Clinical Indications and Protocols
For
Electrotherapy and Ultrasound
Table of Contents

Electrotherapy ........................................................................................................................................ 2
Electrotherapy Overview .......................................................................................................................... 2
Clinical Protocols and Rationale ............................................................................................................. 2
  Acute Pain ............................................................................................................................................... 2
  Chronic Pain .......................................................................................................................................... 3
  Relax Muscle Spasm ............................................................................................................................... 4
  Increase Local Circulation ...................................................................................................................... 4
  Prevent / Retard Disuse Atrophy ............................................................................................................ 5
  Muscle Re-education .............................................................................................................................. 6
  Range of Motion ..................................................................................................................................... 7
Electrotherapy Clinical Protocols Summary (Table 1) ........................................................................... 8
Basic Electrotherapy Terminology .......................................................................................................... 9
  Waveform Diagram ................................................................................................................................. 9
  Types of Electrotherapeutic Currents ..................................................................................................... 9
  Basic Waveform Components ............................................................................................................... 9
Overview of Electrotherapy Waveforms on Chattanooga Group Electrotherapy Units ......................... 11
  Interferential (IFC) ................................................................................................................................. 11
  Premodulated ....................................................................................................................................... 12
  Symmetrical Biphasic ............................................................................................................................. 12
  Microcurrent .......................................................................................................................................... 13
  Russian .................................................................................................................................................. 13
  High Volt (High Volt Pulsed Current – HVPC) .................................................................................... 14
Ultrasound .............................................................................................................................................. 16
  What is Ultrasound? .............................................................................................................................. 16
  Heating Rate Calculator ......................................................................................................................... 16
  Treatment Time Calculator ..................................................................................................................... 16
Clinical Protocols and Rationale ............................................................................................................. 17
  Sub Chronic / Superficial Muscle ........................................................................................................... 17
  Sub Chronic / Superficial Tendon and/or Ligament ............................................................................. 17
  Sub Chronic / Deep Muscle, Tendon and/or Ligament ....................................................................... 17
  Chronic / Superficial Muscle .................................................................................................................. 17
  Chronic / Superficial Tendon and/or Ligament ..................................................................................... 17
  Chronic / Deep Muscle, Tendon and/or Ligament ............................................................................... 18
  Scar Tissue or Adhesions / Superficial Muscle ..................................................................................... 18
  Scar Tissue or Adhesions / Superficial Tendon and/or Ligament ......................................................... 18
  Scar Tissue or Adhesions / Deep Muscle, Tendon and/or Ligament .................................................... 19
  Joint Contracture and/or Adhesive Capsulitis / Superficial Joint Tissue .............................................. 19
  Joint Contracture and/or Adhesive Capsulitis / Deep Joint Tissue ...................................................... 19
Ultrasound Clinical Protocols Summary (Table 2) ................................................................................ 20
Ultrasound Terminology ......................................................................................................................... 21
References ............................................................................................................................................... 22

© 2005 Encore Medical Corporation or its affiliates, Austin, Texas, USA. Any use of editorial, pictorial, or layout composition of this publication without express written consent from Chattanooga Group of Encore Medical, L.P. is strictly prohibited. This publication was written, illustrated, and prepared for distribution by Chattanooga Group of Encore Medical, L.P.
Electrotherapy

Electrotherapy Overview

Electrotherapy 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 upon the type of current selected, the parameters of the selected current, and the output intensity. As current flows through the body it can stimulate nerve and/or muscle tissue causing pain relief, muscle contraction to prevent/retard disuse atrophy or re-educate a muscle, relax spasms, or increase local circulation.

Clinical Protocols and Rationale

Acute Pain

Waveform Rationale

The main physiologic effects of Interferential and Premodulated current are to depolarize peripheral sensory and motor nerve fibers creating either an inhibitory effect of the pain transmitting cells in the dorsal horn of the spinal cord (theoretical Gate Control Mechanism) or the activation of supraspinal areas containing neurons capable of releasing endogenous (from the body) opiate substances to block pain (theoretical Endogenous Opiate Mechanism). Motor nerve activation will increase local blood circulation and relax muscles in spasm.

Electrode Placement

Electrode Placement guidelines to successfully manage acute pain with Interferential current are as follows:

- Clinical exam identifying the patient's area and source of pain.
- Skin Preparation: Clean and inspect the skin. Follow electrode manufacturer use guidelines.
- Electrode Placement: The literature describes optimal Electrode Placement having the 4 electrodes precisely around or bracketing the target tissue.

