

# Laser Treatment of Vascular Birthmarks

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**Laser treatment of vascular birthmarks remains one of the more common applications of dermatologic lasers and is the treatment of choice for port-wine stains (PWS) and superficial capillary hemangiomas. Before the development of laser technology, these lesions were treated with radiation, surgical excision and grafting, cryosurgery, and camouflage with cosmetics or tattoos. All of these techniques produced unsatisfactory results or poor aesthetic outcomes. The development of the pulsed dye laser in the 1980s permitted selective photocoagulation and destruction of lesional blood vessels without damage to the surrounding normal skin, thereby producing dramatic clearing of PWS and hemangiomas with minimal risk of scarring.**

## CLINICAL DEFINITIONS AND CHARACTERISTICS

### Port-Wine Stains

**P**ort-wine stains (PWS) are benign vascular malformations composed of ectatic blood vessels in the dermis. They are typically present at birth and occur equally in boys and girls, with a prevalence of 0.3% to 0.5% in the general population.<sup>1</sup> PWS are predominately located on the head or neck and, with advancing age, darken in color from pink to red to purple because of progressive vascular ectasia.

Unlike the "salmon patches" or "angel's kisses" (nevus flammeus neonatorum), which are observed in upward of 40% of newborns, PWS (or nevus flammeus) never regress but instead darken, become increasingly nodular, and often cause psychosocial distress.<sup>2</sup> Many PWS patients have been reported to have self-esteem issues with subsequent difficulties in their personal and professional relations.<sup>3,4</sup> The tendency for most (65%) patients to develop soft tissue hypertrophy and nodularity within the lesion, as well as an increased risk of bleeding and skeletal

anomalies, provide additional compelling reasons to recommend treatment.<sup>5</sup>

PWS are usually isolated lesions but can be associated with Sturge-Weber and Klippel-Trenaunay syndromes, the former characterized by a large facial PWS (particularly in the V<sub>1</sub> distribution) with ipsilateral leptomeningeal and choroidal vascular malformations and glaucoma, the latter characterized by a PWS and hypertrophy of a limb or body part with anomalous superficial veins, deep vein hypoplasia, and lymphatic malformations.

### Hemangiomas

Hemangiomas are common benign vascular lesions of childhood that must be differentiated from PWS. Hemangiomas are present at birth in 2% to 3% of newborns and approximately 10% to 12% of infants by 1 year of age. Unlike PWS, they occur with equal frequency in males and females and undergo such rapid proliferation that lesions may expand greatly in both height and diameter, sometimes reaching gigantic proportions.<sup>6</sup> The growth phase is not only of cosmetic concern but becomes a medical problem when the lesions impinge on a vital structure (e.g., eye, trachea) or ulcerate (leading to infection and, rarely, sepsis). Although most hemangiomas begin a slow involutionary stage by the age of 1 year, it often takes 5 to 12 years for resolution to be completed. Total spontaneous lesional involution is not universally observed, as ~50% of patients are left with residual telangiectasias, redundant fibro-fatty tissue, and epidermal atrophy.

## LASERS BASICS

**L**aser technology was significantly advanced by the work of Anderson and Parrish,<sup>7</sup> who initially described the principles of "selective photothermolysis." Application of their work elucidates how laser energy is preferentially absorbed by the intended tissue target (or chromophore), resulting in controlled, thermally mediated injury and destruction by selectively absorbed pulses of radiation without significant thermal damage to surrounding normal tissue. To achieve selective photothermolysis, three basic elements must be considered: 1) selection of a wavelength of light

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that is preferentially absorbed by the intended tissue target or chromophore (in the case of vascular lesions, oxyhemoglobin); 2) the pulse duration of the laser (or exposure time of the tissue to the laser energy) must be shorter than or equal to the chromophore's thermal relaxation time (defined as the time required for the targeted site to cool to one half of its peak temperature immediately after laser irradiation); and 3) the energy density (or fluence, measured in joules per square centimeter or  $J/cm^2$ ) delivered by the laser must be sufficient to irreversibly damage the target within the allotted time. Therefore, on the basis of these principles, laser parameters (wavelength, pulse duration, and fluence) can be tailored for specific cutaneous applications to effect maximal tissue destruction with minimal collateral thermal damage.

## VASCULAR-SPECIFIC LASERS AND TREATMENT

### Continuous Wave Laser Technology

The introduction of the argon laser in the early 1970s represented the first major advance in vascular lesion therapy. The continuous blue-green beam with wavelengths at 488 and 514 nm could be preferentially absorbed by oxyhemoglobin in the lesional blood vessels. Although successfully used for a variety of vascular lesions, the long exposure times of the argon laser led to nonspecific thermal damage of irradiated skin because of excessive heat diffusion to surrounding tissue, leading to scarring and atrophy.<sup>8,9</sup> In addition, absorption of argon light energy by epidermal and dermal melanin caused a significant amount of hypopigmentation in treated sites. For these reasons, and with the subsequent development of more vascular-specific pulsed dye lasers (PDL), the argon laser, as well as other continuous and quasi-continuous laser systems (including the argon-pumped tunable dye, copper vapor/bromide, KTP, and krypton), are no longer commonly used to treat vascular lesions.

