Surgical Site Infections in Veterinary Patients: A Prospective Investigation of Incidence and Bacteriological Profiles

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Abstract

Background: Surgical site infections (SSIs) remain a major cause of post-operative morbidity, prolonged recovery, and increased treatment costs in veterinary practice. The emergence of antimicrobial-resistant bacteria in surgical environments further complicates effective management of these infections, particularly in resource-limited settings. **Aims and Objectives:** This study aimed to determine the incidence and bacteriological profiles of surgical site infections in small and large animal surgical patients at two veterinary facilities in Sokoto, Nigeria, and to assess the antibiotic and disinfectant susceptibility patterns of the isolated organisms. **Materials and Methods:** A prospective investigation was conducted using 102 surgical site swab samples collected from animals undergoing surgical procedures. Samples were cultured on mannitol salt agar for bacterial isolation. Isolates were identified using Gram staining, catalase, coagulase, and hemolysis tests. Antibiotic susceptibility testing was performed using commonly used antimicrobial agents, while disinfectant susceptibility was assessed against iodine, Dettol, and ethanol. **Results:** Out of the 102 samples analyzed, 78.4% (80/102) yielded bacterial growth. Ruminants accounted for the highest proportion of positive cases, consistent with their higher surgical caseload. *Staphylococcus aureus* (52.9%) was the most frequently isolated organism, followed by *Staphylococcus epidermidis* (25.5%). Both species demonstrated multidrug resistance, particularly to ampicillin and oxacillin. However, all isolates were susceptible to iodine and Dettol, while showing complete resistance to ethanol. **Conclusion:** The study confirms a high prevalence of multidrug-resistant Staphylococcus species associated with surgical site infections in veterinary surgical settings in Sokoto, Nigeria. These findings highlight the need for improved infection control practices, rational antimicrobial use, and effective disinfectant selection. The data generated provide a valuable baseline for future large-scale studies on SSI epidemiology and antimicrobial resistance in the region.

Keywords: Antimicrobial resistance, pilot study, staphylococcus, surgical site infection, veterinary surgery

Introduction

Background and clinical significance

Surgical site infections (SSIs) represent a significant class of post-operative complications in veterinary medicine, leading to substantial patient morbidity, prolonged hospital stays and increased costs for owners(1,2). An SSI is defined as an infection occurring at or near a surgical incision within 30 days of the procedure, or up to 1 year for implant-associated infections (3). The development of SSIs is a complex, multifactorial process, influenced by a delicate interplay of host factors, microbial contamination, surgical techniques and the hospital environment (4). Reported incidence rates in companion animals vary widely, with estimates typically ranging from approximately 0.8%–18%, depending on the species, surgical procedure and diagnostic criteria (1,4). For instance, a large-scale prospective study found an SSI incidence of 5.5% in dogs undergoing clean procedures, with the risk increasing with longer surgical times (1). However, in more complex, clean-contaminated or dirty procedures, incidence rates can be significantly higher (5).

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Impact on patient outcomes and antimicrobial resistance

Beyond the immediate clinical consequences, the implications of SSIs are far-reaching. Patients can suffer from poor surgical site cosmesis, delayed wound healing and require additional, costly surgeries to manage the complications (5). In severe cases, infections that fail to respond to treatment can even lead to euthanasia. Furthermore, SSIs contribute directly to the growing and critical public health problem of antimicrobial resistance (4). The prolonged use of antibiotics to treat these infections increases selective pressure, fostering the emergence and spread of multidrug-resistant (MDR) bacteria. In companion animals, *Staphylococcus pseudintermedius* is the most common cause of canine SSIs, and the increasing prevalence of methicillin-resistant *Staphylococcus pseudintermedius* (MRSP) is a major concern (2). The zoonotic potential of some of these resistant pathogens, such as MRSP and methicillin-resistant *Staphylococcus aureus*, adds another layer of public health risk (6).

Challenges in veterinary infection control

Despite the critical importance of preventing SSIs, several challenges persist in veterinary practice. Comprehensive surveillance programs are less common in veterinary settings than in human medicine, leading to a lack of robust empirical data to accurately assess SSI risk across different procedures, patient populations and clinical environments (3,4). Studies have also revealed inconsistencies in compliance with established aseptic techniques amongst veterinary professionals, highlighting gaps in training and adherence to infection control protocols (4). The rise in MDR pathogens, often linked to the misuse or overuse of antibiotics, further complicates effective treatment and emphasises the need for responsible antimicrobial stewardship (2,6,7). The heterogeneity of veterinary facilities, from small clinics to large referral hospitals, also presents a challenge, as practice standards and resource availability can vary significantly (4).

