LIGHT THERAPY

A HANDBOOK FOR PRACTITIONERS

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shorter wavelengths of light, such as blue light, have higher absorption in superficial tissue and are more strongly scattered in tissue than red or infrared light. Moreover, because blue light has wavelengths in the general range of 450 to 490 nm, it is absorbed by hemoglobin which is abundant in red blood cells, and also by melanin, a common skin pigment. Absorption of blue light by hemoglobin may induce the release of Nitric oxide (NO), a free radical that, in large amounts, can trigger cell death.

Thus, blue light irradiation is believed to trigger hemoglobin in circulating red blood cells to release NO. Because NO has a short half-life of 2 - 3 seconds, the effect is usually local, not widespread, limiting the effect of continuous NO production from reaching other parts of the body. NO is well known to induce cell death or apoptosis. Since blue light is highly absorbed and efficiently scattered in tissue relative to red and infrared light, and because its absorption by hemoglobin can trigger the release of large amounts of NO, a proposed mechanism for the bactericidal and antifungal effects of blue light is that it promotes apoptosis in bacteria, fungi and other pathogens.

SUMMARY OF MECHANISMS INVOLVED

In summary, red and infrared light are absorbed by chromophores such as cytochrome c oxidase, porphyrins, flavins and other light-absorbing entities within the mitochondria and cell membrane. The absorbed light energy is used to trigger a cascade of intracellular reactions, including acceleration of electron transport, modulation of the redox state of the cell, synthesis of Ca^{2+}, and alteration of other signaling processes that result in increased ATP synthesis, synthesis of NO and small amounts of reactive oxygen species (ROS).

The ATP produced is used to power a multitude of metabolic processes, and these may include synthesize of DNA, upregulation of RNA, synthesis of growth factors, cytokines, proteins and enzymes, and the modulation of other biological chemicals needed to repair or regenerate cell and tissue components. Moreover, light therapy triggers the formation of new blood vessels, acceleration of blood flow, cell proliferation, cell migration and increased synthesis and maturation of collagen. This cascade of biochemical reactions and cellular activities give rise to tissue repair, pain reduction, resolution of inflammation, edema reduction, mitigation of necrosis, and/or restoration of normalcy to an otherwise impaired biological process. The interaction between light and tissue also generates a small amount of heat, which together the vasodilatation produced by light-induced NO synthesis, elevates blood flow.

Different wavelengths of light produce different effects. Whereas red and infrared light promote tissue repair, pain reduction, resolution of inflammation, edema reduction, mitigation of necrosis, and/or homeostasis, blue light is bactericidal. It kills bacteria, and as detailed above, it appears to be absorbed superficially and mostly by hemoglobin; causing the production of localized amounts of NO that kill bacteria.

effects of methanol induced toxicity in the retina and the optic nerve. In addition, Dr. Eels and her team have new data indicating that light therapy has the potential to retard the progression of multiple sclerosis in a laboratory model of the disease. Similarly, evidence from the works of Dr. Jeri-Anne Lyons, also of the College of Health Sciences, University of Wisconsin—Milwaukee, suggests that treatment with red 670nm light ameliorates experimentally induced autoimmune encephalomyelitis in mice.

SUMMARY

Light therapy has been shown to promote tissue repair in animal models of wounds, ulcers and burns, as well as human cases of recalcitrant sores, including those that do not seem to respond to any other available form of treatment. The scientific literature offers the rationales for treatment. These include: the photo-physical effects produced when light interacts with tissue, as well as the photobiological effects, including: increased ATP synthesis, nitric Oxide (NO) synthesis and release, singlet oxygen release, modulation of cell signaling, synthesis of RNA and DNA, synthesis of cytokines, growth factors, enzymes and proteins, increased blood flow, and increased cell proliferation and migration.

In addition to the foregoing rationale, statistical meta-analysis studies provide additional strong evidence that light therapy, indeed, promotes tissue repair. Briefly stated, meta-analysis is a powerful statistical procedure for combining the results of a multitude of related studies in order to determine the actual effect of a particular treatment. The procedure is superior to mere literature review, systematic review or other subjective methods because it

uses objective quantitative methods to estimate true treatment effect; thereby eliminating subjective assessment and resolving the controversies concerning the value of light therapy in clinical practice. In this method, treatment effect value of +0.2 is said to represent a small positive effect size, +0.5, a medium effect size, and +0.8 or greater, a large effect of treatment. The corresponding negative values represent small, medium and large negative effects of treatment. In three independently conducted meta-analysis studies, namely, Enwemeka et al. (2004); Woodruff et al. (2004), and Fulap et al. (2009), the overall treatment effects of light therapy on tissue repair were +1.81, +2.22 and +1.94, respectively. These independently determined large treatment effects leave no doubt whatsoever that light therapy is highly effective for promoting tissue repair.

