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ASLMS LASERS, LIGHTS, AND ENERGY-BASED DEVICES:

100 FAST FACTS AND PEARLS FOR BOARD REVIEW AND CLINICAL PRACTICE

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Introduction

Since its inception in 1980, the American Society for Laser Medicine and Surgery has been committed to advancing the use and understanding of lasers, lights, and energy-based devices. Over the past 40 years indications for these devices have expanded rapidly, as has our understanding of how these devices interact with the skin and other tissues. The 100 fast facts and pearls included in this review are meant to prepare learners for both clinical practice and board examinations. Additionally, citations to pivotal trials and relevant reviews are provided for more in-depth review of each topic.

Much of this review will focus on lasers. Rather than offering specific laser parameters for different indications, focus will be on understanding the basic principles underlying laser tissue interaction, the theory of selective photothermolysis, and the most frequently encountered laser indications. Clinical endpoints are highlighted as a guide for determining appropriate laser settings. By attaining a fundamental understanding of these core principles, learners should be able to deduce how a single laser device can be used successfully for several, seemingly unrelated indications. For example, understanding how the long-pulsed 1064 nm Nd:YAG laser can be used to eradicate unwanted body hair in skin of color, diminish the appearance spider veins on the legs, or treat basal cell carcinoma. Similarly, understanding how a picosecond alexandrite laser can treat lentigines, remove undesirable tattoo ink, or rejuvenate photodamaged skin.

In addition to lasers, other sources of therapeutic light including intense pulsed light, ultraviolet light, and light-emitting diodes, and the numerous indications for these tools will be covered. Furthermore, other energy-based devices including radiofrequency, ultrasound, high-intensity electromagnetic stimulation, and cryolipolysis will be reviewed, with a focus on tissue tightening and body contouring.

Fast Facts and Clinical Pearls

1. **LASER stands for <u>l</u>ight <u>a</u>mplification by <u>s</u>timulated <u>e</u>mission of <u>r</u>adiation.**

   Clinical pearl: Understanding the acronym laser allows one to understand the essential components that make up every laser device. An energy source first stimulates the emission of photons (radiation) from a medium contained within the optical cavity. A series of mirrors within the optical cavity allows for amplification of the laser light, as more photons are emitted from the medium. Finally, the amplified laser light is delivered to the patient via a hand piece.

2. **The electromagnetic spectrum encompasses all ranges of radiation (light) that exists and is divided into different regions based on wavelength. These regions include ionizing radiation (<100 nm), ultraviolet (100-400 nm), visible (400-700 nm), infrared (700-1,000,000 nm), and radio wave (>1 mm) regions.**

   Clinical pearl: The majority of lasers and lights used for dermatologic indications are in the ultraviolet, visible, and infrared spectra. Each of these regions has general indications that are dictated by the depth of penetration and the interaction with specific tissue chromophores. For example, ultraviolet wavelengths have very shallow penetration into the skin and have been used primarily for inflammatory skin conditions involving the epidermis. Visible light is well absorbed by melanin and hemoglobin, making it ideal for pigmented and vascular lesions. However, visible light has relatively modest tissue penetration making it less effective at treating deeper pigmented or vascular lesions. Near-infrared lasers have the deepest tissue penetration and can effectively target deeper pigmented and vascular lesions. Mid- and far-infrared wavelengths are not absorbed by melanin or hemoglobin. They are, however, absorbed strongly by tissue water. Consequently, they have several indications that are mediated by heating tissue water.

3. **What differentiates laser light from all other light sources is that they are collimated (parallel and directional), coherent (in phase in time and space), and monochromatic (a single wavelength).**

   Clinical pearl: The optical properties of lasers allow for selective targeting of different structures in the skin and other tissue. Perhaps most important among these is the monochromaticity of laser light. Because different structures absorb different wavelengths of light, careful selection of the wavelength is critical for this selectivity. Lasers contain a medium, for which they are often named, that is responsible for emission of photons upon excitation. Importantly, the composition of the medium determines the wavelength of laser light produced. The medium may be solid (e.g., alexandrite, Er:YAG, Nd:YAG, KTP, ruby, or a diode semiconductor), liquid (e.g., PDL), or gas (e.g., CO_2, xenon chloride, or argon).

4. **Intense pulsed light (IPL) is non-collimated, non-coherent, polychromatic (500 – 1200 nm) light emitted from a xenon flash lamp.**

   Clinical pearl: The polychromatic light emitted from an IPL has both advantages and disadvantages. In terms of advantages, the different wavelengths enable targeting of multiple absorbing molecules at once. This can be beneficial for a condition like poikiloderma, which is characterized by dyspigmentation, diffuse erythema, and telangiectasias. This is also a disadvantage, as selectivity for a single absorbing molecule is lost. This can create the targeting of unintended targets and non-specific heat generation. In addition to less selectivity, IPL light is considerably less powerful than laser light. Therefore, treatment of the same lesion may be less effective with IPL and require more treatment sessions.

   Babilas P et al. Lasers Surg Med 2010;42:93-104

5. **Photons of light encountering the skin can be reflected, absorbed, or scattered. If none of these occur, light is transmitted through the skin without interaction.**

   Clinical pearl: In most cases, the desired interaction for therapeutic light is absorption by a specific structure or molecule. Reflection of photons off the skin's surface, accounting for ~5% of incoming light, not only wastes energy, but it also is a risk to the laser surgeon as it can be reflected into the eye causing irreversible damage to ocular structures. Similarly, transmission of photons, particularly when working in the periorbital region, can be damage the patient's eye. This highlights why protective eyewear for both the laser surgeon and the patient is a necessity when using any laser device.

6. **Molecules in tissue that absorb light are called chromophores. The primary endogenous chromophores for lasers are melanin, hemoglobin, and water.**

   Clinical pearl: Chromophores are photoreceptive molecules that preferentially absorb specific wavelengths of light. Unlike lasers, which are monochromatic, IPL can target all three chromophores at once making it versatile but less selective. However, for many applications, targeting a single chromophore is desired. Therefore, efforts should be made to select a laser that has the greatest absorption for a desired chromophore with the least amount of overlap with undesired, competing chromophores. In addition to the primary endogenous chromophores most frequently targeted for laser applications, other chromophores include lipids, cytochrome oxidase c, opsins, and flavins. Additionally, exogenous chromophores, such as tattoo pigment or 5-aminolevulanic acid (ALA), can also be targeted. The use of other exogenously applied chromophores, such as gold nanoparticles, has rapidly growing interest to further expand the applications for selective laser destruction.

7. **The absorption coefficient is a measure of the probability that a specific wavelength of light will be absorbed by a specific chromophore.**