Electrode Placement guidelines to successfully manage acute pain with Premodulated current are as follows:

- Clinical exam identifying the patient's area and source of pain.
- Skin Preparation: Clean and inspect the skin. Follow electrode manufacturer use guidelines.
- Electrode Placement: The literature describes optimal Electrode Placement having the 2 electrodes precisely around or bracketing the target tissue.
Chronic Pain

Waveform Rationale

The main physiologic effects of Interferential current are to depolarize peripheral sensory and motor nerve fibers creating either an inhibitory effect of the pain transmitting cells in the dorsal horn of the spinal cord (theoretical Gate Control Mechanism) or the activation of supraspinal areas containing neurons capable of releasing endogenous (from the body) opiate substances to block pain (theoretical Endogenous Opiate Mechanism). Motor nerve activation will increase local blood circulation and relax muscles in spasm.

Electrode Placement

Electrode Placement guidelines to successfully manage chronic pain with Interferential current are as follows:

- Clinical exam identifying the patient's area and source of pain.
- Skin Preparation: Clean and inspect the skin. Follow electrode manufacturer use guidelines.
- Electrode Placement: The literature describes optimal Electrode Placement having the 4 electrodes precisely around or bracketing the target tissue.

Electrode Placement guidelines to successfully manage chronic pain with Premodulated current are as follows:

- Clinical exam identifying the patient's area and source of pain.
- Skin Preparation: Clean and inspect the skin. Follow electrode manufacturer use guidelines.
- Electrode Placement: The literature describes optimal Electrode Placement having the 2 electrodes precisely around or bracketing the target tissue.
Relax Muscle Spasm

**Waveform Rationale**

The literature reports some of the physiologic effects of High Volt Pulsed Current (HVPC) being relaxing muscles in spasm by inducing fatigue. Amplitude settings can be set to levels of muscle contraction to induce fatigue.

**Electrode Placement**

Electrode placement guidelines for relaxing a muscle in spasm with High Volt Pulsed Current are as follows:

- Clinical exam.
- Skin Preparation: Clean and inspect the skin. Follow electrode manufacturer use guidelines.
- The treating electrode (lead wire with red ending) positioned over the muscle in spasm.
- The return electrode (lead wire with the black ending) positioned close by.
- Electrode Size: Muscle size dictates electrode size.

Increase Local Circulation

**Waveform Rationale**

The literature has multiple reports showing High Volt Pulsed current increases local blood circulation to the target tissue. Increasing local blood flow with High Volt Pulsed current is also reported to increase tissue oxygenation to an ischemic area when applied over multiple sessions. The current amplitude should be sufficient to produce a comfortable sensation without a motor response.

**Electrode Placement**

- Electrode Placement guidelines for Increasing local blood circulation with High Volt Pulsed Current are as follows:
- Clinical exam.
- Skin Preparation: Clean and inspect the skin. Follow electrode manufacturer use guidelines.
- The treating electrode (lead wire with red ending) positioned directly over or immediately adjacent to the target tissue. Electrode size sufficient to cover treated area.
- The return electrode (lead wire with the black ending) should be the same size of the treating electrode and positioned close by.
Prevent / Retard Disuse Atrophy

Waveform Rationale
The efficacy of electrical stimulation for purposes of preventing or retarding disuse muscle atrophy is well established. A main application is when the stimulation program augments the patient's ability with voluntary exercise to overload the muscle. Russian current with a sine wave carrier frequency of 2,500 Hz and repeated delivery of bursts at patient defined amplitude settings is able to simultaneously depolarize sensory and motor nerve fibers to generate titanic muscle contractions comfortably. The current amplitude setting should be sufficient to produce a comfortable motor response.

Electrode Placement
Electrode Placement guidelines for disuse atrophy with Russian current are as follows:

- Clinical exam.
- Skin Preparation: Clean and inspect the skin. Follow electrode manufacturer use guidelines.
- Electrode Size: The surface area being stimulated should closely approximate the electrode size.
- Distance between Electrodes: The greater the distance the deeper the penetration in the tissue. As a rule of thumb the distance should not be less than the surface area of the smallest electrode used.
- Electrode Position: When stimulating larger muscle groups place electrodes over the proximal and distal ends of the muscle. Electrodes should be positioned longitudinally or parallel to the direction of the muscle fibers.
Muscle Re-education

Waveform Rationale

The use of electrical stimulation as a facilitation tool for neurological patients with primary movement disorders is common in the literature. Using electrical stimulation to elicit a muscle contraction during a functional task requiring the muscles action, i.e. reaching, stepping or grasping, can assist motor learning by increasing sensory awareness and reestablishing patterns of voluntary control. Symmetrical Biphasic and Russian are both effective waveforms in muscle re-education.

Electrode Placement

Electrode Placement guidelines for muscle re-education with Symmetrical Biphasic and Russian are as follows:

- Clinical exam.
- Skin Preparation: Clean and inspect the skin. Follow electrode manufacturer use guidelines.
- Electrode Size: The surface area being stimulated should closely approximate the electrode size.
- Distance between Electrodes: The greater the distance the deeper the penetration in the tissue. As a rule of thumb the distance should not be less than the surface area of the smallest electrode used.
- Electrode Position: When stimulating larger muscle groups place electrodes over the proximal and distal ends of the muscle. Electrodes should be positioned longitudinally or parallel to the direction of the muscle fibers.
Range of Motion

Waveform Rationale

Electrical Stimulation can offer a controlled and repeatable range of motion program with the goal of maintaining or restoring joint range of motion. Parameter settings are similar to other muscle contraction applications but current amplitude settings should only be of sufficient levels to move the joint through the desired range.

