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Research Article

Evaluation of Different Techniques of Teat Ultrasonography in Goats

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ABSTRACT

The purpose of this study was to investigate the potential of ultrasonography for visualization of teats in goats using different techniques. Thirty clinically healthy Bulgarian Dairy White goats, aged 3-7 years, weighing 45-60 kg were studied. They were between the first and third months of lactation and were reared under an identical production system. The ultrasonography of 60 teats was performed by means of diagnostic ultrasound Mindray DP-2200Vet (Mindray, China) and 5, 7.5 and 10 MHz probes. Each teat was scanned by the "direct contact", "stand off" and "water bath" techniques. The possibility of visualization of teat orifice, teat canal, rosette of Furstenberg, teat wall, teat cistern and the boundary between teat and gland cisterns was investigated. The results were processed by statistical software (StatSoft, Microsoft Corp. 1984-2000 Inc.). The "direct contact" and "stand off" techniques allowed the visualization of the proximal teat part, but the structures in the distal part of the teat were hardly visible ($P<0.05$). The probe frequency had a significant impact on the quality of images obtained by these two techniques, and the results were statistically significantly better ($P<0.05$) when a 10 MHz probe was used. The analysis of results established that the "water bath" technique provided the best imaging options (100%) for observation of teat structures in the goat. The utilization of 10 MHz probe gave a high-quality image and could be recommended for diagnostics of different physiological and pathological changes.

Key Words: Goats, ultrasonography, teat

ÖZET

KEÇİLERDE DEĞİŞİK MEME BAŞI ULTRASONOGRAFİ TEKNİKLERİNİN DEĞERLENDİRİLMESİ

Bu çalışma, değişik metotlar kullanarak keçilerde meme başının ultrasonografik görüntülenme potansiyelinin ortaya konulması amacıyla yürütülmüştür. Yaşları 3-7 arasında, 45-60 kg ağırlığında 30 adet klinikman sağlıklı Bulgar Beyaz keçisi çalışma kapsamında değerlendirildi. Keçiler laktasyonun birinci ve üçüncü ayları arasındaydılar ve benzer üretim sistemleri altında yetiştirilmekteydiler. 60 meme başı ultrasonografisi Mindray DP-2200Vet (Mindray, Çin) cihazı ile ve 5, 7,5 ve 10 MHz propları kullanılarak uygulandı. Her meme başı 'direkt temas', 'su yastığı' ve 'su banyosu' teknikleri ile incelenmiştir. Çalışmada, meme başı deliği, meme başı kanalı, Furstenberg rozeti, meme başı duvarı, meme başı sisterni ve meme başı ile bez sisternleri arasındaki sınırlar incelenmiştir. Sonuçlar istatistiki yazılımlar (StatSoft, Microsoft Corp. 1984-2000 Inc.) kullanılarak değerlendirilmiştir. 'Direkt temas' ve 'su yastığı'

teknikleri meme başının proksimal kısmının görüntülenmesini sağlamış, fakat meme başının distal bölgeleri zorlukla görüntülenebilmiştir (P<0,05). Prob frekansının, bu iki teknik tarafından elde edilen görüntülerin kalitesi üzerine belirgin etkisi olduğu ve 10 MHz prob kullanıldığında sonuçların istatistiki olarak (P<0,05) daha iyi olduğu belirlenmiştir. Keçide meme başı yapılarının en iyi görüntülenme (%100) tekniği 'su banyosu' ile elde edilmiştir. 10 MHz probun kullanılması yüksek kalitede görüntü elde edilmesini sağlamış olup, değişik fizyolojik ve patolojik değişimlerin teşhisi için önerilmektedir.

Anahtar Kelimeler: Keçi, ultrasonografi, meme başı

Introduction

Ultrasonography is a fast, accurate non-invasive means for investigation of mammary gland structures in animals. A number of studies (Cartee et al., 1986; Hospes and Seeh, 1999; Stocker and Rüsch, 1997; Takeda, 1989) outline the advantages of ultrasonography for diagnostics of physiological and pathological changes in the mammary gland in ruminants.

