Brachial plexus block associated with balanced anesthesia in caracara plancus for fracture treatment

Bloqueio do plexo braquial associado à anestesia balanceada em Caracara plancus no tratamento de fratura

Received: 01-06-2024 | Accepted: 03-07-2024 | Published: 09-07-2024

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ABSTRACT

This study demonstrates the efficacy of brachial plexus block combined with balanced anesthesia in the treatment of fractures in Caracara plancus, an area rarely explored in veterinary medicine. An adult male caracara with a left humeral fracture was successfully treated using a multimodal anesthetic approach. The combination of dexmedetomidine, ketamine, midazolam, and morphine provided effective anesthesia, resulting in muscle relaxation and hemodynamic stability. The brachial plexus block, performed with the aid of a nerve stimulator, was essential for segmental analgesia. The anesthetic protocol employed allowed for the entire surgical procedure to be conducted pain-free and safely. Postoperative recovery was rapid and uncomplicated, with bone consolidation confirmed by radiographs. It is concluded that the brachial plexus block combined with balanced anesthesia is a viable and safe option for orthopedic procedures in birds of prey.

Keywords: Balanced anesthesia, Locoregional block, Orthopedics, Sedation, Birds of prey.
RESUMO
Este trabalho mostra a eficácia do bloqueio do plexo braquial combinado com anestesia balanceada no tratamento de fraturas em *Caracara plancus*, uma área pouco explorada na medicina veterinária. Um macho adulto de carcará, com fratura no úmero esquerdo, foi tratado com sucesso utilizando uma abordagem anestésica multimodal. A combinação de dexmedetomidina, cetamina, midazolam e morfina proporcionou anestesia eficaz, gerando relaxamento muscular e estabilidade hemodinâmica. O bloqueio do plexo braquial, realizado com auxílio de neurolocalizador, foi essencial para a analgesia segmentar. O protocolo anestésico empregado permitiu a realização de todo o procedimento cirúrgico sem dor e com segurança. A recuperação pós-operatória foi rápida e sem complicações, com consolidação óssea confirmada por radiografias. Conclui-se que o bloqueio do plexo braquial combinado com anestesia balanceada é uma opção viável e segura para procedimentos ortopédicos em aves de rapina.

**Palavras-chave:** Anestesia balanceada, Bloqueio locorregional, Ortopedia, Sedação, Aves de rapina.
INTRODUCTION

Anesthesia in wild birds presents several challenges. The avian respiratory system is highly specialized, with air sacs that facilitate gas exchange, making them more sensitive to inhalational anesthetics and requiring constant monitoring to prevent respiratory depression (Guzman & Beaufrère, 2021). Unlike mammals, birds metabolize drugs more rapidly, potentially leading to a swift anesthetic recovery, necessitating careful attention to dosages used in the species (Hawkins, 2006).

Physiological metabolic variations in wild birds make standardizing anesthetic dosages difficult and can significantly impact the efficacy and safety of anesthesia. High stress during capture and handling can also influence anesthetic responses, highlighting the need for safe restraint methods and stress minimization (Paul-Murphy et al., 2007). Maintaining body temperature is crucial to avoid complications during anesthesia, as birds are susceptible to hypothermia (Rocha & Escobar, 2015).

Recognizing pain signals in birds is challenging, as they often mask this variable, complicating the assessment of analgesic needs and effectiveness. In such cases, preemptive analgesia and the use of locoregional blocks can provide effective pain control (Guzman & Beaufrère, 2021). The brachial plexus block, for example, is a promising technique that can help overcome these challenges by providing segmental anesthesia, reducing the need for systemic anesthetics and their side effects (Soresini et al., 2013; Skelding et al., 2018).

However, the brachial plexus block technique is not yet well established in birds due to anatomical differences and the peculiarities of wild species. Studies show that the application of local anesthetics for brachial plexus block can have variable success rates and still needs improvement to enhance its effectiveness in birds (Figueiredo et al., 2008).

This study aims to describe the application of balanced anesthesia, including the brachial plexus block, in the treatment of a humeral fracture in a Caracara plancus. It discusses the challenges faced and the results obtained, intending to contribute to the improvement of anesthetic techniques for orthopedic surgeries in little-studied birds of prey.
CASE REPORT

An adult male *Caracara plancus*, weighing 833 grams and with a fracture in the left wing, was attended at the *Hospital Veterinário da Uniube* (HVU). The injury was suspected to be due to a collision with a vehicle, and the bird was rescued by environmental police in a peri-urban area near a highway in the municipality of Uberaba.

