THE SIGNIFICANCE OF PULSING IN THE STIMULATION OF TISSUE REPAIR AND REGENERATION BY LIGHT
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- Taught med students at Guys Hospital for 34 years
- There is a big black hole in the literature, partially filled in by other forms of pulsed energy
- Why pulse?
  - Evidence that pulsed LILT can stimulate tissue repair and regeneration
  - Pulses stimulate cell activity: some evidence that better than continuous, but if too fast the cell will think it is continuous
  - Can regulate biological rhythms or cycles
  - Because we can!
- Examples
  - 2hz nerve regeneration
  - 7 hz bone growth
  - 10 hz ligament repair
  - 15, 20, 72 hz granulation tissue growth
  - From tissue growth @topica.com?
  - From Baxter's book:
- Light is electromagnetic energy (EME)
  - LILT is EME
  - EME is the full spectrum of EMR and EMFs (electromagnetic fields)
  - EMR and EMF's interact
  - These interactions affect the metabolism of organisms, including regenerative and reparative activities
- Pulsed EMR and EMRs
  - Pulsed light, IR microwaves, radio waves and EMF’s are stimuli, i.e. environmental changes that organisms respond to
  - Earth's surface and the ionosphere form and electrodynamic resonating cavity
- This produces ELF (extremely low freq) micro pulsations of 0.1-25 Hz, most of the energy being at 10 HZ
  - Organisms respond to these pulsations by metabolic changes
  - All living organisms have evolved in an environment where they are exposed to pulsed EMR from the sun and to gravity
  - They can detect many wavelengths of EMR and also gravitational changes
  - Changing the pulsing can act as a stimulus
- Biological cycles or rhythms
  - Yearly: solar, bird migrations
Monthly: lunar, menses
Circadian: pulsed light for synchrony
Much shorter duration, e.g. milliseconds

Theses have 3 domains:
1. Input pathways that transmit environmental signals to oscillators (e.g. EMR and or EMF variation)
2. Generation of timing signals in the oscillators
3. Output pathways that transmit rhythmic signals to the processes controlled by the oscillators

Pulsed electromagnetic fields (PEMFs)
- Are more biologically active than continuous
- Low freq oscillating fields <1.6 x 10^4 Hz are more effective

EMFs in human brain
- AC fields in nerve detected routinely in EEG
- DC fields in perineural system detected by magnetoencephalography using superconducting quantum interferometric devices
- DC fields, which stabilize nerve conduction, are affected by PEMFs

PEMF variation mechanism
- An external oscillating field causes forced vibration of charged particles on the surface of cell membranes
- Membrane permeability changes occur via electrosensitivity
- Ca++ channels affects
- Cell changes
- Reversible membrane permeability change is the common factor by which electrotherapies: e.g. LILT activate cells after injury
- There are specific ion/ligand binding pathways are affected by PEMFs e.g. CA++ binding to calmodulin which produces CA-dependent signal to enzyme systems
- The kinetics of an EMF target pathway can be used to estimate the frequency range
- 10 HZ variations in the earth’s magnetic field affect biological cycles
- Do 10HZ PEMFs resynchronize cycles for body temperature, BP, sleep/activity etc?
- Could 10HZ LILT resonate with the body best?

Can pulsing be dangerous?
- The body expects lunar, circadian and low energy gravitational changes of 0.1 to 35 HZ
- ELF of 35 to 100 HZ predicted to be damaging to immune systems by Becker 1985—thinks it causes stress
- (She has published stress and healing)
- Higher frequencies could be undetected unless of high energy and for prolonged times—if too fast body may think continuous

