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A New Method for Hemorrhoid Surgery: Experimental Model of Diode Laser Application in Monkeys

HÉLIO PLAPLER, M.D.

ABSTRACT

Objective: **Detailed here is an experimental model in monkeys of a new approach to treat hemorrhoids using a diode laser.** ***Background Data:*** **Hemorrhoids are a common source of pain and suffering. Endovascular laser therapy for variceal veins is a method that potentially could be used in the treatment of hemorrhoids. There is currently no such method described in the literature.** ***Materials and Methods:*** **Hemorrhoids were induced in monkeys by ligation of the inferior hemorrhoidal vein, similar to their cause in humans. After the piles were identified, laser fibers were introduced into them, and they were irradiated with laser energy (810 nm at 1–2 W in 1-sec pulses of 1–2 J each, for a total fluency of 4–10 J).** ***Results:*** **The piles were completely reduced, and histological examination performed 10 d post-surgery showed reduction of the dilated vessels and complete healing. The laser energy was not delivered directly into the veins, but instead to the surrounding submucosal interstitial tissue, effectively reducing the hemorrhoids.** ***Conclusion:*** **The diode laser energy delivered into the hemorrhoids led to their complete resolution. Further clinical trials using this protocol must be carried out to determine its applicability to human hemorrhoids.**

INTRODUCTION

At least once in their lives, more than 80% of the world's population suffers from hemorrhoidal disease due to the gradual congestion and hypertrophy of anal veins. Straining promotes the congestion of these veins, which ceases soon after defecation. As a consequence of constipation, straining makes the veins bulge from the anus, aggravating and accelerating the development of hemorrhoids. Hemorrhoids also affect pregnant women and weightlifters due to their increased intra-abdominal pressure. Heredity also plays an important role, and they are commonly seen in several individuals in the same family.[1,2]

Many cures have been developed for hemorrhoids, including fibrosis precipitated via ischemic necrosis (rubber band ligature),[3,4] application of intense cold (cryosurgery)[3,5] and local heat (photocoagulation),[1, 6–9] as well as by circular suturing.[10,11] Selection of the type of treatment depends on the severity of disease.[12]

Many theories have been postulated about how lasers act to change biological tissues. With regard to hemorrhoids, use of laser energy remains controversial despite recent improvements in technology.[13]

The use of the laser in proctology began in the 1960s, when the Nd:YAG laser was first used for anorectal surgery. The results of these first experiments were disappointing. In the 1980s there was considerable evolution in laser technology, including development of the CO_2 laser and the pulsed laser, which resulted in improvement in outcomes. Chia et al.,[14] using the CO_2 laser, described a reduced need for analgesia and less intense pain after laser surgery compared to that seen after conventional surgery.

In 1993 Senagore et al.,[15] in a randomized prospective study comparing the use of Nd-YAG laser with cold scalpel surgery, demonstrated better results for the laser surgery, and after analyzing 81 patients concluded that those operated by laser had shorter hospital stays and had less pain post-surgery, and that complications such as dehiscence often occurred after cold blade surgery.

Plapler et al.[16] studied healing in 350 patients 1 y post-CO_2 laser hemorrhoidectomy. They concluded that results after laser surgery were better than those after conventional surgery, including less postoperative pain and a more aesthetic scar.

Department of Surgery, Universidade Federal de São Paulo (UNIFESP), São Paulo, Brazil.

In 2000 Zahir et al.[17] performed a retrospective study comparing a total of 50 patients, half of whom had laser surgery, and half of whom had conventional hemorrhoidectomy, and concluded that those receiving the laser treatment had less postoperative pain and reduced hospital expense, as the patients treated with lasers were discharged sooner.

In recent years surgeons have developed a new technique to treat variceal veins of the inferior limbs with a diode laser.[18] This endovascular technique allows the treatment of the enlarged veins with no need for several skin incisions, since it can be performed as ambulatory surgery.

Plapler et al.[19] studied the effect of the diode laser (810 nm wavelength) on interstitial tissue of the anal region of rats and showed that the diode laser leads to minimal alteration, as long as one keeps in mind rules governing laser-tissue interactions.

This study details an investigation of endovascular hemorrhoidectomy using a diode laser, to determine its feasibility for this indication, and to ascertain if improvements in follow-up are seen. Since there is no exposure of the muscular layer or nerves to laser energy, one might expect a considerable reduction in postoperative pain with better patient outcome. The objective is to determine the effectiveness of diode laser energy in treating hemorrhoids in an experimental model in monkeys.

MATERIALS AND METHODS

This project was approved by the Ethics in Research Committee at UNIFESP/HSP, CEP protocol number 0615102, and the license to capture, collect, transport, and perform experiments on the animals was granted by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA), under process number 02027.007959/98-53.

