Uterine Contraction in Sows during Estrus and Puerperium, and in Sows with Multiple Follicular Cysts

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Abstract. Uterine contraction in sows during the estrous and puerperal periods, and in sows with multiple follicular cysts (MFC), were measured using a modified balloon method. On the basis of the graphs thus obtained, the frequency of uterine contractions, their average intensity and Planimeter (Pl) values were compared. In the puerperal period, contraction waves were completely different during suckling and not suckling period. Suckling stimuli affected contraction frequency and Pl values significantly (P<0.01). Immediately after parturition, the frequency of uterine contractions, their average intensity and Pl values tended to be high and decreased with the passage of time. For sows with weak contractions that required assistance in farrowing, intensity and Pl values were significantly low (P<0.05). For sows with small multiple follicular cysts (SMFC) and normal estrus, clear uterotonic activity was observed. Uterine contractile frequencies in sows with SMFC were slightly less frequent than in estrous sows, but greater contractions were observed, showing higher Pl values (P<0.05). These contractions also lasted a long duration. Moreover, intermittent uterine contractions were observed during the puerperal stage, whereas persistent uterotic activity in SMFC and estrous sows.

Key words: Sow, Uterine contraction, Lactation, Ovarian disorder


Uterine contractions play an important role in parturition and the estrous cycle. In humans, uterine contractions have been observed to vary depending on whether a woman is pregnant, not pregnant, postpartum, or has been administered drugs.

Research on uterotic activity in farm animals focuses on three main aspects: 1) the relationship between the estrous cycle and uterotic activity; 2) uterotic activity during parturition; and 3) the efficacy of uterotic stimulants. With regard to the relationship between the estrous cycle and uterotic activity, Bonafos et al. [1] have reported on the cow and Keye [2] has reported on the sow. And recently, some have reported on the efficacy of synthetic compounds on uterotic contraction in sows [3–6]. Relatively few studies have focused on uterotic activity during parturition. As for uterotic activity in the presence of MFC (both large and small), no reports at all have been published.

Among ovarian disorders in the sow, close attention was especially paid to the observation that SMFC is associated with irregular uterotic activity. This uterotic activity was measured and compared against uterotic activity in sows with large multiple follicular cysts (LMFC) and sows with normal estrus.
Materials and Methods

Sows

Totally, 26 breeding sows weighing between 180 and 230 kg kept in Kanagawa and Shizuoka prefectures (Japan) were used for this study. Three sows delivered in summer were used to confirm the influences of the hot temperature. Twelve postpartum; 6 normal parturition and 6 sows with uterine inertia, 5 normal estrus (same sows entered standing estrus within the previous 24 h and 14th days of diestrus), 3 SMFC and 3 LMFC were used to determine the differences of uterine contraction. Sows were F1 breeds of Landrace × Large White, with 1 to 8 parities and the average number of piglets per litter was 11–13.

Seasonal effects on uterine contraction

To obtain appropriate data on uterine contractions, seasonal influence upon uterine contractions was determined.

Postpartum sows

Postpartum sows were held in a recumbent position in a farrowing pen without restraint or anesthetization. After confirmation of the final expulsion, a sterilized balloon-catheter device was inserted deep into the proximal site of the uterine body via the vagina and cervix. Approximately 750 ml of air were pumped into the balloon with a disposable pump such that the inflated balloon contacted closely and gently to the inner uterine wall without pressing the uterine walls. A pressure transducer, pressure amplifier, and pen recorder were then hooked up. At 15–30 min after insertion of the balloon, uterotonic activity was recorded for more than 30 min (Fig. 1). During measurement, in order to eliminate the influence of suckling stimuli and cries of piglets, a clear separate was made between suckling and not suckling periods. Sows were allowed to nurse piglets during 1 h periods between measurement sessions.

Estrous and multiple follicular cyst (MFC) sows

Before recording, estrous and MFC sows were examined by rectal palpation to determine whether they were in normal estrus or had an ovarian disorder, and also to determine whether uterine contractions were taking place. The sows selected for study: 1) were in normal estrus; 2) had entered standing heat within the previous 24 h; 3) were at the same stage of estrus; and 4) had not yet mated. Criterion to diagnose SMFC was followed by Toriumi et al. [7].

