Clinical use of a 15 watt diode laser in small animal surgery: Results in 30 varied procedures

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ABSTRACT

The use of a 15-watt diode laser in 30 surgical procedures in dogs and cats was reviewed. Ease of use, operator safety, hemostasis control, wound healing, surgical time, complication rate, and pain control were observed and recorded. Procedures performed were partial pancreatectomy, nasal carcinoma ablation, medial meniscus channeling, perianal and anorectal mass removal (5), hemangioma and hemangiopericytoma removal from two legs, benign skin mass removal (7), liver lobectomy, partial prostatectomy, soft palate resection, partial arytenoidectomy, partial ablation of a thyroid carcinoma, photovaporization of the tumor bed following malignant tumor resection (4), neurosheath tumor removal from the tongue, tail sebaceous cyst resection, malignant mammary tumor and mast cell tumor removal. The laser was found to be very simple and safe to use. Hemostasis was excellent in all but the liver and prostate surgeries. The laser was particularly effective in preventing hemorrhage during perianal, anal, and tongue mass removal. It is estimated that a time and blood loss savings of 50% over that of conventional surgery occurred with the use of the laser. All external wounds made by laser appeared to heal faster and with less inflammation than those made with a conventional or electrosurgical scalpel.

Keywords: Diode laser, surgical procedures, dogs, cats, veterinary surgery, hemostasis, wound healing

1. INTRODUCTION

1.1. Background

The surgical application of laser light has advanced rapidly within the last 10 years. Laser systems that use wavelengths ranging from 800-1100 nanometers (nm) are used to denature pathological tissue by local thermal effects. The aim is to destroy pathologic cells without causing damage to surrounding healthy tissue. Another surgical application of laser light is to divide tissues by causing very precise depths and widths of photovaporization. The near infrared wavelength laser generators, up until recently, were primarily represented by the neodymium:yttrium aluminum garnet (Nd:YAG) laser, which generates a wavelength of 1064 nm. However laser application now includes a new generation of near infrared wavelength surgical laser. This is the fiber-coupled diode laser that generates a slightly shorter wavelength (980 nm) using a gallium aluminum arsenide (GaAlAs) semiconductor medium. Despite the availability of this type of laser, reports of clinical application in veterinary medicine have been lacking.

1.2. Purpose

The purpose of this study was to retrospectively investigate the clinical results of the use of the newly developed 15-watt fiber-coupled gallium aluminum arsenide (GaAlAs) semiconductor diode laser for various surgical applications.

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2. MATERIALS AND METHODS

2.1. Characteristics of the study

The study was a retrospective non-blinded preliminary study performed by four investigators in a clinical setting involving two veterinary practices.

2.2. Patient selection

Clinical patients for the study were dogs and cats that underwent laser surgery at either Carson-Tahoe Veterinary Hospital, Carson City, NV, or Georgia Veterinary Specialists, Alpharetta, GA. The diode laser was used based on previously published set of clinical indications. The list of clinical indications used is published in Table 1.

Table 1 Clinical indications used of the selection of diode laser to be used in the surgical procedure

Ablation of a mass and hemostasis in the genitourinary tract
Ablation of a mass and coagulation in the pulmonary airway
Ablation of a mass and hemostasis in the gastrointestinal tract
Excision, vaporization and coagulation of tissues intra-abdominally
Incision, excision, vaporization and coagulation tissues in oculoplastics
Intraocular tissue coagulation (cyclophotocoagulation)
Incision and excision of soft tissues in general and plastic surgery
Incision and excision of soft tissues in orthopedics, ears, nose, throat (ENT), and head and neck surgery
Hemostasis in neurosurgery
Incision and excision of soft tissues in cardio-vascular and thoracic surgery
Incision and excision of soft tissues in gynecology, obstetrics, and theriogenology
Photocoagulation and photovaporization of lesions of the skin and subcutaneous tissues

The list for Table 1was compiled from publications provided by CeramOptec, Inc. for use in veterinary medicine and by Surgical Laser Technologies, Inc. for use in human medicine. In the later a list published by the Federal Drug Administration (FDA) concerning clearance for use of a contact laser system in humans was found.[1,2] Table 1 is similar to this FDA clearance list. The owner of the animal had granted permission for use of the laser.

