

Leonardo Longo

LASER MANUAL

Volume I

MEDICAL TECHNOLOGY



Officina Editoriale Oltrarno

Laser Manual
Medical technology
Leonardo Longo

Design by:
Davide Di Maggio

Lay-out:
Valter Nocentini

Photos (edited) by:
Leonardo Longo

Drawings edited by:
Officina Editoriale Oltrarno S.r.l.

Printed in 2014 by:
Tipografia Il Ponte - Reggello (Fi)

For:
Officina Editoriale Oltrarno S.r.l. - Firenze
<http://www.oeofirenze.it> e-mail: info@oeofirenze.it
Copyright © 2014
Officina Editoriale Oltrarno S.r.l. - Firenze

This book is protected by copyright. No part of this book may be reproduced in any form or using any means, including photocopy, or used by any other means of information. The publishing company reserves the right to promote, in its own interest, legal action against those who arbitrarily do not adhere to this regulation. Moreover, the editor, authors and publisher are not responsible for errors or omissions or for any consequences of the application of the information in this book, and do not guarantee, expressly or implicitly, the totality, exactness and completeness of the contents of the publication. The application of this information remains the professional responsibility of the physician.

The Publisher

Leonardo Longo

LASER MANUAL

MEDICAL TECHNOLOGY



Officina Editoriale Oltrarno

PREFACE

Almost thirty years have passed since I wrote my first book on laser therapy. Then lasers were known mostly as surgical instruments while the non-surgical effects were being experimented exclusively in eastern Europe and Japan, and almost ignored by the rest of the international scientific community.

Now the world research scene has changed profoundly: after the arrival of Clinton and his health reform the United States also discovered that lasers are not only a surgical instrument and they are finally demonstrating “scientifically” that they can also be very useful for regenerating tissue and as an anti-inflammatory and analgesic, together with or even as a substitution for many drugs.

The fact that lasers can be used as diagnostic instruments and as a means of therapy and surgery would justify the institution of a new specialization that could be called “Laserology” (but this term has already been copyrighted in the USA) or “Medical Laser Technology”.

This would allow optimization of the intellectual and economic resources since the same instruments could be used and experimented in the most diverse sectors of medicine and surgery.

The time is now ripe for this step, just as happened years ago for X-rays and radiology.

The World Federation of Societies for Laser Medicine and Surgery is proposing a master’s in “Laserology”, but it is still meeting with little interest by other international institutions.

This manual proposes to be the base for “Medical Laser Technology”, where we attempt to describe and simplify the fundamental concepts of physics, biology, histology, medicine, surgery that justify the use of laser on the human body. We also describe elements of animal research, never an end in itself, but projected to understanding the mechanisms of these radiations on the different biological tissues.

We have tried to take a practical approach to the whole volume: not endless theoretic and bibliographic quotes but a few basic elements for everyday practice. The authors and editor intend to follow up this basic manual with a series of specialized manuals, written by pioneers in the material and made extremely simple and comprehensible precisely from the study of this “basis”.

Hoping we have created something positive, I have only to wish all my readers “good work”.

Leonardo Longo

GENERAL INDEX

Preface	3
Chapter 1 - Generalities	13
L. Longo	
History	15
Organization of the research	16
Principal physical characteristics	18
Natural light sources and laser sources	22
Laser sources	22
Mechanism of laser emission	22
Types of lasers	24
Dosimetry	26
General indications	28
Precautions	31
Effects of laser radiation on the eyes	31
Effects of radiation on the skin	33
References	34
Chapter 2 - Laser / Biological Tissue Interaction	35
L. Longo	
Absorption and light penetration	37
Biological effects	47
Histological effects	51
Energetical effects	58
Biochemical effects	59
Surgical effects	61
References	64
Chapter 3 - Laser physics for Biomedical applications	65
M. L. Pascu	
Introduction	67
Laser definition and principle of operation	69
Properties of the laser radiation	81
Monochromaticity	81
Coherence	83
Directionality	84
Brilliance	89
Polarization	89
Useful information for practical applications	90
Annex 1	90
Annex 2	91
Annex 3	99
References	100

