Laser Dermatologic Surgery and Optical Tomography of Skin Lesions

reported by Dr. K. K. Ho

Date:	13 September, 2001
Venue:	Room 403, Professorial Block, Queen Mary Hospital
Speaker:	Prof. Stuart Nelson
Organizer:	Dept. of Medicine, HKU and HKSDV; Joint Scientific Function

Introduction

In 60's, Light Amplification by Stimulated Emission of Radiation (LASER) medicine started with empirical use in various specialities before going to parameterization phase that the wavelength, coherence, monochromaticity, fluence and thermal energy were clearly defined and studied. After gathering more and more knowledge, we are more clear on its fundamental understanding and its clinical implication.

Basics of laser surgery

The basic principle of laser surgery is stimulated emission of photon to the target. Chromophore in the target tissue takes up the thermal energy and is destroyed. Because different chromophores have their own specific range of absorption spectrum, laser with various wavelength is designed to target different chromophores such as oxyhaemoglobin, melanin and water. Thermal relaxation time is defined as the amount of time necessary for 50% of the peak heat to diffuse out of the target. It is an important concept because if the light energy exceeds the thermal relaxation time, thermal energy will diffuse out of the target uncontrolled and non-selectively to the surrounding tissue, causing scarring, hypopigmentation, hyperpigmentation and textural change of the skin. The main theme of controlled thermal dissipation is to reduce complications of laser surgery for a better cosmetic result. In order to attain selective photothermolysis, one must master the skill of laser machine with respect to wavelength, pulse duration, energy fluence, spot diameter and repetitive rate.

Laser resurfacing

Carbon dioxide laser and erbium:YAG laser have been used for photoaging skin, removing rhytides, actinic damages and wrinkles for years. The basic principle is to vaporize the superficial cell layers by targeting the water molecules selectively. The primary effect is to vaporize superficial dermis layer by layer. Residual photocoagulation causes the shrinking of the collagen. Then, in inflammatory phase, the secondary effect causes re-epithelialization, the growth of neo-dermis and increase fibroblastic activities to form new collagen.

Non-ablative laser and dynamic cooling device

The goal of non-ablative laser is to preserve the epidermal layer and selectively photocoagulate the desired dermal depth. It is accomplished by using far-infrared region to avoid the absorption spectrum of melanin and target the low or intermediate absorption spectrum of water molecule. Dynamic cooling device is designed to cool down the overlying epidermal layer to prevent photocoagulation. It depends on a device that has a high spatial selectivity and generates large temperature gradient cold cooling medium. In short, the cryogen is sprayed over the targeting tissue in term of millisecond to cool down the superficial epidermis to -60^{o}C before laser emission in order to preserve the normal overlying epidermis. Because cryogen will vaporize shortly after spraying, it will not cause any cold damage to the epidermis. The cryogen used is non-inflammable, non-toxic and environmental friendly. All in all, dynamic cooling device is an important adjunctive method for resurfacing. It can be combined with other treatment modalities such as Botox injection and chemical skin peeling. In the future, it will be very useful in dermal remodelling or toning.

Port wine stain

Researches in birthmarks in children were done by the speaker, especially port wine stain (PWS). He

combined dynamic cooling device with various laser modalities to maximize the light dosage, to decrease the pain and post-treatment oedema. However, the speaker still cannot solve the problems of how many treatments should be advised after initial assessment and who will response. Even using the pulse dye laser to treat PWS, the success rate is still low if the definition of success is complete blanching. It is mainly because of the poor understanding of PWS geometry. In PWS, the size and depth of the vessels varies individually and even from site to site of the same individual. Different size and depth of vessel requires specific wavelength and pulse duration that must be set precisely in order to achieve good cosmetic result.

Optical tomography

As a result of the dissatisfaction in laser surgery in PWS, Optical Coherence Tomography (OCT) and Optical Doppler Tomography (ODT) are developed to delineate the anatomic details of PWS geometry. Light source is used in OCT instead of acoustic wave, and analogy can be drawn between OCT and ultrasonography. A schematic two-dimensional graph will be constructed after the collection of all reflected scattered light ray. In ODT, the image of blood vessel and flow can be detected by combined doppler velocimetry and optical sectioning capability. Once the PWS geometry is determined, specific wavelength and pulse duration could be defined and used to photocoagulate the targeting vessel. Immediate after treatment, ODT is capable to detect re-perfusion residual vessel that can be re-treated in a single treatment till the signal is negative to improve the efficacy. Apart from treating PWS, ODT can be used in microsurgery of skin flap to assess the site and size of vessel and the viability of the skin graft after surgery.

Learning points:

The goal of non-ablative laser is to preserve the epidermal layer and selectively photocoagulate the desired dermal depth. In PWS, the size and depth of the vessels varies individually and even from site to site of the same individual. Different size and depth of vessel requires specific wavelength and pulse duration that must be set precisely in order to achieve good cosmetic result.