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Practical information for progressive dairy professionals

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Ultrasound of the bovine mammary gland and its role in mastitis control

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Maximising optimal health of the mammary gland plays a fundamental role in the productivity and profitability of the modern dairy cow. Mastitis not only results in poorer milk quality, but also causes loss of productivity, increased financial loss secondary to treatment and increased culling rates in the herd.

Prevention of mastitis is as important as treatment. In order to minimise the effects of mastitis, prompt recognition and treatment is imperative. Accurate diagnosis and prediction of prognosis is greatly enhanced by the use of a variety of diagnostic techniques.

After palpation of the mammary gland and related lymph nodes, these include examination of milk secretion by hand and/or machine milking, the California Mastitis Test and microbiological examination of milk, probing of the teat canal and injection of methylene blue dye into the gland and diagnostic imaging techniques including radiography, ultrasonography and endoscopy.

Regarding imaging techniques, ultrasound has largely replaced the use of radiography as it is non-invasive, widely available and allows examination of the teats and the udder parenchyma. Endoscopy is also a useful tool, but only allows examination of the teat canal and cistern.

General structure

The bovine mammary gland is composed of four quarters. Each gland has an individual secretory gland drained by a teat. There is no communication between the duct systems of the individual glands.

The udder is supported by suspensory ligaments which are designed to withstand the weight of the udder.

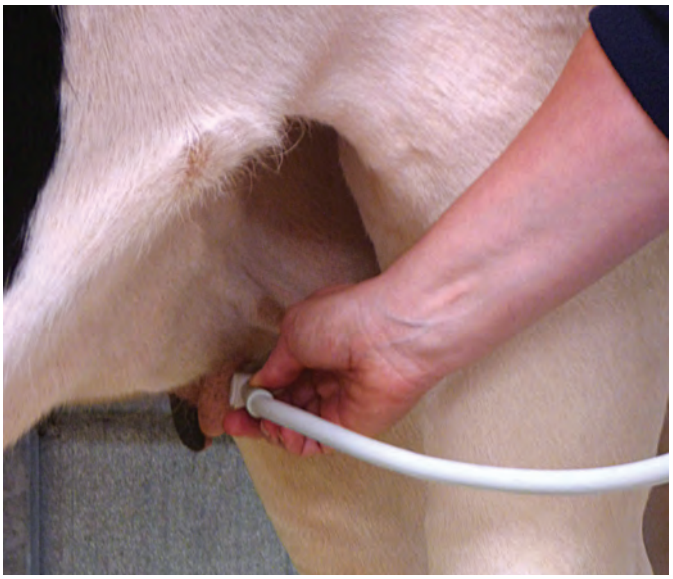


Fig. 2. Photograph demonstrating how ultrasonographic images of the teat in transverse section are obtained. (C. Regan).

The median suspensory ligament helps to separate the left and right sides of the udder. The front and rear quarters are only separated by a thin membrane.

Internal structure

Milk is produced in the secretory cells, alveoli. The alveoli are surrounded by contractile cells that play a fundamental role in the oxytocin-induced milk ejection. Several alveoli form a lobule. Ducts allow milk to drain from the alveoli down to the gland cistern.

Structure of the teat

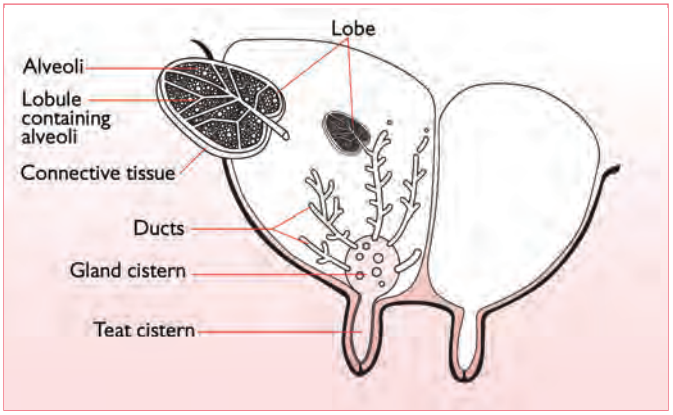
The teat consists of the teat canal and the teat cistern. The teat canal lies between the teat cistern and the tip of the teat. The teat lining produces keratinous material that has antibacterial properties and thus forms a major barrier against invaders of the mammary gland that are attempting to establish infection.

At the tip of the teat, there is a circular muscle forming the teat sphincter, whose function is to retain milk in the intervals between milking as well as providing a physical protective barrier.