2.3. Characteristics of the laser system used

The laser that was tested clinically was a diode laser. It had the following characteristics: laser type = near infrared laser light generated with diodes fabricated from gallium aluminum arsenide (GaAlAs) semiconductor material; wavelength generated = 980 +-30; output power = 15 watts; power range = 1-15 watts; power increments that can be selected = 1 watt; fiber connector = SMA -905; operating mode = continuous and pulsed; pulse duration = ON 0.1 to 99.9 sec.; pulse duration OFF = 0.1 to 99.9 sec.; aiming beam = visible laser diode, wavelength generated with aiming beam = 635 nm with 3-4 mW power; laser medium cooling system = air cooled; laser unit dimensions = 16 cm high, 22 cm wide, 34 cm long; weight = 9 kg; power requirements = 300 watts; aiming mechanism = fiberoptic; connecting fibers = silica quartz contact and non-contact fibers with diameters of 400 and 600 um; safety standards = complies with federal drug administration and certifying federal regulations as a class IV laser. [3]

2.4. Data collected and analyzed

Data as indicated in Table 2 was recorded from the patient's medical records. Subjective and objective conclusions were made from this data. Comparisons were made, when possible, between results obtained from similar surgical procedures done without the aid of the diode laser with incisions accomplished with

scalpel blade or electrosurgery, and hemostasis accomplished with ligature or monpolar or bipolar electrocoagulation. Due to the small number of procedures performed and evaluated no statistical analysis of the data was accomplished.

Table 2 Data collected with each patient in which the 15 watt-diode laser was used

Signalment: species, breed, age, and sex
Operative indication use of the laser: incision, excision, hemostasis, and vaporization of cells, other
Procedure performed
Ease of use of the laser
Complications occurring
Pain control required postoperatively
Operator safety and level of difficulty in complying with safety regulations
Hemostasis control (excellent, good, fair, poor)
Wound healing characteristics of the external wounds
Estimated amount of blood saved compared to use of electrosurgery
Amount of surgical time the procedure took
Estimated time saved (if any) compared to other comparable surgeries where the laser was not used
Tumor or infection type and recurrence time for infection or tumor that had the tissue bed photovaporated

3. RESULTS

3.1. Overview (number and characteristics of procedures performed)

The diode laser was used in 30 procedures performed on 20 canine and 2 feline patients from the two hospitals (Carson-Tahoe Veterinary Hospital, Carson City, NV and Georgia Veterinary Specialists, Alpharetta, GA). Procedures in which the laser was used are summarized in Table 3

Table 3 Thirty surgical procedures in which the diode laser was used (categorized according to area)

Ablation and hemostasis in the genitourinary tract
- partial prostatectomy for prostatitis and adenocarcinoma in an 8 yo MC Mixed breed dog

Ablation and photocoagulation in the pulmonary airway
- partial arytenoidectomy for partial laryngeal collapse in a 10 yo FS Springer Spaniel Mixed dog
- soft palate resection for en elongated soft palate in a 10 yo FS Springer Spaniel Mixed dog

Ablation and hemostasis in the gastrointestinal tract
- anorectal mass removal in a 6 yo M Labrador Retriever
- surgical ablation of a very aggressive anaplastic rectal carcinoma in a 13 yo MC Labrador
- rectal mass resection and photovaporazation in a 10 yo MC Mixed Breed – Doberman
- partial pancreatectomy for an islet cell adenocarcinoma in a 10 yo MC Golden Retriever
- anorectal carcinoma removal in an older aged MC Collie
- rectal mass – tag removal (not biopsied) in a14 yo Mixed breed dog

