Laser Treatment of Vascular Lesions

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Disclosures: Off-label uses will be discussed
Drug donated by Allergan
Equipment provided by Solta; Syneron/Candela; Thermi RF; Vivosight; R2 Derm
Consultant: Shanghai Fudan-Zhangjiang Bio-pharmaceutical Co., Ltd, Syneron-Candela, Allergan, Sciton
Research Supported by Allergan, ASLMS; NIH; Sturge Weber Foundation, UC Irvine ICTS

Overview

- The Science of Vascular Lesion Treatment
- Port Wine Birthmarks
- Infantile Hemangiomas
- Angiofibromas associated with Tuberous Sclerosis
- Telangiectases/Rosacea/Angiomas
- Eye Protection
- Pain Management for Laser Treatments

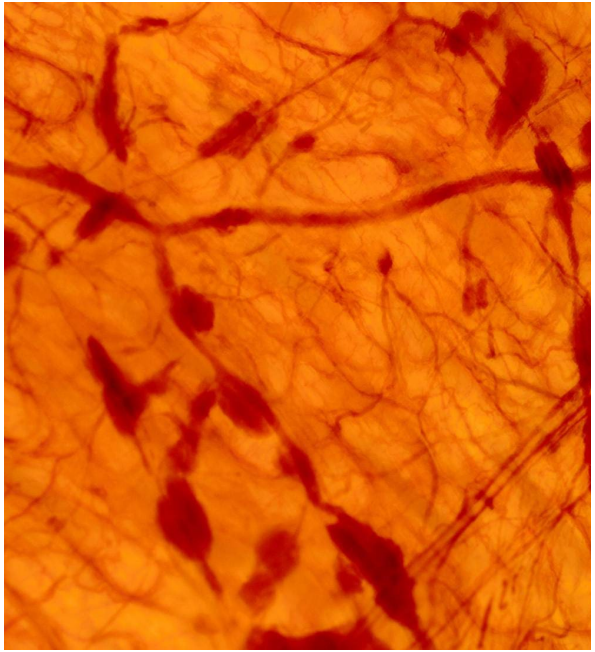
Theory of Selective Photothermolysis

- Laser energy preferentially absorbed by one structure in tissue
  - Melanin, dermis, blood, tattoo ink, etc
- Surrounding tissue has low absorption
- Selective absorption of radiant energy resulting in selective heating/destruction of tissue
- Crucial Parameters
  - Wavelength
  - Pulse duration
  - Energy

