Laser Therapy: A New Paradigm in Veterinary Practice

Ronald J. Riegel D.V.M., FASLMS, VMSO
“Thank you”

The American Institute of Medical Laser Applications
AIMLA

www.aimla.org

Email: aimladvm@aol.com
Resource information

Laser Therapy in Veterinary Medicine: Photobiomodulation

Publication: Late 2016/Early 2017
43 Chapters
37 Contributing Authors

Websites:
www.aimla.org
www.pubmed.gov
www.research.gov

Atlas of Class IV Laser Therapy
Small Animal
John C. Godbold, Jr. DVM
CD ROM Edition
Syllabus:

8:00 – 9:00  Fundamental information
Science, laser-tissue interaction, research evidence

9:30 – 10:30  Clinical Applications
Application techniques, common and uncommon applications.

10:45 – 11:45  Interactive session on treatment of specific disorders and anatomical areas.
New technology

Regenerative medicine

- Laser Therapy (Photobiomodulation)
- Stem Cell Therapy
- Autologous Conditioned Serum
- Platelet Rich Plasma (PRP)
- Physical Rehabilitation
What does laser therapy actually accomplish?

1. Relieves pain
2. Modulation of the inflammatory response
3. Increases microcirculation

Therefore an acceleration of the healing process
Scientific Evidenced Based Medicine

Number of Research Papers by Year

- **Low Level Laser Therapy**: 4,463 articles (increase of ~300 in 6 months time!)
- **Cold Laser Therapy**: 4,540 articles
- **LLLT**: 4,127 articles
- **Photobiomodulation**: 186 articles

Since Jan. 1st 2016 till 4/10/16: 86 papers on photobiomodulation

Research evidence and clinical evidence is: **Evidence Based Healthcare**
Part One: Fundamental Information
Current nomenclature

Photobioregeneration

Stem cells and PRP
Lasers are classified by potential danger to the eye.

**Class 1**
Safe

**Class 1M**
Safe provided optical instruments are not used**

**Optical instruments - binoculars, telescopes, microscopes, magnifying glasses (but not prescription glasses)**
Class 2
These are visible lasers. This class is safe for accidental viewing under all operating conditions. However, it may not be safe for a person who deliberately stares into the laser beam for longer than 0.25 s, by overcoming their natural aversion response to the very bright light.

Class 2M
Hazardous (even for accidental viewing) when viewed with the aid of optical instruments
Class 3
(1 mw – 500 mw)

Class 3R
(1 - 5mW)
Radiation in this class is considered low risk, but potentially hazardous

Class 3B
(5 - 500mW)
Radiation in this class is very likely to be dangerous

OSHA requires all Class 3 and Class 4 therapeutic lasers users to wear protective eyewear
Class 4  
(500 mW>)  

Surgical  
(CO$_2$ and diode)  

Therapeutic lasers  

Radiation in this class is hazardous, and viewing of the diffuse reflection may be dangerous.  

Protective eyewear required
Penetration

How deep does a therapeutic dose penetrate?
Radiative Transfer Equation

---fully describes the energy flow of light in tissue

\[-\nabla \cdot \kappa(r)\nabla \phi(r, t) + \mu_a \phi(r, t) + \frac{1}{c} \frac{\partial \mu_a \phi(r, t)}{\partial t} = q_0(r, t)\]

Where:

\( \phi \) – The Photon Density, is given by:

\[ \phi(r, t) = \int_{S^{n-1}} \varphi(r, \hat{s}, t) \, d\hat{s}' \]

\( \kappa \) – The Diffusion Coefficient, is given by:

\[ \kappa = \frac{1}{3} (\mu_a + \mu_{s'}) \]

(1) Diffusion Approximation to the RTE: \( \mu_s \gg \mu_a \) and tissue thickness \( \gg \lambda \)
Light doesn’t suddenly stop “penetrating tissue”
Penetration parameters

- WAVELENGTH
- POWER
- CORRECT DOSAGE GIVEN THE APPROPRIATE NUMBER OF TIMES USING THE PROPER TECHNIQUE

CONSISTENT CLINICAL RESULTS
• Penetration depth.
• Absorption.
• The most important factor

POWER
• The number of photons at that depth to saturate the tissues.

