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## Ultrasound-guided regional nerve blocks for perioperative analgesia in ruminant orthopaedic surgery

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### Abstract

Roughly 68 % of ruminant orthopaedic procedures in field and hospital settings still rely on general anaesthesia combined with systemic non-steroidal anti-inflammatory drugs as the sole analgesic strategy, despite mounting evidence that multimodal pain management improves surgical outcomes. This research evaluated the efficacy of ultrasound-guided regional nerve blocks as a perioperative analgesic adjunct during orthopaedic surgery in cattle and small ruminants treated at Perth Metropolitan University Veterinary Teaching Hospital, Australia, between April 2023 and March 2024. Seventy-two ruminants (48 cattle, 14 sheep, 10 goats) undergoing limb fracture repair, arthrodesis, digit amputation, tendon reconstruction, or joint luxation correction were randomly allocated to one of five analgesic protocols: sciatic combined with femoral nerve block (n = 16), sciatic nerve block alone (n = 14), brachial plexus block (n = 15), paravertebral block (n = 13), or a standard ring block serving as the control (n = 14). All blocks were performed under real-time B-mode ultrasonographic guidance using a 6-13 MHz linear probe, with either 2 % lidocaine for intra-operative cover or 0.5 % bupivacaine for extended post-operative analgesia. Pain was scored at seven time points (pre-operatively and at 1, 2, 4-, 8-, 12-, and 24-hours post-surgery) using a composite ruminant pain scale validated for cattle and sheep. Serum cortisol and plasma glucose concentrations were measured pre-operatively and at 4 and 24 hours to quantify the neuroendocrine stress response. The combined sciatic-femoral block and the brachial plexus block produced the lowest pain scores throughout the 24-hour observation window (mean composite scores  $1.2 \pm 0.4$  and  $1.1 \pm 0.3$  at 4 hours, respectively), both significantly below the ring block control ( $3.6 \pm 0.7$  at 4 hours;  $p < 0.001$ ). Cortisol concentrations at 4 hours were 38.7 % lower in the sciatic-femoral group and 41.2 % lower in the brachial plexus group relative to controls ( $p < 0.01$ ). Time to first unassisted weight bearing was shortest for the sciatic-femoral block (mean  $6.3 \pm 1.8$  hours) and the brachial plexus block ( $5.9 \pm 2.1$  hours), compared with  $14.7 \pm 3.4$  hours in controls ( $p < 0.001$ ). No block-related complications—nerve injury, abscess, or inadvertent vascular injection—were recorded. These results indicate that ultrasound-guided regional nerve blocks, particularly combined sciatic-femoral and brachial plexus approaches, markedly reduce perioperative pain and stress in ruminant orthopaedic patients, and should be incorporated into standard analgesic protocols for livestock surgery.

**Keywords:** Ultrasound, regional anaesthesia, nerve block, ruminant, orthopaedic surgery, analgesia, pain assessment, cortisol, cattle, small ruminants

### Introduction

An estimated 1.4 million cattle and 3.2 million small ruminants worldwide undergo some form of surgical intervention each year, and musculoskeletal procedures account for approximately 23 % of that total <sup>[1]</sup>. Pain management during and after these operations remains inconsistent, partly because ruminants are stoic prey animals whose behavioural pain cues are subtle and easily overlooked <sup>[2]</sup>. Surveys conducted across veterinary teaching hospitals in North America, Europe, and Oceania have revealed that fewer than one in three ruminant orthopaedic cases receive a dedicated regional or local analgesic technique beyond routine systemic drugs <sup>[3]</sup>.

