

Introduction to Laser Surgery in Small Animals  
Installation Agenda

**Objective:** To allow the general practitioner to become more familiar with basic laser safety & physics, and how it interacts with the tissue. A general discussion of basic soft tissue applications, to include dermatology, and abdominal surgery applications to better allow the practitioner to make intelligent decisions on how to use a laser in his/her practice.

1) **Laser Safety-(Lecture)**

- a) The Operating Room
  - i) Posted signs
  - ii) Eye protection
    - (1) Proper selection of eye wear
  - iii) Fire potentials
  - iv) Physical hazards – power cords, laser burns
  - v) Reflection of laser light-direct vs. specular reflection
- b) The Patient
  - (1) Ocular protection
  - (2) Extraneous wound protection
  - (3) Proper sterilization procedures
  - (4) Drapes
  - (5) OR table
    - (a) Thermal blankets
- c) The Doctor
  - i) Responsibilities towards
    - (1) Patient
    - (2) Assistants
    - (3) Self
      - (a) Gloves, gowns
- d) Laser Safety Officer
  - i) Responsibilities
    - (1) Training
    - (2) Equipment knowledge
      - (a) What to do in an emergency

2) **Equipment:** Laser, Plume Evacuator

- a) Complete review of function
- b) Cleaning, filter disposal (red-bag)
- c) Positioning in operating room
- d) Laser-safe surgical instruments

3) **Use of Laser**

- a) Acceptable procedures
- b) Harmful procedures
- c) Selection of proper settings
- d) Myths of the Laser

4) **Marketing**

- a) How to charge
- b) How to educate clients & staff (end lecture)

5) **Laboratory (Hands On Surgical Training)**

- a) Review of Anatomy as it applies to laser surgery
- b) Feline declaw
- c) Feline/canine ovariohysterectomy
- d) Feline/canine neuter
- e) Lumpectomy

# Pre-Installation Summary

## Laser Physics – A General Overview

Light bulbs and laser both generate light, the common name for electromagnetic energy that we can see. Laser wavelengths fall between the infrared and ultraviolet wavelengths of electromagnetic radiation, including both invisible and visible spectrum. LASER is an acronym that stands for Light Amplification by the Stimulated Emission of Radiation. Only laser wavelengths between 400 and 700 nm are visible to the naked eye.

Carbon Dioxide laser generates energy through the following process: The carbon dioxide atoms in their resting state are excited to a higher energy state by the absorption of energy in the form of thermal, electric, or optical energy. After the energy is absorbed by the CO<sub>2</sub>, the atom spontaneously returns to its ground state and liberates that absorbed energy as a photon, a process known as stimulated emission. The emitted photons resonate between mirrored ends on the laser chamber. These bouncing photons stimulate and excite other atoms in the medium. Momentum builds until a highly concentrated beam of light passes through a partially transmissive mirror at one end of the laser chamber.

Laser light is best described as being;

- Coherent - of one wavelength (10,600 nm for CO<sub>2</sub> lasers)
- Monochromatic – of one color
- Collimated – or non-divergent, traveling in unison, reinforcing each other

## Types of Laser-tissue Interactions

Laser must be converted into another form of energy to produce therapeutic effects in the body. Photothermal interactions occur when laser light is absorbed by tissue and converted into heat energy, which results in a rise in tissue temperature. Water is heated directly with carbon dioxide laser energy, other molecules, such as hemoglobin and protein may be heated indirectly. The absorption of laser energy in any tissue is the sum of absorptions of each of the tissue components coupled with the absorption coefficient of water.

When a laser is pointed at a tissue, it may be reflected, absorbed, scattered throughout the tissue, or transmitted through the tissue. This effect (strength) is dependent on;

- The wavelength of the laser
- The absorption coefficient of the tissue for the laser (800 for the CO<sub>2</sub> laser)
- The power setting and time, expressed in joules (watts/second)
- The size of the beam, termed focal spot size

Power density is a measurement of the rate of work within a defined area, reported as W/cm<sup>2</sup>. Power density is also referred to as irradiance. Energy density is a measurement of the total work accomplished within a defined area and is generally reported as J/cm<sup>2</sup>. Simply put, a more narrow beam has a higher power density, which results in more work being performed on a given area of tissue, resulting in less collateral trauma when compared with a wider beam.