Study rationale and objectives

The ongoing evolution of surgical practices, the persistent threat of antimicrobial resistance and the identified gaps in adherence to infection control protocols necessitate continuous investigation into the epidemiology and management of SSIs in veterinary patients. This study addresses these needs by conducting a pilot prospective investigation of SSIs in a clinical veterinary setting. By systematically collecting and analysing data on SSI incidence and bacteriological profiles, this research aims to provide valuable empirical evidence to inform and improve clinical practice. Specifically, the objectives are as follows:

1. Determine the overall and species-specific incidence of SSIs within the study population
2. Identify and evaluate potential risk factors for SSI development, with a focus on surgical type, duration and sterilisation protocols
3. Characterise the bacteriological profiles of isolated pathogens and assess their antimicrobial susceptibility patterns
4. Provide evidence-based recommendations to improve surgical protocols and minimise SSI occurrence, thereby enhancing patient safety and promoting responsible antimicrobial stewardship.

Materials and Methods

This study was conducted over a 6-month period, from May to October 2024, at two veterinary facilities in Sokoto State, Nigeria: The Veterinary Teaching Hospital (VTH) at Usmanu Danfodiyo University, Sokoto and the Veterinary Clinic in the Aliyu Jodi area of Sokoto metropolis. These locations were chosen for their robust caseloads, high reputation and the diverse range of surgical procedures performed. Both facilities offer comprehensive veterinary services encompassing medical, surgical, diagnostic, paediatric, obstetric and gynaecological care.

The study population comprised all animal patients presented for elective or emergency surgical interventions during the designated period. An average of ten animals underwent surgery each week across both centres, including approximately four to six elective cases. Patients of various species, breeds, sexes and age groups were eligible for inclusion, while any animal presenting with a pre-existing wound infection was excluded from the study.

Data were systematically collected prospectively for each enrolled patient, utilising structured observation and detailed case documentation. Information recorded included the animal's characteristics (species, breed, age and sex), the specific type of surgical procedure, its classification (clean, clean-contaminated or contaminated) and a record of perioperative management, including antibiotic use, anaesthesia protocols and aseptic preparation techniques. Following surgery, animals were clinically monitored until discharge, with post-operative wound assessments conducted at regular intervals to document any signs of infection.

A patient was considered to have developed a SSI if clinical evidence of a wound infection appeared within 48 h after surgery. Diagnosis was based on the established criteria, including the presence of purulent discharge, redness, swelling, pain or tenderness, wound dehiscence, abscess formation or fever (3,4). Although the Centres for Disease Control and Prevention/National Healthcare Safety Network guidelines define SSIs as infections occurring within 30 days post-surgery (or up to 90 days for surgeries involving implants) and classify them as superficial incisional, deep incisional or organ/space infections, the present study focused on early-onset SSIs relevant to immediate post-operative care. All the collected data were organised and subjected to the descriptive statistical analysis. Frequencies and percentages were employed to summarise the categorical variables such as species, type of surgical procedure and the incidence of SSI. Associations between relevant variables and the occurrence of SSIs were evaluated, with the results subsequently presented in clear tables and charts.

Ethical Approval

Ethical approval to carry out the research was obtained from the Institutional Animal Care and Use Committee (IACUC) of the Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto, Nigeria on January 2025 (Approval No.: UDUS/ACUC/2025/AUP/R08).

Results

Incidence and prevalence of infections

Over the 6-month study period, a total of 102 surgical site swabs were collected from various animal patients. Following incubation on mannitol salt agar, bacterial growth was confirmed in 80 (78.4%) of these swabs, while 22 (21.6%) showed no growth [Table 1].

Distribution of isolates

Swabs were collected from caprine, ovine and canine patients. Staphylococcus species were detected across all species, with ruminants contributing the highest number of positive cases. This likely reflects their greater surgical caseload during the study period, as well as anatomical and management factors that may predispose them to infection. Larger body size and extensive skin surface area increase the risk of bacterial contamination during surgery, while housing conditions, such as overcrowding and exposure to contaminated bedding or feed, may facilitate the proliferation and transmission of pathogens. In addition, factors such as stress, nutrition and pre-existing skin or systemic conditions can compromise immune defence, making ruminants more susceptible to post-operative infections. Infections were recorded following both elective procedures (e.g., orchidectomy, which was observed in caprine patients) and dehorning, as well as contaminated procedures (e.g., rumenotomy and laceration repair). As expected, contaminated surgeries were associated with a higher rate of bacterial growth compared with clean procedures, confirming the influence of surgical type on infection risk.