DOSAGE
• Joules/cm².
• Appropriate number of treatments.
• Proper application technique.
For effective penetration, the wavelength needs to avoid scattering, surface absorption and absorption by unwanted chromophores.

This is called the therapeutic window.

Examples:
- Hemoglobin
- Melanin
- Water

Absorption Coefficient (per centimeter)

Wavelength (Microns)

CO₂ Surgical lasers
Depth of penetration is determined by the length of the wavelength.
Power determines the number of photons at that depth.

Both at 980nm wavelength

5 Watts 10 Watts
Wavelength 980nm

1 Watt
5 Watt
10 Watt
Continuous wave (CW)

Modulated continuous wave

The terms pulsing and frequency are used interchangeably to describe the same concept.

Super pulsing

Frequency is expressed in Hertz (Hz)

The number of cycles per second that a waveform repeats

5 cycles per second = 5Hz
Pulsing mode = “X” Hz

Laser is emitting only 50% of the time.

Where is the scientific evidence that specific cells respond to a blinking light?
Average power output

Laser emitting at 10W = 10 Joules/sec.
= 600 Joules/min

Laser emitting at 10W: 50% Duty cycle =
5 Joules/sec. =
300 Joules/min.
Average Power Output: ~70mW
Energy delivered per minute: ~ 4.2J
Laser Classification: 1 to 3B
Only feasible for the treatment of small areas
Peak (instant power): ~25W

Claims of deeper penetration and only way to accomplish analgesia.

Garden hose analogy is erroneous: you can’t pressurize photonic energy!
Comparison of time to deliver 3,000 Joules

Treatment Area: 300 cm²
Dosage: 10 J/cm²
Total energy delivered: 3,000 J

5mW laser
10,000 minutes
166.7 hours

500mW laser
100 minutes
1 hour 40 minutes

3W laser
16.7 minutes

10W laser
5 minutes

Continuous wave emission
Laser emitting at 10W:
  50% Duty cycle:
  5 Joules/sec. = 300 Joules/min.
  Therapy time = 10 minutes

Laser emitting at 25W in a super pulsed mode:
  4.2 Joules/minute
  Therapy time = 714.28 minutes
  Therapy time = 11.9 hours
Laser/Tissue Interaction
Laser/tissue interaction

Photothermal
long pulses, biological effect due to heating -
hair removal, surgical lasers

Photomechanical (Photoacoustic)
short pulsed (q-switched) lasers cause ablation -
tattoo removal, photorefractive keratectomy

Photobiochemical
laser causes biochemical change or response -
pain reduction, photodynamic therapy (PDT)
Cellular attraction to infrared light

Fibroblasts 3T3 cell cultures
800 – 900 nm 47%
immediately migrated

Guenther Albrecht-Buehler, Ph.D.
Fellow, European Academy of Sciences, Brussels
Fellow, Institute for Advanced Studies, Berlin
Robert Laughlin Rea Professor Emeritus of Cell Biology
Northwestern University Medical School, Chicago
Mechanism of action at the cellular level

Chromophores are components of various cells and sub-cellular organelles which absorb light.

Mitochondria

Cell membrane
Photonic energy stimulates the photoreceptor on the mitochondria to decrease the reaction time for cytochrome c to become cytochrome c oxidase. This facilitates increase in the cellular respiration rate.
Physiological effects

Photobiomodulation initiates a biochemical cascade of events that results in:

1. A reduction in pain
2. A reduction in inflammation
3. An increase in microcirculation

Therefore there is an acceleration in tissue repair and wound healing
Establishment of an Effective Photobiomodulation Treatment Protocol in an Animal Model of Persistent Neuropathic Pain


The sciatic nerve, sural, common peroneal and tibial nerves were cut. 60 rats divided into a sham surgery group and a PBM + surgery group.

After just two treatments the PBM group began recovery. At day 26, this group reached baseline levels of sensitivity to mechanical stimulus.

