Cutaneous Laser Surgery

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Visible-Infrared Range
What does it stand for?

- **LASER**
  - L Light
  - A Amplification
  - S Stimulated
  - E Emission
  - R Radiation

- **3 Components:**
  - Pumping system
    - Energy source/power supply
  - Lasing medium
  - Optical cavity
Lasing Medium

- Supplies electrons for the stimulated emission of radiation

- Determines wavelength of laser
  - Expressed in nm

- 3 Mediums:
  - Gaseous (CO2, argon, copper vapor)
  - Solid (diode, ruby, Neodymium:Yag)
  - Liquid (tunable dye, pulse dye)
Laser vs. IPL

- **LASER**
  - coherent, monochromatic light

- **IPL = intense pulsed light**
  - non coherent light
  - 515-1000nm
Monochromatc

- Laser light is a single color
  - color = specific wavelength of each laser
Wavelength

- Wavelength determines
  - Chromophore specificity
    - Chromophore = tissue target that absorbs a specific wavelength of light
  - Depth pulse travels
Chromophore & Absorption Spectra

**Chromophore/Target**
- Hemoglobin
- DNA, RNA, protein
- Melanin
- Black ink tattoo
- Water

**Wavelength Abs. Spectra**
- Blue-green and yellow light
- UV light
- Ultraviolet > Visible >> near IR
- Visible and IR
- IR
Absorption Curves
Terms to Know

- **Energy**
  - Joules, the capacity to do work

- **Power**
  - Rate of energy delivery (Watts = J/sec)

- **Fluence**
  - Energy density (J/cm²)

- **Thermal Relaxation Time (TRT)**
  - Time required for an object to lose 50% of its absorbed heat (cooling time) to surrounding tissues
Thermal Relaxation Time (TRT)

- time required for an object to lose 50% of its absorbed heat (cooling time) to surrounding tissues

- directly proportional to size of an object (proportional to square of its size)

- smaller objects cool faster (shorter TRT) than larger ones (longer TRT)
Selective Photothermolysis by Anderson and Parrish (Science, 1983)

- **Selective Photothermolysis**
  - Thermocoagulation of specific tissue target with minimum damage to surrounding tissue

- **Requirements:**
  - 1. chromophore (target) selectively and specifically absorbs laser wavelength
  - 2. pulse duration < thermal relaxation time (TRT) of the chromophore
  - 3. sufficient energy density (fluence) for thermal damage
Selective Photothermolysis

- Pulse duration \(<<\) thermal relaxation time (TRT) of target
  - must be long enough to lead to thermal damage of selected target but short enough to not produce excessive collateral damage to surrounding tissues
Spot Size

For a given wavelength and fluence:

- larger spot size = less scattering of energy and deeper penetration
  - (benefit plateaus at 10 mm)

- smaller spot size = requires higher energy to compensate for increased scattering effect
  (minimum of 5mm spot size required to treat mid-dermal and deeper lesions)
Laser emission patterns: Pulse, CW

- **Pulsed**
  - beam emission in single pulses, at predetermined pulse durations

- **Continuous**
  - beam emission at a continuous, constant energy level
  - pulse duration is continuous, for as long as device fires

- **Short pulse**
  (nanoseconds, ns; picoseconds, ps)
  - targets smaller structures (melanosomes, tattoo particles)
  - Q-switched lasers

- **Long pulse** (micro, μs; milliseconds, ms)
  - targets larger structures (blood vessels, hair follicles)
OxyHb & Melanin Absorption

- Oxyhemoglobin has primary absorption peaks at bluegreen-yellow portions of visible light (418, 542, 577 nm), which overlap with melanin absorption.

- Another broad band hemoglobin absorption peak occurs between 800-1000 nm, less related to melanin.

Objective: Thermolysis of oxyHb and not melanin.
Absorption Curves for Deoxy-Hb and Oxy-Hb
Surface cooling

Must Protect Melanin in the skin via

- Forced air
- Contact with cooled sapphire/copper tip
- DCD = Dynamic Cooling Device

For larger vessels:
- May be wise to cooling after the pulse to avoid retrograde heating of epidermis after the laser pulse
Vessel Size and Depth

- As depth and size of vessels change, so do absorption characteristics
  - Smaller, more superficial bright red vessels need shorter wavelengths.
  - Deeper vessels need longer wavelengths and pulse durations.

- **Spot size** diameter should be double the size of the target vessel.

