研究課題：自由電子レーザーによる尿路結石破砕に関する基礎的研究

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【研究目的】

日本大学電子線利用施設において自由電子レーザー(FEL)を用いた医学基礎実験が可能になり、理論的に特異的な波長のレーザー光を照射することにより、物質固有の現象が誘起される可能性のあることから、尿路結石破砕に利用し、ESWL、Endourology などの従来の治療法の問題点を克服する治療法の開発に結びつけることができるかを検討した。

【研究概要】

① 尿路結石検体に対する FEL 直接照射による形態的変化に関する検討
② KBr 錠剤法により処理された尿路結石検体に対して FEL を照射し、照射前後の赤外スペクトル吸収帯のパターン変化を比較検討
③ 尿細管細胞（培養細胞）に FEL を照射し、照射後の細胞ストレスに関して評価検討

【まとめ】

上記項目①、②に関して実験を終了した。現在③に関して実験進行中である。

FEL 照射にて尿路結石の形態的変化は惹起できなかったが、赤外スペクトル吸収帯のパターン変化を確認した。FEL 照射により、物質固有の現象は誘起され変化をもたらしたと考えた。培養細胞を用いた実験に際しては、可視光〜近赤外の波長を用いて細胞ストレスを軽減させる作用を惹起できるかを検討する予定である。

【研究業績等】

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Experimental and Clinical Study of Holmium: YAG Laser with Adjustable Pulse Duration

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(Keywords: Ho: YAG laser system, laser lithotrypsy, shock wave)

We evaluate more practical pulse duration to disintegrate the stone. We used Heraeus Corporation's SPHINX Ho40 in these study. 1. We measured the total energy to perforate through the stone models by three different pulse duration (150. 300. 600 μsec.). 2. We experimented the energy of each single pulse, power of shock wave. 3. We observed the thermogenesis during the lithotripsy for each pulse duration. The shorter pulse duration was, the higher peak power was. The shock wave was also more effective to disintegrate stones by using short pulse duration. In contrast, longer pulse duration made thermo genesis increase. In Ho: YAG laser, short pulse duration is especially suitable for lithotripsy, and long pulse duration is not suitable, though it is effective in increasing thermogenesis.

Holmium: YAG laser is used for treatment of urolithiasis, transurethral laser ablation for benign prostate hypertrophy and bladder tumor. Pulse duration was fixed in the previous Ho: YAG laser system. We evaluate more practical pulse duration to disintegrate the stone. SPHINX Ho40 (Heraeus Corporation) can change pulse duration freely in the range from 150 μsec. to 800 μsec.

Materials and Methods:

1. We measured the total energy to perforate through the stone models by three different pulse duration (150. 300. 600 μsec.). 2. We experimented the energy of each single pulse, power of shock wave. 3. We observed the thermogenesis during the lithotripsy for each pulse duration. 4. Disintegration effect of Ho:YAG is compared with other lithotrypsy system in clinical cases.

Results: 1. It was possible that it went through in the smallest amount of total energy in fragment by the pulse duration 150 μsec. 2. The maximum amount of energy of the one that pulse duration is short is higher. Though the amount of energy was 12.6V, the amounts of energy with 800 μsec decreased with the pulse duration 150 μsec to 6.46V which was about 40%. 3, The highest temperature was compared when the irradiation of laser was started and finished. The shorter pulse duration was, the higher peak power was. The shock wave was also more effective to disintegrate stones by using short pulse duration. 4. Each clinical success rate is Ho:YAG(85.1%), Alexsandrite (80.6%)and Lithoclast (74.5%).