RATIONALE FOR WAVELENGTH SPECIFIC TREATMENT

BLUE LIGHT

- General Sanitization
- Bactericidal Effect
- Fungicidal Effect

RED LIGHT

- Resolution of Inflammation
- Reduction of Edema
- Pain Relief
- Superficial Tissue Repair
- Absorbed in Superficial Layers of Tissue*

IR LIGHT

- Tissue Repair, Superficial or Deep (best for deep tissue injuries)
- Pain Relief
- Resolution of Inflammation
- Reduction of Edema
- Penetrates to Deeper Layers of Tissue*

* See page 14

FOOTNOTE

For red and infrared light, the items in each box are listed in order of preference. If one is to choose one wavelength of light—red or infrared light, not both—the suggestion is that red light should be used to resolve inflammation and reduce edema in preference to infrared. By the same token, infrared light should be used for tissue repair and pain relief in preference to red light; except when such pain, edema or tissue damage is clearly superficial. Since we know that wavelengths between 600 nm and 1000 nm reduce pain, resolve inflammation and promote tissue repair, but do not know of a "magic bullet" wavelength for each particular condition, it is better to combine both wavelengths, red and infrared, in many cases. However, the clinician must exercise adequate professional judgment in making such decisions, particularly as patients differ from one person to the next. Whereas a patient with one condition may respond well to red light, another patient with the same ailment may respond better to infrared light, etc.

It should be noted that peripheral nerves are extensions of nerve cells which themselves are located in the dorsal root ganglion of the spinal cord.

Available evidence suggests that light therapy appear to inhibits pain more readily when the nerve cell body is irradiated in addition to stimulating the peripheral nerve axons. The logic lies in the fact that the nerve cell itself initiates and modulates the production of several mediators of inflammation, tissue repair and overall healing, such as nitric oxide, prostaglandins, cytokines, endorphins, growth factors, etc. Thus, whereas direct stimulation of the nerve inhibits nerve conduction velocity, alters somatosensory evoked potential and complex muscle action potential in order to dull the sensation of pain, transcutaneous irradiation of the nerve cell body in the paravertebral region of the corresponding spinal segment of the nerve promotes the synthesis and release of pain modulating chemicals, and the advancement of axonal repair.

SUMMARY

In summary, available data suggest that the foregoing factors account for the pain relieving effects of light therapy observed in clinical practice. Therefore, the finding that light therapy ameliorates pain due to arthritis, carpal tunnel syndrome, post-herpetic neuralgia, head, neck and shoulder disorder, lumbago with or without sciatica, temporomandibular joint disorder and painful inflammatory conditions, such as epicondylitis, costochondritis, tendinitis, joint sprain and fasciitis does not come as a surprise. And this is well supported by recent meta-analysis of the literature (Enwemeka et al., 2004; Fulap et al., 2010). As detailed in Chapter three, in meta-

analysis treatment effect value of +0.2 is said to represent a small positive effect size, +0.5, a medium effect size, and +0.8 or greater, a large effect of treatment. The corresponding negative values represent small, medium and large negative effects of treatment. In their meta-analysis of well controlled studies before year 2000, Enwemeka et al. (2004) showed that light therapy had a large (+1.11) true effect of treatment on pain reduction. In their subsequent analysis of well controlled studies published between 2000 and 2007, Fulap et al. (2010) reported a large treatment effect of +0.84; again showing that light therapy significantly promotes the relief of pain. These findings strengthen previous reports (Brusseau et al., 2000; Gur A. et al., 2002, 2003a, 2003b, 2004; Hirschl, et al., 2004; Chow et al., 2006; Douris et al., 2006; Ekim et al., 2007;) which indicate that light therapy is beneficial for pain relief, regardless of etiology.

LIGHT THERAPY IS INDICATED FOR THREE CATEGORIES OF AILMENTS. THESE INCLUDE
(1) TISSUE REPAIR
(2) INFLAMMATION
(3) PAIN.

