Revista ARACÊ
ISSN: 2358-2472

COMBINED PHOTOBIOMODULATION AND OZONE THERAPY FOR TREATING A SECONDARY INFECTION BY KLEBSIELLA PNEUMONIAE IN A FEMALE DOG: A CASE REPORT

ASSOCIAÇÃO ENTRE FOTOBIOMODULAÇÃO E OZÔNIOTERAPIA NO TRATAMENTO DE FERIDA COM INFECÇÃO SECUNDÁRIA POR KLEBSIELLA PNEUMONIAE EM UMA CADELA – RELATO DE CASO

ASOCIACIÓN ENTRE FOTOBIOMODULACIÓN Y OZONOTERAPIA EN EL TRATAMIENTO DE UNA HERIDA CON INFECCIÓN SECUNDARIA POR KLEBSIELLA PNEUMONIAE EN UNA PERRA – REPORTE DE CASO

https://doi.org/10.56238/arev8n2-098

Submitted on: 01/21/2025 **Publication date:** 02/21/2026

Gisele Dias da Silva[1], Maria Amélia Fernandes Figueredo[2], João Carlos de Souza Santos[3], Neusany Neves Prado[4], Bruno Ribeiro dos Santos[5], Taianne da Silva Prates[6], Fernando Alzamora Filho[7]

ABSTRACT

Klebsiella pneumoniae (KP) is a Gram-negative, opportunistic bacterium that causes local and generalized infections and may exhibit resistance to multiple antibiotics. This study aimed to report the association of ozone therapy (OT) and photobiomodulation (PBM) in the treatment of a surgical wound contaminated with multidrug-resistant KP. A female Chow Chow dog presented with paresis of the pelvic limbs and avulsion of 13 cm² of cutaneous tissue in the lumbar region, resulting from being run over. Post-operatively, there was dehiscence and infection of the surgical wound, which was treated with antibiotics and anti-inflammatories, without clinical improvement. Bacteriological examination identified KP that was multidrug-resistant to 11 antibiotics. The patient was referred to the Veterinary Hospital of the State University of Santa Cruz and underwent OT by bagging (30 mcg/ml) and intrarectal (1.5 mg) and FBM with diode laser (P: 0.1W), with wavelengths of 660 nm and 808 nm. The dosimetric parameters, energy (J) and fluence (J/cm2), varied according to the characteristics of the lesion. As the treatment progressed, the patient presented a gradual decrease in pain, improved ambulation, reduction of exudate and edema, infection control, and the presence of granulation tissue in the wound bed, corroborating the progressive reduction of the wound area until complete closure of the lesion. The combination of OT and FBM was effective in the case presented, with complete wound resolution, showing it to be a promising therapeutic option for wounds infected with multidrug-resistant pathogens. However, further studies are needed to establish protocols and confirm the improvement of

[1] Doctoral Student in Animal Science at the Universidade Estadual de Santa Cruz (UESC). E-mail: gdsilva@uesc.br
[2] Dr. in Animal Science in the Tropics. Universidade Estadual de Santa Cruz (UESC). E-mail: mel@uesc.br
[3] Veterinarian. Universidade Estadual de Santa Cruz (UESC). E-mail: jcssantos.mev@uesc.br
[4] Veterinarian. Universidade Estadual de Santa Cruz (UESC). E-mail: nnprado.mev@uesc.br
[5] Doctoral Student in Animal Science at the Universidade Estadual de Santa Cruz (UESC). E-mail: bruno.ribeirods@hotmail.com
[6] Veterinarian. Clínica Veterinária Casa do Bicho, Ilhéus, Bahia. E-mail: taianneprates@gmail.com
[7] Dr. in Animal Science in the Tropics. Universidade Estadual de Santa Cruz (UESC). E-mail: fafilho@uesc.br

Revista ARACÊ
ISSN: 2358-2472

the effects observed in this report

Keywords: Drug Resistance. Laser Therapy. Ozone. Wound Healing.

