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*Mini Review***Clinical Implications of Antegrade vs Retrograde Intramedullary Pinning Techniques for Canine Long Bone Fractures****Manu Prabh Sharma* and Ashwani Kumar**

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Abstract

Intramedullary pinning remains a fundamental and widely utilized technique for stabilizing long bone fractures in dogs. Antegrade (also called normograde) and retrograde are two intramedullary pinning techniques. Retrograde pinning technique is considered comparatively easy but it can't be used universally for all lone bone fractures of small animals. The anatomy of the long bone-joint interface, along with the surrounding major structures such as muscles, tendons, and nerves, plays a crucial role in determining the appropriate intramedullary pinning technique for a specific bone. This review article provides a comprehensive overview of the various approaches, consideration and landmarks for antegrade and retrograde intramedullary pin placement in the femur, humerus, tibia and radius-ulna of canine patients.

Keywords: *Intramedullary pin, Antegrade, Retrograde, Long bone fracture*

Of all long bone fractures, femoral fractures occur more often followed by tibial, radio-ulnar and humeral fractures (Gupta et al., 2024). While various internal fixation methods exist, intramedullary techniques are the most commonly used, relatively easy to perform, requires minimal instrumentation and are less expensive for managing various fracture configurations (Piermattei et al., 2006).

Intramedullary pinning, done using either technique, provides adequate axial stability when fills 60-70% of the narrowest medullary canal and resists bending forces, with limited rotational resistance at the pin-bone interface. These pins can be inserted in either a antegrade or retrograde manner. Antegrade pinning technique is safe and can be applied universally for all long bone fractures being repaired by both closed and open reductions. In contrast, retrograde pinning technique is considered comparatively easy and could only be used during open reductions but it can't be used universally for all long bone fractures of small animals.

The anatomy of the bone-joint interface, along with the surrounding major structures such as muscles, tendons, and nerves, plays a crucial role in determining the appropriate intramedullary pinning technique for a specific bone. This review aimed

to provide a comprehensive overview of the various approaches, considerations and landmarks for the antegrade and retrograde intramedullary pinning techniques for the major long bones fractures of dogs.

Anatomic Considerations for choosing Intramedullary Technique

Retrograde pinning starts inserting the pin from the fracture site, advancing it out one end of the bone, which is most likely proximal; so this pin should not damage any adjoining structures close to the pin exit point in the proximal joint. Besides, there should be a non-articular region in a straight path with the medullary cavity. Every long bone does not meet these conditions so retrograde pinning can't be used in all bones. Therefore, based on this unique anatomical requirement, certain bones like femur, humerus and ulna qualify for retrograde method of pin insertion. Detailed anatomical studies have documented that even if retrograde pinning is possible for a particular bone, antegrade pinning should be preferred. The concerns of intramedullary pinning techniques for various long bones are discussed as under:-

Femur: Greater trochanter of canine femur and trochanteric fossa located near to the hip joint serve as landmark for intramedullary pinning. Based on the anatomical features, femur is suitable for intramedullary pin insertion using retrograde method. However the ex-vivo studies conducted in the past reveal that retrograde pinning predisposes canines for the risk of sciatic neuropathy due to deeper exit point created by the pin tip during retrograde pin insertion (Palmer et al., 1988).

To reduce the risk of iatrogenic sciatic nerve injury during retrograde insertion, keeping the limb in adduction with the hip joint in a neutral flexion and rotation position is recommended (Piermattei et al., 2006). However, 85 degree or less coxofemoral adduction may highly associated with sciatic nerve injury (Palmer et al., 1988). In retrograde pinning, the position of the cut end of pin was found to be more medial i.e close to the femoral head (Fig. 1a & b) and caudal in superficial and middle gluteal muscle than antegrade (Palmer et al., 1988). Additionally, distal fractures have more incidence of nerve impingement in retrograde pinning. Therefore, antegrade pinning is preferred in femur to avoid nerve damage.

The pin insertion site for antegrade pinning in femur is from the trochanteric fossa and normograde placement is preferred in femoral bone (Piermattei et al., 2006) because it is easier to insert the pin in a more lateral position in trochanteric fossa, close to greater trochanter (Fig. 1a & b), and away from the femoral head and to avoid impingement of the sciatic nerve. However, iatrogenic damage to the sciatic nerve may be avoided by keeping the limbs adducted (15 degree from table plane) and hip joint in neutral flexion (110 degree) (Palmer et al., 1988). Sciatic nerve injury is a significant and relatively common complication of IM pinning in dogs and cats, with reported incidence rates

of 14.3% and 23.1%, respectively. Another study by Kill et al (2018) reported 11.5% complications of sciatic neuropathy in supracondylar femoral fractures in dogs repaired by end threaded pin. Major cause of sciatic injury is repeated nerve contusion by the IM pin (particularly with longer proximal end and inserted in a retrograde manner) and entrapment of the nerve by surrounding fibrous tissue. In antegrade pinning, the position of the cut end of pin was found to more lateral and cranial in superficial and middle gluteal muscle, this supposed to act as muscle barrier between sciatic nerve and IM pin. During surgery, flexing the coxofemoral joint from 85° to 110° increases the distance between the antegrade pin end and the sciatic nerve (Palmer et al., 1988).

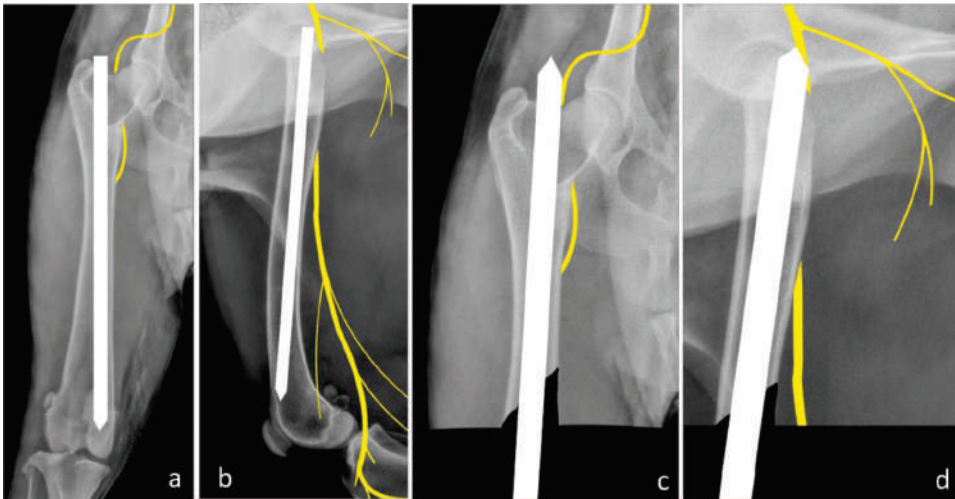


Fig. 1. Antero-posterior (a) and lateral (b) radiographs showing intramedullary pin placement in the femur using an antegrade technique that can be inserted laterally, avoiding sciatic nerve (yellow). While using a retrograde method pin will exit close to the sciatic nerve on anteroposterior (a) and lateral (b) views.

To improve the fracture site stability, deep placement of IM pin into distal femoral epiphysis is suggested. However, distal seating of pin often depends upon the cranial bowing of the femoral shaft. Pronounced cranial bowing may often lead to inadvertent penetration of distal cranial cortex just proximal to trochlea (Piermattei et al, 2006). Deeper placement of pin in distal cancellous bone can be achieved via the retrograde technique (Fig. 2). Whereas, antegrade pin placement may result in the pin exiting trochlear groove, causing severe damage to the articular surface of the stifle joint (Lorinson et al., 1997), so lesser seating of the pin in the distal fragment is commonly recorded (Fig. 3). Overreduction is a technique that facilitates deeper insertion of pin into distal cancellous bone, thereby improving stability (Piermattei et al, 2006).

In femur, antegrade pinning can also be done from the distal end of bone, through the intercondylar fossa, just cranial to the origin of cruciate ligament (Nunamaker and

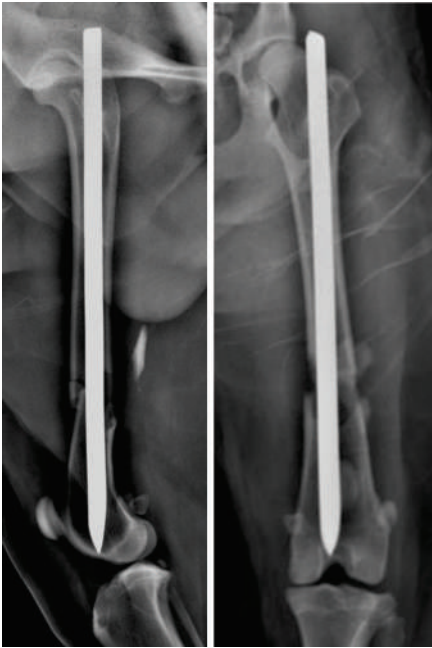


Fig. 2. Lateral and AP radiographs of femur fracture repaired by retrograde technique showing deeper pin seating in the distal fragment but proximally pin is close to the femur head i.e pin placement is relatively medial that predisposes to sciatic neuropathy.

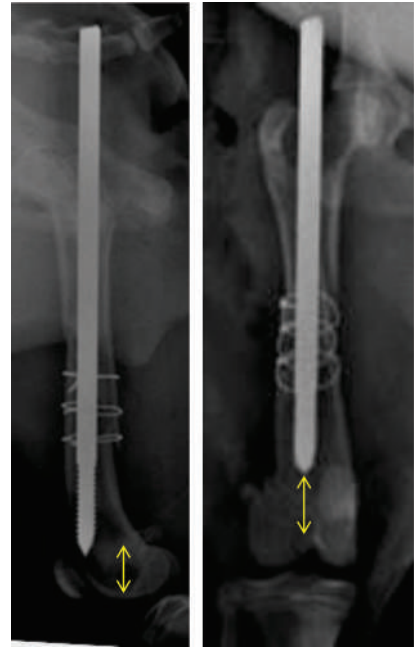


Fig. 3. Lateral and AP radiographs of femur fracture repaired by antegrade method showing shallow seating of the pin in the distal fragment but proximally pin is relatively far from the femur head i.e pin placement is relatively lateral.

Newton, 1985). This technique may be more preferable for supracondylar or distal femoral fractures (Stigen, 1999). The pin is advanced upto the proximal cancellous bone, then cut and embedded below articular cartilage. However, difficulty in removing the pin after insertion is generally not considered a significant clinical issue.

Tibia: Retrograde pinning in tibia is generally discouraged as the pin exits significantly more caudally and laterally on tibial plateau (Fig. 4b), which involves a high risk of iatrogenic injury to the stifle joint, femoral condyle's articular surface, cruciate and straight patellar ligaments (Dixon et al., 1994; Payne et al., 2005; Sissener, 2007). If retrograde pin placement is used, it is necessary to direct the pin towards craniomedial aspect of the tibial plateau to prevent damaging the cranial cruciate ligament which is very difficult to achieve practically in the opinion of the authors. Previous studies reported that nondirected retrograde pin have a significantly higher incidence of associated joint trauma than directed retrograde or antegrade pins. Directed retrograde pin exits proximally very close to the ideal entry point used for antegrade pin insertion (Dixon et al., 1994).

Therefore, the technique of craniomedially directed retrograde pin placement may be considered acceptable for open reduction and fixation of tibial fractures, particularly, if used for proximal to mid diaphyseal fractures and if pins are properly seated proximally (Dixon et al., 1994; Payne et al., 2005). However, in mid or distal diaphyseal fractures of the tibia, the pin follows the medullary cavity and exits the proximal tibia near the intercondylar eminence on the tibial plateau, resulting in penetration of the stifle joint and interference with the femoral condyle during joint motion (Pardo, 1994). So summary, the intramedullary pin insertion in the canine tibia using retrograde method is not preferred and considered contraindicated.

In tibia, antegrade IM pin is inserted from the medial aspect of the base of tibial tuberosity, just behind the straight patellar ligament. In this position the pin enters the medullary cavity in front of the joint without penetrating the joint space (Fig. 4a) (Nunamaker and Newton, 1985; Dixon et al., 1994). To protect the stifle joint, antegrade pinning is recommended for tibia. During insertion, it is advised to keep the stifle in a flexed position at right angle. The pin should be angled slightly medially and caudally till it enters the medullary cavity (Sissener, 2007). To avoid damage to the articular surface of the femoral condyle, the pin should be trimmed so that less than 1.5 cm protrudes

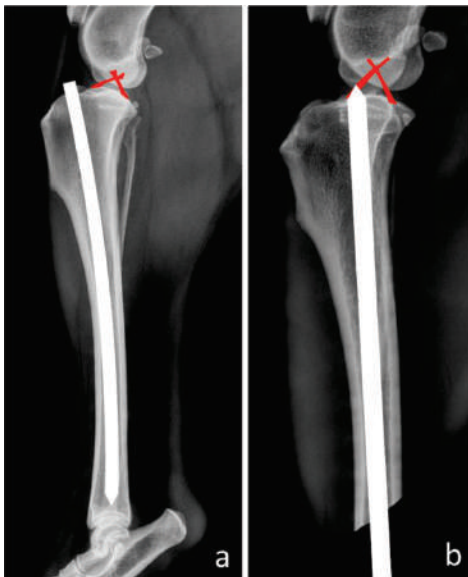


Fig. 4. Intramedullary pin inserted in tibia using a antegrade method will avoid stifle joint, femoral condyle and cruciate ligaments (a); whereas pin inserted in a retrograde method will exit too caudally and can damage these vital structures (b)

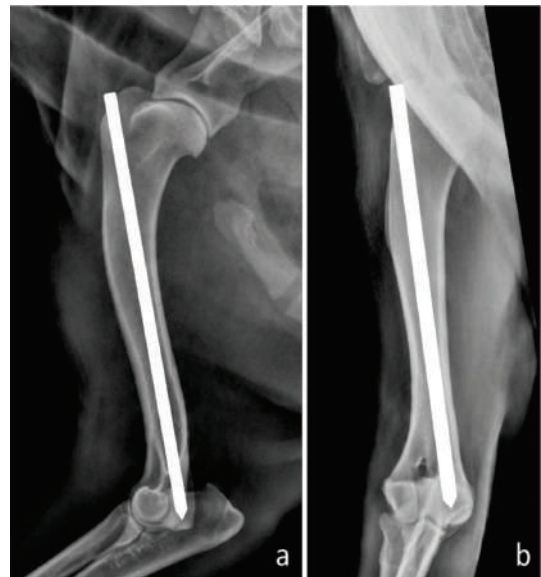


Fig. 5. Intramedullary pin inserted in the humeral fracture using a antegrade or retrograde method will be seated in the medial humeral condyle. Lateral (a) and anteroposterior (b)

from the proximal end (Dixon et al., 1994). However, the prevalence of femoral condylar interference in antegrade pinning is significantly lower (Pardo, 1994).

Humerus: Retrograde pinning in humeral fractures, particularly distal diaphyseal and supracondylar fractures, is easier and accurate (Piermattei et al., 2006). Retrograde insertion is best accomplished by directing the pin starting at the caudomedial aspect of the medullary cavity from fracture site and directed proximally into the marrow cavity to exit at the cranio-lateral aspect of the greater tubercle, avoiding impingement of the shoulder joint (Fig. 5a & b) (Sissener et al., 2005; Sissener, 2007). Directed retrograde pin provides more predictable cranial exit point at greater tubercle proximally, this more cranial penetration point is advantageous as it reduces the risk of joint penetration during insertion. However, this approach may lead to a reduced length of pin purchase in the proximal fragment due to the natural curvature of the canine humerus (Sissener et al., 2005).

The pin insertion site for antegrade pinning is cranio-lateral aspect of the greater tubercle near its base, keeping the pin perpendicular to the bone, until the pin is secured in the bone (Sissener, 2007). The point of entry is determined by the natural curvature of the humerus and should be placed as proximally as possible while still allowing the pin to be accurately directed distally toward the medial epicondyle (Nunamaker and Newton, 1985). The pin is then passed along the caudo-medial cortex of the bone and anchored in the medial epicondyle (Sissener et al., 2005). Ideally, the pin should be seated distally within the medial epicondyle (Fig. 5b), especially in cases of distal humeral fractures. Therefore, the pin size should be selected not only based on the diameter of the humeral isthmus, but also to ensure it can be properly accommodated within the medial epicondyle (Milgram et al., 2012). Also, it was suggested that large diameter pin is directed towards centro-distal of medullary canal and is seated just proximal to supratrochlear foramen (Piermattei et al., 2006). The complex geometry of the humeral condyles makes it difficult to achieve proper seating of the pin. Sissener et al. (2005) reported that, pin diameter should be at least 50% of the isthmus diameter in antegrade pinning of proximal fragment without compromising the medial epicondylar cortex. However, the study did not specify the depth of penetration of medial epicondyle. Antegrade pin insertion into the humerus is relatively challenging due to the small target area and the sloped surface at the greater tubercle, which can lead to slippage of the pin during initial placement attempts (Sissener et al., 2005).

For distal humeral fractures, antegrade pinning from distal fragment is also recommended. The pin is inserted with the elbow in flexed position, through the non-articular area located on the distal aspect of medial epicondyle as well as lateral epicondylar ridge (Shipov et al., 2015). The pin size should be selected as large as possible for optimal stability, yet small enough to pass through medial epicondyle without cortical

damage. This technique allows maximum purchase of the pin in the distal humerus providing optimal stability (Milgram et al., 2012; Shipov et al., 2015). However, medial epicondylar cortical damage may be noticed with large diameter pins, therefore Shipov et al. (2015) suggested using pins with a diameter equal to 36-45% of medullary canal at the 80th percentile of the humeral length. Thus, these pins result in occupying approximately 30-50% of the medullary canal at the level of medial epicondyle.

Radius & Ulna: Intramedullary pinning of radius is not indicated because of its relatively smaller medullary canal and the joint surfaces fully covering the both ends of the bone, which prevent direct, in-line access to the canal (Schrader, 1991) without perforating the articular cartilage (Fig. 6 a & b). However, young medium sized dogs with wider medullary canals may be considered for intramedullary pinning (more precisely elastic nailing) using distal metaphyseal antegrade pinning (Fig. 6 c & d) (Sodhi et al., 2024).

Retrograde pinning of radius is also contraindicated as, exit point of pin generally interferes with the adjacent joint (Fig. 6 a & b) (Schrader, 1991). Although the retrograde insertion of IM pin into the radius, exiting through the distal radiocarpal joint has been advocated in the past (Nunamaker and Newton, 1985) but it caused significant damage to the radio-carpal joint.



Fig. 6. Radial bone is unsuitable for intramedullary pinning using either retrograde i.e. distal (a) or proximal (b) bone fragment. However, an antegrade approach can be used from distal metaphysis to proximal i.e. Rush pinning or elastic nailing technique. Antero-posterior (c) and lateral (d) radiographic views.

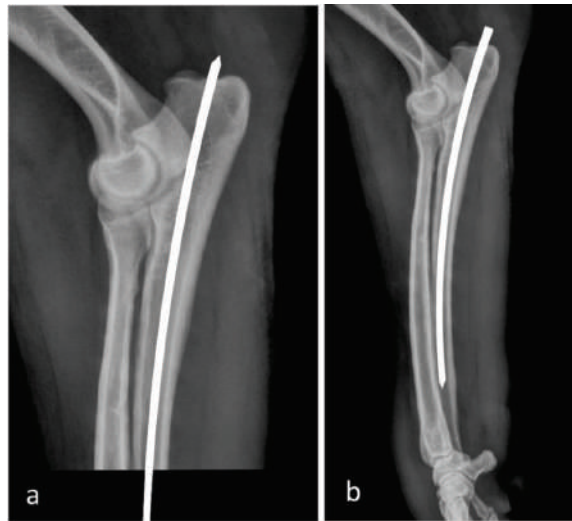


Fig. 7. Intramedullary pin placement in the ulnar boner using a retrograde (a) and antegrade (b) technique is safe

In the ulna, retrograde pinning can be performed (Fig. 7 a & b); however, careful attention must be given to the direction of the pin to avoid inadvertent penetration of the elbow joint. The IM pin in ulna may be placed from the olecranon process using antegrade technique (Nunamaker and Newton, 1985).

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Mini Review

Empowering Animal Healthcare with AI to Combat Antimicrobial Resistance

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Abstract

Artificial Intelligence (AI) is revolutionizing the fight against antimicrobial resistance (AMR), a critical global health threat. AI-driven predictive analytics can identify patterns of resistance, forecast outbreaks, and guide personalized antibiotic therapies by leveraging large-scale clinical and epidemiological data. Machine learning algorithms facilitate rapid pathogen identification, resistance profiling, and real-time monitoring, thus enabling precise decision-making. These technologies support the development of advanced diagnostic tools, reducing reliance on broad-spectrum antibiotics and fostering timely, targeted treatments. AI-driven surveillance systems improve the detection of AMR trends and enhance global monitoring capabilities. AI's transformative impact on healthcare holds promises for mitigating the AMR crisis and improving patient outcomes.

Keywords: *Artificial Intelligence, Antimicrobial resistance, Machine learning, Drug designs*

Antimicrobials have become essential in modern healthcare, protecting humans, animals, and plants from deadly pathogens. These chemicals inhibit or kill microbes such as bacteria, viruses, fungi, and parasites_ are classified into antibiotics, antivirals, antifungals, and antiparasitics. However, their efficacy has diminished due to resistance from mutations, leading to antimicrobial resistance (AMR). AMR poses a global threat, making infections harder to treat and increasing chances of disease spread, severity, and mortality. The 68th World Health Assembly endorsed a global action plan in year 2015 to combat AMR, through awareness, communication, education, and training. Thereafter, every year, November 18-24, “World AMR Awareness Week” is celebrated throughout the world, and in the year 2024’s theme was “Educate, Advocate, Act Now.” The WHO implements strategies to address AMR, through improved diagnostics, antibiotic stewardship, biosecurity measures, combination therapies, vaccine development, optimized drug delivery systems, and the use of artificial intelligence (AI) tools for drug discovery and identification of resistance patterns (Talaat et al., 2022; Bo et al., 2024).

AI has seamlessly integrated into our personal and professional lives, including

the life sciences. AI is already widely utilized in medical sciences for various applications such as disease diagnosis, enrolling patients for clinical trials, robotic surgery, analyzing complex algorithms, and screening chemical libraries for drug development (Leite et al., 2021). As the human population continues to grow, coupled with limitations in developing new therapeutics to combat emerging infections, alternative tools are needed to enhance the screening process and address antimicrobial resistance. AI stands at the forefront of these innovative solutions, offering numerous ways to help. It's predictive modeling, data analysis, and pattern recognition capabilities make AI an invaluable asset in the ongoing fight against antimicrobial resistance, providing new avenues for discovery and treatment. This mini review updates insight into basic role of AI in disease surveillance and the judicious use of antimicrobials in veterinary healthcare in the veterinary healthcare system.

Role of AI in Antimicrobial Stewardship Programme

Stewardship is defined as “the careful and responsible management of something entrusted to one’s care.” The concept of antimicrobial stewardship deals with all the aspects related to the careful and judicious use of antimicrobials. This concept is equally applicable to agricultural and animal husbandry sectors, too. It is, therefore, the responsibility of every individual, including veterinarians, paraveterinarians, pharmacists, and medical doctors, to play a crucial role in ensuring the appropriate use of antimicrobials, minimizing resistance, and safeguarding both animal and public health. Doctors and pharmacists can promote rational medicinal distribution by implementing measures such as restricting and certain classes of antimicrobials, cycling of antibiotics, staff education about optimal antimicrobial therapy while considering the patient’s health (Rice, 2018), and ensuring patient compliance. This approach will help to reduce costs, improve therapeutic outcomes, and reduce AMR (Rice, 2018), ultimately enhancing health and strengthen the animal healthcare system. Additionally, it reinforces measures like infection prevention and control, medication safety and patient safety care. Though it seems to be easy, for a large number of clinical patients (inpatient and outpatient cases), the implementation is quite difficult, with challenges like a lack of motivation for change and awareness, a lack of oversight and control of antimicrobial use in many countries, and over-the-counter therapy (McEwen and Collignon, 2018).

