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Risk factors for puerperal endometritis in the sow

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Abstract

Puerperal endometritis in sows may detrimentally affect the health of sows and reduce reproductive performance in their subsequent litters. Therefore, the present study aimed to determine risk factors for puerperal endometritis in sows. In total, 139 second-parity, Yorkshire × Landrace sows from a swine farm were recruited. Information including parity number, gestation length, litter size, number of dead-born piglets per litter, use of manual extraction of foetuses, intrapartum oxytocin use, and postpartum vaginal discharge were recorded. Puerperal endometritis was defined based on the characteristics of the vaginal discharge. Logistic regression was used to determine the significant risk factors for puerperal endometritis. The incidence of puerperal endometritis was 20.1% (28/139). Manual extraction of foetuses, farrowing duration, and number of dead-born piglets per litter were determined as the most significant risk factors for puerperal endometritis. All of these factors were positively associated with the disorder. The present study showed that puerperal endometritis was common in the sow. Determination of risk factors for puerperal endometritis contributes to the understanding of the disorder and helps farm practitioners spot and treat sows at risk early.

Keywords: postpartum, reproduction, sows, vaginal discharge
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Introduction

Parturition is initiated by the inflammatory response and in the postpartum period, this inflammation process still works to repair the wounded uterine endometrium. During this reparation process of the uterus, placental remnants and inflammatory products are disposed of via vaginal discharge. The average physiological postpartum vaginal discharge is 4–5 d (Nam, 2020; Grahofer *et al.*, 2021) and increased volume of the vaginal discharge may increase the odds of endometritis (Grahofer *et al.*, 2021). Endometritis may be a reason for culling sows since 90% of culled sows had cystitis and endometritis as reported by a study in Austria (Sipos *et al.*, 2014). Uterine involution is delayed due to postpartum metritis (Björkman *et al.*, 2018). In a recent study, we reported that although the pregnancy rate and subsequent litter size was not substantially reduced by prolonged vaginal discharge (>5 d), the weaning-to-service interval increased substantially in the sows with prolonged postpartum vaginal discharge (Nam, 2019a). Furthermore, piglets raised by sows with prolonged postpartum vaginal discharge were more likely to acquire diarrhoea; the diarrhoea occurred earlier in these piglets although the duration of diarrhoea was not associated with postpartum vaginal discharge (Nam, 2019b). In a recent study in Switzerland, Grahofer *et al.* (2021) did not find a strong association between vaginal discharge and return-to-oestrus rate, total born, and number of live-born piglets. In contrast, Waller *et al.* (2002) reported that a postpartum vaginal discharge of more than 6 d decreased the conception and farrowing rates.

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Previous studies have investigated factors affecting puerperal disorders in the sows. Bostedt *et al.* (1998) studied 140 gilts and reported that puerperal illness was more likely to present in gilts that had prolonged farrowing, large litter size, and stillborn piglets. We also demonstrated that prolonged farrowing, more than five parities, stillbirths, increased postpartum body temperature, and manual extraction of foetuses increased the risks of prolonged postparturient vaginal discharge in sows (Nam, 2020). Similarly, Bjorkman *et al.* (2018) studied 99 Yorkshire × Large White, parity 2–5 sows and found that prolonged farrowing, manual extraction, intrapartum oxytocin use, impaired placental expulsion, and number of stillbirth were associated with postpartum metritis, which was characterized by increased uterine size and intrauterine fluid accumulation. Manual extraction increased the pathological vaginal discharge score in the sows within the first five days postpartum (Grahofer *et al.*, 2021). A study conducted in tropical diseases reported that long farrowing duration increased the risk of postparturient disorder characterized by abnormal vaginal discharge (Tummaruk and Sang-Gassanee, 2013).

