Chapter 81

The role of acupuncture in motor rehabilitation in wild animals

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Amábile Edith Back Köhn
Bachelor of Veterinary Medicine at the Instituto Federal Catarinense - Campus Araquari/SC

Lygia Karla Sanches Francelino
Veterinary acupuncturist and wild animal clinician

Robert Lenoch
Professor of Veterinary Medicine at the Instituto Federal Catarinense - Campus Araquari/SC

ABSTRACT
The objective of this paper was to analyze the use of acupuncture in the motor rehabilitation of wild animals, through a survey of bibliographic references on the subject. The techniques observed were needling, laserpuncture, electroacupuncture and moxibustion. Case reports of motor disorders and the respective species affected were analyzed: pododermatitis *(Haliaeetus leucocephalus and Oryctolagus cuniculus*), paralysis (*Geochelone carbonaria, Ramphastos toco, Spheniscus demersus, Vulpes vulpes)*, spinal trauma (*Tupinambis merianae)*, intervertebral disc disease (*Cynomys ludovicianus*), degenerative joint disease (*Haliaeetus leucocephalus)*, and fractures *(Oryctolagus cuniculus*). Acupuncture has proven effective in promoting analgesia and neuromodulation and reducing inflammation, being an important ally in the treatment of neuropathies and pathologies of the locomotor system. Thus, it is possible to verify that the use of acupuncture in locomotor diseases has optimized the time, recovery and cure process, besides providing a better quality of life to wild patients.

Keywords: Acupuncture, Motor rehabilitation, Wild animals, Veterinary medicine.

1 INTRODUCTION

According to Funk et al. (2001), like domestic animals, wild animals can develop motor alterations from a variety of causes, with neurological, musculoskeletal, or pain being the most commonly encountered. Due to environmental deterioration, disease occurrence has emerged as a central issue in species conservation. According to Kaneko (2010), acupuncture is one of the branches belonging to Traditional Chinese Medicine, dating back approximately five thousand years. Until today, its efficiency in the treatment of pain, inflammation, and neuropathies is well known through thousands of scientific articles and case reports. Acupuncture acts in pain control through local and systemic actions, such as the release of endorphins, serotonin, and other neurotransmitters, thus promoting the regeneration of the affected areas and increasing blood flow and local tissue microcirculation.

According to Scognamillo-Szabó (2008), Brazil is currently one of the countries that stands out in research on acupuncture in the world. In these studies it is clear the wide applicability of acupuncture in small and large animals. In situations such as neuromuscular disorders and pain control, veterinary acupuncture has been advocated as one of the most effective forms of treatment. Despite the vast literature on the effects of acupuncture in people or domestic animals, or experimental animals, there are few reports

on acupuncture treatment in wild animals. This subject is of great relevance for species conservation, health and welfare of unconventional pets. In this context, this work aims to analyze acupuncture in the motor rehabilitation of wild animals, highlighting some species and the respective motor disorders presented, such as: pododermatitis (*Haliaeetus leucocephalus* and *Oryctolagus cuniculus*), paralysis (*Geochelone carbonaria*, *Ramphastos toco*, *Spheniscus demersus* and *Vulpes vulpes*), spinal trauma (*Tupinambis merianae)*, intervertebral disc disease (*Cynomys ludovicianus*), degenerative joint disease (*Haliaeetus leucocephalus*) and fractures (*Oryctolagus cuniculus*).

2 TECHNIQUES AND CONCEPTS DESCRIBED IN THIS STUDY

2.1. MOTOR REHABILITATION

According to Rocha (2020), motor rehabilitation is the science of applying biomechanics, physics, anatomy, physiology, and psychology to patients with dysfunction, injury, pain, or physical abnormality. It aims to correct and restore the patient's physical conditions through exercises and stretching, thus restoring his movements, strength, posture, and mobility, restoring his functional loss, reducing disabilities, enhancing the patient's functionality, as well as relieving the pain that afflicts him.

Neural reorganization or neuroplasticity is a preliminary goal of neurological recovery in order to provide the resumption of function. According to Borella (2009), learning depends on persistent and long-term changes in the strength of synaptic connections. With task repetition, there is an increase in the number of active regions of the brain. In recent studies by Borella (2009), they report that synaptogenesis precedes the reorganization of motor maps and both occur during late stages of skill learning. This synaptic formation that occurs in learning-dependent plasticity is important for cortical functional changes.

