RESECTION OF THE LIVER WITH KTP LASER: A COMPARATIVE STUDY WITH ND:YAG LASER ON RAT

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Abstract

Potassium Titanyl Phosphate (KTP) laser is one of the latest introduction in the field of general surgery, which has a wavelength of 532 nm and produce a green visible light giving a good aim accuracy. A study of experimental hepatic resection was performed with contact or near-contact KTP laser and was compared with that of YAG laser (wavelength 1064 nm) in rat liver. Eleven-week-old male Wister rats (n equals 30) weighing between 300 to 330 grams were used in the experiment. They were randomly devided into two groups for KTP and YAG lasers. The KTP/YAG Surgical Laser System (Laserscope®, California), which has the option for accessing either the Nd:YAG or the KTP energy independently within few seconds was used. A transverse nonanatomical resection of the ventral lobe of the liver was performed with contact or near-contact application and the required time and bleeding were recorded for both lasers with different power settings (5, 10, 15 watts). Rats were sacrificed in 5 steps, viz just after the operation, on the 3rd, 7th, 14th and 21st postoperative day to compare the postoperative healing in both groups. On morphological examination of the resected end of the ventral lobe, KTP showed a sharper cutting than YAG with minimal lateral tissue damage. In YAG group the lateral thermal damage was marked especially the zone of coagulation. In the study we also found that the time required to perform the resection was always much higher in case of YAG than that of KTP. But in measuring the bleeding amount there was no major difference in case of both lasers. Histopathological slides confirms comparatively extensive lateral thermal damage in case of YAG and the postoperative healing process was found better in KTP group.

Introduction

Still the postoperative complications of liver resection viz. liver failure, bleeding, infection, sepsis etc. cause a great deal of morbidity and mortality. These complications are frequently related to intraoperative bleeding, extent of tissue damage, bile leakage and so on. Operative techniques and tools are important factors in preventing these complications. Lasers are considered to offer an improvement in the situation. There are a number of lasers which are used in general surgery. All lasers have its own properties and biological effects on target tissue. Due to very scanty study on lasers in liver surgery until now, the role of this new device in liver surgery is not cleared.

Most of the available study showed the use of contact or noncontact Nd:YAG laser for liver resection. Until now there is no
study except a few by our group on the frequency-doubled YAG i.e. KTP laser in liver surgery. In the present study, therefore, the safety and efficacy of KTP laser have been studied on rat liver during resection as well as compared with that of Nd:YAG laser. Assessment included required time for resection, amount of bleeding during resection, tissue damage and postoperative healing.

Materials and Methods

Thirty eleven-week-old male Wister rats weighing between 300 to 330 grams were used in the experiment. They were randomly divided into two groups for KTP and YAG lasers. After induction of anesthesia with spontaneous respiration, a long incision in the anterior abdominal wall was given and the liver was exposed. The ventral lobe of the liver was selected for a nonanatomical resection with contact or near-contact application of both lasers. No occlusion of blood vessels was used. The KTP/YAG Surgical Laser System (Laserscope®, California), which has the option for accessing either the Nd:YAG or the KTP energy independently within few seconds was used for laser delivery. The resections were performed in three different power settings, i.e., at 5, 10 and 15 watts with both lasers. Laser beam was delivered through a 400 micrometer glass fiber in a continuous mode and a perfect beam was maintained by cutting the end of the fiber when necessary.

Required time for resection was recorded by a stop watch. The amount of bleeding also recorded by an electronic weighing machine after collection of the blood discharged up to one minute after the resection was finished. The rats were sacrificed in 5 steps, viz. just after the operation, on the 3rd, 7th, 14th and 21st postoperative day to compare the healing process in both groups. After operation the abdomen was closed using absorbable sutures and no drainage or antibiotic were used. Rats were sacrificed by continuous bleeding from the abdominal aorta. After removal of the liver in toto by sharp dissection at the time of sacrifice, it was washed thoroughly by saline water to remove the blood attached with. Then the total liver was fixed in formalin for about a week to 10 days. Microscopic evaluation of the resected end of all five groups were performed and compared the healing process under microscope in case of both lasers. In the cases where the cut surface made adhesion with the underlying lobe, no separation of lobes was performed. Two types of staining were performed: Hematoxyline & Eosine (H.E.) and Azan Mallory (Azan).