Machine learning (ML), is an AI subset that includes algorithms to automatically learn insight and thereby can predict patterns from data, helping us to make better decisions in every aspect of healthcare. Identification of inappropriate prescribing practices, choosing the appropriate antibiotic therapy, or predicting AMR, are some of the areas where machine learning will help to strengthen antimicrobial stewardship. In clinical settings with a complex and heterogeneous nature of illness, machine learning analyzes a great number of electronic records in a short span of time and has the ability to predict

the type of disease with its early identification like sepsis, immune score, associated risk factors, diagnosis of infection, treatment selection (Beaudoin et al., 2016) and prediction of antimicrobial resistance. Antibiotics are used in hospitals, where AI/ML may be used to highlight situations where administered antibiotics do not match the approved first-line treatment or where broad-spectrum antibiotics are to be used without an explicit indication. It will help in analysing the microbiological data to detect evolving antibiotic resistance patterns, advising on antibiotic selection, dosage, duration, and de-escalation based on individual patient data. Machine learning models like extreme gradient boosting (XGB) and light gradient boosting machine (LGBM), discriminate scenarios requiring discontinuation of medicine, transition of drug administration, and early or late reduction of antibiotic use. This information helps to adapt antibiotic formularies and to revise antibiotic use guidelines according to local resistance profiles. For instance, the dosing of antibiotics such as vancomycin and amikacin, targeted drug delivery of colistin, and other personalized antibiotic regimens have also been positively accomplished with the help of AI only.

From a veterinary medicine perspective, AI provides solutions to mitigate the issue of AMR. Although, biodiversity exists in the animal population factors such as species, breed, health, size, feeding pattern, and digestive system may pose hindrances in implementing AI into the veterinary clinical practice, however, slow and consistent effort in this direction may produce better results in the near future. Efforts need to be directed to train each of the veterinary healthcare professionals and farmers to get acquainted with AI system. AI is increasingly being integrated into the veterinary profession, providing several helpful applications such as Disease Surveillance and Diagnosis: analyze medical images, such as X-rays, ultrasounds, and CT scans, to detect abnormalities or conditions like tumors, fractures, or infections (Pinto et al., 2020), Predictive Analytics for Disease Prevention: process large amounts of data from animal health records to identify patterns and predict outbreaks of diseases (Pappas et al., 2019), Veterinary Drug Development and Optimization: discovery and development of new veterinary drugs by simulating interactions between molecules and predicting the efficacy of drugs for specific animal diseases (Gong et al., 2019), Treatment Recommendation Systems: analyze data from patient histories, lab results, and veterinary best practices to suggest tailored treatment plans for individual animals, ensuring that they receive the most effective and appropriate care (Kelly et al., 2020), Livestock Management: monitor the quality of feed, track growth rates, and optimize breeding programs to improve the productivity and health of animals, track the health and behavior of livestock (Shaver et al., 2019), Behavioral Analysis: monitor animal behavior, identifying signs of stress, pain, or disease through analysis of motion patterns, vocalizations, or other behavioral cues (Rzepecki et al., 2021) and Antimicrobial Stewardship: analyze trends in antimicrobial use and resistance,

providing veterinarians with data to make informed decisions about the appropriate use of antibiotics and reduce the risk of antimicrobial resistance (Tembo et al., 2020).

Role of AI in Clinical Decision Support System

A clinical decision support system (CDSS) is a health information technology system based on patient data (accessed via electronic health records) and medical knowledge, helping clinicians to make data-driven, evidence-based decisions (Chen et al., 2023). Machine learning (ML) based CDSS can help us to build up comprehensive clinical data that clinicians can use for future reference with full confidence. This may be accomplished by analyzing large datasets to identify patterns and trends related to drug utilization, efficacy, and safety. Moreover, this data-driven approach enables healthcare providers and policymakers to make evidence-based decisions and implement population health management strategies (Lavigne et al., 2019) like early identification of diseases and efficient resource allocations. AI analyses drug interaction databases to identify the potential interactions and adverse effects when multiple medications are taken together. This capability decreases the risk of medication errors ensuring that the patients receive the safest and most effective treatments (Zhang et al., 2024).

While the adoption of Electronic Health Records (EHRs) is widespread in the Western world, it remains in its infancy in India, particularly in both human and veterinary hospitals. Implementing EHRs in veterinary practice in India can offer numerous benefits, similar to Clinical Decision Support Systems in the medical profession. Veterinary EHRs can facilitate comprehensive data collection, enabling more accurate diagnosis, treatment planning, and monitoring of animal health. Current regulation in India that allows Registered Veterinary Practitioners to provide veterinary services and to play crucial role in disease monitoring and surveillance (NITI Aayog, Government of India, 2023). However, there is a pressing need to integrate EHRs into veterinary practice to enhance the quality and efficiency of care. By leveraging EHRs, veterinarians can access historical health data, track disease patterns, and improve communication with pet owners and other healthcare providers. This integration will ultimately contribute to better animal health outcomes, safety, and a more robust veterinary healthcare system in India.

Role of AI in Drug Design and Discovery

Designing, discovering, and developing drugs is a resource-intensive and time-consuming process, often takes 12-15 years to bring a new compound into therapeutic use (Paul et al., 2021). However, the advent of AI has significantly accelerated this process, making it an invaluable tool in the pharmaceutical industry. Machine learning (ML) can screen millions of compounds and can quickly identify the most promising antimicrobial candidates, along with their high-accuracy interactions. Additionally, AI facilitates target identification, dynamic modeling, design, and synthesis, optimizing

drug formulations for stability and solubility while evaluating and dosing them, saving substantial resources (Han et al., 2023). Furthermore, deep learning techniques, a subset of ML, have the predictive potential to forecast how these compounds will behave in the human body, significantly reducing the time and cost associated with drug development (Paul et al., 2021). Data-driven methods can predict novel antibiotic compounds, while image-based methods help to identify resistant bacteria. AI can leverage genomic data to predict potential resistance sites and related enzymatic functions, laying the groundwork for designing better antimicrobial molecules (Han et al., 2023).

Advantages of using AI

Artificial Intelligence in the fight against AMR that offers a promising and innovative solution. AI-based decision support systems and antimicrobial stewardship programs can guide clinicians in selecting appropriate antibiotics, enhancing treatment efficacy. AI hastens the analysis of genomic data, enabling early identification of resistance markers. Additionally, AI facilitates the discovery and design of new antibacterial drugs through predictive modeling and computational simulation. AI encourages multidisciplinary collaboration among computer scientists, biologists, physicians, and other experts to address AMR related challenges. Furthermore, AI integrates diverse data sources, including genomic, phenotypic, clinical, and population data, to enhance the predictive potential of models used to assess AMR. This allows for proactive interventions based on the early detection of increasing resistance, ultimately improving patient outcomes and public health (Lavigne et al., 2019; Sayers and Tatusova 2019; Nguyen and Lee 2020; Riahi and Keshavarz 2021).

Future Prospects of AI in Animal Healthcare System

The future of AI in animal healthcare practice holds immense promise. AI-driven technologies will revolutionize diagnostics, treatment plans, and disease prevention. Machine learning algorithms can analyze vast amounts of veterinary data, identifying patterns and predicting outbreaks, enabling timely antimicrobial interventions. AI-powered imaging tools will enhance the accuracy of diagnostics, while predictive analytics will help customize treatments, improving animal health outcomes. Additionally, AI can facilitate remote monitoring and telemedicine, providing real-time health insights and enabling veterinarians to make informed decisions from a distance. Overall, AI's advancements will elevate the quality of veterinary care, promoting better health and well-being for animals through selective use of antimicrobials and preventing potential drug interactions thereby combating AMR.

Challenges and Limitations of AI

The dynamic nature of microbial evolution necessitates the constant updating and retraining of AI models, which can quickly become outdated. This requires significant

resources and continuous monitoring to maintain accuracy and relevance. Additionally, AI algorithms must be meticulously designed to prevent bias and discrimination, as biased training data can lead to erroneous and inequitable outcomes. It is crucial to ensure that the training data is representative of diverse populations. Furthermore, the complex nature of AI systems demands ongoing evaluation and independent validation to ensure their operational efficiency and reliability in clinical settings. This requires thorough study, rigorous testing, and quality assurance to identify and rectify potential issues. Addressing these challenges is essential to harness AI's full potential in combating antimicrobial resistance (AMR) and improving healthcare outcomes.

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*Mini Review***Plant Derived Natural Acaricides in Livestock: A Pragmatic Approach****Afroz Jahan*, M.K. Lonare and Raut Akash**

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Abstract

Ticks and tick-borne diseases cause substantial economic losses in livestock production worldwide. Although synthetic acaricides remain the primary method for tick control, their widespread and improper use has led to the emergence of resistant tick populations. In response, plant-based acaricides are gaining attention as promising natural alternatives. These botanical compounds often contain diverse bioactive constituents with multiple modes of action, reducing the risk of resistance development. Moreover, natural acaricides are typically eco-friendly, cost-effective, and safer for both animals and the environment, making them particularly beneficial for resource-limited farmers.

Key words: *Acaricidal resistance, Animals, Biopesticides, Natural alternative, Tick borne disease*

Livestock production plays a crucial role in ensuring food and nutritional security, promoting public health, supporting rural development, generating employment, and driving economic growth in India. However, ticks and tick-borne diseases pose significant challenges to livestock rearing, affecting 80% of the global cattle population (Solomon and Tanga, 2020). Ticks are blood-sucking ectoparasites responsible for transmitting tick-borne diseases to livestock and humans. These diseases are widespread and represent a major bottleneck to the economic viability of livestock farming in India. The global economic burden of tick-borne diseases is estimated to be US\$30 billion annually. The use of synthetic acaricides is the most widely used to control ticks. The estimated worldwide market value of acaricides is US\$ 405.2 million in year 2022 and expected to reach US\$ 594.1 million by 2030 (ADSR report, 2024). The animal husbandry industry alone accounts for roughly one-quarter of acaricides market. The overuse and misuse of acaricides is associated with several drawbacks, including significant economic losses, development of resistance in tick populations, environmental pollution, and potential contamination of meat and milk with chemical residues. Beyond the resistance dilemma, the use of acaricides can have harmful effects on animals, humans and the environment.

Concerns over the use of synthetic acaricides have driven researchers to explore novel alternatives, particularly plant-based options, as sustainable and effective

substitutes. Natural plant extracts offer a promising avenue for developing eco-friendly, effective, and safe acaricides. Plants contain diverse active components with unique modes of action, which can help delay the onset of resistance mechanisms in ticks with reduced or no toxicity to mammals.

Economic Impact of Tick Borne Diseases including Public Health Concern

Livestock serves as a crucial source of income for small land holder or landless farmers, providing financial stability and food security to the marginal farmers. There are more than 900 species of ticks exist globally and responsible for several vector-borne diseases directly or indirectly affect the growth of the livestock industry (Dantas-Torres and Otranto, 2022). Tick-borne pathogens are transmitted through tick saliva which contain a neurotoxin that may cause host skeletal muscle paralysis. They may affect the animal health through blood loss, general stress, damage to hide and skin, and irritation, inflammation, hypersensitivity even secondary bacterial infections and myiasis. Indirectly, ticks suppress immune function and serve as vectors for various pathogens, further impacting animal health and productivity worldwide. Several important tick-borne diseases of veterinary and public health importance are transmitted by ticks that can utilize both domestic and wild animals as hosts (Manjunathachar et al., 2014; Quadros et al., 2020).

Tick Control Strategies

Tick control requires attention from researchers, as many important livestock diseases are transmitted by ticks. Various tick control programs have been implemented in modern livestock management to control and mitigate the adverse effects of ticks on both animals and humans. Effective management of tick-borne diseases requires a comprehensive approach that integrates tick control, disease prevention through vaccination, and the treatment of clinical cases. Tick control methods can be broadly categorized into chemical approaches, and non-chemical strategies. Non-chemical methods include grooming, pasture spelling, endosymbiotic approach, biological control, genetic manipulation, biopesticides, herbal acaricides, and vaccination with tick antigens (Welsh et al., 2019). The most recent and important strategy is the use of synthetic acaricides such as amidines, benzoyl phenyl ureas, benzene hexachloride/cyclodienes, carbamates, macrocyclic lactones, organophosphates, and pyrethroids (Sudhakar et al., 2013). However, the use of acaricide is not a sustainable long-term solution due to the rapid development of resistance in tick populations along with several drawbacks. Therefore, a shift from conventional synthetically derived acaricides to more sustainable and naturally plant derived tick control options is needed.

Role of Herbal Medicines in the Management of Ectoparasites

Globally, more than 200 plant species with tick-repellent or acaricidal properties

are known. The mode of action of many plant-derived compounds used for tick control is not completely understood. Plant essential oils, which are the most studied plant-derived compounds for tick control and prevention (Benelli and Pavela, 2018; Jyoti et al., 2024). They are complex mixtures of natural, volatile organic compounds predominantly composed of terpenic hydrocarbons. Some essential oils cause neurotoxic effects, such as inhibition of acetylcholinesterase, antagonism with the receptors of the octopamine neurotransmitter, or closure of the chloride channels by gamma-aminobutyric acid (GABA) (Camilo et al., 2017). Treatment with essential oils (EOs) from some plants can affect tick mortality, fecundity, and egg hatching rate (Gross et al., 2017). Likewise, the exact mode of action of many plant essential oils has not been elucidated, and a few studies have been conducted to understand how these naturally occurring compounds act on ticks. EOs seem to have no specific mechanism of action; however, they cause feeding inhibition, inhibition of chitin synthesis, decrease in growth, development or reproduction, affect tick behavior and have neurotoxic and cytotoxic effect by targeting MAO, GABA, TRP, Octopamine and tyramine receptors resulting in toxic effects (Jyoti et al., 2024). A representative list of plant based acaricides and tick repellents is presented in Table 1 (Quadros et al., 2020).

Table 1: Representative list of plant based acaricide and tick repellants.

Source	Phyto-constituent	Active against	Effect
<i>Thymus vulgaris</i>	Thymol	<i>R. sanguineus</i>	Acaricide
<i>Ocimum</i> spp, <i>Artemisia</i> spp	Eugenol	<i>I. ricinus</i> , <i>R. appendiculatus</i> , <i>R. microplus</i> , <i>R. sanguineus</i>	Acaricide
<i>Allium sativum</i>	Allicin	<i>R. microplus</i> , <i>H. anatolicum</i>	Acaricide Repellent
<i>Plumbago zeylanica</i>	Plumbagin	<i>A. variegatum</i> , <i>H. marginatum</i>	Acaricide
<i>Azadirachta indica</i> <i>Melia azedarach</i>	Azadirachtin	<i>A. cajennense</i> , <i>R. microplus</i>	Acaricide
<i>Artemisia abrotanum</i>	β -citronellol	<i>I. ricinus</i>	Repellent
<i>Citrus</i> spp. (Oranges, lemons, and grapefruits)	Limonene	<i>R. microplus</i>	Acaricide
<i>Origanum vulgare</i> , <i>Lepidium flavum</i>	Carvacrol	<i>H. marginatum</i> <i>R. appendiculatus</i>	Acaricide
<i>Cymbopogon</i> spp.	Geraniol	<i>R. microplus</i> <i>I. ricinus</i>	Acaricide Repellent
<i>Ocimum basilicum</i>	Linalool	<i>R. microplus</i>	Acaricide
Cannabis, Lemongrass, Verbena	Myrcene	<i>H. marginatum</i>	Acaricide

Current Status and Future Perspectives of Research on Herbal Acaricides in India

Plant-based acaricides or natural alternatives are increasingly being explored as novel biopesticides for agricultural use. Some formulations derived from plants are even listed as “Generally Recognized as Safe” (GRAS) by the U.S. Food and Drug Administration (FDA) (Ellse and Wall, 2014). These medicinal plants have been traditionally used to prevent and treat tick-borne diseases in both humans and animals. Many of these plants have not undergone systematic scientific evaluation regarding their efficacy, mechanisms of action, and active chemical constituents. Recently, however, there has been a notable rise in controlled experimental studies aimed at validating and quantifying the acaricidal activity of plants and plant-derived products used in traditional medicine (Willer et al., 2019).

Numerous researchers have studied a wide range of plant species. They demonstrated significant potential as tick repellents and acaricidal. Notable plant species include *Piper longum*, *Atropa belladonna*, *Dalbergia sissoo*, *Nicotiana tabacum*, *Azadirachta indica* (Isman, 2020); *Annona muricata* and *Annona squamosa* (Broglione-Micheletti et al. 2009). The acaricidal effects of these plants are largely attributed to their diverse secondary metabolites, such as terpenoids, steroids, alcohols, fatty acid-derived substances, coumarins, sulfur-containing compounds, and aldehydes (Lalnunpari et al., 2023).

Drug development and its approval are a regular process, but the development of plant-based remedies is a challenging task and has regulatory hurdles. To develop the identified compound into a drug and drug formulation is a cumbersome process and requires substantial funding for comprehensive field trials, especially those involving complex livestock–wildlife interactions, chemical standardization, toxicity assessments on non-target species, and investigations into the synergistic or antagonistic effects of botanical compounds. Also lack of standardized methods for both extraction and standardized tick bioassay methods.

Advances in analytical technologies have facilitated the identification, fingerprinting, and chemical characterization of individual compounds within plant extracts (Benelli and Pavea, 2018). Furthermore, the rapid advancement of nanomedicine has opened new avenues for the application of nanoparticles in acaricidal drug discovery. Nanoparticle and nanoemulsion formulations can enhance the activity and efficacy of biopesticides (Boeke et al., 2004). Green-synthesized nanoparticles derived from plant extracts are easy to prepare, eco-friendly, cost-effective, and show promise in tick control (Banumathi et al., 2017). Encapsulation into nanosystems may help overcome challenges related to physicochemical properties such as limited stability and handling thereby enhancing the overall efficacy of plant-based medicines.

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*Mini Review***The Silent Menace: Understanding and Tackling Equine Piroplasmosis****Deepak Sumbria*, Vikrant Sudan and L.D. Singla¹**

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Abstract

Equine piroplasmosis, primarily caused by Theileria equi (T. equi) and Babesia caballi, presents a significant challenge to the global equine industry, particularly in tropical and subtropical regions. These protozoan parasites, transmitted by multiple tick genera including Boophilus, Hyalomma, Dermacentor, Amblyomma, and Haemaphysalis, cause severe health complications in equines, resulting in substantial economic losses. T. equi has emerged as the predominant causative agent in many regions, with prevalence rates ranging from 3.66% to 49.78% in Punjab, India - depending on diagnostic methodologies, environmental conditions, and management practices. The disease manifests across a broad clinical spectrum, ranging from acute cases resulting in sudden death to chronic complications including liver failure, abortion, and neonatal infections. The pathogenesis of T. equi infection primarily involves haemolytic anaemia, oxidative damage to red blood cells, and thrombocytopenia, leading to characteristic clinical signs such as jaundice, tachypnoea, and progressive weight loss. Accurate diagnosis relies on an integrated approach combining traditional blood smear examination, serological testing, and advanced molecular techniques like PCR. Current treatment protocols center around antiprotozoal drugs such as imidocarb dipropionate and buparvaquone, supported by comprehensive care measures. However, effective control demands a multifaceted strategy incorporating robust tick management programs, strict isolation protocols for infected animals, and prompt therapeutic intervention. Recent advances in understanding the parasite's biology, pathogenesis mechanisms, and diagnostic capabilities have enhanced the management strategies, though significant challenges remain. This article synthesizes current knowledge of T. equi infection, emphasizing diagnostic innovations and treatment approaches, while highlighting the critical need for continued research to mitigate its economic impact on the equine industry worldwide.

Keywords: *Theileria equi, ticks, life cycle, treatment, control*

The bond between humans and animals has deep evolutionary roots, with horses playing a particularly essential role in human progress across centuries. Serving as partners in transportation, sports, therapy, and companionship, horses have been integral to human civilization. Yet, in tropical and subtropical regions, the equine industry faces severe challenges due to tick-borne diseases. Among these, equine piroplasmosis (EP)

caused by *Babesia caballi* and *Theileria equi* (formerly *B. equi*), stands out as a major concern. These two protozoan parasites are transmitted by a wide array of tick species, including *Boophilus*, *Hyalomma*, *Dermacentor*, *Amblyomma*, and *Haemaphysalis* (Scoles & Ueti, 2015). *T. equi*, a smaller piroplasm, contrasts with the larger *B. caballi* (Onyiche et al., 2019) and is distributed worldwide (Fig 1). While serological reports in India have indicated the presence of *B. caballi* (Sumbria et al., 2016a), molecular confirmation remains elusive, likely due to the proximity of Punjab to Pakistan, where numerous *B. caballi* cases have been documented (Hussain et al., 2014). As a result, *T. equi* is currently the primary agent of EP in India, and this article will focus exclusively on this parasite. As per ICAR-NRCE, the seroprevalence of *T. equi* in India was observed to be approximately 15-25% (<https://pib.gov.in/PressReleasePage.aspx?PRID=2071817>).

The disease caused by *T. equi* exhibit a wide range of morbidity and mortality in equids, posing a significant threat to the economic stability of developing nations, particularly India. In Punjab, the prevalence of *T. equi* fluctuates between 3.66% and a staggering 49.78%, depending on the diagnostic methods employed (Sumbria et al., 2016b; Sumbria et al., 2017). Furthermore, prevalence rates vary due to several factors, including species, age, sex, agro-climatic zones, and various farming practices such as tick management, deworming/vaccination, and the presence of other domestic animals on farms (Sumbria et al., 2016b). Transplacental transmission of *T. equi* also emerges as a critical concern (Sudan et al., 2015).

A deep understanding of the effects, epidemiology, and biology of *T. equi* infection is essential for veterinarians and livestock owners. Gaining insight into the disease's pathogenesis, advancements in diagnostics, and the development of treatments is key to crafting effective control measures. This knowledge can help mitigate the financial impact of EP and reduce its prevalence. The aim of this article is to inform readers about the detrimental effects of *T. equi* infection, its diagnosis, and the practical management strategies needed to curb its spread.

Life Cycle

In Equids: The life cycle of *T. equi* begins when an infected tick attaches to an uninfected equid and injects sporozoites, which have developed in the tick's salivary glands, into the host's bloodstream. Inside the vertebrate host, the sporozoites invade the lymphocytes and undergo schizogony, resulting in the formation of both micro- and macro-schizonts (Koch's blue body). These forms ultimately transform into merozoites. Once released from the schizonts, the merozoites invade red blood cells (RBCs), initiating merogony, during which they form various pyriform bodies-some of which exhibit the characteristic 'Maltese cross' appearance. The infected RBCs undergo hemolysis, releasing more merozoites that continue to infect new RBCs, perpetuating the cycle (Onyiche et al., 2019).

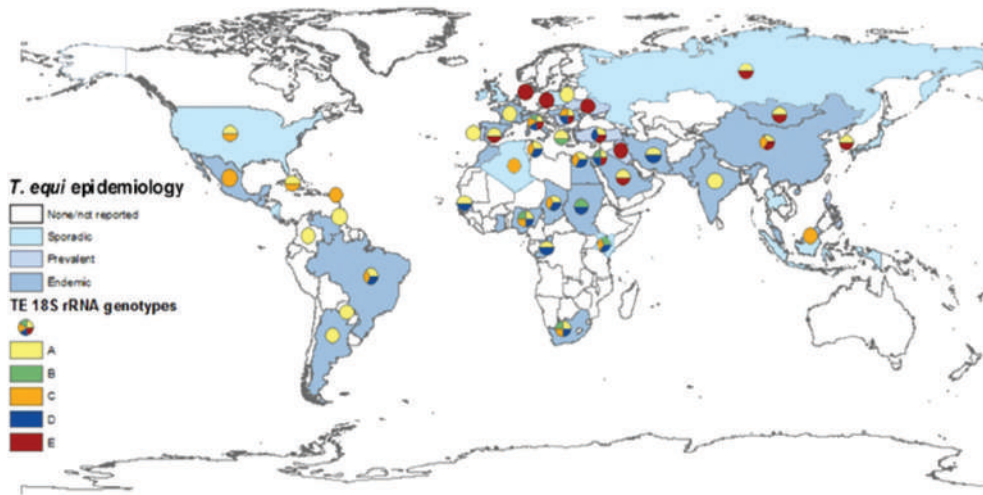


Fig. 1. Worldwide prevalence of *Theileria equi* from 2000-2019 [Adopted from Tirosh-Levy et al., (2020)]

In Ticks: Following blood feeding, the lysis of RBCs releases merozoites, which differentiate into sexual stages. In the lumen of the tick, spindle-shaped microgamonts develop from the ring forms. These microgamonts fragment to produce numerous thread-like microgametes. The ring forms also develop into round macrogametes. The microgametes and macrogametes fuse to form a zygote within the epithelial cell. This zygote morphs into a motile, club-shaped ookinete, which migrates to the salivary glands where it transforms into sporonts. From these sporonts, sporogony occurs, producing infectious particles (Fig. 2).