Anderson R, Parrish J, Science 1983; 220:524-527

Immediate blood vessel hemorrhage after pulsed dye laser treatment

Courtesy of D. Li, GX Wang, Y L He, W J Wu Z X Ying, YX Wang

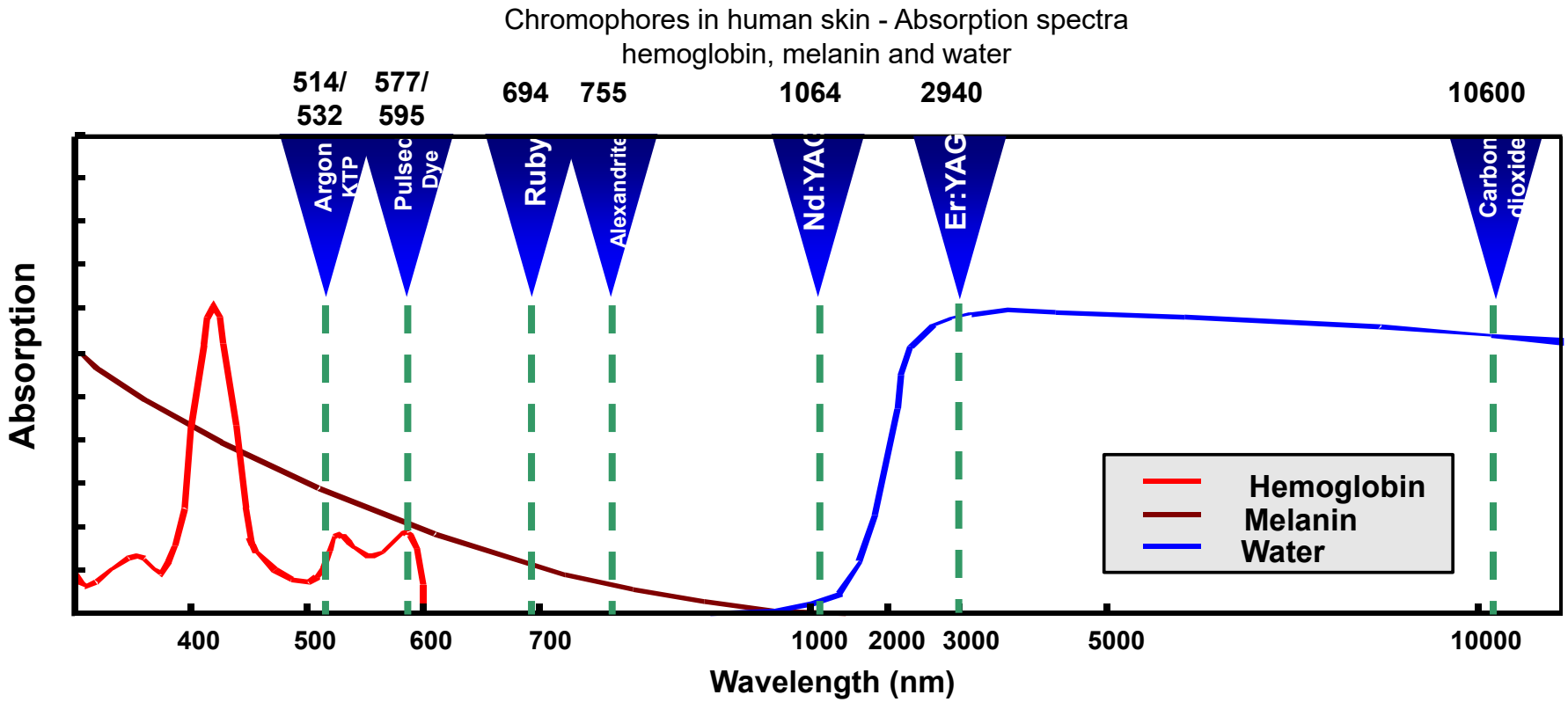


Wavelengths/Devices for Vascular Lesions

Light Based Treatment Options

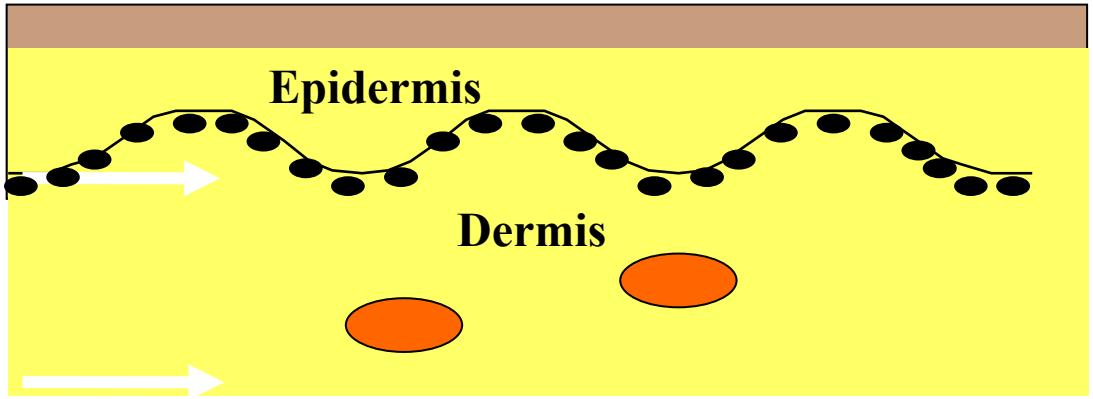
- Argon – historical
- **Pulsed Dye Laser**
- **532 nm Nd:YAG**
- **755 nm Alexandrite**
- 810 nm Diode
- 1064 nm Nd:YAG
- Intense Pulsed Light
- Combined Wavelength or Energy Devices