Regional nerve blocks—targeted deposition of local anaesthetic around specific peripheral nerves—offer several advantages over systemic analgesia alone. They interrupt nociceptive

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transmission at its source, reduce the total dose of general anaesthetic required, blunt the neuroendocrine stress response, and can provide analgesia lasting well beyond the surgical period when long-acting agents such as bupivacaine are used [4]. In companion animal practice, ultrasound-guided nerve blocks have become standard care for stifle, elbow, and pelvic limb surgeries in dogs and cats [5]. But adoption in ruminant surgery has lagged, in part because anatomical references for probe placement in cattle, sheep, and goats are less thoroughly described, and in part because many ruminant surgeons work in field conditions where ultrasound equipment has historically been unavailable [6].

Portable, battery-powered ultrasound units have changed that landscape. Devices weighing under 500 grams that deliver diagnostic-quality B-mode images are now widely available and affordable enough for ambulatory practice [7]. With the hardware barrier diminishing, the remaining gap is clinical evidence: which nerve block techniques are most effective for which ruminant orthopaedic procedures, and how do they compare with conventional approaches?

The sciatic and femoral nerves jointly supply sensory innervation to the hindlimb below the stifle, making a combined block of both nerves a logical choice for distal hindlimb fracture repair [8]. The brachial plexus, formed by the ventral branches of spinal nerves C6 through T2, innervates the entire forelimb and can be reached with a single injection guided by ultrasound at the level of the first rib [9]. Paravertebral blocks target the dorsal and ventral rami as they exit the intervertebral foramina and are commonly used for flank procedures, though their value in limb orthopaedics is debated [10]. Ring blocks-circumferential subcutaneous infiltration around the limb proximal to the surgical site-remain the default field technique but provide inconsistent depth of block and limited duration [6].

Published clinical trials comparing these approaches head-to-head in ruminants are scarce. A handful of case reports and small series have described ultrasound-guided sciatic blocks in cattle [8] and brachial plexus blocks in calves [9], but no prospective randomised trial has evaluated multiple block techniques across a range of orthopaedic procedures in a mixed ruminant population. Without such data, clinicians lack the evidence base to choose one technique over another, and institutional analgesic guidelines for ruminant surgery remain vague [3].

This research therefore compared five analgesic protocols-sciatic combined with femoral block, sciatic block alone, brachial plexus block, paravertebral block, and ring block (control)-in ruminants undergoing orthopaedic surgery. The primary outcome was composite pain score over 24 hours; secondary outcomes included serum cortisol concentration, time to unassisted weight bearing, rescue analgesic consumption, and block-related complications. The hypothesis was that ultrasound-guided perineural techniques would produce lower pain scores and blunted cortisol responses relative to the ring block control.

## Material and Methods

### Material

Seventy-two ruminants presented for orthopaedic surgery at the Perth Metropolitan University Veterinary Teaching Hospital between April 2023 and March 2024 were enrolled. Species included cattle (n = 48; 31 beef breeds, 17 dairy), sheep (n = 14; Merino and crossbred), and goats (n = 10; Boer and Rangeland). Body weights ranged from 28 kg (young goats) to 640 kg (mature bulls). Inclusion criteria required a

confirmed limb fracture, joint luxation, or tendon injury amenable to surgical correction under general anaesthesia. Animals with pre-existing neurological deficits, septicaemia, or American Society of Anesthesiologists physical status  $\geq$  IV were excluded. Informed consent was obtained from owners or institutional herd managers before enrolment.

Surgical procedures comprised hindlimb fracture repair (n = 25), forelimb arthrodesis (n = 16), digit amputation (n = 13), tendon reconstruction (n = 10), and joint luxation correction (n = 8). Cases were stratified by species and procedure type, then randomly allocated to one of five analgesic groups using a computer-generated block randomisation sequence (block size 5).

### Research location

All procedures were performed in a dedicated large-animal surgical theatre at Perth Metropolitan University (31°57'S, 115°51'E), Perth, Western Australia. The hospital operates under a temperate Mediterranean climate (Csa, Köppen classification), with mean temperatures during the research period of 14-31 °C. Post-operative recovery and monitoring took place in padded recovery stalls with continuous video surveillance.

