Surgical techniques of the laser vascular anastomosis and thermal effects in the vascular wall by CO₂ laser irradiation

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In 1982, a new CO₂ laser and laser microsurgical technique have been developed for the anastomosis of small vessels(0.3-1.4mm in diameter) in our laboratory¹⁾. The success of consistent and rapid laser vascular anastomosis of the small vessels(96%) basically required (1) small tissue penetrating specific CO₂ laser, (2) optimal power density of the laser(1.5-2.0 joule/mm²), (3) small focused beam(90-120um in diameter) and (4) placement of the laser beam on the well-adapted vascular edge of the anastomosis. The laser irradiated patent arteries indicated less necrosis and scarring and faster healing than conventional suture arteries in the pathological studies²⁾³⁾. In this investigation, to open the laser vascular anastomosis technique on the various sized vasculature, the fundamental thermal effects of CO₂ laser irradiation in the vascular wall and changes of surgical techniques depend on different vascular diameters have been studied.

method

Twenty rats weighing 300-350g were anesthetized with 21mg/kg sodium pentobarbital(I.P.) and followed at 10 minutes latter 60mg/kg ketamine(I.M.). The caroted, femoral and abdominal arteries were separated from the surrounding tissues, and laser vascular anastomosis were performed with previously reported laser irradiation technique¹⁾²⁾³⁾. The microvascular anastomotic technique with the laser includes, end to end anastomosis with three stay sutures at a position of about 120° with 10-0 monofilament and end to side anastomosis with four stay sutures, pulling the adjoining two stay sutures in mutually opposite directions and accurately adapting each vascular edges at the region of the anastomosis, irradiation by the laser is given for a few seconds. To establish the proporsal surgical techniques for the various diameters vascular anastomosis with laser, the effects of suture bites length from the vascular edges and strength of stay sutures pulling tension on the obtaining the good pathological wound healing were studied.

The clinical and pathological results were evaluated at one to two

weeks after surgery. The thermal effects on and in the sutured vascular wall by CO₂ laser irradiation were analysed using finite element method of the heat distribution. The effect of water distribution for the absorption of thermal effects of CO₂ laser was also studied with topographic water distribution spectroanalysis method in the vascular wall⁴⁾.

results

The vascular wall adaptation force and laser thermal effect in the vascular wall were influenced by two surgical maneuvers, one is the pulling force the adjoining two stay sutures and another one is bites length from the vascular anastomosis edges. These idea was supported from that laser thermal effects distribution in the vascular wall studies. In the adventitia, thermal effect was highest in the middle part of it and in the media, the temperature was lower than that in adventitia, it elevated at 45°-85°C which was higher than critical temperature(48°-70°C) of the characteristic changes of collagen⁵⁾ (Fig.1). As the consequent of modification of surgical maneuvers on the laser vascular anastomosis brought the small scar formation in the small vessels and consistent tissue adhesion in the large vessels without damage of intima(Fig.2).

When this laser vascular anastomosis technique was utilized on the large blood vessels(bigger than 2mm diameter), the stay sutures were required more than three. As one of these reasons, the thermal effects on the longitudinal large collagen fibers are not enough to make an adhesion without damage of intima by CO₂ laser irradiations. The water, which is high absorption factor of the CO₂ laser, distribution study in the vascular wall showed lower water content in and around the longitudinal large collagen fibers than the short small collagen fibers. Therefore, the thermal effects on the large collagen fibers are not enough which compared to small collagen fibers on the laser vascular anastomosis to do without damage on the intima. In fact, in our pathological studies of collagen changes in the anastomosed area, longitudinal large collagen fibers showed loose connection than as seen in the short small collagen fibers.

conclusions

The laser technique for the vascular anastomosis, basically, it is useful on the small vessel anastomosis. And for the large vascular anastomosis by laser technique will be necessary more stay sutures than tree. We clarified the proposal surgical techniques for the

various sized vascular anastomosis and there pathophysiological reasons.

refernces

- 1) Hayschi N, T Tsubokawa, BA Green, F Inaba, and Y Tsuzi; Micro-laser surgery in anastomosis of small vessels and the effect of laser on blood vessels. J Japan Soc Laser Medicine 3(1):587-592, 1982 (J)
- 2) Hayashi N, and T Tsubokawa; Laser technique for the anastomosis of small vessels. J Nihon Univ. Med. 42(2):135-140, 1983
- 3) Hayashi N, T Tsubokawa, y Tsuzi, R Niki, K Kumano, F Inaba and BA Green. Small vessel anastomosis by laser microsurgery. Noshinkei Geka 11(1):17-21, 1983 (J)
- 4) Hayashi N; Water distribution in the vascular wall (no publication)
- 5) J Risteli, Bachinger HP, Engel J, Furthmayr H and Timpl R: Eur. J Biochem. 108:239-250, 1980

Fig.1

Laser energy distribution on the vascular surface and in the vascular wall for the laser vascular anastomosis.

Fig.2

Stay suture techniques for the diffent diameter vessels on laser vascular anastomosis.