In the last decades, litter size of hyperprolific sow lines has been substantially increased, with a concomitant increase in farrowing duration. Farrowing is a painful and stressful process consuming huge energy (Melo and Peraçoli, 2007; Mainau *et al.*, 2016; Yang *et al.*, 2019; Navarro and Mainau, 2020) and it is closely associated with puerperal disorders in the sows. Therefore, the present study aimed at investigating the association between farrowing traits (farrowing duration, litter size, number of dead-born piglets per litter, manual extraction of foetuses, and intrapartum oxytocin use) and puerperal endometritis in the sow.

Materials and Methods

This study was reviewed and approved by the Committee on Animal Research and Ethics of Faculty of Veterinary Medicine, Vietnam National University of Agriculture (CARE-2022/02).

This study was conducted on 139 second-parity sows on a farm in Bac Giang province, Northern Vietnam, during March and August, 2022. The selection of only second-parity sows was due to the sows' availability during the study period. Pregnant sows were kept in individual gestation crates and moved to the farrowing crates a week before farrowing. The temperature in the farrowing room was 23–30 °C and was modulated by a water cooling system and fans. Sows were bathed once or twice a day, depending on the ambient temperature. During pregnancy, sows were fed 2.0–3.0kg of an commercial feed per day. Feed was reduced 3 d before farrowing to ~1 kg per day, and then gradually increased to an *ad libitum* level of ~6 kg per day at day 6 postpartum. The farrowing crates had a concrete-slatted floor and the piglet area had a hard plastic, slatted floor. Newborn piglets were dried and suckled then kept in an incubator heated by an infrared lamp.

Sows were monitored every 15 min from the birth of the first to last piglet. Total born (litter size), number of stillborn, and mummified piglets were recorded. Stillborn piglets were those found dead after birth without signs of skin autolysis. Because postmortem examinations were not allowed on the farm, categorization of stillbirths could not be conducted. Mummified piglets were those found dead after birth and had brown/black skin. Farrowing duration (h) was calculated as the period between the birth of the first and the last piglets. The use of oxytocin (20 IU/sow) and manual extraction was also recorded. These obstetrical interventions were conducted by the farm's veterinarians. When a birth interval exceeded 45 min, these obstetrical interventions were applied but usually the sows were left untreated. After farrowing, sows were intramuscularly injected with oxytocin (20 IU/sow) once per day during the first 3 d postpartum to stimulate the disposal of placental remnants and inflammation products. Sows were also injected intramuscularly with Amoxicilin trihydrate (15 mg/kg) at least for the first 5 d postpartum, with an interval of 48 h. The injection of oxytocin and Amoxicillin trihydrate was conducted in the morning. Vaginal discharges were observed twice per day in the morning and the afternoon before the farrowing crates were cleaned. The cessation of vaginal discharge was reported after two consecutive observations with no vaginal discharge. The duration of postpartum vaginal discharge was the period between the birth of the last piglet and the time of vaginal discharge cessation. The characteristics of the vaginal discharge were used to classify the uterine inflammation status. If the vaginal discharge contained pus with various ranges of colour such as red, brown, yellow, grey, or green with odour, the sows were classified as having "puerperal endometritis"; otherwise the sows were classified as having "no puerperal endometritis". The classification of uterine inflammation into endometritis instead of metritis was based on the finding in which most of puerperal inflammation of the uterus is endometritis (Dial and MacLachlan, 1988; Grahofer *et al.*, 2021).

Logistic regression was used to determine risk factors for puerperal endometritis following two steps. Firstly, individual independent risk factors were examined with univariate logistic regressions. The risk factor that gave a *P*-value <0.1 was retained for multivariate logistic regression analysis, which was built through a forward, stepwise selection of significant variables. Variance inflation factors were calculated to assure that no multicollinearity existed in the final multivariate logistic model (Rstudio

Desktop 1.4.1106). The Hosmer–Lemeshow goodness of fit test was used to calculate if the observed endometritis rate fitted the expected endometritis rate. The Nagelherke R^2 value was also calculated to measure the proportion of total variation of metritis that could be explained by the independent variables in the final model. Spearman's rho correlations between different risk factors were also calculated to explain the association among them and the dependent variable. Student *t*-test was used to compare the duration of postpartum vaginal discharge in sows with and without endometritis. All tests were conducted in SPSS program (IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY: 152 IBM Corp). A *P*-value <0.05 was set as the significance level.