INTRODUCTION

In 1968, Mulvaney first attempted to fragment urinary stones using a Ruby laser system[1] In Japan, Tanahashi applied continuous wave carbon dioxide laser to disintegrate stones[2] Watson and Dretler developed a pulsed dye laser for lithotripsy (MDL-1) and showed excellent results for the stone disintegration[3]. After that, the Alexandrite laser, which was a crystal laser, was put to practical use[4]. Holmium: YAG laser is used for treatment of urolithiasis[5], transurethral laser ablation for benign prostate hypertrophy[6] and bladder tumor[7]. Pulse duration is fixed on Ho:YAG laser in the present market, and is usually 250-350 μ sec. The aim of this study is to evaluate more practical pulse duration to disintegrate the stones.

MATERIALS AND METHODS

Ho: YAG laser SPHINX Ho 40 (Lisa laser products OHG company) was used as a laser oscillator. This device can change pulse duration freely in the range from 150 μsec. to 800 μsec. Pulse energy can be set up in the range from 0.5J to 3.8J. On the other hand, pulse rate is variable from 8 to 20Hz. The wavelength of laser, which occurs from this device, is 2124nm, and maximum output is 60watt.

1.We measured the total energy to perforate through the stone models by three different pulse duration (150. 300. 600 μsec.).

2. We experimented with the energy of each single pulse, power of shock wave.

3. We observed the thermogenesis during the lithotripsy for each pulse duration.

4. Disintegration effect of Ho:YAG is compared with other lithotrypsy system in clinical cases.

RESULTS

1. Laser was irradiated with the purpose of comparing effect on fragment with pulse duration to the model stones in the water. Laser pulse duration irradiated by using 150, 300, 600 μsec in the calculus model. The time taken to pass through the stones was then measured. The condition of irradiated laser was fixed on 2.0-16.0W 8Hz. The energy needed before going through the model calculus. The shorter the pulse duration, the smaller the amount of energy required to go through the calculus.(Fig 1.) 2. We experimented with the energy of each single pulse, power of shock wave. To compare the occurrence energy of single pulse, photoditector and oscilloscope were used. Following pulse duration was examined 150, 300, 600 and 800 μ sec. Laser was irradiated to photoditector in the water to masure a energy of each single pulse. Fig. 2a shows the occurrence electric potential of each pulse duration recorded with the oscilloscope. The shorter pulse duration was, the higher maximum amount of energy of single pulse was. Fig. 2b show the amount of shock wave energy of each single pulse in the different pulse duration. Laser was irradiated to piezoelectric element in the water to measure an occurrence of the shock wave in each pulse duration. The measurement result of the shock wave energy of the single pulse is shown in this wave. As the pulse duration was long and wave became short, the amount of energy decreased. The amount of energy was

about 40%at 800μsec in comparison with the amount of energy at 150μsec. The shorter pulse duration was, the higher peak power was. 3. We observed the thermogenesis during the lithotripsy for each pulse duration. The quantity of heat which occurred at the time of the model stone disintegration of each pulse duration was compared. A heat way quantity meter was attached to the calculus, and difference in temperature of the calculus after the irradiation was compared with the one before the irradiation of laser in the water tank in each pulse duration. The highest temperature was compared when the irradiation of laser was started and finished. Though the amount of energy was same, the temperature differed by pulse duration. Longer pulse duration caused thermogenesis to increase.(Fig. 3) 4. It is compared with a disintegration effect by other lithotrypsy systems in the clinical cases (Ho:YAG 52 cases. Alexsandrite laser lithotryptor 67 cases. Lithoclast mechanical lithotryptor 114 cases). It was evaluated as a success when fragment was made less than 4mm. Each success rate is Ho:YAG(46/52. 85.1%), Alexsandrite (54/67. 80.6%)and Lithoclast (86/114. 74.5%). The stone disintegration in the clinical cases caused satisfactory results.

CONCLUSIONS

The shock wave was also more effective to disintegrate stones by using short pulse duration. In contrast, longer pulse duration caused thermogenesis to increase. In Ho: YAG laser, short pulse duration is especially suitable for lithotripsy, and long pulse duration is not suitable.