Excision, photovaporization and photocoagulation in the intra-abdominal areas
- liver lobectomy for mass resection in a 12 yo MC Mixed breed dog

Incision, excision, vaporization and coagulation in oculoplastics
- removal of a 2 mm tumor mass from the right upper eyelid of a 12 yo MC Mixed breed dog

Intraocular tissue coagulation (cyclophotocoagulation)
- No procedures in this category

Incision and excision of soft tissues in general and plastic surgery
- tumor resection from left perineal region (perianal gland adenoma, 3 tumors) 6 yo M Labrador
- multiple mass resections (4) from the skin in a 12 yo FS Scottish Terrier
- mammary gland resection for tumor removal in a 12 yo FS toy poodle dog

(table 3 continued on next page)

Table 3 continued

Incision, excision, photovaporization of soft tissues in orthopedics, ENT, and head and neck surgery
- medial meniscus resection with channeling of the remaining portion in a 5 yo M Husky
- partial ablation of a malignant thyroid tumor in a 10 yo FS Spaniel Mixed breed dog
- Excision of a neurofibroma involving the surface and body of the tongue in a 12 yo FS poodle
- excision of a mass cell suspected tumor from the pina of the ear of a 6 yo MC Mixed breed dog
- ablation and photovaporization of the residual bed of a nasal carcinoma in a 9 yo MC Boxer
- photovaporization of remaining turbinate tissue on severe infection in a 10 yo MC DMH cat

Hemostasis in neurosurgery
- no procedures in this category

Incision and excision of soft tissues in cardio-vascular and thoracic surgery
- small vessel ablation of surrounding tissues in the neck in a 10 yo FS Spaniel Mixed breed dog

Incision and excision of soft tissues in gynecology, obstetrics, and theriogenology
- No procedures in this category

Photovaporization and coagulation of lesions of the skin and subcutaneous tissues
- photovaporization of five1-2 mm diameter skin tumors in a 12 yo FS poodle
- photovaporization after sebaceous gland adenocarcinoma removal in a 10 yo FS German Shepherd
- photovaporization of a surgical bed where a mast cell had been removed in a 12 yo MC DSH cat
- tumor excision (hemangioma) of the right front leg in a 12 yo FS Pointer
- tumor resection (hemangiopericytoma) of the left rear leg in a 6 yo M Labrador Retriever
- tumor excision (mast cell tumor) from a 5 yo F Spaniel Mixed breed dog
- tumor resection (benign sebaceous cyst adenoma) in a 8 yo MC Mixed breed dog
- tumor ablations of two skin tumors believed to be malignant in a 4 yo MC Mixed breed dog

All laser application was performed using the contact fiber which had either a conical, round, or knife-like tip. Selection of the type of tip or probe to use was based on previous experience by the first author with use of sapphire contact probes and a 60-watt Nd:YAG laser and by information published on the difference between contact and noncontact laser use.[2,4,5]

3.2. Ease of diode laser use

The diode laser was found to be easy to use in all cases. Instructions for use were easy to follow. Setting up the laser took approximately 10 minutes. Because of the laser's small size it could be moved easily. It only required regular 120-volts AC household current. Therefore there was no difficulty in providing electrical power to the laser. Often both the diode laser and an electrosurgery unit were both set up and used in the same area of the operating room. The optical fibers (400 and 600um diameter, with the various types of tips) could be cleaned; the tips striped with a stripping instrument (Micro-Strip) supplied by CeramOptec, Inc., The quartz fibers could then be coiled and packaged and resterilized with either ethylene oxide or by autoclaving. Sterilization indicators were placed within each package to ensure sterility. The hand piece was easy to resterilize by either ethylene oxide or by autoclaving.