Study sample

Ten male nail monkeys (*Cebus apella*), average age 12 y, weighing between 3.5 and 4.5 kg, procured from the Centro de Reabilitação Animal do Parque Ecológico do Tietê–DAEE were sent to the veterinary hospital of Bandeirante University of São Paulo (UNIBAN), where they were kept in individual cages with appropriate food and water. They were kept under these conditions for 5 d so they could adapt to the new environment and adjust their circadian rhythm.

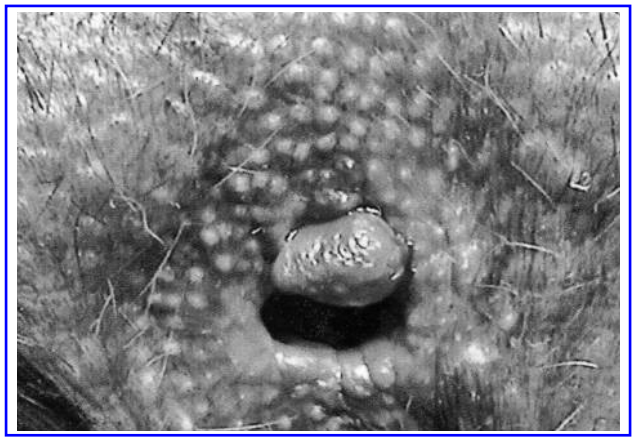

FIG. 1. Hemorrhoid 10 d after inferior hemorrhoidal vein ligation.

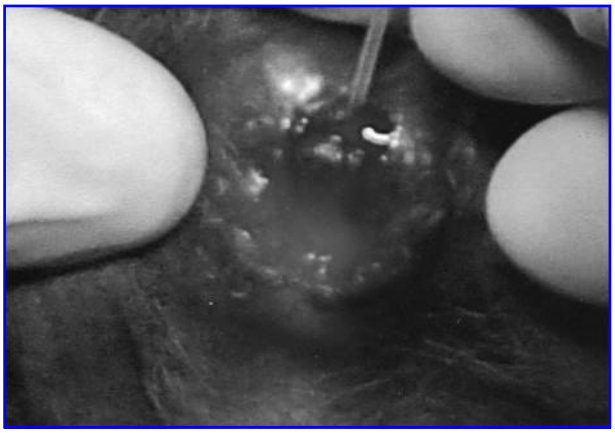

FIG. 2. Image of the laser fiber inserted into the hemorrhoid.

Anesthetic protocol

The animals were anesthetized with an intramuscular injection of ketamine chloride 15 mg/kg, midazolam 0.5 mg/kg, and atropine sulfate 0.02 mg/kg; venous access via the cephalic vein was provided for fluid infusion (10 mL/kg/h). Anesthesia was maintained with isofluorane in oxygen (1.5 L/min) given via a 3.5F tracheal tube.

Experimental protocol

The experimental model used to induce hemorrhoids has been previously described.[20] Under general anesthesia, we performed a perineal incision in the edge of the external sphincter of the anus on the right side, and isolated and tied the inferior hemorrhoidal vein with absorbable 3-0 Vicryl®. The incision was closed by continuous suture with absorbable 4-0 catgut.

The animals were examined daily to assess their hemorrhoids, which were seen on about the tenth postoperative day.

Once the piles were identified (Fig. 1), the animals were anesthetized and placed on the operating table. The hemorrhoid was then punctured and the diode laser (Diamond Lasers, London, UK) delivered energy through an optic fiber (Fig. 2) of 600 μm, emitting a wavelength of 810 nm at 1–2 W in 1-sec pulses, pulling the fiber gradually outward until the pile was sealed. The total amount of energy delivered was 4–10 J. These parameters were determined experimentally because they were found to seal the vein, but caused no visible thermal damage to the surrounding tissue.

The animals were observed daily and 9 d after the laser therapy we collected a sample of tissue from the treated region for histological analysis, and mucosa obtained from the left side was used as a control. Ten days after the laser procedure the animals were fully active and in good health.

RESULTS

Three out of ten animals (30%) developed clear external hemorrhoidals. Diode laser energy delivered into the hemorrhoids resulted in immediate retraction of the tissue in all animals.

On postoperative follow-up the hemorrhoids were macroscopically visibly completely reduced (Fig. 3) in all three animals. Both behavior and appetite were normal, and there were no visible scars. There was also no diarrhea or straining.

Microscopy of the control tissues (tissue taken from the left side of the anal canal) showed that the mucosa of the large intestine is coated by a simple cylindrical epithelium rich in absorptive and caliciform cells. The lamina propria has connective tissue and many intestinal glands made up mostly of caliciform cells. The anal canal is coated with cylindrical stratified epithelium with no keratin. The lamina propria also has many sanguineous cells.