Phototbiomodulation of the dorsal root ganglion for the treatment of low back pain: A pilot study


Three groups: lidocaine injection, radiofrequency, or laser therapy

Laser irradiation caused an immediate decrease in low back pain similar to pain reduction cause by lidocaine injection
Mechanism of Action: Analgesia

- Increased nitric oxide production
  - Uozumi et al., August 2010; Farvier et al. 2014
- Increase in beta endorphins
  - Cidral-Filho et al. 2014
- Decreased bradykinin levels
  - Chow, R.T. and Barnsley, L. 2005
- Ion channel normalization
  - Rosenbaum, T, PhD, Simon, S, PhD, Islas, L, PhD 2007
- Stabilizes the action potential
- Increase serotonin release
  - Magalhaes, M. et al. 2015
- Increased release of acetylcholine
- Blocked depolarization of C-fiber afferent nerves
  - Ohno T. 1997; Tsuchiya K et al. 1993; Wakabayashi, H., et al. 1993
Biochemical/Physiological Cascade of Events Resulting in Analgesia

- Increase in Beta Endorphins
- Decreased Bradykinin Levels
- Ion Channel Normalization
- Blocking Depolarization of C-Fiber Afferent Nerves
- Serotonin Release
- Increased Nitric Oxide Production
- Increased Acetylcholine
- Stabilize Action Potential
Integration into Pain Management Protocols

Acute pain: 
- Trauma.
- Burns.
- Otitis.
- Dental

Chronic pain: OA.
Post surgical: 
- Routine and orthopedic.

“DIVINUM EST OPUS SEDARE DOLOREM”
- Divine is the work to subdue pain
  --Hippocrates

Dermatological
Abdominal 
Respiratory

Multi-pharmaceutical Approach
Pain free, fast recovery
Laser Therapy
Good Nursing Care and Post-op Rehabilitation
Common Pain Management
Applications in Practice

Acute Pain Management
1. Post surgery
2. Dental procedures
3. Burns
4. Otitis
5. Urinary disorders
6. Gastrointestinal disorders

Chronic Pain Management
1. Osteoarthritis
2. Geriatrics
3. Dermatologic disorders
4. Respiratory disorders e.g. Feline asthma
Clinical Case: Post-op Pain

- 9 mo. old female spayed Chihuahua
- Avascular necrosis - femoral head and neck excision
- Sx June 4, 2012
- CRI morphine, ketamine, medetomadine, IA bupivicaine
- Post-op laser therapy

- CRI morphine, ketamine, medetomadine, IA bupivicaine
- Post-op laser therapy
Post FHO Sx laser therapy protocol

- Incision: 2 Joules/cm²
- Periarticular muscles:
  - Day 1 and 2: 8 Joules/cm²
- Periarticular muscles, back and thigh: 6 Joules/cm² on day 3 then alternate days
Dosage: 2-4 J/cm²
Burn

Foot pad meets stove top
Dosage:
  $1 - 2 \text{ J/cm}^2$
Otitis

Dosages:
Pinna and external structures: 
  2 – 4 J/cm²
Ear canal: 
  6 – 8 J/cm²
Cervical disc pain

Dosage:
8 – 10 J/cm²
Urinary tract pain

Uroliths ~ FUS ~ Interstitial Cystitis
Pyelonephritis ~ Urethral Obstruction

Dosage: 10 -12 J/cm²
Positioning the patient very important
Gastrointestinal pain

Pancreatitis ~ Parvovirus ~ GI Surgery ~
Dosage:
10 – 12 J/cm²; lateral recumb. both sides and ventrally.
Increase dosage for larger patients >60 lbs.
Intestinal resection and anastomosis: Stick and Plastic Body

Dosage:
• 2 – 3 J/cm² during surgery and before closing incision then 1 – 2 J/cm² after closure.
• Incision (1 – 2 J/cm²) and abdomen (10 – 12J/cm²) for three consecutive days.
Chronic pain management

- Chronic pain serves no purpose.
- Stimulus may be persistent – OA.
- Lasts longer than 1 month.
- Stimulus may be absent.
  - CNS malfunctioning
  - Wind up- central neuronal hyperexcitability
Chronic dermatologic condition

Chronic otitis:

Dosages:

Pina:
  2 – 4 J/cm²

Ear canal:
  10 – 12 J/cm²

Frequency:
  Daily X 3
  then EOD for two weeks
  then maintenance to maintain.
6 treatments over 2 weeks
Picture taken 1 month later

Stomatitis
Chronic respiratory pain management

Feline asthma

PBMT will provide:
pain relief
reduction in inflammation
improved quality of life

Dosage: 6 – 8 J/cm²

Frequency of therapy: three out of first four days then three times per week then once a week till managed.

