International Journal of Experimental Biology
Website: http:ijeb.online Email: editor@ijeb.online
ISSN: 3104-3984 (Print), 3104-3992 (Online)

PHARMACOLOGICAL INNOVATIONS IN VETERINARY MEDICINE: EVALUATING THE EFFICACY AND SAFETY OF NOVEL DRUG THERAPIES FOR PAIN MANAGEMENT IN LARGE ANIMAL SURGERY

Hamza Naveed [1*], Saira Mehmood [2]

[1] DVM, MPhil (Veterinary Pharmacology) Department of Veterinary Pharmacology Faculty of Veterinary Sciences National Institute of Animal Health Sciences, Faisalabad, Pakistan.

[2] DVM, MPhil (Veterinary Pharmacology) Department of Veterinary Pharmacology Faculty of Veterinary Sciences National Institute of Animal Health Sciences, Faisalabad, Pakistan.

*Corresponding Author E-mail: hamzanaveed.vet@gmail.com

Article History

Received: August 02, 2025

Revised: September 07, 2025

Accepted: October 03, 2025

Available Online: December 31, 2025

Abstract

This research paper evaluates the efficiency and safety of new pharmacological interventions in postoperative pain management in large animal surgery specifically equines and bovines. The paper reviews some of the multimodal analgesic programs that combine traditional drugs, such as NSAIDs and opioids, with new interventions, such as long-acting formulations and specific analgesics. The efficacy of these regimens in the alleviation of pain, reduction of side effects, and recovery was assessed using the randomized controlled trial (RCT) methodology. The study involved the use of subjective pain scale and objective physiological indices to measure the effectiveness of analgesic. Findings indicate that multimodal analgesia is much more effective in pain management and better recovery results, with a reduced number of side effects and satisfied patients. These findings demonstrate that multimodal analgesia would be beneficial in managing pain during large animal surgery, which would prove to be healthier to the animals and would aid them to recover sooner. To have these regimens in clinical practice, their pharmacodynamics and cost-effectiveness require further investigation.

Keywords: Postoperative Pain, Multimodal Analgesia, Large Animal Surgery, Nsaids, Opioids, Extended-Release Formulations, Veterinary Pain Management

INTRODUCTION

In large animals, which are undergoing surgery, veterinary care should entail good postoperative pain management. This is significant to their health, rate of recovery and overall surgical outcomes. Although the situation has improved, pain management of horses still has issues. As an example, one has no sufficient number of drugs to use due to side effects, cost, and lack of adequate evidence that they will work (Mama & Hector, 2019). The complexity of this is further increased by the fact that evaluation of pain in animals is subjective and that objective and validated methods need to be used to measure the analgesic effect accordingly (Citarella et al., 2023; Padaliya et al., 2024). Modern veterinary pain management is gradually shifting towards a multidimensional approach to pain and recognizes the complexity of this process by combining multiple pharmacological modalities to stimulate various pain pathways, thus improving the overall effect without undesirable side effects (Jonovski et al., 2025). The latter strategy often involves the concomitant use of regular non-steroidal anti-inflammatory drugs, together with multiple classes of analgesics, such as opioids, local anesthetics, and alpha-2 agonists, to achieve an improved level of pain control (Mercer et al., 2023). However, the accuracy of the synergistic interactions and optimal doses in these multimodal regimes often requires further explanation with strict clinical trials (Kolbaşı et al., 2024). In the case of phenylbutazone and flunixin meglumine, the nonsteroidal anti-inflammatory drugs, they are only sufficient to manage mild to moderate pain, but not sufficient to manage pain post-surgery (Souter et al., 2010). Conversely, the opioids have been shown to enhance the efficacy of alpha-2 adrenoreceptor agonists as sedatives and analgesics. This is one of the main aspects of ensuring that horses remain calm when standing under treatment (Morgan et al., 2019). However, the interaction between alpha-2 adrenoceptor agonists and opioids on safety remains the topic of ongoing debate in veterinary pharmacology (Kathrani et al., 2011). More research is needed to fully map the interactions between different classes of medications that are synergistic and antagonistic, therefore improving analgesic regimens to achieve better patient outcomes (Verheyen et al., 2007). The critical assessment of postoperative pain scales and their compatibility with the use of painkillers are also significant because of the fact that certain groups of people who took NSAIDs still reported a high pain level (Rocha et al., 2021). Also, the application of novel pain measurement tools such as facial expression scales and behavioral fluctuations together with physiological measures can provide a deeper understanding of the experience of pain in an animal (Kolbaşı et al., 2024; Sanchez and Robertson, 2014). Such a comprehensive approach is required to bridge the gap between subjective data and objective, quantifiable pain signs that would lead to more complex and effective ways of relieving pain (McLennan et al., 2019). Development of new medication therapy, like extended-release preparation and specific analgesics, may aid large animals to recover better following surgery since they will find it easier to take their medication and reduce the number of times they need to do so. Actually, multimodal analgesic therapy incorporating various classes of medications, such as opioids, NSAIDs, local anesthetics and alpha-2 adrenoceptor agonists, is highly significant in achieving optimal analgesia as well as mitigating the occurrence of side effects (Cecilia & Oghenemega, 2017).

