

SUCCESSFUL LEFT PELVIC LIMB AMPUTATION IN A WHITE-HEADED MARMOSSET (*Callithrix geoffroyi*) FOLLOWED BY RELEASE INTO THE WILD

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ABSTRACT

Surgical reports involving wild animals are still scarce in the literature, particularly those documenting successful survival through surgery and postoperative handling stress in captivity. This study aims to present a case of *Callithrix geoffroyi* following total pelvic limb amputation. A young female white-headed marmoset weighing 395 grams, rescued by highway patrol in Guarapari – ES, with anatomical and functional deformities of the pelvic limb, including a multi-fragmented femoral shaft fracture. Given the severity of the fractures and limitations in applicable osteosynthesis techniques, amputation was necessary, considering spinal canal size, animal behavior, and potential for successful release. The white-headed marmoset resumed activity three hours post-surgery and was transferred to the Wildlife Sector at the Veterinary Hospital, housed in a wireframe cage with balanced nutrition, water, and environmental enrichment. Daily monitoring over 10 days assessed behavior, pain, nutrition, and surgical site healing. Upon complete wound recovery, the marmoset was transferred to wildlife management authorities for planned release. During this process, no aggressive behavior was observed from other white-headed marmosets, prompting the opening of the cage and the white-headed marmoset's voluntary movement towards a fruit tree among conspecifics.

Keywords: Captivity. Mitigation. Wildlife surgery.

INTRODUCTION

White-headed marmosets are the smallest anthropoids, body weight in adults varies from 105 g in Pygmy Marmosets (*Callithrix pygmaea*) to 700 g in Black Lion Tamarin (*Leontopithecus chrysopygus*) living in groups of 3-15 individuals (GARBER, 1992).

The *Callithrix* is mainly found in Brazil (ACCIOLY, 2000), being the species *C. geoffroyi* (Humboldt, 1812), also popularly known as white-headed marmoset, encountered endemically in the Atlantic Forest. It is a neotropical primate that occurs in southern Bahia, eastern region of Minas Gerais, and in practically all state of Espírito Santo (GRELLE; CERQUEIRA, 2006; MENDES, 1995; PASSAMANI, 1998). They have nails like claws in all manual digits for feeding; also allowing them to hold on to tree trunks and other large vertical supports (GARBER, 1992). They are exudative insectivores, where feeding consists of fruits, insects and plant sap (ACCIOLY, 2000; PASSAMANI, 1998). Their canine teeth are elongated and allow them to pull away the bark from plants inducing the flow of juices and sap (RYLANDS; FARIA, 1993). Due to their high metabolism and low-fat reserves, carbohydrate is consumed during the early morning hours by means of fruit and sap, providing energy for foraging insects that serve as a source of protein (PASSAMANI, 1998).

Animals caught in the wild and allocated in captivity should be minimally handled and socialized with the environment, thereby maintaining their behavioral characteristics (ROSSI et al., 2013). White-headed marmoset can become accustomed to and dependent on the human species (PAULA et al., 2005), hindering reintegration in nature. Kraemer et al. (1997) report that in addition to self-mutilation these animals may become more aggressive with younger animals or even group leaders, in the event of reintegration in a non-outlined manner.

Price et al. (2012) reported that the release and reintegration of captive non-human primates to free-living, especially those of the *Callithrix* sp. species should be meticulous and gradual, preferably of whole groups, and hierarchically structured in captivity, instead of isolated individuals.

During the early adaptation, it is recommended that food previously available be offered in captivity, in covered locations in the free area, so that the marmosets not yet adapted to food

collection have food available, although in the spring and summer food supply in nature is so abundant that they do not need the food offered in captivity (PRICE et al., 2012).

Literature states that there still are few surgical reports involving wild animals, especially reports in which animals survived the surgical procedure and stress due to manipulation, in captivity during the postoperative period (RODRIGUES et al., 2009). Thus, the aim of this study was to report captive adaptation and reintegration of a marmoset, *C. geoffroyi*, after total pelvic limb amputation.

CASE REPORT

A young female white-headed marmoset (*C. geoffroyi*) weighing 395 grams rescued by the ES-060 (Rodovia do Sol) highway patrol in the city of Guarapari – ES referred to the Veterinary Hospital of the University Vila Velha (UVV), on August 27th, 2015, with altered anatomical and functional conformation of the pelvic limb.

After clinical evaluation and discarding other physical changes, an alteration in the pelvic limb without skin scarification, and with anatomical deformity was confirmed. The animal was sedated using an association of 10 mg/kg of ketamine and 0.5 mg/kg of midazolam and directed to radiography of the affected limb. Examination revealed a transversal and longitudinal multi-fragment femoral shaft fracture, without fragment exposure maintaining the anatomy of the proximal and distal joints, and a transverse fracture in the distal third of the tibia and fibula, with no signs of bone union (Figure 1).