Results

Table 1 summarizes the reproductive parameters of the studied animals. On average, the litter size of the investigated sows was 13.3 ± 2 piglets. The litter size varied considerably among sows from 2 up to 20 piglets. The number of stillborn piglets and mummified piglets varied from 0–5 piglets per litter, resulting in stillbirth and mummified rates of 5.0 and 1.8%, respectively. During farrowing, about one-fifth of the sows needed manual extraction. The duration of postpartum vaginal discharge in sows with endometritis was longer than that in the sows without endometritis (6.2 vs 3.5 d, *P* <0.001). One-fifth of the studied sows suffered from puerperal endometritis.

The number of dead-born piglets per litter was positively correlated with farrowing duration (Spearman's rho correlation = 0.223, *P* = 0.008). Gestation length was negatively associated with litter size (Spearman's rho correlation = -0.187, *P* = 0.027), but had no association with farrowing duration (Spearman's rho correlation = 0.013, *P* = 0.876). The farrowing duration, incidence of manual extraction, number of dead-born piglets per litter, and litter size in the sows with intrapartum oxytocin administration did not differ from those in the sows needed no intrapartum oxytocin administration (*P* = 0.125, 0.853, 0.840, and 0.053, respectively). Sows with manual extraction had longer farrowing durations in comparison with the sows experiencing no manual extraction (4.4 vs 3.6 h, *P* = 0.01).

Table 1 Descriptive statistics of 139 investigated sows

Investigated criteria	Number of animals	Mean ± SD/Incidence	Range
Gestation length (day)	139	116.0 ± 1.7	113–120
Litter size	139	13.3 ± 2.8	2–20
Number of stillborn piglets/litter	139	0.7 ± 1.0	0–5
Number of mummified foetuses/litter	139	0.2 ± 0.8	0–5
Farrowing duration (h)	139	3.8 ± 1.3	0.5–10
Number of dead-born piglets per litter	139	0.9 ± 1.4	0–10
Duration of vaginal discharge in sow without endometritis (day)	111	3.5 ± 0.7	2–5
Duration of vaginal discharge in sow with endometritis (day)	28	6.2 ± 1.7	5–10
Manual extraction (%)	139	18.0 (25/139)	-
Puerperal endometritis (%)	139	20.1 (28/139)	-
Use of intrapartum oxytocin (%)	139	17.3 (24/139)	-
Stillbirth rate (%)	1849	5.0 (93/1849)	-
Mummified foetus rate (%)	1849	1.8 (33/1849)	-

SD: standard deviation

Univariate logistic regression analysis showed that farrowing duration, litter size, manual extraction, and number of born-dead piglets per litter were associated with puerperal endometritis in the sows. In contrast, gestation length and use of oxytocin during farrowing were not correlated with puerperal endometritis (Table 2).

Table 2 Univariate logistic regression analysis of potential risk factors for puerperal endometritis in 139 second-parity sows

Factors	Incidence (%)	OR	95% CI	*P*
Gestation length (day)	-	0.857	0.663–1.109	0.242
Farrowing duration (h)	-	2.326	1.562–3.462	<0.001
Litter size	-	1.212	1.021–1.437	0.028
Manual extraction (%)				
No	10.5 (12/114)	1		
Yes	64.0 (16/25)	15.111	5.491–41.584	<0.001
Number of dead-born piglets per litter				
None	6.0 (4/67)	1		
1 piglet	23.3 (10/43)	4.773	1.390–16.388	0.013
2 or more piglets	48.3 (14/29)	14.7	4.230–51.089	<0.001
Use of oxytocin during farrowing				
No	18.3 (21/115)	1	0.679–5.007	0.230
Yes	29.2 (7/24)	1.843		

