Ain Shams University
Faculty of Medicine

New trends in application of laser in general surgery

An Essay submitted to fulfill master degree of general surgery

By

Basem Mohamed Abdelazim Gharib Abdelrahman

MBBCH

Supervisors

Prof. Dr. Awad Hassan Elkayal

Prof. of general surgery

Ain-shams University

Dr. Mohamed Ibrahim Hassan

Lecturer of general surgery

Ain-shams University

Dr. Ebrahim Mohammed Elzayat

Consultant of general surgery

Mansoura International Hospital

AIN-SHAMS UNIVERSITY

2016

ACKNOWLEDGEMENT

First and foremost thanks are due to **ALLAH** the beneficent and merciful of all.

I would like to express my deep gratitude and appreciation to ***Prof. Dr. Awad Hassan Elkayal, Prof. of general surgery, Ain-shams University,*** for his continuous help and unlimited support.

I am greatly indebted and grateful to ***Dr. Mohammed Ibrahim Hassan, Lecturer of general surgery, Ain-shams University,*** for his continuous encouragement to bring this work to the attempted goal.

I'm also thankful to ***Dr. Ebrahim Mohammed Elzayat, Consultant of general surgery, Mansoura International Hospital,*** for his help and advice.

Basem Mohamed Abdelazim Gharib

2016

LIST OF ABBREVIATIONS

BCC	Basal cell carcinoma
CABG	Coronary artery bypass graft
CC	Cholangiocarcinoma
CR	Complete response
CT	Computed tomography
CW	Continuous wave
ECT	Electrochemotherapy
EP	Electroporation
ERCP	Endoscopic retrograde cholangiopancreatography
EVLA	Endovenous laser ablation
GaAs	Gallium arsenide
GOJ	Gastro-oesophageal junction
GSV	Great saphenous vein
HAL	Hemorrhoidal artery ligation
HCC	Hepatocellular carcinoma
HeNe	Helium-neon
HIFU	High intensity focused ultrasound
IH	Infantile heamangimas
IL	Interleukin
ILT	Interstitial laser thermotherapy
IR	Infrared

KTP	Potassium titanyl phosphate
LA	Laser ablation
LA	Laser angioplasty
MCF-7	Michigan cancer foundation - 7
MRI	Magnetic resonance imaging
MTZs	Microthermal treatment zones
Nd-YAG	Neodymium-doped yttrium aluminium garnet
PDL	Pulsed dye laser
PDT	Photodynamic therapy
PW	Pulsed wave
PWS	Port wine stains
RFA	Radiofrequency ablation
ROS	Reactive oxygen species
SCC	Squamous cell carcinoma
SCCIS	Squamous cell carcinoma in situ
SVG	Saphenous vein graft
THD	Transanal hemorrhoidal dearterialization
UV	Ultraviolet

CONTENTS

List of Figures

ABSTRACT

Lasers have many applications in general surgery. In hepatobiliary surgery, laser are used for percutaneous lithotripsy using the holmium:YAG laser for patients with primary hepatolithiasis, laser laparoscopic cholecystectomy, and interstitial ablation for hepatic tumours including hepatocellular carcinoma, and colorectal liver metastases.

Photodynamic therapy is used for hilar cholangiocarcinoma where a photosensitizing drug known to preferentially accumulate in tumor cells is administered, and the tumor is exposed to nonthermal laser light of the appropriate photoactivating wavelength after a time interval required for the drug to accumulate in tumor tissue.

In anorectal surgery, the hemorrhoidal laser procedure ‘‘HeLP’’ technique is a new surgical procedure where the closure of terminal branches of the superior rectal artery is achieved by means of a laser beam. In anal fistula, complete excision of the fistula track with subsequent repair of the sphincter muscle was performed where laser use results in minimal trauma to the sphincter muscle resulting in minimal trauma to the sphincter muscle with a reduced risk of developing troublesome fecal incontinence.

Keywords: New Trends, General Surgery and Laser.

INTRODUCTION

Since 1967 the introduction of the first co2 laser, many application have been proposed for laser technology in general surgery. Always with abundant optimism but often with poor success. Obviously laser is infrequently employed by the general surgeon, a fact due to the cost of the devices and satisfactory performance of electrocautery ***(Evrard, 2010).***

Laser light has unique properties that enable transmission oh high amounts of energy to a narrowly defined site. Now recent understanding of laser tissue interaction favors the development of new systems designed for specific medical applications ***(Parrish and Wilson 2011).***

Biological effects may be thermal, chemical or mechanical. Medical procedures involve mainly thermal tissue destruction by coagulation (>60 degrees c) or ablations (>300 degrees c). The effect is governed by tissue optical and thermal properties and laser variables: contact / non contact, focus, output power (W), and exposure time (s). The laser medium governs the wave length emitted ***(Van Hilleger Sbergr, 2012).***

The Co2 laser light (10600nm) requires transmission through articulating arms with mirrors where as Nd: YAG (1064nm), and argon (4881515nm) light can be transmitted through flexible quartz fibers. Co2 laser are used mainly for Precision tissue ablations; Nd: YAG laser can coagulate or Vaporize Larger tissue areas and argon laser applications involve vascular destruction, based on selective absorption by hemoglobin ***(Van Hilleger Sbergr, R 2012).***