We will now turn our attention to how tissue responds to the laser. As photons are absorbed by the tissue target, tissue changes result from the degree of temperature change across the tissue. The typical laser ablation produces a tissue crater where vaporization has occurred. The temperature in this area has exceeded 100°C, the water in the tissue moves from a liquid to a gas state, increasing the interstitial pressure, and ultimately explodes the cell. Should the temperature exceed 150°C, proteins are broken down, leaving behind a layer of carbonization referred to as **char**. To avoid this, do not leave the beam in the same area too long, as this will result in a "heat-sinking effect". In the area immediate to the zone of vaporization, 60-100°C, there is protein denaturation resulting in a zone of necrosis. The most distal area is a zone of thermal injury in which the temperature has not exceeded 60°C. Thus, when a specific wavelength is well absorbed by the target tissue, there is a rapid rise to the ablation threshold, rapid absorption of the energy, minimal distance traveled of the beam into the tissue, and a resultant minimizing of collateral tissue damage. Low power densities or poor absorption of the wavelength applied over a long period of time will result in char formation, and greater collateral damage.

The laser surgeon has four methods to manipulate the laser beam's power density;

- (1) **Power** – this is the watt-setting of the laser unit (joules)
- (2) **Spot size** of the laser beam
- (3) **Distance of the hand-piece from the tissue** – defocusing a collimated laser beam will spread the energy over a larger area. By increasing the laser power, you are able to vaporize greater quantities of tissue in a given period of time. Defocusing a laser beam will increase its ability to coagulate bleeding vessels.
- (4) **Speed of the veterinarian's hand as it moves across the tissue** – move too fast across the tissue and the laser beam will not have enough time to penetrate the tissue; moving too slow results in deeper cutting and penetration into the tissue, as well as increased collateral trauma.

### Beam Delivery Modes

Lasers may be operated in one of three modes:

- (1) *Continuous wave (CW)* in which the shutter remains open and the laser beam is released continuously during activation at the watt setting entered. Thermal energy accumulation in tissue is controlled by your foot on the pedal. In simple terms, CW is for cutting. There will be some collateral damage, how much depends on how you control the four factors discussed above. With some collateral damage, there tends to be a little coagulation of tissue as it is cut through, resulting in some hemostasis.
- (2) With a laser set in *pulse mode*, the beam is released in bursts of specified time and rate, at the watt setting entered. This mode is used to deliver higher powers into tissue with more control. One would consider using this mode for: debarking, distichia, or if the unit did not have superpulse, this could mimic superpulse mode. Pulsed modes help reduce the amount of unwanted energy deposited into the tissue once the surgeon releases the foot pedal.
- (3) In *superpulse mode*, very high peak power pulses are delivered in short durations to achieve ablation of tissue without exceeding the *thermal relaxation time of tissue*. In other words, this mode reduces heat accumulation and collateral damage. This mode is useful in areas where one would want to avoid collateral damage, such as digital amputation. The end result is less char and a cleaner and more precise cut, but less hemostasis. Some veterinarians only use superpulse mode. In the case of superpulse mode, the power setting is the *average* power delivered. The peak setting on some machines may go as high as 100, and even 320 watts to deliver this. Spot sizes greater than 1 mm will produce char.

One of the most common questions we get is "Which mode should I use?" If you wish to have more hemostasis during the incision, it is best to use continuous wave. The trade-off is that you will obtain more char on the edges of the wound. It is imperative that you remove the char prior to wound closure. The super pulse mode delivers a cleaner incision with less char and collateral trauma, but bleeding is more likely.

Our general recommendations when you are first getting started are to use a lower power setting, GO SLOW, and follow the safety rules of laser surgery. For most procedures you are going to perform, we recommend you start out on a 4-8 watt setting, continuous wave or superpulse, until you get the feeling of how the laser and the patient are going to react. Then you work your way up from there. Try experimenting with higher power settings, and the superpulse mode on a piece of wood before you use a patient. Aim for a cutting depth of 0.1 – 0.2 mm with minimal char and bleeding, this would define a safe laser incision.

By far, one of the most difficult procedures to master with a LASER is the feline onychectomy. Our recommendations are to: (1) review the anatomy (to include the pictures provided by **your sales person**), (2) review the procedure as described in various surgery books using the scalpel, and (3) attempting the procedure on a euthanized cat prior to trying it on a live cat. Never use a live patient for the first time when learning a new laser procedure. This procedure can be simplified by utilizing, in this author's opinion, a lateral approach to the amputation process.

