Udder Edema of Jersey Cattle Affected with Rectovaginal Constriction

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Introduction

Constriction of the anus and vulvo-vestibular area (RVC) due to homozygosity of a simple autosomal recessive gene, has been described in Jersey cattle (13-15,19). Common problems, in addition to rectovaginal constriction, are difficulty in performing artificial insemination and pregnancy diagnosis, dystocia, and severe udder edema at calving time (14).

Udder edema has been defined as an excessive fluid accumulation in the intercellular tissue spaces of the udder (21). Numerous investigators have reported prevalence in high milk-producing dairy cows, especially heifers (3-6,12,21,23,26,27,33,35). Attempts to determine the cause of udder edema in dairy cattle in general have resulted in many proposed mechanisms (1,4-6,10-12,20,23,26,27,36,37). It has been recognized that normally there is a small amount of fluid continually lost from the circulation (31). Tiny pores in the microvascular endothelium permit the passage of water and electrolytes but prevent the passage of proteins (28). Evans blue, Trypan blue, and Pontamin blue have all been used to determine the degree of vascular permeability (17,18,22,24,29,30). These dyes combine with plasma proteins to form a stable dye-protein complex that is normally prevented from passing through the microvascular endothelium because of pore size (24).

This report describes gross and microscopic pathological features of udder edema in Jersey cattle affected with rectovaginal constriction.

Materials and Methods

Animals. Ten Jersey cows affected with rectovaginal constriction (RVC) which developed udder edema near calving, were used in this study. These cows were part of a herd used to study the genetics of RVC (Table 1). Four cows, one normal Jersey, and three normal Hosteins served as controls (Cases 11-14, Table 1).

The udder was clinically examined daily in the RVC Jersey cows to determine the stage of maximum development of udder edema. The subcutaneous abdominal veins (milk veins) were also clinically evaluated with special emphasis being placed on the size of the foramen in the rectus abdominis muscle (milk wells) where the subcutaneous abdominal vein (milk veins) entered the abdominal cavity to join the internal thoracic veins.

Before euthanizing, the RVC Jersey cows affected with udder edema were used to study the permeability of the mammary blood vessels to Evans blue. Four 1-2 cm stab incisions of the skin were made in the ventral aspect of the udder to collect interstitial fluid. Milk was also collected from all four quarters of all cows during the height of udder edema. Following collection of control intersitial fluid and milk samples, one gram of 1% solution of Evans blue[a] was

TABLE 1. Edema cases and other data in RVC Jersey and Controls

Cow No.	Necropsy No.	Age (Years)	RVC	Udder Edema	Remarks
1	81-1831	4	Yes	Yes	Delivered by cesarean section
2	81-265	4	Yes	Yes	Delivered by cesarean section
3	81-780	4	Yes	Yes	Delivered by cesarean section
4	81-1904	3	Yes	Yes	Delivered by cesarean section
5	81-295	6	Yes	Yes	Delivered by cesarean section
6	81-256	4	Yes	Yes	Delivered by cesarean section
7	81-483	3	Yes	Yes	Delivered by episiotomy
8	81-830	?	Yes	Yes	Delivered by episiotomy
9	81-482	3	Yes	Yes	Delivered by episiotomy
10	81-1382	3	Yes	Yes	Delivered by cesarean section
11	81-1512	?	No	No	Normal delivery
12	82-345	5	No	No	Died due to dystocia
13	82-346	5	No	No	Normal delivery
14	82-334	5	No	No	Normal delivery

[a]*Fisher Scientific Company, Fair Lawn, New Jersey 07401.*

administered intravenously. This was followed by the collection of milk and interstitial fluid every 15 minutes for 2 hours. Changes in the color of the milk and interstitial fluid before and after Evans blue injection were monitored.

Necropsy Procedure. All cows were terminated and an immediate standardized necropsy procedure was performed. The entire udder, milk veins, milk wells, and the subcutaneous tissues and muscles covering the abdomen from all cows, except two cows that were used for latex infusion veins, milk wells, and the subcutaneous tissues and muscles covering the study, were removed intact. Careful gross examination was done on the udder skin, subcutaneous tissues, parenchyma, vessels, supramammary lymph nodes, pudendal arteries and veins, perineal arteries and veins, milk veins, and milk wells.

Histopathology. Sections from the above tissues were fixed in 10% buffered neutral formalin, processed routinely, sectioned 6 microns and stained by Van Gieson's and hematoxylin eosin (H&E) stain.

Latex Infusion. Two RVC-affected cows were randomally selected for studying udder vascular systems. Shortly following euthanasia, the abdominal cavity was cross-sectioned through the area of the first lumbar vertebra. All abdominal viscera was removed, and the abdomianl aorta and vena cava were exposed and cannulated by a polyethelene canula. The blood vessels were immediately rinsed with heparinized saline[b] while the udder was intact.

