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Brachial plexus block in American Kestrels (*Falco sparverius*) using a peripheral nerve stimulator with different doses of lidocaine

Bloqueio do plexo braquial em quiri-quiri (*Falco sparverius*) com auxílio de estimulador de nervos periféricos utilizando diferentes doses de lidocaína

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Highlights

Muscle relaxation parameters were unreliable as indicators of blockade.
Anesthetic volume and dosage influenced the efficacy of the brachial plexus blockade.
The analgesiometer was ineffective for assessing sensitivity in *Falco sparverius.*

Abstract

This study evaluated the efficacy of different lidocaine doses for brachial plexus anesthetic blockade in *Falco sparverius* using a peripheral nerve stimulator. The objective was to assess the motor response of the wings and the latency to loss of motor function after the blockade. Eight healthy birds, rescued from the Wildlife Rehabilitation Center of UFPEL, were divided into two groups to receive either 6 mg/kg or 10 mg/kg of 2% lidocaine. Anesthesia was induced with isoflurane before lidocaine was applied to the brachial plexus, with the correct site determined via nerve stimulation. None of the birds achieved complete motor blockade, although two exhibited partial wing drooping. Sensory evaluation was limited by inconsistent responses to the von Frey electronic analgesic, hindering comparisons of baseline pain values. The volume of anesthetic diluted in 0.9% NaCl appeared to influence the results, as birds receiving larger volumes showed some motor response, unlike those given smaller volumes. These findings suggest that achieving motor blockade with lidocaine in small birds of prey like *F. sparverius* may be challenging using the tested doses and volumes and that the anesthetic volume is likely a determining factor for successful blockade. Future studies should incorporate sensory parameters as criteria for anesthetic success and further investigate the safe and effective dosages of local anesthetics in this species.

Key words: Anesthesia. Birds of prey. Regional blockade. Falcon.

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Resumo

O presente estudo investigou a eficácia de diferentes doses de lidocaína no bloqueio anestésico do plexo braquial em *Falco sparverius,* utilizando estimulador de nervos periféricos. O objetivo foi avaliar a resposta motora das asas após o bloqueio e o tempo de latência para a perda da função motora. Oito indivíduos saudáveis, resgatados no Núcleo de Reabilitação de Fauna Silvestre da UFPEL, foram divididos em dois grupos para receber doses de 6 mg kg e 10 mg kg de lidocaína a 2%. Durante o experimento, a anestesia foi induzida com Isoflurano, seguida da aplicação da lidocaína no plexo braquial, buscando o local correto de aplicação através da estimulação nervosa. No entanto, nenhum dos animais apresentou bloqueio motor completo, embora dois indivíduos tenham demonstrado uma queda parcial da asa. A avaliação sensorial foi dificultada pela ausência de respostas consistentes ao uso do analgesímetro eletrônico de von Frey, limitando a comparação dos valores basais de dor. Observou-se que o volume de anestésico, diluído em solução de NaCl a 0,9%, pode ter influenciado nos resultados, uma vez que animais que receberam volumes maiores demonstraram alguma resposta motora, ao contrário dos que receberam volumes menores. Conclui-se então que o bloqueio motor com lidocaína em pequenas aves de rapina, como o *F. sparverius,* pode ser difícil de obter usando as doses e volumes testados, e que o volume do anestésico pode ser um fator determinante para o sucesso do bloqueio. Futuros estudos devem investigar o uso de parâmetros sensoriais como critério de sucesso anestésico, além de explorar de forma mais detalhada a dosagem segura e eficaz de anestésicos locais nessa espécie.

Palavras-chave: Anestesia. Aves de rapina. Bloqueio regional. Falcão.

Introduction

Falco sparverius is one of the smallest raptor species globally, widely distributed across the Americas and inhabiting open areas such as deserts, natural grasslands, and agricultural lands. It shows sexual dimorphism in size and coloration, with males being smaller than females. Breeding occurs in the spring and summer and, once paired, they remain loyal to their mates for life. Their diet mainly consists of small vertebrates and arthropods (Ferguson-Lees & Christie, 2001; Joppert, 2020).

