IMPLEMENTING CO_2 LASERS IN DERMATOLOGY CASES

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INTRODUCTION

CO_2 laser surgery is growing in popularity in veterinary dermatology. This surgical modality has been around for a long time, and as equipment becomes more accessible the popularity of this technique continues to grow. Additionally, clients are beginning to ask directly for treatments that go beyond sterile surgical steel. Learning this technique is relatively straight-forward and lends nice surgical outcomes. However, this modality is not without potential harm to the patient and surgical team if proper techniques and standard safety protocols are not followed.

HOW IT WORKS

LASER stands for light amplification by stimulated emission of radiation.[1] There are many types of lasers in use today which may be used in research and science, medical therapy, engineering, industry, and weaponry. Common medical laser types include CO_2, diode, YAG and others. One of the most popular medical lasers used in veterinary dermatology is the CO_2 laser, which emits a colorless, infrared light at a specific wavelength of 10,600 nm (the wavelength of visible light is approximately 400 to 700 nm).[1] At this wavelength it has a high affinity for intercellular water within tissue. A laser beam is created when a single wavelength of electromagnetic radiation is compressed into a small, focused beam of light with mirrors. This allows the light to travel long distances. Laser light energy is reportedly ten times brighter than the sun. When a laser beam encounters a tissue, the impact it will have on that tissue will depend on the wavelength (power) of the laser beam, the amount of time the laser is exposed to the tissue, and the laser beam diameter (called spot size). Laser photon energy, or irradiance, is measure in Watts/cm2. There are four properties that describe how lasers and tissues interact: absorption, transmission, scatter, and reflection.[1]

Absorption results when tissue molecules called chromophores absorb the laser photons, resulting in alteration of the tissue via photochemical, photothermal, and/or photomechanical effects. Photochemical effects occur when low power laser energy is exposed to tissue for a long period of time as occurs when skin becomes sunburned after prolonged sun exposure. In a controlled setting, photochemical lasers can be used to provide pain relief and reduce inflammation in deep tissue laser therapy since the laser light interactions with tissue chromophores to promote activation of the natural anti-inflammatory pathways in the body. Photothermal effects occur when increased temperature created by a powerful laser beam creates tissue vaporation, which typically occurs when laser energy measures at least 100ºC. This is the basic mechanism by which medical surgical laser's function. Photomechanical effects occur when highly powerful laser impulses cause thermal expansion and create damage via acoustic waves, which break up target material into small particles much like a shockwave. Examples of uses of photomechanical laser usage include tattoo removal or photo refractive keratectomy.

Transmission results when the laser photons pass through the more superficial tissue to interact with deeper tissues. An example of this would be diode laser therapy for use to treat retinal tears and hemorrhages. Diode laser photons selectively interact with chromophores such as melanin pigment within the retina, which allows it to pass through superficial layers of the eye (e.g. cornea) without creating damage.

Scatter occurs after the laser photons enter the tissue and disperse in different directions. This type of tissue interaction is not useful with CO_2 lasers because it creates unintentional damage to surrounding tissue. This may occur when lasing over carbonized biological materials.

Reflection occurs when the laser photons bounce off an object without penetration or interacting with it. The laser beam will change direction, which may result in unintentional harm to the patient or laser operator.

The effect of the laser on the tissue can be changed by adjusting the energy output (watts), the spot size (laser beam diameter), and the laser-tissue contact time. Larger spot sizes increase the risk of scatter and have less depth of penetration while smaller spot sizes have less scatter and more depth of penetration. The spot size is determined by the distance from the tissue, wavelength, and lens focal length.

CO_2 surgical lasers have a wavelength of 10,600 nm, which is in the infrared/invisible light spectrum. These are considered Class IV lasers due to their ability to create direct and indirect damage to skin and eyes. The laser photons are absorbed by water within cells leading to cellular disintegration by vaporization. There is little scatter and collateral thermal damage with these types of lasers due to accuracy of the beam; however, poor user technique can cause these side effects to occur. CO_2 surgical lasers are not selective for certain pigmented chromophores in tissues like diode lasers, which means that CO_2 surgical lasers non-selectively destroy all living tissue. Once vaporization of cells occur, carbonized cellular material is released in a smoke plume that needs to be evacuated from the environment to reduce damage to the laser operator. CO_2 surgical lasers are primarily used for their accurate cutting properties and are reported to have decreased healing time due to the positive effects on pain, edema, hemostasis, and preventing infections. CO_2 lasers can be used for a wide variety of external and internal procedures including mass removal, skin/tumor ablation, perianal surgery, cystotomy, ovariohysterectomy, neuter, soft palate resection, correction of stenotic nares, dental procedures, eyelid procedures, enucleation, and much more. Cost of laser procedures is similar to that of traditional scalpel surgical techniques, and pricing guidelines will be established by the frequency of use of the equipment. Disadvantages to use include training and safety, limited use with bones or other hard tissues, and slower healing with poor laser technique.[2]

CO_2 LASER SAFETY CONSIDERATIONS[1]

