

Ultrasonographic Distribution and Duration of Udder Edema in Post-partum and Over-bagged Dairy Cows

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Abstract

The objective of this study was to determine the ultrasonographic distribution and duration of edema in the mammary gland of dairy cattle due to recent parturition or prolonged duration of not milking ("over-bagging"). Mammary glands of 74 post-partum cows were imaged ultrasonographically within 24 hours of parturition and every 48 hours until ultrasonographically negative for mammary gland edema for 96 hours. All post-partum cows were imaged 10-11 hours after last milking. Distribution of edema on ultrasonographic examination of the mammary gland was also mapped on 26 over-bagged cows at exhibitions. Sixty-eight of 74 (91.8%) post-partum dairy cattle had ultrasonographically detectable udder edema. Post-partum edema was centered at the ventral midline region at the junction of the udder and body wall between the subcutaneous abdominal veins. Edema persisted for an average of 14.7 days in the fore and 14.8 days in the rear quarters. No edema was detected after 22 days post-partum in any cow. In the fore udder of over-bagged cows, edema was centered on the peripheral vein mid-height on the lateral surface of the fore quarters. In the rear quarter, edema was centered in the mid to ventral aspect of the median crease. Average time since last milking in the "over-bagged group" was 19 hours, and average days-in-milk was 104 days. These two patterns of distributions are important for differentiation from injection-induced edema in show cows, and ultrasonographic differences between physiological and artificially induced edema are discussed.

Keywords: bovine, dairy cattle, ultrasonography-large animal, post-parturient disease, edema

Résumé

L'objectif de cette étude était de déterminer l'étendue à l'échographie et la durée de l'œdème dans la

glande mammaire des vaches laitières suite à un vêlage récent ou à une période prolongée sans traite. La glande mammaire de 74 vaches post-partum a été examinée à l'échographie dans les 24 heures suivant le vêlage et à tous les deux jours jusqu'à ce que l'œdème de la glande mammaire disparaisse à l'échographie pendant 96 heures. Toutes les vaches post-partum étaient examinées à l'échographie entre 10 et 11 heures suivant la dernière traite. L'étendue de l'œdème dans la glande mammaire a aussi été examinée par échographie chez 26 vaches d'exposition avec une période prolongée sans traite. L'œdème du pis a été détecté à l'échographie chez 68 vaches laitières en post-partum sur le total de 74 (91,8%). L'œdème post-partum était centré dans la région ventrale de la ligne médio-ventrale à la jonction du pis et du corps entre les veines abdominales sous-cutanées. L'œdème persistait en moyenne 14,7 jours dans les quartiers avant et 14,8 jours dans les quartiers arrière. L'œdème n'a pas été détecté plus de 22 jours suivant le vêlage chez ces vaches. Dans les quartiers avant des vaches avec traite incomplète, l'œdème était centré près de la veine périphérique à mi-hauteur sur la surface latérale des quartiers. Dans les quartiers arrière, l'œdème était centré dans les régions médianes et ventrales du sillon médian. La durée moyenne depuis la dernière traite dans le groupe de vaches avec traite incomplète était de 19 heures et le nombre moyen de jours en lait était de 104 jours. Ces deux profils de distributions sont importants pour différencier l'œdème de traite incomplète de l'œdème causé par une injection chez les vaches d'exposition. Les différences à l'échographie entre l'œdème physiologique et l'œdème induit artificiellement sont discutées.

Introduction

Ultrasound is an important tool for investigation of bovine mammary disease. The clinical utility of ultrasound to describe lesions in and around the udder has been demonstrated in numerous reports.^{1,5} Less well

known is the utility of ultrasound to identify artificial augmentation of udders at dairy cow expositions.

Investigators have determined the ultra-sonographic appearance and duration of infused isobutane gas in dairy cow udders,⁶ as well as the appearance, distribution and duration of edema following the subcutaneous injection of argyrol.³ Both agents are used at dairy shows to artificially augment size or shape of the udder. While their use has significantly declined with increased use of ultrasound at dairy shows, concern remains regarding differentiating the appearance and distribution of naturally occurring (post-partum, "over-bagging") edema in the dairy udder from injection-induced edema.

The purpose of this study was to describe the distribution and duration of post-partum edema and the distribution of over-bagging edema in dairy cows. We hypothesized that the distribution of edema in the dairy udder following parturition or over-bagging would be similar to that found in a previous report,³ and therefore could be differentiated ultrasonographically from artificially induced udder augmentation.

Materials and Methods

Ultrasonographic examinations were made using a 7.5 MHz rectilinear transducer and machine system.^a Isopropyl alcohol was used as a coupling agent and images were directly digitized.^b Machine settings were kept constant throughout both phases of the study. This research protocol was approved by the Animal Care and Use Committee at the University of Wisconsin-Madison School of Veterinary Medicine.

