Kafkas Universitesi Veteriner Fakultesi Dergisi
Journal Home-Page: http://vetdergikafkas.org
E-ISSN: 1309-2251

Kafkas Univ Vet Fak Derg
32 (2): 291-298, 2026
DOI: 10.9775/kvfd.2026.36166

RESEARCH ARTICLE

# Diagnosis of Postpartum Endometritis in Dairy Cows Using a Portable Endovideo-Vaginoscope with PCR Confirmation

Dauletbek MURATBAYEV [1], Yernur SAKHARIYEV [1], Shynar TASTEMIROVA [1], Isatai JAKUPOV [2], Ainur AKHMADIYEVA [1], Cihan KACAR [3], Yavuz OZTURKLER [4 (*)]

[1] Department of Veterinary Medicine, Faculty of Veterinary and Agricultural Sciences, Shakarim University, Semey, Abai Region, KAZAKHSTAN
[2] Department of Veterinary Medicine, Faculty of Veterinary Medicine and Animal Husbandry Technology, S. Seifullin Kazakh Agrotechnical Research University, Astana, KAZAKHSTAN
[3] Department of Obstetrics and Gynelogy, Faculty of Veterinary Medicine, Kafkas University, TR-36100 Kars - TÜRKIYE
[4] Department of Reproduction and Artificial Insemination, Faculty of Veterinary Medicine, Kafkas University, TR-36100 Kars - TÜRKIYE

(*) **Corresponding author:**
Yavuz Öztürkler
Phone: +90 474 242 6836/5232
Mobile: +90 533 611 5799
E-mail: yavuzozturkler@gmail.com

How to cite this article?

**Muratbayev D, Sakhariyev Y, Tastemirova S, Jakupov I, Akhmadiyeva A, Kacar C, Ozturkler Y:** Diagnosis of Postpartum Endometritis in Dairy Cows Using a Portable Endovideo-Vaginoscope with PCR Confirmation. *Kafkas Univ Vet Fak Derg*, 32 (2): 291-298, 2026.
DOI: 10.9775/kvfd.2026.36166

**Article ID:** KVFD-2026-36166
**Received:** 24.01.2026
**Accepted:** 23.04.2026
**Published Online:** 26.04.2026

## Abstract

Endometritis remains a major cause of reduced reproductive efficiency in dairy cattle, necessitating practical methods for clinical detection and identification of bacterial etiology under farm conditions. The aim of this exploratory field study was to evaluate the practical applicability of a complex diagnostic protocol utilizing a novel portable endovideo-vaginoscope custom-designed for farm use. The device features autonomous heating (to prevent lens fogging), Wi-Fi data transmission, and smartphone integration and was used alongside laboratory verification. In the Abai region of Kazakhstan, 100 Holstein-Friesian cows were screened on days 20-30 postpartum. Clinical signs of endometritis were detected in 21 animals (21%) by video-vaginoscopy, after which uterine contents from affected cows were aseptically collected for bacteriological culture and PCR analysis. Under the aerobic culture conditions used, laboratory findings most frequently identified *Escherichia coli* and/or *Staphylococcus aureus*, including in mixed bacterial infections. PCR analysis identified the *fimH* gene in *E. coli*-positive material and the *nuc* gene in *S. aureus*-positive material, supporting the bacterial etiology of the inflammation visualized instrumentally. Antimicrobial susceptibility testing revealed a high prevalence of resistance to ampicillin and oxytetracycline among the isolates, whereas gentamicin and cephalosporins demonstrated high in vitro activity. The novelty of this study lies in the field validation of a portable device with thermostabilization and wireless archiving capabilities. Overall, the results indicate that this protocol, combined with molecular verification, provides a practical field-adapted approach for the diagnosis and monitoring of postpartum uterine health in remote farm settings.

**Keywords:** Abai region, Bovine endometritis, Diagnostics, *Escherichia coli*, *fimH, nuc*, PCR, Portable endovideo-vaginoscope, *Staphylococcus aureus*

## Introduction

Postpartum endometritis, clinically characterized primarily by mucopurulent or purulent vaginal discharge after 21 days in milk (DIM), remains a major cause of reduced reproductive efficiency in dairy cattle, as it is associated with impaired conception rates, increased days open, and significant economic losses [1-4]. Beyond the direct economic burden, postpartum uterine disease has important sanitary implications at the herd level, because persistent uterine infection contributes to increased antimicrobial use, higher treatment costs, and management challenges related to animal welfare and biosecurity [3,4]. In modern dairy herds, the risk of clinical postpartum uterine disease remains substantial; therefore, the practical value of any diagnostic strategy depends on its on-farm reproducibility, rapid turnaround time, and the ability to document findings for monitoring and decision-making [3,4].

The pathogenesis of endometritis is viewed as the result of an interaction between bacterial contamination in the early postpartum period, trauma or contamination of the reproductive tract, and the endometrial immune response. However, colonization does not invariably lead to clinical inflammation. Mechanisms of "resilience" -specifically pathogen avoidance, tolerance, and resistance (elimination)- are critical in determining whether

contamination progresses to established disease, and recent reviews emphasize that the endometrium functions as an active organ of innate immunity shaping the severity and consequences of postpartum uterine disease [5-7].