RESUMO
A *Klebsiella pneumoniae* (KP) é uma bactéria Gram-negativa, oportunista que ocasiona infecções locais e generalizadas, podendo apresentar resistência a múltiplos antibióticos. No presente trabalho objetivou-se relatar a associação da ozônioterapia (OT) e fotobiomodulação (FBM) no tratamento de ferida cirúrgica contaminada com KP multirresistente. Uma cadela, Chow Chow, apresentou paresia dos membros pélvicos e avulsão do tecido cutâneo de 13 cm2 na região lombar, decorrente de atropelamento. No pós-operatório, houve deiscência e infecção da ferida cirúrgica, sendo tratada com antibiótico e anti-inflamatório, sem melhora clínica. O exame bacteriológico identificou KP multirresistente a 11 antibióticos. A paciente foi encaminhada para o Hospital Veterinário da Universidade Estadual de Santa Cruz e realizou OT por bagging (30mcg/ml) e intraretal (1,5mg) e FBM com laser de diodo (P: 0,1W), com comprimento de onda de 660 nm e 808nm. Os parâmetros dosimétricos, energia (J) e fluência (J/cm2), variaram de acordo com as características da lesão. Com o avançar do tratamento, a paciente apresentou diminuição gradativa da dor, melhora na deambulação, redução do exsudato e edema, controle da infecção e presença de tecido de granulação no leito da ferida, corroborando com redução progressiva da área da ferida até o fechamento total da lesão. A associação entre a OT e FBM foi eficaz no caso apresentado, com resolução completa da ferida, mostrando ser uma opção terapêutica promissora para feridas infectadas com patógenos multirresistentes. No entanto, são necessários mais estudos para estabelecer protocolos e confirmar a melhora dos efeitos observados nesse relato.

Palavras-chave: Resistência a Medicamentos. Terapia a Laser. Ozônio. Cicatrização de Feridas.

RESUMEN
Klebsiella pneumoniae (KP) es una bacteria oportunista gramnegativa que causa infecciones locales y generalizadas y puede presentar resistencia a múltiples antibióticos. Este estudio tuvo como objetivo informar la asociación de la ozonoterapia (OT) y la fotobiomodulación (PBM) en el tratamiento de una herida quirúrgica contaminada con KP multirresistente. Una perra Chow Chow presentó paresia de las extremidades pélvicas y avulsión de 13 cm² de tejido cutáneo en la región lumbar, como resultado de un atropello. En el postoperatorio, se presentó dehiscencia e infección de la herida quirúrgica, que se trató con antibióticos y antiinflamatorios, sin mejoría clínica. El examen bacteriológico identificó KP multirresistente a 11 antibióticos. El paciente fue remitido al Hospital Veterinario de la Universidad Estatal de Santa Cruz y se le realizó OT mediante embolsado (30 mcg/ml) e intrarrectal (1,5 mg) y FBM con láser de diodo (P: 0,1 W), con longitudes de onda de 660 nm y 808 nm. Los parámetros dosimétricos, energía (J) y fluencia (J/cm²), variaron según las características de la lesión. A medida que avanzaba el tratamiento, el paciente presentó una disminución gradual del dolor, mejoría en la deambulación, reducción del exudado y el edema, control de la infección y presencia de tejido de granulación en el lecho de la herida, lo que corroboró la reducción progresiva del área de la herida hasta el cierre completo de la lesión. La combinación de OT y FBM fue eficaz en el caso presentado, con resolución completa de la herida, lo que la convierte en una opción terapéutica prometedora para heridas infectadas con patógenos multirresistentes. Sin embargo, se

Revista ARACÊ
ISSN: 2358-2472

requieren más estudios para establecer protocolos y confirmar la mejora de los efectos observados en este informe.

Palabras clave: Resistencia a Fármacos. Terapia Láser. Ozono. Cicatrización de Heridas.

