EXPERT COMPUTER PROGRAM FOR THE MANAGEMENT OF LASER SURGERY

Hugo Juri [1], Marcelo Rubio [2], Alejandro Germanier [2] Darío Sbarato [2]

[1] Cátedra de Informática Médica, Fac. Cs. Médicas. Universidad Nacional de Córdoba.
[2] Facultad de Matemática, Astronomía y Física. Universidad Nacional de Córdoba.

SUMMARY

Since 1960 when the first laser was produced, different types of lasers were developed and over one hundred of them are actually used in medicine. These facts makes very difficult for a surgeon to optimally utilize different types of laser in varying surgical circumstances, unless a laser expert is actual'y participating in the procedure. As this presence is impractical, if not impossible in every case, we are offering a computer program which presents information in a flexible and friendly way; it is self perfecting and greatly expandable.

Key Words: Laser surgery - Expert System.

INTRODUCTION

Soon after the first functioning laser was presented by Theodore Maiman in 1960, a large number of lasers were available for different uses [5].

Lasers were introduced early in experimental [7, 16] medicine but was not until 1972 that Isaac Kaplan [15] developed the first practical "light scalpel", the CO_2 Sharplan Surgical Laser. Since then only eighteen years have passed but over one hundred types of lasers were introduced in medicine, and thousands of lasers are actually used in operating rooms in over one hundred countries around the world.

We started our work in 1978 [8] with a CO_2 laser and since then we have investigated with all major surgical lasers [9, 11, 17, 19, 20] that is, Argon and Neodimium-Yag along with CO_2, as well as other medical lasers including He-Ne, Diode, Gallium Arsenide and Argon pumped Dye laser [1, 3, 12, 13].

Each one of these lasers offers different wavelengths that, depending upon other laser parameters such as power, focal point, etc., will react differently in contact with the tissue [4, 6].

At the same time, the optical and caloric parameters of the tissues, as are their colors, content of inorganic material, refrigeration by their blood supply, tissue density, etc., will modify the effect of laser on them.

All these variables need to be described in biophysical terms as: power density, energy density, light extinction, thermal degradation and thermal distensibility, which depend on power measured in Watts, energy in Joules, focal Joules, focal point, caloric profiles, etc.

Unless the surgeon has a thorough knowledge of these parameters, it is impossible to operate correctly the laser in real time without the help of a laser expert on site.

The later is becoming impractical-if not impossible, with the wide proliferation of lasers in the operating room.

As it is not possible to offer this widely variable information in the form of a book or tables, we are presenting an "expert" computer program of friendly operation with an easy language, which is self perfecting (learn from experience) and expansible.

This program is to be used and discussed by the surgeons prior or during the surgical procedure, along with

the other surgical data, such as medical imaging, laboratory, patient history and physical, etc.

MATERIAL AND METHODS

The software consists of a "shell" which once fed with information is capable of informing the surgeon about the type of laser, power setting and time of use for any specific situation. The lenguage used is Basic or Pascal and can run with any PC or can be added as feature to the laser equipment.

The information to be introduced in the shell are: 1) caloric profiles produced by each laser, with progressive power setting and progressive time settings (eg. Nd-Yag, 1060nm. 5W, 1 sec. to 10 sec.; then 10W, 1 sec. to 10 sec. and so on until reaching 100W, 10 sec.). The targets are, a) in vitro: bovine tissue; b) animal experiments; c) surgical procedures under expert control (Examples: bovine liver in vitro, porcine liver on animal experiment, human liver biopsy in surgical procedure under expert control). The different types of lasers are shown in Table I.

Table I. Different types of Laser used.

THE LASERS USED ARE:
1) A CO_2 LASER 10W. CW*
2) A Nd-Yag LASER 1060 nm, 100W. CW.
3) A Nd-Yag LASER 1320 nm, 100W. CW.
4) A ARGON LASER 5W. CW.
5) A ARGON LASER 10W. CW.

* CW means continuous wave

The temperatures are measured with fine thermocouples that measure temperature differential of 0.2 grades centigrade introduced in the tissue and the caloric profile is produced by a computer program previously developed by our group [14].