Figure 1 - Ventral-dorsal radiographic projection illustrating the pelvic region of the white-headed marmoset patient revealing the existence of a transversal and longitudinal multi-fragment femoral shaft fracture, without fragment exposure maintaining the anatomy of the proximal and distal joints, and a transverse fracture in the distal third of the tibia and fibula, with no signs of bone union, in the left pelvic limb.

Due to the severity of the fractures, the invasiveness of the osteosynthesis technique that could be applied and, considering the difficulty of handling the animal daily to perform surgical care, and considering that it was a free-living specimen, we opted for limb amputation. The animal was kept hospitalized and fasted for 12 hours. To perform anesthesia, combinations of ketamine and midazolam were administered at doses of 15.0 mg/kg and 0.5 mg/kg intramuscularly (IM), respectively, as pre-anesthetic medication. Venous catheterization was not established, thereby precluding anesthetic induction intravenously, requiring that the same be performed by inhalation using isoflurane anesthesia with the help of a mask, as well as monitoring of the patient's parameters. After induction, tracheal intubation was performed using a 14 G catheter coupled to a non-rebreathing system adapted for the patient's size, and throughout the trans-operative period, the animal was monitored and showed no anesthetic complications, receiving respiratory support by mechanical ventilation.

The animal was positioned in a right lateral decubitus with the affected limb facing up (Figure 2B). Total trichotomy of the member, from the flank to the distal portion, as well as surgical antisepsis and positioning of the drapes was performed. The distal portion of the member was protected with a sterile crepe bandage, to allow better handling of the member during the procedure.

A semicircular lateral cutaneous incision from the flank to the ischial tuberosity, along with a medial cutaneous incision parallel to and distal from the inguinal crease, connecting the cranial and caudal extremities of the lateral incision. The skin distal to the incision was dissected, muscle structures were also dissected and sectioned, blood vessels clamped twice and sectioned. The medial joint capsule was incised, and the femoral head ligament sectioned with the aid of scissors, allowing removal of the member (Figure 2A).

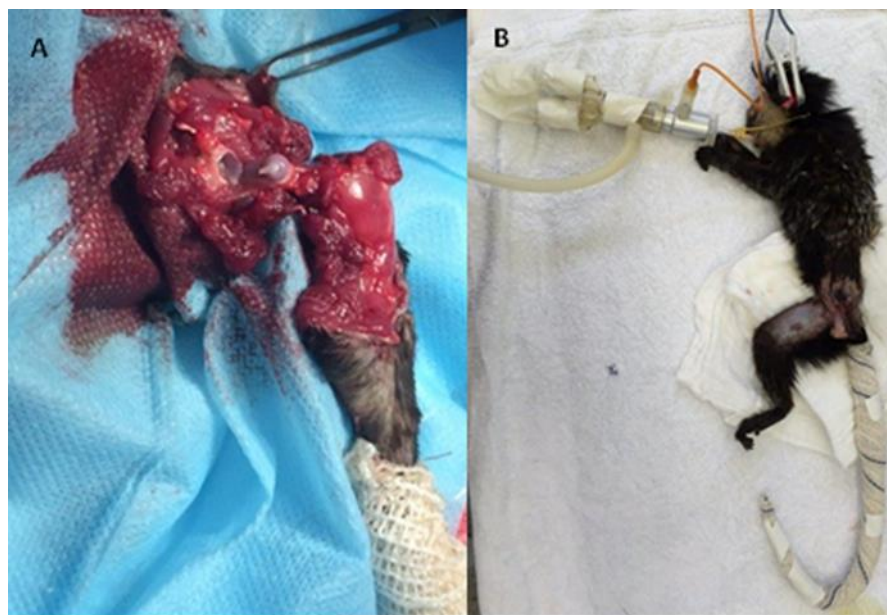


Figure 2 - A) After conducting the skin incision and sectioning the muscle structures, the medial joint capsule was incised, and the femoral head ligament sectioned with aid of scissors, allowing the member's removal. **B)** Animal in immediate post-surgical conclusion without the left pelvic limb and still under anesthesia care. Animal kept on tracheal intubation using a 14 G catheter coupled to a non-rebreathing system adapted for the animal's size, by which he received respiratory support by mechanical ventilation and was monitored by oximetry.