During the physical examination, severe malnutrition, mild dehydration, a heart rate of 213 beats per minute, a respiratory rate of 65 movements per minute, a rectal temperature of 40°C, and intense pain upon manipulation of the left wing were observed. For sedation and pain control, 2 mg/kg of midazolam (Cloridrato de Midazolam, Hipolabor, Sabará, MG, Brazil), 1 µg/kg of fentanyl (Citrate Fentanyl, Cristália, Belo Horizonte, BH, Brazil), both via intranasal, and 1 mg/kg of meloxicam (Maxicam 0.2%, Ouro Fino, Cravinhos, SP, Brazil), intramuscularly, were administered.

Orthopedic evaluation revealed mobility and an increased volume on the medial aspect of the proximal portion of the left humerus. Radiography showed a multiple fracture in the proximal third of the left humeral diaphysis, with intense proliferative bone reaction and the presence of a bone fragment, indicating an old fracture with hypertrophic nonunion.

The bird was kept in a special enclosure for wild animals at the HVU for two weeks to promote general recovery, reduce capture stress, and ensure effective pain management. During hospitalization, 5 mg/kg/BID of tramadol hydrochloride (Teuto, Cravinhos, SP, Brazil), twice a day, intramuscularly, along with 1 mg/kg/SID meloxicam (Maxicam 0.2%, Ouro Fino, Cravinhos, SP, Brazil), were administered intramuscularly.

On the day of surgery, after pre-anesthetic evaluation confirming normal parameters, anesthesia was initiated with 5 µg/kg of dexmedetomidine (Dexdomitor®, Zoetis, Campinas, SP, Brazil), 15 mg/kg of ketamine (Cetamin®, Syntec, Santana de Parnaíba, SP, Brazil), 3 mg/kg of midazolam (Cloridrato de Midazolam, Hipolabor, Sabará, MG, Brazil), and 0.5 mg/kg of morphine sulfate (Dimorf®, Cristália, Itapira, SP, Brazil), all administered intramuscularly in the same syringe. After 15 minutes, the animal was intubated with a 3.0 endotracheal tube, connected to an open Baraka circuit, providing 100% oxygen at 1 L/min and 0.5% isoflurane (Isoforine®, Cristália, Itapira, SP, Brazil). Monitoring included electrocardiogram, oximetry, capnography, and esophageal temperature, using the multiparameter monitor SDAMonitor12 (SDAMED, Paulínia, SP, Brazil) throughout the anesthesia.
The bird was positioned in dorsal decubitus with wings extended, feathers were removed from the region, and antisepsis was performed with 2% chlorhexidine degemerig solution (Riohex®, Rioquímica, Cravinhos, SP, Brazil) and 0.5% alcohol chlorhexidine solution (Riohex®, Rioquímica, Cravinhos, SP, Brazil). The brachial plexus block was performed with a neurostimulator (BGE Médica, São Paulo, SP, Brazil). The needle was inserted at the intersection of the caudal scapulohumeral and caudal coracobrachial muscles, positioned cranially, between 45° and 65° relative to the spine. Lidocaine (Xylocaine, Hipolabor, Belo Horizonte, MG, Brazil) 2 mg/kg was administered when the neurolocator indicated negativity at 1 milliampere (mA) and positivity at 2 mA, avoiding intraneural application.

Figure 1: Image of the brachial plexus block procedure in a Caracara plancus with a left humeral fracture. Note the needle insertion point for anesthetic deposition near the brachial plexus (red arrow).

Next, osteosynthesis of the humerus was performed through a ventral approach to the bone. The plate-rod technique was used for bone stabilization, ensuring rigid and adequate fixation of the fracture. The brachial plexus block was effective, allowing general anesthesia to be maintained superficially, serving only for the chemical restraint of the patient. Throughout the surgical procedure, the animal remained stable, with no complications (Table 1). Anesthetic recovery was rapid and smooth, occurring three minutes after the discontinuation of isoflurane, with the animal awakening without signs of pain.
In the postoperative period, the patient was treated with 10 mg/kg of enrofloxacin (Kinetomax®, Bayer, São Paulo, SP, Brazil) once daily, intramuscularly, for seven days. Additionally, 1 mg/kg of meloxicam (Maxicam 0.2%, Ouro Fino, Cravinhos, SP, Brazil) was administered once daily, intramuscularly, for the first two days, with the dose reduced to 0.5 mg/kg/SID for an additional three days. Furthermore, 3 mg/kg of tramadol hydrochloride (Teuto, Cravinhos, SP, Brazil), every 12 hours, intramuscularly, was administered for seven days.