Etiologically, clinical endometritis in cattle is polymicrobial and dynamic over time. In addition to *Escherichia coli*, *Trueperella pyogenes* and anaerobic taxa (e.g., *Fusobacterium, Porphyromonas/Prevotella, Bacteroides)* are frequently associated with postpartum uterine disease. A crucial pathogenetic feature may be not only the presence of bacteria but also their localization and tissue invasion. The application of fluorescence in situ hybridization (FISH) to endometrial biopsies has demonstrated that specific anaerobes can be detected intracellularly within the epithelium and in the lamina propria, supporting the concept of tissue invasiveness as a factor in the persistence of inflammation [8]. In parallel, increased attention has been given to antimicrobial resistance (AMR) in uterine isolates and to rational antibiotic stewardship, because empirical treatment without pathogen verification or susceptibility testing increases the risk of failure and selection for resistance [9,10].

From a practical perspective, the "bottleneck" often lies in clinical diagnosis under field conditions. Traditionally, clinical endometritis is identified via visual assessment of vaginal contents (speculum/vaginoscopy, Metricheck device, gloved hand) based on discharge scoring systems. While these methods may show comparable predictive value for reproductive outcomes, they can yield different diagnostic frequencies for the same animals, indicating a risk of variability and misclassification [11]. Given the lack of a single "gold standard," modern studies increasingly refine diagnostic criteria and evaluate test performance using probabilistic approaches and Bayesian latent class models to estimate sensitivity and specificity under field conditions [12-16]. This has supported interest in instrumental visualization that allows standardization, image storage, and subsequent audit of findings-particularly relevant for geographically dispersed farms and remote production settings, where specialist access and quality control of reproductive examinations may be limited [17-20].

In this context, portable video/electronic solutions facilitate vaginoscopy by providing stable visualization with digital archiving for longitudinal monitoring and consultation [17-20]. At the same time, laboratory verification remains critical: culture confirms viable pathogens and enables AMR profiling, while molecular methods (PCR/RT-PCR) offer greater speed and specificity, especially in mixed infections. For *E. coli*, the *fimH* adhesin has been reported among virulence factors associated with clinical endometritis, supporting its use as a marker for potentially more pathogenic strains in the postpartum period [21]. For *Staphylococcus aureus,* the *nuc* gene is a widely accepted species-specific PCR marker used for rapid identification [22]. Contemporary experimental and field data continue to clarify how *S. aureus* and other microbial components influence endometrial inflammation and the uterine microbial community [23], and studies of genital *E. coli* populations suggest that reservoirs and virulence determinants may differ between healthy animals and cows with postpartum uterine disease, which is important for interpreting PCR results clinically [24,25].

Overall, modern approaches to the field diagnosis of clinical endometritis are increasingly viewed as a multi-stage reproducible protocol comprising: (i) standardized visual assessment of vaginal discharge (with a trend toward digital capture for comparability); (ii) aseptic sampling from the uterine cavity/cervical canal; (iii) culture confirmation with AMR profiling; and (iv) targeted molecular verification of key pathogens and/or virulence markers to confirm etiology and improve comparability between herds [3,11,15,19]. In this framework, a protocol combining portable video-vaginoscopy adapted for farm conditions (including optics thermostabilization/anti-fogging, wireless transmission, and image archiving) with bacteriology and PCR detection of *fimH (E. coli)* and *nuc (S. aureus)* markers appears logically sound and addresses both diagnostic subjectivity and etiological verification [24].

Accordingly, the aim of this exploratory field study was to assess the practical applicability of a portable endovideo-vaginoscope, used in combination with bacteriological culture and PCR, for the detection of clinical endometritis and for descriptive characterization of associated bacterial findings in Holstein herds.

## Material and Methods

### Ethical Statement

The study was conducted with written consent from the farm owner and approved by the Institutional Ethics Committee of Shakarim University (Protocol No. 16, dated September 10, 2025).

### Study Design

This study was conducted on the commercial dairy farm "Kalihanuly" in the Abai region of Kazakhstan. A total of 100 Holstein-Friesian cows, producing approximately 25 L of milk per day, aged between 3 and 8 years, were screened during the early postpartum period (20-30 days in milk, DIM). The herd was managed under routine commercial farm conditions in the study region, and all examinations were performed on-farm. The laboratory analyses were carried out at the "Agrotechnopark" Research Laboratory of Shakarim University. The study

was designed as an exploratory field-validation study; uterine samples were collected only from cows meeting the clinical definition of endometritis, and no clinically healthy control group was included.

### Feeding and Body Condition

The cows were fed a Total Mixed Ration (TMR) consisting of alfalfa hay, corn silage, and concentrates, formulated to meet the nutritional requirements of lactating dairy cattle. Water was provided ad libitum. At the time of enrollment (20-30 DIM), the average body condition score (BCS) of the animals was within the optimal range (approximately 3.0-3.5 on a 5-point scale) [26].

### Reproductive History

Review of the medical history revealed that the study cohort included animals with a history of dystocia and retained fetal membranes (>12 h postpartum). Additionally, cases of acute puerperal metritis treated during the early postpartum period (0-10 DIM) were recorded in the history of several cows. These conditions had either clinically resolved or transitioned into the chronic forms studied here by the time of enrollment [1].