As a raptor species, the American Kestrel faces various challenges threatening its survival, including habitat loss and fragmentation caused by urban and agricultural expansion, predation by humans, retaliation due to conflicts with human activities, illegal trafficking, and exposure to agrochemicals and pesticides. Collisions with human structures, such as wind turbines, buildings, fences, electrocution, and entanglement in kite strings also pose significant threats to the species (Newton, 1979; Soares et al., 2008). Due to these issues, many individuals suffer trauma or injuries requiring referral to Wildlife Rehabilitation Centers for treatment and recovery, crucial for conservation (Santos et al., 2018; C. E. F. Cruz et al., 2022).

Trauma is the leading cause of bird admission in rehabilitation centers, with fractures being the most common injury (Silva, 2018). Among these, fractures of the upper limbs/wings are the most frequently encountered (Bortolini et al., 2013; Cavalcanti et al., 2021; Moreira, 2021) and typically require correction through rest, splinting, or osteosynthesis (Hellmer & Redig, 2006). For surgical interventions involving fracture correction, locoregional anesthesia is preferred due to its reduced requirement for general anesthetics, enhanced intraoperative and postoperative analgesia, and faster recovery of function in the operated limb (Carroll, 2008; Campoy & Schroeder, 2013; Garcia, 2015).

Although advances in veterinary anesthesia continue, there is still a lack of studies on the use of local anesthetics in birds, mainly due to insufficient knowledge of appropriate doses, pharmacodynamics, and pharmacokinetics, with much of the available data being extrapolated from domestic chickens (*Gallus gallus*) (Melo et al., 2004; Figueiredo et al., 2008; Cunha et al., 2012).

This study aims to assess the effectiveness of different doses and concentrations of lidocaine for anesthetic blockade of the brachial plexus in American kestrels (*F. sparverius*) using a peripheral nerve stimulator.

Materials and Methods

Eight adult American Kestrels (*Falco sparverius*) six females and two males, weighing between 0.085 kg and 0.113 kg were selected from the Wildlife Rehabilitation Center and Wildlife Screening Center at the Federal University of Pelotas (NURFS-CETAS/UFPEL). All individuals were healthy, classified as ASA I according to the physical status classification system, and deemed suitable for release. The birds were captured in the aviary, restrained, and placed in transport boxes and cages draped with cloth to minimize visual stimuli and keep them calm.

Before performing the anesthetic blocks, the kestrels were randomly divided into two groups based on the anesthetic dose they would receive. Each bird was physically restrained by holding its legs and securing its wings tightly against its body, and a cloth was placed over its face to reduce visual stimuli and stress. Baseline pain levels were then measured using an electronic von Frey anesthesiometer (Insight®, São Paulo). Pressure was applied to the humeral, radio-ulnar, and metacarpal regions of the chosen wing, with each site assessed three times at 1-minute intervals to calculate the average baseline pain response. Painful responses were defined as vocalizations, pecking, movement, or attempts to escape, following the criteria described by Figueiredo et al. (2008) (Table 1). An additional sensory parameter was sought because the species did not respond to pinching with hemostats fitted with protective rubber tubing a method previously used in chicken studies (Figueiredo et al., 2008).

Table 1
Pre-block sensory evaluation with an electronic von Frey anesthesiometer (Insight®, São Paulo) in *F. sparverius* (American Kestrel)

Animal	01	02	03	04	05	06	07	08
Wing	Right	Left	Right	Left	Left	Right	Left	Right
Humerus (1 - 2 - 3)	NA - NA - NA	NA - NA - NA	NA - NA - NA	NA - NA - NA	NA - 284 - 299	NA - NA - NA	NA - NA - NA	NA - NA - NA
Radius/Ulna (1 - 2 - 3)	526,9 - 521,4 - NA	466 - 556 - 530	257 - 176 - NA	416 - 155 - 383	343 - 248 - NA	NA - NA - NA	NA - NA - NA	634 - 529 - NA
Metacarpus (1 - 2 - 3)	571,4 - NA - NA	291 - 417 - 228	167 - 178 - NA	386 - 176 - 337	307 - 95 - NA	NA - NA - NA	NA - NA - NA	310 - 238 - NA

NA = No answer.