Chapter 4 - Laser Beam Interaction With Tissues **103**

M. L. Pascu - M. Romanitan - M. Burcea

Introduction	105
Laser medical equipment structure	106
Basic elements about the laser beam – tissue interaction	113
Dose calculation for laser irradiation	114
Physical processes characterizing the laser beam penetration into the tissue	115
References	122

Chapter 5 - Broadband visible light for therapy and sterilization purposes **103**

R. Lubart

Introduction	125
Broadband visible light for therapy	126
Broadband visible light and sperm cells	126
ROS modulate sperm function	126
Visible light-induced ros production in sperm cells	126
Increased human sperm penetration ability following visible light irradiation	128
The effect of visible light irradiation on human sperm motility	128
Broadband visible light and wound healing	128
The effect of broadband visible light on no formation in endothelial cells	128
Broadband visible light induces healing of diabetic or venous foot ulcers	130
Broadband visible light and mesenchymal stem cells	130
Effect of broad band visible light on msc proliferation	130
Ros production by msc cells following illumination with broad band visible light	130
Broadband visible light for killing cells	132
Visible light and pathogens	132
Broadband light-induced bacteria destruction	132
Ros production by pathogens following illumination with broad band visible light	134
Broadband visible and oral mucositis.	134
The efficacy of broadband visible light for the prevention of oral mucositis	135
Summary	135
References	136

Chapter 6 - Trends in basic research on laser biomedicine **139**

M. L. Pascu - A. Militaru - M. Boni - V. Nastasa - T. Alexandru - A. Staicu - I. R. Andrei

Introduction	141
Laser beams interaction with microdroplets	142
Unresonant interaction of laser beams with microdroplets	142
Introduction	142
Experimental set-up	144
Results	145
Interaction of the laser beam sent in the equatorial plane of the	

droplet and focused in its geometrical centre.	148
Interaction of the laser beam incident on the droplet in the equatorial plane, and focused on the front surface.	150
Interaction of the laser beam incident on the droplet in the equatorial plane and focused on its back face	155
Conclusions on the unresonant interaction of laser beams with distilled water droplets	156
Resonant interaction of laser beams with microdroplets	156
Conclusions on the resonant interaction of laser beams with microdroplets	162
Molecular modifications of medicines by exposure to laser radiation	162
Phenothiazine studies	163
The experimental set-up and the associated measuring systems	165
Results	167
Bioactivity of the irradiated cpz and cpz products	171
Acknowledgements	177
References	178

Chapter 7 - Laser induced fluorescence in biomedicine **183**

M. L. Pascu - R. Pirvulescu - M. O. Romanitan - A. Smarandache

Introduction	185
Effects of laser – tissue interaction	189
Photochemical interactions	189
Photodynamic therapy (PDT)	189
Photobiostimulation	193
Thermal interaction	195
Photoablation	199
Plasma – induced ablation	200
Photodisruption	201
Laser induced modifications in drugs: spectroscopic study.	202
Materials and methods	202
Results and discussion	207
Mtx and 5-FU	207
Polidocanol	217
Conclusions	220
Laser induced autofluorescence used to differentiate normal tissues from tumor brain tissues	222
Introduction	222
Materials and methods	222
Sample preparation	224
Experimental set-up	224
Results	227
Discussion	240
References	242

Chapter 8 - General Indications **249**

L. Longo

Diagnostic lasers	253
Non-surgical laser therapy	257
Photodynamic cleansing and sterilization of sores	263
Laser surgery	265
Effects of pulsed light and leds on biological tissues	270
Contraindications	274
References	275

Chapter 9 - Laser Safety: Keys to Compliance **277**

P.J. Smalley

Risk Management Step One: Knowledge of Standards, Regulations, and Practice Guidelines	280
Risk Management Step Two: Identification of Hazards and Risks	281
Risk Management Step Three: Implementation of Control Measures	283
Establishing Control Measures	283
The Laser Safety Officer	284
Procedural Control Measures	285
Controlled Access	285
Ocular Hazards and Protection	287
Ocular Hazards	288
There is no such thing as an “eyesafe” Class 3b or Class 4 laser!!!	289
Flammability and Reflection	290
Testing and Calibration	291
Electrical Hazards	292
Airborne Contaminants	292
Risk Management Step 4: Audit of the Safety Program	293
Observation is more effective if done without prior notification	296
Risk Management Step 5: Education and Training	296
Documentation	297
References	298