teat wall showed no statistically significant increase in udder oedema thickness and was therefore proved unsuitable as a measuring position. The locations udder middle and udder base showed a less distinctive course of udder oedema development and more significant differences between the front and hind quarters than the location teat base. Therefore, teat base was selected as the measuring location in the main study.

Other factors possibly affecting the severity of the udder oedema

In the preliminary experiment, for the majority of measuring timepoints no associations between total free oestrogens in plasma or sodium and potassium in saliva and mean udder oedema thickness could be found (Tables 3 and 4). For this reason, these parameters were not included in the main study. Only healthy animals without signs of clinical mastitis were included in this study. The cytobacteriological examination of milk samples was performed to examine if subclinical or unspecific mastitis had an influence on udder oedema thickness.

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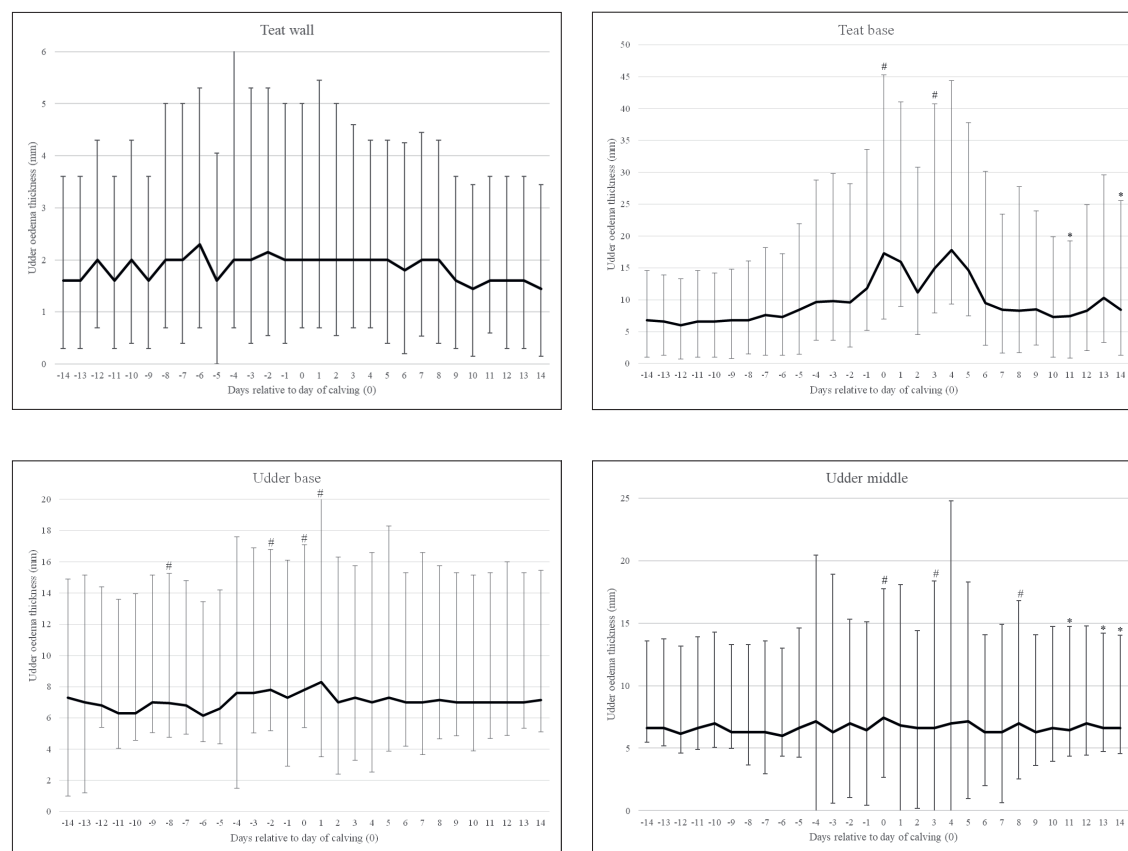


Figure 4: Preliminary experiment to find the optimal measuring position for the main study (n=10, cows with a pronounced udder oedema without signs of clinical mastitis). Udder oedema thickness of all four udder quarters in mm at four different measuring positions (teat wall, teat base, udder base, udder middle). Negative whiskers illustrate the first quartile (Q25), the black line shows the median and the positive whiskers indicate the third quartile (Q75). #: value of this day significantly different to value of day -14; *: value of this day significantly different to value of day 0 ($p \leq 0.05$).