The major part of attempts for ultrasonography of teats were performed in cows (Ayadi et al., 2003; Flőck et al., 2004; Klein et al., 2005; Trostle and O'Brien, 1998) and sheep (Franz et al., 2003; Hiepler et al., 2009; Mavrogianni et al., 2004; Nudda et al., 2000). The method was used for detection and differentiation of teat stenosis (Dinç et al., 2000; Hospes and Seeh, 1999; Stocker et al., 1989), teat wall proliferation and fibrosis (Couture and Mulon, 2005), foreign bodies, milk stones and congenital defects in the area of the udder (Franz et al., 2009) and for diagnostics of mastitis, haematomas, abscesses (Flőck and Winter, 2006; Trasch et al., 2007) and mammary gland tumours (Gonzalez de Bulnes et al., 1998).

Several researchers (Olechnowicz and Jaśkowski, 2009; Ślősarz et al., 2010; Wőjtowski et al., 2002 and 2006) have reported the use of teat ultrasonography in goats for detection of teat cistern and teat canal alterations occurring in mechanical milking.

There are no data about the influence of probe frequency and the technique of investigation on ultrasound imaging of the different structures of caprine teat.

The purpose of this study was to investigate the potential of different ultrasonography techniques for imaging of teats in goats.

Materials and Methods

Thirty clinically healthy Bulgarian Dairy White goats, aged 3-7 years, weighing 45-60 kg, reared and fed uniformly, were studied. They were between the first and third month of lactation and were milked manually twice daily (in the morning and in the evening). Twelve hours before the ultrasonography, the kids were separated from the goats.

The health of teats was examined by inspection, palpation and California mastitis test was performed as described by Schalm et al. (1971). All animals showing deviations from normal were excluded from the study.

The ultrasonography of teats was performed 6 hours after the morning milking with ultrasound Mindray DP-2200Vet (Mindray, China) and a linear probe. Each teat was scanned consecutively at 5, 7.5 and 10 MHz probe frequency.

Teats were scanned in three different techniques - "direct contact", "stand off" and "water bath".

In the "direct contact" technique, the transducer was placed on the teat skin and a contact gel (Eco-ultra gel, Milano, Italy) was applied for better visualization (Cartee et al., 1986).

The "stand off" technique was performed as described by Rambadu et al. (2008). The teat was placed in a contact gel-filled latex condom, and the gel-covered transducer was applied on its outer surface.

The "water bath" technique consisted immersion of the teat in a plastic cup filled with water (temperature 30-35 °C) and application of the gel-covered probe to the outer surface of the cup (Franz et al., 2001).

The visualization of the teat orifice, teat canal, the rosette of Furstenberg, teat wall, teat cistern and the boundary between teat and gland cisterns was evaluated.

The results were processed with statistical software (StatSoft, Microsoft Corp. 1984-2000 Inc.) by means of ANOVA and non-parametric test of proportions, using the Student's t-criterion.

Results

Ultrasonography in vertical scan mode showed that the teat orifice was visualized as a small anechoic formation at the teat's tip. Immediately over it, the teat canal was seen as a thin white hyperechoic line surrounded from both sides by parallel, thick hypoechoic zones. The rosette of Furstenberg appeared as a homogeneous hypoechoic structure at the boundary between the teat canal and the teat cistern (Figure 1). The ultrasonographic image of the teat wall allowed the distinction of three layers - the skin (outmost light hyperechoic line), the musculature (medium hypoechoic layer) and the mucosa (innermost hyperechoic layer).