Electrode Placement

Electrode Placement guidelines for joint range of motion with Symmetrical Biphasic and Russian are as follows:

- Clinical exam.
- Skin Preparation: Clean and inspect the skin. Follow electrode manufacturer use guidelines.
- Electrode Size: The surface area being stimulated should closely approximate the electrode size.
- Distance Between Electrodes: The greater the distance the deeper the penetration in the tissue. As a rule of thumb the distance should not be less than the surface area of the smallest electrode used.
- Electrode Position: When stimulating larger muscle groups place electrodes over the proximal and distal ends of the muscle. Electrodes should be positioned longitudinally or parallel to the direction of the muscle fibers.
<table>
<thead>
<tr>
<th>Condition</th>
<th>Waveform</th>
<th>Carrier Frequency</th>
<th>Frequency</th>
<th>Amplitude</th>
<th>Cycle Time: On/Off Time</th>
<th>Ramp Time</th>
<th>Treatment Time</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute Pain</td>
<td>Interferential / Premodulated</td>
<td>4,000 Hz</td>
<td>80 - 150 Hz</td>
<td>To Patient Tolerance</td>
<td>n/a</td>
<td>n/a</td>
<td>30 min.</td>
<td>* Vector Scan: 40% Automatic</td>
</tr>
<tr>
<td>Chronic Pain</td>
<td>Interferential / Premodulated</td>
<td>4,000 Hz</td>
<td>1 - 10 Hz</td>
<td>To Patient Tolerance</td>
<td>n/a</td>
<td>n/a</td>
<td>30 min.</td>
<td>* Vector Scan: 40% Automatic</td>
</tr>
<tr>
<td>Relax Muscle Spasm</td>
<td>High Volt Pulsed Current (HVPC)</td>
<td>n/a</td>
<td>100 pps</td>
<td>To Visible Muscle Contraction / Motor Response</td>
<td>5/5</td>
<td>2 sec.</td>
<td>30 min.</td>
<td>* Polarity: Negative</td>
</tr>
<tr>
<td>Increase Local Circulation</td>
<td>High Volt Pulsed Current (HVPC)</td>
<td>n/a</td>
<td>100 pps</td>
<td>To Patient Tolerance c/out Eliciting Motor Response</td>
<td>Continuous</td>
<td>2 sec.</td>
<td>60 min.</td>
<td>* Polarity: Negative, Sweep: Continuous</td>
</tr>
<tr>
<td>Prevent / Retard Muscle Atrophy</td>
<td>Russian</td>
<td>n/a</td>
<td>50 pps (Burst Freq)</td>
<td>To Visible Muscle Contraction / Motor Response</td>
<td>10/50</td>
<td>2 sec.</td>
<td>20 min.</td>
<td>* Duty Cycle: 50%, Anti-Fatigue: Off</td>
</tr>
<tr>
<td>Muscle Re-Education</td>
<td>Symmetric Biphasic or Russian</td>
<td>n/a</td>
<td>35 (bps - Russian / Hz Symm Biphasic)</td>
<td>To Visible Muscle Contraction / Motor Response</td>
<td>4/12</td>
<td>2 sec.</td>
<td>20 min.</td>
<td>* Phase Duration: 200msec, Anti-Fatigue: Off (Russian)</td>
</tr>
<tr>
<td>Range of Motion</td>
<td>Symmetric Biphasic or Russian</td>
<td>n/a</td>
<td>35 (bps - Russian / Hz Symm Biphasic)</td>
<td>To Visible Muscle Contraction / Motor Response</td>
<td>4/12</td>
<td>2 sec.</td>
<td>20 min.</td>
<td>* Phase Duration: 200msec, Anti-Fatigue: Off (Russian)</td>
</tr>
</tbody>
</table>
Basic Electrotherapy Terminology

Waveform Diagram
The waveform is the geometric or visual representation of the stimulus or current. The diagram has a horizontal dimension representing time and a vertical dimension representing amplitude (intensity) or voltage. The vertical dimension represents the direction of current flow. Waveforms above the isoelectric baseline represent the flow of charged particles in one direction and waveforms below the line represent flow in the opposite direction.

Types of Electrotherapeutic Currents

Alternating Current (AC)
Alternating Current is the continuous or uninterrupted bi-directional flow of current. Interferential Stimulation and Premodulated Stimulation are examples of Alternating Currents.

Direct Current (DC)
Direct Current is the continuous or uninterrupted unidirectional flow of charged particles. Direct Current has been historically utilized for stimulating denervated muscles.