- Pigmented skin may be damaged by shorter wavelengths.
  - *Careful analysis of skin type important prior to treatment.*
  - *No tan!*
Wavelength Penetration
Factors To Keep in Mind

- Wavelength
- Pulse duration
- Spot size
- Fluence
- Rep Rate / Time between pulses
- Cooling
- Handpiece Orientation (perpendicular to skin)
What happens to the vein?

Possible short-term outcomes

- No effect
- Embolized coagula
- Vessel constriction (vessel constricts and blood moves out like in a water balloon)
- Complete but reversible stenosis
- Complete and irreversible stenosis with large coagulum blocking flow
Wavelength Penetration

- 418 nm
  - Most specific
  - Poor penetration

- 542 & 577 nm
  - Relatively specific
  - Papillary dermis

- 800-1064 nm
  - Relatively specific
  - Most penetrating
Key Concepts

- **Wavelength**
  - Optimal for the depth and diameter of the vessel through its entire course

- **Pulse duration**
  - Want thermocoagulation of the entire target vessel diameter

- **Effective fluence**
  - to treat the vessel

- **Cooling**
  - to protect the epidermis or surrounding tissue
Why Legs Veins are Hard to Treat?

- Most telangiectasia are associated with high reverse pressure from associated reticular veins.
- Deeper location of leg veins.
- Thicker and larger walls of leg veins.
- Reduced oxygenation state esp. when using Yag.
- Competing melanin absorption.
Light Therapy for Veins

- Flashlamp Pulsed Dye Laser 585-600 nm
- KTP Laser 532 nm
- Nd:YAG Laser (Q-switched, pulsed) 1064nm
- Diode Laser 800-810 nm
- Alexandrite 755 nm
- Intense Pulsed Light Source 590-1200nm
Which Laser to Use

- Telangiectatic matting
  - Pulsed dye laser, KTP laser

- Superficial vessels <1mm
  - Pulsed dye laser, KTP laser

- Larger spider veins and deep reticular veins
  - Alexandrite laser, Diode laser
  - Long-pulse Nd:Yag laser
Reasonable Endpoints for Treatment

- Blanching
- Purpura
Laser Optimal for

- Non-cannulizable spider veins
- Venous matting
- Facial veins, port wine, flushing/rosacea
Review of Fitzpatrick Skin Types

- Type 1: Always burns, never tans
- Type 2: Usually burns easily, rarely tans
- Type 3: Burns occasionally, gradually tans
- Type 4: Burns minimally, tans always
- Type 5: Rarely burns, tans profusely
- Type 6: Never burns, darkly pigmented
## Laser vs. Sclerotherapy

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<thead>
<tr>
<th></th>
<th>Laser</th>
<th>Sclerotherapy</th>
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<tbody>
<tr>
<td><strong>How it works</strong></td>
<td>Heats blood to boiling</td>
<td>Chemical initiation</td>
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<tr>
<td><strong>Pain</strong></td>
<td>Intense heat for fraction of a second</td>
<td>Small pinprick. Only painful with Saline</td>
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<tr>
<td><strong>Area Treated per Session</strong></td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td><strong>Treatment tanned legs</strong></td>
<td>No / Yes</td>
<td>Yes</td>
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<tr>
<td><strong>Cost</strong></td>
<td>Up to 100% more per treatment than sclero</td>
<td>Variable depending on total time of session</td>
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<tr>
<td><strong># of Treatments</strong></td>
<td>2-10</td>
<td>1-5</td>
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<tr>
<td><strong>Need for repeat treatments</strong></td>
<td>Frequent</td>
<td>Less frequent</td>
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<tr>
<td><strong>Risks of skin Injury</strong></td>
<td>1-10%</td>
<td>Less than 1%</td>
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Intense Pulsed Light (IPL)

- Not a laser (not monochromatic nor coherent)

- 515-1200 nm
  - 1. FILTERS: Xenon flashlamp filters to narrow band width
    - 550 & 570 filters used in leg vein Rx
  - 2. Pulse DURATION: 2-25 msec
  - 3. Pulse DELAY: 10-500 msec
  - 4. Single, double, triple pulsing

- High fluences
# IPL Pros and Cons

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<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<td>Broad chromophore range</td>
<td>Not selective destruction</td>
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<tr>
<td>- (melanin, hemoglobin,</td>
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<tr>
<td>collagen)</td>
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<tr>
<td>Versatility</td>
<td></td>
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<tr>
<td>- hair removal</td>
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<tr>
<td>- leg veins &amp; telangiectasias</td>
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<tr>
<td>- rejuvenation, poikiloderma</td>
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<tr>
<td>- scars</td>
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<td>- superficial pigmentation</td>
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Thank you for your attention!