The number of tissue variables to be analyzed are limited; i.e: Tissue Density: above normal, normal, less than normal. The most important variables are the type of tissue, temperature, color, vascularity, density, distance to vital structures and type of laser use: incision, evaporation, etc.

Other information to be introduced is: 2) Published information. Research, scientific work and experiences published in the literature on the subject and available by the usual international scientific electronic links.

Also, every year the users experience –good and bad– with the set of parameters, and new information of world literature will be reintroduced to change the old knowledge. This fact transforms this expert system in self perfecting.

The expert system has in fact a rule construction analogous to Mycin [18] with IF "event"...THEN "action" rules that are entered in fairly natural way as may be seen in Table II.

Table II.

EXAMPLE OF SET OF RULES OF THE EXPERT SHELL	
IF	THE TISSUE IS BRAIN
AND	THE COLOR IS NORMAL
AND	THE BLOOD SUPPLY IS NORMAL
AND	THE DENSITY IS INCREASED
AND	VITAL STRUCTURES ARE AT MORE THAN 1 mm LESS THAN 2 mm
THEN	A CO_2 LASER IS TO BE USED

The knowledge base consists of a range of different elements, including "identifiers" (e.g. organs - diagnostic attributes), "facts" (values which are always true, e.g. laser power or wave length), "rules" (Table II), "questions" (the texts needed to extract information from the eventual user, e.g. liver irrigation: above normal, normal, below normal, choose one) and "defaults" (values used if information is not forthcoming).

Table III shows an example of a liver incision running.

Table III.

INPUT: **Liver incisión.**
QUESTION: TYPE OF TISSUE:
A) Normal.
B) Cirrhotic.
C) Atrophic.
D) Local tumor (Hepatoma).
E) Chronic Hepatitis.
INPUT: **C (Atrophic)**
QUESTION: Vascularity:
A) Highly vascular.
B) Moderately vascular.
C) Poorly vascular.
INPUT: **B (Moderately vascular)**
QUESTION: Type of laser action:
A) Incision.
B) Evaporation.
C) Resection.
INPUT: **A (Incision)**
QUESTION: Margins free of vital organs:
A) more than 1 cm.
B) less than 1 cm more than 1 mm
C) less than 1 mm.
INPUT: **B (Less than 1 cm more than 1 mm)**
ANSWER: Nd-YAG — 60 w — non contact — advancing the laser beam 1 cm each 2 seconds (120 J/cm^2).
INPUT: **CO_2? Ar?**
ANSWER: NO.
INPUT: **Why?**
ANSWER: Ar: Maximum penetration 1 mm, great scattering, lesion more than 1 cm at edges.
CO_2: Great precision, but poor hemostasia (only seals vessels less than 1 mm).
INPUT: **Experience.**
ANSWER: A comparative study between Nd-Yag and conventional liver incision. Sultan et. al. Am. J. of Surg. 19 (62-67) Nov. 1992. Less hemorrhage using Nd-Yag. Less Post op. morbidity.

DISCUSSION

Since the first specifically medical application of Artificial Intelligence - Mycin 1976 by Shortliffe, and the development of its associated program TEIRESIAS, great changes in hardware and software technologies have helped to develop the basic anatomy of an expert medical system, separating its knowledge base from the part of the system that actually uses the knowledge to solve problems - the so called "inference machine", in time the base of a "Shell" program.

With its base, many medical expert systems have been developed as CADIAG-Oncocyn, PUFF, and others.

But only few expert surgical systems (Plastic surgery profiles, Orthopedic surgery prosthesis fitting) [2], could be developed, because of the obvious need of special surgical dexterity.

The influence of physics and mathematics in modern surgery (Laser surgery, Radio surgery, Lithotripsy by shock waves, and so on), makes indeed necessary a larger and more complex knowledge base for the surgeon, due to the fast technological developments that undergo continuous changes.

These facts make necessary the development of an expert surgical system to offer computer-based knowledge assistance to the laser surgeon, been this the first expert system on laser surgical technics.

The system needs to be fully developed and practically tested, and improvements will necessarily came trough its "learn from experience" capability.