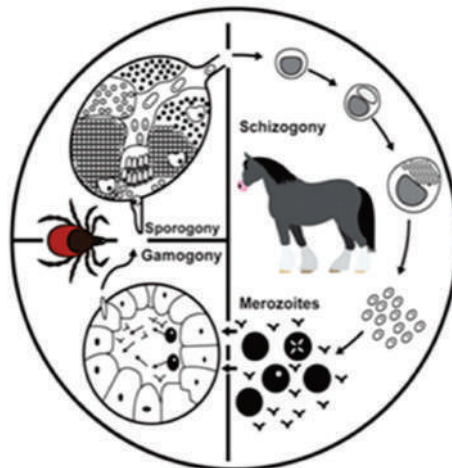


Fig. 2 Life cycle of *Theileria equi* [Adopted from Onyiche et al., (2019)]

Pathogenesis and Clinical Signs: *Theileria equi* causes severe pathological alterations in the vertebrate host. The parasite's multiplying stages lead to haemolytic anaemia, with *T. equi* capable of infecting up to 80% of RBCs (Mehlhorn & Schein, 1998). This infection alters the RBC membrane, disrupting lipid content and reducing blood flow (Gupta et al., 2023). An increase in malondialdehyde and the accumulation of oxidative ions further intensify biochemical changes in infected RBCs. The resulting anaemia causes reduced packed cell volume (PCV), jaundice, and in severe cases, haemoglobinuria. Thrombocytopenia is also commonly observed (Onyiche et al., 2019). The erythrophagocytic destruction of RBCs by macrophages worsens the anaemia. The parasite relies on RBCs for energy, and the increased uptake of phosphorus may contribute to the fragility of infected cells, potentially causing hypophosphatemia (de Waal et al., 1988), leading to ATP depletion.

Clinical signs of *T. equi* infection vary considerably. In cases of per-acute infection, animals may collapse and die suddenly. Haemolysis in these cases leads to anaemia, manifesting as icteric or pale mucous membranes, tachycardia, tachypnoea, weakness, and pigmenturia (Zobba et al., 2008). Acute infections characterized by high fever (104°F), weight loss, peripheral oedema, lethargy, and anorexia. Petechial haemorrhages, resulting from thrombocytopaenia, are typically observed on mucous membranes, including the nictitating membrane. Sub-acute cases may exhibit anorexia, fluctuations in rectal temperature, weight loss, increased pulse and respiratory rates, colic, constipation followed by diarrhoea, and occasionally haemoglobinuria. Chronic infections can lead to liver failure, intravascular coagulation, abortion, or neonatal infections (Allsopp et al., 2007). In endemic areas, the mortality rate from equine piroplasmiasis is 5-10%; however, when naïve equines are involved, this rate can escalate to as much as 50% (Mendoza et al., 2024).

Post-Mortem Findings: At necropsy, jaundice, splenomegaly, oedema, pulmonary oedema, congestion, cardiac haemorrhages, hydropericardium, hydrothorax, hepatomegaly, ascites, enlarged discoloured kidneys, and lymphadenopathy are commonly observed (de Waal, 1992). Pulmonary tissue may show oedema, congestion, and hemosiderin-laden macrophages in alveolar walls. Histopathological examination may reveal renal tubular necrosis with haemoglobin casts, centrilobular liver necrosis, hepatocyte degeneration, and microthrombi in the liver and lungs (de Waal and van Heerden, 2004).

Diagnosis: Early and accurate diagnosis of *T. equi* infection is critical. A comprehensive history and clinical signs should be meticulously documented. The thin blood smear stained with Romanowsky stains is considered the gold standard for diagnosing the haemoprotozoan infections, but its sensitivity is limited (Sumbria et al., 2014). Serological tests such as complement fixation, ELISA, and IFAT offer valuable insight

into epidemiological studies but inherent the limitations of inability to distinguish the pre and post exposure of the infection. Molecular techniques, such as PCR, nested PCR, real-time PCR, and LAMP, are now regarded as the most reliable methods for detecting the parasite's DNA, offering a higher degree of sensitivity especially to rule out the latent or subclinical asymptomatic cases.

Treatment and Control of Equine Piroplasmosis: The management of EP primarily relies on two conventional treatments: Imidocarb dipropionate (ID) and Buparvaquone (BPQ), though several other options exist. For treating *T. equi* infection, various therapeutic approaches have proven effective, including Imidocarb (4.4 mg/kg IM), Buparvaquone (4-6 mg/kg IM), Diminazenediaceturate (3-5 mg/kg IM), and Oxytetracycline (5-7 mg/kg IV) (Mendoza et al., 2024). These primary treatments should be accompanied by supportive care, including anticholinergics, antipyretics, antispasmodics, anti-inflammatory drugs, and analgesics.

Imidocarb dipropionate (ID) functions by inhibiting inositol entry into infected erythrocytes, requiring different dosage regimens for *T. equi* and *B. caballi* infections. When targeting complete parasite elimination in *T. equi* cases, higher doses and extended treatment periods are necessary. However, ID administration can trigger side effects within minutes, including agitation, hyperhidrosis, and digestive complications. These adverse effects can be managed using anticholinergic drugs such as hyoscine, glycopyrrolate, or atropine. Notably, prolonged high-dose ID treatment may lead to liver and kidney damage, with donkeys and mules showing particular sensitivity to these effects.

Buparvaquone (BQP), a more recent development in EP treatment, operates by disrupting the parasite's mitochondrial electron transport chain. It presents a more favourable side effect profile compared to ID, primarily causing local myositis at injection sites. BPQ's lack of species-specific adverse effects in donkeys and mules makes it the preferred choice for these animals.

Other treatments include diminazene and tetracyclines, though these have limitations. Diminazene shows lower efficacy compared to both ID and BPQ, while tetracyclines, particularly oxytetracycline, demonstrate better results against *T. equi* than *B. caballi*, though rarely achieving complete cure.

Current challenges in EP treatment encompass several critical areas: treatment failures (especially with *T. equi* infections), emerging drug resistance, the need for reliable diagnostic monitoring, complications from cross-reactivity in testing, and special considerations for pregnant mares, nursing foals, and food animals. Looking ahead, EP management focuses on three key developments: standardized diagnostic assays (including point-of-care tests), novel therapeutic options like tafenoquine, and vaccine development, currently hindered by gaps in understanding parasite-host interactions.

For effective control of *T. equi* infections, a comprehensive approach is essential. This includes isolating infected animals to prevent parasite spread and implementing robust tick control programs that combine insecticides, herbal remedies, and biological control methods. Concurrent research efforts should prioritize developing an effective vaccine against *T. equi*. The success of EP treatment often depends on combining appropriate therapeutic protocols with the host's immune response development, particularly when managing cases involving international movement between endemic and non-endemic regions.

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*Mini Review***Management of Risk Factors Associated with Postpartum Anoestrus in Dairy Animals****V Yadav* and A K Singh**

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Abstract

Postpartum infertility and anoestrus are intricate phenomena governed by multiple factors that operate either independently or in combination, reducing the productivity of dairy animals. While some factors influencing postpartum reproduction are unavoidable, they can be taken into account when making management decisions alongside other modifiable factors.

Keywords: *Anestrus, Corpus luteum, Dairy animals, Nutrition, Post-partum infertility.*

Altered reproduction is the main factor that limits production efficiency of an animal. Failure of conception in bovines leads to the huge loss of the potential calf crop. Postpartum health of animal and the interval from parturition to estrus largely determines the likelihood of cows becoming pregnant during the breeding season. In this article we discuss about various factors that affect the postpartum interval in dairy animals. There are three main factors which are responsible for postpartum infertility viz. i) delayed uterine involution ii) short estrous cycles and iii) physiological anoestrus due to less IGF-1 concentration which leads to less GnRH production from hypothalamus.

i) Delay in Uterine Involution: It hinders fertility during the early postpartum period. Studies have reported that parity, nutritional conditions, body condition score at calving and postpartum uterine diseases are the major cause for delayed postpartum uterine involution in bovines (Braga et al., 2019). The postpartum recovery of reproductive tract in breeding animals is a critical factor that affect the postpartum days open and also act as a barrier to sperm transport that reduces the pregnancy rate to very low when bred less than 20 days after calving as compared to those bred between 20 - 40 days (Forde et al., 2011)

ii) Short Estrous Cycles: A functional corpus luteum (CL) that maintains progesterone (P_4) concentrations above 1 ng/mL for approximately 2 weeks, ensuring regular estrous cycles (Ghanem et al., 2008). The functional capability of the early postpartum corpus luteum is normal but due to high concentration of prostaglandin from uterus, leads to regression of premature corpus luteum (Crowe, 2008). Therefore, the

regression of corpus luteum occurs before the signal can be given that a pregnancy exists that also contribute to postpartum infertility during first 30 - 40 days after calving. Normal corpus luteum function during early postpartum period can be obtained by treating with a progestin. The mechanism associated with the progestin effect involves a reduction in prostaglandin secreted from uterine endometrium which prolongs the functionality of corpus luteum.

iii) Postpartum Anoestrus: This is commonly referred as the interval between parturition to first estrus. It is affected by several minor as well as two major factors that are described as follows:

Minor Factors

i) Season: The postpartum period will fall in summer or rainy season and will be subjected to heat stress due to high environmental temperature and high humidity in these seasons leading to adverse effect on hormonal and physiological status, causing fertility problems (Srivastava, 2005). The incidence of postpartum anestrus was observed to be non-significantly ($P>0.05$) higher in summer (41.66%) calved animals than autumn (32.98%), winter (28.20%) and spring (26.66%) i.e. autumn and winter calving were favorable for early resumption of ovarian activity (Kunj et al. 2002).

ii) Genotype: The effects may be attributed to actual physiological differences among breeds and/or to confounding factors such as variations in milk production, appetite or feed intake. The impact on the postpartum interval is significant; although it is often predetermined, this factor must be taken into account when managing postpartum cows (Macmillan et al., 1996).

iii) Effect of age and parity: The incidence of postpartum anestrus was observed more, in older animals and very young animals. Kalsotra et al. (2016) reported that the incidence of postpartum anestrus was observed to be non-significantly ($P>0.05$) higher in buffaloes having age 9 years and above (46.42%) followed by 5 years (32.55%), 6 years (32.43%), 7 years (20.00%) and 8 years (29.26%). In older age animals long calving intervals are partly due to greater lactation stress in high producing buffaloes and partly due to seasonality of breeding.

Parity influences the postpartum to estrus interval, which is longer in primiparous than in pluriparous buffaloes (Hafez and Hafez, 2000). The incidence of postpartum anestrus was found to be decreasing from 1st to 3rd parity and then increasing up to 6th parity (Kalsotra et al., 2016).

iv) Presence of a Bull: The presence of a bull accelerates the physiological processes that initiate the resumption of estrous cycles and reduces the postpartum interval. Introducing sterile teaser bulls to cows during the early postpartum period can

be an effective tool for managing postpartum anoestrus in dairy animals (Miller, V. and Ungerfeld, 2008).

Major Factors

1. Suckling: Suckling of dairy animals is a common practice in rural India for calf feeding and milk letdown (Sastry and Thomas, 2005). It is an exteroceptive stimulus that governs the reproductive cycle in female mammals. Continuous suckling affects reproduction across species, ranging from near-total ovulation suppression in sows to minimal impact in seasonal breeders like ewes. Large ruminants, including cattle and buffalo, fall in between, with suckling reducing reproductive efficiency by suppressing GnRH secretion, hindering follicular development and prolonging postpartum anovulation. The effect of suckling on ovulation could be through reduction of frequency and amplitude of episodic luteinizing hormone (LH) release in dairy and beef animals. Weaned cows had increased frequency of pulsatile LH release leading to higher basal serum LH concentration as compared to their suckled counterparts. Increased frequency of pulsatile LH release in non-suckled post-partum cows increases the number of follicular LH receptors and results in improved reproduction early post-partum (Singh et al., 2005).

Mechanism of suckling induced LH suppression: There is depletion of LH stores from anterior pituitary since the receptors for LH are not formed in the immediate postpartum period. This however, is independent of suckling. Therefore, hypothalamic GnRH content do not alter in suckled and weaned animals during early post-partum period, but exogenous GnRH induced LH release is definitely suppressed in the former (Singh et al., 2006). The sensitivity of hypothalamus to the negative feedback effect of gonadal steroids is increased through suckling stimulus resulting in tonic inhibition of LH. As the post-partum interval increases, the hypothalamus becomes less sensitive to suckling stimulus by evading from the negative feedback effect of ovarian steroids.

Effect of suckling on post-partum reproduction: Normal fertility is dependent upon early establishment of ovarian activity after parturition. Intervals from calving to standing estrus and conception are known to be influenced by suckling. Suckled cows (81.0 ± 6.21 days) have longer interval from parturition to the first post-partum estrus than non-suckled cows (41.2 ± 9.03 days; Henao et al., 2000). Similar studies in buffaloes (Arya and Madan, 2001) showed that suckling adversely affects the onset of behavioral estrus (44.17 ± 8.58 days in non-suckled vs 71.67 ± 11.13 days in suckled buffaloes). Furthermore, calving to conception interval was also prolonged in suckled than in weaned animals (98.00 ± 17.53 days vs 70.33 ± 9.56 days). Therefore, successful reproduction could be attained by evading harmful effects of suckling through weaning practices, restricted suckling and/or limited suckling.

2. Nutrition: Optimum nutrition plays a pivotal role in enhancing reproductive efficiency in farm animals. The ovarian activity is suppressed due to poor nutrition through negative energy balance that reduces the bio-availability of glucose in the body. Hegazi et al., (1994) reported longer post-partum anestrus period in buffaloes fed high than low plane of energy (75 vs 66 days). The quality of feed governs profitable animal breeding. Reduced acyclic periods in buffalo fed succulent green fodder (29.0 ± 1.0 days) than dry fodder (34.0 ± 2.0 days). However, lack of green fodder availability round the year limits the reproductive performance of buffalo. Therefore, specific feeding strategies need to be formulated to exploit round the year potential. Alternatively, urea molasses multi-nutrient blocks (UMMB) have been developed as a cost-effective source of energy and protein. Regular supplementation of UMMB for 60 days before calving shortened the onset of post-partum estrus by eight percent and improved pregnancy rates by 40% in anoestrus non-pregnant buffalo (Nanda et al., 2003). Thus, balanced nutrition is a must for optimum reproduction in dairy animals.

Gaps and Future Directions in the Research

Future research should focus on integrating hormonal, nutritional, genetic and technological Approach to develop more effective, sustainable and farm specific strategies for managing postpartum anestrus in dairy animals. While it is known that negative energy balance in high producing animals contribute to anestrus, the optimal dietary intervention to shorten the postpartum anestrus period are not well established. More research is required on trace minerals, vitamins and feed additives (i.e. probiotics, omega-3 fatty acids and bypass proteins) and their role in reproductive performance.

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*Mini Review***Practical Strategies for Anesthesia and Pain Management in Critically ill Dogs and Cats****Vijay Sobti^{1*}**

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Abstract

Anesthetic techniques and pain management in dogs and cats are integral part of any surgical intervention. Proper preanesthetic assessment, premedication, induction, maintenance, monitoring, pre and postoperative pain management ensure the safety and comfort of the patients during and after the surgical procedures. Anesthetic techniques and pain management differ significantly and are more challenging when a dog or cat is critically ill and has to undergo a surgical intervention which may prove life-saving.

Key words: *Anaesthesia, Cardiovascular disorder, Gastrointestinal Disorders, Liver Disorder, Renal disorder.*

Anesthesia is an integral part of any successful surgical outcome. Providing effective anesthesia and intra and post operative pain management in dogs and cats is crucial for ensuring smooth induction and recovery postoperative comfort. The anesthetic procedures describe in this article are being used by the author in the routine clinical practice.

Before administering anesthesia, a thorough pre-anesthetic assessment is essential. This includes evaluating the animal's medical history, conducting a thorough physical examination, and performing diagnostic tests such as blood work, radiographs, or ultrasounds. The goal is to identify any underlying health conditions that may affect the anesthetic plan. A blood test should be done at least a few days before the actual surgical procedure. A minimum database should be obtained depending upon the age of the animal.

Complete Blood Count (CBC): Anemia, leukocytosis and thrombocytopenia are some of the major hematological alterations that concerns anesthetics. Leukocytosis may occur due to multiple reasons such as infection or sepsis and neoplasia predisposing patients to hypotension, poor perfusion, immunosuppression and altered drug metabolism. Short-acting, cardio-stable agents (e.g., etomidate for induction, Isoflurane / Sevoflurane for

maintenance, and opioids for analgesia) are preferred while avoiding drugs that may potentially cause vasodilation or hypotension (e.g., acepromazine, high-dose propofol).

Biochemistry: A minimum panel of biochemical tests is indicated depending upon the age and suspected underlying condition based upon history and clinical assessment. For dogs and cats under 5 years of age, albumin, albumin/globulin ratio, ALP, ALT, AST, GGT, total bilirubin, BUN, Creatinine, BUN/Cr ratio, calcium, chloride, CK, globulin, glucose, phosphorus, potassium, SDMA, sodium, sodium/potassium ratio, TCO₂ [bicarbonate], total protein are generally recommended. For patients 5 years and above, we can add on amylase, cholesterol, lipase, and total T4.

Thoracic Auscultation

Thoracic auscultation must be done to detect any heart murmur / abnormal lung sounds. Grade 1/6 heart murmur is common in many small breeds (Maltese, Shitzu, Chihuahua, Yorkshire Terrier). However, dogs with Grade 4-6 heart murmurs must be further evaluated for any cardiomyopathy especially mitral valve disease and anesthetic plan accordingly modified. Cats with abnormal lung sounds must be evaluated for cardiomyopathy and allergic bronchitis.

Premedication

Premedication involves administering drugs prior to the induction of anesthesia to calm the animal, reduce anxiety, and decrease the required dose of anesthetic agents. Common premedication agents include sedatives, tranquilizers, and analgesics. For dogs and cats which are nervous and or aggressive, oral medication is recommended at home about 2 hours before bringing to clinic. Trazodone for the dogs and gabapentin for the cats is commonly used medication.

For in clinic patients admitted for the surgery, the following drugs in combination can be used before induction of anesthesia:

Atropine, glycopyrrolate, acepromazine, Dexmedetomidine, medetomidine, Butorphanol, hydromorphone, meperidine, morphine, Midazolam. Generally, a combination of acepromazine and Butorphanol acts as a very good premedicant for dogs and a combination of Dexmedetomidine/medetomidine and Butorphanol as a very good pre anesthetic combination for cats. Hydromorphone in combination with acepromazine provides very good analgesia but the dogs do vomit after intramuscular administration. Use of Atropine, glycopyrrolate is generally avoided so that we get the clear picture of the heart is available.

Induction

Induction is the process of rendering the animal unconscious and immobile for the procedure so that the canine /feline patient can be intubated and hooked to inhalant

anesthetics for maintenance. This can be achieved through injectable agents such as propofol, diazepam and ketamine, and Alfaxalone. For diazepam-ketamine anesthesia in dogs, draw up to 5 mg/kg ketamine and equal volume of diazepam (5 mg/ml). Invert syringe back and forth to mix the two drugs adequately. Administer 1/4th of this volume as a bolus. Wait 45 seconds before injecting additional dose. Continue bolus injections until intubation can be performed without resistance.

Alfaxalone is neuroactive steroid and propofol is hypnotic sedative. Brief apnea can result after propofol or Alfaxalone induction. Slow administration will reduce occurrence of apnea (Bigby et al. 2017). Avoid Alfaxalone in patients where tachycardia is a concern.

Both propofol and alfaxalone cause a significant reduction in SAP and diastolic blood pressure without altering heart rates. Both alfaxalone and propofol cause a decreased respiratory rate post induction in the dog; however, not in cats. Alfaxalone can be used in place of propofol for C-sections. Propofol and alfaxalone both can be used with low doses of ketamine as a co-induction.

Quality of recovery following alfaxalone and propofol in dogs is smooth; however, in the cat, rough recoveries may be more commonly seen after alfaxalone induction.

Ketamine, dissociative anesthetic agent; provides some analgesia at subanesthetic doses. In general, ketamine should not be used as the sole anesthetic agent; often combined with α_2 -agonists, benzodiazepines, and opioids. It should be used with caution in patients where increased intraocular/intracranial pressure would be detrimental such as in patients with open globe injuries. Do not use in patients with high sympathetic tone as administration can increase norepinephrine levels and exacerbate side effects of those diseases. Use with caution in patients with coronary artery disease, uncontrolled arterial hypertension, cardiomyopathy, or heart failure.

Ketamine alone results in poor muscle tone; combining with other anesthetics will decrease this effect. Reflexes (blinking, swallowing) may be maintained; patients may not blink so corneal lubrication may be needed.

To prevent laryngospasm during feline intubation, it is highly recommended to spray lidocaine onto the arytenoid cartilages and surrounding tissues after an initial bolus of induction agent when the patient is unconscious enough to allow observation of the upper airway. Wait 15 seconds for mucosal desensitization to occur before attempting intubation. Administer additional induction agent to achieve a proper depth of anesthesia that will permit intubation.

Proper size tube should be used depending upon the size of the animal. When intubating, do not advance the tube cuff end past the tip of the shoulder to avoid entering

the chest and intubating a mainstream bronchus leading to hypoxemia (low SpO₂). Cuff of the endotracheal tube should be sufficiently inflated. Instill a small amount of air necessary to obtain a seal of 20 cm water in the breathing circuit. Eyes should be lubricated with a lubricant. Standard IV fluids are administered at 5 ml / kg/hour for dogs and 3 ml/kg/hour for cats.

Maintenance

Maintenance of anesthesia is achieved by delivering a stable plane of anesthesia throughout the procedure. Inhalant anesthetics such as isoflurane and sevoflurane are popular choices due to their rapid onset, ease of control, and quick recovery times. Anesthesia can be maintained using a breathing circuit system that ensures a continuous supply of oxygen and anesthetic gases.

Three types of breathing circuits are commonly used: Bain, Pediatric and full circle. For patients up to 5 kg body weight, Bain circuit is good, 5-10 kg Pediatric and above 10 kg, full circle should be good.

Monitoring

Continuous monitoring of the animal's vital signs is critical during anesthesia. Parameters such as heart rate, respiratory rate, blood pressure, oxygen saturation, CRT and body temperature should be regularly assessed. Monitoring equipment may include ECG, pulse oximetry, capnography, and blood pressure monitors (Grubb et al., 2020). Close observation helps detect any adverse reactions or complications early.

Pain Management

Preemptive Analgesia: Preemptive analgesia involves administering pain relief before the onset of a painful stimulus, such as surgery. This approach helps prevent the development of central sensitization and reduces postoperative pain. Preemptive analgesics may include nonsteroidal anti-inflammatory drugs (NSAIDs), opioids, and local anesthetics (Hansen, 2008). Meloxicam and Robenacoxib are commonly used and administered just before the start of the surgery. **Local Anesthesia:** Local anesthesia involves the administration of anesthetic agents to a specific area to block nerve conduction and provide pain relief. Techniques include local infiltration, nerve blocks, and epidural anesthesia. Commonly used local anesthetics in veterinary practice are lidocaine and bupivacaine. These agents can be used alone or in combination with other analgesics for enhanced pain control.