All laser operators and assistants must be properly trained on the equipment prior to usage, including developing a thorough understanding of basic laser safety and handling. Beam hazards represent the most concerning type of injury that may occur with laser operation. The laser can cause substantial damage to the operator or assistant should they come into direct or indirect contact with the laser beam resulting in tissue burns and retinal damage. Non-beam hazards include respiratory illness secondary to inhalation of carbonized smoke plume, airway fire within the endotracheal tube, electrical hazards, and other types of fires. Protective clothing (long sleeved shirts and pants, closed toe shoes, gloves, tie back long hair, etc.) will help to reduce damage from accidental beam exposure but will not prevent it completely especially when the laser is at high power usage. Certified M-rated protective eyewear must be worn at all times by anyone in the room while the laser is in operation. Eyewear will vary based on the type of laser being used, so consult the user manual for each laser to be sure the eyewear covers the correct wavelength. Eyewear should be inspected prior to each use for the presence of scratches or damage, which could reduce their effectiveness. Laser approved masks (N99) will reduce inhalation of airborne infectious or carcinogenic material in the carbonized plume. The HEPA filtered smoke evacuator should be used any time the laser is in operation, and it should be positioned less than 5cm from the operation site. Avoid wearing reflective jewelry, cover reflective surfaces, and avoid beam interaction with metal surgical equipment to reduce the risk of reflective beam hazards. Do not use flammable substances, including alcohol for surgical preparation, petroleum lubricants, combustible towels/drapes/sponges, etc. Let all cleaned skin dry completely prior to starting the procedure and use fire retardant polypropylene drapes during surgery. Soaking drapes, gauze, and towels in sterile water or saline will act as a flame retardant as well. PVC endotracheal tubes are flammable, so use of FDA-approved laser resistant endotracheal tubes will help to reduce potentially fatal airway fires. This is most important when patients are intubated and laser operation is in or around the oral cavity. Check for full cuff inflation and pack around the tube and mouth with saline soaked gauze to reduce the risk of gas and oxygen leaking around the endotracheal tube. Alerting hospital personnel when the laser is in use can be achieved by closing doors to the surgical room and placing “DANGER - LASER IN USE” signage on the door at eye level.

EQUIPMENT AND TECHNIQUES[1]

Laser equipment varies, so proper operation and safety will be dependent on the specific machine. There is a steep learning curve when learning to operate your equipment, especially considering the potential hazards with improper equipment usage and safety. Most medical equipment supply companies will send a representative to your practice to train you in proper use and safety of your machine. Always know where your “emergency shut off” button is and be prepared to use it at a moment’s notice. This will immediately stop the laser beam even if the operator's foot is still depressing the pedal. Be sure to read completely the user manual and practice using the machine prior to performing a patient procedure. When training new users, I like to use raw chicken (skin and bone-in), porcine tissue (skin on), peaches, tomatoes and other food items that are similar to live tissue.

CO_2 surgical laser equipment varies, and researching your practice needs is important prior to purchase. CO_2 lasers convert 80-90% of the electrical energy used to create a beam into heat inside the laser tube and laser system, making them poorly energy efficient. This heat must be dispersed to prevent the machine from over-heating. Some equipment is constructed with flexible fiber wave-guides in all-metal tubes and internal cooling fans to allow for improved maneuverability and ease of operation. Other systems use a rigid wave-guide with internal glass tube water cooling systems which contain internal water chambers that need to be checked regularly and are more prone to glass tube fragility. Depending on your medical needs and budget, finding a CO_2 laser that meets your needs is relatively easy.

Some CO_2 surgical laser equipment is supplied with resources and guidelines for routine procedures. This may include video and written tutorials on recommend settings for routine procedures. This is useful when preparing for a surgical procedure. Remember that these are recommendations, and modifications must be made depending on the patient, procedure, and operator. The most important factors controlling laser-tissue interactions are spot size, power, and hand speed (time of laser-tissue contact).

The first step to implementing laser is to decide your diagnostic and treatment goals for each case. Cases in which you hope for histopathological evaluation require different approaches than those in which you are aiming to ablate tissue and promote coagulation. The two main laser surgical techniques are **excision** (primary intention wound healing) and **ablation** (secondary intention wound healing). Excision involves using the laser like a scalpel blade to precisely remove tissue for diagnostic purposes, followed by suture placement and primary intention healing. Ablation involves using sweeping motions to remove affected tissue through vaporization and is described as using the instrument like a "pencil eraser to erase writing on paper."[10] Excision involves use of small spot sizes (e.g., 0.25 mm) to achieve a precise cut whereas larger spot sizes are preferred for ablation (e.g., 1.4-2.5 mm).