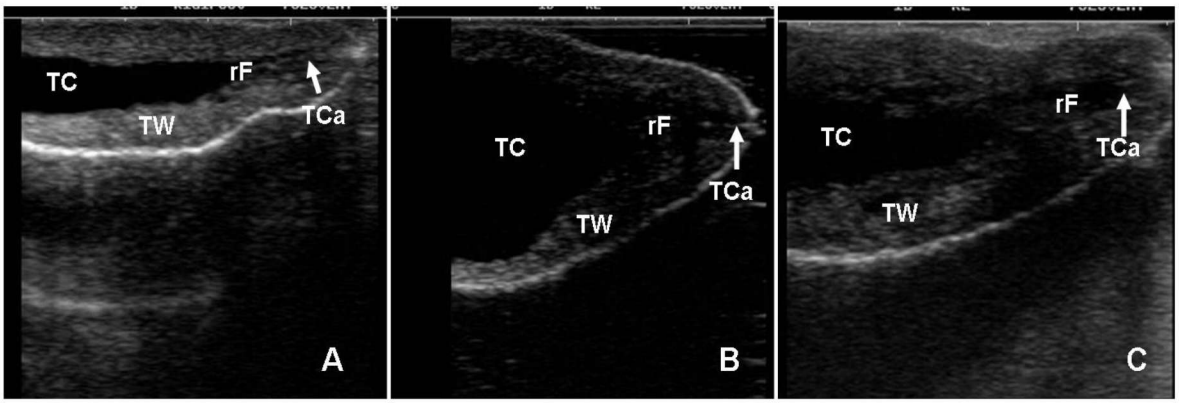

Figure 1. Ultrasound image of goat's teat.

Şekil 1. Keçi meme başının ultrason görüntüsü.

A – "direct contact" technique, vertical scan mode, 10 MHz linear probe
B –"water bath" technique, vertical scan mode, 7.5 MHz linear probe
C –"stand off" technique, vertical scan mode, 7.5 MHz linear probe
(TC – teat cistern; TW – teat wall; rF – rosette of Furstenberg; TCa – teat canal)

The teat cistern lumen was anechoic, while the boundary between the teat and gland cisterns included anechoic structures, corresponding to blood vessels from the venous ring.

The comparative analysis of the effect of probe frequency and the ultrasonography technique on the imaging quality of studied structures is presented in Table 1.

The "direct contact" technique allowed the visualization of the teat orifice and teat canal in 40% of cases when the used probe frequency was 5 and 7.5 MHz, whereas with the 10 MHz probe, the visualization was considerably higher (60%; $P<0.05$). The rosette of Furstenberg was observed in 50% of scans with 5 and 7.5 MHz transducers and in substantially more scans (70%) with the 10 MHz probe ($P<0.05$). The three-layer structure of teat wall was differentiated in 90% of teats scanned by 5 MHz probe and in all teats when a higher probe frequency was used. The teat cistern was seen in all goats regardless of transducer's frequency. The boundary between the teat and gland cisterns was observed in 90% of teats with all three probe frequencies used.

The "stand off" technique performed with 5 and 7.5 MHz probes allowed to observed the teat orifice, the teat canal and the rosette of Furstenberg in 60% of teats, whereas the teat wall, the cistern and the transition between teat and gland cisterns were depicted in all cases. With the 10 MHz probe, the teat orifice and canal were seen in statistically significantly more teat scans (80%) compared to scans with 5 and 7.5 MHz transducers. A similar relationship was observed for the rosette of Furstenberg. The other teat structures were observed in 100% of cases.

The "water bath" technique allowed visualization of all teat structures in 100% of scans. There were no differences with regard to the used probe frequency. The possibility for observation of the teat orifice and teat canal was considerably higher ($P<0.05$) compared to the other two techniques tested.

Table 1. Visualization of teat structures in goats by means of "direct contact", "stand off" and "water bath" techniques using probes of various frequency (n=60).

Tablo 1. Değişik frekanslara sahip problar kullanılarak keçilerdeki meme başının "direkt temas", "su yastığı" ve "su banyosu" teknikleri ile görüntülenmesi (n=60).

Structure	Probe frequency, MHz	"Direct contact", %	"Stand off", %	"Water bath", %
Teat orifice	5	40 (24/60)	60 (36/60)	100 (60/60)*
	7.5	40 (24/60)	60 (36/60)	100 (60/60)*
	10	60 (36/60)a	80 (46/60)a	100 (60/60)*
Teat canal	5	40 (24/60)	60 (36/60)	100 (60/60)*
	7.5	40 (24/60)	60 (36/60)	100 (60/60)*
	10	60 (36/60)a	80 (46/60)a	100 (60/60)*
Rosette of Furstenberg	5	50 (30/60)	60 (36/60)	100 (60/60)
	7.5	50 (30/60)	60 (36/60)	100 (60/60)
	10	70 (42/60)a	90 (54/60)a	100 (60/60)*
Teat wall	5	90 (54/60)	100 (60/60)	100 (60/60)
	7.5	100 (60/60)	100 (60/60)	100 (60/60)
	10	100 (60/60)	100 (60/60)	100 (60/60)
Teat cistern	5	100 (60/60)	100 (60/60)	100 (60/60)
	7.5	100 (60/60)	100 (60/60)	100 (60/60)
	10	100 (60/60)	100 (60/60)	100 (60/60)
Transition zone between teat and gland cisterns	5	90 (54/60)	100 (60/60)	100 (60/60)
	7.5	90 (54/60)	100 (60/60)	100 (60/60)
	10	90 (54/60)	100 (60/60)	100 (60/60)