### Clinical and Instrumental Diagnosis

The diagnostic workflow included medical history review (focusing on calving and postpartum events), a general clinical examination, and endovideovaginoscopic assessment. A custom-designed portable video-vaginoscope was used for visual inspection of the vaginal and cervical mucosa *(Fig. 1)*. The instrument was constructed from medical-grade stainless steel (AISI 304), with a distal module equipped with a miniature video camera, LED illumination, and a built-in heating system to prevent condensation (anti-fogging) and to warm the metal surface.

Real-time video transmission via Wi-Fi allowed the operator to view and record intra-vaginal and cervical findings using a mobile device. To ensure hygiene and prevent cross-contamination, the device underwent thorough mechanical cleaning after each use, followed by high-level disinfection via immersion in a 7.5% hydrogen peroxide solution for 15 min, and finally double rinsing with sterile distilled water.

To clinically assess uterine health, the Vaginal Discharge Score (VDS) system was employed as follows: Score 0 - no discharge or clear mucus.

Score 1 - mucous discharge with small flecks or strands of pus.

Score 2 - mucopurulent discharge (<=50% purulent content).

Score 3 - purulent discharge (>50% pus), possibly with malodor or bloody components.

Clinical endometritis was diagnosed when cows had a VDS >= 2 between 20 and 30 days in milk (DIM) [1,27].

### Sample Collection and Microbiological Analysis

Uterine samples were collected transcervically from cows that showed clinical signs of endometritis on video-vaginoscopic examination (presence of purulent or mucopurulent exudate, n=21). The procedure was performed under aseptic conditions and visual guidance using a certified sampling device (Patent No. 10148, Republic of Kazakhstan). Samples were transported to the laboratory at +4°C and processed within 2 h.

Initial inoculation was performed on MacConkey agar and Columbia blood agar supplemented with 5% defibrinated sheep blood (Oxoid Ltd., Basingstoke, UK). Plates were incubated aerobically at 37°C for 24-48 h. Preliminary species identification was based on colony morphology, Gram staining, and standard biochemical assays: catalase and coagulase tests for staphylococci; oxidase and lactose fermentation tests for Enterobacteriaceae. Because bacteriological culture in the present study was restricted to aerobic incubation, strict anaerobes were not specifically targeted. Molecular confirmation of *E.*

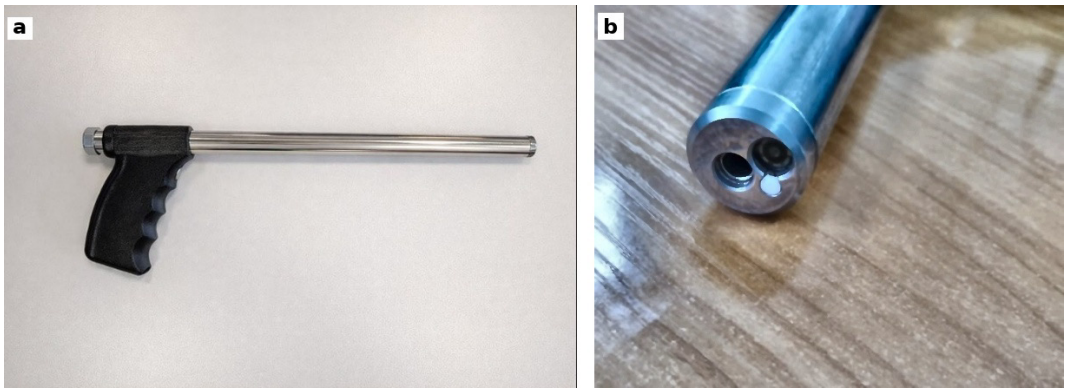


**Fig 1.** Portable endovideovaginoscope designed for cattle examination. **a)** General view of the portable endovideovaginoscope (handle and stainless-steel probe), **b)** Distal tip showing the built-in video camera, LED illumination, and the working/inspection channel

*coli* and *S. aureus* was performed using PCR targeting the *fimH* and *nuc* genes, respectively.

### Antimicrobial Susceptibility Testing

Antimicrobial susceptibility of the isolates was evaluated using the disk diffusion method on Mueller-Hinton agar (Oxoid Ltd., Basingstoke, UK), following CLSI VET01-A4 (2020) guidelines. The following antibiotic disks were used: ampicillin (10 µg), oxytetracycline (30 µg), gentamicin (10 µg), cephalothin (30 µg), ceftiofur (30 µg), enrofloxacin (5 µg), florfenicol (30 µg), and trimethoprim/sulfamethoxazole (1.25/23.75 µg). Zone diameters were interpreted per CLSI criteria, and the proportion of susceptible isolates was calculated using the formula: %S = S/(S + I + R) x 100.

### Molecular Genetic Analysis (PCR)

DNA extraction was performed using a phenol-chloroform protocol. PCR amplification was carried out using DreamTaq PCR Master Mix (Thermo Fisher Scientific, Waltham, MA, USA). Species-specific primers targeting virulence factors were used as previously described [22]:

- nuc gene *(S. aureus):*
  Forward: 5'-ATGAAGTCAAATAAAATCGCT-3'
  Reverse: 5'-TTTGGTGAAAATACTTCTC-3'
- fimH gene *(E. coli):*
  Forward: 5'-TGCAGAACGGATAAGCCGTGG-3'
  Reverse: 5'-GCAGTCACCTGCCCTCCGGTA-3'

Thermal cycling conditions:

- For *nuc*: initial denaturation at 95°C for 5 min; 35 cycles of 94°C for 30 sec, 55°C for 30 sec, and 72°C for 30 sec; final elongation at 72°C for 3 min.
- For *fimH*: initial denaturation at 95°C for 7 min; 35 cycles of 94°C for 30 sec, 57°C for 30 sec, and 72°C for 60 sec; final elongation at 72°C for 7 min.