Identification and characterisation of isolates

Species identification of the isolates recovered revealed *S. aureus* (54 isolates; 52.9%) as the most prevalent pathogen, followed by *Staphylococcus epidermidis* (26 isolates; 25.5%). *S. aureus* isolates were identified as Gram-positive cocci, catalase-positive, coagulase-positive and beta-hemolytic. In contrast, *S. epidermidis* were Gram-positive cocci, catalase-positive, coagulase-negative and gamma-hemolytic [Tables 2-4 and Figures 1 and 2].

Figure 1: Coagulase test slides showing bubble formation in *Staphylococcus aureus* (+) and absence in *Staphylococcus epidermidis* (–)

Antibiotic and disinfectant susceptibility

Antibiotic susceptibility testing revealed the notable patterns of resistance. *S. aureus* showed resistance to tetracycline, ampicillin and oxacillin but was moderately susceptible to

Table 1: Frequency of bacterial isolates identified on mannitol salt agar

Bacterial isolate	Frequency (%)
Positive	80 (78.4)
Negative	22 (21.6)

Table 2: Frequency of *Staphylococcus* species identified on mannitol salt agar

Staphylococcus spp.	Frequency (%)
Staphylococcus aureus	54 (52.9)
Staphylococcus epidermidis	26 (25.5)

Table 3: Gram staining, catalase and coagulase test results of *Staphylococcus* isolates

Species	Number of swabs	Gram staining	Catalase test	Coagulase test
Staphylococcus aureus	54	+	+	+
Staphylococcus epidermidis	26	+	+	–

Table 4: Hemolysis test results of *Staphylococcus* isolates

Species	Type of hemolysis	Samples
Staphylococcus aureus	Beta hemolysis	All
Staphylococcus epidermidis	Gamma hemolysis	All

Table 5: Antibiotic susceptibility of *Staphylococcus aureus* and *Staphylococcus epidermidis* isolates

Antibiotic	*Staphylococcus aureus* (mm)	*Staphylococcus epidermidis* (mm)	CLSI reference (mm)
Tetracycline	11.4	6.3	≥14
Gentamicin	14.8	23.3	≥16
Ampicillin	1.1	0.0	≥16
Oxacillin	2.1	1.8	≥13
Erythromycin	13.8	0.0	≥21
Chloramphenicol	17.3	13.9	≥18

CLSI: Clinical and laboratory standards institute

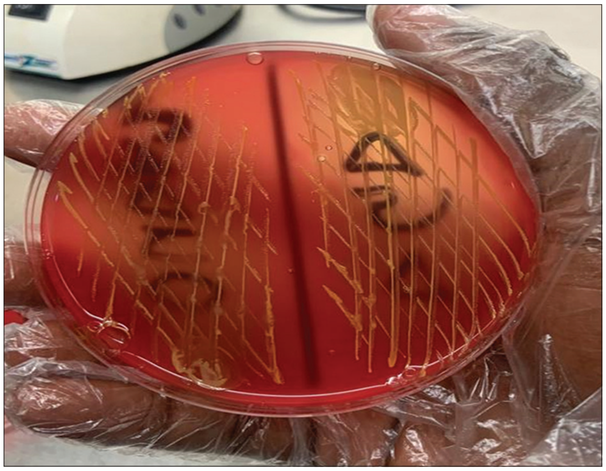

Figure 2: Haemolysis test slides demonstrating beta haemolysis for *Staphylococcus aureus* and gamma haemolysis for *Staphylococcus epidermidis*

gentamicin and erythromycin. *S. epidermidis* demonstrated resistance to several antibiotics, including ampicillin and erythromycin, while remaining highly susceptible to gentamicin [Table 5].

Disinfectant susceptibility, evaluated using the Agar gel diffusion test, indicated that both *S. aureus* and *S. epidermidis* were susceptible to iodine at 10% concentration and Dettol at 5% concentration, but neither showed inhibition by ethanol [Table 6].

Study outcomes

The study identified *S. aureus* as the predominant pathogen (67.5% of positive swabs), with *S. epidermidis* (32.5% of positive swabs) also frequently isolated. Both species exhibited resistance to multiple antibiotics, highlighting challenges for effective treatment. Their demonstrated susceptibility to disinfectants underscores the importance of proper infection-control measures within veterinary facilities. Specifically, iodine at a 10% solution and Dettol at a 5% solution were effective in controlling these pathogens. These findings emphasise the critical role of appropriate disinfectant choice and concentration in preventing SSIs.

