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## **Up to Date in Laser Technology: the "Surgical Laser System"**

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### Premise

The source laser for surgical use goes considered as the heart of a system where the fiber optics the endoscopi, and it manipulates is the other fundamental elements of the " system surgical laser ". The source laser must be choice conoscando the effeti of the cancellation on the woven ones, and in particular way on its main members, in order to obtain effeti of ablation, vaporization, coagulation, trying how much piu possible to maintain the effeti only confined in the woven one that it is wanted to be irradiated. The cancellation laser must veicolare easily through thin fiber optics for being able to only catch up for endo-laparoscopica way otherwise accessible parts of the body with the traditional surgery. The same fiber optics must have various bores, and various geometries d.irraggiamento for poterle introducing in the various operating channels of the endoscopica instrumentation, and in order to execute the various types of treatment. Therefore the fiber optics with the flat, conical endings, to bulb, and the side fiber, they must running be to disposition of the surgeon.

The endoscopici and laparoscopici instruments must be able to use fibers ottivche and to be compatible with the remaining surgical instrumentation (casings, mandrels, luminous optical, sources, arrange of irrigation etc). The endoscopici instruments moreover must have the same ones modalita of use of the other surgical instruments, in such way to allow customary movements to the surgeon. Above all in such endourologia

instrumentation plays an important role, transforming the urological surgery in one not invasive surgery, with excellent results above all for the patients.

We reassume the stages of our research work in the utilization of laser sources in urology:

- In 1989 we have conceived and realized side fiber prismatic (the 1.5).
- In 1990 we have put to point a method of photosensibilization of the calculations in order to induce the formation of plasma and to improve lithotripsy laser (3).
- In 1993 we have conceived "the saw", a uretrotomy in a position to using it is the traditional diathermic handle that the side fiber, or other fiber optics (5.6). Recently the Comeg di Tuttlingen, Germany, have put in catalogue a range of uretrotomy laser, realized on our design. At our first warning all the advent of the diode laser valves the traditional sources did not have requirements adapted for being the ideal source of the "system surgical laser".

### The Diode Laser

The diode laser valve is also CLED (Coherent Light Emitting Diode), derived directly from the technology of the semiconductors, they have very small dimensions, elevated efficiency (> 35 % against 1 % of Nd-YAG), do not need systems of optical alignment, nor of systems of cooling to liquids, therefore they have elevated efficiency and reliability. It was easy with these characteristics to preview that the diode laser valve would have been the craftsmen of the recent technological revolution in action (2), relatively to the realization of laser sources. In fact they are used also like sources of pump for other laser sources, contributing to increase efficiency, the efficiency and therefore to reduce complexity and the dimensions.

- the diode laser power valves are in a position to emitting on a wide range of wavelengths, those of biomedical interest go from 640 to 1100 nm, and into 1940 nm. To the last wavelength the absorption of water and approximately equal to that of the laser to the greater CO<sub>2</sub> and approximately 10 times of the laser to the YAG, and it is possible to use same fiber optics used for the 980 nm.
- In the finalized plan "Elettrotecniche Technologies" of the CNR, in collaboration with the laboratory of the University of Photobiology of Padova, in 1992 we have assembled two diode laser valves coupled to fiber optics with emissions at 780 nm and 815 nm, and powers of 0.6-0.7 W (4); these sources have been used for study of photosensibilizers in the photodynamic therapy of tumors. In 1995 for the clinical use of Zn-cPc and the always in the SnEt<sub>2</sub> of the photodynamic therapy of the tumors, we have assembled one source to diode valves with emission into 670 nm and powers of up to 2 W.

Recently we have assembled one source to diode valves from 15 W with emission into 810 nm.