RESUMEN

Desde que fue producido el primer laser a principios de 1960, diferentes tipos de laseres fueron desarrollados y de éstos una centena son usados actualmente en medicina. Este hecho hace que para el cirujano sea muy dificultoso utilizar de manera óptima los diferentes tipos de laseres, en variadas circunstancias quirúrgicas, sin la asistencia de un experto en laser durante el procedimiento. Como esta presencia es impráctica, sino imposible, proponemos ofrecer un programa de computación, que brinde la información en forma flexible y cómoda. El programa será perfectible y ampliamente expandible.

REFERENCES

1. Avila R, Zamar M, Juri H, Fabro S P de: Effect of He-Ne Laser Radiation on Chick Embryo Mesonephros. J Clin Laser Med Surg 10: (4) 287-290, 1992.
2. Ellis D: Surgery in Medical Computing and Applications. John Wiley and Sons, New York, Chichester, 1987, p. 207-213, 1 st. ed.
3. Fiol M, Rubiales S, Stut G, Juri H, Lacuara J: Comparison of the Effects of He-Ne and Nd-Yag Laser Radiation on Mitotic Activity of Meristema Tic Cell of Allium cepa L Bulbs. Clin Laser Med Surg 8: (4) 35-38, 1990.
4. Fisher J: A Short Glossary of Laser Terminology for Physicians and Surgeons. J Clin Laser Med Surg 9: (5) 345-349, 1991.
5. Fuller T: The Physics of Surgical Lasers. Laser in Surgery and Medicine 1: 5-14. 1980.
6. Fuller T: Fundamental Lasers in Surgery. Surgical Applications of Lasers (year book of Surgery). 11-28, 1983.
7. Gameleya F: Laser Biomedical Research in the URSS. In: Wolbarsht M L (ed) Laser applications in Medicine and Biology vol III. Plenum Press, New York and London, 1977, pp 1-173.
8. Juri H: CO_2 laser in decubitus Ulcer. Lasers in Surgery and Medicine. 7: (4) 296-299, 1987.
9. Juri H: Feasibility of Clinical use of Yag laser in treatment of Lumbar disc disorders. J Blood Med Surg 5: (3) 5-6, 1987.
10. Juri H, Palma A: Laser Beam in Surgery. J Blood Med Surg 3: (2) 65-66, 1985.
11. Juri H, Palma A: The CO_2 laser in treatment of decubitus Ulcer. J Neurological and Orthopaedic Surgery. 7: (2) 29-35, 1987.
12. Juri H, Palma A: Helium Neon effect of Laser Radiation in Rats infected with thromboxane B. Spie 1422: 128-135, 1991.
13. Juri H, Palma A, Frank F: Na^+ - K^+ Transport - Cotransport and Cell volume of Rat eryhrocytes Submitted to He-Ne Laser Radiation. Proceedings of the 7th Congress Int Soc of Lasers, Munich, 707, 1987.
14. Juri H, Rubio M, SSbarato R, Germanier A: A Comparative Study Of Caloric Pro-

files Produced by Nd-Yag Laser Radiation and Infrared Incoherent Light on an Experimental Bovine Tissue. J Clin Laser Med Surg (in Press).

15. Kaplan I: The CO_2 Laser in Clinical Surgery: Past, Present and Future. J Clin Med Surg 9: (5) 341-345, 1991.

16. Kavetskiire: Lasers in Biology and Medicine. Zdorov'e, Kiev, URSS, 1989, pp 3-13, 1 st ed.

17. Lapin R, Juri H: Cavernous Hemangiomas of the Liver. J Blood Med Surg 8: (1) 27-30, 1991.

18. Shortliffe E H: Computer Based Medical Consultations. Mycin, New York, Elsevier/North Holland, 1976, 1 st ed.

19. Skobelkin O: Aportes e Investigaciones. Centro Nacional de Utilización de Láseres en URSS. En: Medicina y Cirugía. Juri H (ed). Ed Salvador, Argentina, 1990, pp. 283-350.

20. Skobelkin O K, Ryabov V, Litwin G, Juri H: Comparative Study of Nd-Yag laser Applications in Surgery of Pancreato Biliary System. J Blood Med Surg 8: (1) 42-43, 1990.