2.1.1 Traditional Chinese Veterinary Medicine

According to Schoen (2006), Traditional Chinese Veterinary Medicine (TCMV) is based on theoretical and empirical knowledge accumulated over centuries in China. Kaneko (2010) mentions that one should take into consideration the idea of balance and harmony between the body and its internal and external environment; as well as the most recent research in the area shows. As per Xie and Eckermann-Ross (2012), the fundamental principles of MVTC are to identify patterns of disharmony in the body's *Yin-Yang* energies and use herbs, acupuncture, food therapy, exercises, and a combination to restore balance - and thus the health of the individual. *Yin* refers to the parasympathetic system: resting, energy storage, decreased heart rate, and vasodilation. *Yang refers to the* sympathetic system, energy discharge, increased heart rate, and vasoconstriction.

MVTC has been applied to exotic animals, including birds, rabbits, elephants, monkeys, giant pandas, tigers, jaguars, turtles, and many others. Kaneko (2010), mentions that the diagnosis by MVTC is

made by detailed observation of the patient, not only by the history, but also by its interaction with external factors and observed symptoms.

2.1.2 Scientific basis of acupuncture

According to Kaneko (2010), acupuncture is one of the forming branches of MVTC. Scientifically, the penetration of the needle triggers several events in the body such as the release of inflammatory mediators (histamines, bradykinin, prostaglandin, serotonin), hormones and enzymes; stimulation of alpha and beta- receptors, of tendon and muscle spindles; activation of the pain inhibitory mechanism (inhibiting afferent pain impulses and inducing the release of endorphins); improvement in lymphatic flow and local circulation; stimulation of collagen production, induction of humoral and thermoregulatory effects, among others. Cooke (2006), adds that besides these effects, studies point to the increase of neuroplasticity mediated by acupuncture.

According to Scognamillo-Szabó and Bechara (2001), acupoints consist of cutaneous regions rich in sensory nerve endings, blood vessels, tendons, periosteum, and capsules, besides a large concentration of mast cells. Their stimulation allows access to the Central Nervous System (CNS). These acupoints also have different electrical properties than the adjacent areas: high conductance, lower resistance, organized field patterns, and electric potential difference. The combination of these characteristics makes the acupoint extremely reactive to the small stimulus caused by the insertion of the needle.

3 ACUPOINT STIMULATION TECHNIQUES OBSERVED IN THE SELECTED REPORTS:

3.1 NEEDLING

Kaneko (2010), says that the needling procedure is performed by inserting needles into acupuncture points, which cross the dermis and can reach the muscles. This method is the best known and applied in Veterinary Medicine. The acupuncturist has several sizes of needles available, and the most used material is stainless steel.

3.2 MOXIBUSTION

According to Kothbauer (1990), moxibustion consists in the stimulation of acupoints through the local application of heat. Becke (1989), adds that the term "moxibustion" comes from the Japanese "**mogusa**" - dried mugwort. According to Lima (2013), the smoke of mugwort, the main component of moxa, reduces macroscopic and histological inflammatory scores during reepithelialization, in addition to reducing bleeding and tissue fibrosis; moreover, it has the ability to increase fibroplasia, collagenogenesis, and angiogenesis, also possessing antioxidant effect - potentiating healing.

3.3 LASERPUNCTURE

Pryor and Millis (2015), point out that the also called laser therapy or photobiomodulation, consists of the stimulation of acupoints by laser therapy, interacting with cells and promoting stimulation of them. Laser therapy effects are also documented as an increase in the rate of angiogenesis, control of inflammation, normalization of ion channels, stabilization of the cell membrane, vasodilation, among others.

Liu et al. (2007), says that *low level* laser therapy is an advanced method that has been applied with varying power in order to treat a variety of diseases, including fractures, wounds, pain and immunomodulation. According to Silva (2012), studies indicate that the application of laser at infrared wavelengths can increase osteoblastic proliferation, collagen deposition, and bone formation.

3.4 ELECTROACUPUNCTURE

According to Bezerra (2017), the main difference between manual acupuncture and electroacupuncture is the use of electrical devices that, connected to the needles, transmit stimuli with the aim of clearing and balancing the flow of energy (*Chi*). In this technique the stimulation is accompanied by visible contractions, as the needle is inserted into the skeletal muscle.

Cameron (2009), says that electroacupuncture has an analgesic action around 10 to 20 minutes faster than manual acupuncture. In addition, it is mostly used fewer needles to produce analgesia. While mechanical stimulation of the needles only provides analgesia, electroacupuncture can be used for both analgesia and anesthesia.