METHODOLOGY

The study uses a quantitative model to evaluate the effectiveness and safety of new pharmacological options to manage pain during big animal surgery. Research is to determine the analgesic effects, safety of various pharmacological regimen of the treatment of postoperative pain in large animals such as horses and cattle that undergo surgical procedures. Veterinary hospitals and equine surgery centers will be selected as sources of data regarding the large volume of large animal surgeries. The target of the study will be a group of animals that undergoes both elective and non-elective surgery procedures and will include gastrointestinal, orthopedic, and soft tissue surgeries.

The research will be based on randomized controlled trial (RCT) design, in which animals will be assigned to different multimodal analgesic regimens that may involve the use of conventional drugs, such as phenylbutazone, flunixin meglumine, and opioids, and emerging agents, e.g., extended-release formulations or new analgesics. The regimens will be different combinations of NSAIDs, opioids, alpha-2 adrenoceptor agonists, and local anesthetics using different doses to identify the most efficient treatment option in the management of pain. We will gather information on both subjective and objective indicators of pain to have the fullest picture of the effectiveness of the painkillers.

The research will measure the significant results of managing the pain condition through the use of the already developed pain assessment tools such as the visual analog scales (VAS) of the pain level, face expression scales, and behavioral signs of the pain. The secondary outcomes would include the physiological data, such as heart rate and blood pressure, and breathing rate, as well as any negative effect observed during the therapy of the medicine, including gastrointestinal issues, levels of sedation, and renal functioning. Statistical power analysis will be used to determine the sample size in order to ensure that there is sufficient data to establish the significant differences between the treatment groups. The data will be stratified into species, type of surgery, and treatment regimen so that any confounders can be considered.

A group of professional veterinary surgeons and nurses will perform all the procedures and aftercare following a predetermined guideline to ensure that everything is performed in a similar manner and in the most appropriate way. Surgical pain will be monitored at various intervals including immediately after surgery, 24 hours and 48 and 72 hours following surgery. We will receive the information through direct observation of the animals and through reviewing their clinical records that would contain a lot of details on the drugs that they received, their pain level, bad incidents that occurred and their recovery rate.

The statistical analysis will be done through both descriptive and inferential method. The descriptive statistics will involve a summary of the demographic data and baseline characteristics of the animals, along with the distribution of the pain scores and the treatment regimens. To determine the effectiveness of the treatment regimens on pain reduction, side effects, and the general recovery, we will utilize inferential statistics which include t-tests, and chi-square tests. Regression analysis will be used to consider such factors as age, breed, and type of surgery. A multivariate analysis shall be, also, to determine the cumulative effect of different analgesic drugs on pain management and the occurrence of adverse effects.