The muscles (thigh adductor, gracilis, semitendinosus and biceps femoris) were sutured with 2-0 polyglactin 910 (Vicril®), using Sultan (X) stitches, and the skin suture was performed with 3-0 mononylon with separate Wolff stitches (Figure 2B). Postoperative analgesia was established with 0.2 mg/kg of butorphanol diluted in 0.8 ml of saline solution, via subcutaneous (SC), in a single dose. Three hours after completion of the surgical procedure, the animal was active again and sent to the Wildlife Sector at the Veterinary Hospital - UVV,

being held in a wireframe cage measuring 100x50x50 mm (height x width x depth), with balanced feeding, water, and a branch to encourage movement.

The animal was monitored daily for 10 days until removal of the stitches, evaluating behavior, pain, nutrition, and potential interference with the surgical site. No medication was administered after conclusion of the surgical procedure, being prescribed only repellent ointment on the site of the stitches. The animal was fed normally during the post-surgical period, and kept its normal behavior, vocalizing, climbing up the gridded wall and the existing branch in the vivarium, demonstrating balance during deambulation and jumping.

On the tenth day after the stitches were removed, the surgical wound was fully healed, and the animal was referred for later release near the site of rescue. Prior to release, the animal was transported in a cage which was placed in a shaded terrain, with grass and near a fruit tree. In the first minute, interaction between individuals of the same species, 2-5 animals, approaching the cage, with vocalization, and attempting engagement with the white-headed marmoset. No aggressive behavior of the flock toward the marmoset was observed, which allowed the team responsible for the release to approach the cage open the door and step away again. After opening the cage, there were no other marmosets around and the amputated marmoset observed the location, explored the environment, and left the cage about 2 minutes after its opening, directing itself to the tree, which was climbed with ease.

RESULTS AND DISCUSSION

Trauma is a common occurrence in wild animals (CARISSIMI et al., 2005) a total of 3,943 animals struck by vehicles on the ES-060 were registered during the period from May 2001 to December 31st, 2014, probably less than the actual number of accidents (RODOSOL, 2015). Due to this high number of animals being run over, rescues of still impaired animals generated the need for surgical procedures to assure them life quality.

Reports of surgical cases in free wildlife or captive animals demonstrate scientific interest, as these articles are considered of scarce availability, especially involving patients who survive the surgical procedure and the stress of handling, and adapt to their physical condition (RODRIGUES et al., 2009).

In choosing the surgical method for the treatment, a technique that involved minimal manipulation of the patient in the postoperative period was selected, since animals caught in the wild and allocated in captivity should be minimally manipulated (ROSSI et al., 2013) and the stress of handling could lead to self-mutilation (KRAEMER et al., 1997). However, if only the characteristic of the fracture was considered, external fixation fasteners may have been recommended, however, the indications by Rossi et al. (2013) and Kraemer et al. (1997) would be contradicted because the fastener device requires daily cleaning of metal rods that transfix the bone through the skin.

Thus, the indication for amputation of the pelvic limb corroborates with the recommendations of Stone (1985), who recommends this procedure in cases of permanent injury, poor member functionality prognosis, and/or patient adaptability and management. One of the group's concerns was with the animal maintaining its balance in the absence of its member, but a rapid adaptation to this new physical condition was observed, since it could get around, jump and climb showing any motor restrictions.

The anesthetic protocol used was chosen based on literature regarding anesthesia in nonhuman primates. A combination of ketamine and midazolam was employed: ketamine provided chemical immobilization, while midazolam induced muscle relaxation and allowed for a reduction in the dose of the dissociative agent, enabling safer handling of the animal (LONGLEY, 2008). Isoflurane was used for anesthesia induction due to the lack of venous access, its rapid anesthetic action, and its safety in small primates. Isoflurane was also chosen for maintenance, considering the ease of endotracheal intubation in these animals, as well as its safety and rapid recovery (LONGLEY, 2008; THOMAS et al., 2012).

In the immediate postoperative period, the animal experienced prolonged anesthetic recovery, likely due to the administration of butorphanol at the end of surgery. As an opioid, this drug has a mild sedative effect and can enhance existing sedation, with its action lasting for 1-4 hours (LAMONT; MATHEWS, 2007; SANTOS et al., 2010). During the hospitalization period, care was taken to prevent socialization between the animal and the staff responsible for its clinical and dietary management, avoiding physical and verbal contact in order to preserve the animal's natural behavioral characteristics.

CONCLUSION

The study on the surgical treatment of wild animals injured by vehicle collisions highlights the complexity and challenges involved in rehabilitating these patients. Data analysis shows a high number of animals struck by vehicles on the ES-060 highway, highlighting the urgent need for interventions that ensure the survival and quality of life of these individuals. The choice of surgical method was carefully considered to minimize stress and postoperative manipulation, based on recommendations from various authors and the specifics of the injuries. The decision to amputate the pelvic limb, though drastic, proved to be appropriate, as it allowed the animal to quickly adapt and maintain its essential motor skills.