Current clinical applications of lasers in general surgery are presented in two sections. The first section deals with conventional incisional surgical access laser techniques. The second section deals with the fast and rapidly growing endoscopic access laser surgical techniques, or minimally invasive endoscopic gastrointestinal laser surgery. Such clinical applications: laparoscopic Laser cholecystectomy, common bile duct stones, pancreatic resection, bleeding peptic ulcer ***(Hunter 2010).***

Now Laser can be used for inoperable bleeding cases and obstructing colorectal carcinomas management ***(Brunetavd, 2011).*** Recently, laser can be used with effective results in management of varicose veins ***(Callam, 2011).***

AIM OF WORK

To review updates in application of laser in surgery and its effectiveness results and reduction of postoperative complications.

OVERVIEW

Definition

Laser is an acronym for Light Amplification by Stimulation Emission of Radiation. Lasers are sources of high-intensity, monochromatic light that can be employed in the treatment of a variety of diseases depending on the wavelength, the pulse characteristics, and the true irradiance of the laser being used and the nature of the clinical condition being treated. ***(Dover et al., 2010).***

History

No one realized the potential of the laser until 1954, when practical research turned the theory into reality. Arthur L Schawlow, PhD, a researcher at Bell Laboratories, Murray Hill, NJ, and Charles H Townes, PhD, a consultant to Bell Laboratories, proposed that if atoms are stimulated in a specific active medium inside a laser cavity, photons will multiply at an accelerated rate ***(Andersen, 2011).***

Schawlow and Tomes theorized that the stimulation alone would not be effective unless a condition called population inversion occurred. If out of several million atoms only a few atoms are excited ***(Andersen, 2011).***

Schawlow and Townes determined that the greater the percentage of electrons in the excited state, the greater the probability of stimulated emission ***(Andersen, 2011).***

In 1960, physicist Theodore H. Maiman, PhD, Hughes Aircraft Co, Malibu, Calif, created the first working laser-a flashlamp-pumped ruby laser that generated millisecond pulses of 694 nm of red light ***(Andersen, 2011).***

Shortly after Maiman unveiled his invention, scientists at Bell Laboratories replaced the flash-lamp with an arc lamp and created a ruby laser that could be run continuously ***(Andersen, 2011).***

In 1960, the helium-neon (HeNe) laser was developed by Ali Javan, a scientist at Bell Laboratories. It was the first laser

wavelength that could be delivered in continuous mode ***(Andersen, 2011).***

The HeNe laser wavelength is used also in conjunction with invisible lasers, such as the carbon dioxide (CO2), holmium, and yttrium aluminum garnet (YAG) wavelengths, to allow surgeons to visualize the invisible surgical beam ***(Andersen, 2011).***

The year 1964 was prolific for laser development, particularly wavelengths that could be used in surgery ***(Hecht, 2012).***

Between 1989 and 1992, a dramatic shift in surgical intervention occurred when the medical community overwhelmingly accepted laser laparoscopic cholecystectomy as the standard for the management of symptomatic biliary disease. ***(Andersen, 2011).***

Basic Concepts of Laser Light

Laser Light has several characteristics that make it unique: (1) it is monochromatic, meaning that it is one of specific

wavelength; (2) it is collimated, meaning that the rays of light are parallel; (3) it is coherent, meaning that the rays of light are in phase with each other; and (4) it is of high intensity ***(Carroll and Humphreys, 2013).***

There are 3 main parameters to consider when using lasers: wavelength, fluence, and pulse duration. In general, the wavelength of a laser is fixed. Fluence and pulse duration can be adjusted by the physician ***(Nelson and Lask, 2011).***

Physicians should select a sufficiently high fluence to damage the intended target tissue, but not so high as to cause surrounding tissue damage and scarring ***(Hirsch et al., 2012).***

Finally, the thermal relaxation time means the time necessary for the heated, targeted tissue to lose half of its heat to the surrounding tissues ***(Hruza et al., 2013).*** In general, in order to have selective treatment, physicians want to heat the targeted tissue faster than the rate at which the heat is lost to surrounding tissue ***(Hirsch et al., 2012).***

Laser Systems

A laser consists of a transparent crystal rod or a gas- or liquid-filled cavity (gas or fluid laser) constructed with a fully reflective mirror at one end and a partially reflective mirror at the other end. Surrounding the rod or cavity is an optical/electrical source of energy that will raise the energy level of the atoms within the rod or cavity to a high and unstable level, a process known as population inversion ***(Chong, 2011).***

Mechanisms of Laser Actions

- **Photocoagulation**

In thermal lasers, tissue pigments absorb the light and convert it into heat ***(Chong, 2011).***

These laser photocoagulators operate in continuous mode or very rapidly pulsed (thermal) mode. The green argon laser is the workhorse of this class ***(Tasman and Jaeger, 2012).***

- **Photodisruption**

Photodisruption lasers release a giant pulse of energy with a pulse duration of a few nanoseconds. When this pulse is