Amplicons were visualized by agarose gel electrophoresis (3%) under UV illumination.

### Statistical Analysis

Because this study was exploratory and based on convenience sampling under field conditions, no a priori power analysis was performed. Statistical analysis was conducted using R software v4.3.2 (packages: epiR, AMR, binom) and GraphPad Prism v10.2. The results are presented primarily as descriptive data. Categorical variables (e.g., pathogen detection and antimicrobial susceptibility categories) are reported as counts, proportions, and 95% confidence intervals (CI) calculated by the Wilson method. Where appropriate, comparisons of proportions were explored using Fisher's exact test or the chi-square test. A P value <0.05 was considered statistically significant, but all inferential results were interpreted cautiously given the limited sample size and the absence of a healthy control group.

## Results

Endovideo-vaginoscopic examination of cows diagnosed with clinical endometritis *(Fig. 2)* revealed characteristic pathomorphological changes in the cervico-vaginal region. Direct visualization identified pronounced hyperemia and edema of the cervical mucosa and vaginal fornix, with the mucosal surface appearing moist and glossy. A mucopurulent exudate, distinguished by the loss of transparency and the presence of turbid, viscous mucus containing whitish-yellow flocculent purulent inclusions, was observed accumulating predominantly at the external cervical os. Based on the proportion of purulent material within the mucus (pus ≤50%), the clinical presentation was classified as VDS 2, providing direct visual confirmation of an active inflammatory process within the reproductive tract.

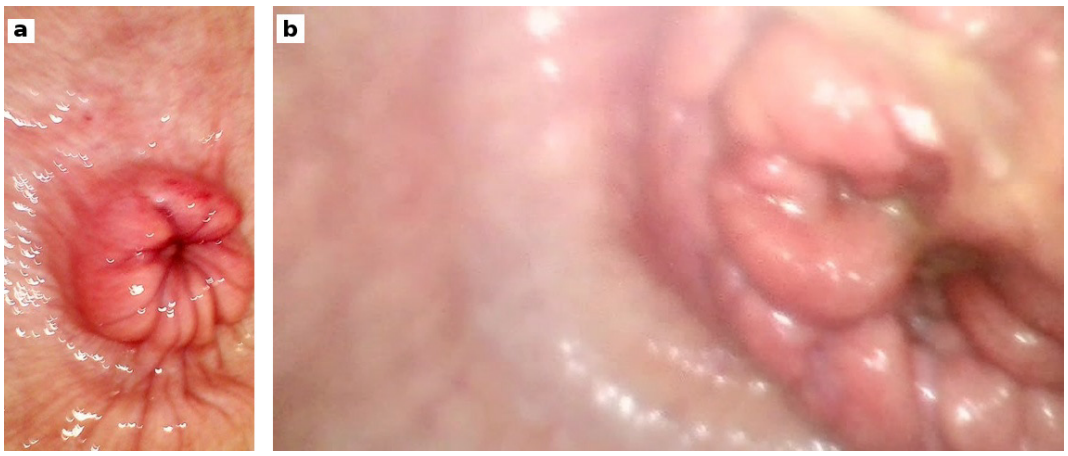


**Fig 2.** Cervico-vaginal images of clinical endometritis obtained via endovideovaginoscopy. **a)** External cervical os with marked hyperemia and edema, **b)** Mucopurulent exudate and swollen mucosa around the external cervical os, corresponding to a Vaginal Discharge Score (VDS) of 2

### Microbiological Profile and Molecular Verification

Bacteriological analysis of 21 samples from cows with clinical endometritis showed that *S. aureus* and *E. coli* were the most frequently isolated bacteria under the aerobic culture conditions used. *S. aureus* was isolated in 11 cases (52.4%) and *E. coli* in 9 cases (42.9%). In several samples, mixed microbial associations (co-infections) were observed, consistent with the polymicrobial nature of postpartum endometritis.

Polymerase chain reaction (PCR) was used for molecular verification and further characterization of the detected bacteria. PCR was performed on a subset of samples (n=15 for *fimH* and n=14 for *nuc),* because some specimens yielded insufficient material and/or DNA of inadequate quality for reliable amplification. These PCR findings should therefore be interpreted as confirmatory results for the tested subset rather than as prevalence estimates for the full cohort.

*fimH* gene *(E. coli).* Among the 15 DNA samples tested, a specific 508 bp amplicon was detected in 10 cases *(Fig. 3).* The presence of the *fimH* gene, encoding type 1 fimbrial adhesin, supports the adhesion potential of these *E. coli* strains and is consistent with their possible involvement in persistence of endometrial inflammation [21].

*nuc* gene *(S. aureus).* Among the 14 DNA samples tested, a specific amplicon corresponding to the *nuc* gene was identified in 11 cases *(Fig. 4).* The *nuc* gene is a species-specific marker for *S. aureus,* encoding thermostable nuclease (DNase), and served here as a confirmatory molecular marker for the tested material [22].

### Antimicrobial Susceptibility Testing

The results of antimicrobial susceptibility testing (AST) for the isolated pathogens are presented in *Table 1.* Interpretative categories were assigned according to veterinary-specific CLSI standards (CLSI VET01-A4, 2020).