Postoperative Pain Management: Effective postoperative pain management is essential for promoting recovery and ensuring the animal's well-being. Postoperative analgesia may involve the continued use of NSAIDs, opioids, and other adjunctive medications. Regular pain assessment using validated pain scales helps tailor the pain management

plan to the individual animal's need. Meloxicam and Robenacoxib are commonly used and are given 3 days post surgery.

Breed and Disease Specific Considerations

Brachycephalic dog breeds, such as Bulldogs, Pugs, Boxers, Shitzu, Pekingese pose unique challenges during anesthesia. Due to their anatomical structure, characterized by a shortened skull and elongated soft palate, these breeds are prone to airway obstructions and respiratory difficulties. Dose of Acepromazine as a premedicant is reduced by 25 percent of the normal dose (Gruenheid et al. 2018). For Greyhounds, reduce the dose of Acepromazine by 50 percent. Greyhounds, in particular, may become hyperthermic in response to this stress, and the hyperthermia can continue throughout anesthesia and into recovery. To minimize stress and reduce the likelihood of hyperthermia, it is useful to schedule procedures early in the day, premedicate soon after hospital admission, keep their owners with them until after premedication has taken effect and minimize the duration of the hospitalization period if possible

During anesthesia, maintaining a patent airway is paramount. Pre-oxygenation is recommended to increase oxygen reserves. Endotracheal intubation should be performed with utmost care, using appropriately sized tubes to ensure a secure airway without causing trauma. Ventilation must be closely monitored, and mechanical ventilation may be necessary. Recovery should be closely supervised, ensuring that the animal remains in a sternal position to facilitate breathing and prevent airway collapse. Endotracheal tube should be taken out only when the dog is fully awake.

Anaesthetic Techniques for Critically ill Dogs and Cats

Cardiovascular Diseases: For dogs and cats with cardiovascular disease, anesthesia is not absolutely contraindicated but carries a higher risk of complications compared to healthy animals. Anesthetic recommendations would include the avoidance of ketamine, telazol, dexdomitor (or other alpha-2 agonists), and acepromazine. Consider premedication with an opioid/benzodiazepine (Midazolam and Butarphanol) and induction with Propofol, Etomidate or Alfaxan. Reduction in IV fluid rates to 1/2 surgical rates. Heart rate, respiratory rate and blood pressure under anesthesia should be monitored.

Renal Diseases: Anesthesia for dog and cats with renal disease requires attention to fluid balance and renal perfusion. Preoperative hydration and correction of electrolyte imbalances are essential. Avoiding nephrotoxic agents and minimizing the use of NSAIDs (meloxicam) can help protect renal function. Premedication with midazolam and butarphanol is preferred. Alfaxalone 2 mg/kg and midazolam 0.05 mg/kg can be used. Allow 20 minutes for onset of maximum effects of midazolam. Inhalant anesthetics like isoflurane or sevoflurane are preferred due to their minimal renal impact. Intraoperative

monitoring should include blood pressure and urine output, while postoperative care involves continued fluid therapy and close monitoring of renal parameters.

Liver Disease: Liver disease affects the metabolism and clearance of anesthetic drugs, requiring careful selection and dosing of agents. Agents with minimal hepatic metabolism, such as propofol or remifentanyl, are preferred. Premedication with Butorphanol/methadone can be done (Kerr & Swanton, 2023). Acepromazine and Xylazine are avoided as premedicants. Alfaxalone or a combination of propofol and ketamine can be used for induction. Do not use NSAIDs (including Acetaminophen) in the perioperative period. Postoperatively, supportive care includes maintaining adequate nutrition and monitoring for signs of hepatic encephalopathy.

Diabetes Mellitus: Dogs and cats with diabetes mellitus require careful perioperative glucose management. Preoperative assessment includes ensuring stable blood glucose levels and adjusting insulin therapy. During anesthesia, frequent monitoring of blood glucose is necessary, with dextrose supplementation as needed. Anesthetic agents such as propofol and alfaxalone are preferred (Costa & Jones, 2023).

Gastrointestinal Tract Disorders: Anesthesia for dogs with gastric dilation and volvulus (GDV)/gastrointestinal obstruction/foreign body is challenging. These patients are presented with varying degrees of acute compromise depending on the duration and severity of the abdominal distention, torsion, and gastric and intestinal wall necrosis. Surgery is indicated for GDV as soon as abdominal distention is relieved and circulating volume has been restored.

Fentanyl and methadone in combination with midazolam / diazepam can be used as pre medicant (Kerr & Swanton, 2023). Avoid alpha-2 agonists. Alfaxalone or ketamine/diazepam can be used for induction and isoflurane for maintenance. Propofol induction may cause unacceptable splenic enlargement and pronounced hypotension. All NSAIDs are contraindicated in these patients until they have resumed eating.

For cats with acute abdomen, assess hydration status, degree of abdominal distention, and discomfort. When vomiting/diarrhea are present, measure serum sodium, potassium, and chloride levels within 8 hours of anesthesia to aid in your choice of perioperative fluid therapy. Correct electrolyte and hydration abnormalities before anesthesia. Butorphanol or methadone can be used as pre medicant (Kerr & Swanton, 2023). Alfaxalone or ketamine/diazepam or ketamine and propofol can be used for induction and isoflurane for maintenance.

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Mini Review

Carboxymethyl Cellulose in Preventing Intra-Abdominal Adhesions in Equine Surgery

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Abstract

Colic is the most common reason for exploratory surgery in equine practice, during which the entire abdominal cavity is manipulated to identify and simultaneously treat the suspected lesion(s). Pathophysiological events, iatrogenic surgical trauma and exploration may predispose the horse to postoperative ileus and intraabdominal adhesions. Understanding the importance of abdominal lubricants and prophylactic strategies during exploratory surgery is crucial. Among various adhesion barriers, 1% sodium carboxymethyl cellulose is widely used in Western countries; however, its application under Indian conditions remains limited. This mini-review describes the current strategies for facilitating abdominal exploration and preventing intra-abdominal adhesions in equine surgery.

Key words: *Carboxymethyl cellulose, Exploratory laparotomy, Intra-abdominal adhesions.*

Colic is the most common reason for exploratory laparotomy in equine, in which an attempt is made to palpate the entire abdominal cavity to find out the probable lesion(s) and simultaneously treat them. Colic originating from the gastrointestinal tract (GIT) is among the deadliest emergency surgeries in equine, with high morbidity and mortality rates. Primary lesion(s) causing GIT obstruction, distension due to gas and fluid accumulation, and/or displacement cause inflammation due to vascular compromise. Edema and distension of the intestines make them fragile for rupture during exploration of the abdomibnal cavity. Besides, iatrogenic trauma during exploratory surgery may predispose the horse to postoperative ileus and intra-abdominal adhesions (Alonso et al., 2014). Understanding the importance of lubrication of the peritoneal cavity during exploratory surgery is crucial. This mini-review describes the current strategies for facilitating abdominal exploration and to preventing intra-abdominal adhesions in equine surgery.

Incidence of Postoperative Peritoneal Adhesions in Equines

Horses often face serious and sometimes deadly complications like ileus and intra-abdominal adhesions, following abdominal surgeries. Intra-abdominal adhesion

bands, composed of scar tissue, can lead to recurrent episodes of colic and become a significant cause of postoperative mortality in horses. Factors such as parturition, colonic displacement, and castration are believed to predispose horses to intra-abdominal adhesion formation, likely due to localized inflammation or trauma. (Giusto et al., 2022). Studies report that 18% to 25% of horses undergoing such surgeries develop adhesions (Baxter 1991), though many more cases likely go undetected. Once formed, these adhesions are difficult to eliminate as they frequently return after being surgically removed. This is especially problematic in foals and horses that undergo small intestinal resection and anastomosis, whose long-term outlook is often poor (Ellis et al., 1999).

Current Approaches for Preventing Intra-Abdominal Adhesions

Surgeons can implement various techniques to reduce the risk of adhesion formation. These methods are cost-effective and based on sound surgical principles, such as maintaining strict aseptic conditions, using powder-free synthetic gloves, minimizing tissue trauma, ensuring continuous irrigation of the bowel, limiting the use of electro-surgical tools, achieving precise hemostasis, selecting fine, biocompatible sutures, and restricting tissue dissection to only what is necessary (Claunch and Mueller 2012; Alonso et al., 2014).

Veterinarians and researchers have long been searching for effective ways to prevent postsurgical adhesions. Over time, several improved surgical techniques have been invented including the use of various medications like anti-inflammatories, antibiotics, heparin, and peritoneal lavage to reduce tissue damage and inflammation. Adhesion barrier products are generally attempted to minimize the effects of tissue trauma after it has occurred by reducing inflammation, enzymatically digesting fibrin, or separating damaged tissue surfaces (Hague et al., 1999). Adhesion barrier products have also been tested, typically applied at the end of surgery to physically separate healing tissues. However, some scientists have turned their focus toward an earlier intervention i.e. tissue protective agents. Unlike barrier agents that act after injury, tissue protective solutions are applied before or during surgery, with the goal of preventing damage in the first place. These agents shield the delicate serosal surfaces of the intestine, helping reduce the trauma that triggers adhesions. Among these solutions, sodium carboxymethylcellulose (SCMC)—a water-soluble, polyanionic cellulose derivative has shown a great promise as tissue protective agents. Available in low, medium, and high molecular weight forms, SCMC has proven effective in many species such as rabbit (Diamond et al., 1988), ewe (Moll et al., 1992), ponies (Murphy et al., 2002). In horses, medium-weight SCMC has been used successfully. Murphy et al. (2002) found highly viscous solutions of HMW (molecular weight > 500kd) SCMC more efficacious at preventing adhesions in rats after caecal abrasion than are less viscous or lower molecular weight solutions. The importance of molecular weight may be that such solutions form a boundary layer that

is more difficult to dilute or wipe off, resulting in a longer residence time on the bowel surface. Another study conducted by Goldberg et al. (1980) revealed that hydrophobic or electrostatic interactions can be an important reason for biophysical adhesion between mesothelial cells and materials used during surgery, such as gloves, instruments, and drapes. Hydrophilic SCMC solutions can form a protective and lubricious coating that minimizes these interactions and prevents adhesive and abrasive contacts between the mesothelium and foreign material.

Clinical Studies on Adhesion Control

Adhesions often form in response to fibrin and inflammation after peritoneal injury. Interestingly, while they can occasionally support healing, by providing blood supply to damaged tissues or helping incisions close, they are more often harmful than helpful. That's why researchers have continued to refine preventive strategies for adhesion formation. Among these efforts, SCMC stands out. In laboratory studies with ponies, ewes, and small animals, SCMC solution applied inside the abdomen prevented adhesion formation and even reduced their recurrence after surgical removal (Hay et al., 2001). It works by physically separating tissue surfaces during healing.

One retrospective study (Mueller et al., 1995) demonstrated safety of SCMC on clinical outcomes or long-term survival, though it didn't demonstrate how many adhesions were prevented. Building on this knowledge, researchers proposed a new idea: what if SCMC could be applied to the intestine before any trauma occurs, particularly at sites of surgical manipulation like jejunal anastomosis? They believed that this approach could reduce adhesions without causing complications (Hay et al., 2001).

In the quest to improve recovery after abdominal surgery in horses, researchers have focused on reducing one of the most serious complications—*intra-abdominal adhesions*. These adhesions can lead to recurrent colic and significantly worsen long-term outcomes. Some key studies have shown promising results for the use of 1% SCMC as a preventative treatment (Hay et al., 2001).

Murphy et al. (2002) explored the biocompatibility and effectiveness of high-molecular-weight (HMW) CMC in ponies undergoing clean-contaminated procedures, designed to mimic colic surgery. Remarkably, none of the CMC-treated ponies developed peritonitis or abscesses. Outcomes that aligned with lab findings showing CMC does not support bacterial growth. While all ponies recovered without obvious signs of colic, the untreated control group showed significantly elevated heart rates, rectal temperatures, and weight loss that are clear indicators of stress and poorer recovery. These findings suggested that CMC not only prevented adhesions but also improved overall postoperative well-being. The researchers concluded that 1% HMW CMC could safely and effectively be used in routine abdominal surgeries, including coating the intestines before procedures like enterotomy.

Supporting this, Hay et al. (2001) provided more direct evidence of adhesion prevention. In their experimental study, all control horses developed intra-abdominal adhesions, particularly at jejunal abrasion and anastomotic sites. In contrast, only one horse treated with SCMC developed adhesions at the abrasion sites, and none had adhesions at the anastomotic locations. The difference was statistically significant, highlighting SCMC's protective effect concerning development of intraabdominal adhesions. These results showed that intraperitoneal application of 1% SCMC markedly reduced the frequency of adhesions and could be particularly beneficial for horses at high risk of developing postoperative adhesions.

A 2016 systematic review and meta-analysis by Munsterman et al. offered a broader perspective on the existing evidence. Out of 354 peer-reviewed studies that met the search criteria, only nine were directly relevant to the intra-abdominal use of barrier agents such as CMC solutions, HA/CMC membranes, HA solutions, and fucoidan. A study conducted by Singh (2016) indicates that intraperitoneal use of SCMC significantly improves post-caesarean survival and fertility rates in buffaloes, while also reducing the severity of adhesion formation.

Despite the limited number, the meta-analysis revealed that horses treated with these barriers had significantly lower odds of developing adhesions compared to untreated controls. Among the individual treatments, CMC solutions and HA/CMC membranes demonstrated the strongest association with reduced adhesion formation.

Building on this, a 2004 study by Eggleston et al. explored the mechanical and clinical impacts of coating jejunal anastomoses with SCMC and HA. Their findings added critical insight: horses treated with SCMC combined with serum amyloid A (SAA) had significantly stronger anastomotic healing, as evidenced by higher bursting wall tension, with all intestinal failures occurring away from the surgical site. Moreover, no differences in adhesion formation were found at anastomotic sites between the groups. Importantly, the study concluded that applying SCMC or HA did not impair anastomotic healing, suggesting that these agents are safe for use in delicate surgical areas.

Together, these studies support the routine use of 1% SCMC during equine abdominal surgery to minimize adhesions, reduce postoperative complications, and improve recovery outcomes.

As per personal communication, the University of Pennsylvania is routinely using 1% SCMC + 3% Propylene Glycol (10g SCMC + 30ml Propylene glycol + 970 ml D water) as a barrier lubricant, prophylactically, for preventing intra-abdominal adhesions during exploratory surgery in various species of animals such as equines, camelids, small and large ruminants. Though, authors could not trace any published report on this; however, one patent granted to Takigami et al (2010) that introduced a method for producing a

gel of carboxymethyl cellulose alkali metal salt by mixing with several agents such as propylene glycol that exhibits high elasticity, strength, water retention, and durability. Actually, to dissolve high density SCMC in the water, it required either heating upto 60°C along with constant stirring (Hay et al., 2001). Propylene glycol could be used as an excellent solvent to SCMC which is a biocompatible and non-toxic agent widely used in various cosmetics and pharmaceutical formulations for human and veterinary patients (European Medicines Agency 2017).

Preparation of 1% SCMC

To prepare 1% sodium carboxymethyl cellulose (SCMC) solution, use a 1-liter glass autoclavable bottle. Clean the bottle thoroughly and autoclave it before use. Weigh 10 g of high-density SCMC and transfer it into the sterilized bottle. Add 30 ml of propylene glycol to the bottle and gently swirl to mix. The SCMC powder will absorb the propylene glycol and form a semisolid mass. Next, add triple distilled water (~970 ml) to make the total volume 1000 ml. Autoclave the bottle with the lid open at 121°C for 20-30 minutes. After autoclaving, close the lid tightly under aseptic conditions and store the solution in a refrigerator for further use.

Dosage of SCMC

According to Hay et al. (2001), the 1% SCMC gel can be safely administered intraperitoneally in horses at a dose of 4–6 mg/kg body weight. Doses exceeding 7 mg/kg or larger volumes (2–4 liters) may produce toxicity symptoms, such as postoperative fever, anorexia, and depression, likely due to systemic absorption of SCMC. The total volume of 1% SCMC administered intraperitoneally should range between 500 ml and 2 litres, and should not exceed 2 liters per horse (Hay et al., 2001).

Current Status and Future Research Prospects in India

Currently, there is limited research on the use of 1% sodium carboxymethyl cellulose (SCMC) solution for intra-abdominal applications in equines and other animal species within India. A combination of SCMC with propylene glycol is easy to make and can be adopted as a cost-effective adhesion barrier during exploratory surgeries for preventing postoperative abdominal adhesions in horses and other domestic animals. Further studies on the ideal storage conditions and the shelf life of the autoclaved SCMC solution are warranted.

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*Clinical Article***Surgical Management of Gastric Dilation and Malposition Complicated with Splenic Torsion in a German Shepard dog****Nima Wangdi^{1*}, Kazuhiko Ezura², Tenzin Wangchuk³ and Moti Maya Ghalley⁴**^{1,3,4}National Veterinary Hospital, Motithang, Thimphu-11001, Bhutan²Japan International Cooperation Agency, Japan*Corresponding author email: nimavet2012@gmail.com

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Abstract

This case reviews the successful outcome of gastric decompression and gastropexy as a surgical management approach for gastric dilation and volvulus (GDV) in a 10-year-old male German Shepherd dog. The pet, weighing 28 kg, was referred from the district veterinary hospital with a history of sudden onset of restlessness, retching, tachypnoea and hypersalivation 30 minutes post feeding. The dog was stabilized with intravenous fluids, cefotaxime @ 50mg/kg b.wt., meloxicam @ 0.2mg/kg b.wt. A 16-gauge needle was used to decompress the distended stomach from the right flank. Right lateral radiograph revealed a gas distended stomach containing radio-opaque material; the spleen was pushed caudoventrally suggestive of splenic torsion. Midventral celiotomy under general anaesthesia confirmed gastric dilation with malposition accompanied by splenic torsion. The stomach and the spleen were successfully de-rotated and repositioned to their normal anatomical locations. The dog recovered uneventfully, with no complications or recurrence observed during the two months follow-up period.

Keywords: *Emergency surgery, Gastric dilation volvulus, Splenic torsion*

Gastric dilation-volvulus (GDV) is a gross gas or fluid distension of the stomach, accompanied by mal-positioning, which causes pathology of multiple organs. It commonly affects large or giant breeds of dogs (Broome & Walsh, 2003). Purebred dogs over 3 years of age, either large or giant breeds weighing 30 kg, have been found more susceptible to developing GDV. The ingestion of foreign bodies, diarrhoea, and grass consumption were also associated with an increased likelihood of developing GDV (di Virgilio et al., 2020). In addition to age, body weight, and neuter status, thoracic conformation of the dog has also been reported as an important determinant of susceptibility to GDV (Glickman et al., 1994). Non dietary risk factors for GDV include increasing age, previous history of GDV, fast eating, and feeding from a raised feeding bowl especially in large and giant breed dogs (Glickman et al., 2000a). Splenic torsion is a potentially life threatening condition, most commonly associated with GDV wherein large or giant breed and deep chested dogs like German Shepherds and Great Danes are commonly affected (Mai, 2006). Splenectomy is the only recommended procedure in dogs with chronic splenic torsion when the vascular pedicle cannot be untwisted due to fibrosis, splenic rupture, or

vascular thrombosis; however, this was not the case in the present study. This case study reviews the successful outcome of gastric decompression and gastropexy as a surgical management of GDV complicated with splenic torsion in a 10-year-old male German Shepherd dog.

History and Clinical Findings

A ten-year-old male German shepherd dog was referred in a recumbent position from a District Veterinary Hospital with a history of consuming meat mixed with rice. After 30 minutes of feeding, the dog exhibited symptoms of retching, lethargy, tachypnoea, hypersalivation and defecation. Physical examination revealed enlarged abdomen, tachycardia (182/minute), prolonged capillary refill time (>3 seconds), pale mucus membrane, and hypersalivation. Based on the history and typical clinical signs, the condition was tentatively diagnosed as GDV.

Radiographic Findings

A right lateral radiograph revealed a large, distended, gas-filled gastric shadow pushing the liver cranioventrally and the diaphragm cranially. Additionally, there was craniodorsal displacement of the pylorus and as shown in Fig. 1. The condition was confirmed as GDV based on the radiographic lesions such as presence of marked gastric gas and mispositioning of the spleen.

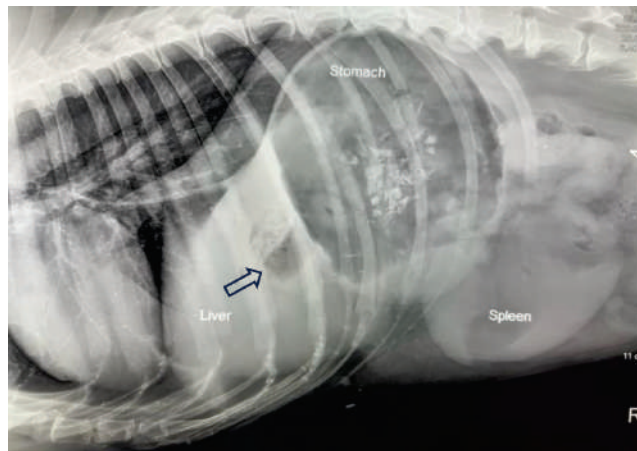


Fig. 1. Right lateral radiograph showing gastric pneumatosis with malpositioning of the pylorus (black arrow) and spleen

Preoperative Treatment and Stabilization

The dog was stabilized with intravenous fluids (Ringer's Lactate @ 60 ml/kg body weight) to correct hypovolemia and electrolyte imbalance. To alleviate pain and discomfort, inj. Meloxicam was given @ 0.2mg/kg, intravenously, along with inj. Cefotaxime @ 50mg/kg twice daily.

Anaesthesia and Surgical Procedure

The dog was premedicated with inj. Xylazine (1mg/kg) and inj. Atropine sulphate (0.04 mg/kg), IM. The anaesthesia with induced a combination of inj. Ketamine (5mg/kg) and inj. Diazepam (0.5 mg/kg), intravenously, till effect. Anaesthesia was maintained through incremental doses of injection Ketamine-Diazepam combination. Preoperatively, stomach decompression through gastrocentesis using a 16-gauge needle was unsuccessful. An exploratory midventral celiotomy was performed, further confirming the condition as the pylorus was moved ventrally across the left side with 360-degree torsion. Before correcting the gastric torsion, the stomach was decompressed via gastrocentesis intraoperatively. The twisted spleen was de-rotated to its normal position, and upon evaluation, no ischemic necrosis was observed. The stomach was then returned to its normal position and an incisional gastropexy was performed using 1.0 Polyglactin interrupted sutures to prevent recurrence.



Fig 2. Placement of gastropexy sutures (Arrow)

Postoperative Care and Management

Postoperative follow-up was done for 5 days with intravenous dextrose normal saline and Ringer's lactate @ 60 ml/kg, daily wound dressing, cefotaxime @ 50mg/kg and meloxicam @ 0.2 mg/kg was given for 3 days. The owner was advised to feed the dog a liquid-based diet starting from the fourth postoperative day. Right lateral radiograph on the 15th day post operative showed stomach with mild gas in the cranial abdomen (Fig. 4). The gastric axis appeared normal. The tail of the spleen was observed in the midventral abdomen. Small intestinal segments were collapsed with small amount of gas in few segments. The dog showed progressive recovery with no complications.

Discussion

Gastric dilatation and volvulus is commonly encountered in deep-chested dogs



Fig 3. Right lateral radiograph of abdomen on post operative day 15 showing normal stomach and spleen

characterized by gastric distension and malpositioning of the pylorus and the spleen as in the present case. Radiography is the key diagnostic aid to confirm the disease typically indicated by a double bubbled appearance due to accumulation of air in the fundus and pylorus (Murugan et al., 2023). However, this characteristic feature was not observed in this study. Instead, a gas-filled stomach along with craniodorsally displaced pylorus accompanied with splenic malposition was evident on the right lateral radiograph confirming GDV. Although, blood and biochemical profiles could not be established considering the urgency of the case, previous studies have consistently reported findings of stress leucogram, reduced PCV and hypokalaemia.