Revista ARACÊ
ISSN: 2358-2472

1 INTRODUCTION

Antimicrobial resistance is an emerging One Health problem whose management requires practical and effective therapeutic innovations in clinical practice (Velazquez-Meza *et al*., 2022). *Klebsiella pneumoniae*, a Gram-negative opportunistic and multidrug-resistant bacterium, is highly relevant to human and animal health (Gerra *et al*., 2022). This study aimed to describe the effects of combined photobiomodulation (PBM) and ozone therapy (OT) in treating a *K. pneumoniae*-contaminated wound in a female dog.

2 CASE REPORT

A female Chow-Chow, 19kg, was presented to the Veterinary Hospital with a traumatic lumbar wound sustained after being hit by a car. Physical examination revealed a 13 cm² skin avulsion and hind limb paresis. The animal had received prior treatment, and surgery was performed to repair the skin laceration. Post-operatively, the wound became infected and the sutures dehisced.

The complete blood count (CBC) revealed leukocytosis due to moderate neutrophilia (neutrophils: 86% of counted leukocytes). An initial therapeutic protocol with commercial antibiotics and anti-inflammatory drugs yielded no clinical improvement. A subsequent CBC showed a slight worsening of leukocytosis (neutrophils: 88% of counted leukocytes). A wound sample was collected for bacterial culture (on specific media) and an antibiogram (disk-diffusion method), which identified *K. pneumoniae* resistant to 11 of the antibiotics tested (Table 1).

Table 1

Antibiogram results for the sample from the surgical wound.

Antibiotic Tested	Results
Ampicillin	Resistant
Amoxicillin-Clavulanate	Resistant
Gentamicin	Resistant
Trimethoprim-Sulfamethoxazole	Resistant
Ceftriaxone	Resistant
Cefotaxime	Resistant
Ciprofloxacin	Resistant
Levofloxacin	Resistant
Cefepime	Resistant
Enrofloxacin	Resistant
Piperacillin-Tazobactam	Resistant

Revista ARACÊ
ISSN: 2358-2472

Amikacin	Sensitive
Florfenicol	Sensitive

Source: Prepared by the authors themselves.

Photobiomodulation combined with ozone therapy (Ozonic® medical ozone generator) was selected to treat the infected wound. On day one of the protocol, only OT by cutaneous topical Ozone/O_2 gas mixture application (bagging) in a 30 mcg/ml concentration, and by intrarectal administration (100mL of the gas mixure in a concentration of 15µcg/mL; 0.08mg/kg) insuflated through an urethral N8 dischargeable probe, were performed. After this first ozone therapy session, the patient was already able to stand (remain in station), which she had not done since the car accident. In the second session, PBM was initiated, using a Red Laser (λ:660 nm; P: 100mW; spot: 0,028cm^2; E: 0.5J/point; energy density of 17,85 J/cm²) on the wound bed and an Infrared Laser (λ: 808 nm; P: 100mW; spot: 0,028cm^2; E: 1J/point; energy density of 35,7 J/cm²) on the wound edge, 30 minutes after OT. Applications were performed weekly. From the third week onward, OT was administered only topically (via bagging). The protocol comprised 12 OT sessions and 16 PBM sessions (Table 2).

Table 2

Combined Photobiomodulation and Ozone Therapy Protocol.

