Areas to consider

- Basic phasing model of injury and repair
- Electro Physical Agents: Key concepts and Principles
- Influence of EPA’s in relation to Tissue Repair
- In passing also consider:
  - Potential mismatch between EVIDENCE and PRACTICE
  - Where might we go in the future?
Prolongation of the Repair Phases Resulting in longer TIME to achieve outcome(s)

?? Maybe this is the NORMAL that many therapists get to see ??
INFLAMMATION is NORMAL, NECESSARY and is controlled by a wide range of CYTOKINES and other CHEMICAL MEDIATORS.

Examples of inflammatory events that have a direct influence (stimulation) of the primary events in the next (proliferative) phase.

CHEMICAL CONTROL SYSTEMS IN THE INFLAMMATORY PHASE

- Prostaglandin E2
- Muscle Fibre Capillary
- Inflammatory Cytokine Pathway
Schulze-Tanzil et al. (2011)
The role of pro-inflammatory and immunoregulatory cytokines in tendon healing and rupture: new insights

Tissue Repair Phases and Timescale

[Diagram showing tissue repair phases and timescale]

Schulze-Tanzil et al. (2011)
The role of pro-inflammatory and immunoregulatory cytokines in tendon healing and rupture: new insights

[Table: The Inflammatory Response to Skeletal Muscle Injury]

<table>
<thead>
<tr>
<th>Cytokine</th>
<th>Pro-Inflammatory</th>
<th>Immunoregulatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>TNF-α</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>IL-1β</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>IL-6</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>IL-10</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>IFN-γ</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>TGF-β</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>PGE2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>VEGF</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Smith et al. (2008)
Sports Med 38(11): 947-969

[72 mediator links identified]
Progress of Inflammation

- Chronic Inflammation
- Repair / Healing
- Resolution

Chronic Inflammation as a result of repeated mechanical or other irritation

Using an 'irritating' or 'provocative' therapy as a means to facilitate the resolution of chronic inflammatory states

Evidence for the presence of chemical 'inflammatory stop' signals

Cellular resolution of inflammation—catabasis

Widgerow (2012)
Wound Repair Regen 20(1): 2-7
The angiogenic response is essential for effective repair material construction.

Collagen production by the Fibroblasts is driven by cytokines and other mediators from the inflammatory phase and is an Oxygen dependent (aerobic) process.

Factors that STIMULATE and those that INHIBIT angiogenesis in repair (from Li et al, 2005, Adv Skin Wound Care 18(9):491-500)
Facilitation of Collagen Synthesis

- Collagen Synthesis is dependent on several key factors:
  - FIBROBLAST presence
  - FIBROBLAST activation
  - OXYGEN
  - NUTRIENTS
- Important to encourage / enable these elements in order to achieve the most efficient collagen production
- Tissue OXYGEN DELIVERY appears to be CRITICAL in this regard
PROLIFERATION STAGE

REMODELLING STAGE

NORMAL TISSUE

PROLIFERATION STAGE

REMODELLING STAGE
After: Lo et al. (2002)
J Anat 200(3): 283-296

Normal ligament

Ligament scar tissue

Tissue Repair Phases and Timescale

- Bleeding
- Inflammation
- Proliferation
- Remodelling

Hours Days Weeks Months

Electrotherapy :: Electro Physical Agents and Repair

What DOES the Evidence say??

(c) Tim Watson 2015
### Model of Electrotherapy / Electro Physical Agents (EPA's)

<table>
<thead>
<tr>
<th>Electro Physical Agents</th>
<th>Thermal Agents / Modalities</th>
<th>Non Thermal Agents / Modalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transcutaneous Electrical Nerve Stimulation (TENS)</td>
<td>Infra Red Irradiation (IRR)</td>
<td>[Pulsed] Ultrasound</td>
</tr>
<tr>
<td>Interferential Therapy (IFT)</td>
<td>Shortwave Diathermy (SWD)</td>
<td>Low Intensity Pulsed Ultrasound (LIPUS)</td>
</tr>
<tr>
<td>Neurovascular Electrical Stimulation (NVEES)</td>
<td>Microwave Diathermy (MWD)</td>
<td>[Pulsed] Shortwave Therapy (PSWT)</td>
</tr>
<tr>
<td>Functional Electrical Stimulation (FES)</td>
<td>Other RF Therapies</td>
<td>[Pulsed] Laser Therapy (LLLT / LILT)</td>
</tr>
<tr>
<td>Current Stimulation</td>
<td>Hydrocollator Packs</td>
<td>[Pulsed] Microwave Therapy</td>
</tr>
<tr>
<td>Thermophoresis</td>
<td>W/ Therapy</td>
<td>Heat Pulsed Electromagnetic Fields (PSWT)</td>
</tr>
<tr>
<td>High Voltage Pulsed Electromagnetic Stimulation (HV-PES)</td>
<td>Electromagnetic Fields</td>
<td>Pulsed Electromagnetic Fields (PSWT)</td>
</tr>
<tr>
<td>Low Intensity Direct Current (LIDC) and Pulsed LIDC</td>
<td>Fluidotherapy</td>
<td>Microcurrent Therapy</td>
</tr>
<tr>
<td>Twin Peak Monophasic Stimulation</td>
<td>Therapeutic Ultrasound</td>
<td>Magnetic Therapies</td>
</tr>
<tr>
<td>Biodynamic Therapy</td>
<td>Laser Therapy</td>
<td>Pulsed Magnetic Therapy</td>
</tr>
<tr>
<td>RF Wave Therapy, Action Potential System (APS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Stimulation: Medium Frequency Stimulation</td>
<td>Cryotherapy / Cold Therapy / k/a / Immersion Therapy</td>
<td>Microcurrent Therapy (MCT)</td>
</tr>
<tr>
<td>Russian Stimulation: Shortwave Therapy, NMD, (int/3D) Based Therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microcurrent Therapy (MCT)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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(c) Tim Watson 2015
Evidenced EPA’s that can (directly) influence Tissue Repair

