
Holmium Laser

Medium Power Holmium Lasers in Endourology

Lecture at the seminar "Exchange of Experience", Genova, September 20, 2002

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Introduction

The first laser introduced for endourological applications was the Nd:YAG laser in the early eighties. At that time only the Nd:YAG laser was available with power levels high enough for surgical applications and a wavelength (1064 nm) that could be transferred through highly flexible quartz-fibers necessary for endoscopic applications.

First introduced for many different applications, its main application is still its ability to coagulate relatively large volumes of tissue e.g. when coagulating bladder tumors or genital warts. With additional tricks (blackening of fiber tip, electro optic feedback system "fibertom") it can be used for cutting tissue (e.g. urethral strictures) too, but due to its low absorption in tissue, due to a correspondingly deep penetration and being a continuously emitting laser it shows large thermal side effects, which are not limited to the actual application site, but go far beyond it. The overall benefit of this laser type reduced these side effects considerably.

Any attempts to use this type of laser for lithotripsy failed just as the absorption of the stones was too low or the power transmission capability of the fibers was insufficient when running the laser in the q-switched mode.

1985 the flashlamp pumped dye laser was introduced. Though being effective in destructing different types of stones, these lasers proved out to be expensive tools regarding the initial investment and the running costs as the laser medium, a coloured liquid, had to be changed frequently. Nevertheless, staying competitive a urological clinic of high standing had to offer both laser types.

However, one was hoping the laser industry would be able to offer an affordable laser system based on solid-state laser technology that can be used for a large variety of endourological applications, **with high efficacy and safety in application.**

Holmium Laser

For a couple of years the holmium laser has been offered for **endourological applications**. Its wavelength (2100 nm) is very well absorbed by water. As water is the main constituent of tissue it can easily be vaporized by this holmium laser. As it is a pulsed laser its emission consists of short pulses with a duration of several hundred microseconds. When applied to a high repetition rate a nice cutting effect can be established. Due to its high absorption in tissue and its short pulse duration, the effect of the holmium laser pulses applied is limited to the area close to the tip of the fiber. Nevertheless, it still creates a **small coagulation zone** surrounding the vaporized area thick enough to prevent bleeding in most cases. Furthermore, it has been proved that the water content of urinary stones was high enough to yield enough absorption for destructing all types of stones regardless of colour, composition, and hardness.

The effect of the holmium laser radiation applied is in both cases the same:

A small volume of water irradiated by the laser pulse is rapidly heated up to a few hundred degrees Celsius. The overheated water converts to steam and expands explosively (one can hear a knocking sound) thus taking away parts of stone or tissue. So it is highly efficient because there is no need to vaporize the tissue or stone as a whole but only as a minor part of it. Actually, this photoablative effect can be considered more or less as athermal as the heating effect is definitely limited to the vaporized spot leaving surrounding tissue practically unharmed.

Beyond that, advanced laser systems offer a **variable pulse duration**. When using short pulse durations the lithotripsy capability will be improved, long pulse durations give a pronounced coagulative effect. Therefore, varying energy, pulse duration, and repetition rate, the laser radiation of the holmium laser can be optimized for the treatment intended: lithotripsy, vaporization, and cutting, and even coagulation or LITT. As the tip of the fiber is close to or in direct contact with stone or tissue, surrounding water absorbs reflected radiation and protects adjacent areas.

So the holmium laser proves out to be a safe instrument when applied under direct vision. And beyond that the holmium laser is quite versatile as it can be used for the treatment of stones and different treatment modalities requiring vaporization or coagulation of tissue.

Low-, Medium-, High-Power – What are the Differences?

In general the holmium lasers being on the market can be roughly divided into three categories:

Low-power holmium lasers with power levels of 10 until 20 watt

Their main application is lithotripsy with certain limitations regarding large and/or very hard stones. Due to the concomitant low pulse repetition frequencies (< 12 Hz) and energies (< 2 J) any applications on tissue are protracted and cumbersome. Regarding the investment and the running costs, even low power lasers have to be considered as expensive, especially in view of the application practically limited to lithotripsy only.