- In 1994, in sequito to a collaboration with the CeramOptec of Bonn, Germany, we have begun the first studies of fotobiologia in order to characterize the length d.onda piu adapted to realize one surgical source diode valve laser. From un.analisi of the phantoms of absorption from 700 to 1100 nm, dell.aqua, of the venoso and arterial blood, we have inasmuch as intomo to 980 nm the ideal conditions in terms of effectiveness existed on the woven ones, coagultivo effect, and possibilita to work immersed in water. Moreover they were reperibili on the market diode valves laser in configuration MOCVD Quantum Well of In<sub>0.2</sub>Ga<sub>0.8</sub>As type with emission to 980 nm, high efficienza (> 40 %), and high threshold of danneggiamento (7.8.9); such diode valves came gia used for pompare drugged optical amplifiers to erbio. From the phantoms it could be stated that to 980 nm greater l.assorbimento dell.acqua and approximately 3 times that to 1064 nm of the greater Nd-YAG and piu of ten times that to 810 nm, cio, added all.assorbimento dell.emoglobina and dell.ossioglobina have made us to presume that with a source to 980 nm, we could obtain effeti photothermal of coagulation ablation-vaporization nonche with relatively low powers.
- In 1995 CeramOptec it has constructed first sources to diode valves to 980 nm, the Ceralas D50, and subsequently the Ceralas D25. They are realized from un.insieme did iodines integrated with fiber optics of numerical opening of 0,14. The radiazione of the diode valves to 980 nm, with with that one of the diode valves of tracking to 650 nm, and convogliata in a fiber bundle connected in parallel, and comes definitively veicolata to valley of the system, in the utilizzatrice fiber that puo to have diameter of the nucleus (the Cores) from 600 μ to 1000 μ. the Ceralas D do not demand optical alignments, maintenances, ne cooling liquids; D50 and in a position to distributing 50 all.uscita W of a fiber flat, and hung 18 kg, D25 distributes 25 W, and hung 12 kg.

To this point our system surgical laser had the source adapted for considerarsi complete.

#### Preliminary Measures

- We have executed measures on the sources Ceralas D, and measures in vitro on reperti human of various nature, confronting the effeti with other laser (Nd-YAG to 1064 nm, diode valves to 810 nm).
- We have verified that l.assorbimento dell.acqua to 980 nm and approximately 3 times greater that to nm, and piu of 10 1064 times greater that to 810 nm (7.8.9).
- We have irradiated reperti human with the various lengths d.onda, and have measured with one microthermocouple the thermal gradient; on woven muscular and prostatici the thermal gradient to 980 nm he was pressoche constant, and piu was elevated that to 810 and also piu elevated that to 1064nm.
- We have estimated the vaporization threshold, irradiate at a distance with same woven sources on the same ones, to parita of densita of power; the threshold of vaporization of the Ceralas D to 980 nm and be estimated 3-4 times inferior that to 810 and 1064 nm.
- We have estimated that the coagulated woven volume of, using one interstiziale fiber, to 980 nm and 8 times greater that 1064 nm (9). Such result puo not to be

explained single dall'assorbimento dell'acqua, but puo to explain itself if account of the effects of absorption of several the cromofori added to the effects of present absorption dell'acqua in high percentages in the dealt woven ones is kept

- We have verified moreover that l'efficacia of the cancellation to 980 nm it does not vary to varying of the arametri optical of various nature, cio facilitates is the standardizzazione that l'uso of the laser in the surgical procedures.

## Clinical Experience

We have executed 104 surgical participations in urologia, using the Ceralas D50 and the Ceralas D25, shared cosi: neoplasie of blister (16), neoplasie of lowlands and high escrettrici ways with percutaneo and transuretrale approach (14), endopielotomie (4), stenosi uretra (28), stenosi neck blister (8), stenosi to uretere (6), VLAP prostathe (22), resezioni of tumors of kidney (6).