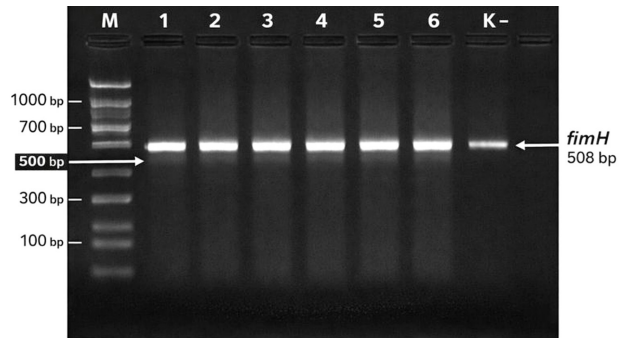


**Fig 3.** Gel electrophoresis of PCR products for detection of the *fimH* gene in *Escherichia coli.* M, 100 bp DNA ladder; lanes 1-15, samples from the uteri of cows with postpartum endometritis. The presence of a specific band at 508 bp indicates a positive result. No amplicons were detected in negative samples

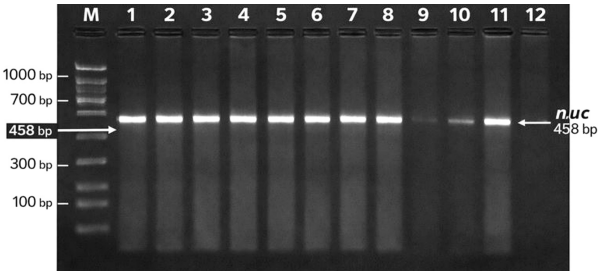


**Fig 4.** Gel electrophoresis of PCR products for detection of the *nuc* gene in *Staphylococcus aureus.* M, 100 bp DNA ladder; lanes 1-14, samples from the uterine cavity of cows with postpartum endometritis. The presence of a specific band at 458 bp corresponds to a positive result. No amplicons were detected in negative samples

***Table 1.*** *Antimicrobial susceptibility profiles of E. coli and S. aureus isolates obtained from cows with clinical endometritis*

| Antimicrobial Agent (Disc Content) | *Escherichia coli* (n=9) | | | *Staphylococcus aureus* (n=10) | | |
|---|---|---|---|---|---|---|
| | S | I | R | S | I | R |
| Ampicillin (10 µg) | 0 | 1 | 8 | 0 | 2 | 8 |
| Oxytetracycline (30 µg) | 2 | 1 | 6 | 2 | 1 | 7 |
| Gentamicin (10 µg) | 7 | 1 | 1 | 10 | 0 | 0 |
| Cephalothin (30 µg) | 6 | 1 | 2 | 8 | 1 | 1 |
| Ceftiofur (30 µg) | 7 | 1 | 1 | 8 | 1 | 1 |
| Enrofloxacin (5 µg) | 5 | 2 | 2 | 8 | 1 | 1 |
| Florfenicol (30 µg) | 6 | 2 | 1 | 8 | 1 | 1 |
| Trimethoprim/Sulfamethoxazole (1.25/23.75 µg) | 2 | 1 | 6 | 9 | 0 | 1 |

*S, susceptible; I, intermediate; R, resistant*

Susceptibility profiles were assessed for all *E. coli* isolates (n=9) and for available pure cultures of *S. aureus* (n=10). One *S. aureus* isolate was excluded from AST due to insufficient growth and inability to obtain a stable pure culture during subculturing.

## Discussion

In this study, clinical endometritis was diagnosed in 21% of the cows examined at 20-30 DIM. This figure is within the range of prevalence reported for postpartum uterine disease in dairy cows [1,4,28]. Local studies in Kazakhstan similarly indicate a high incidence of endometritis; for example, some surveys have reported clinical endometritis rates on the order of 15-30%, and up to 40% in certain herds [29].

Endovideovaginoscopy under farm conditions facilitated the detection and documentation of clinical endometritis in postpartum cows, particularly in animals lacking overt signs of estrus, in which the condition may be underestimated during routine examination. Rather than inferring uterine status indirectly, video-assisted

vaginoscopy enables direct visualization of the cervico-vaginal mucosa and of vaginal discharge characteristics (Vaginal Discharge Score, VDS), which are widely used clinical indicators of endometritis [18]. However, because this study did not include a head-to-head comparison with conventional vaginoscopy, a speculum examination, or the Metricheck device, the present findings should be interpreted as evidence of field feasibility rather than proof of superior diagnostic performance.

The implementation of endovideovaginoscopy extends standard vaginoscopy by enabling digital imaging and documentation. Veterinary practitioners can record photo and video material directly to a smartphone, facilitating longitudinal monitoring and improving reproducibility of VDS assessment. An additional practical advantage is the integrated heating system for the metallic probe, which may improve operator workflow by reducing optical fogging and may improve animal comfort during field examinations, particularly in unheated facilities and cold climates. Rodrigues et al.[17] reported clearer visualization and greater comfort with videovaginoscopy than with a standard speculum examination in heifers. Our portable system additionally incorporates active heating and wireless data transfer, which enhance its practical field applicability; nevertheless, direct comparative validation against conventional methods remains warranted.