Selection of Wavelength

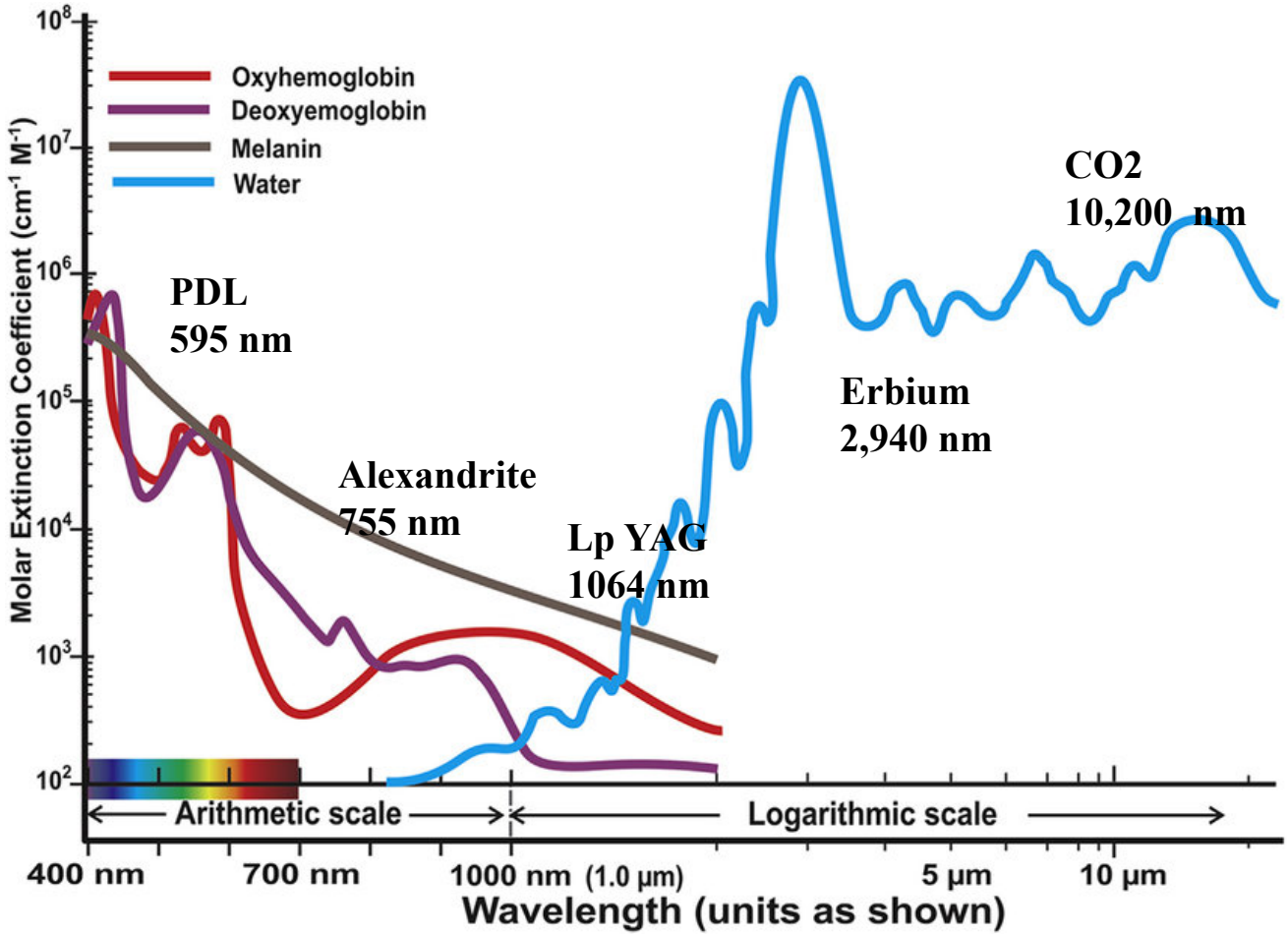


Laser light must pass through pigmented epidermis to get to the targeted blood vessels

