Chapter 4 – Physiological Therapeutics

4

Electrical Stimulating Currents
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PHYSIOLOGICAL EFFECTS OF STIMULATING CURRENTS

1. Relaxation of muscle spasm
2. Stimulation of active exercise/muscle contraction
3. Increased muscle fiber recruitment
4. Circulatory stimulation by pumping action of the muscle
5. Enhancement of reticuloendothelial response to clear away waste products
6. Tissue regeneration
7. Analgesic effects (release of endogenous pain suppressant and stimulation of neurotransmitters)

INDICATIONS FOR USE

1. Pain of known origin (muscle spasm, strain/sprain, contusion, etc.)
2. Muscle spasm
3. Muscle atrophy
4. Muscle re-education
5. Edema reduction
6. Healing process stimulation of muscle strains, fractures, wounds, etc.

CONTRAINDICATIONS FOR USE

1. Over thoracic area of patients with cardiac pacemakers
2. Over the lumbar, abdomen, or perineal area of pregnant women
3. On patients who are unable to provide clear feedback (infants, confused patients, aphasic, head-injured patients)
4. In regions of neoplasm
5. In regions with thrombosis or thrombophlebitis
6. Over the eye
7. Over areas with surgical implants (hips, knees, staples, etc.)
8. Over anterior neck to avoid stimulation of the vagus or phrenic nerve
9. Active electrode over bruise or bony prominence
10. Over irritated or broken skin, unless performing electrotherapy for wound healing
11. Over the heart area
12. Transcerebral
PRECAUTIONS FOR ELECTRICAL STIMULATING CURRENT

1. Hypertensive patients
2. Patients with arrhythmia due to conduction disturbances or those with congestive heart failure
3. Seizure disorder
4. Sensory loss
5. Peripheral vascular disease
6. Allergic reaction to gels, tapes, or electrodes used in electrotherapy
7. Tissues vulnerable to hemorrhage or hematoma
8. Over the head or neck area if history of CVA
9. Patients with impaired cognition
10. Immature nervous system (pediatric)

PREPARING THE PATIENT

The importance of explaining electric muscle stimulation to the patient cannot be emphasized enough. Patients are usually apprehensive about electric stimulating currents the first time it is applied. The sensation of electric stimulation should be explained in a manner that is as reassuring as possible. Most people describe the feeling as “pins and needles” or like “the area just fell asleep.” Particularly with direct current units, the sensation is described as “pricking.” It must be stressed to the patient that electrical stimulating current should never feel painful, and that if at any time they feel too uncomfortable with the treatment, the intensity will be decreased.

Explaining the safety features of the electrical stimulating current units may be necessary for some patients, particularly if a treatment, such as running the current through water in which the patient is immersed, is used (such as treating an acute ankle sprain in a slush bucket with electrical stimulating current pads on the ankle). Naturally, patients are very nervous about being placed in water with electrical current running through it. It may be necessary for clinicians to demonstrate the procedures on themselves before applying the pads on patients.

A reliable protocol to use when first treating a patient with electrical stimulating current is to explain how the machine works and why it was chosen for treatment, then describe how the treatment will feel, then turn the intensity up slowly and ask the patient to state when they start to feel something. Often the patient will be startled by the sensation; give them time to become accustomed to the feeling. After half a minute, turn the intensity up higher until the patient states the intensity is as high as they are comfortable feeling.

Electrode Placement

When using electrical stimulation of sensory nerves for pain suppression, there are several guidelines that will help the therapist select the appropriate sites for electrode placement. Transcutaneous electrical nerve stimulation (TENS) uses similar-sized electrodes placed
according to a pattern and moved in a trial and error pattern until pain is decreased. The following patterns may be used:

1. Electrodes may be placed on or around the painful area.
2. Electrodes may be placed over specific dermatomes, myotomes, or sclerotomes that correspond to the painful area.
3. Electrodes may be placed close to the spinal cord segment that innervates a painful area.
4. Placing electrodes over sites where nerve becomes superficial and can be stimulated easily may stimulate peripheral nerves that innervate the painful area.
5. Electrode placement over trigger point locations.
6. Crossing patterns, also referred to as an interferential technique, involve electrode application such that the electrical signals from each set of electrodes add together at some point in the body and the intensity accumulates. The electrodes are usually arranged in a criss-cross pattern around the point to be stimulated. If there is a specific superficial area (i.e. medial collateral acromioclavicular joint) that you wish to stimulate, your electrodes should be relatively close together. They should be located so the area to be treated is central to the location to the electrodes. If there is poorly localized pain (general shoulder pain) that seems to be deeper in the joint or muscle area, spread your electrodes farther apart to give more penetration to the current.

