06 August 2014 – Australian Doctor

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Treating pain with lasers

6 August, 2014 Dr Roberta Chow 0 comments

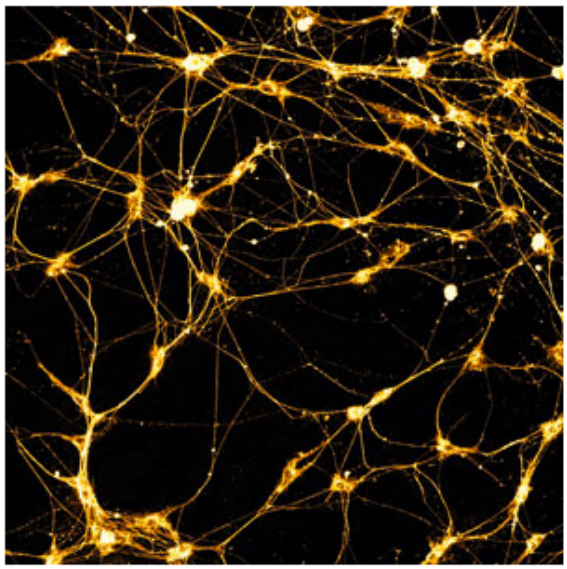
Low-level laser therapy can achieve good pain relief in a range of conditions.

Chronic pain is a common and debilitating condition, costing Australia $34 billion in 2007 and $634 billion annually in the US.[1]

The extent of the problem for GPs in Australia has been quantified by the BEACH and Supplementary Analysis of Nominated Data (SAND) studies, which evaluated 1.4 million GP consultations in Australian general practice.

Painful conditions were the third most common reason for people to visit a GP, with a prevalence of 19.2%. Forty-eight per cent of these patients were diagnosed with osteoarthritis, 29.2% with "back problems", and 7.1% with other forms of arthritis.

Almost one-third of people nominated "other condition" as the cause of their chronic pain, of which 65.1% were musculoskeletal and 14.7% neurological. People with cancer-related pain constituted 2.4% of chronic pain consultations.



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Pharmacotherapy treatments

Current treatment protocols rely heavily on pharmacotherapies such as NSAIDs and opioids, which can cause severe side effects, especially when taken long term and by the elderly.

Even the simple analgesic paracetamol is now recognised as having long-term side effects, and is no longer recommended as a first-line treatment in the UK's National Institute for Health and Care Excellence's guidelines for knee osteoarthritis.

Escalating opioid use and iatrogenic opioid addiction in Australia are increasingly difficult management issues for GPs and their patients with chronic pain.[2] There is an escalating diversion of these drugs to non-therapeutic use. This highlights an urgent need for non-drug approaches to be incorporated into the therapeutic armamentarium to reduce the burden of the epidemic of chronic pain.

Low-level laser therapy

Low-level laser therapy, also referred to as photobiomodulation, is a therapeutic option in which the 'active ingredients' are photons.

While the use of laser, a form of monochromatic light, may seem an improbable answer to the treatment of the complex, multidimensional problem of pain, the therapeutic use of light is not new to medicine.

It is well accepted that many biological systems respond to light, including retinal photoreceptor rods and cones. Photons are used in the treatment of conditions such as neonatal hyperbilirubinaemia, seasonal affective disorder, psoriasis, and are critical to vitamin D metabolism via sun exposure.

Evidence for use

Low-level laser therapy has been used in the treatment of pain for more than 30 years and is now included in the WHO guidelines for treatment of chronic neck pain.[3] In clinical applications, infrared or visible laser light is applied to tender areas at sites of pain.

This simple technique has been evaluated in randomised control trials and systematic reviews, which not only provide evidence for efficacy and effectiveness, but also confirm the absence of significant adverse side effects.

There is high-level evidence for the treatment of neck pain, and moderate levels of evidence for back pain, lateral epicondylitis and frozen shoulder.[4-7]

Reviews of low-level laser therapy may be inconsistent in conclusions and can only be considered sound when they take into consideration the technical aspects of the treatment, including the dose of laser and application technique, which is often overlooked by people unfamiliar with the therapy.