Shorter wavelengths have more melanin interaction



Increased ulceration risk with longer wavelength lasers



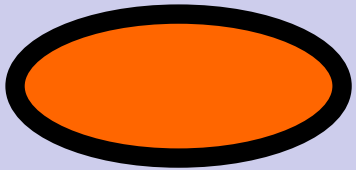
Selection of Pulse Duration = Confinement of Thermal Energy

Target	Size	τ_r
microvessel	10 μm	90 μs
blood vessel	200 μm	1-10 ms
tattoo pigment	0.5-100 μm	20 ns-3 ms
melanosome	0.5-1.0 μm	20-40 ns
melanocyte	7 μm	1 μs

Dierickx CC. Anderson RR et al. Thermal relaxation of port-wine vessels probed in vivo: the need for 1-10 millisecond laser pulse treatment. JID 1995:709-714.

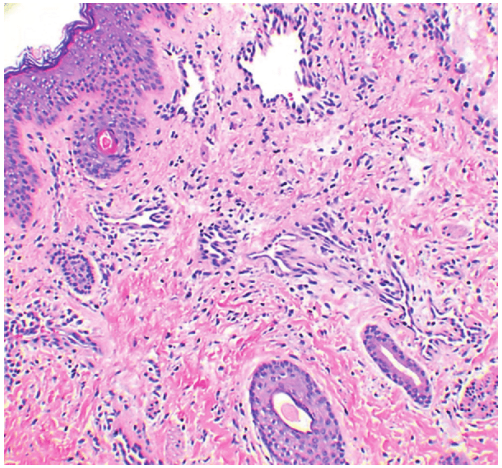
Extended Theory of Selective Photothermolysis

Vessel destruction requires heat diffusion from the blood (chromophore target) to the vessel wall endothelium