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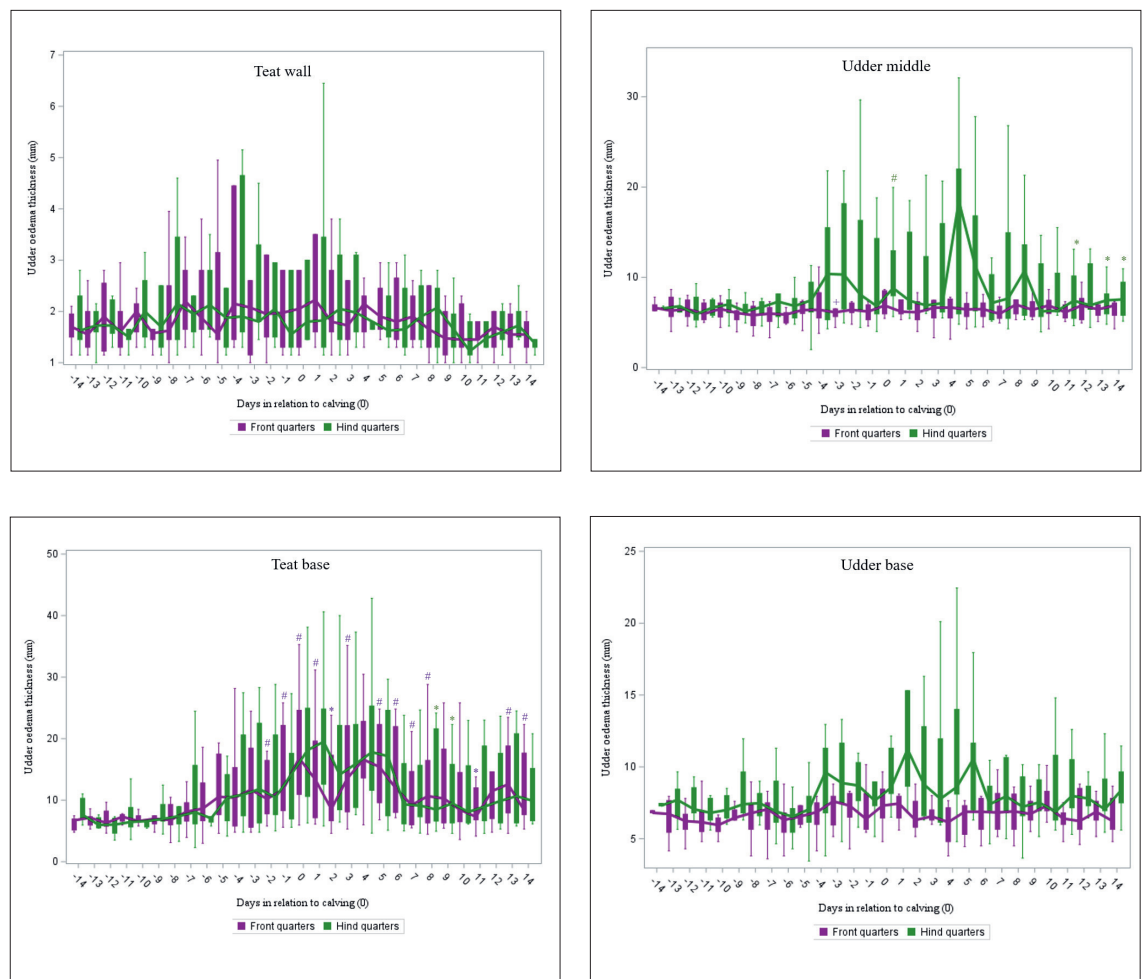