Discussion

Incidence, prevalence and pathogen identification

This study identified Staphylococcus species as the predominant bacterial isolates from surgical sites, with an overall isolation rate of 78.4% (80 out of 102 swabs). These findings are consistent with previous veterinary studies, which frequently report *Staphylococcus* as the most common opportunistic bacterial genus on the skin and mucous membranes of animals (5,8). The high rate of positive swabs highlights the challenge of perioperative contamination, even in procedures classified as clean or clean-contaminated.

Among the isolates, *S. aureus* accounted for 52.9% (27 isolates) and *S. epidermidis* for 25.5% (13 isolates), with *S. aureus* being the more prevalent and virulent species. Biochemical testing revealed that 74.1% of *S. aureus* isolates were coagulase-positive, consistent with their established pathogenic potential (9), while all *S. epidermidis* isolates were coagulase-negative, reflecting their commensal nature. Both species tested positive for catalase and Gram-positive staining, characteristic of the genus *Staphylococcus*.

Table 6: Disinfectant sensitivity (Agar gel diffusion test) of *Staphylococcus aureus* and *Staphylococcus epidermidis*

Agent	*Staphylococcus aureus* (mm)	*Staphylococcus epidermidis* (mm)
Iodine	21.5	23.3
Ethanol	0.0	0.0
Dettol	22.5	30.8

Antimicrobial susceptibility profiles and resistance patterns

The antibiotic susceptibility profiles of the isolated *Staphylococcus* species revealed notable resistance trends with significant implications for empirical antimicrobial therapy in veterinary practice. Overall, the isolates showed resistance to several commonly used antibiotics, particularly ampicillin and oxacillin an indication of potential methicillin-resistant *Staphylococcus* strains. This aligns with previous reports highlighting the growing concern of MDR *S. aureus* in the clinical settings (7). In contrast, moderate susceptibility to erythromycin and chloramphenicol was observed, while gentamicin showed relatively better activity against both *S. aureus* and *S. epidermidis*. However, the higher susceptibility to gentamicin in this study differs from earlier findings (6,10), possibly reflecting regional variations in antibiotic usage and local resistance dynamics. These results underscore the urgent need for robust antimicrobial stewardship and emphasise the importance of culture- and sensitivity-guided treatment to enhance therapeutic outcomes and minimise resistance development.

Disinfectant susceptibility and infection control

The agar gel diffusion test, which is used to detect inducible clindamycin resistance among Staphylococcus species, revealed that both *S. aureus* and *S. epidermidis* were susceptible to iodine and Dettol but completely resistant to ethanol. This corroborates findings that the efficacy of disinfectants is dependent on the specific agent and its concentration (11). The complete lack of efficacy of ethanol against the tested strains highlights its limitations as a stand-alone disinfectant for surgical preparation and suggests that iodine- and chloroxylenol-based products (like Dettol) should be prioritised in clinical practice. The observed variance in susceptibility between the two Staphylococcus species also indicates potential differences in their tolerance to disinfectant agents, reinforcing the need for evidence-based infection control protocols.

Comparative virulence and pathogenesis

The distinction in hemolytic activity between the two species further highlights their differing pathogenic potential. As reported previously, *S. aureus* isolates exhibited beta-hemolysis, indicative of the production of hemolysins that completely lyse red blood cells. This strong hemolytic activity is a significant virulence factor associated with tissue damage and systemic disease (12). In contrast, *S. epidermidis* isolates displayed gamma-hemolysis (or no hemolysis), a finding consistent with its generally lower pathogenicity as a common skin commensal (13). This comparative analysis of virulence factors coagulase production and hemolytic activity provides a more nuanced understanding of the clinical significance of these two species when isolated from surgical sites.

Conclusion

This pilot investigation provides valuable preliminary data on the bacteriological profile of surgical site contamination in a specific veterinary setting. While the study offers important insights, its findings should be interpreted within the context of several limitations, primarily related to its scale and methodology. The small sample size and observational timeframe limit the statistical power to identify less frequent risk factors and the broader generalisability of the results. In addition, our initial follow-up period focused on immediate post-operative complications and may have underestimated the total SSI incidence, as some infections can manifest later.

Despite these constraints, the study successfully established a robust methodology for prospective SSI surveillance and identified prevalent bacterial contaminants and their antimicrobial resistance patterns in this region. This foundational work is instrumental for informing the design of larger, more comprehensive studies. Future research should build on these findings by expanding the sample size, extending the follow-up period to capture delayed infections and incorporating more granular data on patient and procedural risk factors. Adopting standardised protocols for microbiological testing will also be crucial for enabling meaningful comparisons across different veterinary facilities. This will advance our understanding of SSI epidemiology and ultimately lead to more effective infection control strategies in veterinary medicine.

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Data availability statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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