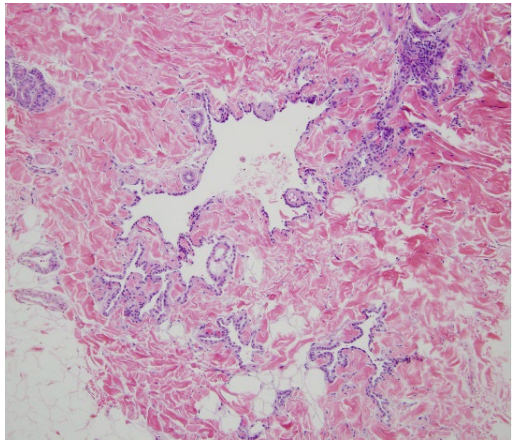


Altshuler et al. Lasers Surg Med 2001; 29:416-32

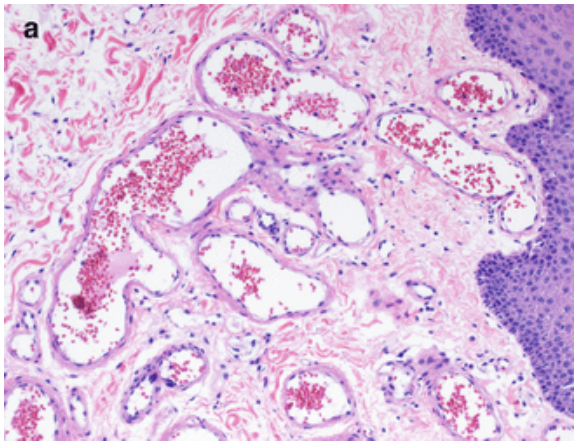
Vessel diameter dictates pulse duration



Capillary malformation



Glomulovenous malformation



Venous malformation

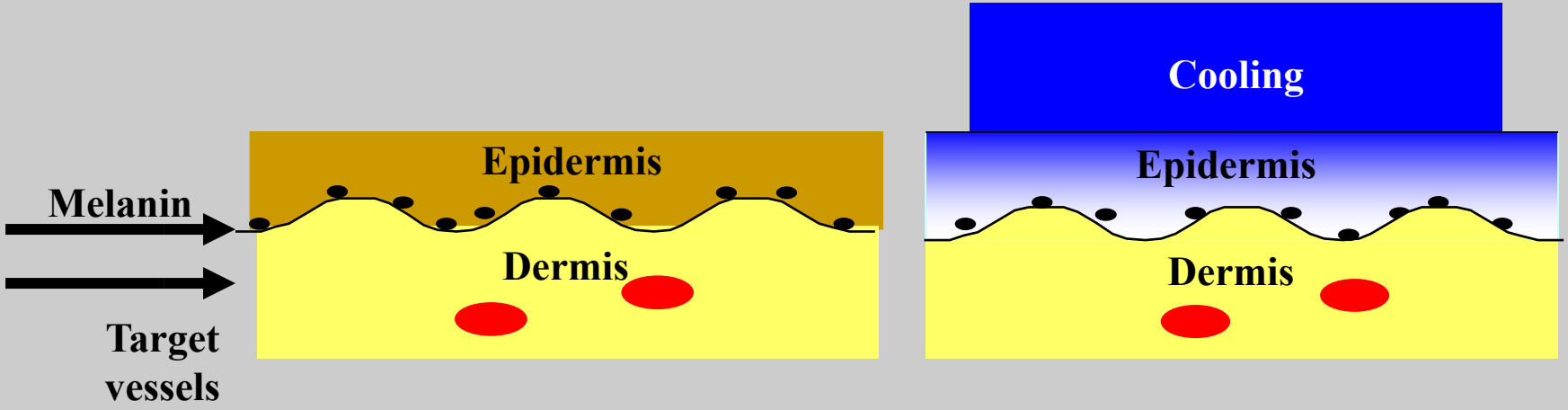
Thermal relaxation time (TRT) is how long it takes the vessel to cool

TRT α vessel diameter^2

A pulse width $\leq$ to TRT confines heat to target vessels during exposure

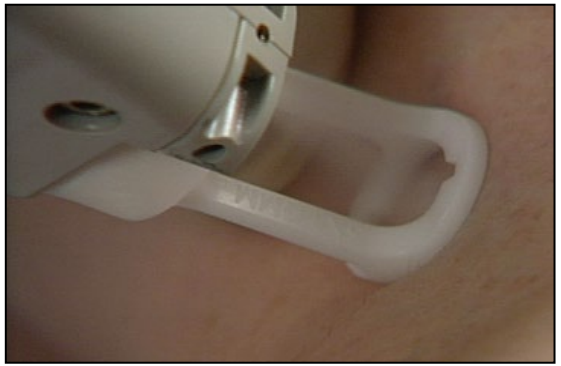
Epidermal cooling prevents epidermal injury

Leaves the target vessels susceptible to laser induced thermal effects/injury



Epidermal cooling…

Allows the use of higher fluences
Allows safe treatment of darker skin types
Decreases treatment discomfort



Cryogen Spray Cooling

Contact Cooling

Air Cooling

Port Wine Birthmarks

At What Age Should you Start Lasing?

As early as you can….pulsed dye laser is safe to use in young infants.

Unclear why but there appears to be a better response when treatments started early possibly due to:

1) Hemoglobin F in infants
2) Vessels less dilated in young
3) Less melanin interference
4) Skin thickness differences

Treatment

- 585 or 595 nm Wavelength
- Can also use 532 nm, IPL
- Vary pulse duration and wavelength over time to achieve optimal results

Desired End Point with PDL

Correct end point:

