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Technical note: The use of a sonomicrometry system for monitoring uterine involution in postpartum dairy cows

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ABSTRACT

Sonomicrometry allows the measurement of the distance between 2 piezoelectric crystals and has been widely used to investigate the contractility of the heart and gastrointestinal tract. The objective of this study was to determine whether this method can be used to quantify the reduction in uterine size in cows postpartum. Seven healthy pluriparous Holstein Friesian cows (3.7 ± 0.7 yr old, parity 2.4 ± 0.5, mean ± SD) were used. Three weeks before calving, 4 piezoelectric crystals were implanted via laparotomy in the myometrium of the greater curvature of the pregnant uterine horn in a longitudinal direction. Sonometric measurements were conducted daily from 2 d before parturition until 14 d after calving, followed by measurements every other day until d 28. Changes in the distance between neighboring crystals were presented as relative changes (%) from baseline values before parturition. The diameter of the previously pregnant uterine horn was measured using transrectal B-mode sonography from d 10 to 28 after calving. The cows were slaughtered 39 ± 6 d postpartum and the uterus was evaluated for fixation of the crystals. The distances between neighboring crystals underwent changes with a reduction of greater than 50% until d 1 postpartum, but no further changes were recorded from d 1 to 7. In the second week, changes in all distances were affected by day postpartum. One distance was affected by day postpartum in wk 3 and 4. There was a positive correlation between the diameter of the previously pregnant horn and the distances between the crystals. Examination of the uterus after slaughter of the cows revealed that 8 crystals (29%) were no longer fixed in the myometrium. Seven of these (25%) could be evaluated completely or partially and 1 (4%) could not be analyzed. Sonomicrometry seems to be suitable for the objective measurement of reduction in uterine length in cows.

Key words: postpartum period, uterus, cattle, sonography

Technical Note

Uterine involution after parturition is a critical part of the reproductive process of the cow. It is characterized by the return of the uterus to its previous size, endometrial regeneration, resumption of ovarian cyclicity, and elimination of bacterial contamination (Sheldon and Dobson, 2004; Frazer, 2005). Disruption of any of these events may affect fertility (Fonseca et al., 1983). Postpartum diseases of the genital tract, such as retained fetal membranes and metritis, and metabolic disorders (ketosis and hypocalcemia), have a negative effect on uterine involution (Fourichon et al., 2000; Ribeiro et al., 2013). Close monitoring of uterine involution is important from a clinical perspective and is also used as a research tool. Assessment of uterine size is particularly relevant in the first few days postpartum, during which time the major part of the involution occurs as evidenced by massive muscle contractions and evacuation of lochia (Gier and Marion, 1968; Zerobin, 1970; Frazer, 2005).

Various methods have been used for the assessment of uterine involution in cows, including transrectal palpation (Morrow et al., 1969; Watson, 1985) and transrectal B-mode sonography (Okano and Tomizuka, 1987; Kamimura et al., 1993; Bekana et al., 1994; Melendez et al., 2004). These techniques are noninvasive and relatively simple and primarily serve to assess uterine size and tone. The main disadvantage of these techniques is that they cannot be used to assess the entire uterus during the first days after calving (Kamimura et al., 1993). Furthermore, the results of these techniques have limited accuracy, and assessment by transrectal palpation is subjective (Okano and Tomizuka, 1987; Bekana et al., 1994). Uterine involution can also be assessed indirectly by measurement of blood flow in the uterine artery using Doppler sonography (Krueger et al., 2009; Heppelmann et al., 2013) or by measurement of intrauterine pressure transcervically (Rodriguez-Martinez et al., 1987; Hirsbrunner et al., 1999; Bajcsy

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et al., 2005) or invasively using microtransducers and tip catheters implanted via laparotomy (Gillette and Holm, 1963; Kündig et al., 1990). Other invasive measuring techniques include electromyography (Kündig et al., 1990; Gajewski et al., 1999; Taverne et al., 2002) and the recording of uterine contractions and stretching using strain gauge transducers (Burton et al., 1987). A commonality of these methods is that they are useful for recording uterine contractions, but they do not measure reduction in uterine size during involution.