Post-partum cows

Seventy-four post-partum Holstein cows from a registered commercial milking herd were selected on the basis of lactation number, milk production, good udder conformation and tractable behavior. No clinical or visual evidence of mastitis, external wounds, insect bites or other medical problems were noted. Farm personnel monitored milk production and general behavior at least twice each day. The owner provided consent for use of the cows.

Ultrasonography was performed within 24 hours of parturition and every 48 hours until ultra-sonographically negative for udder edema for 96 hours. Imaging was performed immediately prior to milking, approximately 11 hours since last milking. Presence or absence of edema was noted and distribution of edema was mapped for each cow. The percentage of cows, by lactation number, with udder edema and average duration of udder edema in the fore and rear quarters were tabulated.

Over-bagged cows

Cows chosen for this phase were withheld from milking in one or more quarters of their udder for more

than 12 hours, had ultrasonographic evidence of edema and presumed ethical integrity of owner, precluding iatrogenic cause of edema. Twenty-six registered Holstein (14), Jersey (6), Brown Swiss (4) and Guernsey (2) cows in their first or second lactation were imaged at a major dairy cattle show. The handler of each cow and show officials provided consent for imaging. No clinical or visual evidence of mastitis, external wounds, insect bites or other medical problems were noted. Distribution of edema, days-in-milk and time since last milking were recorded for each cow.

Results

Edema was ultrasonographically characterized as subcutaneous alternating bands of hyperechoic subcutaneous fascial planes and homogenous hypoechoic fluid (Figure 1). No ultrasonographic concurrent lesions were seen in any cow.

Post-partum cows

Sixty-eight of 74 (91.8%) post-partum cows had ultrasonographically detectable udder edema (Table 1). Eight cows had no fore udder edema, six cows had neither fore nor rear udder edema, and two cows had rear but no fore udder edema. All cows with fore udder edema had concurrent rear udder edema. All animals in their third or greater lactation had udder edema. Six of 50 (12%) first and second lactation cows had no detectable

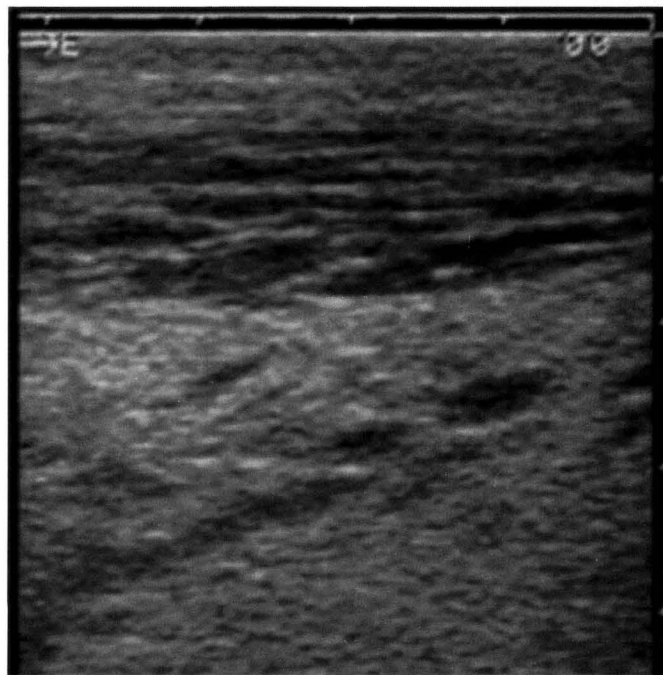


Figure 1. Ultrasonographic image of subcutaneous edema in a two-year-old Holstein cow. Note alternating black and white bands representing edema fluid and fascial planes, respectively.

udder edema. In all cases, udder edema was bilaterally symmetrical between left and right fore or rear quarters and was gravity-dependent. Mean duration of edema was 14.7 days and 14.8 days in the fore and rear quarters, respectively. No edema was detected after 22 days post-partum.

In all affected cows, the edema involved the subcutaneous tissues on the ventral midline between the left and right subcutaneous abdominal veins (milk veins). In 86% (64/74) of the cows, edema was limited to the subcutaneous tissues between subcutaneous abdominal veins and was a contiguous ventral edema cranial to the udder. In 2.7% (2/74) of the cows, edema was more severe, and also extended laterally to the subcutaneous abdominal veins to the crease between flank and udder (Figure 2). Edema remained symmetrical between left and right quarters in all cows throughout the study. As the edema resolved in the more severe cases, it became limited to the region between the left and right subcutaneous abdominal veins. These large vessels have very little ultrasonographically-apparent loose connective tissue between the skin and vessel adventitia, and they may restrict (dam-effect) the distri-

bution of edema until some critical volume or pressure is reached.