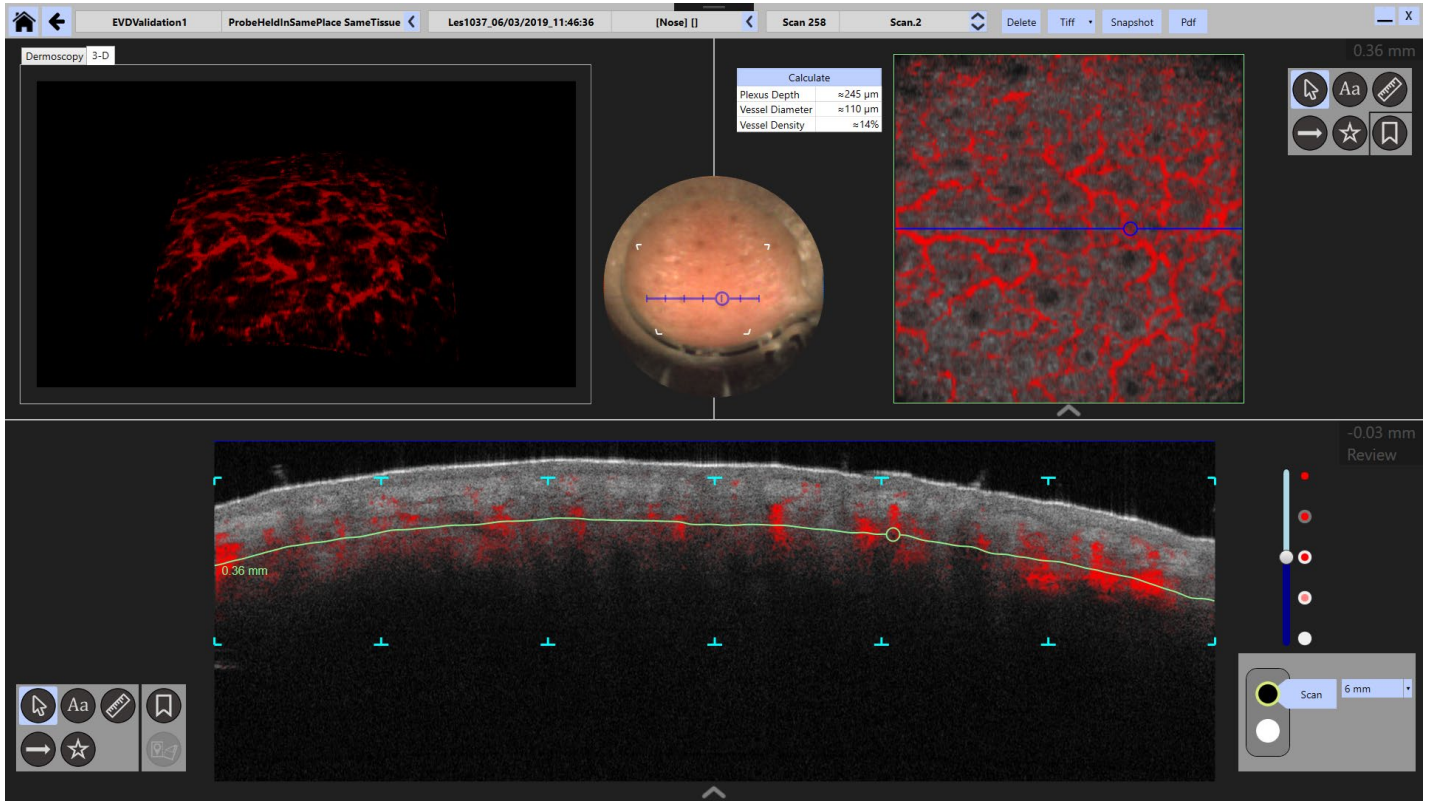
Deep purpura

Incorrect end point:

Tissue greying

- Treatments repeated at 3-4 week intervals for facial lesions in lighter skin types
- Longer intervals between treatments for extremity lesions and if there is significant hyperpigmentation
- *Multiple treatments are required (15 or more is not uncommon)!*

Imaging to Guide Treatment – Optical Coherence Tomography



Generalization – My Approach

- Port Wine Birthmark
  - Shorter pulse durations – but may depend on the lesion – informed decision making may improve results
  - Desired end point-purpura – may be less with longer pulse durations which may benefit some patients
  - Often useful to change pulse durations over a course of treatment or do multiple passes in a single session