The teat cistern is the cavity within the teat. The teat wall consists of the outer skin, the middle muscle and connective tissue and the inner mucous membrane.

The middle layer carries blood vessels, lymphatics and nerves. There are also sensory nerves in the skin. Above the teat cistern is the gland cistern. The important structures of the mammary gland are displayed in Fig. 1.

Fig. 1. Line diagram of a section through the mammary gland displaying the key anatomical structures.



Indications for ultrasound

Indications for performing ultrasound of the udder parenchyma include evaluation of any pathologically enlarged udder without clinical signs of mastitis (e.g. haematoma, abscess or neoplasia), detection of foreign bodies, detection of insertion of air into the gland prior to

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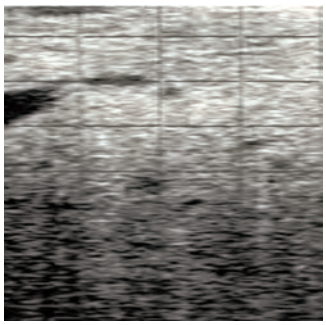
Fig. 3. Normal ultrasonographic appearance of the udder parenchyma. This demonstrates the relative homogeneous echogenicity of the udder tissues with some visible anaechoic vessels. This image was obtained using an Easi-Scan, BCF Technology (linear rectal probe; 4.5-8.5 MHz; ovary/early mode).



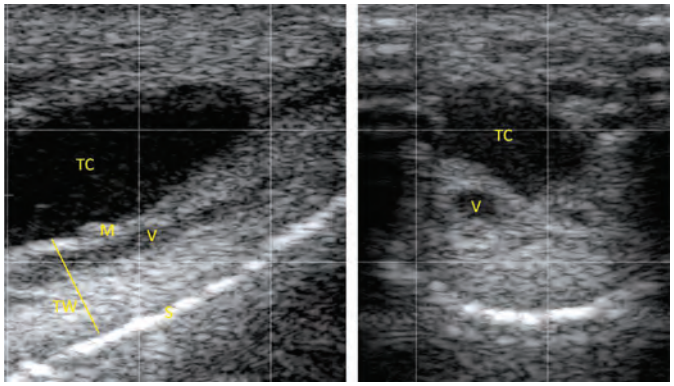


Fig. 4. Normal ultrasonographic appearance of the distal teat below the udder-teat margin in longitudinal (left) and transverse (right) sections. This image was obtained using an Easi-Scan, BCF Technology (linear rectal probe; 4.5-8.5 MHz; ovary/early mode). Abbreviations: V – blood vessel; TC – teat cistern; M – mucosal lining of the teat; S – skin; TW – teat wall (extent shown with solid line).

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competition and as a diagnostic aid in mastitis.

In cases of mastitis, ultrasound does not replace traditional methods for organism identification (bacterial culture) and quantification of mastitis severity (for example, somatic cell counts), but does provide additional information regarding the appearance of the parenchyma and teat, and aids in determining a likely prognosis for that animal.

It has been proposed that there is a correlation between the ultrasonographic appearance of the parenchyma and certain identified organisms responsible for causing mastitis (Arcanobacterium pyogenes and some Gram negative bacteria).

Examination technique

Using ultrasonography, it is possible to identify and evaluate the glandular parenchyma, gland and teat cisterns and the teat canals.

When considering probe choice, there is a trade-off between tissue penetration (amount of tissue that can be examined) and quality of the image obtained.

A lower frequency transducer (phased array, convex or linear) will allow all of the udder parenchyma to be examined, whereas a higher frequency linear transducer will provide the detail required to effectively evaluate the teat and teat canal.

In order to examine the udder parenchyma, examine each quarter in a methodical manner from proximal to distal. Restrain the cow in a crush and examine the cranial quarters from the side of the cow in front of the hindlimbs and the caudal quarters from behind the cow.

The udder parenchyma should be imaged in two planes with the probe placed directly onto the skin of the udder after it has been washed and wet with water and coupling gel applied.

To examine the border between the gland and teat cisterns, the ultrasonographic probe must be applied to the skin at the junction between the udder and the teat and examined in two planes (Fig. 2).

The teat can be examined in two different ways. One is to use a high frequency linear probe like that used for examining tendons, with the probe placed directly onto the skin of the teat. In order to further optimise this image, a 'stand-off' can be used. This can be a commercially available device or can be 'hand-made'.

Hand-made stand-offs include gloves or small bags filled with water or the teat can be submerged within a cup of water.