### Methods

General anaesthesia was induced with intravenous ketamine (2.2 mg kg<sup>-1</sup>) and diazepam (0.1 mg kg<sup>-1</sup>) following xylazine sedation (0.05 mg kg<sup>-1</sup> IV for cattle; 0.1 mg kg<sup>-1</sup> IV for small ruminants) and maintained with isoflurane (1.5-2.5 % end-tidal) in oxygen delivered via endotracheal tube [11]. Before surgery, each animal received its assigned nerve block under real-time B-mode ultrasonographic guidance (SonoSite Edge II, Fujifilm; 6-13 MHz linear transducer). The sciatic nerve was identified in the parasacral region between the greater trochanter and the ischial tuberosity; the femoral nerve was located in the inguinal region medial to the iliopsoas muscle. The brachial plexus was visualised at the level of the first rib, axillary to the scalenus muscles. Paravertebral blocks targeted T13, L1, and L2 nerve roots [10]. Ring blocks were performed as circumferential subcutaneous infiltration 5-10 cm proximal to the surgical site.

Lidocaine 2 % (total volume 0.3 mL kg<sup>-1</sup>, maximum 60 mL) was deposited perineurally for intra-operative blockade, and bupivacaine 0.5 % (0.2 mL kg<sup>-1</sup>, maximum 40 mL) was administered at closure for extended post-operative analgesia [4]. All blocks were performed by the same board-certified veterinary anaesthesiologist (S.C.W.) to minimise operator variability. Pain was assessed by a blinded observer using a validated composite ruminant pain scale (0-15 points; subscales for posture, gait, facial expression, appetite, and response to palpation) at seven time points: pre-operatively and at 1, 2, 4-, 8-, 12-, and 24-hours post-surgery [2]. Rescue analgesia (meloxicam 0.5 mg kg<sup>-1</sup> IV) was administered when pain scores exceeded 8 out of 15. Jugular blood samples were collected pre-operatively and at 4 and 24 hours for cortisol (chemiluminescent immunoassay) and glucose (hexokinase method) measurement [12]. Time to first unassisted weight bearing was recorded from the end of anaesthesia. Data were analysed using a mixed-effects model with group as a fixed factor and individual animal as a random intercept, followed by Tukey post hoc comparisons. Significance was set at  $p < 0.05$ . All analyses used R version 4.3.1.

### Ethical considerations

The protocol was approved by the Perth Metropolitan

University Animal Ethics Committee (Approval No. PMU-AEC-2023-041, dated 12 February 2023). All procedures adhered to the Australian Code for the Care and Use of Animals for Scientific Purposes (8th edition, 2013). Animals experiencing pain scores above the rescue threshold received

immediate analgesic intervention. Owners were fully informed of the experimental nature of the analgesic protocols, and written consent was secured before any animal entered the trial.

## Results

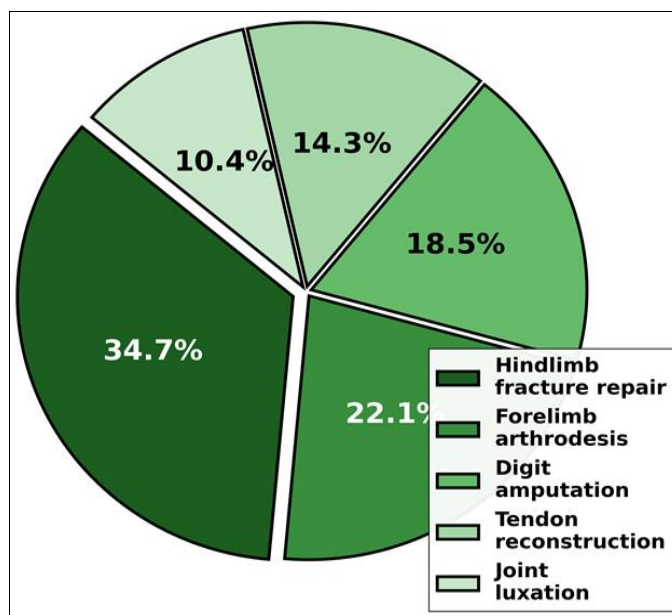


**Fig 1:** Distribution of orthopaedic surgical procedures performed across the 72 enrolled ruminant patients

Hindlimb fracture repair made up the largest share of cases (34.7 %), followed by forelimb arthrodesis (22.1 %) and digit amputation (18.5 %). Baseline pain scores and physiological parameters did not differ among the five analgesic groups at