It is important to remember that there are no "cookbook" settings for laser use in veterinary medicine. Rather, we can depend on consistency with manufacturing of laser equipment, but not consistency in use. To explain, the constant is power setting, delivery mode, and exposure. The variables are: distance of the laser from the skin, thickness of the skin (as well as other physiological properties such as percent water, melanin, and scar tissue), speed with which the veterinarian moves the laser across the skin, and at which angle. So, what you can do on 8 watts at super pulse will not look the same as what someone else may do. That all being said, an average incision on a medium dog is best performed on 8 watts, super pulse preferably, and about 5-6 watts on a cat. When you get comfortable with these numbers, try increasing the power.

To establish consistency in the end-result, I would recommend you trying this. Crack open a raw egg into a small bowl without disturbing the yolk. Practice inscribing your name onto the yolk without (a) breaking it open, and (b) causing as little char as possible on your incision edges. There are no right or wrong settings. The goal is to create the end-result, a laser incision without char or collateral trauma.

## LASER SAFETY

It is important that YOU, the veterinarian and operator of a biomedical laser, understand the following BASIC safety information concerning the use and application of your new LASER. Additional information on the safe use of lasers in veterinary medicine can be found in documents 136.1 & 136.3 from the American National Standards Institute (ANSI) or in the OSHA Directives Publication 8-1.7, online at [www.osha.gov](http://www.osha.gov). Remember that 10.6 micron laser radiation is in the infrared portion of the spectrum, and is therefore invisible to the human eye. Do not look directly into the laser beam or the aiming beam.

Lasers are divided into (4) classes:

*Class I* – not harmful with direct viewing, an example being a grocery store scanner.

*Class II* – the visible light spectrum; these are laser pointers. Although they are not considered harmful, direct and intentional staring will cause harm to the eye.

*Class III* – these lasers are harmful if directly viewed; these are the types found in laser light shows.

*Class IV* – any laser with a power greater than 0.5 watts over 0.25 seconds or those that exceed a fluence of 10 J/cm<sup>2</sup>. **Your new laser is a Class IV laser.**

Other important safety concerns to understand:

1. **LASER PLUME** – It is imperative that you utilize that smoke evacuator that was shipped with your laser. The veterinarian that installed and assisted in your training will have demonstrated this for you. Try to keep the evacuator within 2-3 cm of your operative site whenever possible. Lasers create more plume (smoke) than electrosurgical units do. There are some reports of isolating viable tumor cells from smoke evacuation tubes in human medicine, and this must include potential for bacteria and viruses. This would imply that important safety regulations must include wearing the 0.1 µm surgical masks provided by **your sales person**. Please review the attached summary of Respiratory Hazards and Plume Control. Mullarky et al, *Laryngoscope* 1985 Feb; 95(2):186-7, demonstrated negligible potential for spread of bacteria by the smoke plume. Nonetheless, the plume can be quite irritating to human inhalation, as well as your clients. Be aware of your ventilation system in your hospital, and be prepared to counter noxious fumes in your waiting room should the need arise. The National Institute of Occupational Safety and Health released a health-hazard alert on **dangers of the smoke plume**, a by-product of the thermal destruction of tissue during surgical procedures using a laser or electrosurgical unit. Research has confirmed that this smoke plume can contain toxic gases and vapors such as benzene hydrogen cyanide, dead and live cellular material, and viruses. With no smoke removal, particulate concentrations may increase from the baseline- typically near 60,000 particles per cubic foot to one million per cubic foot, about 5 minutes after electrocautery commences. This concentration level can be high throughout the entire operating room. All occupants of the room are subject to high particle concentration. There is little difference between smoke generated during laser procedures and smoke generated during electrosurgical use. The extremely fine particulates in the smoke plume from the laser or electrosurgical device can penetrate almost all types of surgical masks and lodge deep in the lungs, contributing to interstitial pneumonia and emphysema. With a good, affordable smoke evacuator now available, it is our responsibility to protect ourselves and operating-room personnel. This author now uses a smoke evacuator on all procedures involving electrosurgery or electrocautery. **A.D. Elkins, DVM, Dip ACVS - Veterinary Forum, January 1999**
2. **LASER-INDUCED COMBUSTION** – lasers can cause fires.
  - a. Avoid use of flammable alcohol-based solutions as a surgical prep. Lasing of iodine solutions will cause irritant fumes to be produced. Remember iodine is a halide, in the same group on the periodic table as chlorine. Final rinsing with sterile saline can combat both of these problems well.
  - b. Apply wet gauze material around the immediate surgical site to absorb scattered beam. I usually soak 2-3 gauzes with sterile saline.
  - c. Protect the patient's eyes with wet gauzes or corneal shields.
  - d. Do not aim the laser beam at PVC endotracheal tubes, particularly with 100% oxygen flowing through the tube. When operating in the mouth, surround the endotracheal tube with wet gauzes to absorb the laser energy.

