Journal of Veterinary Science and Public Health

J. Vet. Sc. Public Health, v. 8, n. 1, p. 112-120, 2021

FOURTH DEGREE FACIAL BURN IN DOG: TREATMENT WITH HYPERBARIC OXYGEN THERAPY AND 5% PAPAIN OINTMENT – CASE REPORT

QUEIMADURA FACIAL DE QUARTO GRAU EM CÃO: TRATAMENTO COM OXIGENOTERAPIA HIPERBÁRICA E POMADA DE PAPAÍNA 5% - RELATO DE CASO

Marcelo Fialho Mazzi[1*]. Mariza d'Agostino Dias[2]

[1] Médico Veterinário CRMV-DF 0923 – Medicina Hiperbárica, Clínica Veterinária Planet Dog – Divisão MVH (Medicina Veterinária Hiperbárica) Brasília-DF, Brasil.
[2] Médica Intensivista e Hiperbarista.Doutora em Ciências Médicas pela USP. Médica Supervisora do Grupo Oxigênio Hiperbárico de SP.
*autor para correspondência :
Email: planetdogvet@terra.com.br
DOI: 10.4025/revcivet.v8i1.47696

RESUMO

As queimaduras de 4º grau são ocorrências incomuns na rotina da clínica e cirurgia de pequenos animais e representam um verdadeiro desafio terapêutico. Sua etiologia está ligada primariamente a incêndios descontrolados, contato com soluções quentes, eletrocussão ou ainda agentes cáusticos aplicados maliciosamente. A papaína, proveniente do látex do mamoeiro *Carica papaya*, é um fitoterápico manipulável e vem sendo utilizada largamente no auxílio aos processos de cicatrização tecidual em função do seu poder bactericida, bacteriostático e desbridante seletivo de tecidos necrosados, desvitalizados e infectados. A oxigenoterapia hiperbárica já teve sua eficácia comprovada e reconhecida cientificamente, como uma ferramenta fundamental a ser empregada no auxílio a pacientes humanos e em estudos controlados com animais de laboratório. Na rotina clínica cirúrgica da medicina veterinária, esta terapia ainda recebe o status de inovadora. O presente trabalho relata o caso de uma queimadura facial de 4º grau em uma fêmea canina de 4 anos, tratada com a associação da pomada de papaína 5% e 35 sessões de oxigenoterapia hiperbárica.

PALAVRAS-CHAVES: Queimaduras, Oxigênio, Ferida, Cicatrização.

ABSTRACT

4th degree burns are uncommon occurrences in routine clinical and small animal surgery and represent a real therapeutic challenge. Its etiology is primarily linked to uncontrolled fires, contact with hot solutions, electrocution or even maliciously applied caustic agents. Papain, derived from papaya latex Carica papaya, is a manipulable herbal medicine, and has been widely used to aid tissue healing processes due to its bactericidal, bacteriostatic and selective debridement power of necrotic, devitalized and infected tissues. Hyperbaric oxygen therapy has already been proven and scientifically recognized as a fundamental tool to be used to assist human patients and in controlled laboratory animal studies. In the clinical surgical

routine of veterinary medicine, this therapy still receives the status of innovative. This paper reports the case of a 4th degree facial burn in a 4-year-old female canine treated with the combination of 5% papain ointment and 35 sessions of hyperbaric oxygen therapy.

KEYWORDS: Burns, Oxygen, Wound, Healing.

INTRODUCTION

The skin is the most extensive and visible organ of the organism and constitutes a protective barrier. Its sensory components are responsible for the perception of the environment, as well as stimuli, thus reflecting the state of health and the proper functioning of the organism (SCOTT et al., 2002).

Dermatology represents 25 to 30% in the series of veterinary routine, being an important factor of economic impact in the clinic of small animals (SCOTT et al., 2002).