In all affected cows, the edema involved the subcutaneous tissues in the mid-height to more ventral region of the crease between the rear quarters (Figure 2). The edema remained symmetrical between left and right quarters in all cows throughout the study. In the more severe cases, edema extended lateral to, and more ventrally, in the crease. In no case was there evidence of edema in the high rear udder attachments.

Over-bagged cows

All 26 cows in the over-bagging portion of the study had evidence of edema. More cows had rear (69%) than fore (31%) udder edema. Average time since the last milking was 19 hours, and average time in milk was 104 days. In all cases, distribution was bilaterally symmetrical between left and right quarters.

In seven of eight cows with fore udder edema, the edema was confined to the mid-height lateral aspect of the gland (Figure 3). This area was identified by a small, superficial vein which ran parallel to the long axis of the cow. The remaining cow had edema extending more

Table 1. Ultrasonographic prevalence of fore and rear udder edema in post-partum cows.

Lactation	1	2	3	4	5	6
Number of cows	32	18	10	6	6	2
Fore quarters						
Number of cows	26	16	10	6	6	2
Average duration (days)	15.3	13.5	13.4	17.3	15.3	13
Range (days)	9-22	8-20	3-20	13-20	8-20	13
Rear quarters						
Number of cows	28	16	10	6	6	2
Average duration (days)	13.6	15.3	14.6	17.7	15.3	18
Range (days)	4-20	8-22	9-20	16-19	8-22	18

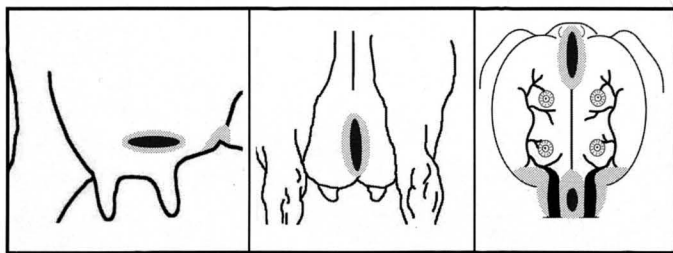


Figure 2. Distribution of edema due to recent parturition. Diagram of udder imaged from right side (left image); rear (center image) and beneath (right image). Note persistent sites of edema in fore and rear quarters (darker hatched) compared to less frequent sites and the wider distribution in more severe cases (lighter hatching).

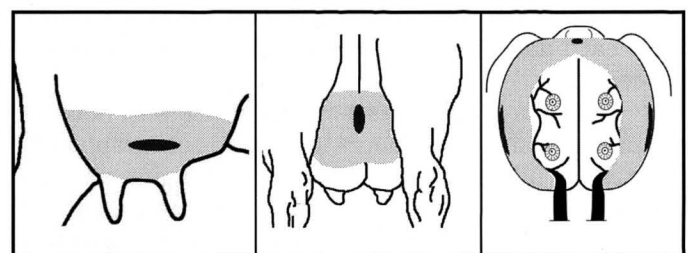


Figure 3. Distribution of edema due to over-bagging. Diagram of udder imaged from right side (left image), rear (center image) and beneath (right image). Note persistent sites of edema in fore and rear quarters (darker hatched) compared to less frequent sites and the wider distribution in more severe cases (lighter hatching).

caudoventrally and cranioventrally. The cranial extent was confluent with the lateral, caudal border of the subcutaneous abdominal vein (milk vein).

Sixty-nine percent (18/26) of the cows had rear udder edema. In all 18 cows, edema involved the subcutaneous tissues of the mid-height median crease (Figure 3). In more severe cases, edema extended from the median crease laterally into the skin folds between the udder and thigh musculature, as well as dorsally into the subcutaneous tissues of the perineum.

Discussion

Edema may form naturally as a result of many factors. Application of the Starling equation dictates that edema can form as a consequence of changes in three factors: increased hydrostatic pressure differential between the blood and interstitial space; increased oncotic pressure differential between the blood and interstitial space; or increased vessel permeability. Localized edema may be secondary to trauma, infection, endotoxemia and hypersensitivity vasculitis.² In the udder, causes of edema include those general considerations and are also associated with udder specific conditions, including mastitis and breakdown of the blood-milk barrier. Although widely recognized, none of these conditions are very well studied. Peripartum edema may form days to weeks prior to calving or immediately post-partum. Peripartum edema may be associated with changes in immunoglobulin concentration, circulatory disturbances associated with gestation, increased grain ingestion and other breed- and age-related issues.⁷ In a study of over 12,000 milking cows it was estimated that 18% develop peripartum edema during the year.⁴

Ethical consideration of cows used for exhibition has gained support nationally and internationally. Considered uncommon as little as ten years ago, most national dairy shows now have an ethics program to detect alterations to participating cows. Part of such consideration is detection of alterations to the udder or milk. Ultrasound can be used for detection of iatrogenically infused isobutane gas⁶ and subcutaneous edema caused by injection of irritating foreign substances³ in the udders of cows. This discovery resulted in a markedly reduced prevalence of these alterations to the udders of cows in dairy shows where ultrasound is used as part of the ethics program.