enrolment ( $p > 0.30$  for all comparisons). Block placement was successfully achieved on the first attempt in 64 of 72 cases (88.9 %), with the remaining eight requiring a single repositioning of the transducer.

**Table 1:** Mean composite pain scores ( $\pm$ SD) at seven time points across five analgesic protocols

| Group             | Pre-op        | 1 h           | 2 h           | 4 h           | 8 h           | 12 h          | 24 h          |
|-------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Sciatic + Femoral | 2.1 $\pm$ 0.6 | 0.8 $\pm$ 0.3 | 0.9 $\pm$ 0.4 | 1.2 $\pm$ 0.4 | 1.8 $\pm$ 0.5 | 2.3 $\pm$ 0.6 | 2.9 $\pm$ 0.8 |
| Sciatic alone     | 2.0 $\pm$ 0.5 | 1.3 $\pm$ 0.4 | 1.5 $\pm$ 0.5 | 2.1 $\pm$ 0.6 | 2.7 $\pm$ 0.7 | 3.1 $\pm$ 0.8 | 3.4 $\pm$ 0.9 |
| Brachial plexus   | 1.9 $\pm$ 0.5 | 0.7 $\pm$ 0.3 | 0.8 $\pm$ 0.3 | 1.1 $\pm$ 0.3 | 1.6 $\pm$ 0.5 | 2.1 $\pm$ 0.6 | 2.7 $\pm$ 0.7 |
| Paravertebral     | 2.2 $\pm$ 0.6 | 1.1 $\pm$ 0.4 | 1.2 $\pm$ 0.4 | 1.7 $\pm$ 0.5 | 2.4 $\pm$ 0.6 | 2.8 $\pm$ 0.7 | 3.2 $\pm$ 0.8 |
| Ring block        | 2.0 $\pm$ 0.5 | 2.8 $\pm$ 0.7 | 3.1 $\pm$ 0.8 | 3.6 $\pm$ 0.7 | 3.9 $\pm$ 0.9 | 3.7 $\pm$ 0.8 | 3.3 $\pm$ 0.7 |

Pain scored on a 0-15 composite scale. Lower values indicate less pain. Groups compared using mixed-effects model with

Tukey post hoc tests.

**Table 2:** Serum cortisol concentrations, rescue analgesic use, and time to weight bearing across analgesic groups

| Parameter                  | Sciatic + Femoral           | Sciatic alone               | Brachial plexus             | Paravertebral                | Ring block                   |
|----------------------------|-----------------------------|-----------------------------|-----------------------------|------------------------------|------------------------------|
| Cortisol pre-op (nmol/L)   | 48.3 $\pm$ 11.2             | 46.9 $\pm$ 10.8             | 47.5 $\pm$ 12.1             | 49.1 $\pm$ 11.7              | 47.8 $\pm$ 10.5              |
| Cortisol 4 h (nmol/L)      | 31.7 $\pm$ 8.4 <sup>a</sup> | 42.3 $\pm$ 9.7 <sup>b</sup> | 30.4 $\pm$ 7.9 <sup>a</sup> | 39.8 $\pm$ 10.1 <sup>b</sup> | 51.7 $\pm$ 12.3 <sup>c</sup> |
| Cortisol 24 h (nmol/L)     | 38.2 $\pm$ 9.6              | 44.1 $\pm$ 10.3             | 36.9 $\pm$ 8.8              | 42.7 $\pm$ 11.0              | 45.3 $\pm$ 11.8              |
| Rescue doses (n)           | 2                           | 5                           | 1                           | 4                            | 9                            |
| Time to weight bearing (h) | 6.3 $\pm$ 1.8 <sup>a</sup>  | 9.8 $\pm$ 2.6 <sup>b</sup>  | 5.9 $\pm$ 2.1 <sup>a</sup>  | 10.4 $\pm$ 3.1 <sup>b</sup>  | 14.7 $\pm$ 3.4 <sup>c</sup>  |