Figure 5: Preliminary experiment to find the optimal measuring position for the main study (n=10, cows with a pronounced udder oedema without signs of clinical mastitis): Udder oedema thickness of front and hind udder quarters in mm at four different measuring positions (teat wall, teat base, udder base, udder middle). The boxplots depict median, interquartile range, and data range (means connected, outliers clipped); #: value of this day significantly different to value of day -14; *: value of this day significantly different to value of day 0; + front vs. hind quarters ($p \leq 0.05$).

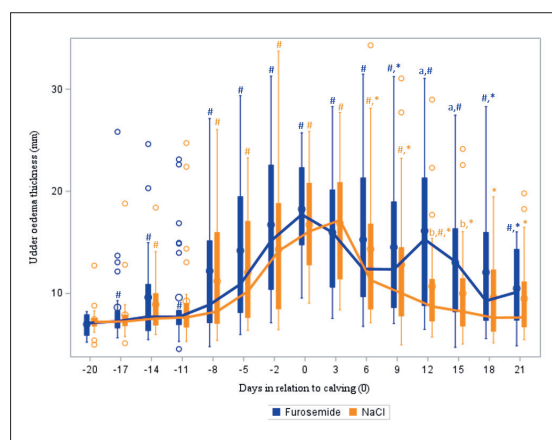


Figure 6: Udder oedema thickness in mm measured at the teat base of all four udder quarters in German Holstein cows; Furosemide group (n=25): 10 ml (500 mg) furosemide injected intramuscularly at day 0, day 1 and day 2; NaCl group (n=25): 10 ml 0.9% NaCl-solution injected intramuscularly at day 0, day 1 and day 2; The boxplots illustrate median, interquartile range, and data range (means connected); #: value of this day significantly different to value of day -20; *: value of this day significantly different to value of day 0; a,b Furosemide vs. NaCl ($p \leq 0.05$).

Neither in the preliminary experiment (n=10, data not shown) nor in the main study (n=50), udder oedema thickness measured at the teat base was influenced by unspecific or subclinical mastitis (Table 5).

Testing the treatment success of furosemide

In the present study, udder oedema thickness of all four udder quarters did not differ statistically significantly from the day of calving until 9 days post partum between the furosemide and the NaCl group (Figure 6).

Discussion

Measuring method

To gain repeatable results, especially if different examiners are involved in the data collection of a study, the basic requirement for measuring the thickness of an udder oedema with ultrasound is a constant measuring pressure. Otherwise, the thickness of the udder oedema changes according to the pressure of the probe on the udder skin. For that reason, a measuring unit (force sensor and transducer) was developed. With this measuring

unit, it was possible to obtain repeatable results under field conditions. To evaluate the severity of udder oedema in dairy cattle, a visual scoring system¹⁰ and a rating system with visual and tactile components²⁸ have been previously developed. Ultrasound has already been used to differentiate physiological udder oedema from artificially induced udder oedema (overbagging, injections or gas infusion).³⁴ Some authors used a conventional ultrasound probe to measure udder oedema in overbagged show cows.² To the best of our knowledge, this is the first study concerning sonographic measurements of udder oedema in dairy cows using a measurement unit with pressure control. Especially in evaluating treatment success, an objective and very precise measuring technique should be used. Concerning the optimal measuring position, the most obvious temporal changes and rare differences between the four udder quarters were found for the location «teat base». The maximum values were recorded between calving and the fourth day post partum. Our results corresponded with former findings.¹ Various measuring positions have already been used. One author scanned the udder from the right side, rear and underneath and described the distribution of