OR: odds ratio, CI: confidence interval, *P*: probability

The final multivariate logistic regression analysis selected farrowing duration, manual extraction, and number of born-dead piglets per litter as the most crucial determinants of puerperal endometritis in the sow (Table 3). The positive association between litter size and farrowing duration (Spearman's rho correlation = 0.352, *P* <0.001) resulted in removal of litter size from the final model. All these risk factors were positively associated with puerperal endometritis. When farrowing duration increased by one hour, the risk of suffering from the disorder increased 2.1 times (OR = 2.135). Sows experiencing manual extraction had 14.442-fold higher odds of having puerperal endometritis than the sows did not require manual extraction of piglets. Sows with one or more born-dead piglets had higher risks of acquiring the disorder than the sows with no piglets born dead (OR = 5.053 and 9.656, respectively). The final multivariate model explained 55.4% of the variation in puerperal endometritis. The Hosmer–Lemeshow goodness of fit test showed that the expected matched the observed puerperal endometritis rate (= 0.256). No multicollinearity existed in the final model since the variance inflation factors were 1.02, 1.04, and 1.02 for farrowing duration, manual extraction, and number of born dead piglets, respectively.

Table 3 Multivariate logistic regression analysis of potential risk factors for puerperal endometritis in 139 second-parity sows

Factors	OR	95% CI	*P*
Farrowing duration (h)	2.135	1.300–3.505	0.003
Manual extraction (%)			
No	1		
Yes	14.442	4.060–51.373	<0.001
Number of dead-born piglets per litter			
None	1		
1 piglet	5.053	1.159–22.030	0.031
2 or more piglets	9.656	2.260–41.247	0.002

OR: odds ratio; CI: confidence interval, P: probability

Discussion

Puerperium is a critical period in the sows because reproductive disorders, including puerperal endometritis, usually occur during this time (Björkman *et al.*, 2018; Björkman *et al.*, 2022). The present study indicated that puerperal endometritis was common in the second-parity sow; the disorder was associated with several risk factors such as manual extraction of the foetus, prolonged farrowing duration, number of dead-born piglets per litter, and large litter size. This findings corroborated the results of previous studies (Bostedt *et al.*, 1998; Björkman *et al.*, 2018; Grahofer *et al.*, 2021; Nam, 2020).

The positive association between farrowing duration and incidence of puerperal endometritis in this study is in agreement with the result reported by Björkman *et al*. (2018). In that study, sows with prolonged farrowing (>300 min) had 7.67- and 5.697-fold higher odds of having an enlarged uterus and intrauterine fluid accumulation, respectively, compared with that of the sows with normal farrowing. The

positive association between farrowing duration and incidence of puerperal endometritis might be explained via the characteristics of the farrowing process. Farrowing is an extremely energy-consuming, painful, and stressful process (Melo and Peraçoli, 2007; Mainau *et al.*, 2016; Yang *et al.*, 2019; Navarro and Mainau, 2020). Therefore, sows with prolonged farrowing, in comparison with sows with normal farrowing, frequently display fever and reduced appetite (Tummaruk and Sang-Gassanee, 2013). These disorders subsequently cause stress, energy loss, reduced feed intake, and energy and electrolyte imbalance (Melo and Peraçoli, 2007). This condition might impair sow immunity (Segerstrom, 2007). Successful farrowing is the result of an adequate oxytocin level that stimulates the contraction of the uterus and the expulsion of foetuses (Hill *et al.*, 2022). Therefore, prolonged farrowing might be a result of an inadequate intrapartum oxytocin level, and the oxytocin shortage might also be present postpartum. The inadequate postpartum oxytocin level hinders the disposal of the foetal membrane and other inflammatory products. These materials are highly nutritious to the bacteria present in the uterus. Collectively, the energy and electrolyte imbalance, the impaired immunity, and the profound growth of bacteria in the uterus of the sows with prolonged farrowing results in puerperal endometritis.

