

MORPHOLOGICAL CHANGES IN THE TISSUES UNDER THE ACTION OF ND:YAG LASER IN PEPTIC ULCER BLEEDING

V. Ignatov, P. Ghenev¹, E. Kiryazov, N. Kolev

Sector of Endoscopic, Laser and Miniinvasive Surgery, ¹Department of Pathology, Prof. P. Stoyanov Varna University of Medicine

ABSTRACT

The authors carry out a morphological study of 60 endoscopic biopsies of stomach mucosa followed-up consequentially in time. The study describes the morphological changes in the tissues under the action of Nd:YAG laser beam in cases of acute bleeding from peptic ulcers. Study proves that Nd:YAG LFC has lasting haemostatic and epithelising effect, i. e. it exerts a long-lasting therapeutic effect.

Key words: bleeding, haemostatic and epithelising effect, gastroduodenal ulcer, histomorphology

INTRODUCTION

After the first years of its application the laser became multifunctional and irreplaceable in some medical aspects although it is still object of continuing research and a challenge for physicians, engineers and scientists. The routine usage of the Nd:YAG LFC method in cases of acute bleeding from gastroduodenal ulcers significantly improved the final result of this serious complication of the gastroduodenal ulcer (1).

The aim of the present study is to describe the morphological changes in tissues under the action of Nd:YAG laser beam in cases of acute bleeding from gastroduodenal ulcers.

MATERIAL AND METHODS

The authors carry out a morphological study of 60 endoscopic biopsies of stomach mucosa followed-up consequentially in time. Operatively removed materials are fixed in 10% neutral formalin and routinely done in the laboratories of the Department of Pathology, Varna University of Medicine. The slices are 5 mkm wide and stained with hematoxylin-eosin. The observations were made with Olympus microscope with digital camera Mitsubishi for documenting the material. The original microscopic magnification is indicated in the text at the applied figures.

The pathological changes in the tissues caused by lasers are mainly because of the thermal damages in them. There are different temperature intervals of morphological changes - from coagulation till complete coagulation necrosis and tissue vaporization.

The light energy absorbed by the tissue after Nd:YAG laser therapy is directly changed in thermal one and induces its heating. If absorbed energy is low the heat could be conducted without damaging the tissue. If absorbed energy overcomes definite limits, there is increasing of the temperature and this leads to coagulation necrosis because of denaturation of the proteins. If the temperature in the tissue is over 100°C the water containing tissue vaporize (3,4).

The stage and dimension of the morphological changes caused by the laser therapy depend on the physical parameters of the laser beam (energy, density, diameter of the beam, wave length and therapy pulse continuance) and on the optical and thermal properties of the tissue.

Nd:YAG laser beams are slightly absorbed by water, so they penetrate through the whole width of the wall. The thermoeffect is realized in dense structures of whole width of the wall. When power is between 60-80 W/cm² with short impulse of 0,5 sec and energy applied is up to 450 J the value of critical temperature is reached for 1-2 sec. It is noteworthy that this doesn't lead to perforation of the wall, nor at the moment of radiation, neither in later periods of Nd:YAG LFC application in cases of acute bleeding from gastroduodenal ulcers (2). Our experience shows that perforation occurs when dealing with the source of bleeding lasts longer than 40 sec (according to literature data - between 45-50 sec).

To study the morphological changes caused by the action of the Nd:YAG laser we inflicted a standard defect in healthy stomach mucosa with diameter of 0,8-1cm, power 60-80 W/cm², with short impulse of 0,5 sec and energy applied of 300-500J in 10 cases 24 hours before operation on the occasion of subtotal gastrectomy or gastrectomy because of cancer.

We have studied the action of the Nd:YAG LFC in 5 cases with bleeding stomach ulcers operated on the 3rd to 5th day after increasing Hb values and stabilization of the

Address for correspondence:

V. Ignatov, Sect. of Endoscopic, Laser and Mininvasive Surgery, Prof. P. Stoyanov Varna University of Medicine, 55 Marin Drinov St., BG-9002, Varna, Bulgaria

haemodynamic indexes in relatively planned course (sub-total gastrectomy).