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Table 3: Spearman correlation coefficients of concentration of total free oestrogens (pg/ml) in plasma and mean udder oedema thickness of front and hind quarters in German Holstein cows (n=10 cows). Grey marking: $p \leq 0,05$

		Days relative to day of calving (0)									
Front udder quarters	Localisation	-14	-11	-8	-5	-2	0	3	6	9	12
	Teat wall	0.67	0.15	0.39	0.49	0.39	-0.37	-0.43	-0.29	0.38	0.14
	Teat base	-0.53	0.23	-0.01	-0.08	-0.21	0.33	-0.13	0.36	0.21	-0.26
	Udder middle	-0.10	-0.16	-0.71	-0.64	-0.31	0.13	0.10	-0.07	-0.19	0.03
	Udder base	-0.71	-0.04	-0.74	-0.57	-0.48	0.3	0.30	0.21	-0.52	-0.03
Hind udder quarters	Teat wall	0.54	0.20	0.89	0.57	0.32	-0.48	-0.33	-0.14	-0.05	0.60
	Teat base	-0.98	-0.10	-0.14	0.18	-0.42	-0.37	-0.13	0.21	0.31	0.52
	Udder middle	-0.83	0.01	-0.52	-0.50	-0.76	-0.32	-0.05	0.61	0.64	0.09
	Udder base	-0.52	-0.22	-0.50	-0.12	-0.52	0.09	0.20	0.46	0.45	0.31

Table 4: Spearman correlation coefficients of concentration of sodium and potassium in saliva (mmol/l) and mean udder oedema thickness of front and hind quarters in German Holstein cows (n=10 cows). Grey marking: $p \leq 0,05$

		Sodium			Potassium		
Front udder quarters		Days relative to day of calving (0)					
	Localisation	-14	0	14	-14	0	14
	Teat wall	-0.44	0.68	0.02	0.54	-0.15	0.63
	Teat base	-0.79	0.12	-0.41	0.66	-0.12	0.22
	Udder middle	0.18	-0.35	0.13	-0.26	0.44	-0.46
	Udder base	0.00	-0.49	-0.06	0.03	0.51	0.26
Hind udder quarters	Teat wall	-0.71	0.73	-0.69	0.71	0.28	-0.05
	Teat base	0.08	0.53	-0.69	-0.14	0.22	0.18
	Udder middle	-0.22	0.33	-0.70	0.14	-0.27	-0.02
	Udder base	0.19	0.08	-0.37	-0.33	-0.19	-0.07

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the oedema, but not the thickness.³⁴ In another study, a defined area of both front quarters from the side and the cleft area of the rear quarters was measured.² The thickness of the oedema was scored according to three levels. Our findings suggest that it is possible to reduce the examination effort concerning physiological udder oedema when taking the teat base as the measuring position.

Other factors possibly affecting the severity of the udder oedema

In the present study, there was no evidence of a connection between total free oestrogens in plasma, sodium and potassium in saliva and the thickness of udder oedema post partum. Our findings contradicted other studies which indicated an association between the severity of udder oedema and free oestrogens,^{17,18,21} or sodium and potassium in saliva.^{19,24} Therefore, limited access especially to NaCl is recommended in late gestation.¹⁴ However, the sample size was very low in our preliminary experiment (n=10) and therefore further studies with a higher sample size are necessary to confirm these results. Udder oedema was shown in earlier studies to increase the risk of intramammary infections caused by *Staphylococcus chromogenes*¹¹ or other pathogens in dairy heifers.^{20,18} Decreased blood circulation and poor adaptation to the milking units were assumed in teats with oedema, this leading to a decrease in udder defence mechanisms which were the underlying cause of the association with clinical mastitis.³³ In the present study, no relationship between subclinical mastitis or unspecific mastitis and udder oedema thickness was found.