### Pulsed Dye Lasers

Introduced to the market in the 1980s, the flashlamp-pumped PDL was the first system specifically developed for treatment of vascular lesions based on the principles of selective photothermolysis.<sup>10</sup> Although original investigators used a 577 nm system,<sup>11-13</sup> the wavelength was later modified to 585 nm to effect deeper tissue penetration without sacrificing vascular specificity.<sup>14-16</sup> Although PDL use was initially recommended only for treatment of vascular lesions in pale skin, more recent reports have demonstrated safe and effective vascular lesion treatment in patients

with darker skin tones.<sup>17,18</sup> In addition, dynamic cooling devices were incorporated in most PDL systems to reduce epidermal disruption, intraoperative discomfort and postoperative risk of dyspigmentation, vesiculation, and scarring.<sup>19</sup> The short pulse duration (0.45-1.5 ms) of the PDL conform to the principles of selective photothermolysis because the thermal relaxation time ( $T_R$ ) of small- to medium-sized blood vessels averages 1 ms. Because of its superior vascular specificity, clinical efficacy, and low side-effect profile, the PDL continues as the laser of choice for most benign congenital and acquired vascular lesions.

PDL laser treatment sessions are typically scheduled at 6 to 8 week time intervals except for proliferating hemangiomas, which require more frequent follow-up examinations and treatment.<sup>20-23</sup> Nonoverlapping laser spots are placed over the entire treatment area, producing an immediate purpuric or weal-and-flare response, depending on the density of blood vessels present and the pulse duration chosen.

Anesthesia is typically achieved with the use of topical anesthesia (e.g., LMX [Ferndale Labs, Ferndale, MI] or EMLA cream) for 30 to 90 minutes before laser irradiation, depending on the product used and patient weight considerations. The concomitant use of a cryogenic cooling spray or air cooling unit (supplied with most modern PDL systems) also reduces intraoperative discomfort.<sup>18,24</sup> Pediatric patients, particularly those with extensive lesions, may require general or intravenous anesthesia. The possibility of flammable substance ignition by laser irradiation dictates the use of properly sealed face masks or endotracheal tubes in these latter cases.<sup>25</sup> In addition, hair-bearing areas should be dampened with water before laser irradiation.

Lower laser energies are typically applied in children and in thin-skinned areas such as the periocular region, neck, and anterior chest. On average, 9 to 12 laser treatments are required for ~80% clearance of PWS, and 2 to 10 treatments are needed for hemangiomas.

## PROGNOSTIC INDICATORS

The response of PWS to PDL treatment depends on several factors, including anatomic location, lesional size, and vessel size. Lesions on the head and neck tend to require fewer treatments than those on the trunk and extremities.<sup>26,27</sup> There are also variations in lesional response in different facial areas, with more sessions needed in the mid-central face than the lateral portions.<sup>28</sup> These differences are attributed to thicker-walled blood vessels in the distal extremities and the presence of other regional dermal elements (e.g., pilosebaceous units) that may impede

delivery of laser energy in the central face. Lesions with smaller surface areas respond more quickly to laser therapy than larger diameter lesions.<sup>29</sup> PWS with more superficially located and moderately sized vessels are better treatment responders than are pink or purple PWS with small or deep vessels, respectively.<sup>30,31</sup>

More rapid clearing of PWS are seen during infancy and childhood than in adulthood.<sup>16</sup> The greater success of laser treatment in younger patients has been attributed to decreased skin thickness (permitting better laser penetration) and smaller lesional surface area. PWS recurrence after successful laser treatment is relatively rare but has been reported. Lesions that are darker (with larger, deeper vessels) or incompletely eradicated from prior laser treatment recur more frequently, suggesting that early treatment (of lighter, thinner lesions) reduces the risk of PWS recurrence.<sup>32,33</sup>

#### LASER TREATMENT OF ULCERATED HEMANGIOMAS

**T**reatment of proliferating hemangiomas has been advocated to elicit faster lesional resolution, reduce further proliferation, and prevent/remedy ulcerations.<sup>34-36</sup> PDL treatment of superficial hemangiomas has been mostly favorable, with thicker and proliferative lesions showing decreased or variable response (presumably because of the limited depth of penetration at the 585 nm wavelength). Ulcerations occur in 12% of focal lesions and 65% of diffuse or segmental lesions. They are most problematic in areas that are frequently irritated (such as the perianal region). Laser irradiation of the ulcerative component has been shown to help heal focal lesions with rapid reepithelialization<sup>37,38</sup> but has led to further progression of segmental lesions.<sup>39</sup> Concomitant corticosteroids are therefore advocated for these latter lesions.

#### TREATMENT MODIFICATIONS/ALTERNATIVES

**A**lthough 585 nm PDL remains the gold standard treatment bearer of congenital and acquired vascular lesions, longer wavelength lasers (e.g., 595 nm PDL, 755 nm alexandrite, 1064 nm Nd:YAG) and intense pulsed light systems have been introduced with the goal of improved dermal penetration.<sup>40-44</sup> Thus, larger caliber vessels with deeper dermal placement may show better response to treatment with these systems.

#### SIDE EFFECTS AND COMPLICATIONS

**M**ost patients experience varying degrees of erythema or purpura after PDL irradiation,

which can last up to 7 to 10 days.<sup>45</sup> Far less commonly, hyperpigmentation, hypopigmentation, and atrophic scarring can be observed, often attributed to use of excessively high laser energy or overlapping pulses. Patients with tans or inherently dark pigmentation should be treated cautiously because of possible competitive absorption of laser energy by epidermal melanin with its increased risk of post-treatment dyspigmentation.

#### CONCLUSIONS

**P**DL therapy has advanced over the past 2 decades to become the treatment of choice for vascular birthmarks. The preponderance of evidence indicates that treatment should be initiated as early as possible in infancy or early childhood to achieve the fastest lesional resolution with the lowest risk of recurrence. Nonetheless, mature, darkly colored and hypertrophic lesions respond well to PDL treatment, making laser therapy a viable solution at any time. Because of the propensity for PWS lesions to become more physically and psychologically debilitating for the patient over time, early laser intervention should be considered a medical necessity. Similarly, hemangiomas that are actively proliferating, impinging on vital structures, or ulcerating also dictate immediate laser intervention.

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