Sonomicrometry allows the objective estimation of the distance between individual piezoelectric crystals based on the measurement of the time required for an ultrasound signal to travel between them. Crystals affixed to the tissue of the organ to be examined can transmit or receive ultrasound bursts (Adelson and Million, 2004), and the distance between transmitter and receiver can be calculated based on a constant signal transit speed of 1.59 mm/μs determined for mammalian soft tissue. Sonomicrometry has been widely used in experimental cardiovascular studies (Korinek et al., 2007), for the investigation of gastrointestinal motility in small animals (Adelson and Million, 2004; Ouyang and Chen, 2005), and for the measurement of changes in muscle length in pigeons and toads (Biewener et al., 1998; Ahn et al., 2003). These studies have shown that changes in the size of an organ can be monitored directly and continuously using sonomicrometry, but differentiation between active and passive movement of an organ is not possible (Adelson and Million, 2004). To date, the use of sonomicrometry in cattle has been limited to the measurement of cervical diameter in the periparturient period (Breeveld-Dwarkasin et al., 2002; van Engelen et al., 2007).

There are no techniques available for the objective assessment in reduction of uterine size during the early puerperal period. Therefore, the current study was carried out to investigate the feasibility of sonomicrometry for this purpose. Our objective was to establish an experimental technique for the assessment of the effects of postpartum disease on reduction of uterine size and whether these effects can be modified by therapeutic measures.

Sonomicrometry System

The sonomicrometry system (Sonometrics Corp., London, Canada) used consisted of 4 piezoelectric crystals, the sonomicrometer (TRX8), the Channel-Selector-Box, and a Sonometrics Data Acquisition Computer. The epoxy-coated crystals were 4 mm in diameter and mounted on a rigid neck part, which was about 15 mm in length and connected to the skin button via a 2-m length of silicone-coated cable (Figure 1). The sonomicrometer generated ultrasound signals in the piezoelectric crystals and converted the received analog signals into digital signals. The length of the transmission pulses was 400 ns and the frequency was 25 Hz. The crystals that served as transmitter and receiver were chosen by means of the Channel-Selector-Box. The selected distance between the transmitting and receiving crystals was monitored on an oscilloscope (54600B 100 MHz, Hewlett Packard, Palo Alto, CA) to check the signal quality. To identify artifacts caused by movements of the cows, video recordings were made of the animals during measurements and recorded and stored on a personal computer.

Animals

Seven healthy pluriparous Holstein Friesian cows housed at the Clinic for Cattle of the University of Veterinary Medicine Hannover, Foundation, were examined from 3 wk before to 4 wk after calving. The cows were 3.7 ± 0.7 yr (mean ± SD) of age and weighed 686 ± 63 kg. Parity was 2.4 ± 0.5, BCS was 3.8 ± 0.4, and the 305-d FCM yield was 7,779 ± 941 kg. The cows were kept in isolated boxes with straw bedding and fed hay and corn silage ad libitum. Before calving the cows received 1 kg of concentrate (18% CP, St.Mv.18 III Pell.; ForFarmers Bela GmbH, Vechta, Germany) twice daily; after calving concentrate was fed according to milk yield. After calving cows were milked twice daily. General clinical examinations were conducted each day

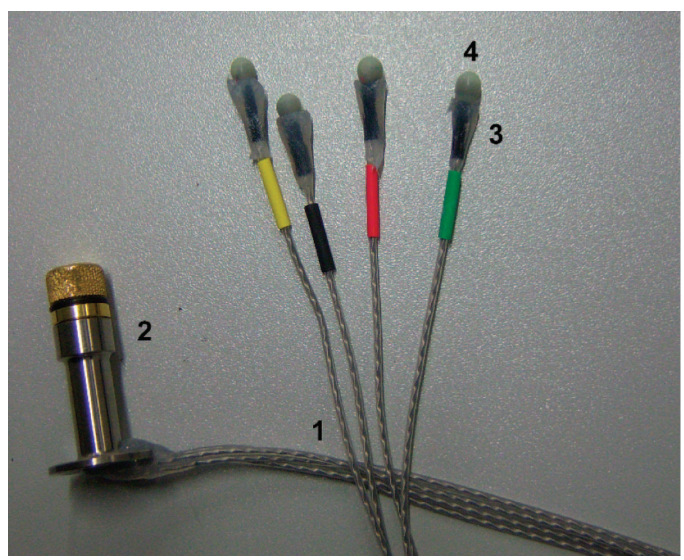

Figure 1. Four piezoelectric crystals (Sonometrics Corp., London, ON, Canada) with silicone-coated cables (1) connected to the skin button (2). A silicone collar (3) was applied to the neck part below the head of the crystals (4) for better fixation of the sutures. Color version available online.