Results

In rat liver resection KTP and YAG laser showed clear differences in their cutting, coagulation and also in postoperative healing. Operating time from the start of resection up to the end in case of KTP with a power settings of 5, 10, and 15 watts were 102.4±2.67, 63.0±3.53 and 46.2±2.74 seconds respectively. On the other hand same with YAG with same power settings were 180.0±12.6, 111.2±5.2 and 94.2±3.52 seconds respectively. It shows a longer time requirements in YAG group (plot). Intraoperative bleeding evaluation showed that in case of KTP with 5, 10 and 15 watts of power settings, the amount of discharged blood were 3.08±0.45, 2.93±0.2 and 3.26±0.32 grams respectively and those of YAG were 2.41±0.4, 3.05±0.48 and 2.99±0.52 grams respectively. Though there were no big differences in both groups regarding intraoperative bleeding, a greater bleeding tendency is noticed in KTP group (plot).
In naked eye observation a greater lateral thermal degeneration was noticed in case of YAG wounds (Fig). Histopathology of the resected liver was performed and examined for lateral thermal damages. In case of YAG the lateral thermal damage was found greater and KTP showed a comparatively sharper cutting. Zones of carbonization and coagulation were markedly greater in case of YAG wounds.

The cut surfaces on the 3rd postoperative day showed a remarkable differences. Here the lateral thermal damages became more demarcated. Hepatocytes showed autolysis and coagulation necrosis developed. In case of YAG the lateral thermal damage is much greater with a large coagulation necrosis.

On the 7th postoperative day the cut surfaces of the ventral lobe showed adhesion with the underlying lobes. But in the adhesion line the thermal damage with the YAG laser remained much greater in comparison to that of KTP laser. Granulation with inflammatory cell infiltration was found more in case of YAG and much less in case of KTP.

On the 14th postoperative day the size of the zone of thermal damages reduced and the process of granulation and fibrosis continued. The KTP cutting line became much thinner than YAG.

On the 21st postoperative day, the cutting line of KTP laser became markedly thinner with almost complete adhesion with the underlying lobe. But that of YAG remained considerably thick with a lot of fibrotic tissue in the line of adhesion (Figs).

Discussion

The CO₂ laser was first used in liver surgery in 1975. From then a number of experimental and clinical studies for liver resection were performed using CO₂ and Nd:YAG lasers. According to the reports, the CO₂ laser provided good cutting effects but hemostasis was quite inadequate. Another disadvantage of CO₂ laser is that it cannot be used by optic fiber. On the other hand noncontact Nd:YAG laser provided good coagulation. Another experimental study comparing the contact and noncontact air delivery Nd:YAG laser has shown the contact method to be much more effective, but in higher dosage of contact YAG laser produced a greater lateral thermal damage. Study comparing ultrasonic dissector (CUSA,
Cavitron ultrasonic aspirator), the non-contact Nd:YAG laser with a conventional finger fracture technique, showed the CUSA was superior to the finger fracture technique by causing less postoperative tissue damage and reduced bleeding whereas noncontact Nd:YAG laser had poor cutting properties and, although it produced hemostasis, the depth of tissue damage was considerable. However other studies showed synthetic sapphire tip contact YAG laser showed a comparatively better cutting effects.

In our present study, we tried to compare the effectivity of KTP laser in liver resection and also compared with that of YAG laser, the most widely used laser in liver surgery. The result of this study showed a unique differences in both lasers. While the KTP laser cuts well, the YAG laser gives a good lateral coagulation hence hemostatic effect. In liver surgery cutting and coagulation both are important to have an optimum result. Since the postoperative healing process also showed a good healing in KTP group, this new laser seems to be useful in such surgical procedures.

Since liver resection is technically difficult and associated with problems in control of bleeding, all new devices and techniques to be used in liver surgery need to be critically evaluated. In our study a combination of both lasers might be thought to be a good result providing both hemostatic cutting and deep coagulation when needed, all with a same bare fiber in liver surgery as well as other surgical operations. Larger clinical studies are needed to evaluate their application in human liver surgery.

Conclusions

1. KTP provides a sharper and faster cutting of the liver tissue with minimal lateral thermal damage in comparison to YAG. KTP is sometimes limited in coagulation hence hemostasis.
2. YAG provided a comparatively better hemostasis in experimental hepatic resection.
3. Postoperative evaluations revealed a better healing process in case of KTP wounds comparing to YAG. Greater lateral thermal damage at the time of application of YAG laser remained as plenty of fibrotic tissue even after 3 weeks postoperatively.

Since KTP laser cuts well without much thermal damage to the surrounding tissue and YAG laser coagulates well to perform good hemostasis, a combination of both laser can be thought highly useful in liver surgery.

References