Pulsed Current
Pulsed Current is the pulse of uninterrupted current on an isolated unit of uni- or bi-directional flow of current that periodically cease for a finite period of time.

Basic Waveform Components

Amplitude (Intensity)
Amplitude, or commonly called Intensity, is the amount of current (or voltage) with reference to the isoelectric baseline. Commonly measured and described in milliamps (mA).

Biphasic
A biphasic waveform is identified by a pulse that deviates in one direction from the isoelectric baseline and then deviates in the opposite direction from the baseline making two phases per pulse. The characteristics of each phase should be fully described since a biphasic waveform can be symmetrical or asymmetrical in relation to the isoelectric baseline.
**Burst**

A Burst (an interrupted train) is a finite series of pulses that are delivered at a specific frequency and are separated by interburst intervals.

**Co-Contract**

In a Co-Contract application the timing of the stimulation is coordinated through two channels to function together.

**Current Format:**

In Constant Current (CC) mode the device will maintain the current level constant by adjusting the voltage (power) to the changing resistance between the skin and the electrode. In Constant Voltage (CV) mode the device will maintain the voltage constant by adjusting the current level to the changing resistance. CC mode is typically recommended for stimulation of the nerve fibers in the skin while CV is indicated for muscle stimulation.

**Frequency**

In a pulsed current the Frequency refers to the number of pulses that occur in a one (1) second period of time and is denoted as Pulses Per Second (pps). Alternating Current (AC) frequency is expressed as Hertz (Hz) and refers to the number of beats per second and it is the Beat Frequency that occurs in Interferential or Premodulated. In Russian the Burst Frequency (burst per second – bps) is the number of bursts or trains that occur in a one (1) second period of time.

**Interphase Interval**

Interphase Interval is the time between two successive phases of a pulse when no electrical activity occurs.

**Interpulse Interval**

Interpulse interval is the time or pauses between two successive pulses in a pulsed current.

**Monophasic**

A monophasic waveform is one that deviates in one direction from the iso-electric baseline and returns to the baseline for a finite period of time. In a monophasic pulse the amplitude and the characteristics of the phase are identical.

**Phase**

The phase is current flow in one direction for a finite period of time. A waveform is either monophasic or biphasic with biphasic waveforms being symmetrical or asymmetrical.

**Phase Charge**

Phase Charge is the total electrical charge of one phase and is measured in microcoulombs (μC).

**Phase Duration**

Phase Duration is the period of time from the beginning to the end of one (1) phase of pulse measured in microseconds (μsec).
**Pulse**

A pulse is a combination of phases that make-up a single repeatable portion of the waveform. If the waveform is uni-directional the phase is the same as the pulse and if it is bi-directional then the two phases together make up one pulse.

**Pulse Duration (pulse width)**

Pulse Duration is the time from the beginning to the end of all phases plus the Interphase interval within a single pulse also measured in microseconds (μsec).

**Reciprocal**

A Reciprocal application is one where you can alternate stimulation between two channels.

**Train**

Train is a characteristic of Alternating Current (AC) and is a continuous repetitive sequence of pulses or cycles. (*Note: Please refer to Phase Duration/Interpulse Interval picture)

---

**Overview of Electrotherapy Waveforms on Chattanooga Group Electrotherapy Units**

**Interferential (IFC)**

**Description:**

Interferential Current is a medium frequency waveform. Current comes out of two channels (four electrodes). The currents cross each other in the area that requires treatment. The two currents interfere with each other at this crossing point, resulting in a modulation of the intensity (the current intensity increases and decreases at a regular frequency).

**Terms:**

**Beat Frequency:**

The frequency at which the amplitude is modulated. This is the effective therapeutic frequency.

**Sweep:**

A timed rhythmical fluctuation of the Beat Frequency. This prevents accommodation. Commonly reported from the field a sweep beat frequency of 80 – 150 is often used for pain.

**Vector Scan:**

Rhythmical fluctuation of the intensity of channels 1 and 2. This increases the size of the effective treatment area between the 4 electrodes.

**Indications**

Interferential Current is a medium frequency current. This type of current has a relatively strong effect on the skin. This makes it well suited for pain control through the stimulation of nerve fibers in the skin.
**Premodulated**

**Description:**
Premodulated Current is a medium frequency waveform. Current comes out of one channel (two electrodes). The current intensity is modulated: it increases and decreases at a regular frequency (the Amplitude Modulation Frequency).

**Terms:**

**Beat Frequency:**
The frequency at which the amplitude is modulated. This is the effective therapeutic frequency.

**Sweep:**
A timed rhythmical fluctuation of the Beat Frequency. This prevents accommodation.

**Scan**
Scan is a form of amplitude modulation and is a percentage of the interferential amplitude (intensity) and will decrease from its maximum level over 15 seconds. Scan is amplitude modulation expressed as a percentage of the amplitude. The rhythmical varying of the current amplitude of each channel produces the perceived movement of the interferential field by the patient.