Immediate postoperative radiographic examination confirmed the proper position of the implants and correct bone alignment. The patient was monitored radiographically every 15 days until complete bone consolidation, which occurred at 90 days. After this period, the bird was transferred to the Wild Animal Screening and Rehabilitation Center in Minas Gerais (CETAS-MG). We were informed that after 3 months of rehabilitation, the animal was released into the rural area of Patos de Minas-MG.
DISCUSSION

It was once believed that birds had a limited capacity to feel pain. However, it is now known that nociception in birds is similar to that in mammals, as studies have demonstrated the presence of the nidopallium in this species, akin to the pain center (Hawkins, 2006; Paul-Murphy, 2007). Anesthesia in birds poses significant challenges for professionals in the field due to their anatomical, physiological, and metabolic peculiarities, making technical knowledge essential to minimize complications.

Pre-anesthetic medication is seldom used in birds, as these animals can often be restrained manually. However, it is known that, besides the risk of injuries from manual restraint, the stress generated by such action can trigger a series of organic alterations. Therefore, pre-anesthetic medication becomes viable and recommended (Paula et al., 2013).

Anesthetics, in general, are used to produce chemical restraint, muscle relaxation, unconsciousness, analgesia, and help reduce stress. The use of balanced anesthesia aims to reduce adverse effects such as cardiorespiratory and vasomotor impacts, enhance analgesia, and improve anesthetic quality and safety (Rocha & Escobar, 2015; Lopes et al., 2023). In this study, we opted for the combination of ketamine, midazolam, dexmedetomidine, and morphine administered intramuscularly. The combination of these drugs in therapeutic doses produced a synergistic effect simultaneously, without causing significant hemodynamic impacts on the patient.

Ketamine is a highly versatile anesthetic drug, with its use established for over 50 years. It acts as a non-competitive antagonist of NMDA (N-methyl-D-aspartate) receptors, responsible for generating hypnosis, anesthesia at high doses, analgesia through antinociception, sympathetic stimulation, and bronchodilation (Sleigh et al., 2014). Its association with benzodiazepine in parrots (Amazona aestiva) produced a good degree of sedation, stress reduction, and significantly decreased the induction time and the MAC (Minimum Alveolar Concentration) of halogenated agents (Paula et al., 2013). In our study, the association of ketamine with midazolam, combined with dexmedetomidine and morphine, allowed orotracheal intubation after 15 minutes, optimizing the time without the need for additional drugs to obtain a patent airway.

The use of alpha-2 adrenergic receptor agonists is commonly employed in dogs, cats, and humans and has seen an exponential increase over the past 10 years (Mumm & Mans, 2022; Franco; Evangelista; Briganti, 2023). They exert their sedative effect by
acting on the locus coeruleus in the midbrain, inhibiting the release of excitatory neurotransmitters such as norepinephrine through the inhibition of adenylate cyclase and reduction of cyclic monophosphate, also promoting potassium efflux and inhibiting calcium entry into nerve endings, leading to membrane hyperpolarization, resulting in sedation and hypnosis (Bao & Tang, 2020; Franco; Evangelista; Briganti, 2023). Dexmedetomidine is a highly selective sedative and analgesic agent that acts on alpha-2 adrenergic receptors, resulting in profound sedation. In the present context, its combination with ketamine and midazolam proved to be an effective strategy to achieve the desired sedation. The use of these pharmacological agents demonstrated satisfactory results, with profound sedation being achieved in a relatively short period of 15 minutes.

By acting on the locus coeruleus of the brainstem and inhibiting the release of norepinephrine, alpha-2 adrenergic agents can inhibit sympathetic nervous excitability, reduce plasma catecholamine concentration, lower blood pressure, and decrease heart rate (Bao & Tang, 2020). However, in the case described, despite the administration of alpha-2 adrenergic agents, suppression of the sympathetic system was not observed, as the patient remained stable throughout the procedure without a drop in the measured parameters. This suggests that when administered in appropriate doses, the side effects of dexmedetomidine may not manifest in the Caracara plancus. Additionally, it is possible that the combination with ketamine and midazolam may have modulated these effects, as ketamine has the ability to stimulate the sympathetic system (Sleigh et al., 2014).