In our study, *T. pyogenes* and strict anaerobes were not isolated. This finding should be interpreted cautiously, because bacteriological culture was limited to aerobic methods and therefore was not designed to recover obligate anaerobic pathogens. Accordingly, the absence of these organisms in the present dataset does not demonstrate their true absence from the uterine environment. Nevertheless, the presence of purulent discharge combined with the isolation of *E. coli* and *S. aureus* supports the bacterial nature of the inflammation in affected cows. Previous studies have shown that up to 15-20% of cases with purulent vaginal discharge may yield no significant bacterial growth, which is consistent with our findings in some samples [19,20].

Analysis of the antibiograms revealed limited *in vitro* activity of several commonly used first-line antimicrobials. In the present study, ampicillin and oxytetracycline showed poor activity against both *E. coli* and *S. aureus* isolates, whereas gentamicin and cephalosporins retained comparatively higher activity. Similar concerns regarding antimicrobial resistance among postpartum uterine isolates have been reported in other settings. In southern Ethiopia, postpartum dairy cows with uterine infections yielded bacterial isolates with variable resistance profiles, highlighting the importance of local susceptibility testing [30]. In China, *S. aureus* isolates obtained from dairy cows also showed substantial resistance and diverse virulence-associated characteristics, supporting the need for cautious antimicrobial selection in bovine practice [31]. In addition, minimum inhibitory concentration data from postpartum bovine uterine isolates demonstrated considerable variability in antimicrobial susceptibility patterns among *E. coli* and *T. pyogenes*, including differences according to clinical status [32]. Likewise, genomic and susceptibility analysis of bovine intrauterine *E. coli* has shown that antimicrobial resistance profiles may differ among strains associated with postpartum uterine infections [21]. Taken together, these findings support our results and reinforce that antimicrobial susceptibility data should be interpreted as descriptive *in vitro* findings from clinically affected cows on a single farm, while treatment decisions should preferably rely on local bacteriological and susceptibility testing. Given the limited number of isolates, these antimicrobial susceptibility findings should be interpreted as descriptive *in vitro* results from clinically affected cows on a single farm.

From a practical perspective, the proposed protocol enables on-farm identification of cows with clinical endometritis based on standardized visual assessment (VDS) with digital documentation, thereby supporting monitoring and record-keeping. The combination of instrumental evaluation with bacteriological culture, antimicrobial susceptibility testing, and targeted molecular verification *(fimH* for *E. coli* and *nuc* for *S. aureus)* strengthens the interpretation of bacteriological findings in clinically affected cows and may support evidence-based antimicrobial selection when treatment is indicated [2,21,22]. The use of a portable, wireless-enabled system may improve the reproducibility of postpartum uterine health monitoring and facilitate data exchange between farms and specialists, especially in remote settings. However, the study has important limitations. Samples were collected only from cows with clinical signs of endometritis, without a contemporaneous clinically healthy control group, which limits pathogen-specific interpretation. Molecular analysis was performed only on a subset of samples because of limited sample volume and/or DNA quality. In addition, the study did not include direct comparison with conventional diagnostic methods and did not assess anaerobic pathogens. Therefore, the microbiological and antimicrobial susceptibility data should be interpreted as descriptive findings from clinically affected cows on a single farm under the conditions of this study.

In conclusion, under farm conditions, the implementation of a portable video-vaginoscopy system combined with bacteriological culture and PCR detection enabled structured on-farm identification and laboratory-supported characterization of clinical endometritis in 21% of cows in the early postpartum period. *E. coli* and *S. aureus* were the most frequently isolated bacteria under the aerobic

culture conditions applied in this cohort. This integrative protocol appears suitable as a practical field approach for reproductive health monitoring and for supporting therapeutic decision-making in remote settings. Nevertheless, further studies including matched healthy controls, anaerobic microbiology, and direct comparison with conventional diagnostic methods are required before stronger conclusions regarding diagnostic accuracy or comparative effectiveness can be made.

## Declarations

**Availability of Data and Materials:** The datasets generated and/or analyzed during the current study are available from the corresponding author (YÖ) upon reasonable request.

**Acknowledgements:** The authors thank the staff of "Kalihanuly" farm and the AgroTechnopark Research Laboratory at Shakarim University for their assistance in animal handling and sample collection.

**Funding Support:** This research was funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant IRN AP22685400: Development and testing of an endovideovaginoscope for artificial insemination and diagnosis of diseases of the genital organs of cows and sheep).

**Ethical Statement:** The study was conducted with written consent from the farm owner and approved by the Institutional Ethics Committee of Shakarim University (Protocol No. 16, dated September 10, 2025).

**Conflict of Interest:** The authors declared that there is no conflict of interest.

**Declaration of Generative Artificial Intelligence (AI):** The authors declare that the article, tables and figures were not written/created by AI and AI-assisted Technologies.

**Authors' Contributions:** Conceptualization: Y.O., C.K.; Methodology and study design: D.M.M., Y.S.S., I.T.J.; Field examinations and sample collection: D.M.M., Y.S.S.; Laboratory analyses (bacteriology and PCR): D.M.M., S.A.T., A.A.; Data analysis and interpretation: D.M.M., Y.S.S., C.K., Y.O.; Writing-original draft: D.M.M.; Writing-review and editing: all authors. All authors read and approved the final manuscript.