Session	Photobiomodulation	Ozone Therapy
1st	Not performed	Bagging: 30 mcg/ml for 10 min; Intrarectal: 1.5 mg
2nd	Wound bed: LV, 0.5 J/point, 7 points; Wound edge: LIV, 1 J/point, 15 points	Bagging: 30 mcg/ml for 10 min; Intrarectal: 1.5 mg
3rd	Wound bed: LV, 0.5 J/point, 5 points; Wound edge: LIV, 1 J/point, 9 points	Bagging: 30 mcg/ml for 10 min
4th	Wound bed: LV, 0.5 J/point, 5 points; Wound edge: LIV, 1 J/point, 7 points	Bagging: 30 mcg/ml for 10 min
5th	Wound bed: LV, 0.5 J/point, 5 points; Wound edge: LIV, 1 J/point, 6 points	Bagging: 30 mcg/ml for 10 min
6th	Wound bed: LV, 0.5 J/point, 4 points; Wound edge: LIV, 1 J/point, 6 points	Bagging: 30 mcg/ml for 10 min
7th	Wound bed: LV + LIV, 0.5 J/point, 3 points; Wound edge: LIV, 1 J/point, 5 points	Bagging: 30 mcg/ml for 10 min
8th	Wound bed: LV + LIV, 0.5 J/point, 3 points; Wound edge: LIV, 1 J/point, 5 points	Bagging: 30 mcg/ml for 10 min
9th	Wound bed: LV + LIV, 0.5 J/point, 3 points; Wound edge: LIV, 1 J/point, 5 points	Bagging: 30 mcg/ml for 10 min
10th	Wound bed: LV + LIV, 0.5 J/point, 3 points; Wound edge: LIV, 1 J/point, 5 points	Bagging: 30 mcg/ml for 10 min
11th	Wound bed: LV + LIV, 0.5 J/point, 3 points; Wound edge: LIV, 1 J/point, 4 points	Bagging: 30 mcg/ml for 10 min
12th	Wound bed: LV + LIV, 0.5 J/point, 3 points;	Bagging: 30 mcg/ml for 10 min

Revista ARACÊ
ISSN: 2358-2472

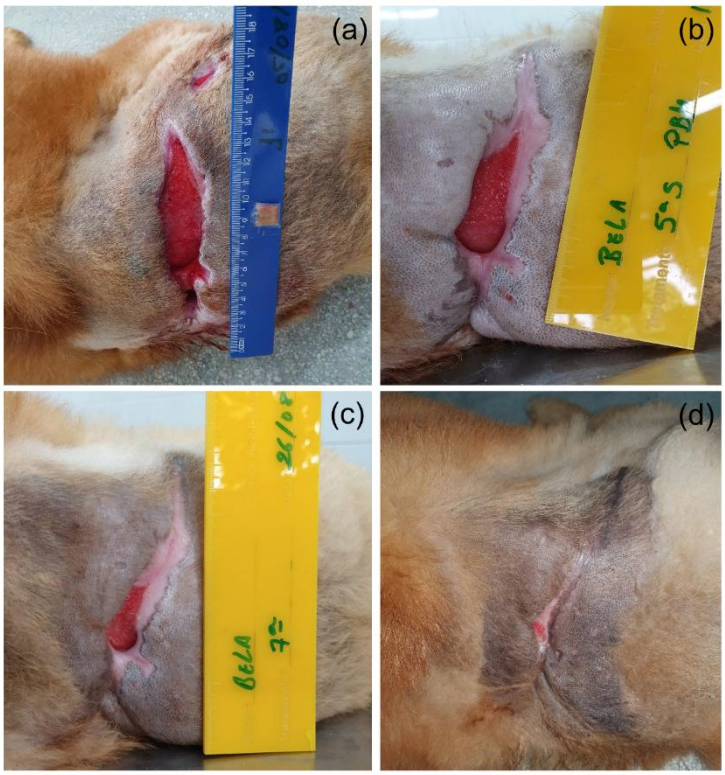
	Wound edge: LIV, 1 J/point, 4 points	
13th	Wound bed: LV + LIV, 0.5 J/point, 1 point; Wound edge: LIV, 1 J/point, 4 points	Not performed
14th	Wound bed: LV + LIV, 0.5 J/point, 1 point; Wound edge: LIV, 1 J/point, 4 points	Not performed
15th	Wound bed: LV + LIV, 0.5 J/point, 1 point; Wound edge: LIV, 1 J/point, 4 points	Not performed
16th	LV + LIV on closed wound (3 J/point, 3 points)	Not performed

LV: Red Laser; LIV: Infrared Laser; J: Joules.
Source: Prepared by the authors themselves.