By consensus, the veterinary literature describes that the constitution of the skin can vary between species, races and individuals, and also vary between the different regions of the body of the same individual as to the thickness, the location and the existence or not of hair follicles and attached glands (SOUZA et al., 2009; VULCANO 2009).

Burns are uncommon occurrences in the routine of the small animal clinic and represent a real therapeutic challenge (ALBERNAZ et al., 2016). Being defined as a lesion with etiology in trauma, thermal, electrical, chemical, or radioactive (SANCHES et al., 2016). Topical medications when improperly used can lead to burns, as well as the malicious application of caustic agents (GOMES et al., 2010).

The degree of burn depends directly on factors such as the duration and intensity of the heat, skin thickness and exposed area, vascularity and age of the patient (STANLEY and RICHARD, 2004). The depth and evolutionary period of the injury are determining factors for its classification (GATHAS et al., 2011).

The modern burn injury classification system refers to how deep the skin has been affected, classifying them as: superficial (first degree), partial (second degree), total thickness (third degree) and fourth degree burns (injuries deep enough to affect the underlying tissues) (PAVLETIC, 2010).

The regions of the face are considered special areas due to their high risk of contamination, the rich blood supply, greater anatomical-functional complexity and the ease of complications, thus requiring specific approaches (MÉLEGA, 2002).

The treatment of burns remains very difficult for most health professionals, due to the large number of complications (SANCHES et al., 2016).

The high infection rates present in burns are the main complicating factor for healing, motivating the search for new therapeutic options aiming at reducing pain and healing time (TELES et al., 2012).

Schmitz (2017), defines papain as a protein that contains proteolytic enzymes and peroxidases that degrade proteins from devitalized tissue and necrosis into amino acids without altering healthy tissue.

Observations of treatments with papain preparations have been shown to facilitate wound healing responses in different etiologies, such as deep burns, ulcers in diabetics, suture dehiscence and pressure ulcers (LEITE et al., 2012).

The first report on hyperbaric chambers for medicinal purposes appeared in the middle of 1622, and was authored by Henshaw (ANDRADE and VIEIRA SANTOS, 2016).

Hyperbaric oxygen therapy (HBOT) has applications in several pathologies and its use has been growing in western countries in the last decades (CRUZ, 2011).

HBOT is defined as a therapeutic intervention, in which the patient inhales pure oxygen (100%) at a pressure higher than sea level pressure (one absolute technical atmosphere - ATA), inside an hyperbaric chamber (ECHM, 2017).

It is a therapeutic procedure enshrined in scientific circles, as provided by Resolution No. 1.457/95 CFM (1995), where one can see both the indications and their relative or absolute contraindications, marked out by the (SBMH, 2017).

Its mechanism of action depends on a complex understanding of the physiological drug interactions resulting from the elevation of the partial pressure of oxygen (THOM, 2009). The physics involved in hyperbaric application is based on several laws such as Boyle-Mariotte's Law, Pascal's Principle, Henry's Law and Fick's Laws (MATHIEU, 2006).

Willers et al. (2015) proposes that the major differential of HBOT lies in its ability to increase local vascularization, thus accelerating the deficient healing process.

HBOT stimulates collagen synthesis and deposit, effecting angiogenesis and acts in synergy with antibiotics to fight infection (MARCONDES and LIMA, 2003).

The total number of treatments required is difficult to predict because the location, extent and depth of lesions vary widely, as well as local grafting (SBMH, 2017).

The objective of this study is to describe the use of hyperbaric oxygen therapy associated with 5% papain ointment, in a case of a 4th degree burn on a dog's face, by corrosive chemical substance, with the monitoring and measurement of the lesion.

MATERIALS AND METHODS

Canine, female, mixed breed, 4 years old, 12 kg. The dog was attended at another veterinary establishment with a deep contaminated lesion on the left side. The tutor informed that the lesion originated from an acid attack. The veterinarian in charge of the case reported having cleaned the wound, debrided the necrotic tissue and attempted to re-approach with stitches. After 7 days of the procedure, the injured area had evolved, with a process of necrosis of the skin tissue. The patient was then referred for evaluation of the possibility of treatment with hyperbaric oxygen therapy in this establishment.