Measurements of uterine contractions were performed with the sows in a standing position and leashed to a holding stall frame, without restraint or anesthetization. The investigator’s right hand was inserted into the rectum and used to hold the cervical canal in place. A balloon catheter for cows with inner guide was inserted deep into the proximal site of the uterine body from the vulva and cervix with the left hand. After the guide was removed, a disposable pump was used to pump water (40 ml) at body temperature into the balloon, which was then fixed closely and gently to the uterine cavity by distention without pressing against the uterine walls (Fig. 1). To avoid extraneous influences upon the balloon, subsequent measurements were conducted with the sow in a recumbent position and, just as was done immediately postpartum, a pressure transducer,
A balloon catheter (Type: FA363, Fujihira Corporation; 20 Fr; designed for use with cows) was used to investigate the estrous, SMFC, and LMFC sows. For measurement of uterine contractions in postpartum sows, a sterilized, handmade air balloon was attached to the open end of a catheter tightened to the tip of a syringe. The catheter was then connected to a pressure transducer (Type: CP-01, Star Medical Corp. Japan), which in turn was linked to a pressure amplifier (Type: PA-001, Star Medical Corp. Japan) and a pen recorder (Type: R-22, Rika Electric Industry Corp. Japan).

The apparatus set-up enabled the uterine contraction to be monitored during the experiment. A digital planimeter (Type: KP-90 Uchida Youko Corp. Japan) was used for Planimeter (Pl) value calculation. (Fig. 1.)

Data treatment

Uterine contractions were plotted in a wave form, the values of which were based upon a composite figure calculated by averaging the frequency, duration, and intensity of uterine contractions during a 10-min period. The intensity of contraction, measured by the digital planimeter, was expressed as a Pl value. Duration of contraction, which was recorded in minutes, was defined as the time that elapsed between the beginning of the contraction until the uterus returned to the base line (Tunus). The Pl value was defined as the integral value of the duration of intrauterine pressure, i.e., it was obtained by calculating the area of the contraction wave above the base line.

Statistical analysis

The Student’s t test was used for verifying a significant difference between suckling and not suckling sows, and between the effects on frequency and intensity of uterine contractions in estrous and SMFC sows.

Results

Seasonal effects on uterine contraction

In measurement of uterine contractions, irregular contraction waves were obtained in both summer and winter. In summer, this was due to the observation that the animal uses its entire body to breathe. In the winter, it happened because the systemic muscles quiver in order to generate heat. It was found that the best contraction waves are obtained in a temperate season, such as spring (Fig.2).

Postpartum uterine contractions and their changes over time

Uterine contractions in lactating sows with suckling stimulus were completely different from those in sows without suckling by piglets (Figs. 3, 4). During the suckling period, uterine contractile frequencies were 3.34 ± 0.59/10 min (All values are mean ± SD), contraction intensity was 11.36 ± 4.94 mmHg, Pl values were 13.11 ± 2.90 mmHg/ min. In the non-suckling period, the respective values were 1.43 ± 0.54/10 min, 7.21 ± 0.56 mmHg, 3.36 ± 1.54 mmHg/min. The values for frequency and Pl in sows with suckling were significantly higher than those of sows without suckling by piglets(p<0.01). From these results, it was concluded that the stimulus of breathing has a great effect upon the uterine contractile frequency and...
Thus, uterine contractions during suckling and non-suckling periods must be compared separately. Therefore, to compare changes over time in postpartum uterotonic activity, data from non-suckling period were used. Three hours following parturition, uterine contraction frequency was $1.73 \pm 0.61$ times/10 min, average contraction intensity was $8.33 \pm 4.47$ mmHg, and the Pl value was $4.28 \pm 1.76$. Each of these readings represents a peak, and they fell thereafter with the passage of time (Fig. 5).

Differences in uterotonic activity in sows with normal parturition versus sows with uterine inertia

For sows which have normal parturition, the average values are $1.49 \pm 0.50$ times/10 min for contraction frequency, $9.34 \pm 4.06$ mmHg for contraction intensity, $4.13 \pm 1.15$ mmHg/min for Pl value. For sows with uterine inertia, the average values are $1.38 \pm 0.59$ times/10 min for contraction frequency, $5.28 \pm 1.43$ mmHg for contraction intensity, $2.67 \pm 1.56$ mmHg/min for Pl. Average contraction intensity and Pl were significantly lower ($P<0.05$) for sows with uterine inertia.

Use of water-infused balloon to compare uterine contractions in estrous and MFC sows

Although contractions were clearly established in estrous and SMFC sows, almost no contractions were observed on 14th days of diestrus or sows with LMFC, therefore levels at these stages was evaluated as zero (Fig. 6). Uterine contractile frequencies per 10 min were $6.40 \pm 1.52$ and $5.33 \pm 0.58$ in estrous and SMFC sows, respectively. No significant differences were found between them. As for duration of contraction, the average for sows in normal estrus was $0.55 \pm 0.16$ min, and for sows with SMFC was $1.37 \pm 0.46$ min. The duration of contraction in sows with SMFC tended to be very long. With respect to intensity of contraction, the average values and Pl values for sows in normal estrus were $4.42 \pm 0.76$ mmHg and $7.02 \pm 2.90$ mmHg/min. In SMFC sows, these values were $9.43 \pm 1.50$ mmHg, $28.94 \pm 7.06$ mmHg/min, indicating significantly higher values ($P<0.05$) than those with normal estrus (Fig. 7).
In the observation of uterine contractions, at three hours after parturition, uterine contraction frequency was $1.73 \pm 0.61/10$ min, average contraction intensity was $8.33 \pm 4.47$ mmHg, and the PI value was $4.28 \pm 1.76$ mmHg/min. Each of these readings represents the maximum level, and they fell thereafter with the passage of time. These findings indicate that uterine contractions decreased with the passage of time.