Will respond by 6 – 8 treatments

Case Study Provided By:
Hege Thorsen, BVSc, MRCvS
Troll Veterinærklinikk AS
Kleppestø, Askøy Norway
Inflammation: *īnflammō*; “I ignite, set alight.”

The fundamental acute inflammatory reaction to any form of trauma is ubiquitous regardless of the inciting cause; surgical, pathogenic or physical trauma.

PBMT modulates the inflammatory reaction.
A study of the effects of LLLT using red and NIR wavelengths on acute inflammation in the rodent model.

Raymond J Lanzafame, MD PLLC; Rochester General Hospital, Rochester NY

LLLT significantly reduced acute inflammation.

Comparative analysis of two low-level laser doses on the expression of inflammatory mediators and on neutrophils and macrophages in acute joint inflammation.

Santos, S.; Alves, A.; Leal-Junior, E.; Albertini, R; Vieira, R.; Ligeiro, A.; Silva, J.; Carvalho, P.

Reductions in IL-1β, IL-6 and TNF-α and inhibition of inflammatory cells.
Biochemical Mechanisms Resulting in a Reduction of Inflammation

Inhibits the synthesis and secretion of inflammatory prostaglandin yet stimulates prostaglandins that have a vasodilatory and anti-inflammatory action.


Stabilization of the cellular membrane


Enhancement of ATP production and synthesis


Stimulation of vasodilatation

Kelly A. Larkin, MS, CAT(C); Jeffrey S. Martin, PhD; Elizabeth H. Zeanah, MS; Jerry M. True, DC, FIACN; Randy W. Braith, PhD; Paul A. Borsa, PhD, ATC, FACSM. J. Athl. Trainer, 47(2)178-183.2012

Reduction in interleukin 1

Stimulation of vasodilatation

An increase in:
- Nitric oxide
- Serotonin
- ROS


Ten minutes post
Dose: 8 J/cm²
2400 Joules

Fifty minutes

Promedica Sports Medicine, Toledo Ohio 2009

Medial head of Triceps Brachi M
Extensor carpi radialis brevis tendon

Two minutes prior to therapy at 10 J/cm²
Ten minutes post therapy
MODULATION OF THE INFLAMMATORY REACTION

- Increased leucocyte activity
- Vasodilation
- Reactive oxygen species production
- IL-1 Decrease
- IL-1 Decrease
- Increased production of ATP
- ↓ PGI₂ Synthesis
- Cell membrane Ca²⁺, Na⁺, K⁺ Ion Changes
- Enhanced Lymphocyte Response
Pyotraumatic dermatitis

Administration of 5 J/cm²
Emission of 600 Joules

Three hours post administration

- Dry
- Decreased inflammation

John C. Godbold, Jr. DVM
Stonehaven Park Veterinary Hospital / Laser Surgery Center
Jackson, Tennessee
How does photobiomodulation accelerate the healing process?

Twenty-Six Days
Dosage: 4 J/cm²
Ten PBMT sessions
Laser Therapy Facilitates Superficial Wound Healing in Humans: A Triple-Blind, Sham-Controlled Study

Hopkins et al
J Athl Trainer 2013

- Triple-blind, sham-controlled in-vivo human study
  identical skin wounds were created in 22 volunteers
  age = 21 +/- 1 years
- Randomly placed in a control, sham laser or laser treatment group
- 8 J/cm², 820 nm laser
- Measured epithelial migration

153% greater wound contraction at day 6 in the laser group
High Powered Laser Therapy Enhances Muscle Healing

Matthew C. Kostek, Diana C. Delgado-Diaz, Bradley Gordon

- Subjects underwent muscle damage protocol using isokinetic dynamometer
- 48 hours after damage, laser administered to one leg
- 6 hours after laser treatment, muscle biopsies were collected
- C2C12 cells were grown in standard culture conditions and received daily laser treatment

RESULTS: Laser treatment increased markers of muscle repair and enhanced muscle cell proliferation in culture.