On clinical examination, a large lesion was found on the left side with necrotic tissue edges, profuse exudation and purulent collection. Remnants of approach points were investigated. The patient did not have any tenderness in the injured area, which indicates that there was a probable lesion of the local sensory nerves. The lesion was meticulously cleaned with 0.9% saline solution and gauze was used to remove crusts, secretions and dirt. Due to the lack of sensitivity, selective surgical debridement of the necrotic edges of the lesion was performed without the need of anesthetic procedures. An anatomical analysis of the lesion revealed extensive tissue damage to the eyelids of the left eye, necrotic points and the presence of a whitish membrane covering the entire left eyeball, with evident points of perforation and loss of turgidity, partial destruction of the malar, zygomatic and orbicularis muscles of the eye, partial bone exposure of the left maxilla with tunneling to the oral cavity, through which the molar teeth and buccal structures were visualized, as well as a complete bone exposure of the left zygomatic arch with delimited blackened region characteristic of bone lysis (Fig.1). Simple wound measurement was performed based on 2 axes (of greater length X of greater width), obtaining the values of 7.0 cm by 6.5 cm. The photographic record was filed for later evaluation by computerized planimetry.

Figure 1. (**A**): Panoramic view of the injury. (**B**) Zygomatic Arch Exhibition (**red arrow**) and partial maxilla exposure **(yellow arrow)**
Font: The authors (2019).

The patient was referred for admission, and the following protocol was established: Oral route, Clindamycin 11mg/Kg/BID for 12 days, Meloxican 0.2mg/Kg/Day for 08 days. The wound was cleaned twice a day, using saline and using gauze to remove crusts and secretions, preserving the ophthalmic region. Topically, only Papain Ointment 5% by Drogavet® was used over the entire lesion every 12 hours. After this protocol was performed, the patient was referred to the hyperbaric chamber.

The protocol established for hyperbaric treatments respected the 24-hour time interval between each session. There was no need for sedation in any of the treatments performed.

The working depth was established at 50 "feet of sea water", therefore at a total pressure of 2.5 ATA (Absolute Technical Atmosphere), lasting 90 (ninety) minutes between the compression / background / decompression phases.

RESULTS

Thirty-five treatments with HBOT were performed and imaging records were performed for clinical evaluation every 5 (five) hyperbaric treatments (Fig. 2).

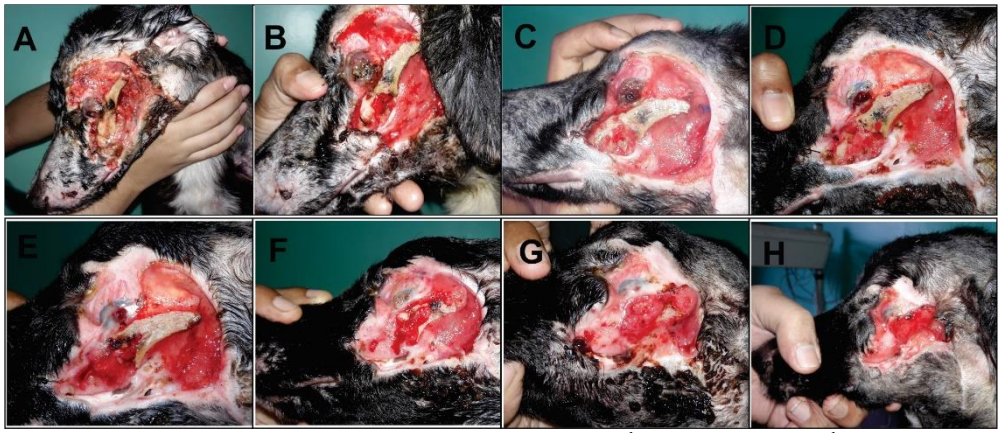

Figure 2. Evolution of the injury. **A**: 1st treatment; **B**: 5th treatment; **C**: 10th treatment; **D**: 15th treatment; **E**: 20th treatment; **F**: 25th treatment; **G**: 30th treatment; **H**: 35th treatment.
Font- The authors (2019).