In sows with uterine inertia that required assistance in parturition, average contraction intensities and PI values were significantly ($P<0.05$) lower than in those with normal parturition. In the sows that required assistance in parturition, among the different factors used to evaluate uterine contractions, average contraction intensity and PI values were especially low, which would seem to indicate that the intensity of contractions and PI values play major role in determining whether parturition will require assistance or not.

It has been reported [8, 9] that oxytocin released in response to suckling stimuli of piglets enhances milk production and accelerates uterine contractions. In our experiment, as well, suckling stimuli from newborn piglets greatly accelerated the frequency of uterine contractions. Thus, there was a significant difference ($P<0.01$) in the uterine contraction frequency and PI values of sows during suckling and non-suckling periods. It was concluded from these results that the increase of uterotonic activity in a sow is primarily the result of accelerated uterine contractions caused by suckling stimuli. Furthermore, even in sows with weak uterotic activity, suckling stimuli form the former born piglets generally gives rise to intense contractions, thus suggesting that the parturition process can be accelerated by using the first born piglet in a litter to stimulate the sow’s teats.

Of various ovarian disorders, we focused particularly on sows with SMFC, which shows the unique or peculiar uterotonic activity. Uterotonic activity was clearly observed in sows with estrus and sows with SMFC, although contraction frequency was slightly lower in SMFC sows. As compared with sows with estrus, which showed intense contractions and significantly higher ($P<0.05$) PI values, contractions lasted longer in SMFC sows. In LMFC sows, however, uterotic activity was not observed. Serum estradiol-17β ($E_2$) concentrations were far higher in LMFC sows than in SMFC sows, while progesterone ($P$) concentrations were approximately the same [7]. The above result is thought to be due not only to the effect of $P$, $E_2$, and oxytocin concentrations in the serum, but also to different levels of uterine sensitivity and to oxytocin receptor.

In comparing the uterotonic activity of estrous and SMFC sows against the uterotonic activity of postpartum sows, contractile intensities and PI values were not compared because different balloons and media were used in the respective studies. It may not make a sense to compare contractile frequencies due to the varying conditions of uterus size; it is, however, noted that there were clearly significant differences between contraction frequencies. These results show that intermittent uterine contractions occurred in postpartum sows while continuous uterine contractions were demonstrated in estrous and SMFC sows. These findings indicate that when
the uterus is in its thick, puerperal state (uterine wall as thin), it contracts differently than during estrus or SMFC, when it is in thin state (uterine wall as thick).

During the luteal phase, it was difficult to insert the catheter because the uterus was in a serpentine shape, and had a balloon-like softness. Just as with LMFC sows, the contraction wave could not be obtained. According to Bonafos et al. [1] uterotonic activity is increasing for several days before ovulation and decreasing for several days after ovulation. The hormone increasing during the before ovulation is circulating P, and, on a temporal basis, P as well as estrogen may stimulate increased tone. In addition, Keye [2] has reported that 1–2 repetitions of high-amplitude contraction are uniformly found before ovulation in sows and after ovulation there are gradual decreases in the amplitude and increases in the frequency. Moreover, uterotonic activity attenuates in the luteal phase. While a number of studies have been conducted on uterotonic activity during estrus, very few have worked with uterotonic activity in sows with uterine disorders. In particular, no reports have been published on the uterotonic activity in SMFC sows.

Balloon catheters have been used in this study to measure uterotonic activity. In terms of close contact with the inner uterine walls of the enlarged postpartum uterine body, we decided to use air instead of water that did not provide a snug fit against the inner uterine walls. However, our study yielded lower values for contraction intensity and PI values due to the phenomenon that air-inflated balloon produced insufficient conduction of the inner uterine pressure. As for measurements of small uteri cavity in estrous and SMFC sows, the use of water-inflated balloons produces better inner uterine pressure readings with pronounced tracings of uterine contractions due to the increase of conductivity. It would have been preferable to use the same type of balloon and medium to measure uterotonic activity in postpartum, estrous, and MFC sows, but varying uterine conditions made this impossible.

References