**SUGGESTED ELECTRICAL STIMULATING CURRENTS AND SETTINGS**

<table>
<thead>
<tr>
<th>INDICATION</th>
<th>TIME</th>
<th>SUGGESTED CURRENT AND CURRENT FREQUENCY</th>
<th>INTENSITY</th>
<th>PAD PLACEMENT</th>
<th>TREATMENT FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>acute pain</td>
<td>15-20 min</td>
<td>Best: interferential at 80-120 Hz</td>
<td>patient comfort</td>
<td>around area of pain</td>
<td>until resolution. can be used hourly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd: HV AC or DC, * or pre-modulated at 80-120 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sub acute pain</td>
<td>15-20 min</td>
<td>Best: interferential at 1-150 Hz</td>
<td>patient comfort</td>
<td>around area of pain</td>
<td>at least 3 times weekly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd: HV AC or DC, * or pre-modulated at 1-150 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>chronic pain</td>
<td>10-20 min</td>
<td>Either: interferential at 1-15 Hz</td>
<td>patient comfort</td>
<td>around area of pain</td>
<td>at least 3 times weekly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Or: HV AC or DC, * or pre-modulated at 1-15 Hz</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>muscle spasm</td>
<td>15-20 min</td>
<td>Either: HV AC or DC, * at &gt;50 Hz</td>
<td>patient tolerance</td>
<td>trace ms fibers</td>
<td>until resolution. can be used hourly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Or: Russian EMS</td>
<td>10 sec on/10 sec off</td>
<td></td>
<td></td>
</tr>
<tr>
<td>edema reduction</td>
<td>15-20 min</td>
<td>Either: HV AC or DC, * at &gt;50 Hz</td>
<td>patient tolerance</td>
<td>around joint / edema</td>
<td>2-5 times daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Or: Russian EMS</td>
<td>10 sec on/10 sec off</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rehabilitation</td>
<td>20-30 min</td>
<td>Best: Russian EMS</td>
<td>strong thumping contraction</td>
<td>trace ms fibers</td>
<td>at least 2 times weekly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd: HV AC or DC, * at &gt;50 Hz</td>
<td>10 sec on/30-50 sec off</td>
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</tbody>
</table>
ELECTRICALLY INDUCED MUSCLE CONTRACTION

Muscle force is varied by changing the intensity to recruit more or less motor units. The greater the force, the greater the demands on the muscle, the greater the occlusion of muscle blood flow, the greater the fatigue. To minimize fatigue associated with forceful contractions, a combination of the lowest frequency and the higher intensity will keep the force constant. The rest time between contractions should be at least 60 seconds for each 10 seconds of contraction time.

MUSCLE REEDUCATION

Muscular inhibition after surgery or injury is the primary indication for muscle reeducation.

Protocols for muscle reeducation do not list specific parameters to make this treatment more efficient, but the following criteria are essential for effective electrical stimulation:

1. Current intensity must be adequate for muscle contraction but comfortable for the patient.
2. Pulses per second (pps) should be high enough to give a tetanic contraction (20–40 pulses per second).
3. Interrupted or surged current must be used.
4. On time should be 10 seconds.
5. Off time should be 30 to 50 seconds.
6. The patient should be instructed to allow just the electricity to make the muscle contract, allowing the patient to feel and see the response desired. Next, the patient should alternate voluntary muscle contractions with current–induced contractions.
7. Total treatment time should be about 15 minutes, but this can be repeated several times daily.
8. High-voltage pulsed or medium–frequency alternating current may be most effective.

MUSCLE PUMP CONTRACTIONS

Electrically induced muscle contraction can be used to duplicate the regular muscle contractions that help stimulate circulation by pumping fluid and blood through venous and lymphatic channels back into the heart.

The following criteria must be satisfied for the electrical treatment to be successful in helping to reduce swelling.

1. Current intensity must be high enough to provide a strong, comfortable muscle contraction.
2. If pulse duration is adjustable, it should be set as close as possible to the duration needed for the motor nerve to be stimulated.
3. Pulses per second should be in the beginnings of tetany range (20 pps).
4. Interrupted or surged current must be used.
5. On time should be 5 to 10 seconds.
6. Off time should be 5 to 10 seconds.
7. The part to be treated should be elevated.
8. The patient should be instructed to allow the electricity to make the muscle contract. Active range of motion may be encouraged at the same time if it is not contraindicated.
9. Total treatment time should be between 20 and 30 minutes; treatment should be repeated two to five times daily.
10. High-voltage pulsed or medium-frequency alternating current may be most effective.
11. Use this protocol in addition to ice for the best effect.

**RETARDATION OF ATROPHY**

The maintenance of muscle tissue, after an injury that prevents normal muscular exercise, can be accomplished by substituting an electrically stimulated muscle contraction.

In designing a program, the practitioner should try to duplicate muscle contractions associated with normal exercise routines. The following criteria can be used as guidelines in developing effective treatment protocols.