On clinical examination, the exudate and purulent collection present throughout the lesion gave rise to a translucent transudate, with a clear and odorless aspect, already in the

first 8 hyperbaric oxygen therapy treatment. This fact led to the review of the initial protocol foreseen for antibiotic therapy with clindamycin for 12 days, reducing it to 8 days. The healing process proved to be effective with the recovery of the aspect of tissue vitality denoted from the 5th hyperbaric treatment, evolving from the initial pale marbled aspect to hyperemic rosacea, showing effective local angiogenesis activity. The retraction of the edges of the lesion was progressive, uniform and concentric, with evident normotrophic tissue remodeling during treatment (Fig. 3).

Figure 3. After the 35th hyperbaric treatment.
Font: The authors (2019).

Simple macrometric measurement by overlaying a ruler over the wound gave an average recovery rate of the injured area of 48.75% during the treatment period. In view of its irregularity and the complexity of mathematical calculations to accurately determine the lesion area, as well as the degree of regression, the images of the beginning and end of the treatment were subjected to a new measurement by morphometric analysis in analytical software. **IMAGE J®,** measuring an initial area of 33.582 cm² against 18.851 cm² was found at the end of the 35th hyperbaric oxygen therapy treatment. The result obtained in the healing process, therefore, was accurately increased to 56.13% regression of the injured area. The depth of the lesion was assessed without measurement during the 35 days of treatment. The patient was referred for reconstructive surgery evaluation, but no new information was obtained about her clinical condition.

DISCUSSION

The occurrence of burns classified as third and fourth degrees in animals is rare and invariably stem from the inability to escape fires, electric shocks or the malicious application of hot or corrosive substances on the animal's body (ALBERNAZ et al., 2016). In this case description, the patient would have been the victim of a corrosive chemical substance, maliciously thrown in her face.

Despite the different forms of classification of burns described in the literature, the total absence of sensitivity at the injury site, as well as the complete destruction of the skin layers and the exposure of bone structures on the face and attachments enabled a quick understanding of facing to a fourth degree burn picture (PAVLETIC, 2010). The location of the lesion (head) was an aggravating factor in this case, both due to the noble structures involved and the type of skin existing in this region, described by several authors as special areas, as highlighted by Mélega (2002). The complete destruction of the eyelids and deep lesions to the eyeball investigated converge to Dornelas et al. (2009), who claim that eyelid burns are one of the most difficult problems for surgeons and that total loss of eyelids without injury to the eyeball is extremely rare.

There are no divergences in both human and veterinary literature on the urgency of adopting a systematic debridement of devitalized tissues in severe burns, always with the objective of reducing substrate to microbial colonies and restoring microcirculation at the edges of the lesion. However, the amount of tissue to be debrided in these situations is still the subject of academic considerations. Several authors like Saxon & Kirby (1992), Pavletic (2010) and Albernaz et al. (2015) argue that debridement should preferably be performed early and aggressively. On the other hand, Brito (2014) reports a significant volume of animal research in which its authors suggest that the recovery of the capillary integrity underlying the lesion in animals treated with hyperbaric oxygen therapy would be more effective, consequently resulting in less aggressive debridement.

In this case report, the choice for a selective surgical debridement was based on Brito (2014).