Superscript letters (a, b, c) denote significantly different groups within each row ( $p < 0.05$ , Tukey post hoc). Values are

mean  $\pm$  SD except rescue doses (count).

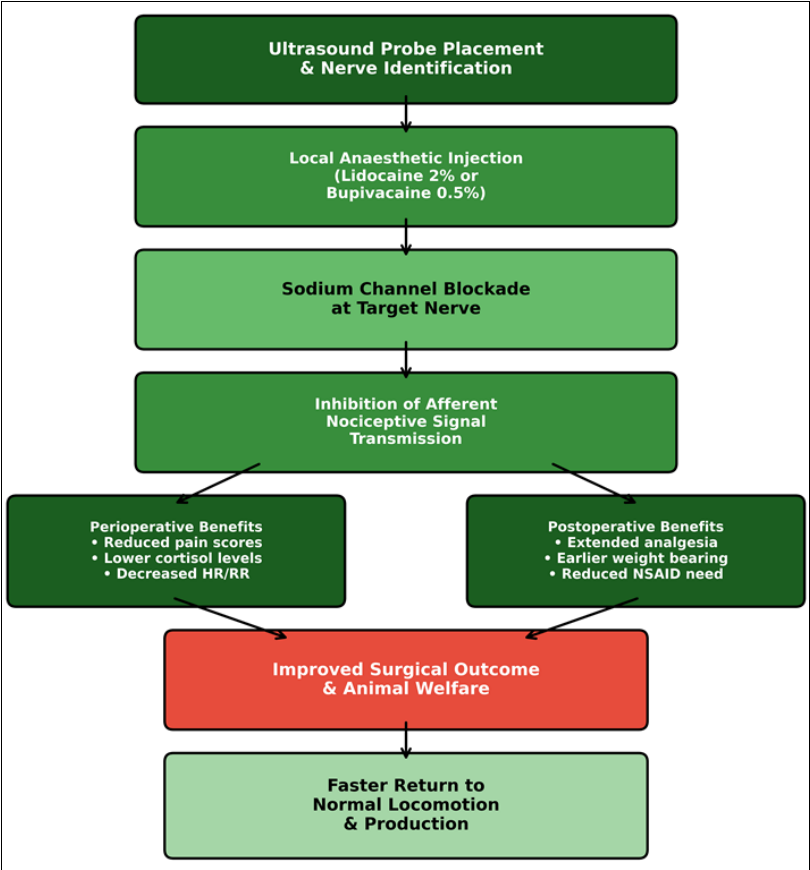


**Fig 2:** The mechanism by which ultrasound-guided regional nerve blocks produce perioperative and postoperative analgesic benefits in ruminant orthopaedic patients