The carcasses were placed in a cooler and a continuous infusion of 10% buffered neutral formalin was performed for 3 days. The formalin container was elevated approximately 2 meters higher than the level of the carcasses to keep high infusion pressure to the udder. After the 3 days of formalin infusion, red and blue latex[c] respectively, was infused into the aorta and vena cava. The carcasses were kept cool for two additional weeks. The udder was then removed and dissected.

Results

Clinical findings. All RVC Jersey cows exhibited typical signs of udder edema shortly before calving *(Table 1; Figures 1 & 2).* The milk veins were large and had tortuous course under the subcutaneous tissues, especially in older cows.

The incised skin, in cows with udder edema, allowed a yellow, straw-colored fluid to drip. The milk was a normal color. Fifteen minutes after Evans blue injection, the color of the milk and interstitial fluid were white-blue and yellow-blue respectively, and the color stayed the same during the entire 2 hours of sampling.

Necropsy findings. In most cases, the edema involved all four mammary glands and was consistently located in the ventral aspect of the udder, especially in the rear aspect of the udder. The longitudinal and sagittal grooves of the udder were nearly obliterated. In some cases, the edema extended under the subcutaneous tissues to the umbilical region. Ischemia and necrotic areas on the skin extending from the lateral aspect of the udder to the thigh were commonly seen *(Figures 3 & 4).* Skin incisions over the edematous areas resulted in cut surfaces with the oozing of smooth, glistening, yellow-blue fluid. The udder parenchyma were also edematous and filled with a blue, clear fluid. The interstitium were thick, edematous, and prominent.

The left milk vein in one RVC Jersey cow was branching at the entrance of the left milk well into two branches. One branch went directly cranial and laterally while the other was directed cranially and medially. The supramammary lymph nodes were large and edematous. Incision in their surface

Fig. 1 Udder of RVC Jersey cow affected with udder edema shortly before calving.

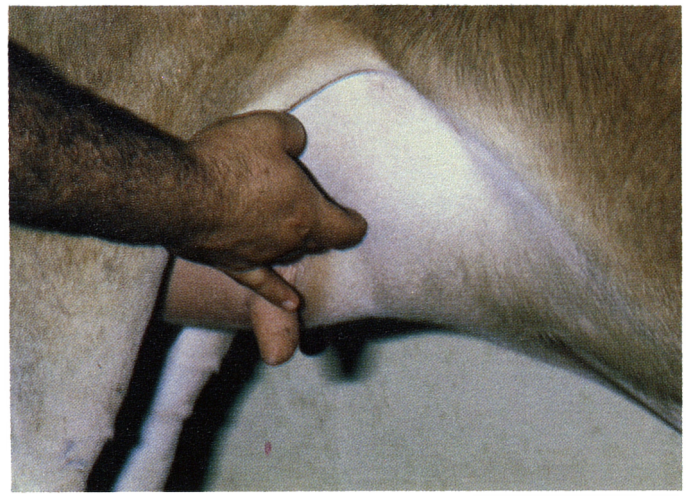
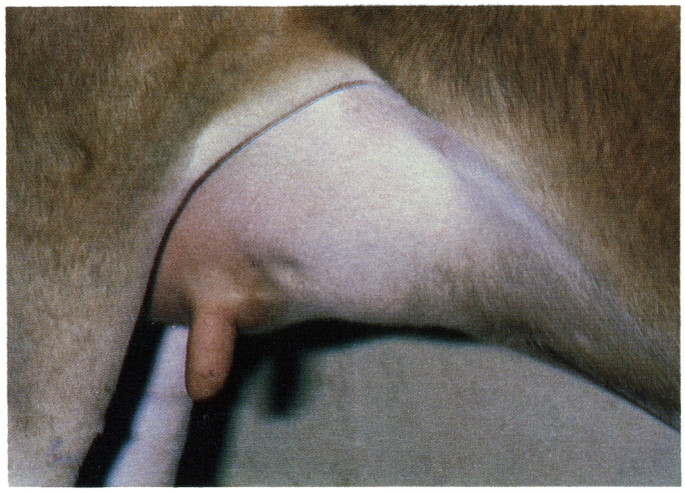


Fig. 2 Udder of RVC Jersey cow affected with udder edema shortly before calving. Notice finger imprints on udder.



[b]*Heparin Sodium 10 U.S.P. Units per ml of saline.*
[c]*Biological Center, 6780 Jackson Road, Ann Arbor, Michigan 48103.*

Fig. 3 Udder of RVC Jersey cow affected with udder edema after calving. Notice deep cracks into udder tissue.