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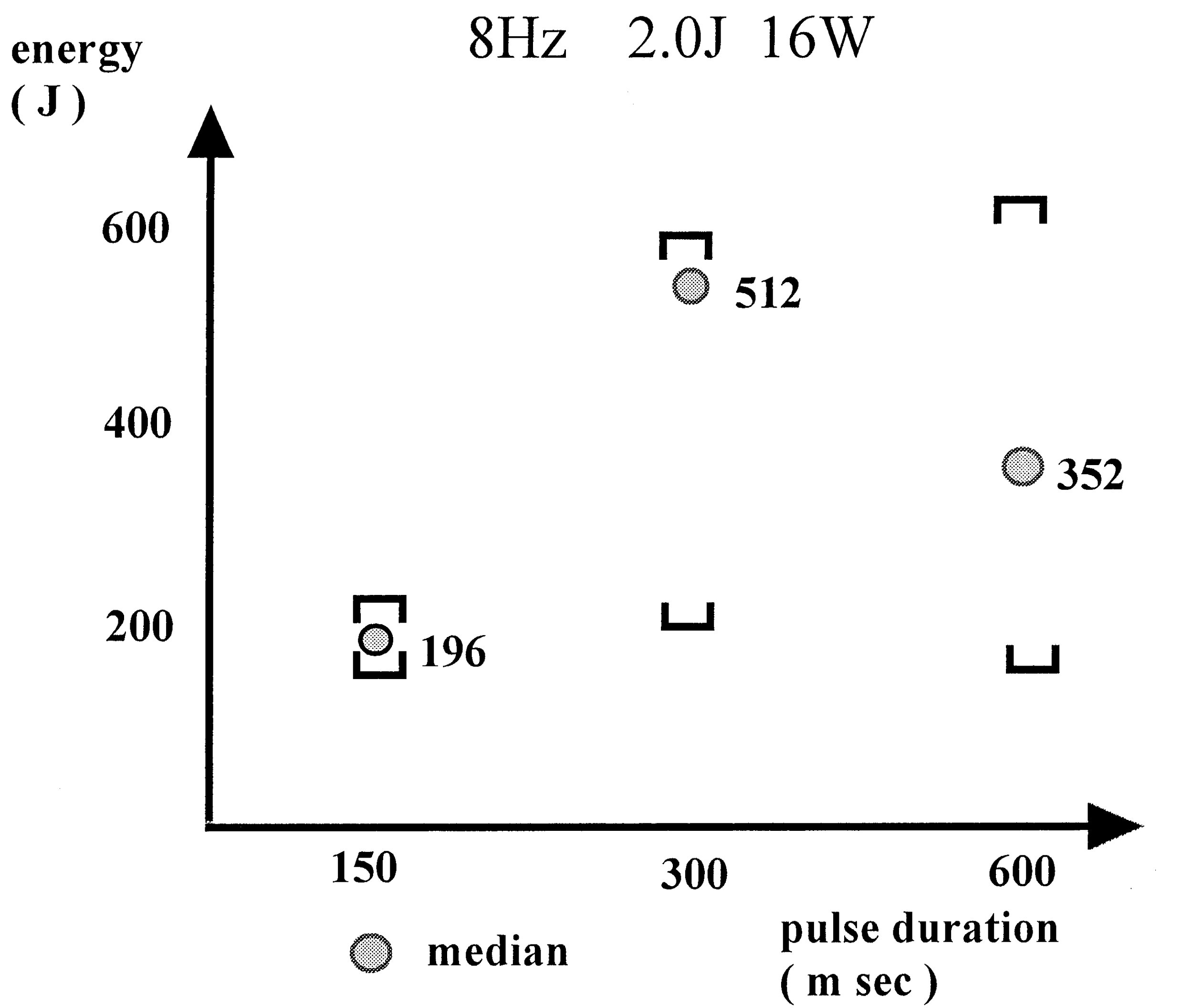
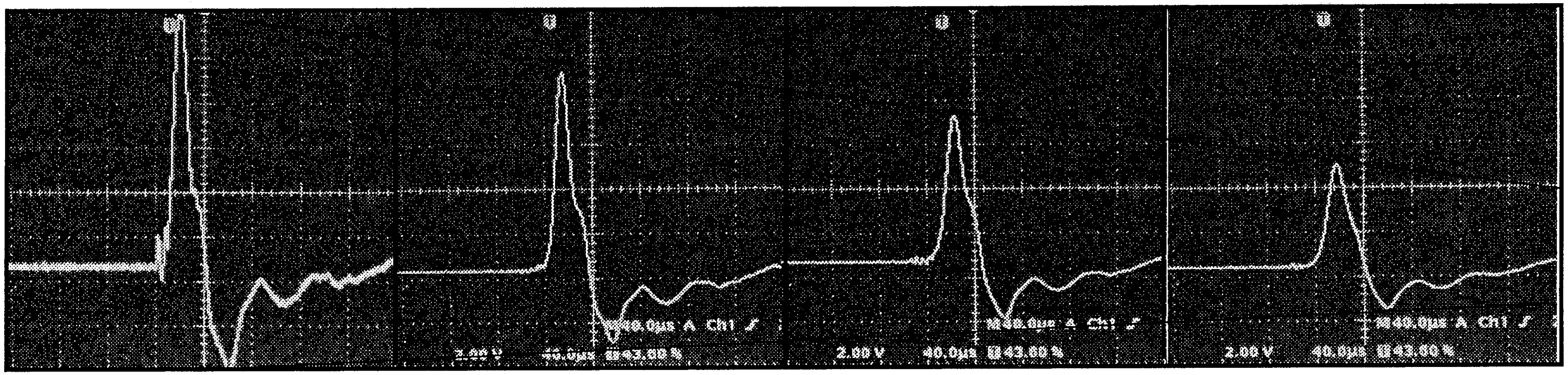