Under the supervision of an experienced anesthesiology specialist, the birds were positioned in dorsal recumbency on the procedure table and sedated via an inhalation anesthetic mask delivering 3% isoflurane, with vaporization maintained between 1% and 2.5% (using a D-Vapor®, Draeger® system adapted to a Colibri portable inhalation anesthesia device, Brasmed®). Once the birds were anesthetized exhibiting muscle relaxation and unresponsiveness to stimuli they were released from restraint. Their feathers were manually parted in the ventral region of the humero-scapular joint on the designated wing for the anesthetic block, alternating between individuals.

The electrodes of the Peripheral Nerve Stimulator (PNS) device (BBraun Stimuplex® HNS12) were placed on the wing opposite to the block site, in the region of the phalanges and patagium. After identifying the brachial plexus, a sono-visible needle (Pajunk® SonoPlex 22G x 50mm) was introduced in-plane with a current of 1.0 mA at a frequency of 1.5 Hz until a motor response of the wing (extension or flexion) was observed at 0.5 mA. The current was then reduced to 0.3 mA to confirm the absence of stimulation before returning to 0.5 mA to elicit muscle contraction. Once the correct location was confirmed with assistance from a neurolocation needle (Pajunk® UniPlex 22G x 50mm) an anesthetic block was performed using 2% lidocaine (Xylestesin®, Cristalia) at doses ranging from 6 to 10 mg/kg in the selected wing.

In individuals 1, 2, 3, and 4, a dose of 6 mg/kg was used, while animals 5, 6, 7, and 8 received 10 mg/kg (Table 2). Notably, the anesthetic was diluted to obtain a larger applicable volume in some cases, and a standard volume of 1 mL of air was administered to optimize the release of residual anesthetic from the needle and achieve the desired effect (Table 2).

Table 2
Relationship Between Animals, Lidocaine Dose, and Administered Volumes for Anesthetic Blocks in Falco sparverius (American Kestrel)

Animal	01	02	03	04	05	06	07	08
Weight	0.103 kg	0.103 kg	0.085 kg	0.108 kg	0.111 kg	0.097 kg	0.113 kg	0.105 kg
Sex	Female	Female	Female	Male	Female	Male	Female	Female
Lidocaine 2% Dosage	6 mg/kg	6 mg/kg	6 mg/kg	6 mg/kg	10 mg/kg	10 mg/kg	10 mg/kg	10 mg/kg
Final administered Volume	0.03 ml	0.06 ml	0.02 ml	0.3 ml	0.1 ml	0.2 ml	0.06 ml	0.3 ml

After applying the local anesthetic, the isoflurane supply was discontinued, and the bird was maintained on an oxygen mask until it recovered from sedation. Upon regaining consciousness, the wing motor function was evaluated to assess the block's effectiveness, based on a chicken study in which the latency for loss of motor function after lidocaine administration was 2.8 ± 1.1 minutes (Figueiredo et al., 2008).

Two veterinarians conducted post-block evaluation, one of whom was an anesthesiology specialist. The bird was held upright by securing its pelvic limbs between the thumb, index, and middle fingers, and the wing was repeatedly moved up and down five times to stimulate flapping an approach adapted from a study in ducks (Brenner et al., 2010). The bird's wing movements were observed, and when the stimulus for upper limb movement ceased, and the wing remained open, the effectiveness of the block was assessed.

Results and Discussion

All animals in the experiment exhibited an absence of motor response to the block immediately after recovering from Isoflurane sedation. However, during the flight test, they exhibited full wing-flapping movement, similar to the non-blocked wing. Furthermore, two individuals (4 and 8) showed some motor response to the block while their wings were stationary. When these individuals remained stationary with open wings following a wing-flapping stimulus, the blocked wing in both individuals drooped slightly compared to the contralateral wing.

Some studies assessing brachial plexus blocks in birds have used muscle relaxation of the blocked wing as a measure of successful blockade (Vilani et al., 2006; Cardozo et al., 2009). However, our study did not observe satisfactory motor blockade, which aligns with findings by Brenner et al. (2010) and Cunha et al. (2013), who also did not see complete wing drooping in all birds evaluated.