Przywara et al., (2014) reported a case fatality rate ranging from 33% to 68% with or without volvulus. Similarly, Glickman et al., (2000b) reported 30 deaths (26.8%) out of 105 dogs with GDV and found that the incidence of GDV increases with age. Furthermore, elevated gastrin level, impaired stomach motility, and prolonged gastric emptying time have been identified as potential risk factors. Tselepidis & Stournara (2008) documented a higher frequency of GDV-associated sudden death in German Shepard dogs compared to other breeds, however the dog under study recovered uneventfully without any complications. Kumar et al. (2021) reported a comparable outcome emphasising that early diagnosis, effective management and proper postoperative care contribute towards an uneventful recovery in GDV affected dogs. The results of this study also corroborate with the findings of Dujowich and Reimer (2008) who stated that, early recognition of GDV and rapid gastric decompression ensures a good prognosis. Furthermore, appropriate decision-making and management can help to achieve a success rate of up to 95% in GDV cases uncomplicated by gastric necrosis (Tivers & Brockman, 2009).

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Mini Review

Managing Diaphyseal Femoral Fractures in Puppies: Current Challenges and Future Prospects

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Abstract

Juvenile dogs are prone to appendicular fractures with high predisposition to femoral fractures. Long bones in growing animals differ in biomechanics, anatomy, and physiology as compared to mature bone, which has implications in the selection of effective fracture treatment methods. Fracture management in juvenile dogs presents a dual challenge: addressing musculoskeletal injuries effectively while safeguarding the animal's ongoing growth and development. This mini review updates current challenges and future prospects for diaphyseal femoral fracture management in puppies.

Keywords: *Femur fracture, Growing dogs, Intramedullary pinning*

Dogs of any age, particularly juvenile, are prone to appendicular fractures with high predisposition to femur (Gupta et al., 2024). Fracture management in juvenile dogs presents a dual challenge: addressing musculoskeletal injuries effectively while safeguarding the animal's ongoing growth and development. Unlike adults, juvenile canines have active growth plates, a higher regenerative capacity, and unique biomechanical characteristics. This creates both opportunities for rapid healing and concerns regarding the long-term consequences of interventions. This mini review explores key orthopedic opportunities, associated concerns, and current directions in managing long bone fractures in juvenile canine patients.

Biomechanical Properties of Juvenile and Mature Bones

Long bones in growing animals differ in biomechanics, anatomy, and physiology as compared to mature bone, which has implications in the selection of effective fracture treatment methods (Palmer, 2009). In juvenile dogs, active epiphyses pose significant concerns during fracture repair, as orthopedic implants may damage these growth plates, particularly while fixing distal diaphyseal fractures, potentially leading to developmental abnormalities. Immature bone is more ductile and has reduced mechanical strength, stiffness, yield stress, and elastic modulus. Additionally, the diaphyseal cortical bone in juvenile dogs is substantially thinner than that observed in adult counterparts leading

to implant failure (Dejardin and Cabassu, 2008). Additionally, in young dogs, the combination of rapid skeletal growth and a naturally flexed stifle joint ($\sim 140^\circ$) increases the risk of joint stiffness when immobilized. This is largely attributed to the development of adhesions and quadriceps muscle shortening (Bardet, 1987). Even short durations of immobilization can result in a condition known as “fracture disease,” often leading to lasting impairment of limb function (Dejardin and Cabassu, 2008).

VARIOUS FRACTURE FIXATION METHODS

External Coaptation: External coaptation is typically not advised for the management of femoral fractures in dogs due to topographic limitations (inadequate immobilization of the coxofemoral joint), thereby necessitating internal fixation (Gibson & Sylvestre 2019). Besides coaptation, Robert Jones or similar padded bandage applied up to the mid-thigh may serve as a fulcrum, leading to increased instability, pain, and soft tissue injury (Gibson & Sylvestre 2019). Distal femoral fractures of immature dogs treated with splints often developed quadriceps contracture, hip subluxation, bone hypoplasia, and increased femoral torsion (Bardet, 1987) thereby necessitating to employ fixation techniques judiciously to prevent such adverse outcomes. However, modified Robert Jones bandaging is being used routinely as an effective pre and post-surgical support bandage in cases of femoral fractures in dogs (Gupta et al 2023; Sodhi et al., 2023). But in the author’s opinion, the long term results of the conservative treatment in managing femoral fractures in puppies is lacking.

As fractures in pups heal faster, the use of conservative methods along with cage rest could be an effective means for managing diaphyseal fractures including femur. Besides, intramedullary pinning being a biological and cost-effective method, there is a need to explore techniques like the comparative stability of simple Steinmann pin with end-threaded pin for the femoral fractures in dogs. Due to high osteoblastic activity in puppies aged under 6 months, diaphyseal fractures typically heal rapidly, usually within 2 to 4 weeks, with rare instances of non-union and delayed union (Perry & Woods, 2018). So, external coaptation could be an effective method for stabilizing long bone fractures in growing dogs (Weinstein & Ralphs, 2004). In growing dogs with diaphyseal fractures, perfect anatomic reduction is less critical due to the rapid healing and remodeling potential of juvenile bone. Minor malalignments often correct with time and growth, especially in diaphyseal fractures (Piermattei et al., 2006).

Intramedullary Pinning (Simple and End-Threaded): Intramedullary pinning of femoral fractures in dogs gave better results than conservative treatments, i.e. external coaptation (Cabassu, 2001). Studies reported that femoral fractures in growing dogs treated with intramedullary pinning can experience certain complications such as pin migration, malunion, coxa valga, alterations in the coxofemoral joint, and premature

closure of growth plates (Black and Withrow, 1979; Schrader 1991). Due to poor metaphyseal density, the holding strength of juvenile bone, is inferior to the mature bone, thus end threaded pins should demonstrate better implant retention than simple Steinmann pin. However, there are lacks of studies comparing the use of simple versus end-threaded pin for managing stable diaphyseal fracture fixation in juvenile dogs.

Elastic Nailing: Titanium and Stainless steel are two commonly used biomaterials for elastic nails in veterinary and medical practice (Gupta and Kumar, 2023). Titanium is light in weight and more flexible than stainless steel, thus preferred in children (Mohamed & Rajeev 2017) and young dogs (Sodhi et al., 2023). Latest studies revealed satisfactory results with Titanium elastic nails for distal femoral fractures in young dogs (Sodhi et al 2023), but no clinical difference was recorded with the use of either material flexible nails for supracondylar / distal metaphyseal femoral fractures in dogs (Gupta et al 2023) and children (Mohamed & Rajeev 2017). Elastic nails are commonly used in medical practice but there is limited published literature in veterinary practice.

Conventional and Elastic Plating: Plate osteosynthesis is the preferred method for managing femoral diaphyseal fractures in juvenile dogs due to the limitations of intramedullary pinning and external fixation. However, Palmer (2009) noted that immature bone being more elastic with thinner cortex, lead to screw loosening in plating procedures. Moreover, the periosteum is thicker in immature bone, promoting rapid healing and acting as a stabilizing sleeve. Implant loosening is a significant complication in young animals as the immature bone is soft in nature. Besides, caution should be exercised to avoid involving epiphysis during plating to prevent deformities.

Elastic Plate Osteosynthesis (EPO) has emerged as an effective technique for managing femoral diaphyseal fractures in puppies. The EPO technique preserves the periosteal sleeve and employs undersized implants, such as Veterinary Cuttable Plates (VCP), which allow controlled movement at the fracture site and promote rapid callus formation (Grundnes and Reikeras, 1993). This configuration, which evenly distributes stress across the plate and reduces pullout stress on the screws, has been shown to yield better results (Dejardin and Cabassu, 2008).

Veterinary cuttable plates are gaining popularity among veterinarians due to their versatility. They can be customized to fit the length of bones, and their narrow, thin, and elastic properties make them ideal for fracture repair in growing dogs and for internal fixation of long bone fractures in puppies (Nanaboina, 2016). Though minimally invasive bone plating (MIBP) preserves the hematoma and surrounding soft tissues, which are crucial for enhanced bone healing, promote rapid union through callus formation (Luenig et al, 2000); however, shorter bones and poor cortical density in immature pups is considered serious constraints for implementing MIBP.

Future Directions

The wider medullary canal and poorly calcified cortex make the growing bone prone to implant related complications. As per the author's practical experience is possible to place intramedullary pins (metallic) up to 50% of the narrowest medullary canal in juvenile dogs as thicker metallic pins would be heavier and may cause more damage. So there an urgent need to develop light weight composite material implants, for juvenile dogs. The patient specific 3-dimensional printed pins / implants would be ideal to cater the need of the specific patients. End threaded pin has been reported with superior implant retention over simple Steinman pin as end-threaded pin holds the distal bone fragment firmly due to its screed end. Future studies on the superiority of end threaded pin would be highly appreciable in immature bone

Another complication encountered in long bone fractures of growing dog is during implant removal. The implant particularly intramedullary pin may get swallowed by the growing bone; thereby such implants could not be removed. So bioabsorbable implants would be of excellent choice in juvenile dogs as these loose their tensile strength very fast and are light in-weight. Besides, use of bioabsorbable implants will avoid second surgery for implant removal. Future prospects demand developing low-cost bioabsorbable implants for juvenile dogs which will stabilize fracture without affecting the bone growth.

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*Case Report***Papillary Carcinoma of Mammary Gland in 3-Year-Old Male Guinea Pig (*Cavia Porcellus*) –A Case Report****Nikita Gupta*, Vandana Sangwan and Kuldeep Gupta¹**

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Abstract

The trend of keeping various exotic species as pet is increasing in the modern society of India. This case study reports mammary gland carcinoma in pet guinea pig. A 3-year-old, male, American guinea pig, diagnosed with a papillary carcinoma of right inguinal mammary gland on histopathological investigation, was successfully treated with excision of tumorous mass under general anesthesia. No re-occurrence was reported upto 1 year follow up. This case study reports diagnosis and successful surgical management of a mammary gland carcinoma in a male 3-year-old, American guinea pig under general anesthesia.

Keywords: *Anaesthesia, Guinea pig, Mammary gland, Papillary carcinoma, Surgery*

Guinea pigs have always been used as laboratory experimental animals and their colony is maintained for a short duration of time, making it unlikely to observe many disease conditions which occur at later stages of life. But, lately there has been increasing trend towards adoption of guinea pigs as pets, and are therefore, maintained for longer duration, leading to their increased presentation with different ailments to veterinary hospitals and clinics (Blumenthal & Rogers, 1967).

Reproductive diseases are the third most common reason for presentation of guinea pig to the veterinary hospitals (Kondert & Mayer, 2017), with mammary tumor constituting 6% of all the cutaneous neoplasms presented (Kanfer & Reavile, 2013). Both male and female guinea pigs have a pair of inguinal mammary glands, which are better developed in females (Birchard & Sherding, 2005). Hence, cases of mammary gland tumor have been reported in both males and females, with higher incidence in males as compared to females and other mammalian species (Kondert & Mayer, 2017). Both young and old are equally susceptible,



Fig. 1: Photograph of an enlarged, ulcerated right inguinal mammary gland.

however, spontaneous tumor are not said to occur in guinea pigs less than 3 years of age (Blumenthal & Rogers, 1967).

Scanty literature is available on the surgical conditions of pet rodents particularly guinea pigs. The present case report describes a 3years-old, male guinea pig, diagnosed with papillary carcinoma of mammary gland, which was successfully treated through complete surgical excision.

Case History and Observations

A 3-years-old, male, American guinea pig, weighing 1Kg was presented to the Department of Veterinary Surgery and Radiology, with a history of red, painful swelling in the right inguinal mammary gland. The swelling once appeared two months back and then it was temporarily resolved with medicinal treatment (Enrofloxacin) as prescribed by a local veterinarian. A month later, the swelling recurred, which slowly developed into a nodular growth refractory to medicinal treatment and became ulcerated too (Fig. 1). The appetite of the pet was near normal; however, the activity was depressed. On physical examination, a nodular growth was palpated in the right inguinal mammary gland region and was suspected as mammary tumor.

Treatment and Confirmatory Diagnosis

The guinea pig was premedicated with xylazine @2mg/Kg body weight, induced with ketamine @ 25mg/Kg body weight and was maintained on isoflurane using a face mask. Both the injectable drugs were given intramuscularly. Under aseptically prepared conditions, the affected mammary gland was excised (Fig. 2) and the subcutaneous tissue and skin were closed routinely. The guinea pig was prescribed with oral course of cephalexin for 5 days and a single shot of meloxicam was given post operatively. Suture removal was advised after 10 days.

The sample of excised gland was preserved in 10% neutral buffer formalin and was sent for histopathological examination for confirmatory diagnosis. The sample was processed using standard paraffin embedding method to make blocks, which were further sectioned at 3 micrometer with microtome. The slides were prepared and were stained with hematoxylin and eosin (H&E) and were viewed under the microscope at power 10X and 40 X. The histopathological findings confirmed the diagnosis of mammary tumor and was classified as papillary carcinoma (Fig. 3a & b). The guinea pig recovered uneventfully and did not show any signs of recurrence upto 6 months post-surgery (Fig.4). Telephonic follow up upto 1 year post surgery did not report any recurrence of tumour.

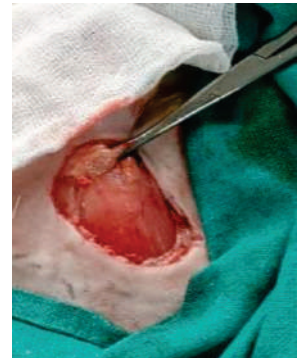


Fig. 2: Intra-operative photograph after complete excision of affected mammary gland in guinea pig.

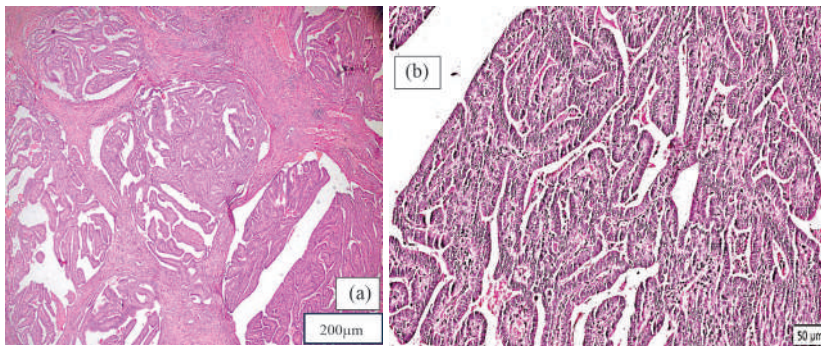


Fig 3. Histopathology Microphotographs showing epithelial cells proliferation in the form of papillary projections along with desmoplasia (H&E 10X) (a), and Neoplastic epithelial cells showing severe pleomorphism, hyperchromasia with minimal proliferation of connective tissue suggestive of papillary carcinoma (H&E 40X) (b).

Discussion

Spontaneous tumors are unlikely to occur in guinea pigs younger than 3 years of age, with higher incidence of occurrence and malignancy in older animals (Bertram et al., 2025). Malignancy of tumour may be ruled out on thoracic radiography (Greenacre, 2004), but confirmatory diagnosis is usually made on histopathological examination and necropsy findings (Birchard & Sherding, 2005).

The male guinea pigs are more commonly reported to be affected with mammary gland carcinoma as compared to females which is rare when compared with other mammalian species (Suárez-Bonnet et al., 2010; Kondert & Mayer, 2017). No particular reason for higher incidence of mammary tumour in male guinea pigs is reported, even though these glands are rudimentary in males. Mammary tumors in guinea pigs are generally locally invasive, large and highly vascular, but rarely metastasize. It can affect one or both the mammary glands.

Various anaesthetic protocols have been described for carrying out surgical procedures in guinea pigs using atropine, xylazine, ketamine, diazepam in different combinations. The recommended dose rate for ketamine is 35-40mg/ Kg body weight and xylazine is 4-8 mg/ Kg body weight. (Anderson, 2009), but in the presented case report, doses much less than recommended range were administered intramuscular, and desired effect was produced. It is further recommended to maintain the patient on mask, mainly with isoflurane, as endotracheal intubation is not possible majority of the times due to small oral cavity of the rodents.

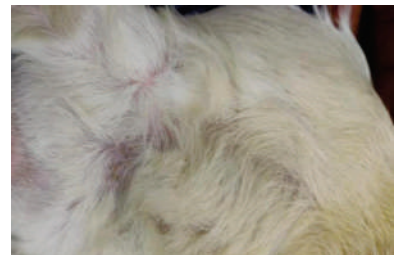


Fig. 4: Photograph showing the healed site of incision covered with hair on 6-month follow-up.

The 60% cases of mammary tumors in guinea pigs are papillary carcinoma (Suárez-Bonnet et al. 2010); whereas, adenocarcinoma is also reported common in guinea pigs (Kaiser, 1989). Complete excision of mammary tumour in guinea pig is reported to have no re-occurrence (Kanfer & Reavill, 2013). However, mean survival rate was found to be similar in untreated versus surgically resected malignant or benign mammary tumour by Raymond et al. (2024). In this case study, the guinea pig continued to survive without any recurrence, at least till one year post surgery.

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*Short Communication***Intraoperative Radiography to Localize Fully Penetrating Metallic Wire in the Reticulum of a buffalo for its Successful Retrieval****Ashwani Kumar and Vandana Sangwan***

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Abstract

A 5-year-old buffalo was radiographically diagnosed with foreign body syndrome and underwent left flank exploratory laparo-rumenotomy under local infiltration anesthesia. During surgical exploration, a linear metallic wire, previously identified radiographically in the mid-diaphragmatic region, could not be accessed due to extensive fibrous tissue. A stab incision was made over the suspected site of the embedded foreign body, but retrieval was unsuccessful. To aid localization, an artery forceps was clamped to one edge of the stab incision as a marker, and a left to right lateral radiograph was obtained, aiming to determine the relative position of the embedded foreign body in relation to the marker (artery forceps). This case study highlights the clinical utility of intraoperative radiography in accurately localizing fully embedded potential linear metallic foreign body (single wire) in the reticulum of bovines, particularly when manual palpation is limited by adhesions.

Key words: *Bovine, Foreign body syndrome, Radiography, Rumenotomy, Surgery*

Bovines, being indiscriminate feeders, often ingest various foreign materials, including sharp metallic foreign bodies (FBs), which can lead to serious complications (Braun et al., 2020). These sharp FBs may perforate the reticular wall in different directions, resulting in conditions such as traumatic reticuloperitonitis, pericarditis and abscess formation (Braun et al., 2020). In many cases, particularly in buffaloes, perforated FBs remain embedded within fibrous tracts (Sangwan et al., 2018; Kumar et al., 2018). Due to excessive adhesions, manual palpation may not always allow precise localization of these FBs. Radiography has proven to be a reliable diagnostic aid for detecting reticular FBs and is highly accurate in identifying perforating ones (Fubini et al., 1990; Makhdoomi et al., 2018).

In orthopedic procedures, intraoperative radiography is commonly employed to guide implant insertion and ensure proper positioning (Kaur et al., 2015; Keil et al., 2018). This case study reports the successful use of intraoperative radiography to localize a fully embedded metallic foreign body in the reticulum of a buffalo.

Case Description

A 5-year-old buffalo underwent radiographic examination, which revealed a linear metallic wire located at the level of the mid-diaphragmatic region, along with additional radiopaque material in the cranio-ventral sac of the reticulum (Fig. 1). The buffalo was subsequently subjected to a left flank exploratory laparo-rumenotomy under local infiltration anesthesia using 2% lignocaine. During surgery, radiopaque materials, including sand and small sharp metallic fragments, were retrieved from the cranio-ventral sac of the reticulum. However, the linear metallic wire visible on x-ray could not be palpated due to the presence of extensive fibrous tissue in that region.

A stab incision was made through the reticular lumen along the fibrous tract in an attempt to retrieve the fully embedded FB, but this initial effort was unsuccessful. Subsequently, the decision was made to perform intraoperative reticulography using a radiopaque marker. An artery forceps was clamped to one margin of the incised reticular wall, and a left-to-right lateral radiograph of the reticular region was obtained. The image revealed the metallic wire positioned cranial to the tip of the artery forceps (Fig. 2).

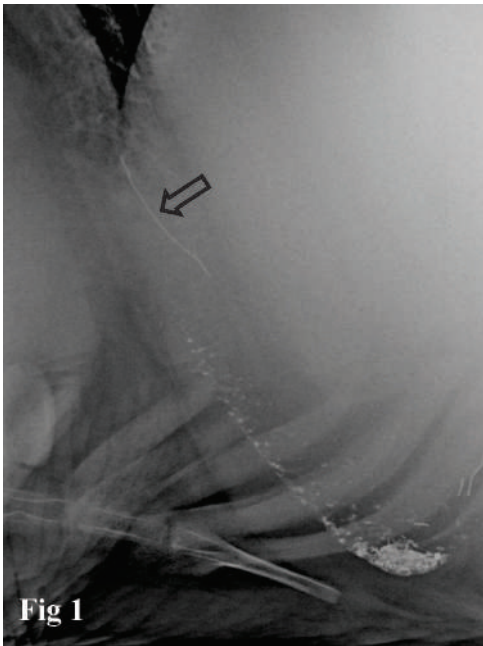


Fig. 1 Preoperative radiograph showing poorly demarcated diaphragmatic line and a linear metallic opacity (wire) in the mid diaphragmatic region and some radiopaque material in the ventral reticulum.

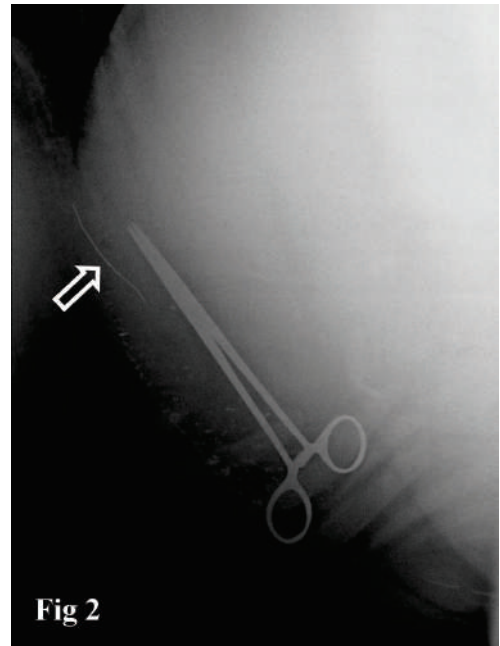


Fig. 2 Intraoperative radiograph showing an artery forceps close to the embedded metallic foreign body (wire) in the reticulum. The radiopaque material in the ventral reticulum that was detected preoperatively has been removed.

Guided by this finding, further surgical exploration and incision along the adjoining fibrous tissue enabled successful retrieval of the metallic foreign body. The rumenotomy and laparotomy wounds were then closed in the routine manner (Sangwan et al., 2018).

Discussion

The diagnostic features of free-lying or perforating FB in the reticulum have been well-documented in the literature, often with high accuracy (Makhdoomi et al., 2018). Embedded sharp metallic FBs in the reticular wall of cows and buffaloes are typically associated with pathological changes such as abscesses, nodules, fibrotic cords, diffuse fibrosis or in some cases, no apparent abnormality. These foreign bodies have been successfully retrieved either by making a stab incision or by squeezing the reticular wall during surgical intervention (Sangwan et al., 2018).

Amongst the various methods used to locate FBs, plain radiography remains one of the simplest, quickest, most accessible, cost-effective and widely recommended techniques. Obtaining two or more radiographic views allows for the reconstruction of a three-dimensional image from two-dimensional images, thereby facilitating accurate localization and retrieval of FBs (Holmes et al., 2005). However, due to anatomical and positional limitations in bovines, it is typically only feasible to obtain a lateral view of the reticulum. The use of artery forceps or other radiopaque markers may aid in determining the relative position of an embedded FB in such cases.

While interventional radiography is routinely employed in both medical and veterinary orthopedic surgeries and various other procedures, but the use of intraoperative radiography specifically for localizing reticular foreign bodies in bovines has not been previously reported. This clinical communication aims to share personal experience in this regard, and further studies involving a larger sample size are recommended to validate these preliminary findings.