Fig.1 The energy needed before going through the model calculus
It goes through the calculus in the small amount of energy as much as a pulse duration is short.



150m sec
16.2V

300m sec
12.1V

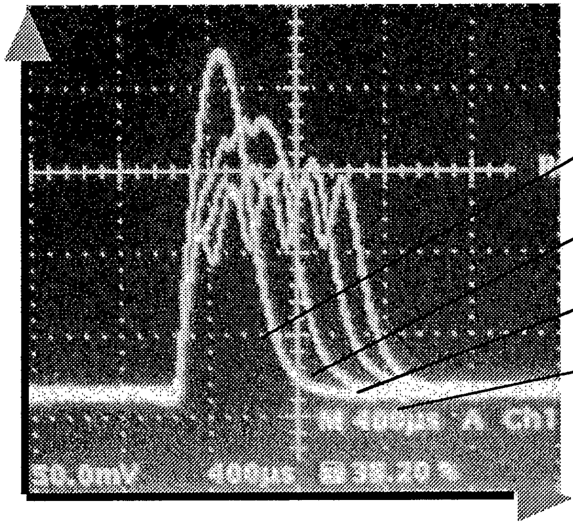
600m sec
9.12V

800m sec
6.46V

Fig.2a

Tektronix digital phosphor oscilloscope

0.5J 8Hz 4.0W



150m sec
300m sec
600m sec
800m sec

Fig.2b

Fig.2 The comparison of the occurrence shock wave of every pulse duration

Fig.2a The maximum value of that energy lowered as much as pulse duration became long.

Fig.2b Though the amount of energy was 12.6V, the amounts of energy with 800μsec decreased with the pulse duration 150μsec to 6.46V which was about 40%.