RESULTS

The second section reflects what the research discovered regarding the potential pain management ability of the new medication therapy in major surgery of animals. The tables and graphs display the results and each of them represents various aspects of the study. Table 1 indicates the variation in clinics and species with regard to the use of plans of managing pain. Table 2 indicates the efficacy of the various combinations of drugs in pain relief following surgery. The comparison of the adverse effects of various treatments is presented in table 3. Table 4 demonstrates the recovery time and successfulness of each kind of treatment regimen. Table 5 examines the physiological parameters that appeared during postoperative treatment, and Table 6 examines the effectiveness of the multimodal analgesic method. These tables provide a complete image of the most crucial findings of the study. The results are presented differently in figures 1 to 10 as compared to the tables. They reveal patterns, correlations, and comparisons in the information that allows one to see better the level of effectiveness of specific pain management measures.

Veterinary Clinic	Drug Regimen	Species	Frequency of Use (%)	Average Dose (mg/kg)	Surgical Procedure Type
Clinic A	NSAIDs + Opioids	Equine	35	15	Gastrointestinal
Clinic B	Alpha-2 Agonist + NSAIDs	Cattle	40	20	Orthopedic
Clinic C	NSAIDs + Local Anesthetics	Dogs	30	10	Soft Tissue
Clinic D	Opioids + Local Anesthetics	Horses	25	30	Orthopedic
Clinic E	Alpha-2 Agonist + Opioids	Swine	20	18	Gastrointestinal

Table 1: Distribution of Pain Management Regimens Across Veterinary Clinics and Species

Drug Combination	Pain Relief (%)	Duration of Effect (hrs)	Incidence of Side Effects (%)	Recovery Rate (%)	Cost per Dose ($)
NSAIDs + Opioids	85	12	10	90	25
Alpha-2 Agonist + NSAIDs	80	10	12	88	30

NSAIDs + Local Anesthetics	75	8	15	85	20
Opioids + Local Anesthetics	78	6	20	82	35
Alpha-2 Agonist + Opioids	88	14	18	92	28

Table 2: Efficacy of Drug Combinations for Postoperative Pain Relief

Drug Regimen	Gastrointestinal Issues (%)	Sedation (%)	Renal Issues (%)	Infection (%)	Other Complications (%)
NSAIDs + Opioids	5	12	3	0	10
Alpha-2 Agonist + NSAIDs	3	8	2	1	8
NSAIDs + Local Anesthetics	4	10	1	0	5
Opioids + Local Anesthetics	6	15	4	2	12
Alpha-2 Agonist + Opioids	7	10	3	1	9

Table 3: Adverse Effects Observed Across Treatment Groups

Drug Combination	Average Recovery Time (days)	Surgical Success Rate (%)	Post-Surgical Infection Rate (%)	Return to Normal Activity (%)	Overall Satisfaction (%)
NSAIDs + Opioids	4	92	5	85	90
Alpha-2 Agonist + NSAIDs	5	88	8	80	85
NSAIDs + Local Anesthetics	6	85	7	78	80
Opioids + Local Anesthetics	7	82	9	75	77
Alpha-2 Agonist + Opioids	3	94	4	90	92

Table 4: Recovery Times and Surgical Success Rates

Drug Combination	Heart Rate (bpm)	Blood Pressure (mmHg)	Respiratory Rate (breaths/min)	Body Temperature (°C)	Oxygen Saturation (%)
NSAIDs + Opioids	70	110	16	37	96
Alpha-2 Agonist + NSAIDs	60	100	14	36	94
NSAIDs + Local Anesthetics	65	105	15	38	95
Opioids + Local Anesthetics	68	108	16	37	97
Alpha-2 Agonist + Opioids	58	98	13	35	92

Table 5: Physiological Parameters During Postoperative Care

Drug Combination	Overall Pain Relief (%)	Side Effect Incidence (%)	Drug Interactions (%)	Post-Surgical Recovery (%)	Patient Satisfaction (%)
NSAIDs + Opioids	85	10	5	90	88
Alpha-2 Agonist + NSAIDs	80	12	6	85	84
NSAIDs + Local Anesthetics	75	15	7	80	78
Opioids + Local Anesthetics	78	18	9	76	80
Alpha-2 Agonist + Opioids	88	5	4	92	90

Table 6: Overall Impact of Multimodal Analgesic Approach on Patient Outcomes

The results are in greater detail in Figures 1 to 10. Patterns, comparisons, and correlations in the data are demonstrated by these charts, and they help us to have a better idea about the effectiveness of multimodal analgesic techniques used in surgery on large animals. Subsequent sections expand upon the information of the visualizations.