The increased incidence of puerperal endometritis in sows needing manual extraction in the present study corroborated the finding of Björkman *et al*. (2018); this obstetrical intervention increased the odds for both enlarged uterus and intrauterine fluid accumulation on days 2–7 postpartum. Similarly, obstetrical intervention increases the severity of vaginal discharge (Grahofer *et al.*, 2021). Manual extraction of foetuses is a common obstetrical intervention when there are signs of dystocia (Nam and Sukon, 2022). This intervention can instantly remove the obstructed piglets from the reproductive canal, thereby saving the piglets. It is also used to reduce farrowing duration. However, this practice might result in damage to the endometrium and can transport pathogenic bacteria into the lumen of the uterus in the absence of hygiene of the worker/veterinarian's hand and/or if the intervention is not conducted with care and gentleness (Giuliodouri *et al.*, 2013). This might exacerbate the physiological inflammation response during and after parturition, causing a pathological inflammatory condition and infection of uterus or endometritis. Furthermore, in the current study, the sows needing manual foetus extraction had a substantially longer farrowing duration than the sows experiencing no manual extraction. Moreover, it is not possible to exclude the possibility that manual extraction of foetuses might also cause stress to the sow. Therefore, it could interfere with endogenous oxytocin excretion since the levels of cortisol and oxytocin are negatively associated in crated sows (Oliviero *et al.*, 2008). All of the abovementioned potential consequences of manual extraction might contribute to the increased incidence of puerperal endometritis in the sows. This practice can confer both benefit and cost to the sow and the piglet, and its effect on the farrowing process should therefore be investigated in future studies.

Since the last decade, the sow has been genetically selected to produce more piglets per litter (Koketsu *et al.*, 2017). Unfortunately, an increase in litter size results in an increase in farrowing duration (Nam and Sukon, 2020a) and in the number of dead-born piglets per litter (Nam and Sukon, 2020b; Lanh and Nam, 2022). In this study, both litter size and the number of dead-born piglets per litter were positively associated with farrowing duration. As discussed above, prolonged farrowing might have several disadvantages for the sows, predisposing them to a higher risk of puerperal endometritis. This might explain the positive correlation between litter size and the number of dead-born piglets per litter and puerperal endometritis in the present study.

We hypothesized in this study that gestation length might have a negative association with puerperal endometritis because gestation length has been found to correlate negatively with litter size (Sasaki and Koketsu, 2007; Rydhmer *et al.*, 2008) and therefore it might have a negative association with farrowing duration. In the current study, gestation length was negatively associated with litter size, but no correlation between gestation length and farrowing duration was found. In a recent study, we found a negative association between gestation length and postpartum vaginal discharge (Nam *et al.*, 2022). Similarly, Egli *et al.* (2022) reported that gestation length was negatively correlated with uterine involution. The finding in the current study might be due to a narrow range in gestation length (113–120 d), whereas in the previous study, it ranged from 112–127 d (Nam *et al.*, 2022).

The use of oxytocin during farrowing has been reported to increase the proportion of sows with increased postpartum uterine size, i.e., 58 vs 38% (Björkman *et al.*, 2018). However, in the present study, oxytocin did not have a strong association with puerperal endometritis. This statistically insignificant effect of oxytocin on puerperal endometritis might be attributable to the fact that sows with intrapartum oxytocin use had a similar farrowing duration, incidence of manual extraction, number of dead-born piglets per litter, and litter size in comparison with those without intrapartum oxytocin use.

Conclusions

This study showed that puerperal endometritis was common in sows; manual extraction of foetuses, prolonged farrowing, and increased number of dead-born piglets per litter were the most important risk factors for the disorder. Determination of risk factors for puerperal endometritis will help farm owners/workers/veterinarians detect sows at risk and intervene with proper care and treatment.

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Conflict of Interest Declaration

The authors declare that they have no conflict of interest.

Authors' Contributions

NHN (ORCID: 0000-0002-2110-0006) collected data; NHN, BTAD (ORCID: 0000-0002-4639-8945), and PS (ORCID: 0000-0002-0899-2572) designed the study, analysed data, interpreted results, and wrote the manuscript.

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