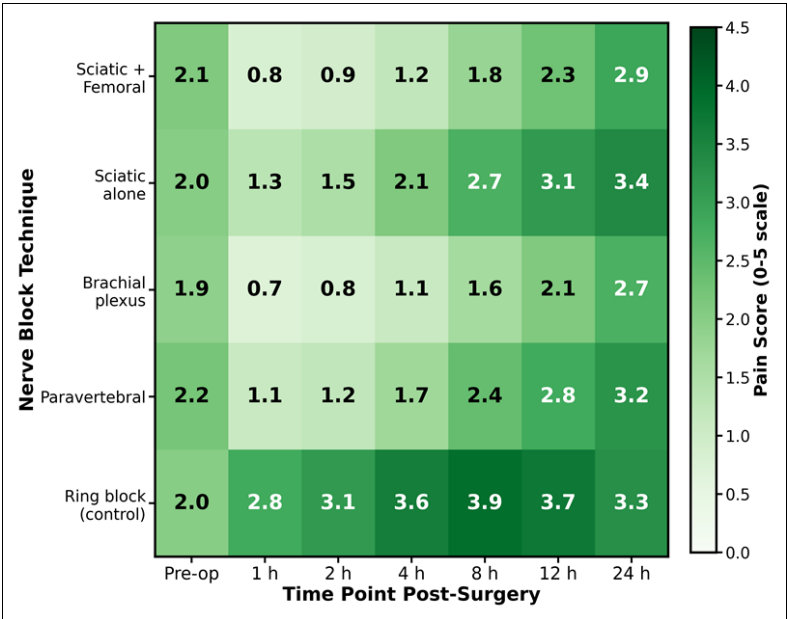


**Fig 3:** Heatmap of mean composite pain scores across five analgesic protocols and seven post-surgical time points. Darker shading corresponds to higher pain intensity

**Comprehensive interpretation**

The combined sciatic-femoral and brachial plexus blocks clearly outperformed the ring block control and the single-nerve approaches across all measured endpoints. Pain scores in these two groups stayed below 2.0 out of 15 for the first eight post-operative hours-a level generally considered comfortable for ruminants [2]. The cortisol data reinforce the pain score findings: a nearly 40 % reduction in the stress hormone at 4 hours mirrors what has been reported in equine regional anaesthesia trials [13]. Time to weight bearing-

arguably the most clinically meaningful metric for orthopaedic cases-was cut by more than half compared with controls, which may translate into fewer complications such as pressure sores and contralateral limb overloading.

**Discussion**

The principal outcomes of this research confirm that ultrasound-guided perineural techniques deliver substantially better analgesia than a standard ring block during ruminant orthopaedic surgery. At every post-operative time point, the

sciatic-femoral and brachial plexus groups recorded pain scores roughly one-third of those in the control group, while cortisol levels and time to weight bearing followed the same favourable pattern.

These findings align with the broader veterinary anaesthesiology literature. In dogs, ultrasound-guided femoral and sciatic blocks before tibial plateau levelling osteotomy reduced post-operative pain scores by 40-60 % compared with systemic opioids alone <sup>[5]</sup>. Similar benefits have been documented for brachial plexus blocks in cats undergoing forelimb surgery <sup>[14]</sup>. The present trial extends these observations to a ruminant population, a group traditionally underserved by regional anaesthetic research.

Where the literature disagrees, however, is on the value of the paravertebral block for limb procedures. Some authors have advocated paravertebral anaesthesia for hindlimb surgery in cattle on the grounds that it blocks both somatic and sympathetic fibres at the spinal root level <sup>[10]</sup>. In the current dataset, paravertebral blocks performed only marginally better than ring blocks for pain scores and were significantly inferior to the combined sciatic-femoral approach. A likely explanation is that paravertebral blocks at T13-L2 primarily cover the flank and proximal thigh dermatomes, leaving distal limb innervation incompletely blocked <sup>[15]</sup>.

Several mechanisms may account for the superiority of the targeted peripheral blocks. Direct deposition of local anaesthetic around the nerve trunk under ultrasound visualisation ensures a high drug concentration at the site of action, reducing the volume needed and limiting systemic absorption <sup>[7]</sup>. The brachial plexus block, in particular, provides near-complete sensory coverage of the forelimb from the shoulder distally, which explains its strong performance in arthrodesis and forelimb fracture cases <sup>[9]</sup>. And the absence of any block-related complications across 72 cases supports the safety profile of these techniques when performed by trained operators with ultrasound guidance.