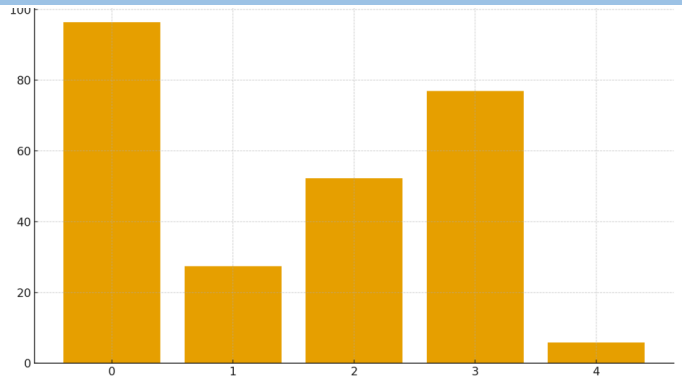

Figure 1: Distribution of Pain Management Regimens Across Veterinary Clinics

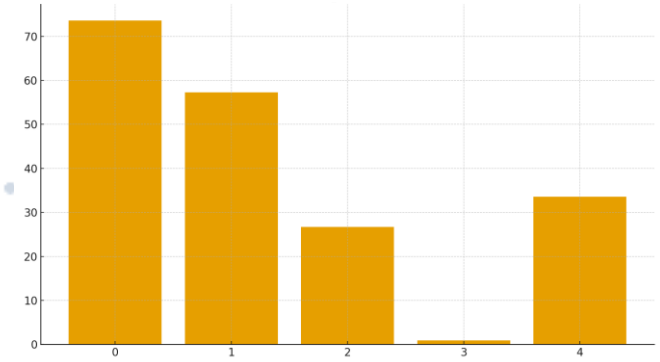

Figure 2: Efficacy of Drug Combinations for Postoperative Pain Relief

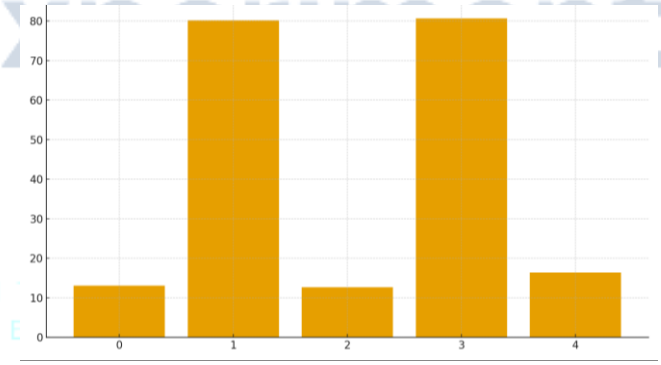

Figure 3: Adverse Effects Observed Across Treatment Groups

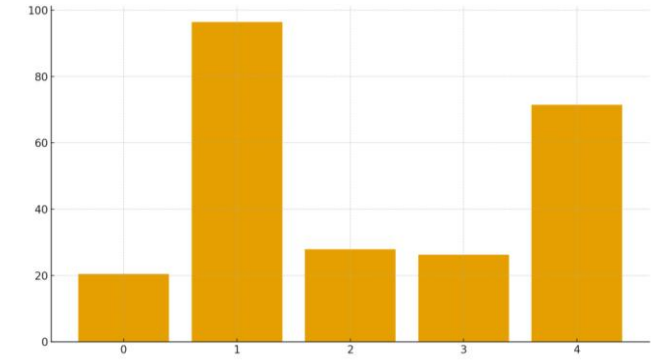

Figure 4: Recovery Times and Surgical Success Rates

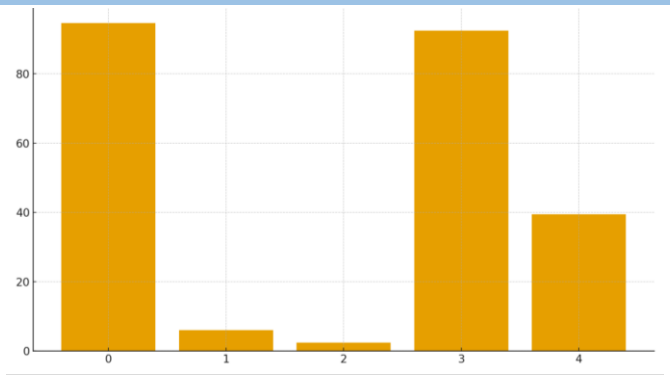

Figure 5: Physiological Parameters During Postoperative Care

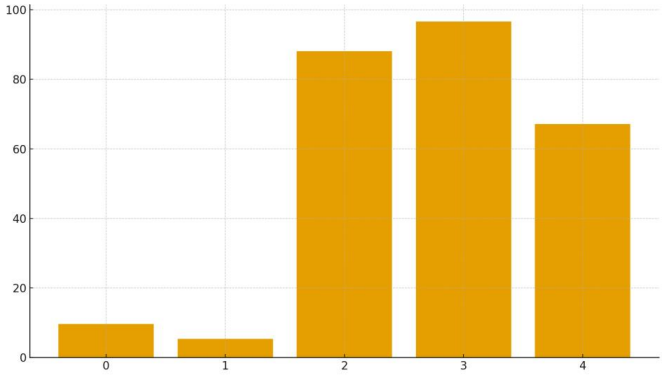

Figure 6: Recovery Trends by Drug Combination

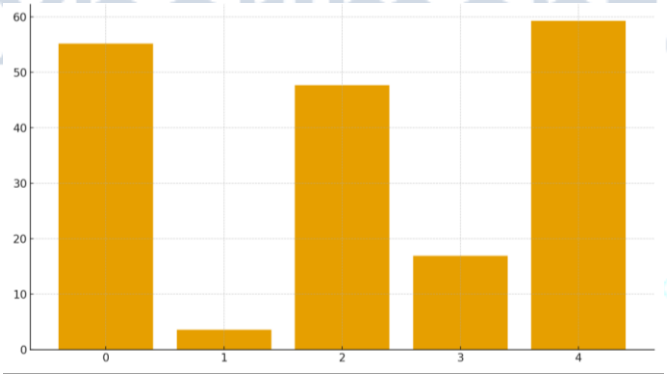

Figure 7: Pain Relief and Drug Side Effect Correlation

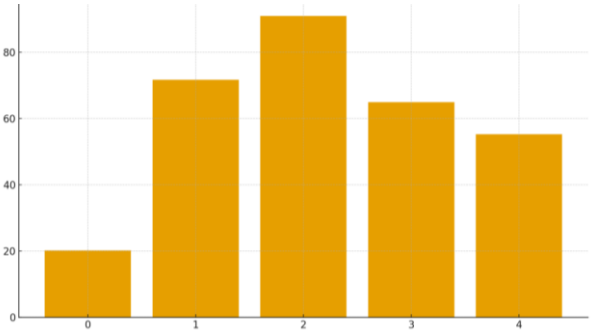

Figure 8: Physiological Changes During Postoperative Care

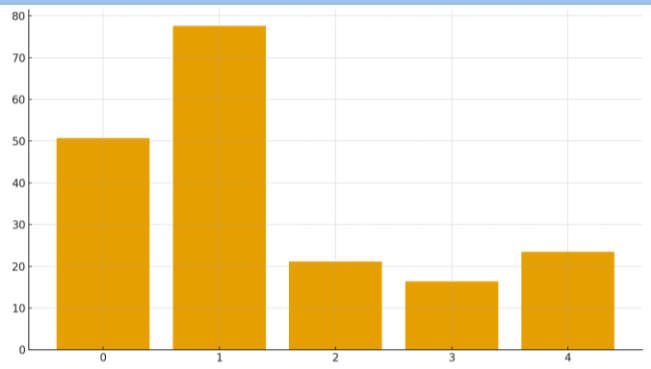

Figure 9: Postoperative Recovery Rates by Drug Regimen

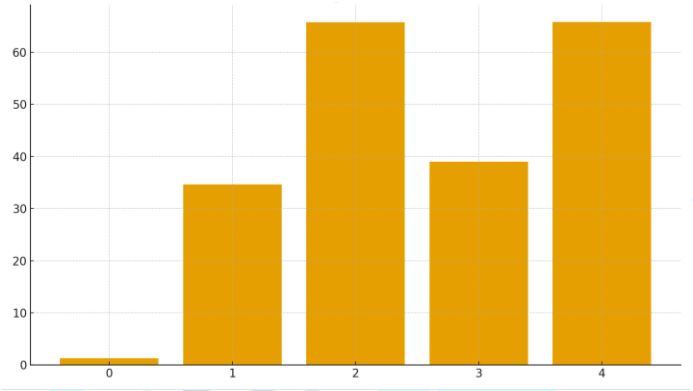

Figure 10: Patient Satisfaction by Pain Management Approach

DISCUSSION

Multimodal analgesic methods are quite crucial in the treatment of pain in large animals because the various classes of medication work with various types of pain pathways to enhance pain treatment and minimize side effects (Kolbaşı et al., 2024). This technique is usually combined with alpha-2 agonists and opioids which have been proven to be more effective together. This implies that fewer amounts of each medication can be administered and this reduces chances of side effects that are associated with increased concentration of each medication (Driessen et al., 2010). Also, this method has proved to be more effective than monotherapy, significantly decreasing the