**Indications:**
Premodulated Current is a medium frequency current. This type of current has a relatively strong effect on the skin. This makes it well suited for pain control through the stimulation of nerve fibers in the skin.

**Symmetrical Biphasic**

**Description:**
The Symmetrical Biphasic waveform has a short pulse duration. It is capable of strong stimulation of the nerve fibers in the skin as well as of muscle tissue. This waveform is often used in TENS devices. Because of its short pulse, the patient typically tolerates the current well, even at relatively high intensities.

**Terms:**

**Frequency Modulation:**
When this feature is active, the stimulation frequency will increase and decrease at a rhythmical frequency to prevent accommodation.

**Burst:**
In this mode the current is delivered in series of successive bursts.

**Amplitude Modulation:**
Rhythmical fluctuation of the intensity to prevent accommodation.

**Channel Mode:**
Choose delivery of the current through 1 or 2 channels.
Single
In the Single Channel Setting the stimulation is delivered through one channel.

Reciprocal
A Reciprocal application is one where you can alternate stimulation between two channels.

Co-Contract
In a Co-Contract application the timing of the stimulation is coordinated through two channels to function together.

Indications:
Symmetrical Biphasic Current has traditionally been used for pain inhibition. Due to its high tolerance by patients it is equally well suited for muscle stimulation.

Microcurrent

Description:
Microcurrent is a monophasic waveform of very low intensity. The literature reports beneficial effects of this waveform in the treatment of chronic, intractable pain as well as post-traumatic / post surgical acute pain. The physiological working mechanism of this effect is as of yet not clearly understood.

Terms:
Method:
Choose the treatment method through electrodes or through a probe.

Polarity:
This refers to the polarity of the red lead wire.

Indications:
Microcurrent is primarily used for managing chronic, intractable pain as well as post-traumatic / post surgical acute pain. The patient does not feel the current due to its very low intensity.

Russian

Description:
Russian Current is a sinusoidal waveform, delivered in bursts or series of pulses. This method was claimed by its author (Kots) to produce maximal muscle strengthening without significant discomfort to the patient.

Terms:
Channel Mode:
Choose delivery of the current through 1 or 2 channels.

Single
In the Single Channel Setting the stimulation is delivered through one channel.
**Reciprocal**
A Reciprocal application is one where you can alternate stimulation between two channels.

**Co-Contract**
In a Co-Contract application the timing of the stimulation is coordinated through two channels to function together.

**Cycle Time:**
Refers to the time that the current is On and Off (in seconds). Example: for a Cycle Time of 10/50, the current will be flowing for 10 seconds and resting for 50 seconds.

**Burst Frequency:**
The number of bursts per second.

**Ramp:**
The time that the current will take to increase to the set intensity level. Ramps occur at the beginning and ending of a timed On cycle.

**Duty Cycle:**
The percentage of the total treatment time that the current is actually flowing.

**Anti-Fatigue:**
In this mode the frequency will be adjusted at regular intervals to minimize fatigue.

**Indications:**
Russian Current is indicated for muscle re-education.

---

**High Volt (High Volt Pulsed Current – HVPC)**

**Description:**
The High Volt waveform has a very brief pulse duration characterized by 2 distinct peaks delivered at high voltage. The waveform is monophasic (current flows in one direction only). The high voltage causes a decreased skin resistance making the current comfortable and easy to tolerate.

**Terms:**

**Method:**
Choose the treatment method through electrodes or through a probe.

**Polarity:**
This refers to the polarity (+/-) of the red lead wire; connect the lead wire to the active electrode.

**Cycle Time:**
Refers to the time that the current is On and Off (in seconds). Example: for a Cycle Time of 10/50, the current will be flowing for 10 seconds and resting for 50 seconds.

**Ramp:**
The time that the current will take to increase to the set intensity level. Ramps occur at the beginning and ending of a timed On cycle.
**Sweep:**
A timed rhythmical fluctuation of the frequency. This prevents accommodation.

**Display:**
Output display on the LCD is in Volts or Peak Current.

**Indications:**
The High Volt waveform is frequently used to increase local blood circulation and relax muscles in spasm.
Ultrasound

What is Ultrasound?

Therapeutic ultrasound is a mechanical stimulus delivered to the body by a means of an ultrasound beam emitted out of an applicator. The ultrasound beam is generated in the ultrasound head by means of an oscillating crystal and transmitted to the body through the aluminum surface of the applicator head and the contact medium.

Therapeutic ultrasound has a frequency range between 1 and 3.3 megahertz (MHz). Ultrasound at 1 MHz targets tissue 3 to 5 cm deep. Deep tissues require longer treatment times because the 1 MHz ultrasound used is absorbed approximately 3 times more slowly than 3.3 MHz ultrasound, and some of the ultrasound is absorbed by superficial tissues before reaching the deeper tissues. Conversely, ultrasound at 3.3 MHz targets tissue less than 2 cm deep, and is absorbed 3 times faster in the tissue than 1 MHz. The heating rate of ultrasound is also dependent on tissue characteristics. Muscle absorbs ultrasound at a slower rate than ligaments and tendons since it possesses less collagen and is more vascular. Superficial collagen rich tissues, such as tendons and ligaments, absorb ultrasound at much higher rate allowing a shorter treatment time. Shorter treatment times, and/or lower intensities, should be used in areas with superficial bones because bones increase local heating by reflecting ultrasound.