A few studies have reported successful brachial plexus blocks for wing surgery in raptors. For example, in a Striped Owl (*Asio clamator*), a blind technique using 0.8 mL of 2% lidocaine promoted noticeable wing drooping (Vilani et al., 2006). In a Harris hawk (*Parabuteo unicinctus*), 2 mg/kg of 0.375% bupivacaine was administered using a PNS-guided technique, though wing position was not reported because the bird was under general anesthesia (Credie et al., 2019). Similarly, in another case with a Striped Owl (*A. clamator*), 2 mg/kg of 2% ropivacaine was used with PNS guidance, but wing position was not documented for the same reason (Nascimento et al., 2019). Therefore, muscle relaxation should not be considered an isolated parameter for assessing the success of the block.

In humans, the efficiency of a brachial plexus block is typically evaluated using sensory parameters such as the loss of pain sensation to a needle prick and the loss of temperature or touch sensation (Ababou et al., 2007; Cornish et al., 2007). However, assessing the quality of the block in animals is challenging from a sensory standpoint, as it mostly involves qualitative analysis.

In our study, we could not establish a baseline average using the von Frey electronic analgesiometer for this species. We observed discrepancies in responses among individuals, an absence of response (especially in the humeral region), and variability in the same individual's responses over time. Similar inconsistencies have been reported in studies with cats (Machin et al., 2018) and healthy dogs, where measurements varied between evaluators and within the same animal (Kerns et al., 2019). Furthermore, the skittish and sometimes paralyzing response of wild animals especially birds to perceived threats like handling further reduces the effectiveness of the von Frey device. Consequently, we did not use the analgesiometer after the blocks because we lacked a reliable baseline for comparison.

Moreover, the birds in our study had an average weight of 0.103 ± 0.008 kg, and this small size may have contributed to the absence of a motor response. Since the volume of anesthetic is calculated based on each animal's weight using a fixed dose, smaller animals receive proportionately smaller volumes. In contrast, studies involving larger species such as Mallard ducks (*Anas platyrhynchos*), which can weigh up to 1.6 kg (Brenner et al., 2010), and 30-week-old chickens (*Gallus gallus*) weighing 4.5 ± 0.4 kg (Cardozo et al., 2009) reported at least partial motor responses. It is also well-established that the efficacy of a locoregional block depends on administering an adequate volume of local anesthetic to achieve the desired neural block (Stoelting & Hillier, 2006).

To overcome the low volume issue, the anesthetic dose was diluted in 0.9% sodium chloride to achieve a total volume of 0.3 mL. Since volume is a crucial factor for an effective locoregional block, it is notable that only individuals 4 and 8 who received this larger volume (0.03 mL and 0.05 mL of lidocaine combined with 0.27 mL and 0.25 mL of saline, respectively) exhibited partial wing drooping when held stationary. In contrast, the other animals that showed no motor response received volumes of 0.2 mL or less.

This observation underscores the importance of volume in achieving a successful block, even when the lidocaine dose remains the same. For example, individuals 5 and 8 both received a dose of

10 mg/kg (0.05 mL of lidocaine); however, only individual 8, who received a larger total volume due to dilution, demonstrated some level of motor blockade. Even so, the animals receiving the larger diluted volume did not exhibit the desired motor response, suggesting that both an adequate concentration at the block site and an appropriate volume are necessary for optimal efficacy (Stoelting & Hillier, 2006). Even after increasing the anesthetic dose to 10 mg/kg and administering a larger volume, the expected response was not achieved.

There is no clear definition in the literature of the toxic dose of lidocaine for birds, particularly for the species studied. The recommended maximum dose for chickens (Gallus gallus) is 4 mg/kg (Ludders & Matthews, 1996). However, some studies have used doses of 7.5 mg/kg, achieving an adequate motor block without adverse effects (Cardozo et al., 2009), and M. L. Cruz (2005) reported using 20 mg/kg safely. In contrast, other studies have observed signs of toxicity at doses as high as 30.51 ± 5.15 mg/kg (Imani et al., 2013).

Conclusion

Animals that received a final volume of 0.3 mL showed partial wing motor block, regardless of the dose. Also, we could not establish a baseline reading for the electronic von Frey anesthesiometer in *Falco sparverius* (American Kestrel).

Declaration of Conflict of Interest

The authors declared having no conflicts of interest.

Authors' Contributions

APM, MLR, AJF, and RTF participated in the practical study. APM, MLR, AJF, RTF, and MNC contributed to writing and reviewing the article.

Bioethics and Biosecurity Committee Approval

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