* statistically significant difference within a row at $P<0.05$;
a: for the first three structure statistically significant difference within a column at $P<0.05$.

Discussion

Real-time ultrasonography provides a new insight in the diagnostics of udder physiology and pathology (Franz et al., 2009; Hospes and Seeh, 1999). The mammary papillae in goats are exposed to numerous mechanical and traumatic influences (offsping' suckling,

milking, direct contact with the floor and the environment etc.) (Gleeson and O'Callaghan, 1998; Gleeson et al., 2002). The anatomic integrity and the normal functioning of teat structures affect udder health (Khan and Khan, 2006). All these facts necessitate the use of precise techniques for determination of the state of teat structures.

According to presented results, the "direct contact" technique is fast to perform. It allows easy visualization of the proximal teat wall, the teat cistern, and the transition between teat and gland cisterns. The opportunity for observation of distal teat structures (teat orifice, teat canal and the rosette of Furstenberg) is however limited. A similar conclusion was made by Rambadu et al. (2008) in buffaloes. Dinç et al. (2000) assumed that this technique is most employed for detection of stenosis and obstructions localized in teat's base.

We believe that probe frequency is essential for obtaining a quality image in direct ultrasound scans of caprine teats. The utilization of linear transducers with frequency of 5 and 7.5 MHz allowed the observation of teat canal and teat orifice in only 40% of scanned teats, whereas the 10 MHz probe provided significantly better options (60%; $P<0.05$). In support of this statement, Franz et al. (2001) concluded that a good-quality image of ruminant teats could be obtained with an 8.5 MHz linear transducer.

The results from the application of the "stand off" technique were similar to those obtained with the "direct contact" scans, especially when distal teat part was investigated. In our belief, the utilization of these two techniques for imaging of teat orifice, teat canal and the rosette of Furstenberg was not appropriate, particularly when 5 MHz and 7.5 MHz transducer were used. Rambadu et al. (2008) made the same conclusion after ultrasonography of buffalo teats with a 7.5 MHz linear probe. The findings of Santos et al. (2004) in cows showed that "direct contact" and "stand off" techniques could be successfully used to detect pathological changes. Our study in goats demonstrated that it was only possible for strictures in the proximal part of the teats by means of a high-frequency (10 MHz) probe.

The "water bath" technique provides a possibility for observation of all teat structures, regardless of their location. Franz et al. (2009) also agreed that the "water bath" method prevented the deformations of teat tip which could impede the visualization of the teat canal along its length. Some authors (Flöck and Winter, 2006; Gufler et al., 1998) recommend the use of a linear transducer with at least 7.5 MHz frequency to attain a high-quality ultrasound image. Santos et al. (2004) identified most precisely the teat anatomical structures in cows. We did not observe any variations with regard to transducer's frequency, and the possibility for observation of distal teat structures was statistically significantly ($P<0.05$) higher compared to the other two techniques. Therefore, we could convincingly suggest that the "water bath" technique was the most suitable for ultrasound imaging of caprine mammary papilla.

The comparison of tested techniques showed that "direct contact" and "stand off" scans could be successfully used for imaging of the teat wall and the proximal teat structures (teat cistern and the boundary between teat and gland cisterns) in the goat. A high-quality ultrasound image could be obtained by the high-frequency (10 MHz) linear transducer. The "water bath" technique allowed observing ultrasonographically all teat structures in goats.

Conclusion

In conclusion, the "water bath" technique provided the best possibility for ultrasound imaging of caprine teat structures. The utilization of 10 MHz transducer yielded a high-quality image and could be recommended for diagnostics of physiological and pathological teat conditions. The results from the present study could be useful with regard to the accurate diagnostics and monitoring of udder diseases in goats.

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