Ultrasound also has the ability to be delivered in Continuous and Pulsed modes. Continuous ultrasound produces greater heating than pulsed ultrasound at a given intensity because the sound wave is not interrupted. When using continuous ultrasound the goal is to increase the temperature of the target tissue by 3 to 8 degrees Celsius by the end of the treatment session. The thermal effect that is generated by therapeutic ultrasound triggers biological changes to occur in the target tissues resulting in the relief of sub-chronic and chronic pain, muscle spasms, and joint contractures. Pulsed ultrasound at a 20% duty cycle provides gradual heating effects in the tissue.

Another consideration when using therapeutic ultrasound is the size of the ultrasound head. The treatment area should not be more than 2 to 3 times the area of the sound head. When using ultrasound for the treatment of scar tissues and/or adhesion, stretching should be applied to the extremity during the treatment, while the tissue is warm, and continued for approximately 3 to 5 minutes after the ultrasound treatment. To determine the heating rate and treatment time please refer to the tables below.

Heating Rate Calculator (Draper et al., 1995)

Heating Rate per Minute in °C/minute = \((0.2 \times \text{Intensity in W/cm}^2 \times \text{Frequency in MHz})\)

Treatment Time Calculator (Draper et al., 1995)

Treatment Time is Between x and y when \(x = \frac{3}{(0.2\times\text{Intensity}\times\text{Frequency})}\) and \(y = \frac{5}{(0.2\times\text{Intensity}\times\text{Frequency})}\)
Clinical Protocols and Rationale

Sub Chronic / Superficial Muscle

Rationale
- 3.3 MHz ultrasound targets tissue less than or equal to 2 cm deep.
- Pulsed ultrasound at a 20% duty cycle provides gradual heating effects in the tissue.
- The treatment time should be between 5 and 7 minutes, depending on intensity. Although 3.3 MHz ultrasound is absorbed 3 times faster than 1 MHz, muscles absorb ultrasound at a slower rate than tendons/ligaments because muscles possess less collagen and have a greater blood supply to dissipate heat, thus requiring slightly longer treatment times.

Sub Chronic / Superficial Tendon and/or Ligament

Rationale
- 3.3 MHz ultrasound targets tissue less than or equal to 2 cm deep.
- Pulsed ultrasound at a 20% duty cycle provides gradual heating effects in the tissue.
- The treatment time should be between 5 and 7 minutes, depending on intensity. Superficial collagen rich tissues such as tendons/ligaments absorb more ultrasound, allowing shorter treatment times.

Sub Chronic / Deep Muscle, Tendon and/or Ligament

Rationale
- 1 MHz ultrasound targets tissue 3 to 5 cm deep.
- Pulsed ultrasound at a 20% duty cycle provides gradual heating effects in the tissue.
- The treatment time should be from 7 to 10 minutes. Deep tissue requires longer treatment times because 1 MHz ultrasound is absorbed 3 times slower than 3.3 MHz and some of the ultrasound energy is absorbed by superficial tissue before reaching these deeper tissues.

Chronic / Superficial Muscle

Rationale
- 3.3 MHz ultrasound targets tissue less than or equal to 2 cm deep.
- Continuous ultrasound (100% duty cycle) produces greater heating than pulsed ultrasound at a given intensity because the wave is not interrupted.
- The treatment time should be between 5 and 7 minutes, depending on intensity. Although 3.3 MHz ultrasound is absorbed 3 times faster than 1 MHz, muscles absorb ultrasound at a slower rate than tendons/ligaments because muscles possess less collagen and have a greater blood supply to dissipate heat, thus requiring slightly longer treatment times.

Chronic / Superficial Tendon and/or Ligament

Rationale
- 3.3 MHz ultrasound targets tissue less than or equal to 2 cm deep.
• Continuous ultrasound (100% duty cycle) produces greater heating than pulsed ultrasound at a given intensity because the wave is not interrupted.
• The treatment time should be between 5 and 7 minutes, depending on intensity. Superficial collagen rich tissues such as tendons/ligaments absorb more ultrasound, allowing shorter treatment times.

**Chronic / Deep Muscle, Tendon and/or Ligament**

**Rationale**
- 1 MHz ultrasound targets tissue 3 to 5 cm deep.
- Continuous ultrasound (100% duty cycle) produces greater heating than pulsed ultrasound at a given intensity because the wave is not interrupted.
- The treatment time should be from 7 to 10 minutes. Deep tissue requires longer treatment times because 1 MHz ultrasound is absorbed 3 times slower than 3.3 MHz and some of the ultrasound energy is absorbed by superficial tissue before reaching these deeper tissues.