Alternative approaches:

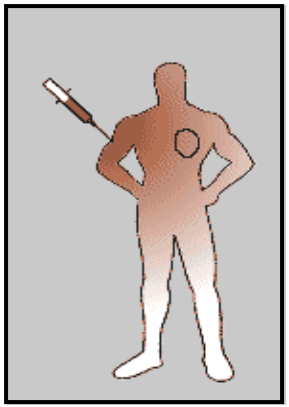
- Multiple passes with longer pulse durations – may be especially useful in older patients with darker skin types

The Future

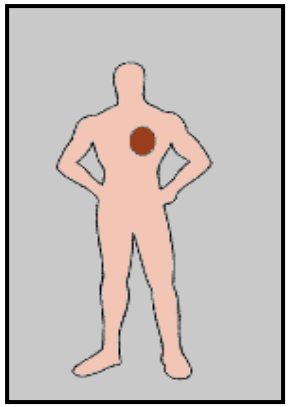
- Port Wine Birthmark
  - Imaging guided energy therapy
    - Light based is still gold standard for now but other energy devices could be involved in the future
  - Individualized genetic analysis providing information on patient specific pathway alteration guiding stand alone or adjunctive drug therapy

Photodynamic Therapy (PDT)

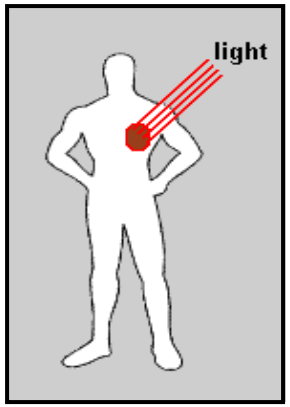
A photosensitizing drug is administered which can be “selectively” accumulated in the target (vasculature).
After a pre-selected time interval, lesion is exposed to light at a wavelength absorbed by the photosensitizer.



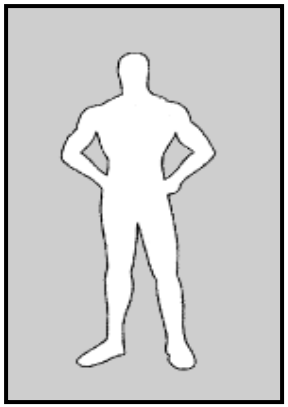
Photosensitizer Injection



Selective Accumulation



Laser Irradiation



Blood Vessel Destruction

Hemoporfin PDT for PWS

- Newer Formulation of hematoporphyrin monomethyl ether
  - 2 weeks of photosensitivity compared to 4 or more weeks
- 100 patients (40, 40, 20 low - 2.5 mg/kg, high dose – 5 mg/kg, control)
- 75% in high-dose achieved improvement compared to 40% in low dose
- All patients with photosensitivity; pain and edema over 95%; crusting 67%; hyperpigmentation common – 46% in high dose group
- Textural change can occur in approximately 1% (personal communication)

Wu Q, Tu P, Zhu X et al. A dose-finding study for hemoporfin in PDT for PWS: Multicenter randomized double-blind phase IIb trial. Photoderm Photoimmunol Photomed. 2018;34(5):314-321.

Infantile Hemangiomas

Infantile Hemangiomas

- Most rapid and significant growth 1-3 months of age and generally completed by 5 months of age
- Many IHs leave behind permanent skin changes – important window of opportunity to treat to optimize outcomes (by 1 month)
- Propranolol is drug of choice 2-3 mg/kg day or topical timolol for small thin superficial IHs
- Surgery and/or laser are most useful for treatment of residual skin changes after involution and may be considered earlier to treat some IHs

Krowchuk DP, Frieden IJ…Whelan MA et al. Clinical practice guideline for the management of infantile hemangiomas. Pediatrics 2018.