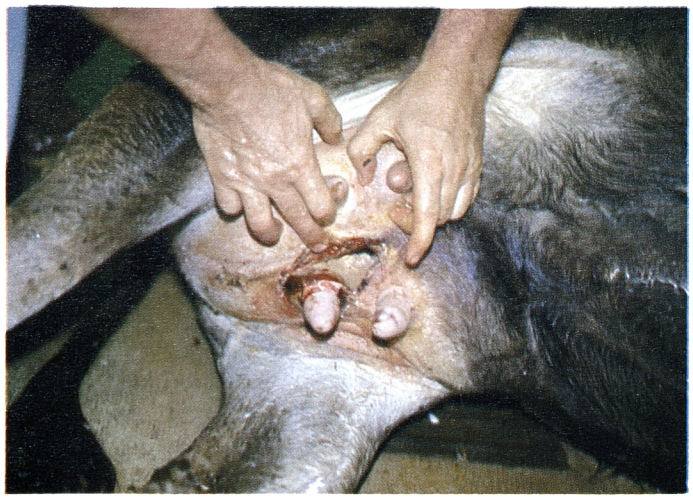


Fig. 4 Udder of RVC Jersey cow affected with udder edema after calving. Notice necrotic areas on skin of udder and thigh.

revealed a bluishcolored lymph, and the cut surfaces were smooth, glistened, and bulged.

Microscopic findings. The most common features of the subcutaneous udder tissues were: edema that appeared as empty spaces between the muscle fibers. In some areas, an acidophilic, homogeneous, faintly stained edema fluid was seen.

The muscle fibers were disrupted and wrinkled. An increased amount of collagen fibers were present. The lymphatics were dilated, tortuous, and variable in size; some were larger than the size of the mammary alveoli. Other lymphatic vessels were ruptured.

The udder parenchyma was also edematous. The interlobular and interalveolar interstitial spaces were edematous. There were congested blood vessels and dilated lymphatics. Mononuclear cells, mostly lymphocytes and eosinophils, were interspersed in the fibrous tissues. The alveolar epithelial cells appeared hyperplastic, and the cytoplasm was almost completely filled with vacuoles.

The supramammary lymph nodes were also edematous. Microscopic changes in the blood vessels were characterized by marked dilation in some venules and arterioles in the udder parenchyma while other venules and arterioles, as well as the milk vein, in RVC Jersey cows were characterized by medial thickening. Van Gieson's stain showed thickening of the tunica media with collagen fibers that appeared as wavy bands running parallel to one another within the tunica media.

Anatomical findings. All arteries and veins were filled with latex red and blue, respectively. Upon udder dissection, the pudendal arteries and veins, the perineal arteries and veins, and their branches were normal.

Arterioles and venules were mostly located in the ventral aspect of the udder, especially near the subcutaneous tissues and around the perineal vessels. Both milk veins were demarcated by ring shape depression of constrictions at the entrance of the milk wells.

Discussion

RVC Jersey cows consistently developed udder edema a few days to a few weeks before calving. Latex infusion studies suggested that the milk wells may be a restrictive point for venous blood flow from the udder resulting in increased venous pressure. The increased pressure results in intralymphatic congestion, mechanical-functional insufficiency of lymph flow, and resulting edema (25). The constriction of the milk wells may be another factor in these RVC Jersey cattle similar to the constriction of the anus and vestibule (13-15).

Our studies with Evans blue demonstrated that there in an increase in udder vascular filtration of fluid and protein. It has been suggested that increased capillary permeability to macromolecules may be the result of capillary pores enlarging or stretching (28). It has been further concluded that elevation of venous blood pressure increases the filtration of fluid from the capillary blood into the tissue spaces approximately in proportion to the rise of venous pressure (9, 32).

We were unable to determine whether the increased filtration occurred in the capillaries, venules, or arterioles. Recently, the use of a colloidal carbon technique in a study on ultrastructural changes associated with pulmonary edema demonstrated that Alpha-Naphthyl-Thiourea (ANTU) caused an increase in permeability of all the capillaries, venules, and arterioles (2,7,16).

Edema does not arise unless the lymphatics are unable to drain the increased interstitial fluid. The appearance of Evans blue in the milk indicated there was excretion of Evans blue protein complex into the udder acini. In addition to the lymphatics, another system of removing excess interstitial fluid reported was an overflow system into the lung alveoli, the intestinal lumen, and peritoneal cavity (34).

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In addition, consistent lesion observed in this cow was dermatitis of the inner thigh to rear udder area. A similar finding was recently noted by other workers (8).

Histopathological findings demonstrated marked edema in the subcutaneous tissues, parenchyma, and supramammary lymph nodes of the udder. Dilation of the venules and the increased collagen deposition in the tunica media of the milk veins may be caused either by the phlebohypertension or an inherited characteristic in this breed of cattle.

Summary

Udder edema is a factor which may be associated with rectovaginal constriction (RVC) in Jersey cattle. Fourteen cows, ten Jersey cows affected with RVC and four normal controls (1 Jersey and 3 Holstein), were used to study the pathological changes in the mammary gland associated with udder edema. Edema involved the entire udder in the Jersey cows affected with RVC but was more pronounced in the ventral aspect and was due to increased vascular filtration of fluid and proteins.

Microscopically, the edematous udder was characterized by excessive fluid infiltration between the muscle fibers of the subcutaneous tissues, the interlobular and the interalveolar interstitial spaces of the udder parenchyma and into the supramammary lymph nodes.

Anatomical studies demonstrated abnormalties of the milk vein and milk wells in some RVC cows. Thus, udder edema appears to be a facultative factor associated with RVC in Jersey cows.

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