## References

1. **Sheldon IM, Lewis GS, LeBlanc SJ, Gilbert RO:** Defining postpartum uterine disease in cattle. *Theriogenology,* 65 (8): 1516-1530, 2006. DOI: 10.1016/j.theriogenology.2005.08.021
2. **LeBlanc SJ:** Postpartum uterine disease and dairy herd reproductive performance: A review. *Vet J,* 176 (1): 102-114, 2008. DOI: 10.1016/j.tvjl.2007.12.019
3. **LeBlanc SJ:** Postpartum reproductive disease and fertility in dairy cows. *Animal,* 17:100781, 2023. DOI: 10.1016/j.animal.2023.100781
4. **Várhidi Z, Csikó G, Bajcsy ÁC, Jurkovich V:** Uterine disease in dairy cows: A comprehensive review of treatment and prevention strategies. *Vet Sci,* 11 (2):66, 2024. DOI: 10.3390/vetsci11020066
5. **Sheldon IM, Cronin JG, Bromfield JJ:** Tolerance and innate immunity shape the development of postpartum uterine disease and the impact of endometritis in dairy cattle. *Annu Rev Anim Biosci,* 7, 361-384, 2019. DOI: 10.1146/annurev-animal-020518-115227
6. **Galvão KN, Bicalho RC, Jeon SJ:** Symposium review: The uterine microbiome associated with the development of uterine disease in dairy cows. *J Dairy Sci,* 102 (12): 11786-11797, 2019. DOI: 10.3168/jds.2019-17106
7. **Sheldon IM, Molinari PCC, Ormsby TJR, Bromfield JJ:** Preventing postpartum uterine disease in dairy cattle depends on avoiding, tolerating and resisting pathogenic bacteria. *Theriogenology,* 150, 158-165, 2020. DOI: 10.1016/j.theriogenology.2020.01.017
8. **Karstrup CC, Agerholm JS, Jensen TK, Swaro LRV, Schou KK, Rasmussen EL, Krogh KM, Pedersen HG:** Presence and localization of bacteria in the bovine endometrium postpartum using fluorescence in situ hybridization. *Theriogenology,* 92, 167-175, 2017. DOI: 10.1016/j.theriogenology.2017.01.026
9. **Iancu I, Popa SA, Degi J, Gligor A, Popa I, Iorgoni V, Nistor P, Imre K, Nichita I, Herman V:** Aerobic uterine pathogens in dairy cattle: Surveillance and antimicrobial resistance profiles in postpartum endometritis. *Antibiotics (Basel),* 14 (7):650, 2025. DOI: 10.3390/antibiotics14070650
10. **Shafique L, Wu S, Aqib AI, Ali MM, Ijaz M, Naseer MA, Sarwar Z, Ahmed R, Saleem A, Qudratullah, Ahmad AS, Pan H, Liu Q:** Evidence-based tracking of MDR *Escherichia coli* from bovine endometritis and its elimination using colistin in the field. *Antibiotics (Basel),* 10 (8):997, 2021. DOI: 10.3390/antibiotics10080997
11. **Pleticha S, Drillich M, Heuwieser W:** Evaluation of the Metricheck device and the gloved hand for the diagnosis of clinical endometritis in dairy cows. *J Dairy Sci,* 92 (11): 5429-5435, 2009. DOI: 10.3168/jds.2009-2117
12. **Denis-Robichaud J, Dubuc J:** Determination of optimal diagnostic criteria for purulent vaginal discharge and cytological endometritis in dairy cows. *J Dairy Sci,* 98 (10): 6848-6855, 2015. DOI: 10.3168/jds.2014-9120
13. **Denis-Robichaud J, Barbeau-Grégoire N, Gauthier ML, Dufour S, Roy JP, Buczinski S, Dubuc J:** Validity of diagnostic tests for purulent vaginal discharge and endometritis in dairy cows using Bayesian latent class analysis. *Prev Vet Med,* 239:106521, 2025. DOI: 10.1016/j.prevetmed.2025.106521
14. **Ernstberger M, Oehl H, Haessig M, Hartnack S, Bollwein H:** Predicting the probability of conception based on a combination of clinical examination results of cows with limited vaginal discharge. *Theriogenology,* 137, 121-128, 2019. DOI: 10.1016/j.theriogenology.2019.07.004
15. **Tobolski D, Krupa M, Polak Z, Pascottini OB, Opsomer G, Barański W:** Exploring the influence of endometritis diagnostic criteria on uterine involution, milk yield and reproductive performance in dairy cows. *BMC Vet Res,* 21 (1):276, 2025. DOI: 10.1186/s12917-025-04727-7
16. **Moore SG, Feehily C, Doyle RC, Buckley F, Lonergan P, Cotter PD, Butler ST:** Associations among postpartum uterine and vaginal microbiota and the development of purulent vaginal discharge in dairy cows. *J Dairy Sci,* 106 (11): 8133-8151, 2023. DOI: 10.3168/jds.2022-22720
17. **Rodrigues GJ, Monteiro BM, Viana RB, da Silva AOA, Monteiro FDO, Teixeira PPM:** New method of video-assisted vaginoscopy in Nellore heifers. *Vet Med Sci,* 9 (6): 2781-2785, 2023. DOI: 10.1002/vms3.1232
18. **Leutert C, von Krueger X, Plöntzke J, Heuwieser W:** Evaluation of vaginoscopy for the diagnosis of clinical endometritis in dairy cows. *J Dairy Sci,* 95 (1): 206-212, 2012. DOI: 10.3168/jds.2011-4603
19. **Westermann S, Drillich M, Kaufmann TB, Madoz LV, Heuwieser W:** A clinical approach to determine false-positive findings of clinical endometritis by vaginoscopy using uterine bacteriology and cytology in dairy cows. *Theriogenology,* 74 (7): 1248-1255, 2010. DOI: 10.1016/j.theriogenology.2010.05.028
20. **Runciman DJ, Anderson GA, Malmo J, Davis GM:** Use of postpartum vaginoscopic examination of dairy cows for the diagnosis of endometritis and the association of endometritis with reduced reproductive performance. *Aust Vet J,* 86 (5): 205-213, 2008. DOI: 10.1111/j.1751-0813.2008.00301.x