Infantile Hemangiomas

- Standard of care is oral propranolol
- Lasers can play a role:
  - Small lesions - possibly in combination with timolol – but may not need laser
  - Early lesions – stop progression – use caution because can ulcerate
  - Treatment of residual lesion or to speed up regression – if beta blockers early enough often will not need
  - Ulcerated lesions

Léauté-Labrèze C, Dumas de la Roque E, Hubiche T, Boralevi F, Thambo JB, Taïeb A.
Propranolol for severe hemangiomas of infancy. N Engl J Med. 2008 Jun 12;358(24):2649-51.

Angiofibromas associated with Tuberous Sclerosis

Angiofibromas/Tuberous Sclerosis

Pulsed-dye laser treatment 10 mm; 1.5 ms; 7.5 J/cm^2; 30 ms cooling

Ablative fractional resurfacing 15 mm; 70 mJ; 40%

Pinpoint electrosurgery to papular fibrotic lesions

0.2% topical sirolimus ointment bid

Bae-Harboe YS, Geronemus RG. Targeted topical and combination laser surgery for the treatment of angiofibromas. Lasers Surg Med. 2013;45:555-7.

Telangiectases
Rosacea – erythema/telangiectases
Angiomas

General Treatment Points

- Each patient different and should watch for endpoints
  - Vessel blanching
  - Should be no graying or whitening of surrounding skin
  - Always start conservative and move up as tissue allows
- Longer pulse durations can be used to minimize purpura
- Can consider multiple passes or cautious pulse stacking

Treatment Device Options

- Pulsed dye laser
  - Longer pulse durations (6 ms or more) can be used to minimize or avoid purpura
  - May require additional treatment 2-4
- Long pulsed 532 nm
  - Remember more melanin absorption so caution in tan skin or darker skin types; If contact cooling keep good contact
- Intense pulsed light

Telangiectases

- Ideally treated without purpura – utilizing longer pulse durations
- Can do multiple passes varying settings and can cautiously pulse stack
- Resistant larger vessels can use longer pulse durations or consider a longer wavelength
- Consider adding oxymetazoline – cost can be an issue for some patients; be aware that if apply alpha 1 agonists to broken skin there can be side effects

Angiomas

- Pulsed dye laser
  - Two approaches
    - 7 mm; 6 ms; 9-10 J/cm^2; cooling – minimal bruising
    - 7 mm; 1.5 ms; 8 J/cm^2; cooling - bruising
- Sometimes left with skin colored residua
- Can use white thin foam board with circular cut-out

  -Intense pulsed light

Patients with darker skin types

Light based devices are still first line treatment for treatment of vascular lesions in patients with skin of color

- -Higher rates of side effects may be seen; mainly dyspigmentation and scarring
- -Moderate energy densities, less pulse overlap, and cooling are recommended

Eye protection
A crucial safety factor

- Consider goggles if treating off the face
  - Often not appropriate for young children who won't keep them on
  - Often don't fit the face of young children
- If facial lesion (not involving eyelid) or young child
  - Laser Aid Eye pads
  - Overlying Gauze

Eye protection
A crucial safety factor

- Corneal Eye Shields:
  - Corneal shield if peri-orbital or eyelid area to be treated
  - Confirm shield is correct size and observe placement
  - Melting of eye shield to eye has been reported with deeply penetrating lasers (Nd:YAG)
  - Make sure to apply shield gently with lubricant
  - Safe to use with drains in the eye if ophthalmologist agrees
  - Make sure to remove at the end of the procedure

Laser Safety

- Can singe hair
  - Often will be temporary
  - With repetitive treatments can get permanent decrease in hair in treatment areas
  - Can protect with aloe vera gel or similar

Options for pain control during laser procedures

- Topical anesthetic
- Nerve blocks
- Systemic Pain Medications
- Nitrous Oxide
- General Anesthesia

Summary

- Laser treatment of vascular lesions
  - Initial indication for use of lasers
  - One of most satisfying treatments for patients and clinicians
- Treatments can be very effective
- Treatments can be performed safely in patients of all ages

Acknowledgements

- Funding Sources
  - National Institutes of Health
  - Sturge Weber Foundation
  - American Society for Laser Medicine and Surgery