4 MOTOR INJURIES IN WILD ANIMALS

4.1 PODODERMITIS

Diez et al. (2020), explains that pododermatitis is a chronic and progressive bacterial infectious disease of the plantar extremity of the hind limb of birds and mammals, especially associated with captivity, which can lead to significant motor alteration in wildlife rehabilitation centers, delaying the reintroduction of animals to their habitat and harming their conservation. Choi et al. (2016) cites that etiological factors include obesity, diet of low nutritional value, inactivity, and inadequate perches. According to Cooper (1985), pododermatitis can be classified into three stages. Stage I is characterized by a localized, hyperemic lesion. In stage II, the lesion is more extensive, often covered by a crusty growth, and there is infection with inflammation. Finally, in stage III, the tissue is organized resulting in abscesses that can affect the deeper layers of tissue, resulting in loss of limb function.

4.2 PARALYSIS

Siqueira (2007), clarifies that paralysis consists of temporary or permanent loss of motor function of one or more muscles or part of the body due to neurological injury (central or peripheral). Peripheral lesions cause sensory loss, pain, and discomfort, and motor losses cause paralysis and, consequently, muscle atrophy. Lloret (2005), cites that the most commonly used treatment in these cases consists of physical therapy and prevention of future injuries. Still (2003), evidences that the association of acupuncture stimulates the recovery of the affected nerve through the stimulation of local acupoints and the corresponding meridians.

4.3 SPINAL CORD INJURY

Bergman (2000)a, explains that Traumatic injuries to the spine and spinal cord occur frequently in veterinary and human medicine, leading to sequelae such as partial or complete loss of motor, sensory and visceral functions. Araujo (2016), describes that spinal cord trauma (SCI) consists of an injury that interrupts the transmission of information from neurons in the body to the brain, either totally or partially. Such traumas can lead to severe sequelae, from paresthesia to quadriplegia. Schwab and Bartholdi (1996) explain that there are four primary injury mechanisms related to spinal cord trauma: impingement associated with persistent compression by rupture of the intervertebral disc, bone fragments and fractures with displacement; impingement associated with transient compression, as in the case of hyperextension; distensions caused by forces related to flexion, extension, rotation or displacement, compromising the blood flow; and, finally, spinal cord laceration or transection. Arias et al. (2007), cites that the consequences of spinal cord trauma in veterinary medicine may lead to permanent locomotor incapacity, death or euthanasia, depending on the injured segment and the severity of the injury, among other factors. According to Bergman et al. (2000)b, treatment is challenging and should be considered an emergency, since a quick and appropriate decision increases the chances of functional recovery. Jeffery (2010), explains that there are options of conservative or surgical treatment, which is necessary when the fracture is unstable or in cases of traumatic compression of the spinal cord, by traumatic disc extrusion or hematoma. Bergman et al. (2000)b, further states that in cases where there is minimal vertebral instability or few neurological changes, conservative treatment may be as beneficial as surgical treatment, and consists of confinement for four to six weeks, analgesia, control of urination and use of external immobilization in the case of fractures and subluxations. Schoen (2001) adds that in patients with myelopathy, acupuncture promotes analgesia, axonal regeneration, increased transmission of nerve impulses at the site of injury, and also anti-inflammatory activity.

4.4 INTERVERTEBRAL DISC DISEASE

According to Srugo et al. (2010), intervertebral disc disease (IVDD) is the most common spinal disease in dogs and usually manifests itself by degeneration of the inner nucleus pulposus, causing secondary rupture of the dorsal fibrous ring and disc herniation, promoting spinal cord trauma (Hansen's type 2; more common in chondrodystrophic dog breeds); or by chronic protrusion of the dorsal fibrous ring, promoting slow, progressive compression of the spinal cord (Hansen's type 1; more common in larger dog breeds). Shores (1992), explains that sequelae of primary spinal cord trauma are determined by the severity of the aforementioned conditions and can range from minor damage causing minimal neurological dysfunction to severe laceration, crushing or distraction, which compromises the function of the neurological system. Concussion at the time of injury is the main cause of initial neurological dysfunction.

Aikaea (2007), states that fenestration alone and hemilaminectomy significantly improve the ability to debride the extruded disc material with minimal manipulation of the spinal cord, which is associated with better outcomes and decreased likelihood of recurrence of clinical signs.

In his study, Downes (2009), proposed that prognosis depended on the nature of injury onset. Scott (1997), argued that the prognosis for dogs that retain deep nociception is excellent and the recovery rate is nearly 100% for normal ambulation with decompressive surgery. For those without deep pain, the recovery rate is approximately 50% (between 7-70% of paraplegic dogs).

Draper (2012), in his study demonstrated that low-level laser therapy reduces ambulation time in dogs after hemilaminectomy, specifically by employing red light (810 nm), stimulating axonal growth and locomotor function and reducing the inflammatory response in a study in laboratory rats.