3.3. Operating room personnel safety

Other than the strict use of the protective eyewear required there was no difference observed in the use of the diode laser and that of a popular electrosurgical unit (ValleyLabs). One small ignition and flaming of a paper surgical drape occurred early in the course of the investigation when the tip of the quartz fiber was held close to a margin that contained the edge of a drape. The small flame was extinguished by covering the area with a cloth drape. At no time was alcohol used as the final prep fluid. When the laser was used near an endotracheal tube the endotracheal tube was wrapped with aluminum foil to prevent ignition of the near 100% oxygen gas column inside the tube. At the beginning of each laser use a Laser Safety Officer was appointed to ensure that all safety guidelines were followed. Operating room suction guided by the surgical assistant was used to evacuate the plume generated from the laser. No accidental burns to patients or operating room personnel occurred. No other complications associated with safety issues occurred.

3.4. Surgical hemostasis and estimation of blood loss savings

Hemostasis was excellent in all but the liver and prostate surgeries. In the liver and prostate surgeries the use of an electrosurgery unit, ligatures and stick-ties were necessary to control the hemorrhage. A continuous closure suture was also needed to stop hemorrhage created in the soft palate when resection of its elongated section was performed. The laser was particularly effective in preventing hemorrhage during perianal, anal, and tongue mass removal. Sutures were used to close these structures and during passage of these sutures hemorrhage occurred indicating good viability despite the presence of a dry field prior to closure. It is estimated that with the use of the laser a blood loss savings of 50% occurred over that which would have otherwise occurred with conventional surgery. Blood loss savings were particularly appreciated with use of the laser with skin mass removal when involving the vascular areas of the face, perineum, or eyelid. Mass removal could be done in an almost bloodless field. Vascular skin tumors such as hemangiosarcomas and hemangiomas were able to be removed without the loss of over 2-5 ml of blood. This is compared to an average estimated loss of 25 to 50 ml with scalpel and/or electrosurgery use.

3.5. Photovaporization technique observations

The tip of the coated fiber was used "paint" the bed of tissues believed to possibly be contaminated with tumor cells or bacteria. Depth was difficult to determine in deep structures such as the surface of the nasal passages. A slight charring appearance resulted after the probe passed over the surface of the tissue being treated. The laser beam struck the surface of the tissues and penetrated less than ¼ -1/2 mm and the rising plume of light smoke was aspirated with the suction tip. Recurrence of infection and tumor occurred in two patients that had photovaporization treatment. The first was a dog with a nasal adenocarcinoma that began having recurrence of nasal hemorrhage 3 weeks after the laser surgery. The second was a cat that had a recurrence of nasal discharge four weeks following photovaporization of the nasal passages. This was done for chronic bacterial rhinitis. In the other seven patients where photovaporization was performed all have been disease free, with no known recurrences of masses that were present before treatment.

3.6. Surgical time

Use of the laser enhanced visibility significantly when removing vascular skin tumors. This allowed removal to be accomplished with more control and in much shorter time periods. Timesavings were compared to the removal of similar skin masses when several were present. Electrosurgery was slightly faster compared to the laser. However compared to the use of a scalpel blade for resection the use of the laser provided a timesaving of approximately 10 –15 minutes per lesion. Surgical time was longer in surgeries involving the liver, pancreas, and prostate in these patients.

3.7. Intraoperative surgical complications

No intraoperative complications other than the surgical drap fire occurred that were not anticipated. When the laser was used to divide liver and prostatic tissue, brisk hemorrhage occurred when larger than 1-2 mm diameter vessels were opened by the advancing laser. This hemorrhage required standard operative techniques to arrest it.

3.8. Postoperative pain control and external wound healing observations

It was the investigators' impression that less pain was observed postoperatively in 8 of the 9 patients that had external wounds created by the use of the laser for removal of either malignant or benign masses or cysts. Wounds on the eyelid, limbs, and perineum associated with laser application subjectively seemed to be less irritative or uncomfortable to the patients compared to those in similar locations made by a scalpel or electrosurgery unit. There also appeared to be less swelling with external wounds caused by the laser as opposed to wounds created by electrosurgery. All wounds healed without incident. Sutures were left in place from 14 to 21 days without complications other than occasional difficulty locating them for removal.