Treatment success of furosemide

Furosemide is a potent short-acting diuretic which causes rapid fluid loss and improves the appearance of muscle tone; therefore, it is a common drug of abuse in livestock

shows.²⁷ Additionally, furosemide is commonly used to treat udder oedema, renal failure, and heart failure in farm animals.⁶ The treatment of the animals with furosemide occurred at day 0 to day 3 post partum. Because of the short-term effect of furosemide, the time slot directly post partum was of major interest. In the present study, furosemide did not have a measurable, positive effect on the severity of udder oedema in the first days post partum. This result was in contrast to former findings.³⁰ In this former study, the authors stated that furosemide had an effect on the regression of udder oedema through a reduction in the blood pressure of the V. epigastrica superficialis. The reduction in blood pressure was measured up to 210 minutes post injectionem. We have to emphasise that our study used only a very limited number of animals and because of the lack of statistical power, our results have to be interpreted with caution. Indeed, further studies with a higher sample size are necessary to confirm this relationship. Additionally, furosemide is approved for intravenous administration in cattle with once- or twice-daily dosage. For organisational reasons, furosemide was injected in the present study intramuscularly and only once per day. This could be a reason for the missing treatment success of furosemide in the present study. However, intramuscular application is an established alternative way of application.⁶ Formers findings in sheep showed that intramuscular injection of furosemide provides similar bioavailability to intravenous injection. Independently of the application method, the diuretic effect lasted up to three hours post injectionem.^{7,16} Probably, dairy cows treated with furosemide drank more water after treatment, because they are thirsty, and in this way the diuretic effect in dairy cows may be reversed.¹ Thus, the only way to improve the therapeutic effect of furosemide can only be achieved by water restriction which is not acceptable for health and animal welfare issues in dairy cows.

Table 5: Udder oedema thickness (mm) in German Holstein cows at the teat base at udder quarter level (Q25 = first quartile, median, Q75 = third quartile) in relation to the findings of the quarter milk samples classified in accordance with the German Veterinary Society (DVG) guidelines (2002) modified by Potrafki. (2005). The category «latent infection» was not diagnosed and data of one quarter are missing (n=50 cows).

		Mastitis category		
		Normal secretion n=111	Unspecific mastitis n=71	Subclinical mastitis n=17
Day of calving	Q25	11.6	11.3	9.3
	Median	17.0	17.3	12.0
	Q75	22.0	23.6	20.6
7 d post partum	Q25	7.6	8.3	8.0
	14 d post partum	10.3	12.6	10.3
	Q75	18.6	24.0	24.0
14 d post partum	Q25	7.0	7.6	8.0
	Median	9.0	9.2	8.3
	Q75	18.6	15.6	23.3

Conclusion

We present the establishment of a method for controlling applied forces during ultrasonographic measurement of the periparturient udder edema resulting in repeatable and comparable data. The teat base turned out to be the best location to monitor the characteristic temporal pattern of udder oedema. This method could be used to objectively test the efficacy of treatment interventions. In the present study, treatment with furosemide did not provoke a measurable, positive effect on the severity of udder oedema post partum. Therefore, further studies with a higher sample size are necessary to confirm this relationship.

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Mesure quantitative par ultrasons de l'œdème de la mamelle chez les vaches laitières pour contrôler l'efficacité d'un traitement diurétique au furosémide