The use of systemic antibiotic therapy in severe burns is the subject of scientific disputes, with divergences as it is not recommended in literary articles, based on the reasoning that micro thrombosis, edema and tissue hypoxia present in the burns would be limiting factors, causing a low concentration of antibiotics in the injured tissues (Honari, 2004). On the other hand, authors such as Menoita et al. (2012) defend the concept of the inevitable formation of biofilm in burns and other injuries. The important infectious potential that this represents justifies the urgency and complexity in the formulation of therapeutic strategies that reduce its action on injuries. In this line of thought, a 4th degree burn, in a special area, with evident contamination and exposure of bone tissues justified the choice of Clindamycin as the antibiotic of choice in this case, as it presents activity against deep infections of soft tissues and osteomyelitis and was based on protocols developed by human hyperbaric medicine (SBMH 2017). In addition, the factors once listed as limiting the use of antibiotic therapy in burns, are the main targets and benefits achieved by hyperbaric oxygen therapy.

The reduction in the period in which the patient was submitted to antibiotic therapy was significant, and it converges with expectations in literary findings when using both papain and supports Campos et al. (2017), regarding hyperbaric oxygen therapy Rabelo (2012), Willers et al. (2015).

Both human and veterinary literature describe a wide use of papain in several situations, considering that it is a herbal medicine with excellent results, without contraindications and of low cost when compared to industrialized coverings (LEITE et al. 2012) and SCHMITZ, 2017).

The inability to repair tissue only through a surgical procedure, the previously performed suture dehiscence, secondary infection and the necrosis condition installed in the patient led the veterinary team in the case to seek the help of treatment with hyperbaric oxygen therapy.

SBMH (2017) defines the 90-minute time as the minimum duration of a hyperbaric treatment, which was adopted in this report.

The working depth established by the literature is minimum of 1.5 ATA and maximum of 3 ATA according to SBMH (2019), and in this report, the patient was treated at 2.5 ATA. It is worth mentioning that in this study no adverse effects were seen in the patient during hyperbaric treatment.

Regarding the complex understanding of physiology in hyperbaric conditions, it is worth mentioning the need for discussion, development and dissemination of a clinical logic, defended by numerous authors, where hyperoxygenation in severe and very serious burns expresses one of its greatest beneficial potentials, reducing hydrostatic pressure in the facial compartment by preserving aerobic glycolysis, reducing local edema and consequently blocking the expansion of the lesion area (BRITO, 2014). In the progressive ischemic process

typical of burns, hyperbaric oxygen therapy provides an intracellular partial pressure of oxygen well above 30 mmHg in the injured tissues, in order to guarantee the levels of immunoglobulins, as well as the functions of polymorphonuclear leukocytes, in addition to stimulating the formation of the collagen matrix, essential for angiogenesis and healing, therefore maintaining viability and determinism in tissue repair (ANTONIAZZI, 2007) and (BRITO, 2014).

Nevertheless, it should be noted that hyperbaric oxygen therapy is an adjuvant treatment method, which does not replace conventional treatment, but rather enhances it, making it more efficient. The synergism found in the simultaneous use of hyperbaric oxygen therapy with the papain ointment was positive and highly effective in tissue restoration, without prejudice to the evolution of the lesion.

Thus, clinical-outpatient, emergency and surgical measures must always be associated, with the burn patient being treated in a multidisciplinary manner by professionals in veterinary medicine.

CONCLUSION

The combination of hyperbaric oxygen therapy and 5% papain to the conventional treatment foreseen for burns proved to be highly effective in this case. No adverse reactions were observed.

REFERENCES

ALBERNAZ, V. G. P.; CASTRO, J. L. C.; SANTALUCIA, S .; HUPPES, R . R.; NARDI, A.B.; PAZZINI, J.M. 2016. Reconstructive Surgical Repair of a Forth Degree Iatrogenic Burn in a Dog. *Acta Scientiae Veterinariae*. 44(Suppl 1): 169.

ALBERNAZ, V.G.P.; FERREIRA, A.A.; CASTRO, J.L.C. 2015. Queimaduras térmicas em cães e gatos. Veterinária e Zootecnia. set; 22(3):322-334.