4. DISCUSSION

4.1. General impressions made of the use of the diode laser

The most outstanding feature noted in this study was that the use of the diode laser in these thirty procedures appeared to provide better visibility during the operation, particularly when used for the removal of tumors in areas where there is a rich capillary blood supply. These areas included the skin of the head, nose, perineum, eyelid, rectum, and lower limbs especially around the footpads. With the laser used as the cutting instrument as opposed to a scalpel blade there was no hemorrhage at all in many cases. Overall it was estimated that blood loss was also estimated to be 50 % less with the use of the laser. Compared to the use of electrosurgery for dividing tissues it was observed that wounds made with the laser were associated with less edema, redness, and pain. It was also a general impression that the use of the laser for the removal of vascular tumors or tumors found in vascular areas in this study also decreased surgical time by approximately 50 %. This is thought to be due to the enhanced hemostasis and consequently excellent visibility that was maintained during the operations.

Reports suggest that the diode laser used provides coagulation effects similar to the Nd:YAG lasers.[6] Both use quartz fibers for guiding the generated laser light to the region of surgical interest. They both can be used in a contact and non-contact mode. Non-contact applications are performed with bare fibers to coagulate superficial lesions with moderate power densities or to cut tissue with high power densities. A gap between tissue and fiber allows good visibility of the region of interest. Moreover, by varying the gap distance different power densities are reached without changing the laser power settings. It is also possible Both diode and Nd:YAG laser light can be guided through fiberoptic quartz bundles and used endoscopically in body cavities and direct the laser beams onto the surface of organs. The contact mode, which was used throughout this investigation, was used to cut tissues and to coagulate tissue volumes superficially as well as interstially. The diode laser, generating 980 nm near infrared light at the tip, always coagulates a larger volume of tissue as compared to the Nd:YAG laser under identical conditions and power settings. Higher device temperatures are reached as well. Therefore if one is already familiar with the use of the Nd:YAG laser, the diode laser will be very easy to master as the two can be used almost interchangeably. The power settings of the diode laser need to be decreased ½ to 1/3 of that used by the Nd:YAG laser[6].

4.2. Ease of use of the diode laser compared to electrosurgery units and other surgical laser units

The diode laser used was small and portable compared to other laser systems the principle author has used (Nd:YAG). It came in its own carrying case and was transported easily between the practice in Nevada and that in Georgia. The only transport related complication occurred when the key needed to activate the system was left behind. A locksmith was able to activate the system by "lock picking" and when the laser was returned to the practice where the key was it was able to be used again. Because the diode laser only requires 300 watts and is internally cooled by fans and not flowing water as other systems operate, no special wiring or plumbing was needed to get the system operational. The diode laser electric power requirements were the same as electrosurgical units (120 volts AC current). The laser could be place on a small stand. A foot pedal and cord and the silica quartz fiber were all that were needed to attach before the unit was operational.

From removing the laser system out of its carrying case to being able to discharge the laser beam, only 10 minutes of set up time was required. This included the placing of a laser caution sign on the door of the operating room, donning the protective glasses, and attaching the suction tubing to the suction unit. Overall, the diode laser was as easy to use as any electrosurgical unit. This included activation with the foot pedal, aiming the laser beam with the hand piece, controlling the power from 1 to 15 watts, changing the mode of laser delivery from continuous to pulsed or vice versa, and varying the duration of the pulse. All that was required was changing the dial or pressing a designated button according to a computer menu illuminated on the laser systems screen. The only difficulty encountered was visualizing the auburn-lighted menu on the screen when in bright light or when trying to view the screen from a sharp angle.

