EFFECTS OF THE ARGON LASER ON CUTANEOUS VESSELS

* *Mithilesh J. Sharma, M D.*

Introduction

Seldom in the history of modern medicine has an innovation in the therapy of disease aroused such sustained interest and curiosity as has the use of the laser for biomedical research and for the treatment of portwine, cavernous, capillary hemangioma, telangiectasia, varicose veins, tattos and hypertrophic scars.

Many clinical investigators have been using laser (15), an instrument of modern physics, for biomedical research and for the treatment of cutaneous (1,2,10, 16) vascular lesions, claiming that the blue-green laser light selectively photocoagulates (3, 5, 6) superficial vessels while leaving the surrounding structures intact.

The data in this field is largely incomplete and various parameters associated with the interaction of laser and biological systems have yet to be determined. The results of preliminary investigations at the Ohio State University and separately by Goldman et al (9) suggested that selective photocoagulation did not occur, and the laser me ely created a controlled, partial thickness burn, in the rabbit ear (7) and in a monkey with a port-wine stain (15).

To further test the preliminary results, a model was devised which permitted serial biopsies of the laser-treated skin, and assisted the determination of the following :

1. The surface appearance of the skin
2. Assessment of the thrombotic effect of the argon laser on blood vessels.
3. In exploration of the methods to increase its effects, and
4. To investigate the application of laser energy as a precise delicate scalpel in the field of plastic surgery.

Materials and Methods

The C-W 5-watt Argon laser, operating at 488nm (blue) and 514nm (green) which is selectively absorbed by the hemoglobin pigment in the blood vessels, was used in this study, conducted for a minimum period of 6 (six) months. The study lasted for 6 1/2 (six and a half) months.

Sixty Sprague Dowley rats were utilized as the test model using ears for exposure to laser radiation. A well-defined fine network of blood vessels was easily accessible on either side of rat's ears. These blood vessels are located between the transparent surface of the skin and the cartilaginous tissue of the ear.

* *Resident, Department of Surgery Mount Carmel Hospital Detroit, Michigan,* 48235.

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— This paper is based on my thesis submitted for MS degree in Plastic Surgery. The thesis was completed under the supervision and guidance of Dr. Robert L. Ruberg, Dr. Saaid Koozekanani and Dr. R. B. Berggren, Chairman of Plastic Surgery, OSU. Dr. Koozekanani provided assistance in the engineering and operational aspects of the laser while Dr. H. M. Sharma provided help in the histologic interpretations and Dr. Robert L. Ruberg provided constructive criticism and suggestions during the course of this study. It is with deep gratitude that I acknowledge their wise counsel.

The advantages of using the rat as a test model were :

1. Easy accessibility of visible vascular tissue
2. Safe test model for short and long-term exposure
3. Easy application of laser
4. Similarity of the components of skin to human, although the animal skin is different from human skin in certain aspects
5. Availability of large number of test models
6. Relatively inexpensive animal to purchase
7. Maintenance of test animals for any length of time is inexpensive
8. Opportunities for future clinical application

Experimentation

The animals were divided into a group of five each for exposure using different power and duration. They were anesthetized with ether inhalation and intraperitoneal pentobarbital sodium (20/40 mg/kg) during the initial experiments; but the biopsies were performed under inhalation anesthesia.

The dorsal surfaces of the ears were shaved and fixed on a board holding the animal. In commercially available laser treatment sysems, the laser spot size is usually 1-2mm, making biopsy of a single treatment site difficult. In these experiments, the spot size was expanded to 1cm, permitting a 4mm punch biopsy to lie entirely within the treated area. For each treatment program, multiple ears were exposed to the same combination of power and duration, (e. g. 2 watts for 10 seconds, 1 watt for 20 seconds, 0.5 watts for 40 seconds, 0.25 watts for 80 seconds and so forth until .125 watts for 160 seconds. * (See table I–shows energy in watts and duration for each treatment group and visible effects following laser treatment)

Biopsies were performed in each treatment group immediately after exposure, after 48 hours and 7th day of the laser treatment. In addition, the animals were preserved for 3 to 6 months and the biopsies were repeated after 3 weeks, 3 months and 6 months respectively. Gross and histologic descriptions were made for each of the above more than 120 specimens.

Results

A blue-white welt rose in the area of the laser treatment immediately (with higher energy and short duration) involving both ventral and dorsal surfaces of the ear. All the lesions were followed by dark reddish brown crusts and scabs after a week and by three weeks, the first 2 groups exhibited ulcerations with seperation of scabs and healing with scarring around the edges.