**Scar Tissue or Adhesions / Superficial Muscle**

**Rationale**
- 3.3 MHz ultrasound targets tissue less than or equal to 2 cm deep.
- Continuous ultrasound (100% duty cycle) produces greater heating than pulsed ultrasound at a given intensity because the wave is not interrupted.
- The treatment time should be between 5 and 7 minutes, depending on intensity. Although 3.3 MHz ultrasound is absorbed 3 times faster than 1 MHz, muscles absorb ultrasound at a slower rate than tendons/ligaments because muscles possess less collagen and have a greater blood supply to dissipate heat, thus requiring slightly longer treatment times.
- For optimal effect, stretching needs to be applied during the treatment while the tissue is warm, and continued for approximately 5 minutes after the ultrasound treatment.

**Scar Tissue or Adhesions / Superficial Tendon and/or Ligament**

**Rationale**
- 3.3 MHz ultrasound targets tissue less than or equal to 2 cm deep.
- Continuous ultrasound (100% duty cycle) produces greater heating than pulsed ultrasound at a given intensity because the wave is not interrupted.
- The treatment time should be between 5 and 7 minutes, depending on intensity. Superficial collagen rich tissues such as tendons/ligaments absorb more ultrasound, allowing shorter treatment times.
- For optimal effect, stretching needs to be applied during the treatment while the tissue is warm, and continued for approximately 5 minutes after the ultrasound treatment.
Scar Tissue or Adhesions / Deep Muscle, Tendon and/or Ligament

**Rationale**

- 1 MHz ultrasound targets tissue 3 to 5 cm deep.
- Continuous ultrasound (100% duty cycle) produces greater heating than pulsed ultrasound at a given intensity because the wave is not interrupted.
- The treatment time should be from 7 to 10 minutes. Deep tissue requires longer treatment times because 1 MHz ultrasound is absorbed 3 times slower than 3.3 MHz and some of the ultrasound energy is absorbed by superficial tissue before reaching these deeper tissues.
- For optimal effect, stretching needs to be applied during the treatment while the tissue is warm, and continued for approximately 5 minutes after the ultrasound treatment.

Joint Contracture and/or Adhesive Capsulitis / Superficial Joint Tissue

**Rationale**

- 3.3 MHz ultrasound targets tissue less than or equal to 2 cm deep.
- Continuous ultrasound (100% duty cycle) produces greater heating than pulsed ultrasound at a given intensity because the wave is not interrupted.
- The treatment time should be between 5 and 7 minutes, depending on intensity. Although 3.3 MHz ultrasound is absorbed 3 times faster than 1 MHz, muscles absorb ultrasound at a slower rate than tendons/ligaments because muscles possess less collagen and have a greater blood supply to dissipate heat, thus requiring slightly longer treatment times.
- For optimal effect, stretching needs to be applied during the treatment while the tissue is warm, and continued for approximately 5 minutes after the ultrasound treatment.

Joint Contracture and/or Adhesive Capsulitis / Deep Joint Tissue

**Rationale**

- 1 MHz ultrasound targets tissue 3 to 5 cm deep.
- Continuous ultrasound (100% duty cycle) produces greater heating than pulsed ultrasound at a given intensity because the wave is not interrupted.
- The treatment time should be from 7 to 10 minutes. Deep tissue requires longer treatment times because 1 MHz ultrasound is absorbed 3 times slower than 3.3 MHz and some of the ultrasound energy is absorbed by superficial tissue before reaching these deeper tissues.
- For optimal effect, stretching needs to be applied during the treatment while the tissue is warm, and continued for approximately 5 minutes after the ultrasound treatment.
<table>
<thead>
<tr>
<th>Condition</th>
<th>Target Tissue</th>
<th>Frequency</th>
<th>Duty Cycle</th>
<th>Treatment Time*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Chronic</td>
<td>Superficial Muscle</td>
<td>3.3 MHz</td>
<td>20%</td>
<td>5 - 7 min.</td>
</tr>
<tr>
<td>Sub-Chronic</td>
<td>Superficial Tendon and/or Ligament</td>
<td>3.3 MHz</td>
<td>20%</td>
<td>5 - 7 min.</td>
</tr>
<tr>
<td>Sub Chronic</td>
<td>Deep Muscle, Tendon and/or Ligament</td>
<td>1 MHz</td>
<td>20%</td>
<td>7 - 10 min.</td>
</tr>
<tr>
<td>Chronic</td>
<td>Superficial Muscle</td>
<td>3.3 MHz</td>
<td>100%</td>
<td>5 - 7 min.</td>
</tr>
<tr>
<td>Chronic</td>
<td>Superficial Tendon and/or Ligament</td>
<td>3.3 MHz</td>
<td>100%</td>
<td>5 - 7 min.</td>
</tr>
<tr>
<td>Chronic</td>
<td>Deep Muscle, Tendon and/or Ligament</td>
<td>1 MHz</td>
<td>100%</td>
<td>7 - 10 min.</td>
</tr>
<tr>
<td>Scar Tissue / Adhesions</td>
<td>Superficial Muscle</td>
<td>3.3 MHz</td>
<td>100%</td>
<td>5 - 7 min.</td>
</tr>
<tr>
<td>Scar Tissue / Adhesions</td>
<td>Superficial Tendon and/or Ligament</td>
<td>3.3 MHz</td>
<td>100%</td>
<td>5 - 7 min.</td>
</tr>
<tr>
<td>Scar Tissue / Adhesions</td>
<td>Deep Muscle, Tendon and/or Ligament</td>
<td>1 MHz</td>
<td>100%</td>
<td>7 - 10 min.</td>
</tr>
<tr>
<td>Joint Contracture / Adhesive Capsulitus</td>
<td>Superficial Joint Tissue</td>
<td>3.3 MHz</td>
<td>100%</td>
<td>7 - 10 min.</td>
</tr>
<tr>
<td>Joint Contracture / Adhesive Capsulitus</td>
<td>Deep Joint Tissue</td>
<td>1 MHz</td>
<td>100%</td>
<td>5 - 7 min.</td>
</tr>
</tbody>
</table>