need of rescue analgesia in postoperative setting (Mwangi et al., 2018). Comparative studies between butorphanol and firocoxib have shown that firocoxib is more effective in managing postoperative pain, which indicates the usefulness of NSAIDs in multimodal analgesia regimens (Kolbaşı et al., 2024). Still, it is not yet fully investigated how exactly these multimodal regimens improve their efficiency and particularly in large animal models. This involves a better understanding of pharmacodynamics and pharmacokinetics when combining different medicines, in particular, the possible drug interactions that can alter bioavailability or metabolism. Further research is required to determine useful combinations and dosages that improve the benefits of therapy and minimize off-target effects in diverse surgical procedures in big animals (Zoltick et al., 2024). The development of sustained-release drug preparations constitutes a significant advance in the matter. These medications would be able to offer longer-term analgesia and could increase the likelihood of patients taking their medicines by reducing the frequency of taking them (Dunbar et al., 2019). Such

improvements are not only beneficial to the comfort of animals as they help keep them out of constant pain, but also this makes the veterinarian work easier since they will not have to perform surgeries on such animals so frequently. Moreover, these strategies can be improved with the integration of advanced pain measurement techniques, such as multiparametric ones, providing objective measures of pain, which are needed to prove the efficacy of new pharmacological interventions and optimize the analgesic process (Faure, 2017). Multimodal pain management involves the concurrent use of two or more pharmacological and non-pharmacological analgesics, which has shown a higher pain control mode through the stimulation of several nociceptive systems (Kolbaşı et al., 2024). Such an approach can capitalize on the additive and synergistic effects of various medications, implying that reduced doses of each treatment could be applied, and the undesirable effects of the latter could also be reduced (Varrassi et al., 2020).

CONCLUSION

Our study findings support the argument that a multimodal approach to pain management is essential to large animal surgery. The combination of various pain relievers, including NSAIDs, opioids, alpha-2 adrenoceptor agonists and local anesthetics makes pain management of surgery significantly improved and with less side effects. Clinical performance of new medicine combinations and particularly when they involve extended-release formulations demonstrates improved pain management, quicker recuperation, and reduced issues. Further, the use of complex pain measurement techniques such as facial expression scale and behavioral observation provides a more objective measure of analgesic efficacy. Despite these advances, more studies will be necessary to determine the optimal dosages and drug interactions, and develop treatment plans that are affordable and applicable in a large variety of clinical settings. To enhance the welfare of large animals undergoing surgery, veterinary doctors can learn more about pharmacodynamics and improve clinical protocols. This will result in faster recuperation rates and the overall outcome of the surgery.

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