This study was initiated as a result of dairy cow exhibitors' and show officials' concerns that physiological udder edema due to recent parturition or over-bagging in first and second-lactation cows, neither considered a serious ethical issue, was being confused with udder edema due to subcutaneous injection of an irritating foreign substance. The aforementioned injections are used to produce a localized region of edema

that augments the shape of the udder, especially at sites of fore and rear udder attachment. When such an injection is made into a site where a fold or cleft normally existed, a smoother contour results. These injections are typically made 1) in the region of the subcutaneous abdominal vein where the udder meets the ventral body wall or 2) high in the rear quarters in the cleft formed by the junction between the thigh musculature and udder. Edema resulting from injection of foreign material remains localized to the site(s) of injection; the distribution is dependent on the volume injected and may persist for one week or longer.³ Anecdotally, at national shows we have seen this form of edema persist as long as two weeks or more.

In the rear udder, it is considered desirable at shows to have a clearly defined median crease. Therefore there is no incentive to cause edema in this location by injection. Results of this study indicate that edema involving the median crease is a consistent feature of over-bagging, and is easily differentiated from injection-induced edema as an isolated finding in the lateral skin folds between the udder and thigh musculature.

It is more challenging to differentiate injection-induced edema from either form of natural edema, especially in the more severe forms, when the natural edema extends into the skin folds between the udder and subcutaneous abdominal vein. In two first-calf heifers the distribution of recent freshening edema in the fore udder overlaps with the distribution of injection edema. Symmetry does not preclude injection-induced edema. However, in the natural forms of edema described in this manuscript, the fascial planes are smooth and regular, compared to the undulating contour of injection-induced edema.³ Injection-induced edema also causes subjective increased attenuation of the ultrasound signal compared to natural forms of edema. This is probably due to a combination of scattering and absorption, secondary to the localized substance injected and concurrent inflammation. Structures deep to the edema pocket often appear ultrasonographically less distinct than they do in natural forms of edema.³

In the fore quarters, edema resulting from parturition or over-bagging frequently affects the tissues surrounding the subcutaneous abdominal vein. When this occurs in over-bagged cows, the distribution is continuous to the mid-height lateral aspect of the fore quarters. In recently freshened cows this distribution is continuous medially to the ventral midline between milk veins. In either case, the distribution is always symmetrical. In cases of injection-induced edema, the distribution is localized to the region of the subcutaneous abdominal vein, where the fore udder meets the ventral body wall. Injection-induced edema is often asymmetric between quarters, as the desired effect is often to

induce a visual symmetry in an otherwise naturally asymmetrical cow.

Results of this study provide the basis for the following generalized guidelines for detection of injection-induced edema:

- All edema should be completely mapped on drawings similar to those provided in the figures.
- In the fore quarters, the operator should determine if there is evidence of edema in the region of the subcutaneous abdominal vein. If the edema is contiguous with the mid-height of the fore udder, the region predisposed to over-bagging edema, the interpretation is over-bagging edema. If no overlap with the over-bagging predisposed site is seen, the interpretation is injection-induced edema.
- In the rear quarters, the operator should examine the clefts between the udder and thigh musculature. If there is evidence of edema in either cleft and no continuity of distribution into the median crease, then the interpretation is injection-induced edema.
- If there is any doubt concerning the overlap of edema into regions commonly seen in natural conditions, the interpretation is made that the cow has not been injected.

Conclusions

Application of these guidelines should provide a highly specific, although relatively insensitive, set of parameters for interpretation of injection-induced u-

der edema. Sensitivity should always be sacrificed for the highest specificity possible to avoid ramifications of a false-positive interpretation.

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Endnotes

^a SIUI CTS-200V, Shantou Institute of Ultrasound Instruments, Inc., Guangdong, China

^b AV340 and DVR 100, Archos Inc., Irvine, CA

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Abstract

Recent research on the effects of excess dietary nitrogen on the fertility of dairy cows

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High concentrations of dietary nitrogen have been associated with reductions in the fertility of dairy cows, but the evidence is not conclusive and many studies have shown little or no effect. This paper reviews recent investigations of the effect of rapidly degradable sources of nitrogen on parameters of fertility, and concludes that high levels of dietary nitrogen do not routinely reduce

fertility, even at intakes above those in normal dairy cow diets. It also concludes that cows may be able to adapt to high nitrogen diets so that diets that may reduce their fertility when introduced at critical periods, for example, when they are inseminated, do not reduce it when introduced at an earlier stage.