- Ultrasound Therapy
- Pulsed Shortwave Therapy
- Laser Therapy
- LIPUS (Low Intensity Pulsed Ultrasound)
- Microcurrent Therapy
- Shockwave Therapy

**EMERGING (EVIDENCED BUT LESS ‘POPULAR’ IN PRACTICE)**
- Magnetic Therapy (incomplete clinical evidence)
- Pulsed Microwave (evidenced but not used)

**ALSO**
- IFT, TENS, NMES, Russian, Twin Peak Monophasic . . .

Dose – Response Relationship

- There is a SUBSTANTIAL volume of published research
- More in relation to EPA’s than for many other areas of therapy
- NOT all supportive – by a long way
- BUT the evidence strongly suggests that it is essential to select the optimal MODALITY and the optimal ‘DOSE’ for optimal effect
- NOT really a surprise – same as all other interventions

EPA DOSE WINDOWS CONSIDERED

Key concepts with electrophysical agents

Tim Watson

Problem with ‘hitting the wrong window’

- More ways of getting the dose ‘wrong’ than ‘right’
- If you deliver the ‘right’ therapy and the ‘wrong’ dose not likely to be optimally effective
- Whether drug based therapy, exercise, manual therapy, acupuncture or any of the electro physical agents
- Plenty of examples in the published literature (reviewed in Watson, 2010)

Examples of Hitting and Missing the Window

Same Modality (Ultrasound)
Same body area (Shoulder)
Ultrasound: Dose Issues

- Ainsworth et al. (2007) Rheumatology 46(5) 815-20
- Ultrasound and manual therapy for shoulder problems
- Multicentered RCT, double blind and placebo controlled
- Manual therapy + verum ultrasound
- OR manual therapy + placebo ultrasound
- Conclude that the addition of US to the manual therapy made no difference to the outcome
- BUT read the detail . . . . . .

Ainsworth et al. (2007)

- US ‘dose’ determined by treating therapist (‘pragmatic’ paradigm)
- 80% of the US treatments actually employed US (not 100% as you might expect)
- Dose info only available for 76% of them
- Power ranged from 0.2 – 1.0 W cm⁻²
- Strongest dose was therefore 5 x ‘stronger’ than weakest
- Treatment times varied by 230% (shortest to longest)
- Whole range of pulse regimes
- Treatment dose ‘differential’ of at least 1100% weakest to strongest (TW calculated)

Ainsworth et al. (2007)

- Given that almost 25% of the ultrasound treatments had no dose recorded
- Given that 20% of people allocated to the ultrasound group did not actually get ultrasound
- Given that the applied doses varied by 100’s of percent (actually >1000%)
- Difficult to draw the same conclusion as the authors
- NOT saying that they are INCORRECT, just that it is difficult to ‘trust’ the findings
Comparision of ultrasound therapy of various durations in the treatment of subacromial impingement syndrome

- RCT to compare the efficacy of ultrasound treatments of various durations for patients with subacromial impingement syndrome
- US at 1 MHz, 1.5 W/cm², Continuous, 5 days/week, 3 weeks
- Group 1 in = 50: 15 sessions of US @ 4 min
- Group 2 in = 50: 15 sessions of US at 8 min
- Both groups get Heat and TENS combined with exercise
- VAS, UCLA, Constant, and BDI scores showed statistically significant within group improvements.
- When the two groups were compared, we found no statistically significant differences in the Constant activities of daily living, Constant external rotation, Constant force and BDI scores (4/8)
- However, the second group scored better than the first group in all the remaining parameters (4/8)
- Thus US effective (both groups), but magnitude of the response is dose dependent