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*Clinical Article***Ear Cropping as A Novel Surgical Approach for the Treatment of Recurrent Aural Hematoma: A Case Series of Three Dogs****Nikita Gupta, Sukriti, Pawandeep Kaur and Vandana Sangwan***

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Abstract

The present report describes the successful treatment of ear hematoma in 3 old dogs presented for re-occurrence by conventional treatment or chronic hematoma. A 7-year-old Beagle, 10-years-old Labrador and a 9-year-old German Shepherd were presented with the complaint of recurrent ear hematoma. All the three dogs had chronic otitis. Since the dogs were old and re-conventional surgery was tiresome and had increased risk of anaesthesia with every surgery. All the three dogs were treated by cropping the ears bilaterally as an alternative to conventional therapy. All the dogs recovered uneventfully. The study recommends ear cropping or pinnectomy as a novel surgical approach for the treatment of chronic recurrent ear hematoma in dogs, with minimal or no complications.

Keywords: Dog, Ear cropping, Hematoma, Recurrence, Surgery

Ear cropping is conventionally termed as a cosmetic procedure to improve physical appearance in certain breeds of dogs. Earlier, it was done to prevent any injury during fight or hunting in working dogs (Packova & Tacakova, 2020). But lately this practice has been banned across the globe due to its contradictory notion towards ethics of animal welfare. However, ear cropping or pinnectomy may be necessary in cases of certain pinnal affections where medicinal therapy and surgical treatment does not yield any favorable result. The chances of recurrence of ear hematoma are negligible after draining the fluid and placing mattress sutures throughout the affected pinna leaving the incision open for continuous drainage (Fossum, 2012), but the recurrence is still reported. Though, the exact cause of recurrence is not known. The present case study reports 3 such cases of dogs with recurrent ear hematoma that were successfully treated with bilateral ear cropping.

Case History and Presentation

Three dogs; a 7 years old Beagle, a 10-year-old Labrador and a 9 years old German Shepherd (GSD), were presented with the complaint of ear hematoma. The Labrador had one ear affected, whereas the Beagle and the German Shepherd had both

ears affected. All the dogs had chronic ear canal infection. The beagle and Labrador had re-occurrence after conventional repair while the GSD hematoma got ruptured due to chronicity. Considering the old age of dogs and recurrent risk of anesthesia and long post-operative care, ear cropping was advised. The otitis was also treated alongside the surgery right from the start, but still it was re-occurring.

Surgical Treatment

All the dogs were premedicated with xylazine @0.5 mg/Kg and atropine @0.04mg/Kg, intramuscularly, and induced with propofol @2-4 mg/Kg given to effect and were maintained on isoflurane mixed in 100% oxygen after intubation. The surgical site was aseptically prepared and the dogs were positioned in sternal recumbency with ear canals temporarily blocked with cotton (Fig.1).

A large artery forceps was placed diagonally along the pinna in such a way that upper point of forceps coincided with the cranial most point of pinnal flap on the medial ear margin and lowermost point was along the lateral border, a point till which the flap was to be excised. The part dorsal to the forceps was excised and the lateral edge was rounded with scissors to prevent dog ear formation. The hematoma got itself drained when the pinna was cropped. Ear cropping was done from the base with very small pinna left, so that no cavity is left. The skin on the concave and convex side of the pinna was sutured together, without involving the cartilage in simple continuous pattern with nylon. The ends of the thread were left long on either side and were not knotted (Fig. 2) to avoid wrinkling of the suture line. Post-operatively dogs were prescribed with antibiotics and analgesics for 5 and 3 days respectively. The owners were advised to keep the ear canal clean and regularly dress the sutures. Suture removal was recommended after 10 days of surgery. All the dogs recovered uneventfully.



Fig. 1. A 9 years old German Shepherd seen positioned in sternal recumbency and is draped accurately for ear cropping



Fig.2. Immediate post-operative photograph of German Shepherd with both ear cropped

Discussion

All the dogs presented were aged and had severe ear canal changes. Otitis in such cases could be a secondary reason for ear hematoma. Beagle and Labradors are prone to otitis due to droopy ears (Hewitt & Bajwa, 2020), while German Shepherds due to erect ears leading to passage of water in canal. Ear cropping tends to improve air flow in the canal and hence, alleviate the risk of infections and may be advantageous for dogs with chronic otitis (Packova & Tacakova, 2020).

Several surgical procedures such as ‘S’ shaped or linear incision with suturing, cannulation of hematoma, placement of drain, suction drainage are recommended to treat hematoma (Hewitt & Bajwa, 2020). The recurrence of ear hematoma is rare after surgical intervention (Fossum, 2012). The exact cause of recurrence in present dogs is not known however, age related non-union of ear skin to the cartilage might be a contributing factor. Ears are highly sensitive to pain due to multiple fine nerve endings, especially in older dogs and hence ear cropping or ear hematoma repair is recommended to be done under general anesthesia only. This technique of ear cropping from the base was found advantageous in such dogs due to the following reasons:

1. Re-occurrence is not possible
2. Multiple anesthesia episodes can be avoided.
3. Long term care of dog is not required as it take 10 days for suture removal while conventional ear hematoma require at least 21 days for suture removal.
4. Multiple antibiotics episodes can be avoided in old dog.
5. Bandaging of conventional ear hematoma repair is tiresome for dog and lead to accumulation of ear canal contents leading to increase in otitis externa, which can be avoided in ear cropping by applying-collar after 2-3 days of surgery and thus indirectly helps in treating otitis externa.

This study recommends ear cropping or pinnectomy in cases of recurrent or complicated ear hematoma in aged dogs, with minimal or no complications.

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*Mini Review***Sodium Ion Channels as Potential Drug Targets****Saima Manzoor* and Saloni Singla**Department of Veterinary Pharmacology and Toxicology
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Abstract

Voltage-gated sodium channels are ubiquitously in the body, present in excitable and non-excitable cells. They are selective for Na⁺ ions only, allowing their entry into the cells. This function is of critical importance in excitation of cells such as neurons and Purkinje fibres. Any abnormality in the functioning of voltage gated sodium channels result in diseases and disorders referred as channelopathies like epilepsy, neuropathic pain and may even lead to cancer. Hence, compounds that possess the ability to block these sodium channels have a therapeutic potential in various disorders that result from the altered function of voltage-gated sodium channels. Therefore, voltage gated sodium channels act a promising and potential therapeutic target for those compounds that can modulate their function and act as ligands for their application in that particular disorder.

Keywords: *Voltage-gated sodium channel, Channelopathy, Nociception, Neurotoxins, Epilepsy.*

The role of voltage-gated sodium channels in the generation of action potential was demonstrated by Hodgkin and Huxley (Bennet et al., 2019). These channels are heteromeric transmembrane proteins with a generalised distribution in different cell types throughout the body that provide selective permeability to Na⁺ ions into the cell. This leads to the accumulation of Na⁺ ions in the interior of cells and causing their depolarization, which is a crucial property in excitable cells like neurons (Mathie 2010). In addition, these channels are also found in non-excitable cells like astrocytes, microglia, and macrophages. These ion channels represent the second largest receptors for drugs following G-protein coupled receptors (GPCRs). Approximately 13.4% of the drugs approved by FDA in the market currently target the ion channels. It has direct implications in conditions, including epilepsy, cardiac arrhythmias, and many more diseases as target therapeutic (Horne et al., 2021).

Sodium ion channels in mammals are of 2 types: voltage-gated sodium channel (VGSC) and the epithelial sodium channel (ESC). The structure of VGSCs consists of pore-forming α -subunits and 1-2 β -subunits. Both these subunits are associated non-covalently (α with β 1 or β 3) or covalently, e.g. by means of a disulfide bond (α with β 2 or β 4) (Horne et al., 2021). The VGSCs has been reported to be of 9 subtypes (Na_v 1.1-Na_v

1,9) (Hernandez and Richards, 2019), all of which act as the molecular targets for a varied range of natural toxins including tetrodotoxin (TTX), batrachotoxins (BTX), saxitoxin (STX), peptide toxins isolated from venoms of scorpions, spiders, sea anemones, cone snails (Ruiz and Kraus, 2015). These toxins interact with various receptor sites on the VGSC, thus inhibiting or modulating the gating properties of the Na_v channels. In these cells play a significant role in various activities like regulation of phagocytosis, cell motility, and metastatic activity (Hernandez and Richards, 2019).

Classification of Sodium Channels

Voltage-gated sodium channels (Nav) are often classified based on their sensitivity to guanidine-based neurotoxins like tetrodotoxin (TTX). They are broadly classified into 2 types.

TTx sensitive	TTx resistant
Blocked in nanomolar concentration	Blocked in micromolar concentration
Na_v 1.1, Na_v 1.4, Na_v 1.6 and Na_v 1.7	Na_v 1.5, Na_v 1.8 and Na_v 1.9

It has 6 major binding sites (Fig.1) located on the VGSCs to which various neurotoxins and related compounds, bind to produce a pharmacological effect (Ruiz and Kraus, 2015). Sodium channel subtypes Nav1.9, Nav1.4 and Nav1.6 are known to generate persistent currents in sensory neurons, muscle fibers and Purkinje neurons, respectively. Mutations in the genes encoding various sodium channel subtypes (SCN1A, SCN2A, SCN3A, SCN8A and SCN9A) cause defects in inactivation gating, increasing persistent I_{Na} , leading to multiple disorders including ataxia and epilepsy.

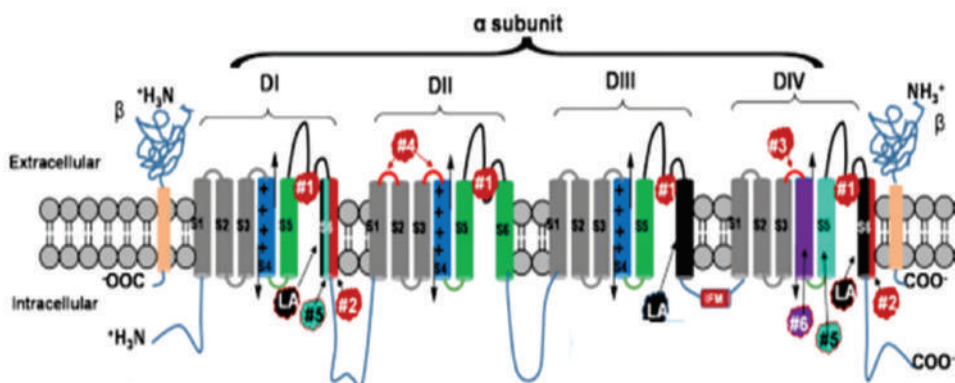


Fig 1. Binding sites located on the VGSCs ((Ruiz and Kraus, 2015).

Dynamics of VGSC

VGSCs consist of a voltage-dependent activating gate and a time-dependent inactivating gate that work in tandem, ensuring efficient depolarization. There are at least 3 functional states of sodium ion channels. (1) Resting (closed) state: This is due to

the membrane repolarisation (membrane potentials fall below -60 mV). In this state, the membrane is sensitive to stimulation, allowing rapid influx of Na^+ ions. (2) Activated (open) state: Here converted into an activated (open) state for brief period of time, continuous influx of ion. (3) Third stage (closed state): Upon certain conformational changes, the channel enters the inactivated (closed) state, preventing further in-ward movement of sodium ions. Many molecules or drugs such as amino acids, isoleucine, phenylalanine, methionine (IFM motif) inactivate the ionic gate and hence play an important role in the inactivation of sodium channels. The inactivation millisecond process characterised by rapid decay of sodium current (I_{Na}) in response to short depolarisations and is known as 'fast inactivation'. However, when nerve and muscle fibres are depolarised for a period of seconds, sodium channels take a considerable time during inactivation (seconds to minutes), resulting in a "slow-inactivation state". This may be due to long-term changes in resting membrane potential or repetitive neuronal firing (Mathie, 2010).

Channelopathies

Advances in the understanding of protein paved the way for understanding of the disease conditions as well as the understanding of various channelopathies. This has ultimately led to the identification of ion channels as drug targets (Bennett et al., 2019). Dysfunction in the VGSCs can be either due to genetic mutations or acquired. Toxins derived from marine animals have a preference for blocking VGSCs, resulting in sensory abnormalities and muscle weakness (Ruiz and Krauss, 2015). One of the important toxins in this class is tetrodotoxin from pufferfish (Tetraodontidae).

Pain: Nociception is defined as the detection of actual or threatened tissue injury and hence provides a survival advantage. Pain signals are sensed by the nerve terminals of the primary sensory neurons (Hernandez and Richards, 2019). VGSCs play a vital role in the generation of action potential that results in neurotransmitter release, transmitting the pain signal to the brain (Mathie, 2010). The conventional analgesics (non-steroidal anti-inflammatory agents, corticosteroids and, opioids) are not very useful in some conditions like neuropathic pain and also have potential for adverse effects such as drug tolerance. In such a cases sodium channels would be target for pain control pathway. The sodium channel subtypes ($\text{Na}_v1.3$, $\text{Na}_v1.7$, $\text{Na}_v1.8$ and $\text{Na}_v1.9$) have been found to have significant role in the activation of nociceptive neurons. Selective targeting of such channels can help to alleviate conditions of pain. $\text{Na}_v1.3$ channel is a potential target for analgesics through it has some homology with other channels (85% homology with $\text{Na}_v1.2$) that limits the likelihood of developing a selective blocker. On the other hand, $\text{Na}_v1.7$ has a relatively specific expression in the peripheral nervous system (PNS) except the olfactory neurons. This implies that the development of analgesics targeted to the channel subtype would not only increase the efficacy and would have fewer side effects (Bennett et al., 2019).

Consequently, diverse novel therapeutic approaches are being used in the development of Na_v 1.7 selective inhibitors, including the use of peptide toxins, small molecules, and molecular antibodies directed against this channel. The following are the various spider venom peptides that target the VGSCs, forming an inhibitory cysteine knot motif and hence blocking the channel:

1. ProTx-II, isolated from the tarantula *Thrixopelma pruriens*
2. Huwentoxin-IV (HWTX-IV), isolated from the Chinese bird spider *Selenocosmia huwena*
3. μ -theraphotoxin- Pn3a, isolated from tarantula *Pamphobeteus nigricolor*
4. Gp-Tx1 peptide is another toxin purified from Tarantula venom
5. Monoclonal antibody like SVMab1 as a potent and selective inhibitor of Na_v 1.7 is of great significance in the alternative approaches to pain management therapy.
6. Peptide μ -SLPTX-Ssm6a, a purified toxin extracted from the Chinese red-headed centipede (*Scolopendra subspinipes mutilans*) inhibits Na_v 1.7 channel and is reported to inhibit the pain related behaviour in terms of reflex withdrawal to noxious stimuli (Ruiz and Krauss., 2015).
7. PF-05089771, a clinical compound, structurally related preclinical tool compound, PF 05198007, have also been reported to have high Na_v 1.7 selectivity by binding to the voltage-sensing region in D4 (Bennett et al., 2019).
8. A-803467, a multitude of novel compounds having potential to selectively block Na_v 1.8 channel subtype hence providing significant analgesia in neuropathic and inflammatory pain have been developed. It is developed by Abbott Laboratories that causes acute and selective blockade Na_v 1.8 channel subtype.
9. PF-01247324, is a novel and orally bioavailable compound developed by Pfizer having potent analgesic activity as reported in rodent models.
10. QX-314, is a quaternary amine derivative of lidocaine and is reported to block 30% of the peak sodium currents. The compound is currently not in the clinical study, however has great potential for its use in a pharmacogenomics approach in the treatment of pain (Hernandez and Richards, 2019).

Epilepsy: Epilepsy is a complex brain disorder manifested by recurrent seizures. It is not a single disease but a group of disorders characterised by a multitude of clinical signs, with the age of onset and underlying causes. Epilepsy is one of the most common neurological diseases of dogs, with a prevalence of 0.6-0.75% in the general dog population similar to the prevalence of epilepsy in humans (Loscher, 2022). Epileptic dogs serve as a natural model for human epilepsy in research and drug development. The International Veterinary Epilepsy Task Force (IVETF) divides epilepsy into the categories of structural

epilepsy this may be due to acquired or inherited structural changes in brain and idiopathic epilepsy (Menezes et al., 2020). In epileptic dogs the percentage of drug resistance is nearly $\geq 50\%$, which is significantly higher than in humans (25-30%). Na_v channels are distributed throughout the body and play an important role in action potential generation. Na_v 1.1, Na_v 1.2, Na_v 1.3 and Na_v 1.6 encoded by the genes SCN1A, SCN2A, SCN3A and SCN8A, respectively are channel subtypes related to epilepsy. Therefore, compounds that can effectively target these channel subtypes present promising potential for their use in controlling epilepsy in the canine population. Both α and β subunits of the VGSC are known to be the cause of epilepsy phenotype (Loscher, 2022). XEN-901 (Xenon) is a potent, highly selective Na_v 1.6 channel blocker. Lacosamide acts by enhancing slow inactivation of neuronal Na_v channels. GS967 (Gilead sciences) is a novel sodium channel blocker that effectively inhibits Na_v 1.6 subtypes and has nearly 10 fold greater potency than phenytoin an anti-epileptic drug. Ranolazine is an anti-arrhythmic drug that blocks late I_{Na} selectively blocking Na_v 1.2 and hence shows significant anti-convulsant activity (Menezes et al., 2020).

Cancer: The VGSC Na_v 1.5 distributed throughout the cardiac tissues is reported to be encoded by the gene SCN5A in dogs and is involved in the generation of action potential (Scornik et al., 2006). This channel subtype has been found to be upregulated in several metastatic cancers like breast, ovarian and colon cancer. It has been reported that in the highly metastatic breast cancer cell line MDA-MB-231, the expression of Na_v 1.5 was 1800 times that in normal breast tissue, whereas the expression was lower in weakly metastatic cancer cell line MCF-7 (Horne et al., 2021). This clearly implies that the expression of Na_v 1.5 subtype has a close association with the metastatic behaviour. Similar reports have been found with the VGSC subtype Na_v 1.7 over expression in certain metastatic cancers cases such as prostate, lung and gastric cancers. In this case inhibition of VGSCs would prevent metastasis and tumour occurrence, especially with the use of tetrodotoxin (TTX). In addition to this, an FDA-approved antiarrhythmic drug, ranolazine, was found effective in preventing the invasiveness of breast and prostate cancer cell lines. Local anesthetic drugs (lidocaine and levobupivacaine) also seem to exhibit antitumor activity in various human breast cancer cell under *in vitro* and *in vivo* condition experimental condition. Compounds that act by inhibiting Na_v 1.5 channel like ropivacaine and naringen are reported to have significant efficacy against metastatic colon cancer and prostate cancer, respectively. Eicosapentaenoic acid which blocks Na_v 1.5 channels, prevents the proliferation of ovarian cancer cell lines (Horne et al., 2021). This confirms the potential of sodium channel blockers in the therapeutic management of various cancers. However, this property of VGSCs remains largely an untapped field and requires more research and better understanding and its application under clinical practice.

Epithelial Sodium Channels (ENaC)

This plays a critical role in the maintenance of blood pressure, electrolyte and fluid balance thus, regulating salt and water homeostasis. It belongs to a family of cation-selective ion channels (Moore and Tarran, 2018). ENaC is expressed in epithelial and non-epithelial tissues throughout the body including the entire length of the multi-ciliated cells in the lung and reproductive tract. It forms the rate-limiting step for transepithelial Na^+ absorption (Loscher, 2022). ENaC is a heterotrimer comprised of homologous subunits α, β, γ , forming a pore that is highly selective for Na^+ and Li^+ over K^+ ions, arranged in a counter clockwise symmetry (Moore and Tarran., 2018). Mutations in ENaC resulting in gain- or loss-of-function, can cause hereditary diseases such as Liddle syndrome (LS), cystic fibrosis (CF) or generalized pseudo hypoaldosteronism type 1 (PHA-1B). The ENaC inhibitors BI 1265162 (Boehringer Ingelheim), GS-9411 (Parion Sciences), AZD5634 (AstraZeneca) show significant potential in the treatment of cystic fibrosis (Gruber and Tzotzos., 2023).

In summary, there have been major advances in sodium channel drug discovery over the last decade however the synthesis of ion channel friendly small molecule libraries to facilitate discovery, and the establishment of meaningful clinical paradigms, including development of target engagement indices, to test rigorously an agent's therapeutic potential, are now the key elements to focus on in order to make development of new ion channel drugs a successful enterprise.

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Short Communication

When Diabetes Turns Dangerous: Understanding Diabetic Ketoacidosis in Dogs

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Abstract

Diabetic ketoacidosis (DKA) is a life-threatening metabolic complication of poorly controlled diabetes mellitus in dogs. It results from insulin deficiency, leading to uncontrolled lipolysis and the generation of ketone bodies, which in turn cause metabolic acidosis, dehydration, and severe electrolyte imbalance. This article provides a comprehensive overview of the pathophysiology, clinical signs, diagnostic markers, and treatment strategies for DKA in dogs. Emphasis is placed on timely diagnosis, aggressive fluid therapy, insulin administration, and monitoring protocols necessary for successful outcomes and improve long-term diabetic management in canine patients.

Key words: *Diabetic ketoacidosis, Electrolyte imbalance, Insulin, Lipolysis, Pathophysiology*

Canine diabetes mellitus, though manageable, can sometimes turn into a critical and life-threatening situation known as diabetic ketoacidosis (DKA). This serious condition arises when insulin levels in the dog's body fall dangerously low, either due to untreated or poorly controlled diabetes, missed insulin doses, or additional stressors such as infections, inflammation, or other concurrent diseases. When there is insufficient insulin, the body cannot use glucose as fuel and starts using fat as a substitute. This condition is known as diabetic ketoacidosis. This metabolic switch produces too many acidic substances called ketone bodies even though it temporarily produces energy. When severe metabolic acidosis is caused by excessive ketones, severe dehydration, and electrolyte imbalance, a dog's health can rapidly deteriorate if treatment is delayed (Macintire, 1993; Elendu et al., 2023).

Pathophysiology The systemic disorder brought on by insulin insufficiency has implications in the pathophysiology of DKA. Insulin regulates fat metabolism and is necessary for the uptake of glucose into cells. Without it, hyperglycemia results from glucose staying trapped in the bloodstream. At the same time, the body releases counter-regulatory hormones such as cortisol, glucagon, growth hormone, and catecholamines

because it perceives this shortage of cellular glucose as starving. These hormones speed up the breakdown of fat by further promoting gluconeogenesis and lipolysis. The liver transforms free fatty acids that are released from fat reserves into ketone bodies, specifically acetoacetate, beta-hydroxybutyrate, and acetone. Metabolic acidosis results from the accumulation of ketones in the blood, which lowers pH. Osmotic diuresis brought on by hyperglycemia exacerbates the illness and results in substantial fluid and electrolyte losses, particularly of potassium, sodium, and phosphate (Feingold et al., 2018.).

Clinical signs: Depending on the severity of the illness, dogs with DKA may exhibit a wide range of symptoms that vary in strength. Initial symptoms, such as increased thirst (polydipsia) and frequent urination (polyuria), frequently resemble those of simple diabetes. More serious symptoms like depression, anorexia, vomiting, diarrhea, and weight loss start to appear as the illness worsens. Dogs may appear dehydrated, feeble, and listless. Some show neurological signs in later stages, such as coma, seizures, or disorientation. Acetone is a volatile ketone that causes a characteristic sweet or fruity odor on the breath, which is one of the telltale symptoms of DKA. As a compensatory reaction to acidosis, Kussmaul respiration—deep, laborious breathing—is occasionally seen.

Diagnosis: A thorough assessment of the dog's medical history, symptoms, and lab results is necessary to diagnose DKA. Three hallmark criteria are usually used to make the final diagnosis: metabolic acidosis, which is indicated by low blood pH or decreased bicarbonate levels; persistent hyperglycemia, which is defined as blood glucose levels over 250 mg/dL; and ketonemia or ketonuria, which is defined as the presence of ketones in blood or urine. An increased anion gap, azotemia, and electrolyte abnormalities such hypokalemia, hyponatremia, and hypophosphatemia are common additional laboratory results. Leukocytosis is commonly seen as a result of underlying infections or stress. Capillary blood ketone measures are also used in modern veterinary clinics, especially for beta-hydroxybutyrate, which is thought to be a more accurate marker than acetoacetate, which is the sole ketone detected by conventional urine dipstick testing (Elendu et al., 2023)

Treatment: Dogs with DKA require rigorous hospitalization, usually for many days, and its management is complicated. Restoring hydration, addressing electrolyte and acid-base imbalances, lowering blood glucose and ketone levels, and determining and treating any underlying or precipitating reasons are the main objectives of treatment. The initial course of treatment is fluid therapy. Intravenous fluids, usually isotonic saline (0.9% NaCl), aid in improving circulation and correcting dehydration. Supplementing with potassium and phosphate is frequently necessary because insulin drives these electrolytes

into cells, which can result in hazardous shortages if not constantly watched (Hillman, 1987; Nelson and Couto, 2014).