- For the treatments laser of the low escrettrici ways we have used resettoscopio the Comeg laser to continuous flow from 27 ch. mod. Guazzieri, with fiber optics from 1000  $\mu$ , powers from 10 to 14 W; the be used maximum power and of 24 W for the VLAP with orbital fiber. - For the stenosi dell'uretra, and the endopielotomie with percutaneo access, we have executed recordings utilizzabndo resettoscopio the Comeg laser mod. They pay from 15,5 ch. with conical fibers from 600  $\mu$ , and powers of 5-8 W.
- For dealing the neoplasie and the stenosi to dell'uretere, the endopielotomie with uretrale access, we have used ureteroscopi rigid, and flexible, with operating channels from 3,5 to 4 ch. and using conical fibers from 600  $\mu$ , with powers of 4-6 W.
- Thanks all'efficacia of the cancellation on the woven one with fibers from 600  $\mu$ , have been sufficient powers of 4-8 W, obtaining cosi, operating emergency, minims carbonizzazioni and minimums thermal damages to the surrounding woven ones; moreover l'ecellente coagulativo effect has allowed to execute the procedures in field esangue, with certain advantages during and after the participations
- In order to execute the resezioni we have used to contact conical fibers, that they allow to irradiate is that laterally all tip of the fiber
- In order to obtain ablations, vaporizations. and coagulations we have used with procedures to contact, and not to contact, fibers with flat, orbital endings, and the side fiber of rifrattivo-prismatico type.
- For the resezione of tumors on the parenchima renal, we have used conical and orbital fibers from 1000  $\mu$ , using powers from 10 to 12 W. and conical fibers from 600  $\mu$  with powers of 5-6 W.

## Conclusions

- Our " system surgical laser " and state completed with l'arrivo of sources to 980 diode valves to nm Ceralas D, than with to resettoscopi the laser of the Comeg, and to fiber optics with various geometries d.irraggiamento, has allowed us to

- execute beyond 100 participations in urologia with absence of sanguinamenti, limited thermal damages, nonche emergency and semplicita operating
- In agreement with our forecasts, the woven cancellations to 980 nm introduces un.assorbimento elevated on, the 3-4 times greater that with the diode valve to 810 nm and the Nd-YAG to 1064 nm, maintaining enable it are of modulating the effects, than to work immersed in water like happens in Urologia.
  - Retrodanni thermal on woven succesivi the all.irraggiamento. Coagualtivo L.effetto and state of great aid above all in the participations with unprovided endoscopici instruments of the continuous flow.
  - L.efficacia of the cancellation to 980 nm, does not vary to varying of the optical parameters of woven
  - Thanks to the low levels of power used in order to execute the participations, the used fiber optics has not endured appreciable danneggiamenti to their endings
  - In synthesis the really effective Ceralas revealed D and, resettoscopi the Comeg has contributed remarkabably to the operating semplicita one, nonche to the precision of the treatments laser the various bores and various geometries d.irraggiamento of fiber optics hanoo allowed to use the various endoscopici instruments and of effectively mmodulare l.irraggiamento on the woven ones. Concluding, the contribution of every element of our " system surgical laser ", has allowed to raise the qualitative level of beyond 100 treatments executed in urologia, above all in terms of invasivita minim for the patients, and of operating emergency and semplicita for the surgeon.

In the Ceralas D, and possible to veicolare in the single utilizzatrice fiber, it is the cancellation to 980 nm and for that one of the laser of tracking to 650 nm. Therefore puo to conceive itself to realize a diode valve laser with piu lengths d.onda, and as an example to use the cancellation to 1940 nm for having cut effects on the woven ones, like laser CO2, with with the cancellation to 980 nm that it has a good coagualtivo effect. Sara therefore possible to realize a source diode valve laser with 25 W to 980 nm, 10 W to 1940 nm, for being able to execute the photothermal surgery, and 2 W to 670 nm that they will be able to serve is like tracking laser that in order to execute the fotodinamica therapy of the tumors; these sources diode valve laser multifrequencies, will be moreover small, reliable and simple to use.

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