The anesthetic protocol used, combining ketamine and midazolam for immobilization and muscle relaxation, along with isoflurane for induction and maintenance of anesthesia, was effective and safe for the species in question. However, the prolonged recovery from anesthesia, influenced by the administration of butorphanol, underscores the importance of continuous monitoring and adjustments in postoperative care.

Special attention to the animal's socialization and interaction during hospitalization emphasizes the need for sensitive and respectful management to preserve the animal's natural behavior and well-being. In summary, the treatment and rehabilitation of wild animals require a delicate balance between medical efficacy and stress minimization. Future studies and practices should consider these variables to improve recovery and quality of life for these animals.

AMPUTAÇÃO DE MEMBRO PÉLVICO ESQUERDO EM UM SAGUI-DE-CABEÇA-BRANCA (*Callithrix geoffroyi*) SEGUIDA DE SOLTURA NA NATUREZA

RESUMO

Relatos cirúrgicos envolvendo animais selvagens ainda são escassos na literatura, especialmente aqueles que documentam a sobrevivência bem-sucedida através da cirurgia e do estresse de manejo pós-operatório do tratamento. Este estudo tem como objetivo apresentar um caso de *Callithrix geoffroyi* após amputação total de membro pélvico.

Uma jovem fêmea de sagui-da-cara-branca pesando 395 gramas, resgatada pela patrulha rodoviária em Guarapari – ES, apresentava deformidades anatômicas e funcionais do membro pélvico, incluindo uma fratura multifragmentada do fêmur. Dada a gravidade das fraturas e as limitações nas técnicas de osteossíntese aplicáveis, a amputação foi necessária, considerando o tamanho do canal medular, o comportamento do animal e o potencial de liberação bem-sucedida. O sagui-da-cara-branca retomou suas atividades três horas após a cirurgia e foi transferido para o Setor de Animais Silvestres do Hospital Veterinário, mantido em uma gaiola de arame com nutrição balanceada, água e enriquecimento ambiental. O monitoramento diário ao longo de 10 dias avaliou comportamento, dor, nutrição e cicatrização do local cirúrgico. Após a completa recuperação da ferida, o sagui foi transferido para as autoridades de manejo de fauna para liberação planejada. Durante este processo, nenhum comportamento agressivo foi observado de outros animais, o que levou à abertura da gaiola e ao movimento voluntário do sagui-de-cara-branca em direção a uma árvore frutífera.

Palavras-chave: Cativo. Cirurgia de animais selvagens. Mitigação.

EXITOSA AMPUTACIÓN DEL MIEMBRO PÉLVICO IZQUIERDO EN UN MARMOSET CABEZA BLANCA (*Callithrix geoffroyi*) SEGUIDA POR LA LIBERACIÓN EN LA NATURALEZA

RESUMEN

Los informes quirúrgicos que involucran animales salvajes aún son escasos en la literatura, especialmente aquellos que documentan la supervivencia exitosa a través de la cirugía y el estrés del manejo postoperatorio en tratamiento. Este estudio tiene como objetivo presentar un caso de *Callithrix geoffroyi* después de la amputación total de un miembro pélvico. Una joven hembra de tití cabeza blanca que pesaba 395 gramos, rescatada por la patrulla de carreteras en Guarapari – ES, presentaba deformidades anatómicas y funcionales del miembro pélvico, incluyendo una fractura multifragmentada del fémur. Dada la gravedad de las fracturas y las limitaciones en las técnicas de osteosíntesis aplicables, la amputación fue necesaria, considerando el tamaño del canal espinal, el comportamiento del animal y el potencial de liberación exitosa. El tití cabeza blanca retomó sus actividades tres horas después de la cirugía y fue transferido al Sector de Fauna Silvestre del Hospital Veterinario, alojado en una jaula de alambre con nutrición balanceada, agua y enriquecimiento ambiental. El monitoreo diario durante 10 días evaluó el comportamiento, el dolor, la nutrición y la cicatrización del sitio quirúrgico. Tras la completa recuperación de la herida, el tití fue transferido a las autoridades de manejo de fauna para su liberación planificada. Durante este proceso, no se observó comportamiento agresivo por parte de otros titís cabeza blanca, lo que

llevó a la apertura de la jaula y al movimiento voluntario del tití cabeza blanca hacia un árbol frutal entre sus congéneres.

Palabras clave: Cautiverio. Cirugía de fauna silvestre. Mitigación.

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