ELECTROTHERAPY

OVER VIEW OF CURRENTS AND CLINICAL WAVEFORMS

Dinesh Verma, PT
WHAT IS ELECTROTHERAPY:

- It is the application of electrical stimulation transmitted through the body via electrodes for therapeutic purposes.
- The current flows through the body from one electrode to the other and causes different physiological reactions depending on the type of current selected, the parameters of the selected current and the output intensity.
Clinical Stimulators
- Patients tissue completes an electrical circuit
- The lead wires carry the current from the stimulator through the electrodes to and through the patient
- The skin is a resistor impeding current flow
General Electrophysiology

- Target Tissue
  - Sensory or motor nerve
  - The subcutaneous tissue is a conductor
- The current flows through the target tissue to the other electrode and up the other lead wire to the stimulator

The patient completes the circuit
Electrode Issues

- Electrodes should be placed so the flow of current can reach the target tissue.
- The farther apart the deeper the penetration.
- Placed too close the potential exists for greater concentration superficially this can result in discomfort or burn.
Current Flow

The rate of current flow depends on two factors; the force (voltage) driving the electrons and the amount of resistance offered by the conducting pathway defined as lead wires, electrodes and skin.

Ohm’s Law: Current \( (I) = \frac{\text{Voltage}}{\text{Resistance}} \)
Electrode Skin Interface

- The skin is a resistor to the flow of current
  - Good skin preparation is important
  - To lower impedance clean the skin
  - Proper electrodes and conductive medium are essential
Resistance

- Skin, resistance is 1500 Ohms. Skin resistance increases with age, obesity, presence of dirt; dead skin cells, and oils.

- Length of the pathway.
  - Lead wire length is set to a standard to minimize resistance.
  - The greater the distance between electrodes the greater the resistance.
Resistance

- **Carbon Rubber Electrodes** - New carbon electrodes have 50-75 ohms of resistance. With normal use and cleansing resistance usually exceeds 1000 Ohms.

- Options you have: Carbon Rubber, Metal and Sponge, and Self-Adhesive Electrodes

- **Self Adhesive Electrodes** typically have 20 Ohms of resistance which stays stable.
The Clinician has the option. Select electrodes that will have high impedance or electrodes with low impedance.

If they select electrodes with high impedance:

They will use more voltage or intensity, risk patient discomfort, and possibly get no outcome.
Electrotherapy Applications

What therapeutic purposes do you use electrotherapy for?
Clinical Applications

- In rehabilitation electrical stimulation is commonly used to manage a variety of clinical problems or conditions.
  - Symptomatic relief of chronic, intractable pain
  - Management of pain associated with post-traumatic or post operative conditions.
  - **Acute**
    - Relaxation of muscle spasms
    - Prevent or retard disuse atrophy
Uses of Electrical Stimulation

- Increasing local blood circulation
- Muscle re-education
- Maintaining or increasing range of motion
- Immediate postsurgical stimulation of calf muscles to prevent venous thrombosis
## Literature review of applications: USA

<table>
<thead>
<tr>
<th>Application</th>
<th>IFC</th>
<th>Premod</th>
<th>VMS</th>
<th>HVP</th>
<th>Micro-Current</th>
<th>Russian</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pain Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Chronic</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Spasms</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Post-Operative</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Muscle Weakness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min to moderate</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Moderate to Sever</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Disuse Atrophy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Re-education</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Increase ROM</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Prevent Venous Thrombosis</strong></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Inflammation / Edema</strong></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Increase local circulation</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Tissue healing</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Spasticity management</strong></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracture management</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Waveforms?