ANDRADE. S.; VIEIRA SANTOS. I.C.R. 2016. Oxigenoterapia hiperbárica para tratamento de feridas. Revista Gaúcha de Enfermagem; jun; 37(2). Available from: http://seer.ufrgs.br/index.php/RevistaGauchadeEnfermagem/article/view/59257/37613 . Accessed December 10, 2018.

ANTONIAZZI, P. 2007. Oxigenoterapia Hiperbárica e Mediadores Inflamatórios na Sepse. Prática Hospitalar •Ano IX •Nº 51 •Mai-Jun. p. 29-33.

BRITO, T. 2014. Tratamento coadjuvante com oxigenoterapia hiperbárica em pacientes grande queimados. Revista Brasileira de Queimaduras. 13(2):58-61.

CAMPOS, S.B.S.; CAMARGO, A.K.; OLIVEIRA, P.R.P.A.; FELIPE, T.L.; SANTOS, V.D.C.; CARDOSO, R.L.G.; CAMPOS, G.S. 2017. Uso do extrato de papaína a 5% na cicatrização de ferida cutânea em equino – relato de caso. Revista Acadêmica de Ciência Animal; 15 (Supl 1): S413-414.

CFM – Conselho Federal de Medicina. Resolução nº 1.457/95. Available from :

CRUZ, P.V. 2011. Aplicações Actuais da Oxigenoterapia Hiperbárica em Otorrinolaringologia. Cadernos Otorrinolaringologia. Clínica, Investigação e Inovação. Serviço de Otorrinolaringologia do Hospital da Marinha, Lisboa. 1-6. Available from : <http://www.cadernosorl.com/artigos/5/5.pdf>. Accessed February, 2019.

DORNELAS, M. T.; ROCHA, A. P. F.; CAZARIM, D. B . 2009. Tratamento das queimaduras em áreas especiais. HU Revista, Juiz de Fora, v. 35, n. 2, p. 119-126, abr./jun.