How it works

Early concepts explaining low-level laser therapy effectiveness have included the gate control theory, endorphin up-regulation and serotonin modulation.[8] In the past decade, research has focused on specific peripheral effects, in particular anti-inflammatory effects demonstrated in several experimental models.

These effects include suppression of COX-2 mRNA expression, suppression of interleukin-6, decreased mRNA expression of kinin receptors and of inflammatory cytokines, and reduced COX-2 expression.[9-13] In some of these studies, anti-inflammatory effects of laser irradiation are equivalent to anti-inflammatory medications, such as meloxicam and dexamethasone.[14,15]

Neural blockade specifically targeting nociceptors is another important mechanism for the pain-relieving effects of low-level laser therapy. This has been the subject of my research over the past 10 years. The principle is that photons are partially and reversibly absorbed by superficial peripheral nerve endings, reducing action potential amplitudes and conduction velocity, and mimicking some functions of local anaesthetic injections. This reduces afferent noxious stimulation to the dorsal horn, initiating a signalling cascade to second-order neurons and to the pain matrix.

A review of the effects of laser on nerves confirmed the "blockade" effects in humans as well as animals. This was confirmed in our rat sciatic nerve study, which demonstrated that both red and infra-red laser slowed sensory and motor nerve conduction. When repeated over a number of treatments, long-term suppression of pain leads to long-term pain relief.[16,17]

How does light alter cell and tissue function?

Mitochondria are central to the transduction of light into photochemical and photophysical effects. The mitochondrial membrane contains the terminal enzyme — cytochrome C oxidase — in the Kreb's cycle, which has a photoacceptor with the capacity to absorb photons.

When cytochrome C oxidase absorbs a certain energy level of light, it is proposed that conformational change of the enzyme reduces electron transfer efficiency. This in turn leads to reduced adenosine triphosphate (ATP), which reduces the capacity of the nerve to generate action potentials causing depolarisation blockade.

Concurrently, the cytoskeleton of the neuron — the infrastructure for fast axonal flow along which molecular motors transport mitochondria (and other organelles) from the cell body to the endings in the skin — is disrupted. Fast axonal flow and hence transport of mitochondria and other organelles is blocked, leading to the reduction in available ATP for nerve function. This leads to a disruption not only of cytoskeleton structure and function, but also to the disruption of any ATP-dependent activities.

Immunohistochemistry studies have demonstrated the structural changes as the formation of reversible varicosities along axons, also seen with local anaesthetic agents, in which mitochondria "pile up" where the cytoskeleton is disrupted (see figure 1).[18-21] Live imaging studies in the same model demonstrate the same phenomenon with cessation of movement of mitochondria along the axon.

Clinical use of low-level laser therapy

In the clinical situation, this "local anaesthetic effect" translates to patients reporting reduction in tenderness and pain, sometimes in association with a sensation of "numbness", during the course of treatment.

Importantly, reduction of afferent stimulation results in reduced synaptic activity with second-order dorsal horn neurons, which modulates afferent input to higher centres.

Neuroplasticity underlies this capacity of the nervous system to modulate responses to laser-induced neural blockade, leading to long-term pain relief.

Conclusion

Low-level laser therapy is a modality with a long history and strong evidence to support its use in pain management. It is not a miracle treatment, but can achieve good pain relief in a spectrum of conditions especially where other treatments have failed.

It has few side effects and is tolerated well by older patients. It can be used as monotherapy or adjunctive therapy, where it can play a role in drug-sparing or facilitation of rehabilitation. The range of conditions able to be treated is wide. It requires some technical expertise and knowledge, but for most doctors it is easy to learn and to incorporate in day-to-day practice.

Successful outcomes, like all medical management, depend on good clinical skills linked with an understanding of the nature of pain and mechanisms of the effects of laser. Laser medicine has the potential to be as well known as laser surgery and become a stand-alone specialty in mainstream medicine.

Dr Chow is a GP specialising in pain medicine.

Dr Chow is president of the Australian Medical Laser Association, a multidisciplinary, non-profit organisation formed in 2005 to promote education and research into the field of laser medicine. She has no financial interest in any companies selling or promoting lasers. She works in her own medical practice, Quantum Pain Management.

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