- Before we proceed further we need to understand what are the different Waveforms?
- What do they mean?
Three Categories of Electrotherapeutic Currents

- **Direct Current:**
  Historically referred to as “Galvanic Current” + involves the continuous or uninterrupted flow of charged particles.
  - Stimulating denervated muscle
  - Iontophoresis
Alternating Current

- Historically referred to as “Faradic Current” involves the continuous or uninterrupted bi-directional flow of charged particles.
  - Interferential Stimulation
  - Premodulated
  - Russian (modulated)

Beat Frequency: 100 Hz
Pulsed Current

- Pulsed or interrupted current is an isolated unit of uni- or bi-directional movement of charged particles that periodically ceases for a finite period of time.
  - Twin Peak High Volt Pulsed Current
  - VMS, VMS Burst, Microcurrent, Common TENS, Low Volt
WAVEFORM ANATOMY

- **DIRECT CURRENT**
  - Simple representation
  - Has Polarity effects i.e. defined Positive OR negative Pole.
  - In new age Electro units – it is possible to reverse the polarity.

![Direct Current diagram]
Waveform Anatomy

- ALTERNATING CURRENT

- The waveform is the geometric or visual representation of the stimulus or current.

![Diagram showing waveform anatomy with labels for Amplitude and Wavelength]
Phase – The phase is current flow in one direction for a finite period of time. A waveform is either monophasic or biphasic.
Waveform Anatomy (cont.)

- **Pulse** – It’s a combination of phases that make-up a single repeatable portion of the waveform.
Waveform Anatomy (cont.)

- **Monophasic** – The pulse deviates in one direction from the iso-electric baseline and returns to the baseline for a finite period of time.

  +

  Baseline

  -

  Monophasic can be Square or Twin Peak and it will have a polarity.
Waveform Anatomy (cont.)

- **Biphasic** – A pulse that deviates in one direction of the iso-electric baseline then deviates in the opposite direction from the baseline making two phases for each pulse.
Waveform Anatomy (cont.)

Interphase Interval

Pulse Rate

Phase Duration
CLINICAL WAVEFORMS

- Introduction to Types of Waveforms
Clinical Waveforms

- 11 approved clinical waveforms available to clinicians in the US
  - Five for pain control.
    - Interferential, Premod, Microcurrent, TENS (x2)
  - Six for muscle contraction.
    - VMS, VMS Burst, Russian, High Volt, DC, H-Wave
Interferential Quad-Polar

- Alternating Current
- Continuous medium-frequency sine wave
- Uses two channels of differing carrier frequencies to create a “beat” frequency within the tissues.
- Scan - amplitude modulation
- Sweep - frequency modulation
- Intensity - output amplitude
Interferential

Channel 1
5,000 Hz

Channel 2
5,100 Hz
Interference Current

Beat Frequency: 100 Hz

Interferential Current – is simply taking two channels of medium frequency current and arranging the electrodes in a crossing pattern.
Interferential Characteristics

- Amplitude modulated, medium frequency, sine wave and the current waveform is generated in the tissues being treated.
Premodulated Bi-Polar Interferential

- The two medium frequency sine waves are mixed in the system and delivered to the patient with two electrodes.
Premodulated Current

Beat Frequency: 100 Hz
Premodulated Characteristics

- Alternating current
- Two electrode technique
- Mixing two continuous bidirectional sine waves in the electrotherapy system.
  - One fixed medium frequency carrier.
  - One variable medium frequency.
Clinical Benefits

- Comfortable
- Simple two pad setup
- Easily applied to small joints of the upper extremity
Microcurrent

- Monophasic rectangular wave with selectable or alternating polarity
- Stimulation at a subsensory level
Microcurrent

- It is believed that if one wishes for “tissue healing” to occur the parameter settings are at ultra-low frequencies, under 1 Hz, and ultra-low amperage 10-100μA.
- Pain modulation frequencies range from 3 Hz (acupuncture) to 30 Hz and current output between 150 and 600 μA.
Clinical Issues

- Little evidence based information on parameters or application
- Most all information is empirical
- Little in the literature
Clinical Benefits

- Galvanic skin response mode (GSR) finds points of low impedance.
- Probe technique allows for direct stimulation over trigger-points and acupuncture points.
- Electrode placement can be utilized. Probe use to select electrode site is useful.
TENS

A symmetrical or asymmetrical pulsed current waveform that is used with two electrodes (single channel).