In 15 cases a biopsy from ulcers was taken 1-2 months after Nd:YAG LFC in acute bleeding from gastroduodenal ulcers.

Acute lesions - up to 24 hours

The morphological characteristic of the acute lesions after Nd:YAG LFC in case of acute bleeding by stomach and duodenal ulcers are presented on Fig. 1 and 2.

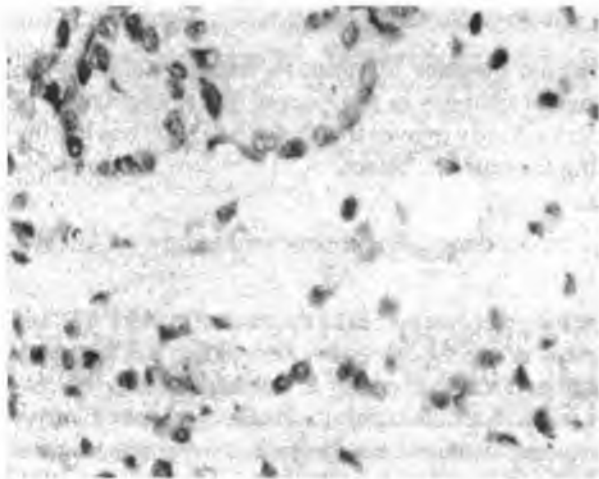


Fig. 1. Two glands with damaged basal lamina, small blood vessel, large edema of the submucosa with great number of leukocytes. Staining with HE. Magn. x800

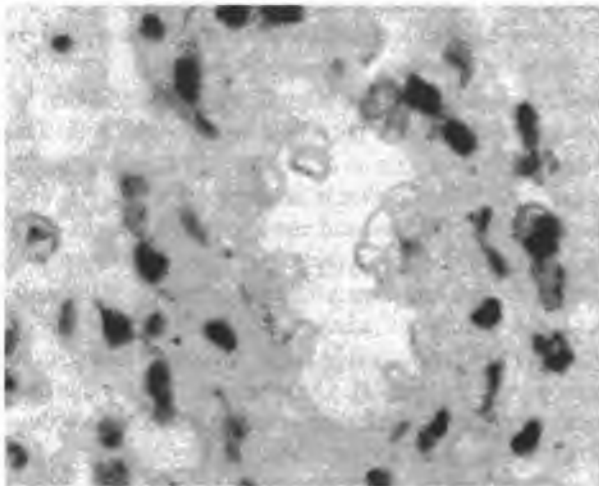


Fig. 2. Small arterial vessel with inflammatory infiltration around the vessel and its wall. Severe submucous edema. Staining with HE, Magn. x800.

At 30 J/cm², marked mucosal edema is found in the treated area after laser therapy. There is also shedding of the surface epithelium and dissociation of the epithelial cells. At energies up to 100J/cm², coagulation necrosis takes place in the submucosa or as far as the muscle layer. The collagen fibers in the edematous submucosa appear shrunken and significantly thickened. Under high magnifi-

cation they are arched or angular in form and show a marked cross-striation.

One day after laser therapy, the edema in the laser zone area is regressed. The treated area stands out from its still edematous surroundings. An extensive mucosal ulceration develops reaching to the submucosa. Thrombocytes are found in the capillaries and there are thromboses in the venules. The arterioles show fibrinoid necrosis of their walls. The muscle fiber necroses are now clearly visible. The non-nucleated muscle fibers are condensed to a compact hyalin mass, and homogeneous band-shaped coagulation necrosis is present.

Morphological changes after 3-5 days

Morphological changes on the 3rd-5th day after Nd:YAG LFC in case of acute bleeding of gastric and duodenal ulcers are shown on Fig. 3 and 4.



Fig. 3. Obliterating thrombus and preserved arterial vessel wall. Staining with HE, Magn. x400.