ECHM, European Committee for Hyperbaric Medicine. 2017. Available

from: <http://www.echm.org/>. Accessed December, 2018.
GATHAS, A.Z.; DJALETA, D.G.; NOVIELLO, D.S.; THOMAZ, M.C.A.; ARÇARI, D.P. 2011. Atendimento do Enfermeiro ao paciente Queimado. Rev. Saúde em Foco, Teresina, v.4, n.2, p.74-78, abr-jun. Available from <http://unifia.edu.br>. Accessed February 14, 2019.
GOMES, M.C.; PASSOS, S.R.; LUCAS, F.A. 2010.Tratamento de queimaduras em animais de grande porte - Revisão de literatura. PUBVET, Londrina, V. 4, N. 33, Ed. 138, Art. 931.
HONARI, S. 2004. Topical therapies and antimicrobial in the management of burn wounds. Critical Care Nursing Clinics North America.;16:1-11.
http://www.portalmedico.org.br/resolucoes/cfm/1995/1457_1995.htm. Accessed February, 2019.
LEITE, A.P.; OLIVEIRA, B.G.R.B.; SOARES, M.F.; BARROCAS, D.L.R. 2012. Uso e efetividade da papaína no processo de cicatrização de feridas: uma revisão sistemática. Rev. Gaúcha Enf., v.33. p.198-207.
MARCONDES, C.M.; LIMA, E.B. 2003. A oxigenoterapia hiperbárica como tratamento complementar das úlceras de membros inferiores – parte I. Revista Angiologia & Cirurgia Vascular. 12(2):54-60.
MATHIEU, D. 2006. *Handbook on hyperbaric medicine* (p. 15-24). Ed Springer, Dordrecht, NL.
MÉLEGA, J. M. 2002. Cirurgia plástica: fundamentos e arte: Princípios gerais. Rio de Janeiro: Editora Medsi.
MENOITA, E.; SANTOS, V.; GOMES, C.; SANTOS, A. S. 2012. Papel de lós biofilms en las heridas crônicas. Journal of Aging and Innovation. Volume 1, Edição 3.
PAVLETIC, M.M. 2010. Management of specific wounds. In: Atlas of small animal wound management and reconstructive surgery. 3rd ed. Iowa: Wiley-Blackwell; p.170-181.
RABELO, R. C. 2012. *Emergências de Pequenos Animais*. Elsevier, São Paulo, BR.
SANCHES, P. H. S.; SANCHES, J. A.; NOGUEIRA, M.J.; PERONDI, N. M.; SUGAI, M. H.; JUSTULIN, A. F.; VANTINE, G. R.; NETO, O. T. 2016. Perfil epidemiológico de crianças em Unidade de Tratamento de Queimados no interior de São Paulo, Revista Brasileira de Queimaduras., 15(4):246-50.
SAXON, W.D., KIRBY, R. 1992. Treatment of acute burn injury and smoke inhalation. In: Kirk RW, Bonagura JD. Kirk's veterinary therapy XI. 11th ed. Philadelphia: Saunders;. p.146-53.
SBMH- Sociedade Brasileira de Medicina Hiperbárica. Diretrizes de Segurança Qualidade e Ética. 2017. Available from: https://sbmh.com.br/wp-content/uploads/2018/04/DIRETRIZES-2016-2018-28-11-17-Revisada.pdf Accessed October 19,2018.
SBMH- Sociedade Brasileira de Medicina Hiperbárica. Diretrizes para a prática da Medicina Hiperbárica e fornecimento de tratamento com Oxigenoterapia Hiperbárica (DMH). 2019. Available from: https://sbmh.com.br/wp-content/uploads/2019/04/Grupo-6-Seguranca-em-Servicos-de-Medicina-Hiperbarica.pdf Accessed June 14, 2019.
SCHMITZ, A.C. 2017. Uso de papaína na cicatrização de ferida em um equino . Revista Acadêmica Ciência Animal;15(Supl.1):S409-410.
SCOTT, D., MILLER, W., GRIFFIN, C. 2002. Estructura y función de la piel. Dermatologia En Pequeños Animales, 6ª Ed. Buenos Aires, Intermédica, 1-69.
SOUZA, T. M.; FIGHERA, R. A.; KOMMERS. G. D.; BARROS.C. S. L. 2009. Aspectos histológicos da pele de cães e gatos como ferramenta para dermatopatologia. Pesquisa Veterinária Brasileira. Fev;29(2):177-190.

STANLEY, M. J.; RICHARD, R.L. 2004. Queimaduras. In: O' SULLIVAN, Susan B.; SCHMITZ, T. J. Fisioterapia: avaliação e tratamento. São Paulo: Manole, p. 845-871.

TELES, G.G.A.; BASTOS, J. A. V.; AMARY, A.; RUFATTO, L. A.; RITTY, R. S.; PINOTT I BROGLIO, L. A.; SOUZA, L. S. 2012. Tratamento de queimadura de segundo grau superficial em face e pescoço com heparina tópica: estudo comparativo, prospectivo e randomizado. Revista Brasileira de Cirurgia Plástica;27(3):383-6.

THOM, S. R. 2009. Oxidative stress is fundamental to hyperbaric oxygen therapy. *Journal of applied Physioly*, 106, 988-95.

VULCANO, L. 2009. Histología y Fisiología de la Piel. Fogel F., Manzuc P. Ed. Dermatologia Canina Para La Práctica Clínica Diaria. 1ª Ed. Buenos Aires, Intermédica., 1-7.

WILLENSE, T. 2002. Dermatologia clínica de cães e gatos. Barueri: Manole, São Paulo, p. 143.

WILLERS, S. C. A.; ZORZELLA, M.; ALBARELLO, J. R.; AMARAL, B. P. & Müller, D. C. M. 2015. Avaliação de comportamento de animais submetidos ao ambiente hiperbárico para modelagem e controle de feridas cutâneas - *Proceeding Series of the Brazilian Society of Applied and Computational Mathematics*, 3(1).