Whatever method is used, ultrasound coupling gel should be applied between the probe and the teat or at all interfaces from the probe to the teat if a 'stand-off' is used. As with other structures, the teat should be examined in two planes.

Normal appearance

The normal bovine mammary gland is moderately echogenic (Fig. 3). The appearance of the ultrasonographic image obtained is due to the even distribution of connective tissue which is relatively echogenic and the udder parenchyma which is less echogenic. The anechoic areas correspond to either blood vessels or milk ducts.

The milk in the gland cistern is anechoic or may contain some small echogenic particles. The ducts are clearly visible as they enter the gland cistern. There is some variability in the image obtained depending on the fill of the ducts and cisterns.

The demarcation between the gland and teat cistern is identified by the presence of large, round-shaped anechoic structures in the teat wall that represent large vessels.

The gland cistern is anechoic surrounded by a hyperechoic edge which corresponds to the mucosal membrane.

The teat wall appears as three layers. There is a thin, bright, echogenic line internally that corresponds to the mucosa.

There is then a thicker, homogeneous, hypoechogenic layer which corresponds to the muscle and connective tissue, within which are anechoic cavities that correspond to vessels. Externally there is a thin, bright, echogenic line representing the skin. The lumen of the teat cistern is anechoic when distended with milk (Fig. 4).

Abnormalities in cows

Ultrasonographic abnormalities identified in cases of mastitis do show some variation, which varies with chronicity of disease and type of organism involved (Fig. 5).

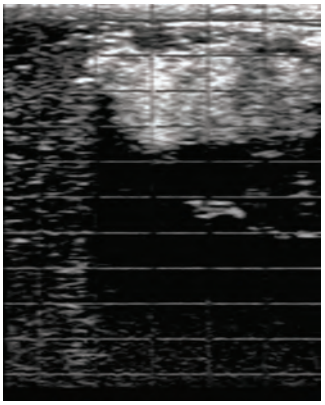

Fig. 5. Ultrasonographic appearance of the udder parenchyma from a cow with mastitis. This image shows loss of normal udder parenchyma that is hyperechogenic in appearance with distention of the gland cistern imaged here. This image was obtained using an Easi-Scan, BCF Technology (linear rectal probe; 4.5-8.5 MHz; late mode).

Compared with the normal udder, the parenchyma can be more or less echogenic or similar to the normal gland, especially when the infection is caused by certain Staphylococcal species.

Small hyperechogenic areas that shadow are suggestive of gas formation within the parenchyma, and have been associated with infections caused by Gram negative bacteria.

These findings usually extend throughout all of the parenchyma of the affected quarter.

Arcanobacter pyogenes is frequently associated with the presence of multiple spherical regions approximately 1cm in diameter that are more hypoechogenic than the parenchyma with hyperechogenic centres (Fig. 6).

In cases of mastitis, the milk within the cisterns and teat has an increased echogenicity, occasionally with echogenic spots due to the increased cellular content.

Oedema that collects beneath the skin means that hyperechogenic layers of connective tissue are seen with hypoechogenic layers between them are consistent with the oedema.

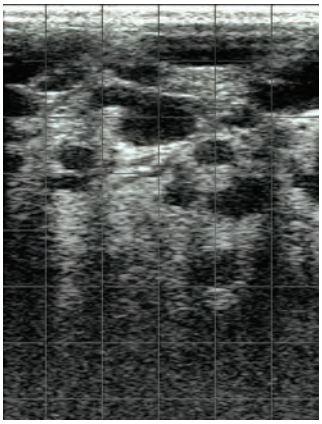

Fig. 6. Ultrasonographic appearance of the udder parenchyma from a cow with mastitis caused by A. pyogenes. The parenchyma contains multiple, small hypoechogenic regions. This image was obtained using an Easi-Scan, BCF Technology (linear rectal probe; 4.5-8.5 MHz; ovary/early mode).

Fig. 7 demonstrates the ultrasonographic appearance of an udder haematoma obtained from a cow with a markedly enlarged mammary gland.

Conclusion

Ultrasonography of the mammary gland is a non-invasive technique that is easily performed. Using appropriate equipment, the teat canal, teat and gland cisterns and udder parenchyma can be visualised.

The use of ultrasonography can help to differentiate possible causes, likely prognosis and monitoring response to therapy. ■

Fig. 7. Ultrasonographic appearance of the udder parenchyma from a cow with a markedly distended udder. Ultrasound confirmed that this was due to a haematoma. This image was obtained using an Easi-Scan, BCF Technology (linear rectal probe; 4.5-8.5 MHz; ovary/early mode).