Le but de la présente étude était d'enregistrer l'évolution de l'œdème de la mamelle périnatal par échographie chez les vaches laitières et d'étudier les effets thérapeutiques du diurétique furosémide. À cette fin, un appareil avec un capteur de force pour la sonde à ultrasons a été développé, ce qui a assuré la génération de données dans des conditions de pression similaires et ainsi des résultats reproductibles et comparables. Dans un essai préliminaire avec dix vaches, des mesures échographiques ont été effectuées quotidiennement à quatre endroits par quartier à partir de 14 jours ante partum jusqu'à 14 jours post partum. L'étude principale portait sur 50 vaches laitières. Le groupe expérimental (n=25) a reçu 500 mg de furosémide par voie intramusculaire le jour du vêlage ainsi que les premier et deuxième jours post-partum. Le groupe témoin (n = 25) a été traité avec 10 ml de solution de chlorure de sodium à 0,9 % (NaCl) aux mêmes moments. La période expérimentale a été étendue de 21 jours ante partum jusqu'à 21 jours post partum et comprenait 15 mesures échographiques à trois jours d'intervalle. Les mesures ont été effectuées à la base du trayon, qui s'est avérée être l'emplacement le plus approprié dans la phase préliminaire. Des échantillons de lait de chaque quartier ont été prélevés le jour du vêlage, 7 et 14 jours post-partum. L'épaisseur moyenne de l'œdème de la mamelle entre le groupe traité au furosémide et le groupe témoin ne différait pas. En conclusion, une méthode de mesure échographique de l'œdème de la mamelle sous des forces appliquées comparables a été établie. La base du trayon s'est avérée être un endroit approprié pour surveiller l'évolution temporelle caractéristique de l'œdème de la mamelle. Dans la présente étude, le traitement au furosémide n'a pas eu d'effet

Misurazione quantitativa dell'edema della mammella nelle vacche da latte mediante ultrasuoni per il monitoraggio dell'efficacia del trattamento diuretico con furosemide

Lo scopo di questo studio è di misurare il decorso dell'edema peripartale della mammella utilizzando l'ecografia nelle vacche da latte e di studiare l'effetto terapeutico del diuretico furosemide. A tale scopo, è stato creato un dispositivo con un sensore di pressione per la sonda a ultrasuoni, che ha permesso delle misurazioni in condizioni di pressione simili e quindi ha ottenuto risultati ripetibili e comparabili. In uno studio preliminare, le misurazioni a ultrasuoni sono state effettuate quotidianamente su 10 vacche, in quattro punti per quarto di mammella, per un periodo che andava da 14 giorni prima del parto fino a 14 giorni dopo il parto. Lo studio principale è stato condotto su 50 vacche da latte. Agli animali del gruppo sperimentale (n=25) sono stati somministrati 500 mg di furosemide per via intramuscolare il giorno del parto e il primo e il secondo giorno post partum. Gli animali del gruppo di controllo (n=25) hanno ricevuto 10 ml di soluzione di cloruro di sodio allo 0,9% allo stesso momento. Il periodo sperimentale è stato prolungato fino a 21 giorni ante partum e 21 giorni post partum e ha incluso 15 misurazioni con gli ultrasuoni effettuate a tre giorni di intervallo. Le misure sono state eseguite alla base del capezzolo, posizione identificata come la migliore per la misurazione nello studio preliminare. I campioni di latte dei quarti sono stati prelevati il giorno del parto, il 7° e il 14° giorno. Non è stato possibile stabilire una correlazione tra la mastite subclinica e la gravità dell'edema della mammella. Inoltre, lo spessore medio dell'edema della mammella non differiva tra il gruppo trattato con furosemide e il gruppo di controllo. In sintesi, è stato possibile realizzare un metodo per misurare l'edema della mammella utilizzando gli ultrasuoni con condizioni di pres-

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positif mesurable sur la gravité de l'œdème de la mamelle post-partum chez les animaux de l'étude. Enfin, d'autres études avec une taille d'échantillon plus élevée sont nécessaires pour confirmer cette relation..

Mots clés: bovin, Dimazon®, œdème, mamelle, échographie, quantification

sione comparabili. La base del capezzolo si è rivelata la posizione ottimale di misurazione per gli studi sulla progressione dell'edema della mammella. Nel presente studio, il trattamento con furosemide non ha avuto alcun effetto positivo misurabile sulla severità dell'edema della mammella post partum nelle vacche da latte. Tuttavia, ulteriori studi con un campione più ampio sono necessari per confermare definitivamente questa relazione.

Parole chiave: Bovini, Dimazon®, edema, quantificazione ecografica della

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