High-power holmium lasers with power levels of 60 until 100 watt

These lasers certainly offer more than enough power, quite often in excess of the actual needs. Amongst lithotripsy most applications do not require more than 30 till

40 W apart from the enucleation of the prostate. On the other side only a few centers are able to raise the funds for the initial investment that can be three times more than for low-power lasers. They also will hardly be able to earn the money for the running costs.

As there are up to four laser heads implemented in one case the number of optics is greatly enlarged. The laser beams of all different laser heads have to be joined into one thin optical fiber by additional sets of optics, which have to be kept in precise alignment for proper functioning. In addition the main supply requires high current multiphase connectors that are not available in each operating theatre.

As the power consumption is really high and practically all the electrical power will be converted to heat, even the air conditioning of the operating theatre has to be adapted.

Medium-power holmium lasers with power levels of 30 until 40 watt

Lasers of intermediate power levels seem to be an interesting option between the former cited low- and high-power versions: only slightly higher in costs than low-power systems these lasers **offer a much larger variety of different endourological applications** that are not limited to **lithotripsy** only. They also can be used for all kinds of **hard and soft tissue applications** including even the **enucleation of the prostate**, maybe with minor constraints. Therefore such a system is frequently used.

The electrical supply is in most cases a **standard wall plug**, available in all operating theatres.

Our One Year Experience with a Medium-Power Holmium Laser

Since early 2002 we have been using the Ho:YAG laser AURIGA (WaveLight Laser Technologie AG, Erlangen, Germany). Its maximum power is **30 W** with maximum treatment frequencies of up to **20 Hz**. Additionally the duration of the pulses varies from **200–600 µs** according to the preselected application.

Therefore this system provides **all endosurgical features** such as ablation / vaporization, stone disintegration, cutting, and coagulation. The energy is transmitted via **230, 365, 600 or 800 µm fibres**. Special applicators like side-firing applicators or even **LITT applicators** are available too. No special electrical plugs are needed (**230 V, 16 A, single phase**).

The AURIGA is easily transportable so we are using it in three different operating theatres according to our requirements.

Results

The laser was in use in a twelve months period for the indications as follows:

- 52 ureteroscopic laser lithotripsy
- 10 ureteroscopic tumor treatments
- 18 laser endopyelotomies (LEP)
- 35 laser urethrotomies (LUI)
- 10 bladder neck incisions
- 21 transurethral laser enucleations of the prostate (TULP)

There was no technical failure in any of these cases. Compared to our previous experience with the neodym:YAG laser for management of strictures and tumors the holmium laser proved to be superior regarding ablative as much as incisional capabilities, mainly based on the non-thermal photoablative effect of the device. With the latter laser urethrotomies could be performed under local anaesthesia (lubricant) causing significantly less pain in comparison to the thermal effect of the Nd:YAG laser.

Concerning the **TULP** we were able to enucleate prostatic adenoma up to 120 g, particularly in case of larger glands (> 80 g) this represents a technically challenging procedure. Furthermore, the morcellation using different morcellators has not been satisfying yet. Therefore we currently combine the laser enucleation with a morcellating bipolar resection of the subtotally

enucleated lobes. The advantage of it is the performance of adequate enucleation according to the technique of laser enucleation, but the morcellation is performed with the bipolar resectoscope, also using normal saline as irrigant, thus avoiding any influx (i.e. post-TUR syndrome) even in case of longer operation times (i.e. 120 minutes).

Conclusions

A medium-power laser system like the AURIGA laser proved to be effective in a variety of endourological indications providing an **optimal comfort for the patient** treated **under local anesthesia** only.

Ever since this system has been introduced we didn't use our two other lasers (dye laser, Nd:YAG) anymore. However, regarding TULP further technical improvements might be required (i.e. adequate morcellator).

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