- e. Intestinal gases with high methane content have the potential to become flammable in the presence of a laser beam. When performing anal sacculotomy, it is highly advisable to place a purse-string suture in the anal sphincter.
- f. Paper drapes and gowns may catch fire. At the very least, you will burn small holes into the paper.

### 3. OPERATOR/PATIENT BURNS

- a. The easiest way to prevent from getting burned, or worse yet, ocular injury, is to not point the beam at yourself, or any member of your surgical team. If you hit yourself with the laser, expect it to hurt! Erythema, and possible blistering will occur shortly afterwards. In more extreme exposures, such as high power settings or lengthy exposures, expect charring to occur. DO NOT point the laser at anyone's eye, including your patient. Although regular eyeglasses or safety glasses may afford adequate protection from laser damage, we recommend you **set the example** in your hospital by wearing laser-approved safety glasses.
- b. Place moistened gauzes over your patient's eyes. Remember when you are lasing an extremity the patient is usually on the other side, so avoid extraneous burns. Everyone in the operating room MUST wear safety goggles (provided) specific for the laser wavelength you are utilizing.
- c. Avoid pointing the laser at your surgical instruments as it will be reflected. Laser-safe instruments are available. You will find a laser safe instrument pack in your marketing kit. Additional laser safe instruments can be purchased from us. Always return your laser to STANDBY mode when not in use.
- d. Pay close attention to the surgical table. This is often neglected by beginning laser surgeons. Thermal blankets, whether water or electrical-cooled are susceptible to laser burns. The shiny surface of the table is capable of reflecting laser energy back at you, the patient, or someone else in the room.

### 4. ELECTRICAL SAFETY – the voltages necessary for the operation of your CO<sub>2</sub> laser are potentially hazardous to operating personnel when handled either in a careless or unknowledgeable manner. Only personnel with the knowledge of the electrical system of this device should attempt to make either inspection and/or repairs to this device. DO NOT OPEN the cabinet during the warranty period. If you detect abnormal smells or sounds coming from the laser, shut it down immediately and contact technical support. Do not attach an extension cord to your laser longer than 15 feet.

- ### 5. POST APPROPRIATE SIGNS – in accordance with the Federal Laser Product Performance Standard, all Class IV lasers must have posted outside the operating room a warning sign that states (your sales person has included this with your laser), this sign should be on the operating room door;
- a. Laser Radiation – Avoid Eye or Skin Exposure to Direct or Scatter Radiation
  - b. Statement of "Laser Surgery in Progress – Eye Protection Required"
  - c. Type of Laser or the emitted wavelength, pulse duration, and maximum output
  - d. The Class of Laser Being Used

### 6. MICELLANEOUS RECOMMENDATIONS

- a. Keep a small fire extinguisher in your operating room.
- b. Make sure technicians and assistants can hear you call for assistance during surgery.
- c. Keep a small bowl of sterile saline and gauzes readily available during surgical procedures.
- d. Place surgical instruments and laser in a manner that makes them both readily accessible during surgery. The following is recommended.
  - i. Left handed – surgery instruments on your immediate left, place the laser on the opposite side of the table, on your left.
  - ii. Right handed – surgery instruments on your immediate right, place the laser on the opposite side of the table, on your right.
- e. Shrouds are available from your sales person to provide sufficient sterility of the handpiece without having to remove it and resterilize it between procedures. Be careful not to allow the end of this shroud to slip past the end of the laser tip, as it may result in burning of the shroud.
- f. It is highly recommended that if you declaw cats using the guillotine-method, that you study the scalpel method, or ask your sales person for drawings of the laser method. Ideally, we would recommend you practice this technique several times on a cadaver before performing it on a live animal.