In the experimental tissues (taken from the right side of the anal canal) the colon showed the same morphology as that seen in the control group; however, there was intense lymphocytic infiltration into the lamina propria. The anal canal was coated with a nonkeratinized stratified epithelium, with lamina propria rich in cells with lymphocytic infiltration. In general, there were fewer blood vessels in the anal canal of the hemorrhoidal tissues than in control tissues.

DISCUSSION

Since Milligan et al. described their open surgical technique[21] there have been discussions about which is the best method to treat hemorrhoids, and there is still no consensus today. Treatments include rubber band ligation and stapling, as well as the use of laser therapy, liquid nitrogen, infrared light, and ultrasonic surgery. All aim to decrease pain in the postoperative period and to improve healing.

The endovascular technique used to treat variceal veins[22] was a new concept in vascular surgery. This technique may be used on all veins, it and opened up new possibilities for treating lesions such as port-wine hemangiomas and hemorrhoids.

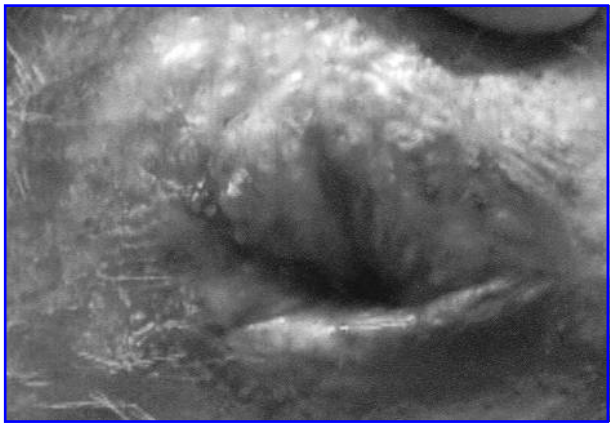

FIG. 3. Final appearance 10 d post-treatment.

Using this technique, Navarro et al.[18] found that 100% of variceal veins were sealed in 33 patients on 1-y follow-up after surgery with a diode laser. In a prospective study of 84 patients undergoing laser surgery using an endovascular diode laser, Min et al.[23] achieved 97% sealing of the greater saphenous vein in the first week, and 99% in the second week, with 9-mo of follow-up.

Human experimentation raises ethical concerns. For this reason it was necessary to create an animal experimental model that allows the production of hemorrhoids in order to study their treatment. We could not find any anatomical description of the perineal region of monkeys. In a previous unpublished study Plapler compared the monkey's perineal region to that of the human and discovered similarities between them with regard to perineal venous drainage.

In light of these similarities and because monkeys stand erect as do humans, the monkey seemed like a good experimental candidate in which to study hemorrhoids. Ligation of the inferior hemorrhoidal vein leads to decreased venous drainage and causes hemorrhoids to form. However, other mechanisms are at work in the formation of hemorrhoids, and merely interrupting venous drainage does not explain how hemorrhoids form, as is demonstrated by the fact that only 30% of the animals developed hemorrhoids. However, even this low percentage allowed us to study hemorrhoids. Concomitant ligation of both the right and left inferior hemorrhoidal veins could be done, but it would be unnecessary and could cause the animals great suffering. In a previous pilot study we ligated right or left veins with no difference in the results. In this study we only ligated the right vein.

There are no reports on endovascular application of a laser to treat hemorrhoids. In fact, the tortuous dilated veins that form hemorrhoids do not allow laser energy to be delivered directly into the vessels; instead it is delivered into the interstitial tissues. The tissue retraction seen in the hemorrhoid soon after laser application shows that even if the energy is applied near the vessels instead of inside them, the treatment still leads to resolution of hemorrhoids. The fact that some dilated veins remained, though only a few more than those seen in the control group, indicates that the laser acts by shrinking the tissue around the veins, collapsing them.

No statistical analysis was necessary because though there were just a few animals that developed hemorrhoids, the results were quite consistent (100% resolution). Also because this experiment was carried out in an animal model, it was not possible to evaluate reductions in pain, although the behavior of the animals post-surgery suggested that they were in little or no pain.

CONCLUSION

Though intravenous laser treatment of hemorrhoids is not feasible, interstitial laser treatment appears to lead to their resolution and to complete healing. Further studies using this method are needed in humans to assess its effects on pain and itching, and long-term follow-up must also be done to determine the potential clinical usefulness of this technique.

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Address reprint requests to:
Dr. Hélio Plapler, M.D.
Associate Professor
Department of Surgery
Universidade Federal de São Paulo
Rua Tomas Carvalhal 884 ap 51
CEP 04006-003, São Paulo, Brazil

E-mail: helio@plapler.com.br

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