There is nothing new about using light as a therapeutic EMR stimulus, often in pulsed mode
- E.g. circadian daylight, dark at night
- >4000 years sunlight used in Egypt
- Still used to treat Seasonal affective disorder
- Mammalian cells respond differently to red and blue 100 years ago, has been used to treat psychiatric conditions
- LASER became available in 1960’s
- Red light can be used to destroy tissue, with stimulation of healing at the edge
- Constructive Laser LILT
  - Mw power level
  - Single or cluster probes
  - Can be pulsed or continuous
  - Have to do statistically analysis
  - Monochromatic
  - Collimated
  - Coherent
  - Red or infrared
  - Light can be produced by LEDs, semiconductor P-N junctions that produce EMR (range 180nm-1mm) primarily by spontaneous emission
  - GaAlA lasers: semiconductor, 780-890 nm, pulsed or continuous, typically 30-100 mw
- Biological LEDs have been in existence for millions of years
  - Could be characteristic of living organisms
  - E.g. matrix of bone
  - P-N semiconductor diodes doped with metal ions, e.g. protein/crystal aggregates such as the collagen (n)/apatite (p) matrix of bone
  - E.g. neuroepidermal junctions
  - E.g. protein aggregates such as tendon, ligaments, myofibrils
  - Fluoresce
  - Help produce bioelectric currents using light and other forms of energy
  - Help control biological activity e.g. wound healing via these biocurrents
- But what if the light they receive is pulsed?
  - Cellular effects of LILT relevant to healing
  - Mechanisms producing these effects
  - Which pulsing regimes work?
  - Why do we need to improve tissue repair?
    - Delayed healing
    - Hypertrophic or keloid scars
  - How do wounds heal?
    - Acute inflammation: increased macrophages
      - Swelling is the only bad guy, beside pain
• Necessary step, acceleration is preferable to inhibition, need the growth factors that are mitogenic and angiogenic
• Chronic inflammation is bad, inhibit with drugs
• LILT accelerates resolution of acute inflammation, but will only help those with delayed healing
• Her study: He-Ne 632 ngm 6.5 mW/cm2 continuous
• 904 nm 200 ns pulses 700 Hz or 1200 Hz
• 15 min for 5 days
• All effective physical methods assist the body to heal itself. Help by reducing inflammation
  o Proliferation: granulation tissue
    • See lots of fibroblasts
    • 700 hz stimulated contraction by 3 days, just speeded up, pulsing
    • 1200 hz did not work, was inhibitory
    • Less elastic scar tissue
    • LILT treated wounds are stronger and have more collagen
    • LILT can stimulate growth factor release from fibroblasts
  o Remodeling: scar
    • Light coherence not important
    • Right light works on everything
    • Mast cell sensitivity varies, injured cells more sensitive
    • In injured skin 660 and 820 Hz work

Mechanisms+
  o The same wavelengths that stimulated growth factors
  o 4 joules/cm2 most effective dose
  o 16Hz?
  o Causes membrane permeability which stimulates tissue repair
  o Tertiary, systemic effects exist, from photons etc, via growth and nerve factors
  o Red light affects mitochondria
  o Infrared absorbed by mitochondria and membranes, creates NO
    o Reduces edema

To get chronic wounds to heal, make them into acute wounds (debrided) then accelerate the resolutions of acute inflammation e.g. LILT

What LILT research needs:
  o More double blind clinical trials
  o Optimization of pulsing regime and other treatment parameters
  o Noninvasive assessment of efficacy by digital photography and ultrasound biomicroscopy
  o Measure the effectiveness, e.g. reducing edema
  o Wound healing assessment using 20 MHz ultrasound lets you be objective, 62 microns resolution
    o =High frequency ultrasound (HFUS)
    o =High resolution ultrasound (HRUS)
  o Use for acute evaluation
Have to define healing: re-epitheliazation?

The Body Electric Beck, Rbt, 1985
Laser Therapy 2002 turner and Hode

Colchrane Review says there is no effect from LLLT on healing
  • Trouble is they used some rubbish papers
  • In the early days didn’t know what they were doing
  • Need NAALT to help people design new studies

Smith’s book Electromagnetic Man

Maybe we think beyond pulses and frequency