The wound area progressively reduced until the lesion closed (Figure 1). In the second week, the wound bed showed slight reduction. By the third session, ambulation improved. In the seventh week of treatment, the animal exhibited greater hind limb mobility and coordination (e.g., voluntary scratching without pain). By the sixteenth session, the wound had completely closed, the patient could move her limbs normally, and was discharged from treatment.

Figure 1

Progression of the wound healing process. a-d: Wound evolution, showing reduction of the wound bed and re-epithelialization of the edges until lesion closure



Source: Personal Archive, 2026

Revista ARACÊ
ISSN: 2358-2472

3 DISCUSSION

Bacterial contamination is one of the most frequent causes of healing complications, especially in skin wounds (Kožár *et al.*, 2018), as observed in this case. Suture dehiscence associated with infection is attributed, among other factors, to the proteolytic activity of enzymes and other bacterial components that compromise tissue repair, ultimately leading to the rupture of sutured tissues (Claeys, 2016). Systemic antibiotic use is considered a measure to control local infections and prevent systemic involvement (Leise, 2018), justifying the initial protocol in this case.

Despite this, antimicrobial resistance has become a challenging problem in recent years, with excessive and indiscriminate antibiotic use identified as the primary epidemiological factor contributing to this issue (Palma *et al.*, 2020). This may explain the lack of improvement in the animal's clinical and hematological parameters when antibiotic therapy was instituted.

Antibiograms play a crucial role in addressing growing antimicrobial resistance in Veterinary Medicine by identifying the susceptibility of the isolated bacterial agent to antibiotics, thereby guiding the establishment of alternative protocols for various clinical situations (Scarborough *et al.*, 2020). In this case, bacterial culture and an antibiogram (disk-diffusion method) identified *K. pneumoniae* as the infecting agent, revealing its resistance to 11 different antibiotics.

Low-concentration ozone therapy has demonstrated effective therapeutic responses in various pathological conditions and is considered a low-cost, non-invasive treatment with few side effects (Hidalgo-Tallón *et al.*, 2022). In treating infected skin wounds, reactive oxygen species released by ozone (O_3) act directly on infectious agents, causing their death (Zeng *et al.*, 2018), this justifies the topical application (bagging) used in the established protocol.

Besides its antimicrobial effects, O_3 can interact with fatty acids and other antioxidants to stimulate immune cell activity, thereby potentiating their action. Consequently, rectal insufflation is widely used in veterinary medicine for systemic inflammatory conditions (Sciorsci *et al.*, 2020). In addition to topical ozone, rectal insufflation was performed in this case to modulate the systemic inflammatory process, evidenced by the described neutrophilic leukocytosis.

Photobiomodulation relies on the absorption of photons from laser light, which stimulates cellular metabolism and the release of inflammatory modulators, oxidants, and

Revista ARACÊ
ISSN: 2358-2472

growth factors (Zein *et al.*, 2018). This mechanism may explain the progressive reduction of the lesion bed and epithelial proliferation at the wound edges.

Successful treatment requires considering the available laser device parameters, animal species, and protocol objectives. Regarding dosage, lower energy densities are considered stimulatory, while higher densities are inhibitory (Freitas *et al.*, 2016). In this protocol, energy delivered per point ranged from 0.5 to 1J, aiming to stimulate cellular metabolic activity, thereby modulating the inflammatory process and accelerating repair.