Quick Results and Conclusion

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>8 min US group</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS</td>
<td>5.22±0.5</td>
<td>5.14±0.65</td>
</tr>
<tr>
<td>Constant pain</td>
<td>3.92±0.41</td>
<td>8.32±0.17</td>
</tr>
<tr>
<td>Constant external rotation</td>
<td>12.8±0.21</td>
<td>12.2±0.10</td>
</tr>
<tr>
<td>Constant force</td>
<td>7.24±0.94</td>
<td>8.32±0.17</td>
</tr>
<tr>
<td>Constant pain</td>
<td>6.14±0.7</td>
<td>7.4±0.54</td>
</tr>
<tr>
<td>Constant external rotation</td>
<td>5.74±0.15</td>
<td>7.7±0.51</td>
</tr>
<tr>
<td>Constant force</td>
<td>5.29±0.06</td>
<td>7.0±0.16</td>
</tr>
<tr>
<td>Occiput Frontal</td>
<td>15.7±0.22</td>
<td>15.3±0.16</td>
</tr>
<tr>
<td>UCLA Score</td>
<td>22.7±0.09</td>
<td>20.3±0.01</td>
</tr>
<tr>
<td>BDI</td>
<td>12.29±7.08</td>
<td>11.9±0.18</td>
</tr>
</tbody>
</table>

Values are means ± S.D. *p<0.05 from two-tailed Student's t-test.

Both 4 and 8 min US have sig clinical effects BUT 8 min greater effect

Mechanism of Effect

Considerable Commonality

- There is evidence the several EPA's have a significant effect on tissue repair
- There appears to be a commonality in terms of HOW this is achieved
- The CHEMICAL MEDIATOR, CYTOKINE, GROWTH FACTOR enhanced expression, synthesis and release
- Growing body of evidence
EVIDENCED, ‘CLASSIC’ INTERVENTIONS
ULTRASOUND / LASER / PULSED SHORTWAVE

- Inflammatory optimiser – NOT anti-inflammatory
- Stimulates / promotes the normal proliferation events
- Encourages scar tissue remodelling – NOT the ‘removal’ of excess scar tissue
- Differential effects in terms of WHICH tissue type
- Which enables the MODALITY clinical decision

Tissues Absorption Characteristics

<table>
<thead>
<tr>
<th>ULTRASOUND Dense Collagen Based Tissues</th>
<th>PULSED SHORTWAVE Ionic, low impedance (WET) tissues: Muscle Nerve Areas with Oedema, Haematoma, Effusion</th>
<th>LASER Superficial Vascular Tissues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ligament</td>
<td>Open wounds</td>
<td>Muscle Nerve</td>
</tr>
<tr>
<td>Tendon</td>
<td></td>
<td>Areas with Oedema, Haematoma,</td>
</tr>
<tr>
<td>Fascia</td>
<td></td>
<td>Effusion</td>
</tr>
<tr>
<td>Joint capsule</td>
<td></td>
<td>Tendon sheath . .</td>
</tr>
<tr>
<td>Scar tissue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What about the ‘non’ classical modalities?

Low Intensity Pulsed Ultrasound (LIPUS)

- Strong evidence (incl RCT) and NICE support
- Established as an effective intervention in the management of BONE injury
- Fresh fracture: Delayed Union: Non-Union
- Reduces the TIME it takes to achieve repair in fresh fractures
- Improves the union rate in delayed and non-unions
- Being investigated for numerous other MSK presentations - ongoing

Shockwave based Therapy

- Different versions – main difference being FOCUSED or RADIAL
- RADIAL (non-destructive) strongest support in therapy arena
- Employed as a PROVOCATIVE stimulus
- Strongest support in CHRONIC TENDINOPATHY
- Also being investigated for numerous other clinical presentations
- Does NOT replace other therapy – used as an ADJUNCTIVE intervention
Microcurrent Therapy

- Been around (different names) for many years
- Strong established effect with BONE and SKIN lesions
- More recent developments with other MSK presentations including muscle, ligament, tendon
- SMALL current delivered over LONG treatment times gaining strongest support

Treatment: NUMBER OF SESSIONS and TREATMENT FREQUENCY is an issue

- Many of the studies employ treatment at frequencies which are not easily delivered in current (practice or NHS) terms, nor realistically the number of sessions
- E.g. Daily ultrasound for 2 weeks: effective but can you deliver it and can the patient afford it?
- BUT there is an increasing availability of HOME BASED Rx – TENS, NMES, Ultrasound, Pulsed Shortwave, Microcurrent . . .

Conclusion I

- Tissue repair sequence is effective and remarkably well organised and controlled
- In therapy, we often get to see the inhibited, slow, delayed or in some other way disturbed repair events – skewed view
- Role of therapy (logic and evidence) is to STIMULATE : PROMOTE : ENHANCE this process – NOT to change it
- Substantial volume of evidence to say this is what we do
Conclusion II

- Electro Physical Agents (EPA’s) have an evidenced role in the context of enhancing tissue repair
- Numerous modalities which fulfill this role ALONGSIDE other therapy – part of the PACKAGE
- DIFFERENT MODALITIES achieve optimal influence in DIFFERENT TISSUES
- DOSE issues are paramount
- Therefore clinical decision making needs to take account of both MODALITY and DOSE
- If so, the evidence is supportive of a beneficial effect on repair

THANK YOU

www.electrotherapy.org