A group of animals exposed to a 0.5 watt energy showed an evidenee of visible effect, but the lesions healed completely resulting in normal appearing ears within three weeks. However, a power of 0.25 watts for 80 seconds and 0.125 watts for 160 seconds produced negligible immediate visible effects. These groups showed a delayed appearance of brown crusts which healed completely in a weck producing normal appearing ears. The tissue decoloration was not uniform in all the animals; some showed minimal effects, others none.

The histological changes in thc skin were of varying severity but the basic changes were common to all the groups. With higher

Table 1

The Relationship of Power, Duration and Total Energy to Visible and Histologic Effects

Groups	Power in Watts	Duration in Seconds	Spot Size	Energy in Joules	Visible Effects	Histologic Effects
I.	2	10	1 cm.	20 J	Visible white Wale of 6 mm size	Marked tissue disruption
II.	1	20	1 cm.	20 J	Visible effect of 6 mm.	Similar as group I
III.	.5	40	1 cm.	20 J	Faint wale of 4 mm. size	Tissue disruption less. Early thrombosis of vessels.
IV.	.25	80	1 cm.	20 J	No immediate remarkable visible effect.	Thrombosis of vessels demostration.
V.	.125	160	1 cm.	20 J	Late visible effect	Thrombosis of blood vessels demonstrables. Less tissue disruption.
VI.	.125	80	1 cm.	10 J	No visible effect	Subcorneal vesicle formation.
VII.	.125	40	1 cm.	5 J	No visible effect	No tissue disruption.
VIII.	.125	20	1 cm.	2.5 J	No visible effect	No demonstrable tissue disruption.
IX.	.125	10	1 cm.	1.25 J	None	

power there was complete loss of epidermis at the site of laser impact and homogenization of the collagen and early platelet, fibrin thrombi in some blood vessels. With lower power, there were spaces present between epidermis and dermis due to vapourization of tissue produced by laser impact. After 48 hours, the changes were followed an ulcer and coagulation necrosis which showed healing by granulation after two weeks. Powers below 0.125 watts for 10, 20, 40 and 80 seconds showed subcorneal vesicle formation and thrombosis of some very small vessels. There was no damage to the skin appendages.

Discussion

The interactions of laser radiation with skin are complex in animals and resemble those observed in human skin. Skin appears to be constant with a thermal mechanism for damage. The process of tissue breakdown is related to the physical parameters of the irradiating source such as wavelength, energy density, pulse duration, beam image size and power density.[11] It is the initial high energy content of the laser beam which, together with its coherence,[8] results in the transmission of an excessive amount of energy and its absorption by the target tissue, skin.

The component molecules of skin absorb so much energy that they vibrate and produce heat.[14] This thermal damage is usually confined to a limited area of the laser-absorbing layer. The whitening effect seen on the epidermis following Argon laser radiation does not seem to be a result of selective absorption by the red pigment of the blood vessel, but appears to be a generalized tissue disruption.

The radiation effect of a laser is essentially a thermo coagulation[4] like an electrical burn such as that demonstrated by a power of 2 watts for 10 seconds. With higher energy, the amount of tissue disruption was out of proportion to the amount of thrombosis. However, with lower energy, there was some evidence of thrombosis in small vessels without disruption of epidermis .

In this study conducted for a period of 6 (six) months. one important phase of wound healing has been noticed; the development of new blood vessels, which has been found to significantly increase by irradiation with laser.[5]

Conclusion

The study supports the feasibility of using the Argon laser for selected lesions of the skin which the past investigators have used. However, the data does not support the concept of preferential absorption of blue-green radiation by the red blood cells.

Selective coagulation could not be seen in any ear where there was immediate visible effects. The lesions healed with subsequent fibrosis after two to four weeks with white-appearing epithelium.

Total energy delivered to the tissue was kept constant, yet different visible and histologic effects were achieved by varying power and duration. Twenty joules energy delivered as 2 watts for 10 seconds produced an immediate white spot and ultimate full-thickness necrosis with late healing. Twenty joules delivered as 125 milliwatts for 80 and 160 seconds produced minimal visible effects but did have some histologic suggestion of intravascular thrombosis.

The study conducted for a minimun period of 6 (six) months confirms that laser irradiation does not produce selective coagulation although ultimate healing with a thin epithelium can produce an acceptable clinical result. possible selective coagulation with lower dose, longer duration treatment regimens suggest that this alternative treatment program may ultimately permit a better cosmetic result through preservation rather than regeneration of normal structures.

Since lasers are classified as non-ionizing radiation and no malignancy has been reported form repeated laser impact on investigators or following chronic exposure of laboratory personnel, it is safe to use in the treatment of various skin lesions.

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