We have attached a summary of Power Density and our training agenda. Please review all material herein prior to your scheduled training.

**Power Density** is a function of both laser power and spot size and is approximated by the simple formula: watts/cm<sup>2</sup>. **When using the carbon dioxide laser, char-free ablation with minimal tissue damage is usually accomplished at a power density of 5,000 watts per centimeter squared or greater.** When a pulsed laser is used, the same tissue effect may be accomplished at a far lower average power density.

Optimum power densities are located at the focal point of the laser.

<u>Power (watts)</u>	<u>0.2mm spot size</u>	<u>0.4mm spot size</u>	<u>0.8 mm spot size</u>
1	2,500	625	156
2	<b>5,000</b>	1,250	313
3	7,500	1,875	469
4	10,000	2,500	625
5	12,500	3,125	781
6	15,000	3,750	938
7	17,500	4,375	1,094
8	20,000	5,000	1,250
9	22,500	5,625	1,406
10	25,000	6,250	1,563
11	27,500	6,875	1,719
12	30,000	7,500	1,875
13	32,500	8,125	2,031
14	35,000	8,750	2,188
15	37,500	9,375	2,344
16	40,000	10,000	2,500
17	42,500	10,625	2,656
18	45,000	11,250	2,813
19	47,500	11,875	2,969
20	50,000	12,500	3,125
21	52,500	13,125	3,281
22	55,000	13,750	3,438
23	57,500	14,375	3,594
24	60,000	15,000	3,750
25	62,500	15,625	3,906
26	65,000	16,250	4,063
27	67,500	16,875	4,219
28	70,000	17,500	4,375
29	72,500	18,125	4,531
30	75,000	18,750	4,688

**Superficial Contraction/Coagulation occurs at 5-300 watts/cm<sup>2</sup>**

**Tissue Vaporization occurs at 300-1,200 watts/ cm<sup>2</sup>**

**Incisional Vaporization occurs at 1,200-15,000 watts/cm<sup>2</sup>**

For those who own lasers with fixed beam sizes, changing the size of the beam is a function of increasing the distance from the intended surgical site. This is referred to as "**defocusing the beam**". As the beam is defocused, power density will decrease as you pass the focal point of the laser beam.

## Marketing Laser Surgery

Everyone has their own idea of how to market something to their clients in their practice. Below is simply a list of ideas that some of us may forget from time to time.

- Telephone: on-hold messages, after hours messages
- Invoices: printout at the bottom a small statement about lasers
- Reminder cards
- Call your local newspaper
- Posters in the office, to include pictures from **Star Wars** movies
- Pamphlets about the clinic
- Website – free website is available from [www.vetcentric.net](http://www.vetcentric.net)
- Logos on surgical scrub tops, lab coats
- Buttons with Logos such as “Less pain, quicker recovery from surgery? Ask me how.”
- New puppy/kitten packets
- Vinyl posters on the front of the building
- ½ page ads in local newspapers
- Preoperative check off sheets
- Yellow page ads
- Business cards
- Newsletters to other vets or clients about the laser
- #1 by far is **client education** --- **this includes** technicians, receptionists, and anyone involved with direct client contact.
- It is also important to market your laser to your staff. If they don't believe in it, they won't recommend it to clients. Show your successes to your staff. Videotape declaws postoperative.

Everyone asks “How do I charge for the laser?” The amount, of course is certainly going to be area-specific. For example, what I get in Seattle may be considered too high in South Dakota. A typical “laser use fee” starts around 1-1.5 times your exam fee. With proper client education, the cost will be irrelevant to most of your “A” clients. Other ideas include:

- Add \$1.00 to your exam fee, then...
- Add \$15 to every elective procedure, and use the laser --- mandatory, no questions asked
  - This will turn away some clients
- Offer it as a choice to clients, at an additional 1-1.5 times exam fee
  - Some DVMs start out around \$15 and work their way up until people stop selecting laser as an “add-on”; others find it offensive that if it is so good, why make a choice?
  - As an optional add on, the fee should be in the \$35-60 range, depending on the procedure
- Establish multiple levels of laser use --- I, II, III, IV and so on – charging more as the level goes up. Most people establish the levels in increments of 5-10-15 minutes laser use. Still others use the level to designate degree of difficulty of the procedure.
- YOU decide which cases the laser is useful for then charge appropriately. Do not ask the client if they want the laser used or not.