4.3. Safety considerations with the diode laser as compared to other surgical laser units

Similar to other medical lasers, use of the diode laser in this study required the use of protective eyewear. The protective glasses are specific for laser radiation in the wavelength range from 950-1010 nm with an optical density of 5. The near infrared light generated by the diode laser, passes through the transparent components of the eye and focuses on the retina where it can cause a retinal burn. This precaution is similar as for other lasers used medically [Neodymium:yttrium aluminum garnet (Nd:YAG), potassium triphosphate (KTP), Argon, carbon dioxide (CO_2)]. However, as opposed to these other lasers the nominal ocular hazard distance (NOHD) is 2 meters from the distal end of the fiber. The others are much longer. Penetration of the laser beam is much more controllable with the diode laser as compared to Nd: YAG (5 mm). However, as compared to the argon, KTP, or CO2 laser the diode laser penetrates tissue much deeper; 2mm verses 1 mm and 0.2 mm respectively. There is also much more of a thermal effect with CO2 generated laser light, as compared to the diode generated laser light. Light of this wavelength is strongly absorbed by water with minimum scattering. Since most tissues are more than 80% water, virtually all CO2 laser energy is absorbed within the first 0.2mm of depth. With the diode laser light, tissue absorption is optimal at 980 nm, as compared with that of the Nd: YAG generated laser light (wavelength of 1064 nm).

4.4. Photovaporization with the diode laser; effectiveness in the irradication of neoplasia, infection

According to the manufacturer of the diode laser used the system offers the desired tissue penetration with no background tissue damage. Effects are similar regardless of the tissue type and homogenous lesions are reliably obtained. No treatment protocol adjustments are required. Neoplastic tissue can be more readily vaporized at low power settings than healthy normal tissues. Excision using the laser divides soft tissues sharply with little or no bleeding in most cases. Both of these abilities were observed with the diode laser in this study. Both photovaporization and photosectioning were used effectively in the irradication of various benign and malignant tumor masses. However, recurrence was suspected based on reappearance of clinical signs in the patient with an aggressive nasal adenocarcinoma. In the one patient with deep seated infection in the nasal passage clinical signs also returned. It is difficult to determine if these clinical failures were because of inability of the laser beam to kill the organisms involved following its direct application, or if recurrence occurred because the beam could not be applied effectively in all the recessed areas of the nose. The latter was suspected to be the principle reason for failure. Further clinical investigations will be necessary to determine irradication effectiveness. From this preliminary study, it appears that the use of the laser is effective in helping in the prevention of tumor or infection recurrence, especially in tissues where there are not many recesses where tumor or infective cells could escape direct laser beam application.

5. CONCLUSIONS

The diode laser used in this preliminary clinical investigation was very easy to transport, set up, and use in two veterinary hospitals that were over 2500 miles apart. The diode laser unit used (CeramOptec, 15 watt) in thirty varied surgical procedures in dogs and cats was found to be very effective in preventing capillary hemorrhage and allowing the surgical field to stay dry and easily visualized. This allowed for shortened operating times, decreased blood losses, and consistently more precise tissue dissection, particularly in very vascular areas or when dealing with very vascular masses. Use of the laser to remove lesions involving the skin of the face, tongue, head, perineum, and rectal regions was found to be very effective compared to incision/excision made by scalpel blade or electrosurgery unit. Hemostasis was excellent in all regions except in the liver and prostate surgeries. It is estimated that a time and blood loss savings of 50% over that of conventional surgery occurred with the use of the laser. All external wounds made by laser appeared to heal faster and were subjectively noted to be associated with less pain, edema, and inflammation than those made with a conventional scalpel blade or an electrosurgical unit. Although further clinical studies need to be performed, it is concluded from this investigation that the 15-watt diode laser (CeramOptec) is very

effective and useful in the practice of veterinary surgery. The 15-watt diode laser with fiberoptic contact tips should be recognized as an important addition to the armamentarium of the veterinary surgeon.

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