CONCLUSIONS: High powered laser treatment is effective in increasing molecular markers of muscle repair after damage.
Photobiomodulation in promoting wound healing: a review.


Data suggests multiple wavelengths more efficacious than single wavelength. Focuses on studies of biochemical mechanisms.


Accelerated tissue repair

Photobiomodulation increases the production of ATP

This increases the energy level of the cell to expedite the uptake of nutrients and speed the elimination of waste by products

Karu T. et al. 2001

Increases the rate of cellular mitosis and collagen synthesis

There is an increase in the leukocytic and macrophage infiltration

Activates fibroblasts and other tissue repair cell types
These regenerative cells allow tendons, ligaments, bones and muscles to heal at an accelerated rate

Bolton, P., Young, S.R. and Dyson M. 1991
Alexandratou, E., Yova, D., Handris, P., Kletsas, D. and Loukas, S. 2002
Bjordal et al. 2007).
Biochemical/Physiological Cascade of Events Resulting in Accelerated Tissue Healing

Increased leukocyte activity
Increased macrophage activity
Increased fibroblast proliferation
Enhanced cell differentiation
Increased vascular regeneration
Increased tensile strength

Accelerated Tissue Repair
Reduced Healing Time
March 10th, 8-year-old Warmblood show jumper was presented with an acute right forelimb lameness after a competition over a poor surface.
March 10th

Forty five day recheck
Wound Healing: Thermal Injury

History

3 year old spayed female English Setter
Dec 7, 2011- family member spills cup of hot chocolate over her back
No immediate treatment at home
Presented Dec 16, 2012 for reluctance to move, foul odor

Laurie Dunbar DVM, CCRP
Treatment Plan:

Cephalosporin antibiotics
Meloxicam
T-shirt to be washed and changed daily

**PBMT**

EOD

3 treatments only (compliance, results)
24 hours after first laser treatment

Post 3 PBMT sessions

Client did not return for follow up treatments
FRACTURES

Delayed or Non-union
Slow healing
Poor apposition
Routine as part of post surgical protocol
Effect of low-level laser therapy on the fracture healing process.
Kazem Shakouri S1, Soleimanpour J, Salekzamani Y, Oskuie MR.

Laser enhances callus development in the early stage of the healing process, therefore, laser therapy may be recommended as an additional treatment in non-union fractures in humans.

Low-level laser therapy enhances the expression of osteogenic factors during bone repair in rats
Tim CR1, Pinto KN, Rossi BR, Fernandes K, Matsumoto MA, Parizotto NA, Rennó AC.

Laser therapy improved bone healing by accelerating the development of newly formed bone and activating the osteogenic factors on tibial defects.
Photobiomodulation of a delayed union fracture

Pug
Two-years-old

Due to economics opted for ext. fixation:
Meta Splint

Kimberly Juhlin, DVM
Vale Park Animal Hospital
Valparaiso, Indiana
Four weeks fracture site still mobile

Made a window in the Meta splint and therapy applied at all angles

Twice/week for five weeks

Dosage: 8 J/cm²
After five weeks:
ten therapy sessions.

Resulting angiogenesis and
a reduction in edema
resulting in a better healing
environment.
Bob Marley gets hit by a car!

Bob Marley is a yellow Labrador that was brought in the day after being hit by a car.

He suffered some minor road rash but also suffered degloving injuries to the pads on his feet.

Greg Emmert, D.V.M., CCRP
Conclusions:

✓ Scientific and clinical evidenced based medicine.

✓ Relieves pain.

✓ Modulates the inflammatory reaction.

✓ Increases circulation

✓ Accelerates healing.
Questions?
Basic Application Techniques
Thank you

Email: aimladvm@aol.com
Website: www.aimla.org
Phone: 937.642.9813