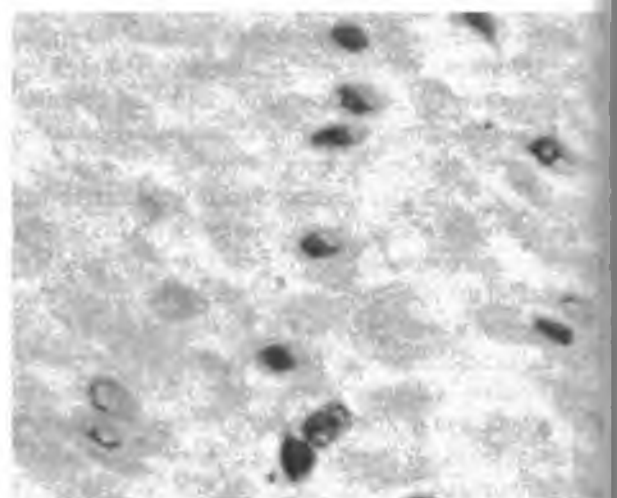


Fig. 4. Smooth muscle of stomach wall with preserved nucleus and interstitial edema. Staining with HE, Magn. x1600

After a few days, depending on the physical parameters, the superficial and deep tissue changes with the Nd:YAG laser are significantly more extensive than those in the acute phase.

This is irreversible because all damage is already achieved at 58°C, although then is no immediate macro- or microscopic evidence of this. The increase in necrosis is promoted by multiple distribution of the Nd:YAG laser in tissue and by heat conduction. On the other hand, the higher thrombosis potential and the consequent blood perfusion disturbance can play a role in the increased ulceration.

For the surgeon-endoscopist, this means that he must expect larger superficial and deep lesions, than the acute lesions visible at endoscopy, and that the full extend of the lesions can only be recognized after a few days.

After 3 to 5 days, repair and resorption processes can be recognized, coming in from the surrounding vital areas.

On the surface reepithelization is seen, with a single epithelial layer originating in the bordering intact mucosa, and growing out to cover the necrotic tissue. Organization of the laser necrosis takes place through granulation tissue growing in from the submucosa - ingrowing capillaries, fibroblast proliferation and phagocytes dominate the picture in laser necrosis.

Renewal formation of smooth muscle cells takes place, mainly from migratory transformed fibroblasts of the granulation tissue (5).

Changes after 1 to 2 months

These changes are shown on Fig. 5 and 6. At this point, the ulceration is more or less healed. The mucosa looks normal histologically and with the naked eye, although a relatively small connective tissue scar can be seen in the submucosa and the muscularis propria.

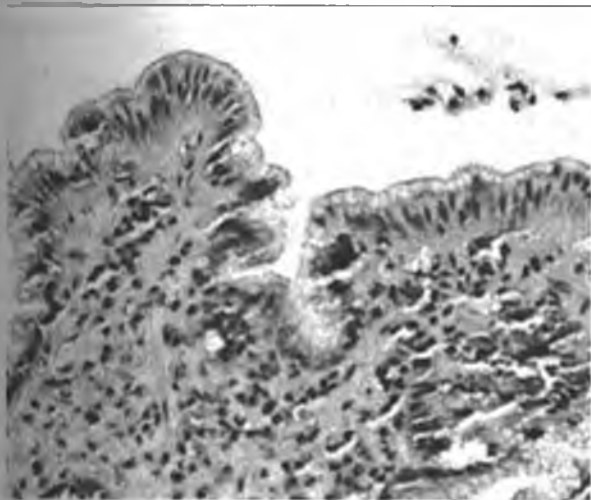


Fig. 5. Microphotography of biopsy of bleeding peptic ulcer treated with Nd:YAG LFC - after 2 months presenting continuous stratum epithelium with light edema, hyperemia and poor lymphocyte infiltration in the submucosa; necrosis of the bottom of the ulcer and large arterial vessel obliterated by thrombus. Staining with HE, Magn. x200.

Typical feature in healing process of sources of acute bleeding after Nd:YAG LFC is the develop of aseptic inflammation within absence of neutrophile infiltration in the border between coagulation necrosis and intact tissues.

