BASIC STUDIES ON FIBER-OPTIC INDUCED CO₂ LASER

Taichin MORITA, Hiroshi SAITOH, Hozue YAMAGUCHI, Masaki NISHIMURA,
Ryuzaburo TANINO, Mitsuhiro OSADA,

Department of Plastic Surgery, Tokai University Hospital, Kanagawa, Japan

1, Introduction

The most useful advantage of the CO₂ laser scalpel is its hemostatic effect. In 1977 Sharplan 791 CO₂ laser equipment was first imported to Japan and applied in clinical use. At the same time, several types of CO₂ laser devices were also developed in Japan. However, most of them use the wave guide through the mirror joint system (MJS) from the laser oscillator to the handpiece, and therefore its actual operability is very unsmooth. Fiber-optic induced CO₂ laser equipment has remarkable improvement in this regard. On the other hand, the laser beam loses its coherency by passing through the fiber with a wider spot size and consequently, damage of adjacent tissue increases as compared to the mirror joint system induced CO₂ laser beam. A new type of fiber-optic induced CO₂ laser equipment (FOI CO₂ laser) used in this study has been developed by Matsushita Research Institute Tokyo Inc.. Its maximum power is 30 watts, fiber diameter is 0.5mm, fiber length is 150cm and the spot size is 0.5mm.

2, Material and Methods

This study includes the following 2 groups:

Study 1: CO₂ laser beam of 15watts with 0.1sec. pulse width was irradiated to a power checker made by acrylicresin. The resulting crater was magnified under a microscope 10X and the diameter of the orifice(W) and the depth(D) were measured by microgauge.

Study 2: The liver of matured rats were incised by a continuous wave of 10watts of the CO₂ laser beam. The speed of the incision was about 15mm/sec.. After the livers were incised, the whole body was immediately irrigated by heparin added normal saline. Next, India ink was injected through the same catheter. After this maneuver, a hepatectomy was performed, and 100 to 200 u microsections were made in a routine preparation. These sections were magnified 10X, and the avascular area(Y) and the incisional depth(X) was measured by computer. Following this, The avascular area per 1mm incisional depth (Y/X) was calculated.

3, Results

STUDY 1: Measurement of the crater

New FOI CO₂ laser: Wm=0.610mm, Dm=4.028mm

In the 4th Congress of the International Society of Laser Surgery, we reported the following results,

MJS CO₂ laser: Wm=0.284mm, Dm=5.074mm

Prototype FOI CO₂ laser: Wm=0.946mm, Dm=1.998mm

STUDY 2: Measurement of the avascular area

New FOI CO₂ laser: Y/X=0.838mm²/mm(standard deviation[SD]=0.16)

The following figures are the measurement results of the MJS CO₂ laser scalpel and electrosscalpel, and the prototype FOI CO₂ laser, using Wister rat livers in the same manner.

MJS CO₂ laser: Y/X=0.65mm²/mm, 0.77mm²/mm(SD=0.22, 0.17)

Prototype FOI CO₂ laser: Y/X=1.06mm²/mm(SD=0.31)

Electrosscalpel: Y/X=1.66mm²/mm(SD=0.88)

4, Discussion

In the study 1, diameter of the crater orifice with the prototype FOI CO₂ laser is approximately 3 times wider than that of the MJS CO₂ laser, but its depth is about 2/5 times smaller. With the new FOI CO₂ laser, diameter of the crater orifice is approximately 2 times wider than that of the MJS CO₂ laser, its depth is about 4/5 times smaller. Comparing the figures of the avascular area per 1mm incisional depth obtained in study 2, the avascular area of the prototype FOI CO₂ laser is about 1.5 times as large as the MJS CO₂ laser, but the avascular area of the new FOI CO₂ laser is about 1.3 times as large as the MJS CO₂ laser. Therefore the thermal tissue damage caused by the new FOI CO₂ laser is anticipated to be around the midrange between the MJS CO₂ laser and the prototype FOI CO₂ laser. These facts indicate that the characteristics of each beam are completely different. In addition, the difference of energy density of each laser strongly influences the results of this study. Energy density is said to be proportioned to a square of beam spot size. Therefore the new FOI CO₂ laser is 4 times as large as the prototype FOI CO₂ laser in energy density.

5, Conclusion

- 1). Diameter of the crater orifice created by the new FOI CO₂ laser is approximately 2/3 times smaller than that of the prototype FOI CO₂ laser, however its depth is about 2 times deeper.
- 2). Damage of the adjacent liver microvasculature induced by the new FOI CO₂ laser is approximately halfway located between the MJS CO₂ laser and the prototype FOI CO₂ laser.
- 3). Operability improvement of the handpiece.

From these facts, it can be generally expected that using the new FOI CO₂ laser will consistently provide a sharper scalpel.