The primary method of treatment for DKA is insulin therapy. Insulin is regularly given as periodic intramuscular injections or as a continuous rate infusion (CRI). Blood glucose and ketone levels can be gradually and steadily reduced using the CRI approach, which also makes strict management and monitoring easier. The goal is to avoid hypoglycemia while keeping blood glucose levels within a safe range, usually between 150 and 250 mg/dL. For continued diabetic care, the insulin regimen is switched to a long-acting subcutaneous formulation once the patient stabilizes and starts eating (Macintire, 1993). Throughout the entire course of treatment, monitoring is crucial. Assessments of vital signs, blood glucose, electrolytes, and hydration status must be made often, sometimes hourly in the early stages. Although it is uncommon, cerebral edema is a potentially fatal consequence of DKA that can be indicated by changes in respiratory or neurological state. Blood gas analysis is also used to assess acid-base status, and sodium bicarbonate may be cautiously given if fluid and insulin therapy alone are unable to alleviate acidosis (Elendu et al., 2023).

Management: To avoid recurrence, it is equally crucial to identify and treat the underlying cause of DKA. Stressors including pancreatitis, urinary tract infections, or endocrine abnormalities like Cushing's disease frequently cause DKA. To identify the precipitating component, more blood tests, urine cultures, and diagnostic imaging may be required. After stabilizing, the dog moves from critical care to long-term diabetes treatment, which includes monthly veterinary checkups, a diabetic-friendly food, and customized insulin therapy (Higgs, 2013). The rapidity of diagnosis, the severity of the condition at presentation, and the existence of concomitant conditions all have a significant impact on the prognosis for dogs with DKA. Research indicates that over 70% of dogs treated with DKA survive, with the majority needing to stay in the hospital for five to six days. However, results can be much worsened by undiagnosed underlying conditions or delayed treatment. Early detection and timely action are therefore crucial (Macintire, 1993; Elendu et al., 2023).

Gaps and Scope of Research in India: Clinical Veterinary research is still in its infancy in India, especially when it comes to companion animal endocrinopathies such as diabetic ketoacidosis (DKA). Large-scale epidemiological studies that accurately depict the prevalence and clinical diversity of DKA in Indian canine communities are conspicuously lacking. The lack of standardized, evidence-based protocols that are adapted to local situations frequently results in a wide range of diagnostic and treatment approaches. Furthermore, prompt and precise diagnosis is hampered by the underutilization of sophisticated diagnostic techniques such as continuous glucose monitoring and beta-hydroxybutyrate testing. The lack of multi-institutional clinical trials that evaluate

treatment efficacy, long-term outcomes, and recurrence rates represents another notable gap. Additionally, little is known about region-specific characteristics like owner compliance, dietary trends, and breed vulnerability. Strengthening the Veterinary diagnostic infrastructure, encouraging collaborative investigations, and incorporating digital tools for disease management and surveillance are key to the future of clinical research in India. More focused and significant research may be conducted with the help of national databases and links between academia and industry, which will ultimately improve clinical results in Veterinary practice.

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Mini Review

An Overview of Assessing the Quality and Grading of Chicken Eggs for Pricing, Marketing, and Storage

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Abstract

The poultry industry is showing a very good growth rate due to increased domestic demand for chicken meat and eggs. Eggs are an important source of valuable nutrients in the human diet due to the presence of high biological protein. Assessment of egg quality is very important for supplying good quality eggs to the consumers, better prices to the producers, grading, transportation and marketing of eggs. Egg grading depends on the quality (cleanliness, thickness) of their different components, such as shell, shell membrane, albumin and yolk that maintains nutritional quality and longer shelf life. External and internal qualities of eggs can be measured by candling, calculation of Haugh unit and yolk index. In India grading of chicken eggs is based on the weight (extra-large, large, medium and small) and quality of eggs (Grade A and B). This article overviews the role of egg shell, albumin, yolk and air cell in assessing the overall quality of chicken eggs. Quality evaluation and grading are decisive factors for determining the pricing, marketing and storage quality of eggs.

Keywords: *Air cell, candling, Haugh unit, yolk index*

The poultry industry in India is showing fast and steady growth in our country. As per BAHS (2024), total egg production in India is 142.77 billion nos. Egg production has shown a growth rate of 3.17% in comparison to the previous year, which is 2022-23. India is now 2nd largest producer of poultry eggs after China (BAHS, 2024). Among the total egg produced, 80% production is reported from the commercial poultry i.e., organised sector. The top five egg producing States of India are Andhra Pradesh (17.85%), Tamil Nadu (15.64%), Telangana (12.87%), West Bengal (11.37%) and Karnataka (6.62%). These states together contribute 64.37% of the total egg production in the country. The contribution of Punjab in the total egg production of country is 4.52%. The Per capita availability of eggs in India has reached to 103 eggs per annum but still it is too less than the recommended value i.e. 180 eggs/person/year recommended by the Indian Council of Medical Research.

Chicken eggs are a major source of important nutrients such as proteins, fat, minerals and vitamins (Miranda et al., 2015). Eggs contain about 12-17% protein which provides all the essential amino acids. For this reason, the egg protein is considered

of high quality. The protein efficiency ratio of egg protein is 3.9 which is the highest among all biological proteins such as casein- 2.5, pea nuts-1.8, soy protein- 2.2, wheat gluten-0.8 and whey protein-3.2. Consuming two servings per day can fulfil about 25 percent of our daily protein requirement. About 4.5 grams of fat is present in one egg which is composed of essential fatty acids such as linolenic and arachidonic acid which are important components of the human diet. Eggs also contain essential minerals like iron, phosphorus and zinc in abundant quantities (Fraeye et al., 2012). Eggs also contain water- and fat-soluble vitamins (Vitamin A, D, E, K and B complex vitamins) in abundance. The egg is an important part of human nutrition, especially for children, lactating and pregnant women (Natoli et al., 2007). Considering the nutritive value of eggs, it is important to assess the quality and grading of eggs to ensure the supply of safe and wholesome product to the consumers along with providing fair prices to the poultry farmers.

EGG QUALITY ASSESSING PARAMETERS

A chicken egg mainly consists of a shell, shell membranes, albumin (egg white), and yolk. About 11% of the egg consists of shell, 58% egg white or albumin and 31% yolk. The quality of eggs is mainly evaluated on the basis of its size and weight, quality of shell, shape of shell, quality of albumin and yolk. Evaluation of quality of eggs is essential for consumer acceptance as it is as important food product and also for its price fixation, storage and marketing.

1. Egg Shell: Egg shell is outermost hard but fragile protective covering of eggs. Though nonedible, but it is very important determinant of good quality eggs (Ketta and Tumova, 2016). It prevents entry of the microbes inside the albumin and egg yolk, thus saves it from getting spoiled. Chicken egg shells are found in different colours, mainly white and brown shell eggs are seen in the market. The colour of egg shell is decided by the breeds of chickens. In general, the egg shell colour of white feathered hens (white leghorn) is white whereas of brown feathered hens (Rhode Island Reds and Plymouth Rocks) is brown. It is very important for egg shells to be clean and strong. The strength of the shell depends on its calcium content, which in turn depends on the amount of minerals included in the diet of hens, especially the calcium. Excessive thinness of the egg shells results in cracks on the shell and their abundance may be a sign of poorly hatched eggs (Wengerska et al., 2023). There will be a rapid evaporation of moisture in thin-shelled eggs, and at the same time, the dissolved carbon dioxide in the egg white will come out, which will deteriorate the quality of egg white (albumin) and egg yolk. Besides excessive thinness of the egg shell has been documented as the main reason for their cracking or breaking during storage and transportation (Hamilton and Bryden, 2021).

2. Air Cell: An air cell is found at the broad end of the egg in between the two-shell membrane. When eggs are stored for a longer period, their moisture evaporates,

increasing air cell size which indicates the poor quality of eggs (Samli et al., 2005). Good quality eggs have an air cell depth of 1/8-3/16 inches. In poor quality eggs, the air cell depth increases to more than 3/8 of an inch. Due to an increase in air cell size, old eggs float in water, whereas fresh eggs sink in water.

3. Egg Albumin (Egg white) As a result of increase in the storage time of eggs, the quality of the albumen also decreases (Gao et al., 2017). The pH of albumen in fresh eggs is 7.6, which can increase to 9.7 in eggs stored for a longer time at higher temperature and low humidity (Scheideler et al., 2010). Increased alkalinity in stored eggs results in a thin consistency of albumin. On breaking the old or spoiled eggs, albumin will flow like water, whereas in fresh eggs, the albumin will spread in a circular shape around the egg yolk.

4. Egg Yolk: Long term storage of eggs at higher temperature depletes the quality of egg-yolk (Gao et al., 2017). During storage of eggs, water is transferred from the albumen to the yolk leading to swelling of the yolk part, and rupture of the vitelline membrane. Due to the breakdown of this membrane, mixing of albumin and eggshell will be there that will increase the microbial spoilage of eggs (Jin et al., 2022). The alkalinity of the yolk also increases with the storage time of eggs (Jin et al., 2011). When fresh eggs are broken, the yolk expands into a spherical shape and the albumin expands around it. When old/spoiled eggs are broken, mixture of yolk and albumin will be obtained.

METHODS FOR EVALUATING EGG QUALITY

1. Candling: Candling is an excellent way to evaluate the quality of eggs without breaking them. In this method, the egg is exposed to a bright light source that passes through it. A ray of light passing through the egg reveals its internal structure and the condition of the shell (Ragni et al., 2010). From candling, we get the following information-

- Crack in the shell
- Size of air cell
- Thickening/thinning of albumin
- Condition and mobility of the yolk
- Possible presence of blood spots, dead tissue
- Possible presence of mold
- Developing embryo

2. Haugh's Unit: Haugh's unit is determined to assess the quality of egg albumin (Monira et al., 2003). Haugh's units are calculated by measuring the height of the concentrated albumin and the weight of the egg. Haugh's unit is an important measure to assess internal egg quality and freshness. Tripod micrometre is used to measure the height

of the inner thick egg albumin. Good quality eggs have Haugh units higher than 72. In poor-quality eggs, it may decline to 60 or less.

The formula for calculating the Haugh unit (HU) is: $HU = 100 \log (H + 7.57 - 1.7W^{0.37})$

In this formula, H is the height of the albumen in millimetres and W is the weight of the egg in grams.

3. Yolk Index: Yolk index indicates the quality of egg yolk (Marzec et al., 2016). It is a ratio of yolk height to yolk diameter. It is measured using micrometre and Vernier calliper. Eggs with an index of yolk index more than 0.28 are considered fresh. When eggs are stored for a long time, the yolk index decreases.

EGG GRADING

Grading of eggs is the process of classification of eggs on the basis of weight, quality of shell, albumin and yolk. Grading has important commercial application in the price fixation and marketing (Kingori, 2012). Grading also provides the assurance of egg quality to the consumers. As per the norms of Bureau of Indian Standards (BIS, 1981) and Agricultural Produce -Grading and Marking (AGMARK, 1968), Chicken eggs can be graded in in two ways-

- A. On the basis of weight of eggs.
- B. On the basis of quality of eggs

A. Egg Grading Based on Weight: The weight of chicken eggs ranges from 40 to 70 grams which. depends on various factors like the heredity of the birds, the season of laying eggs, the age of the birds and their diet. The weight of an egg does not have a direct relationship with the quality of eggs. Smaller eggs may have a higher proportion of yolk and shell as compared to large eggs.

On the basis of weight, eggs are divided into four categories (AGMARK, 1968).

- **Extra-large Eggs** - The eggs having weight was more than 60 grams.
- **Large Eggs** - The eggs having weigh between 53 grams to 59 grams.
- **Medium Eggs** – Eggs having weight ranges from 45 grams to 52 grams.
- **Small Eggs** - The eggs having weight from 38 grams to 44 grams.

Eggs weighing less than 38 grams are very small eggs and these are not considered for grading/classification.

B. Egg Grading Based on Quality of Egg Component: Eggs are divided into two categories (Grade A and B) based on the quality of shell, albumin, yolk and air cell (As per BIS, 1981).

Sr No.	Egg Component	Grade A	Grade B
1.	Egg shell	Very clean, without any cracks (intact), strong and normal in shape.	Clear to moderately stained, strong but pitted and unusual in shape.
2.	Air cell	The depth of the air cell <8 mm and is positioned at a fixed level.	The depth of the air cell is <8 mm and its position is fixed or free.
3.	Albumin (Egg white)	Clear and thick	Clear but slightly thin
4.	Yolk	The yolk is clear and situated in the centre of the egg. It is free from all kinds of spots like blood and flesh, having unclear edges.	The yolk deviates from the centre of the egg.

Quality evaluation and grading of eggs is important practice in the layer industry. The automation of grading systems may help the speed up the growth of layer industry in India. There is need to evolve non-destructible, simple, and more objective methods that can determine the quality and grades of eggs.

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Mini Review

Key Welfare Indicators for Dairy Animals: Assessment and Management

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Abstract

Ensuring dairy animal welfare is crucial for both ethical farming and productivity. Welfare indicators are categorized into animal-based (health, behaviour, and physiological responses) and resource-based (housing, feeding, and management). Key health indicators include body condition, lameness, injuries, mastitis incidence, and reproductive health. Behavioural indicators assess natural behaviours, avoidance distance, resting patterns, and feed intake, while physiological indicators track stress hormones, heart rate, and digestion efficiency. Resource-based factors like housing space, ventilation, bedding quality, nutrition, and handling practices significantly impact welfare. Proper implementation of these measures enhances productivity, milk yield, and longevity across dairy species such as cows and buffaloes..

Keywords: *Behaviour, Dairy animals, Health, Management, Nutrition, Welfare indicator*

Ensuring well-being of the dairy animals is essential for both animal health and farm productivity. Welfare indicators help evaluate their overall condition by assessing their health, behaviour, and environment. These indicators fall into two main categories: animal-based indicators (which focus on the animal's physical and behavioural well-being) and resource-based indicators (which examine housing, management, and environmental conditions).

1. ANIMAL-BASED INDICATORS

A. Health Indicators

These indicators help detect potential health issues, injuries, and nutritional concerns.

- **Body Condition Score (BCS):** Among these, the BCS is widely used and validated as an objective measure of subcutaneous fat reserves. Rather than offering a general interpretation, recent studies have emphasized its predictive value for metabolic health and productivity. The BCS, typically scored on a

5-point, is strongly correlated with reproductive efficiency, milk yield, and risk of periparturient disorders. Optimal BCS at calving is associated with better fertility and milk output. The adoption of automated BCS assessment technologies, such as 3D cameras and image recognition software, has improved the objectivity and reliability of scoring, minimizing inter-observer variability and enhancing real-time herd monitoring (Amin et al., 2023).

- **Lameness Score:** Evaluates an animal's mobility on a 1-to-5 scale, with higher scores indicating severe lameness. Poor flooring, inadequate hoof care, or infections like digital dermatitis often contribute to mobility issues (Sadiq et al., 2017). Studies in buffaloes show similar lameness patterns and impacts on productivity (Garg et al., 2020).
- **Injuries and Lesions:** Observing cows and buffaloes for wounds, bruises, or hair loss can help identify issues related to overcrowding, poor stall design, or improper handling.
- **Mastitis and Somatic Cell Count (SCC):** Mastitis, an inflammatory condition of the udder often caused by bacterial infection, remains one of the most prevalent and costly diseases in dairy animals. SCC is a standard proxy used to detect subclinical and clinical mastitis. The permissible SCC threshold in bulk tank milk is <200,000 cells/mL, according to the European Union and United States Pasteurized Milk Ordinance standards. Levels above 250,000 cells/mL in individual cows are typically indicative of subclinical mastitis (Ruegg, 2017). However, buffaloes show comparable thresholds to cows, and proper milking hygiene and stress reduction are effective preventive measures. The elevated SCC levels are also associated with physiological and environmental stressors suggesting that stress—whether from thermal load, overcrowding, or poor management—can predispose dairy animals to mastitis or exacerbate its severity.
- **Reproductive Health:** Reproductive performance is an integrated reflection of an animal's physiological resilience, nutritional balance, and overall welfare. Key metrics include conception rate, calving interval, and postpartum recovery time. Deviation from optimal values is often linked to chronic stress, negative energy balance, and subclinical disease. Cooke et al. (2018) found that cows subjected to elevated stress levels (measured via cortisol and haptoglobin) during the peripartum period exhibited significantly longer postpartum anoestrus intervals, impairing timely breeding. In buffaloes, stress and nutrition similarly impact ovarian activity and fertility (Perera, 2011).
- Environmental and social stressors, such as overcrowding and regrouping, have also been shown to suppress oestrus expression and delay ovulation (Dobson et

al., 2007), further underscoring the multifactorial basis of reproductive health in dairy systems.

B. Behavioural Indicators

Behavioural indicators are critical, non-invasive tools for assessing the welfare status of dairy animals. Deviations from normal behaviour patterns often serve as early signs of stress, discomfort, or suboptimal management conditions.

- **Expression of Natural Behaviours:** Cows and buffaloes have an innate need to perform behaviours such as grazing, ruminating, grooming, lying, and social interaction. Tethering reduces the frequency of such behaviours in dairy cows (Knierim et al., 2020). In addition, buffaloes seek wallowing or water access to regulate body temperature (Napolitano et al., 2004).
- **Avoidance Distance:** Avoidance distance at the feeding rack or in free approach is used as a validated indicator of human–animal relationship quality. High avoidance indicates stress from negative handling, shown in both buffaloes (Sutherland et al., 2013) and cows (Waiblinger et al., 2006).
- **Lying and Resting Behaviour:** Dairy animals naturally lie down for 12–14 hours per day to rest and ruminate. Inadequate lying time is a strong indicator of discomfort, poor stall design, or health issues. Sadiq et al. (2017) reported that dairy animals with inadequate bedding or poorly designed stalls spent more time standing, leading to increased risk of lameness and hoof problems. Moreover, reduced lying time correlates with elevated stress and decreased milk production.
- **Feed and Water Intake:** Decreased intake of feed and water often indicates stress, illness, or poor feed quality. Botheras et al. (2007) demonstrated that dairy animals exposed to unpredictable or aversive events consumed less feed and showed reduced feeding bouts. Furthermore, access to clean palatable water is essential for maintaining rumination and milk yield.
- **Ruminating Behaviour:** Rumination is a critical behaviour reflecting both digestive efficiency and comfort. Rumination time drops during illness or poor feeding, affecting digestion and milk production (Munksgaard et al., 2003). Cooper et al. (2007) found that comfortable lying spaces enhanced rumination time by allowing cows to ruminate undisturbed, which in turn improved feed digestibility and milk yield.

C. Physiological Indicators

Physiological indicators provide objective, quantifiable insights into a cow's internal state, offering valuable measures of stress, health, and nutritional status. These indicators often complement behavioural observations in comprehensive welfare assessments.

- **Cortisol Levels (Stress Hormone):** Cortisol is a well-established biomarker of acute and chronic stress in dairy cattle. It can be non-invasively measured in blood, milk, saliva, hair, and faces without inducing a handling stress. Zanella et al. (2000) demonstrated elevated cortisol levels in cows subjected to negative handling or social disruption, correlating with increased heart rate and reduced immune function. Similarly, elevated cortisol is found to be linked to heat stress and aggressive handling in buffaloes (Andrade et al., 2020).
- **Heart and Respiratory Rates:** Heart rate (HR) and respiratory rate (RR) are sensitive to pain, illness, and environmental stressors. Normal heart rate (HR) and respiratory rate (RR) under thermoneutral conditions are 60–80 beats/min and 30–40 breaths/min in adult dairy cows, and 50–70 beats/min and 20–30 breaths/min in adult buffaloes (West, 2003). Increased HR and RRs are commonly observed during heat stress, lameness, or mastitis.
- **Rumen Fill Score:** Rumen fill scoring is a practical method to assess recent feed intake and gut function. Scored by visual inspection and palpation of the left paralumbar fossa, it ranges from 1 (very empty) to 5 (very full). A sunken or hollow left flank typically suggests insufficient intake, poor-quality feed, or impaired rumen motility. The dairy animals with a score ≤ 2 were found in negative energy balance or suffering from digestive disorders during early lactation (Roche et al., 2009).

2. RESOURCE-BASED INDICATORS

These basically evaluate the cow's environment.

A. Housing & Comfort

Resource-based indicators assess the quality of the environment provided to the animal, particularly housing design, hygiene, and comfort. These factors directly influence cow welfare, health, and productivity.

- **Space Allowance:** Adequate lying and movement space are essential to reduce competition, allow natural behaviours, and prevent injuries. Dairy cows typically require at least 3.5–4.5 m² per cow in free-stall systems for resting. Buffaloes need ≥ 4 m² in covered areas and double in open systems. Providing lesser space than recommended was found associated with increased standing time, reduced lying bouts, and higher rates of aggressive interactions in dairy animals (Miller-Cushon & Jensen, 2025).
- **Ventilation & Temperature Control:** Proper airflow, cooling fans, and shade structures are essential for preventing heat stress, which reduces feed intake, rumination, and milk yield. According to Collier et al. (2019), cows experience thermal stress at temperatures above 25°C, with observable declines in milk yield

and reproductive performance.

- **Housing Cleanliness:** Stall hygiene directly impacts animal's health, particularly for mastitis and hoof diseases. Dirty bedding increases bacterial exposure, especially to *E. coli* and *Streptococcus* spp., leading to udder infections. Leach et al. (2009) recommend at least twice-daily stall cleaning to minimize pathogen buildup and reduce the incidence of lameness from slurry accumulation.
- **Bedding Quality:** Soft, dry bedding enhances cow comfort, promotes longer lying times, and reduces injuries like lameness and hock lesions. Sand bedding has been proved ideal compared to straw and rubber mats with respect to the better hock health and cleanliness, longer lying times and reduced incidence of lameness (Cook et al. 2008).

B. Feeding & Nutrition

Feeding and nutritional conditions are critical for optimum productivity, health, and welfare. These indicators assess the availability, quality, and accessibility of feed and water resources.

- **Access to Clean Water:** Providing fresh, clean water ad libitum is essential for maintaining rumen function, thermoregulation, and milk yield. Cows producing high levels of milk can consume 70–150 liters of water per day, especially in warm conditions (Beede, 2006). Lactating buffaloes may consume up to 100 L/day, especially in hot climates (Collier et al., 2019).
- **Balanced Diet:** A nutritionally balanced ration should meet the animal's requirements for energy, fibre, protein, minerals, and vitamins. Deficiencies in nutrients—especially energy or protein—can lead to negative energy balance, resulting in weight loss, reproductive failure, and metabolic diseases. Lactating dairy cows and buffaloes are recommended to consume ~1.5–1.7 Mcal of net energy/kg DM with 28–34% neutral detergent fibre to support production, rumen health, and chewing activity (NRC, 2021).
- **Feed Availability and Competition:** Limited feeding space leads to aggression, reduced feed intake, and hierarchical stress, particularly in subordinate cows. A minimum of 60 cm of linear feed bunk space per cow and 75–90 cm per buffalo is recommended, especially during total mixed ration delivery (DeVries et al., 2004; Singh et al., 2018). Huzzey et al. (2006) showed that cows with greater feed bunk access had longer feeding times, more frequent meals, and lower cortisol levels, indicating reduced stress and improved welfare.

C. Management & Handling

Management practices—including the way animals are handled, monitored, and raised—are crucial components of welfare in dairy systems. These indicators reflect the

human-animal relationship and proactive health management.