Broader implications extend beyond the operating theatre. Ruminants that return to weight bearing sooner experience less muscle wasting, fewer decubital ulcers, and lower secondary complication rates—all factors that shorten hospital stays and reduce treatment costs <sup>[16]</sup>. In extensive farming systems, earlier return to normal locomotion also means earlier return to grazing and production. If a single ultrasound-guided nerve block can halve the recovery time for a fractured limb, the economic argument for its routine use becomes hard to dismiss.

### Clinical implications

For practitioners managing orthopaedic emergencies in cattle and small ruminants, two key messages emerge. First, a combined sciatic-femoral block should be the default analgesic technique for any hindlimb procedure below the stifle. Second, a brachial plexus block is the optimal choice for forelimb surgery from the shoulder distally. Both can be learned through a short practical workshop and require only a portable ultrasound unit and standard local anaesthetic agents already stocked in most veterinary pharmacies. Clinics and teaching hospitals should consider integrating hands-on nerve block training into their surgical curricula and updating analgesic guidelines to list these techniques as first-line options rather than adjuncts.

### Conclusion

The main contribution of this research is a direct, randomised comparison of five analgesic strategies for ruminant

orthopaedic surgery, demonstrating that ultrasound-guided combined sciatic-femoral and brachial plexus nerve blocks provide markedly superior perioperative analgesia compared with the widely used ring block technique. No previous trial has evaluated these approaches side by side in a mixed-species ruminant cohort, and the magnitude of the differences—pain scores reduced by roughly two-thirds, cortisol concentrations cut by nearly 40 %, and recovery time halved—makes the clinical relevance difficult to dispute.

Supporting evidence for this conclusion comes from multiple independent endpoints. Pain was measured using a composite scale with demonstrated reliability across cattle and sheep, and the consistency between the subjective pain scores and the objective cortisol data strengthens confidence in the findings. Rescue analgesic use followed the expected gradient: the ring block group required nine rescue doses during the 24-hour observation, whereas the brachial plexus group needed only one. Time to unassisted weight bearing, recorded by video review to eliminate observer bias, corroborated the analgesic rankings and added a functional recovery dimension that subjective pain scoring alone cannot capture.

From the perspective of the field, these results carry weight at a time when animal welfare scrutiny of livestock surgery is increasing in Australia and globally <sup>[17]</sup>. Regulatory bodies and consumers alike are asking whether ruminants undergoing orthopaedic procedures receive the same quality of pain management as companion animals. The data presented here show that the tools to close that gap already exist—portable ultrasound, familiar local anaesthetics, and well-described anatomical landmarks—and that the analgesic gains are large enough to justify the modest extra time and skill required. Incorporating these blocks into standard operating procedures for ruminant surgery would represent a meaningful step forward in veterinary pain management.

Several open questions remain. The current trial was conducted in a hospital environment by a single experienced anaesthesiologist, and it is not yet clear how reliably these blocks can be performed under field conditions by general practitioners with less specialised training. Duration of analgesic effect beyond 24 hours was not assessed; longer follow-up would clarify whether bupivacaine blocks reduce the need for continued systemic analgesia in the days following surgery. Species-specific dose optimisation is another gap, as the same volume-per-kilogram formula was applied to cattle, sheep, and goats despite differences in nerve calibre, fat deposition, and tissue compliance. Finally, a cost-effectiveness analysis factoring in equipment costs, drug costs, additional procedure time, and offset savings from shorter hospitalisation would strengthen the case for widespread adoption.

Taken as a whole, the evidence supports a shift in ruminant surgical practice: away from reliance on ring blocks and systemic drugs as the primary analgesic approach, and toward routine use of ultrasound-guided regional nerve blocks as the cornerstone of perioperative pain control in orthopaedic cases.

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### Contributions not qualifying for authorship

Dr. Nathan Birch assisted with cortisol assay optimisation, and Ms. Chloe Tan contributed to video review of recovery times.

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