NAKED EYE COMPARISON BETWEEN CUTTING AND COAGULATION EFFECTS OF KTP AND Nd:YAG LASER APPLICATION ON RAT LIVER

Sarder A. Nayeem, Toshiro Konishi, Yumiko Ohtomo, Tohru Itoh, Kazuyuki Shimomura, Tamaki Noie, Hideki Abe, Yasustugu Bandai and Yasuo Idezuki

Second Department of Surgery, University of Tokyo, Tokyo, Japan

ABSTRACT

This study was designed to assess the relative cutting and coagulation effects of KTP laser (wavelength 532 nm.) vs. Nd:YAG laser (wavelength 1064 nm.) on the rat liver. Eleven-week-old male Wister rats were used in the experiment. Comparisons were made at different energy levels applied for different time period. Both contact and noncontact (working distance 5 mm) applications were performed to induce lesions. The KTP/YAG Surgical Laser System of Laserscope®, which has the option for accessing either the Nd:YAG or the KTP energy independently within few seconds was used. Sacrifice times were immediately after lesion induction by continuous bleeding from the abdominal aorta. Comparative evaluation consisted of morphological examination of the wounds with measurements of the widths, depths and different zones of lateral thermal damages. The results of the study indicated a considerable differences between the two surgical lasers in their cutting and hemostatic capabilities while used in liver tissue. KTP laser showed a better and definite cutting capabilities with a reasonable hemostatic effect while YAG gave a deep coagulation effect with larger lateral thermal damage. But YAG showed a poor vaporization or cutting performance. A combination of both seemed to be highly effective in liver surgery for both cutting and hemostatic purposes.

INTRODUCTION

Laser was introduced as a surgical tool in the late 1960’s and already has taken its place in the operation room beside scalpel and electrosurgical instruments. Where the scalpel can only cut, and electrosurgical instruments can cut and coagulate, the laser can perform a third action in addition - it can cut, coagulate and vaporize tissue. The three major types of lasers used in surgery are the Carbon Dioxide Laser (CO₂), the Neodymium-doped Yttrium Aluminum Garnet Laser (Nd:YAG), and the Potassium Titanyl Phosphate Laser (KTP). Among these the latest introduction is the KTP laser developed by John Bierlein at DuPont, having a wavelength of 532 nm. The authors have studied the cutting and coagulating efficacy of KTP laser on rat liver as well as compared with those of Nd:YAG laser.
MATERIALS AND METHODS

Eleven-week-old male Wister rats were used in the experiment. After induction of anesthesia, giving a long incision in the anterior abdominal wall the liver was exposed. The median lobe, the left lateral lobe and the right lateral lobe of the liver were selected for laser application. The KTP/YAG Surgical Laser System (Laserscope, San Jose, California), which has the option for accessing either the KTP or the Nd:YAG energy independently within few seconds, was used. Both KTP and Nd:YAG lasers were applied with different power settings from 5 to 15 watts and different time periods. Both contact and noncontact (working distance was 5 mm) applications were performed at least twice for each type of application. For laser delivery 0.4 mm diameter bare fibre was used and a perfect beam was maintained by cutting the end of the fibre when seemed necessary. After the application the rats were sacrificed by continuous bleeding from the abdominal aorta and the total liver was taken out by sharp dissection and washed properly in saline water. The laser wounds were examined macroscopically and measured for different zones of thermal damage in the surface and after having longitudinal sections under hand glass and in photographs of magnified (about 5 times magnification) views.

RESULTS

The KTP and YAG lasers have shown clear differences in their macroscopic thermal damages to rat liver. In the surface view KTP laser induced smaller lesions during contact application, but larger in case of noncontact application. But when the depths of the wounds were compared in the longitudinal sections KTP laser almost always (both in contact and noncontact) made much deeper lesions in comparison with that of YAG laser. The zone of vaporization or loss of tissue was always markedly greater in case of KTP both in diameter and depth. On the other hand the zone of coagulation was relatively greater in case of YAG laser in almost all types of application.

Contact applications induced deeper lesion than non-contact, whereas non-contact application gave wider lesions than contact in case of both KTP and YAG laser. In the longitudinal sections KTP wounds gave appearances of long-V and flat-V and YAG wounds gave appearances of U and half-moon in case of contact and noncontact application respectively (figures).

At the time of application less bleeding occurred in case of YAG, compared with that of KTP. Especially in non-contact application YAG laser caused almost no bleeding while KTP caused a little or none.
DISCUSSION

Laser uses photons, the light energy to produce its effects on tissue. By conversion of these photons from light energy into heat and using this heat on target tissue, laser gives the ultimate biologic effect. Delivering a stream of photons of single color, in a single direction laser helps us to get a unique accuracy and a high doses of energy to the tissue in a very precise way. The bouncing of photons in a tissue site, which is termed as scatter continues until all the photons are converted into heat being absorbed by the tissue or being reflected leave the tissue.

Vaporization gives the the ultimate cutting effect of laser, it is always associated with coagulation which causes hemostasis. In fact hemostasis cannot be achieved unless lateral thermal damage is created.

Comparisons of wound radius, vaporization and coagulation on surface view:
Contact application for 5 sec.

Comparisons of depth, vaporization and coagulation on longitudinal section:
Non-contact application for 5 sec.

In this study we have compared the effect regarding the vaporization as well as coagulation produced by the application of KTP laser which has a wavelength of 532 nm and Nd:YAG laser of 1064 nm. Though the KTP laser light is virtually not absorbed in water and passes readily through water, this visible light laser is highly absorbed in hemoglobin and thus produces less scatter than the Nd:YAG. Due to these characters KTP laser vaporizes tissue well but sometimes limited in its coagulation abilities.
Plots have been produced to compare the extent of the wounds on the surface and their depths with those of the vaporization and coagulation zones. In the plots of noncanoact application we can see the absence of zones of vaporization in case of YAG upto 10 watts power settings for 5 seconds, whereas those of KTP were remarkably present. However in case of contact application zones of vaporization of YAG were present but much smaller than those of KTP. In both contact and noncontact application plots show that the presence of coagulation zones in case of YAG were much greater that those of KTP.

We found a relatively greater areas of lateral thermal damage and deep coagulation effect in case of YAG laser application. KTP laser showed a deeper and sharper cutting effect with a little lateral thermal damage but reasonable coagulation and hemostasis.

**CONCLUSIONS**

In our experiment a number of conclusions can be drawn that KTP laser has a greater vaporization effect, hence cutting capability with a reasonable hemostasis, though sometimes is limited in its coagulation abilities. KTP was faster and deeper in cutting in case of both contact and noncontact application. Nd:YAG laser used with bare fiber gives a deep coagulation, hence effective hemostasis but a poor vaporization or cutting effect. A combination of both lasers easily available while using KTP/YAG Surgical Laser System can provide both hemostatic cutting and deep coagulation when needed, all with a same bare fiber in liver surgery as well as other surgical operations.

Acknowledgement: We express our utmost thanks to the Medical Department of HOYA Corporation, Tokyo, to give us the opportunity to use their KTP/YAG Surgical Laser System unit in their own laboratory. We also give our thanks to Mr. Rokuro Miyazawa of the Department of Medical Photography, University of Tokyo, for his excellent photography of our specimens.

**REFERENCES**