4.5 DEGENERATIVE JOINT DISEASE

Kalladka (2014), explains that the etiology of degenerative joint disease (DAD) involves an ongoing degenerative inflammatory process, where mechanical or metabolic factors exceed the adaptive capacity of the joint and contribute to the initial damage of cartilage and/or synovial tissues. According to Tanaka (2008), the overload alters the metabolism of the chondrocytes on the joint surface, which go into apoptosis and trigger the degradation of hyaluronic acid, the main component of synovial fluid, promoting changes in joint lubrication.

According to Choi et al. (2016), acupuncture may be a potential option for permanent captive raptors for musculoskeletal conditions such as degenerative joint diseases.

4.6 FRACTURE

Fractures can be defined as a partial or complete break in the bone and can be classified as either open or closed, depending on the presence of skin injury.

According to Kazem et al. (2010) low-level laser therapy (LLLT) is a biophysical method of

intervention in the fracture repair process. The principle involved is the photophysical-chemical effect, in which the laser light interacts at the biomolecular level, through bioelectrical, bioenergetic and biochemical cellular processes. Pinto (2013), explains that in this way the mechanism of action occurs through biomodulation of the inflammatory process, along with chemical mediators, inhibiting prostaglandins, and promoting the stimulation of fibroblasts in tissue repair, thus increasing the synthesis of collagen, accelerating the process of angiogenesis and increasing vasodilation. Thus, the Laser promotes fracture healing and callus formation.

Zhang et al. (2014), explains that acupuncture is able to reduce inflammation, increasing local blood circulation and reducing pain through peripheral, spinal and supraspinal mechanisms, and is used in fracture recovery. Wegner et al. (2013), also adds that it can be associated with the moxibustion technique, which promotes improved blood circulation, improving healing.

5 CASE REPORTS AND RESEARCH LISTED WITH THIS STUDY

According to Silva (2007), in his case report on paraplegia in a Teiú lizard (*Tupinambis merianae)*, acupuncture and electroacupuncture sessions were performed on the local and distal acupoints of the lesion. In the local approach, acupoints were stimulated lateral to the spine, cranial and caudal to the fracture, in order to stimulate the Back Shu points. At the distal points, the insertion of the needles was adjacent to the hip joint representing, respectively, points VB30 and E36. In some points electrodes were attached to the needles in order to promote transcutaneous electrical neurostimulation (TENS) at a frequency of 25 Hz for 15 minutes. The sessions were held once a week, and from the third session on, the lizard already had regained perception of nociceptive stimuli and increased motricity in the pelvic limbs. After two months of treatment, the animal was discharged from hospital, as it was able to walk properly.

A case of paraplegia in a Prairie Dog *(Cynomys ludovicianus)* has also been described. According to Bakker (2018), the animal was affected by a traumatic intervertebral disc herniation that caused paraplegia. In this case there was a need for surgical treatment, and a hemilaminectomy was performed in the L1-L2 disc space. After that, acupuncture sessions were performed, but the acupoints were not described. After 3 months the animal presented complete recovery of the hind limbs and excretory function was resumed.

In Paralysis, Scognamillo- Zabó (2008), described the case of a free-living Red Jabuti (*Geochelone carbonaria)* that presented this motor lesion and acupuncture sessions were performed using the acupoints R11, VG16, VB1, E36, VB20, VB34 and B40. The animal was discharged after three weeks of treatment, as it recovered its ability to walk and eat unaided. However, he remained in captivity, not returning to the wild. According to Souza (2015), in his case report on paralysis in a Toucan (*Ramphastos toco),* the animal presented atrophy in the tarsus-metatarsus muscles, cranially turned fingers, absence of superficial and deep sensitivity in the fingers, difficulty in moving around due to the change in gait, which made it

impossible to perch, staying all the time on the ground. Sessions were performed weekly using acupoints around the tarsus-metatarsus and the toes of the animal's left paw, following the "encircling the dragon" technique, and the needles were left for approximately 5 minutes. There was a significant improvement in two weeks of treatment, causing the animal to present sensitivity in the paw and fingers, which modified the positioning getting close to the anatomical one.

Crouch (2009), also described a case of paralysis, which was bilateral of the pelvic limbs of an African Penguin (*Spheniscus demersus*) in which acupuncture and physiotherapy sessions were performed. The acupoints VG14, VB29, VB30, B60 were used. After 6 weeks of treatment the animal was able to stand up at a 45° angle during physical therapy. The animal never walked completely upright again, but was able to return to all daily activities, although more slowly than the others.