Complete repair of the stomach wall structures are observed after 1 to 2 months after LFC.

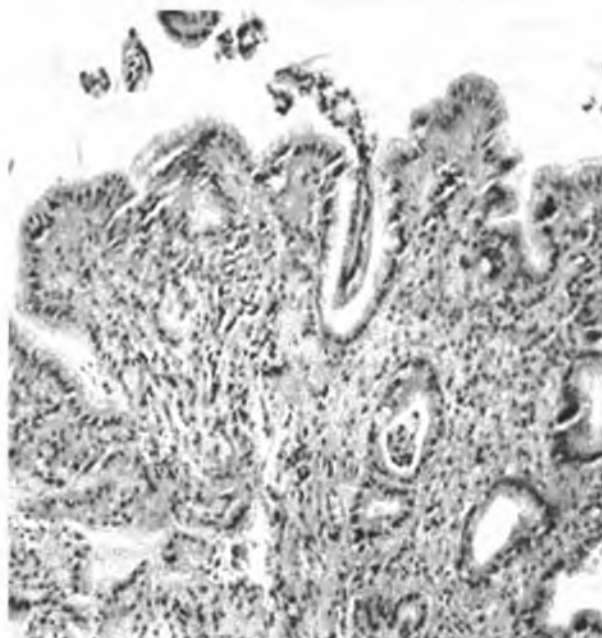


Fig. 6. Microphotography of restituted structure of stomach mucosa in the area of coagulation (lfc), showing covering epithelium and submucosal glands with lymphocyte infiltration and soft fibrosa. Staining with HE, Magn. x100

Prepared experimental data about reparative processes in coagulated with laser acute bleeding ulcers, determined optimal density and power parameters and methods of lfc created a preconditions for clinical using of the laser beam - endoscopic lfc in treatment of bleeding gastroduodenal ulcers.

Regular stage in the mucosa regeneration process is pseudopyloric character of the fundus glands with following differentiation of mucosal cells in type of parietal and main cells. Complete restitution of the stomach mucosa structure in the area of coagulated induced erosive-ulcerous defects, arising on the background of nonchanged stomach wall in the area of stomach corpus, are presented after 45-60 days behind LFC. There are a tie between the morphofunctional status on the whole mucosa of the stomach corpus and the type of reorganization of the epithelial glands in the LFC area.

CONCLUSION

Morphological studies after Nd:YAG LFC have proving their strong hemostatic and epithelisation effect, i.e. there are permanent therapeutic effects.

REFERENCES

1. Скобелкин, О. К., Т. М. Титова, А. М. Сафронов, В. И. Елисеенко. Лазерная фотокоагуляция при острых желудочно-кишечных кровотечениях.- В: Лазеры в хирургии. Под ред. О. К. Скобелкин. Москва, Медицина, 1989, 152-171.
2. Kelly, D. F., S. G. Brown, M. B. Galder, H. Pearson, B. M. Q. Weaver, C. P. Swain, P. R. Salmon. Histological changes following Nd:YAG laser photocoagulation of canine gastric mucosa.- *Gut*, 24, 1983, 914-920.
3. Sander, R., H. Posl, A. Spuhler, H. Hitzler. Der Neodymium-YAG Laser: Ein effektives Instrument für die Stillung lebensbedrohlicher Gastrointestinalblutungen.- *Leber Magen Darm*, 11, 1981, 31-36.
4. Sander, R., H. Posl, M. Strobel, E. Unsolid, F. Frank, A. Spuhler. Nd-YAG Laser in der Gastroenterologie - Erste Ergebnisse experimenteller und klinischer Studien mit der 1,32 μm Wellenlänge.- *Laser*, 2, 1986, 167.
5. Zimmermann, I., J. Stern, E. Keiditsch, F. Frank, A. Hofstetter: Restitution und Reparation nachausgedehnter primärer und sekundärer Neodymium-YAG-Lasernekrose der Rattenharnblase.- *Laser Med. Surg.*, 3, 1987, 215-223.