- **Gentle Handling Practices:** Handling practices significantly affect behaviour, stress levels, and productivity of dairy animal. Rough handling, such as the use of electric prods, loud shouting, or abrupt movements, has been shown to elevate plasma cortisol concentrations, reduce milk yield, and increase avoidance behaviour (Rushen et al., 1999).
- **Routine Health Monitoring:** Preventive health care, including regular veterinary examinations, vaccinations, and parasite control, has been considered a key to detecting disease early and reducing morbidity. Mee (2007) emphasized that herd health monitoring programs incorporating lameness scoring, mastitis detection, and BCS are associated with improved longevity and productivity.
- **Calf Care:** Timely feeding of 4 liters of high-quality colostrum (>50 g IgG/L) within 2 hours of birth, along with proper housing, ventilation, and nutrition, is essential for both dairy calves and buffalo calves to reduce disease risk and enhance early growth (Chigerwe et al., 2009; Ranjan et al., 2006). Proper housing, ventilation, and nutrition during early life are also linked to reduced disease incidence and stress leading to improved weight gain.

Research Gaps and Future Scope of Research on Animal Welfare in India

Animal welfare research in India remains sparse and heavily reliant on Western models, which may not adequately address the diverse agro-climatic conditions, species differences (e.g., buffaloes vs. cows), and smallholder-dominated farming systems prevalent in the country. There is a significant lack of region-specific, validated animal-based welfare indicators, particularly for buffaloes. Moreover, limited research exists on the impact of heat stress, traditional housing, and manual handling practices on animal behaviour and physiology. Behavioural welfare markers are underexplored, and systematic studies on farmer awareness, attitudes, and adoption of welfare-enhancing practices are minimal. These gaps hinder the development of a contextualized, evidence-based welfare framework for Indian livestock..

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*Short Communication***Integrated Approaches to Air Pollution Control in Poultry Facilities****Shwetambri Jamwal* and Yashwant Singh**

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Abstract

Poultry housing environments are characterized by complex internal atmospheres containing various gases, including ammonia (NH₃), carbon dioxide (CO₂), methane (CH₄) and hydrogen sulphide (H₂S) primarily generated from the microbial degradation of poultry droppings. Ammonia, a major pollutant, results from the breakdown of uric acid and urea in manure under anaerobic conditions and poses serious threats to bird health, productivity and human safety. Key influencing factors such as bird density, manure handling, ventilation, temperature and feed composition are crucial for management of poultry houses as they directly impact bird health, productivity, environmental quality and overall biosecurity. A range of mitigation strategies across housing, litter and nutritional management like emphasizing optimized ventilation, use of chemical amendments, precision feeding, enzyme supplementation and biofiltration systems are essential for air quality. The adoption of integrated, science based interventions is crucial for minimizing gaseous emissions, enhancing bird welfare, safeguarding worker health and promoting environmental sustainability in poultry production systems.

Keywords: *Air quality, Ammonia, Bird, Pollutant, Poultry*

Poultry houses contain a dynamic internal atmosphere comprising various gases such as nitrogen (N₂), oxygen (O₂), carbon dioxide (CO₂), water vapour and small amounts of other gaseous substances. One of the primary contributors to air contamination in these environments is the accumulation of poultry droppings. These excreta are rich in organic materials and nitrogen compounds. As droppings pile up, the lower layers become oxygen deprived, creating anaerobic conditions. This environment facilitates microbial activity that breaks down organic and sulphurous compounds, leading to the production of gases like methane (CH₄), ammonium (NH₄⁺) and hydrogen sulphide (H₂S). These gases eventually volatilize into the barn air, particularly increasing ammonia (NH₃) levels. Generated from manure, ammonia is a major pollutant, with recommended indoor concentrations below 25 ppm to protect bird and worker health. High levels can cause respiratory disorders, reduced productivity and increased disease susceptibility in poultry, as well as eye, skin and respiratory irritation in workers (Bist *et al.*, 2023). Ammonia concentrations as low as 21 ppm can cause eye irritation in poultry handlers. Therefore,

timely removal of manure especially when NH_3 levels approach 15 ppm is essential for protecting human health and optimizing farm profitability (Fabian, 2019).

Types of Air Pollutants in Poultry Housing

The air inside poultry facilities can become contaminated by various pollutants, which can be grouped into the following categories:

- i. Particulate matter (PM): This includes dust from dried manure, feather and skin fragments and fine feed particles that become airborne. PM can carry pathogens, heavy metals and ammonia contributing to respiratory diseases in poultry and humans (Bist & Chai, 2022).
- ii. Airborne pathogens: Dust particles often carry bacteria, viruses and fungal spores, including *Aspergillus fumigatus*, which can be harmful to both birds and humans.
- iii. Gaseous emissions:
 - a. Ammonia (NH_3): Produced during the breakdown of poultry manure under moist and warm conditions. To maintain healthy flock performance, ammonia levels should not exceed 25 ppm.
 - b. Greenhouse gases: Poultry operations emit methane (CH_4), nitrous oxide (N_2O) and CO_2 , contributing to climate change.

Ammonia in Poultry Facilities

Ammonia plays a dual role in the environment because while it serves as an essential nitrogen source for plant growth and soil fertility, excessive accumulation can lead to air and water pollution, harming ecosystems and health. While it can neutralize acidic pollutants from fossil fuels and form particulate matter (NH_4^+ aerosols), its presence in poultry houses is primarily detrimental. Ammonia is generated from microbial degradation of uric acid and urea in manure and represents a nitrogen loss that could otherwise benefit crops as fertilizer. Both aerobic and anaerobic conditions contribute to its formation in housing and manure storage areas.

Major Ammonia Sources

- a. Urine (approx. 70%): Avian excreta contain high levels of uric acid, ammonia salts, and small amounts of urea and creatinine. Microbes quickly break down uric acid to produce ammonia.
- b. Faeces (approx. 30%): Contribute to ammonia through the degradation of nitrogenous materials.
- c. Volatilized NH_3 : This form is the primary airborne pollutant in poultry barns.

Consequences of Elevated Ammonia Levels

High ammonia concentrations negatively affect poultry:

- a. Growth performance: Decreased feed intake and reduced weight gain.
- b. Egg production: Lowered laying rates and poor egg quality, including increased albumen pH and decreased albumen height.
- c. Bird health: Respiratory tract damage, heightened vulnerability to infections like Newcastle disease, and higher rates of conditions such as air sacculitis and *Mycoplasma gallisepticum* infection.

Carbon Dioxide in Poultry Environments

Carbon dioxide accumulates from several sources, including bird respiration, fuel combustion, and microbial decomposition of organic matter. Brooding heaters using propane also add to CO₂ levels. The rate at which birds produce CO₂ is directly tied to their metabolic heat output, which varies with body weight, temperature, and activity. Diurnal changes can cause CO₂ levels to fluctuate by about 20%.

Factors Influencing Gas Production and Emission

Multiple variables affect the generation and release of harmful gases:

- i. Bird's density and weight: Greater bird numbers and body mass result in more waste and higher gas emissions.
- ii. Manure surface area: Larger droppings areas enhance anaerobic activity and gas release.
- iii. Manure retention time: Prolonged storage inside barns promotes microbial breakdown and gas buildup.
- iv. Ventilation efficiency: Poor ventilation increases indoor gas concentrations.
- v. Temperature and season: Warmer conditions and seasonal shifts can speed up microbial processes and gas volatilization.
- vi. Airflow and litter properties: Air movement, litter moisture, pH, temperature, and C:N ratio impact microbial activity and urease enzyme function.
- vii. Feed composition: Diets high in protein increase nitrogen in waste, leading to more ammonia.

Table 1. Integrated Mitigation Strategies to Air Pollution Control in Poultry Facilities

Strategy Type	Target Pollutant	Effectiveness	Citations
Litter Additives/ Amendments	NH ₃	50–90% reduction depending on application rate and system	Bist <i>et al.</i> , (2023)
Acid Scrubbers/ Biofiltration	NH ₃	Up to 95% reduction; highly effective but can be costly	Bist <i>et al.</i> , (2023)

Vegetative Buffers (VEBs)	NH ₃ , PM	Reduces NH ₃ to 8% and PM ₁₀ /PM _{2.5} to ~13% of original; more effective in daytime	Yang <i>et al.</i> , (2023)
Electrostatic Ionization	PM _{2.5}	Up to 32% reduction with longer wires; electricity use increases with system length	Bist <i>et al.</i> , (2024)
Oil/Water Spraying	PM ₁₀ , PM _{2.5}	21–60% reduction depending on system and bird type	Bist & Chai, (2022)
Frequent Cleaning/Manure Management	NH ₃ , PM	Reduces both pollutants; simple and cost-effective	Bist & Chai, (2022)
Dietary Manipulation	NH ₃ , Dust	Reduces emissions by altering nutrient excretion	Bist <i>et al.</i> , (2023)
Smart Prediction/Control	NH ₃ , CO ₂	Advanced models improve real-time air quality management	Bist <i>et al.</i> , (2023)

Mitigation Techniques for Air Pollutants

Managing harmful gases in poultry houses requires a combination of environmental, litter, and nutritional interventions:

1. Housing Management

- i. Optimized ventilation: Smart systems that are automated, sensor-based environmental control system are used in poultry housing to continuously monitors conditions such as gas concentrations (e.g., ammonia, CO₂), temperature, and humidity in real-time to maintain optimal air quality and comfort (Godinho *et al.*, 2025).
- ii. Hygiene practices:
 - a. Removal of old litter and waste at regular intervals.
 - b. Thorough washing and disinfection between flocks.
 - c. Adequate downtime for pathogen control.
 - d. Regular dust removal during production.
- iii. Dust Suppression: Aerosols of oils or water can reduce airborne dust by up to 50%.
- iv. Ozone Use: Effective in killing microbes and neutralizing gases. High-density ozone (≥ 40 mg/m³, >70% humidity) can kill 100% of bacteria and viruses in empty poultry houses within 30 minutes, also removing harmful gases and odors. (Okhrimenko et al., 2020)

- v. Vegetative Barriers: Trees and shrubs around barns help capture ammonia, filter particles, and serve as windbreaks.
- vi. Biofiltration Systems: Air passed through microbial filters can remove dust, odours and gases effectively (Bist *et al.*, 2023).
- vii. Air Scrubbing: Water-based systems, particularly with acidic solutions, can capture NH₃ and particulates (Bist *et al.*, 2023).
- viii. Electrostatic Precipitation: Charges particles in the air, which are then collected on plates, reducing airborne contaminants significantly (Bist *et al.*, 2024).

2. Litter Management

- i. Chemical Amendments:
 - a. Urease Inhibitors: Substances like zeolites, alum, and various salts reduce microbial activity and absorb moisture and odours. Zeolites can be applied directly to litter or manure surfaces or mixed with bedding material such as sawdust or straw, at a recommended dosage of 5–10% of the bedding material's weight or 500–1000 grams per square meter of floor area, once every one to two weeks (Schneider *et al.*, 2016).
 - b. Ammonia Binders: Compounds such as citric acid, yucca extract, and nitro-compounds lower pH and trap ammonia. Citric acid can be sprinkled directly onto litter or manure at a dosage of 100–150 g/m² for dry application or diluted in water as a 5–10% solution and sprayed at 200–300 ml/m² (Ivanov, 2001)
- ii. Litter composting: Controlled composting with proper moisture and carbon-nitrogen balance stabilizes nitrogen and reduces emissions. Additives like zeolites and aluminium salts further improve outcomes.

3. Nutritional Management

- i. Optimizing protein levels: Feeding only the necessary protein reduces nitrogen waste.
- ii. Precision feeding: Matching amino acid profiles to birds needs (phase feeding) minimizes excess nitrogen excretion. By adjusting the amino acid content of feed according to the birds' specific needs at different growth stages, less nitrogen is excreted as a byproduct. This approach helps reduce the environmental impact of poultry farming and can also improve feed efficiency and reduce costs (Tikate *et al.*, 2021).
- iii. Feed quality assurance: Using consistent ingredients avoids over-supplementation.
- iv. Enzyme additions: enzymes enhance protein digestion and reduce waste nitrogen.

- v. Improved digestibility measures: More accurate assessments of nutrient availability aid better feed formulations.
- vi. Immunization approaches: Vaccines or maternal antibodies targeting enzymes like urease and uricase can reduce ammonia production.
- vii. Direct-fed microbials (DFM): Certain probiotics improve digestion and gut health, reducing nitrogen excretion indirectly. For instance, 0.10% *Lactobacillus* culture has been found to reduce mortality in chickens from 8.2% in control birds to 3.2% (Fathi, 2013).

Gaps in Research and Future Prospects

Despite advancements in poultry air quality management, research in India remains limited on region specific thresholds for gas emissions and their localized health impacts on both poultry and workers. Many mitigation strategies, such as biofiltration, electrostatic ionization, and sensor-based control systems, lack validation under Indian climatic, economic and infrastructure conditions. Additionally, integration of smart ventilation and precision feeding systems is minimal in small to medium scale Indian poultry farms. Future research can be focused on cost effective, scalable interventions tailored to tropical conditions with farmer friendly training programs.

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*Short Communication***Bharat Pashudhan App: A Vital Tool for Genetic Improvement of Livestock in India****Swati Agrawal***Department of Animal Genetics and Breeding
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Abstract

In India, rearing of animals is not only a source of occupation but also a way of living, which has received a revolutionary shift with the introduction of advanced technologies in livestock farming practices. For better management of animal genetic resources and to enhance the productivity of farm animals the livestock owners as well as the animal breeders are seeking digital solutions. The Bharat Pashudhan App is a promising digital tool designed to facilitate livestock management and provide vital support to all those involved in stacking of livestock data. By serving as a source of large-scale phenotypic data on different aspects of animal production, reproduction, health and growth, Bharat Pashudhan App will perform a crucial role in genetic upgradation and formulation of livestock breeding programs in our country.

Keywords: *Animal breeding, Bharat Pashudhan App, Genetic improvement, Livestock.*

The agricultural landscape of India varies extensively and the livestock provides valuable support to the socio-economic dynamics of rural communities. From meat production to wool production, and from dairy farming to draught power, farm animals have a significant contribution towards day-to-day earning of millions of farmers. Indian livestock owners are increasingly seeking digital solutions for enhanced production and efficient management of their livestock. An invaluable digital solution has emerged in the form of the Bharat Pashudhan App which is a user-friendly digital resource with the capacity to transform livestock management and record keeping. It can be highly advantageous, particularly in the context of formulation and implementation of animal genetic improvement programmes. India is the highest milk producer in the world but the productivity per animal is quite low. Poor genetic potential is a major factor contributing to low productivity of indigenous animals. Availability of sufficient amount of phenotypic data can help boost the rate of genetic progress through adoption of unconventional breeding strategies. By digitization of livestock data pertaining to economically important characters, the app aides a centralised system developed for the recording and analysis of gathered phenotypic information.

Genesis and Functionalities of the App

The Bharat Pashudhan app was conceptualized by Department of Animal Husbandry & Dairying, Government of India in association with the National Dairy Development Board (Project “Bharat Pashudhan”. National Digital Livestock Mission). It originated under the “Bharat Pashudhan” National Digital Livestock Mission (NDLM) and uses a unique 12-digit Tag ID assigned to each animal. The app was officially launched on March 2, 2024 as an ingenious initiative to provide the livestock owners and policy makers with an explicit database on production, reproduction, breeding, health and other aspects of livestock rearing, thus serving as a platform for remarkable growth (Livestock Sector to have Digital Footprints Bharat Pashudhan/ 1962- Data Power in the hands of the livestock farmers; PIB, 2024). Field workers and animal owners use the app to upload and retrieve information regarding livestock transactions while the policy makers and animal breeders can utilise the collected information for further analysis. The following modules include some important functionalities of the app (National Digital Livestock Mission Blueprint):

Animal Management – This module includes registration of owner and his animals, transfer of ownership, change in ear tag, modification in details etc.

Animal Breeding – Data on artificial insemination, bull master/ semen straw evaluation, embryo transfer, test AI plan, pregnancy diagnosis, growth monitoring, milk recording and sampling are collected within this module.

Animal Health – Data related to disease testing, treatment, deworming, vaccination, surgery, disease reporting and post-mortem of animals is recorded within this module.

The app also has provision for the livestock owners to login through registered IDs to view the app’s data and access information on different breeds of livestock, their performance, characteristics and adaptability to different climates, prevailing livestock diseases along with their symptoms. Useful educational resources such as tutorials and articles on important topics related to rearing of farm animals are also incorporated in the app. With the help of this feature farmers can make informed decisions on breeding and management of livestock to improve their productivity and quality.

Genetic Status and Improvement Strategies for Indigenous Livestock

India has a wealth of varied and abundant livestock genetic resources. Each livestock species has several well-defined breeds which have been characterised and registered and their number is increasing with each passing year. Each breed has its unique traits and is valued for its ability to resist certain diseases and thrive in different agro-climatic conditions. However, the production potential of most of the indigenous breeds is quite low. A major reason for low productivity is poor genetic potential of a large proportion of population of each breed with only few elite or genetically superior

animals present in the population. Genetic upgradation is a cornerstone of improved livestock management. Genetic improvement can be brought about by selection and multiplication of elite germplasm through appropriate breeding strategies. However, a prerequisite for selective breeding is the presence of genomic diversity within the native breeds which is slowly being lost due to indiscriminate crossbreeding, habitat loss, and change in agricultural practices. With the objective of boosting productivity several high-yielding crossbreds have been developed in the country but this has resulted in the dilution of genetic purity of many indigenous breeds (Sarang et al., 2024). To address this problem the concerned government departments and research institutes have initiated a variety of conservation and genetic improvement programs for the native breeds of livestock. Efforts including breed registration, adoption of conservation strategies, and use of sustainable breeding practices play a pivotal role in nurturing the genetic health of indigenous livestock. Additionally, the advent of state-of-the-art genomic tools and application of latest technologies can further enhance the productivity as well as resilience of both native and improved breeds (Muner et al., 2025). However, the lack of availability of organised and accurate phenotypic data on traits of economic importance is the biggest challenge in the successful implementation of any genetic improvement program using modern tools and technologies. The rate and amount of genetic change that breeding programs can affect in livestock production largely depends on recording and analysis of phenotypic data. Collection of data at field level, by entering the details of every animal on day-to-day basis in the Bharat Pashudhan app, is likely to be the biggest contributor and the primary source of information on the observable characteristics of the animals.

Bharat Pashudhan App can Propel Genetic Improvement

The different ways in which this app can enhance the rate of genetic improvement can be discussed as under:

a. Comprehensive Data Management

Maintenance of detailed records is one of the fundamental requirements for genetic improvement. The Bharat Pashudhan app provides an excellent platform for comprehensive management of data.

- **Breeding Records:** Each breeding event such as date of AI, sire details, number of breeding attempts and their outcomes pertaining to each animal can be easily recorded in the app. The breeding records facilitate the tracking of genetic lineage of livestock.
- **Health and Performance Data:** Users can record the occurrence of diseases, their treatments and production metrics. This data can be subsequently used to assess the impact of genetic variation among animals on susceptibility to diseases

and response to a treatment regime. This will help in identification and selection of genetically superior animals for breeding.

b. Facilitating Informed Breeding Decisions

The Bharat Pashudhan app provides tools that aid data-driven breeding decisions.

- **Genetic Information:** The phenotypic data available in the app can be used to determine genetic profiles of different animal populations and breeds. This will enable breeders to choose the best pairs for breeding on the basis of genetic compatibility for desired traits.
- **Performance Analysis:** Analysis of the performance data can help in the identification of the most elite animals thus allowing targeted breeding to enhance a particular character.

c. Disease Management and Genetic Selection

Overall genetic upgradation calls for the selection of disease resistant animals. By supporting this aspect the Bharat Pashudhan app can mediate effective disease management.

- **Disease Tracking:** The app data can be used to track the occurrence of diseases and disease trends within a herd. By studying the effect of genetic traits of animals on disease susceptibility, a breeder can select individuals with greater disease resistance for the purpose of breeding. Early monitoring of the trend of diseases may also be helpful for better management and control of diseases.
- **Vaccination and Treatment Records:** Vaccination and treatment records of each animal can be accurately maintained, thus ensuring the animals health. Healthier animals will probably reproduce at a desirable rate and pass on the favourable genetic traits to their progeny.

d. Integration with National Programs

The Bharat Pashudhan app is a component of a broader national livestock improvement strategy. Its functionalities co-align with several national policies and programs.

- **Data Integration:** The data collected through this app can be integrated with other national databases for focussed genetic improvement. This integration can provide valuable insights on broader genetic objectives.
- **Policy Support:** Being a part of a national data system, the app can help in policy-making and implementation of proposed programs. The data-driven strategies are expected to be more effective in improving the overall genetic merit of livestock.

e. **Educational and Technical Support**

The Bharat Pashudhan App supports education and training of livestock farmers by providing valuable resources. Awareness among the farmers is necessary for efficient execution of genetic improvement programs.

- **Best Practices:** Educational material on important guidelines and improved practices for scientific breeding can be obtained from the app. This facilitates the adoption of advanced techniques by farmers to improve livestock genetics.
- **Expert Advice:** On the basis of the compiled history of each animal available in the app, the farmers can seek more accurate advice from veterinarians and breeders to streamline the animals managemental tasks.

Digitalization of India's Livestock Sector and its impact

The Bharat Pashudhan app is a proficient, safe, transparent, consolidated and reliable IT tool which can revolutionize India's livestock sector through:

- Increased Productivity** – By supporting organised breeding and genomic selection strategies, the app will improve the genetic potential for productivity among the animal populations. A permanent boost in the production traits such as milk yield, growth rate, meat yield will enhance productivity and ensure sustainable livestock operations.
- Improved Livestock Health** – Selection of disease resistant animals and active disease management will positively affect the overall health of a herd. Rearing of healthier animals will lead to reduction in veterinary costs and guarantee animal welfare.
- Economic Profits** – Increase in productivity and reduction in treatment related costs will be realised as higher economic returns for farmers. An improvement in the genetic background of farm animals will also result in better quality of animal products, thus making livestock farming economically more viable.
- Sustainable Operations** – By promoting scientific management and breeding of livestock with reduced need for medical interventions, this app will make livestock farming sustainable for a long term.
- Data-Driven Policies** – Formulation of national programs in accordance with the data provided by the app will support an evidence-based approach of policy making. Hence, the programs and policies will well align with the needs of the livestock sector and ensure achievement of expected results.

Future Challenges

For maximum exploitation of the Bharat Pashudhan app one may need to address and overcome the following challenges:

- a. **Digital Literacy** – To ensure its overall success it is essential that the veterinarians and farmers become proficient in handling the app. Organisation of training programs on regular basis at field level will help in building literacy and encourage widespread usage.
- b. **Data Security** – To establish trust among the farmers, safeguard their privacy and protect sensitive field information, the security measures adopted must be robust and impenetrable.
- c. **Lack of Connectivity** – Limited internet connectivity makes the use of digital resources in remote areas almost impossible. This issue needs to be addressed on priority for effective use of app across all regions.
- d. **Continuous Improvement** – Continuous updation of the app on the basis of user feedback is essential for its appropriate functioning. This can be done by incorporating any technological advancements and user-oriented changes which make the app relevant and effective with alterations at the genetic and environmental level.

In summary, a huge step has been taken towards the digitalisation of the Indian livestock sector by introduction of the Bharat Pashudhan app. Serving as a platform for collection and management of comprehensive data, the app supports datacentric breeding decisions and genetic improvement programs which are expected to be more effective in driving genetic changes. It has the potential to modernize Indian livestock farming practices by influencing all aspects of animal production and management.

To carry out genetic upgradation of our livestock population at an appropriate rate, genomic selection is the method of choice. However, the biggest hurdle in the adoption of this methodology is the non-availability of accurate phenotypic data on field animals. As the Bharat Pashudhan app is evolving and expanding its reach, real-time recording and tracking of the day-to-day events associated with each animal has become possible. The invaluable support that this app will provide to the animal breeders, geneticists and policy makers is beyond doubt.

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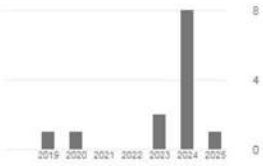
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