Providing adequate analgesia is extremely important in any species, but in birds, recognizing pain is more difficult due to the lack of facial, verbal, or behavioral manifestations. Therefore, pain should be treated in the presence of tissue damage, potentially painful procedures in other species, or even abnormal behavior (Guzman & Beaufrère, 2021; Aliansyah; Chng; Xie, 2022). With the use of preemptive analgesia employing analgesics before a noxious stimulus occurs, morphine was administered in the present case to prevent and reduce pain. As a full µ-agonist opioid used in the treatment of moderate to severe pain, morphine is among the opioids used in birds. In addition to providing analgesia, the use of morphine in doses of 0.1, 1, and 3 mg/kg significantly reduced the minimum alveolar concentration of isoflurane in a study conducted with 18 chickens (Concannon; Dodam; Hellyer, 1995; Guzman & Beaufrère, 2021).
Local anesthetics are pharmacological agents designed to block the conduction of nerve impulses by interfering with sodium channels in neurons. These channels are responsible for transmitting the action potential, and by blocking them, local anesthetics prevent the generation and conduction of the pain impulse. The use of local anesthetics to produce brachial plexus block has been described in birds (Soresini et al., 2013; Guzman & Beaufrère, 2021). However, the technique is not yet well established in all species due to anatomical differences and the peculiarities of wild species, such as those in the present study.

The brachial plexus is a system of intercommunicating nerves that innervates the thoracic limb, and blocking it allows for the production of analgesia and surgical anesthesia of the limb while providing an inhalant-sparing effect (Soresini et al., 2013; Guzman & Beaufrère, 2021). This block can be performed by blind palpation, ultrasound, or neurostimulation. A study conducted on chickens to test brachial plexus block using a neurostimulator with a stimulation frequency between 2 and 5 Hz and a current of 0.12 mA showed a success rate of 66% (12 out of 18 cases) (Figueiredo et al., 2008). These results suggest that the technique still requires improvement to enhance its effectiveness in birds. In the present case, the chosen technique for brachial plexus block was with the aid of a neurostimulator, using an axillary approach with lidocaine at a dose of 2 mg/kg. This approach proved effective since there was no increase in anesthetic requirement after the start of surgery and nociceptive stimuli, and the parameters remained stable without signs of nociception.

Local anesthetics have the potential for toxicity. Lidocaine can be used in birds at a maximum dose of 4 mg/kg and bupivacaine at a dose of 2 mg/kg (Guzman & Beaufrère, 2021). In the present study, the use of 2 mg/kg of lidocaine for performing the perineural block did not show adverse toxicity effects, in accordance with the dose described above. In the prospective study by Figueiredo et al. (2008) evaluating brachial plexus block in chickens, there was no significant difference in the latency time and duration of the sensory block between lidocaine and bupivacaine.

Inhalation anesthesia is the most commonly used method, and isoflurane is the anesthetic of choice. Both isoflurane and sevoflurane cause dose-dependent cardiorespiratory depression. Birds generally require a MAC of isoflurane ranging from 1 to 2.5%. The black eagle and red-tailed hawk require 1.46 ± 0.3 and 2.05 ± 0.45 MAC, respectively (Guzman & Beaufrère, 2021). In the case described, inhalation anesthesia with isoflurane was chosen, but no cardiorespiratory depression was observed, and there
was no need for a MAC higher than 0.5%. The lower anesthetic requirement during surgery and the obtained hemodynamic stability were likely due to the balanced anesthesia with the efficient combination of locoregional block, reducing undesirable pharmacological effects.

In summary, the combination of dexmedetomidine, ketamine, midazolam, and morphine constitutes a promising multimodal approach to achieving satisfactory sedation, with intense muscle relaxation and a high degree of hypnosis. The inclusion of the brachial plexus block was essential to ensure anesthesia by preventing nociceptive stimuli from reaching the central nervous system, while the other drugs were mainly used for chemical restraint, thus contributing to hemodynamic stability and minimizing the adverse effects of anesthesia in *Caracara plancus* (Southern Caracara).

**CONCLUSION**

In conclusion, balanced anesthesia, including brachial plexus block, is an effective approach for treating fractures in *Caracara plancus*. The combination of dexmedetomidine, ketamine, midazolam, and morphine provides satisfactory anesthesia with intense muscle relaxation and a high degree of hypnosis, while the brachial plexus block ensures adequate analgesia and contributes to hemodynamic stability during the procedure.

Additionally, preemptive analgesic management with morphine and rigorous monitoring during anesthesia were crucial to minimizing the risk of pain and anesthetic complications, demonstrating the importance of a multimodal and individualized approach in the orthopedic treatment of wild birds.

**ACKNOWLEDGMENTS**

The authors thank CAPES for financial support and the University of Uberaba for providing infrastructure for animal care. Special thanks to Dr. Carlos Alberto Valera, Prosecutor of the Public Ministry of MG, for his dedicated efforts towards wild animals. We also thank CAPES-PDPG 3/4 for supporting the Emergency Strategic Consolidation of Academic Graduate Programs.
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