Common TENS Units and Low Volt (LV) Waveform Examples.
High Voltage Pulsed Current

High Volt current is a rapid succession of two brief high voltage impulses. The current flows in only one direction, which is determined by the selection of either a “positive” or “negative” polarity setting.
Symmetrical Biphasic Square Pulsed Current
Parameter Selection

VMS
- Cycle time – continuous or variable
- Frequency – 1 - 200 Hz
- Ramp – 0.5 – 5 sec
- Phase duration – 20 – 1000 micro sec
- Treatment time – 60 min
- Amplitude -
  - Sensory or motor response
    - Sensory level stimulation is cited to increase blood flow
Literature Parameters

VMS Parameters
- Mode Single channel
- Cycle time: 4/12
- Frequency: 100 Hz
- Ramp: 2 seconds
- Phase duration: 200 uSec
- Treatment time: 15 minutes
- Amplitude to a motor response
Clinical Benefits and Applications

- Adjutable parameters that lend itself to a diverse level of application.
- Pain modulation*
- Muscle re-education
- Edema reduction*
- Spastisity management

*Not approved by the FDA – common off label use.
VMS Burst

- A train of three consecutive symmetrical biphasic square waveforms, followed by a rest.
- The burst frequency is the number of burst per second (bps) of the waveform.
Parameter Selection

VMS Burst
- Channel Mode
  - Single Channel
  - Reciprocal
  - Co-contract
- Cycle time
- Burst Frequency
- Phase Duration
- Anti-fatigue
- Treatment time
- Amplitude – Sensory or motor response
The VMS Burst is the VMS waveform delivered in a BURST mode and has shown to provide a stronger contraction in larger muscle groups compared to the VMS.

Significantly more comfortable then the Russian waveform during a strong contraction.
Russian

Characteristics

- Sinusoidal pulsed alternating current with a 2,500 Hz carrier frequency.
- Current modulated at 50 Hz
Russian Current

This waveform became popular in the 1970’s as it was described by a Russian scientist Yakov Kots to produce muscle contractions of 110-130% MVIC (maximum voluntary isometric contraction) with no discomfort.
Clinical Benefits and Applications

- Comfortable stimulation
- Strong muscle contraction
- Sine wave is reported to cause less fatigue
- Minimum to moderate muscle weakness
Diadynamic Currents

- Discovered by Pierre Bernard in 1950
- Has a very limited number of English Language peer review publications.
- Not approved in USA as clinical waveform for Physiotherapy applications.
Diadynamic Currents

- ARE ALL MONOPHASIC SINUSOIDAL CURRENTS
- DF – diphase fixe = fixed diphase
- MF – Monophase Fixe = Fixed monophase
- CP – Courtes periodes = Short Periods
- LP - Longues periodes = Long periods
- RS – rythme syncope = syncopal rhythm
Diadynamische Stromformen

MF

CP

DF

CPISO

LP
Diadynamic Currents

- Pain reduction and blood circulation improvement.
- CP and LP prevents muscle habituation.
- a DF treatment will often be done before a CP treatment.
- Heavy skin burden.
- Pain - killing : low dose
  Improve blood circulation : High dose
Ultra-Reiz current

- Ultre Reiz = 2 / 5 = Träbert
- Puls duration: 2 ms, Puls pause: 5 ms
- Schmerzstillende und kreislauf förderende Wirkung.
- A vertebral treatment can be done before a local treatment
- Treatment time always 15 minutes; Dosage always until toleration
Ultra Reiz Current

Diagram:
- Amplitude
- Duration:
  - 2 ms
  - 5 ms
ELECTROTHERAPY

GOOD LUCK WITH WAVE FORMS !!!

Dinesh Verma