8Hz 3.0J total 1400J

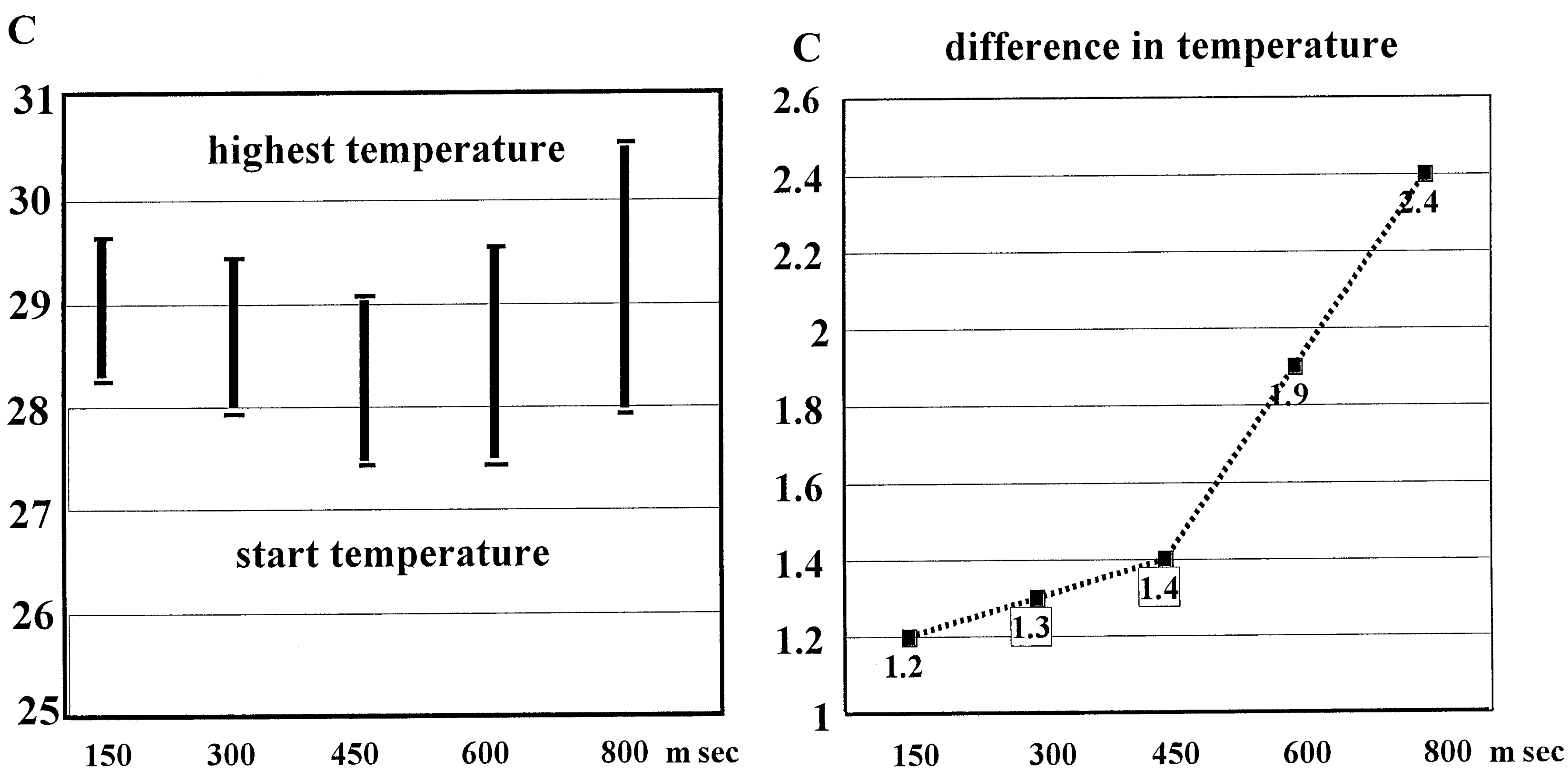


Fig.3 The comparison of the occurrence quantity of heat of every pulse duration
Though the amount of energy was same, changes f the temperature were different by pulse duration.