21. **Yang LM, Wang YH, Peng Y, Min JT, Hang SQ, Zhu WY:** Genomic characterization and antimicrobial susceptibility of bovine intrauterine *Escherichia coli* and its relationship with postpartum uterine infections. *J Integr Agric,* 15 (6): 1345-1354, 2016. DOI: 10.1016/S2095-3119(15)61170-4

22. **Brakstad OG, Aasbakk K, Maeland JA:** Detection of *Staphylococcus aureus* by polymerase chain reaction amplification of the nuc gene. *J Clin Microbiol,* 30 (7): 1654-1660, 1992. DOI: 10.1128/jcm.30.7.1654-1660.1992

23. **Li Z, Teng Y, Feng S, Hu Z, Zhao J, Ding H, Fang Y, Liu H, Ma X, Guo J, Wang J, Lv W:** Microbial responses and changes in metabolic products in bovine uteri infected with *Staphylococcus aureus*. *Int J Biol Macromol,* 262 (Pt 2):130039, 2024. DOI: 10.1016/j.ijbiomac.2024.130039

24. **Gonzalez Moreno C, Torres Luque A, Oliszewski R, Rosa RJ, Otero MC:** Characterization of native *Escherichia coli* populations from bovine vagina of healthy heifers and cows with postpartum uterine disease. *PLoS One,* 15 (2):e0228294, 2020. DOI: 10.1371/journal.pone.0228294

25. **He X, Wang J, Jiang L, Wang X, Wang Y, Liu Y, Cheng Y, Xu F, Li X:** Uterine microbiota composition in dairy cows with different vaginal discharge scores: Suggesting *Caviibacter* as a potential pathogen in mild purulent metritis. *Microorganisms,* 13 (8):1728, 2025. DOI: 10.3390/microorganisms13081728

26. **Edmonson AJ, Lean IJ, Weaver LD, Farver T, Webster G:** A body condition scoring chart for Holstein dairy cows. *J Dairy Sci,* 72 (1): 68-78, 1989. DOI: 10.3168/jds.S0022-0302(89)79081-0

27. **Okawa H, Fujikura A, Wijayagunawardane MMP, Vos PLAM, Taniguchi M, Takagi M:** Effect of diagnosis and treatment of clinical endometritis based on vaginal discharge score grading system in postpartum Holstein cows. *J Vet Med Sci,* 79 (9): 1545-1551, 2017. DOI: 10.1292/jvms.16-0593

28. **Kurt S, Salar S, Özdal Salar M:** Antibiogram and pathogen isolation from vaginal discharge in dairy cows with metritis. *Vet Hekim Der Derg,* 90 (2): 66-70, 2019. DOI: 10.33188/vetheder.509535

29. **Gabdullin DE, Julanov M, Tagayev O, Zainettinova DB, Kadraliyeva B, Zakirova F, Kozhayeva A, Sidikhov B, Zholdasbekov A, Yertleuova B, Aitpakova Z:** Evaluation of blood parameter changes on treatment efficacy in cows with purulent-catarrhal endometritis in farms of West Kazakhstan Region. *Int J Vet Sci,* 15 (1): 225-232, 2026. DOI: 10.47278/journal.ijvs/2025.113

30. **Shafique L, Wu S, Aqib AI, Ali MM, Ijaz M, Naseer MA, Sarwar Z, Ahmed R, Saleem A, Qudratullah, Ahmad AS, Pan H, Liu Q:** Evidence-based tracking of MDR *Escherichia coli* from bovine endometritis and its elimination by effective novel therapeutics. *Antibiotics (Basel),* 10 (8):997, 2021. DOI: 10.3390/antibiotics10080997

31. **Dan M, Yehui W, Qingling M, Jun Q, Xingxing Z, Shuai M, Kuojun C, Jinsheng Z, Zibing C, Zaichao Z, Xuepeng C:** Antimicrobial resistance, virulence gene profile and molecular typing of *Staphylococcus aureus* isolates from dairy cows in Xinjiang Province, northwest China. *J Glob Antimicrob Resist,* 16, 98-104, 2019. DOI: 10.1016/j.jgar.2018.08.024

32. **Basbas C, Garzon A, Silva-Del-Rio N, Byrne BA, Karle B, Aly SS, Champagne JD, Williams DR, Lima FS, Machado VS, Pereira RV:** Evaluation of antimicrobial resistance and risk factors for recovery of intrauterine *Escherichia coli* from cows with metritis on California commercial dairy farms. *Sci Rep,* 12:13937, 2022. DOI: 10.1038/s41598-022-18347-w