Power and mode settings are also crucial when choosing your laser settings. In general, high power allows for less time the laser is interacting with tissue, which promotes less inflammation and better wound healing. New laser users oftentimes choose power settings too low, which requires them to repeatedly passing the laser beam over the tissue to achieve a desired depth of cut. Extra laser-tissue time interaction equates to delayed healing. The laser has different working modes including continuous, SuperPulse, single pulse, and repeated pulse. In general, SuperPulse allows for rapid repeated bursts of laser energy interspersed with rest periods to allow tissue to cool down, which decreases tissue damage and promotes wound healing; however, this mode is less efficient at promoting coagulation.[10] SuperPulse is most used with small spot sizes and high power for excision. Continuous mode delivers a continuous beam of laser energy without relaxation time, which makes it a superior mode for coagulation and ablation of tissue.[10]

Excision	Ablation
Small tip/spot size (0.25 mm)	Large tip/spot size (1.4-2.5mm)
Medium to High power	High power
SuperPulse mode	Continuous mode
Preserves tissue for diagnostic testing	Unable to perform diagnostic testing on tissue
Less efficient for coagulation	Efficient for coagulation

Common uses in veterinary dermatology include treatment of follicular cysts, sebaceous adenomas, nodular sebaceous hyperplasia, pigmented viral plaques in dogs, small cutaneous hemangiomas or hemaniosarcomas, feline ceruminous cystomatosis, gingival hyperplasia, idiopathic nasodigital hyperkeratosis, cutaneous papillomas, plasma cell pododermatitis, inflammatory aural polyps or other otic tumors, fibrocollagenous skin tags, actinic keratosis or Bowen's in situ carcinoma, acral lick granulomas, pedal cysts and furunculosis, and chronic lip fold dermatitis through lesion removal and/or ablation.[3-9] Mass removal for submission for histopathology is achievable with a CO_2 laser, and I generally take a slightly wider surgical margin than with traditional scalpel blade removal to account for laser-induced tissue shrinkage during vaporization.

Post-operative care is minimal for most procedures, especially when primary closure laser technique is used. Post-operative care is longer when coagulation and ablation techniques are used and secondary intention healing is utilized. Tissue swelling and pain after simple procedures (e.g. mass removal) using a laser are minimal because the laser cuts, coagulates, and seals nerve endings and lymphatics simultaneously. However, if the laser is used to ablate larger areas of tissue (e.g. ceruminous cytomatosis, Bowen's in situ carcinoma, oral papillomatosis, acral lick lesions, cystic pedal furunculosis), then pain control post-operatively is recommended with a combination of non-steroidal anti-inflammatory and opioid medications. Prevent the animal from licking the treated areas to avoid healing complications and infection. I usually bandage paws for three to five days post-operatively for minor procedure, or until healed for complex procedures like interdigital mass removal and pedal furunculosis. Topical silver sulfadiazine cream, medical grade honey, and other wound dressing may used to promote healing, reduce inflammation, and treat or prevent bacterial infection of treated areas.

CONCLUSIONS
CO_2 laser is the leading modality in surgical laser in veterinary dermatology due to its excellent performance for soft tissue, including skin. It can be utilized for numerous dermatological conditions. Specific protocols do not exist since performance is dependent on the surgeon's technique, primarily hand speed, spot size, and power settings. Learning CO_2 surgical laser basic principles and techniques via guided training and ongoing practice will improve an individual's surgical outcomes over time.

REFERENCES
1. Fader DJ, Ratner D. Principles of CO2/erbium laser safety. *Dermatol Surg*. 2000 Mar;26(3):235-9.
2. Bolt L: Introduction to laser surgery. AAFP Proc Fall 2003. vin.com/Members/proceedings/Proceedings.plx.
3. Schick R and Schick M. CO2 laser surgery in veterinary dermatology. *Clinics in Dermatology*. 1994;12(4):587-589.
4. Duclos DD, Hargis AM, Hanley PW. Pathogenesis of canine interdigital palmar and plantar comedones and follicular cysts, and their response to laser surgery. *Vet Dermatol* 2008;19(3):134-141.
5. Duclos DD. CO2 laser excision of skin tumors. *Veterinary Practice News*. 2014;3:32-33.
6. Vitruk P. How CO2 lasers cut, coagulate soft tissue. *Veterinary Practice News*. 2014;12:36-37.
7. Duclos DD. Canine fibroadnexal hamartomas treated by CO2 laser excision. *Veterinary Practice News*. 2015;6:32-33.
8. Knight EC, Munday JS, Stone BM, Shipstone MA. Carbon dioxide laser treatment of extensive pigmented viral plaque lesions in a golden retriever dog. *Vet Dermatol*. 2016 Oct;27(5):442-e117.
9. Ierace MK, Canfield MS, Peters-Kennedy J, Kane CW. Combined carbon dioxide laser and cryosurgical ablation of rostral nasal septum squamous cell carcinoma in 10 dogs. *Vet Dermatol.* 2018 Oct;29(5):431-e142.
10. Pieper JB, White AG. Applications for Laser in Veterinary Dermatology. *Vet Clin North Am Small Anim Pract*. 2025 Mar;55(2):251-284. doi: 10.1016/j.cvsm.2024.11.005. Epub 2025 Jan 3. PMID: 39755502.