Still about paralysis, Lloret (2005), reported a case about a Red Fox *(Vulpes Vulpes)*, which had a traumatic radial nerve paralysis. Acupuncture and physical therapy sessions were performed. In the acupuncture sessions, the acupoints selected were B11, B13, IG10, IG15, P5, PC3, C3, IG4, P7, VB34, E36, IG11, VG20, which are located around the affected nerve and in the corresponding meridian acupoints. After 10 days the animal showed increased mobility of the elbow and carpus, with almost complete recovery of extension at the elbow and approximately 80% of extension of the carpus.

Regarding degenerative joint disease, Choi (2016), presented a case report of a Bald Eagle (*Haliaeetus leucocephalus)* that besides degenerative joint disease also presented pododermatitis. This bird underwent several acupuncture sessions during 4 months, using acupoints E36, IG4, B40, B60, VB34 and Ba Feng. An excellent clinical improvement was obtained in this case, including improvement of the lameness from grade 5 to grade 1, and concomitantly, the pododermatitis that was grade 3 was cured.

Brown (2008), described a case of pododermatitis in a guinea pig (*Cavia porcellus), in* which low-level laser therapy sessions (gallinium 904-laser nm) at 1 J/cm² were performed daily on the lesion, but he did not mention how many sessions were performed in total. The healing was efficient, but the management should be changed to avoid recurrences. Low-level laser therapy was also described by Liu (2007), in which he performed a research with 20 rabbits performing laser therapy (Ga-Al-As laser) at 4.8 J/cm² directly on the bone fracture site. The results were satisfactory, with an increase in bone volume and adequate fracture repair.

The table below elucidates the case reports and research selected in this study in order to facilitate understanding and location.

Table 1 - Analysis of case reports and research listed in this study.

Espécie	Autor do estudo	Lesão Motora	Método MVTC	Acupontos - Região	Duração Tratamento	Resultados
Tupinambis merianae - Lagarto Teiú	SILVA, 2007	Paraplegia	Acupuntura + Eletroacupuntura	Back shu, VB30, E36	2 meses	Retomada de percepção à estímulos nociceptivos
Cynomys ludovicianus - Cão da pradaria	BAKKER, 2018	Paraplegia	Acupuntura + hemilaminectomia	–	3 meses	Recuperação completa dos membros posteriores
Geochelone carbonaria - Jabuti Vermelho	SCOGNAMILLO-SZABÓ, 2008	Paralisia	Acupuntura	R11, VG16, VB1, E36, VB20, VB34, B40	3 semanas	Recuperou a capacidade de andar sem auxílio
Ramphastos toco - Tucano	SOUZA, 2015	Paralisia	Acupuntura	Técnica de "cercar o dragão"	2 semanas	Melhora no posicionamento dos dedos
Spheniscus demersus - Pinguim Africano	CROUCH, 2009	Paralisia	Acupuntura + Fisioterapia	VG14, VB29, VB30, B60	6 semanas	Capaz de se elevar em um ângulo de 45 ° durante a fisioterapia
Vulpes vulpes - Raposa	LLORET, 2015	Paralisia	Acupuntura + Fisioterapia	B11, B13, IG10, IG15, P5, PC3, C3, IG4, P7, VB34, E36, IG11, VG20	10 dias	Mobilidade do cotovelo e do carpo aumentaram
Haliaeetus leucocephalus - Águia careca	CHOI, 2016	DAD* e pododermatite	Acupuntura	E36, IG4, B40, B60, VB34 e Ba Feng	4 meses	O grau de claudicação foi de 5 para 1; A pododermatite foi para grau zero
Cavia porcellus - *Porquinho da índia*	BROWN, 2008	Pododermatite	Terapia a laser de baixo nível	1 J/cm²	–	Cicatrização eficiente
Orcytolagus cuniculus - Coelho	LIU, 2007	Fratura	Terapia a laser de baixo nível	4,8 J/cm²	1 mês	Reparo adequado da fratura

Source: adapted from SILVA, 2007; BAKKER, 2018; SCOGNAMILLO- SZABÓ, 2008; SOUZA, 2015; CROUCH, 2009; LLORET, 2005; CHOI, 2016; BROWN, 2008; LIU, 2007.
*DAD - Degenerative Joint Disease

6 CONCLUSION

Acupuncture has been effective in promoting analgesia, neuromodulation, and reduction of inflammation, and is an important method in the treatment of neuropathies and locomotor system pathologies. Thus, it is possible to verify that the use of acupuncture in locomotor diseases has optimized the time and process of recovery and cure, as well as providing a better quality of life for patients .

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