Gradual and progressive recovery of pelvic limb movement was observed, attributed to laser light's capacity for direct and indirect analgesia and edema reduction (Silva *et al.*, 2023). Regarding the combination of ozone therapy and photobiomodulation, Lazerin & Etkisi (2018) state that when these treatments are combined, their effects are potentiated, as they share common molecular effects, leading to synergism in modulating the inflammatory response and accelerating tissue repair and remodeling.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Velazquez-Meza, M. E., Galarde-López, M., Carrillo-Quiroz, B., & Alpuche-Aranda, C. M. (2022). Antimicrobial resistance: One Health approach. Veterinary World, 15(3), 743–749. https://doi.org/10.14202/vetworld.2022.743-749

2. Guerra, M. E. S., Destro, G., Vieira, B., Lima, A. S., Ferraz, L. F. C., Hakansson, A. P., Darrieux, M., & Converso, T. R. (2022). Klebsiella pneumoniae biofilms and their role in disease pathogenesis. Frontiers in Cellular and Infection Microbiology, 12, Article 877995. https://doi.org/10.3389/fcimb.2022.877995

3. Claeys, S. (2016). Dehiscence. In D. Griffon & A. Hamaide (Eds.), Complications in small animal surgery (pp. 57–63). Wiley-Blackwell. https://doi.org/10.1002/9781119421344.ch9

4. Zeng, J., & Lu, J. (2018). Mechanisms of action involved in ozone-therapy in skin diseases. International Immunopharmacology, 56, 235–241. https://doi.org/10.1016/j.intimp.2018.01.040

5. Hidalgo-Tallón, F. J., Torres-Morera, L. M., Baeza-Noci, J. B., Carrillo-Izquierdo, D., & Pinto-Bonilla, R. (2022). Updated review on ozone therapy in pain medicine. Frontiers in Physiology, 13, Article 840623. https://doi.org/10.3389/fphys.2022.840623

Revista ARACÊ
ISSN: 2358-2472

6. Sciorsci, R. L., Lillo, E., Occhiogrosso, L., & Rizzo, A. (2020). Ozone therapy in veterinary medicine: A review. Research in Veterinary Science, 130, 240–246. https://doi.org/10.1016/j.rvsc.2020.03.026

7. Kožár, M., Hamilton, H., & Koščová, J. (2018). Types of wounds and the prevalence of bacterial contamination of wounds in the clinical practice of small animals. Folia Veterinária, 62(4), 39–47. https://doi.org/10.2478/fv-2018-0036

8. Palma, E., Tiloca, B., & Roncada, P. (2020). Antimicrobial resistance in veterinary medicine: An overview. International Journal of Molecular Sciences, 21(6), Article 1914. https://doi.org/10.3390/ijms21061914

9. Leise, B. S. (2018). Topical wound medications. Veterinary Clinics of North America: Equine Practice, 34(3), 485–498. https://doi.org/10.1016/j.cveq.2018.07.006

10. Scarborough, R., Bailey, K., Bradley Galgut, B., Williamson, A., Hardefeldt, L., Gilkerson, J., & Browning, G. (2020). Use of local antibiogram data and antimicrobial importance ratings to select optimal empirical therapies for urinary tract infections in dogs and cats. Antibiotics, 9(12), Article 924. https://doi.org/10.3390/antibiotics9120924

11. Freitas, L. F., & Hamblin, M. R. (2016). Proposed mechanisms of photobiomodulation or low-level light therapy. IEEE Journal of Selected Topics in Quantum Electronics, 22(3), 1–17. https://doi.org/10.1109/JSTQE.2016.2561201

12. Lazerin, R. Y. I. O. D., & Etkisi, B. (2018). Biostimulatory effects of diode laser and ozone on wound healing in rats. Meandros Medical and Dental Journal, 19(1), 160–167. https://doi.org/10.4274/meandros.97269

13. Zein, R., Selting, W., & Hamblin, M. R. (2018). Review of light parameters and photobiomodulation efficacy: Dive into complexity. Journal of Biomedical Optics, 23(12), Article 120901. https://doi.org/10.1117/1.JBO.23.12.120901

14. Silva, T. G., Ribeiro, R. S., Mencalha, A. L., & Fonseca, A. S. (2023). Photobiomodulation at molecular, cellular, and systemic levels. Lasers in Medical Science, 38, Article 13. https://doi.org/10.1007/s10103-023-03801-6