Treatment Time is variable due to intensity.
The treatment area should not be more than 2 to 3 times the size of the sound head.
**Ultrasound Terminology**

**Applicator**
The hand assembly used to deliver ultrasonic energy. The applicator includes the sound head, transducer, and related electronics.

**Beam Non-Uniformity Ratio (BNR)**
Beam Non-Uniformity Ratio is the ratio of the spatial peak intensity to the average intensity. By nature, an ultrasound beam is not homogeneous. The BNR is a ratio of the highest intensity found in the beam field to the average intensity as indicated on the output display of the unit. The industry standard is $5:1$. Because of the areas of increased intensity, the sound head should be moved continuously during the treatment.

**Collimating**
Collimating describes the shape of the ultrasound beam. While neither focused nor dispersed, this ultrasound beam resembles a column when applied from the unit through the sound head.

**Continuous Mode**
The output of the ultrasound is not interrupted during the treatment time. This mode imparts the most energy to the tissues and is used when a maximal effect is desired (See Duty Cycle).

**Coupling Media**
An agent used to insure that the ultrasound is transmitted from the sound head to the target. Gels or lotions labeled for therapeutic ultrasound use are recommended.

**Display:**
Output display can either express intensity or power. Intensity is the power per unit area of the sound head expressed in Watts/centimeter squared (W/cm$^2$). Power is the amount of acoustic energy per unit time expressed in Watts (W).

**Duty Cycle**
The percentage of time that ultrasound is being delivered during the treatment. Options are Continuous (100%) or Pulsed modes. The duty cycle describes the pulsed modes of ultrasound. The lower the percentage, the lower the temporal average intensity.
Effective Radiating Area (ERA)
The area of the sound head from which ultrasound energy radiates. A measure of the ultrasound beam made underwater, 5 mm from the radiating surface of the sound head. The ERA is always smaller than the geometric area of the sound head, but should be as close as possible. The measurement is used to calculate the ultrasound intensity in W/cm².

Frequency
The number of compression/refraction cycles per unit of time expressed in cycles per second (MHz). Selectable to 1 or 3.3 MHz with the 2 cm², 5 cm², or 10 cm² sound head (only 3.3 MHz is available with the 1 cm² sound head). The lower the frequency, the longer the wavelength, and the deeper the penetration of ultrasound.

Lead Zirconate Titanate
A synthetic crystal used to create the ultrasound beam by vibrating 1,000,000 (1 MHz) or 3,300,000 (3.3 MHz) times per second. This type of crystal is both durable and efficient in its functions.

Power
A measure of the intensity of the ultrasound delivered to the patient. Unit of measure is watts (W).

Pulse Duration
Refers to the amount of time the ultrasound is being delivered in the pulsed mode. For example, in the 20% duty cycle mode, the ultrasound is delivered for 2 msec and off for 8 msec (at 100 Hz) throughout the treatment period.

Pulse Frequency
The pulse frequency is the number of pulses per second and is expressed in hertz. The available pulse frequency on the Intelect® Transport Ultrasound is 100 Hz.

Pulsed Mode
The output of the ultrasound is automatically interrupted during the treatment time. This limits the amount of energy delivered to the tissues.

Sound Head
The aluminum face of the applicator that contacts the patient’s skin. It covers a transducer mechanism that converts electrical energy to mechanical energy in the form of a vibrating crystal.

Ultrasound Intensity
Ultrasound power delivered to the patient expressed in total power as watts (W) or in terms of the sound head’s effective radiating area, watts per centimeter squared (W/cm²).

References