1. Current intensity should be as high as can be tolerated by the patient. This can be increased during the treatment as some sensory accommodation takes place.
2. If pulse duration is adjustable, it should be set as close as possible to the duration needed for the motor nerve to be stimulated.
3. Pulses per second should be in the beginnings of tetany range (20 – 85 pps).
4. Interrupted or surge-type current should be used.
5. On time should be between 6 to 15 seconds.
6. Off time should be at least 1 minute, and preferably 2 minutes.
7. The muscle should be given some resistance, either gravity or external resistance provided by the addition of weights or by fixing the joint so that the contraction becomes isometric.
8. The patient can be instructed to work with the electrically induced contraction, but voluntary effort is not necessary for the success of this treatment.
9. Total treatment time should be 15 to 20 minutes, or enough time to allow a minimum of 10 contractions. The treatment can be repeated two times daily.
10. A medium-frequency alternating current stimulator is the machine of choice.

**MUSCLE STRENGTHENING**

1. If adjustable, pulse duration should be set as close as possible to the duration needed for the motor nerve to be stimulated. In general, longer pulse duration should include more nerves in response.
2. Pulses per second should be in the tetany range (20 – 85 pps).
3. Surged or interrupted current with gradual ramp to peak intensity is most effective.
4. On time should be in the 10- to 15-second range.
5. Off time should be in the 50-second to 2-minute range.
6. Resistance usually is applied by immobilizing the limb.
7. The patient can be instructed to work with the electrically induced contractions. Fatigue is a major factor in this setup. Electrical stimulation treatments should be scheduled at least three times weekly.
8. A medium-frequency alternating current stimulator is the machine of choice.

**INCREASING RANGE OF MOTION**

Electrically stimulating a muscle contraction pulls the joint through the limited range. The protocol needed to affect joint contraction is the following:

1. Current intensity must be of sufficient intensity and duration to make a muscle contract strongly enough to move the body part through its antigravity range. Intensity should be increased gradually during treatment.
2. If pulse duration is adjustable, it should be set as close as possible to the duration needed for the motor nerve to be stimulated.
3. Pulses per second should be at the beginning of tetany range (20-30 pps).
4. Interrupted or surged current should be used.
5. On time should be between 15 and 20 seconds.
6. Off time should be equal to or greater than on time, fatigue is a big consideration.
7. The stimulated muscle group should be antagonistic to the joint contraction.
8. The patient is passive in this treatment and does not work with the electrical contraction.
9. Total treatment time should be 90 minutes daily. This can be broken into three 30-minute treatments.
10. High-voltage pulsed or medium-frequency alternating current stimulators are the best choices.

**STIMULATION OF DENERVATED MUSCLE**

Electrical currents may be used to produce a muscle contraction in denervated muscle. The primary purpose for electrically stimulating denervated muscle is to help minimize the extent of atrophy during the period while the nerve is regenerating.

The following treatment parameters have been recommended for stimulating denervated muscle.

1. Current with an asymmetric, biphasic (faradic) waveform with a pulse duration less than 1 msec may be used during the first 2 weeks.
2. After 2 weeks, either an interrupted square wave direct current, progressive exponential wave direct current, each with long pulse duration of greater than 10 msec, or a sine wave alternating current with a frequency lower than 10 Hz, will produce a twitch contraction. The length of the pulse should be as short as possible but long enough to elicit a contraction.
3. The pause between stimuli should be four to five times longer (about 3-6 sec) than the stimulus duration to minimize fatigue.

4. Either a mono-polar or bipolar electrode setup can be used with the small-diameter active electrode placed over the most electrically active point in the muscle.

5. Stimulation should begin immediately following denervation using three stimulation treatments per day involving three sets of between 5 and 20 repetitions that can be varied according to fatigability of the muscle.

ELECTRICAL STIMULATION OF SENSORY NERVES FOR PAIN CONTROL

Acute Injury
Enkephalin release model is used in treating pain from acute injuries, problems with the musculoskeletal system, or postoperative pain. The following criteria can be used as guidelines in developing effective treatment protocols.

1. Current intensity should be adjusted to tolerance but should not cause a muscular contraction, the higher the better.
2. Pulse duration (pulse width) should be 75 to 150 µsec or maximum possible on the machine.
3. Pulses per second should be 80 to 125, or as high as possible on the machine.
4. A transcutaneous electrical stimulator waveform should be used.
5. On time should be continuous mode.
6. Total treatment time should correspond to fluctuations in pain; the unit should be left on until pain is no longer perceived, turned off, then restarted when pain begins again.
7. If this treatment is successful, you will have some pain relief within the first 30 minutes of this treatment.
8. Any stimulator that can deliver this current is acceptable. Portable units are better for 24-hour pain control.

Reoccurring Chronic Pain
Changing the bias of the central nervous system and increasing the descending influences on the transmission of pain are best accomplished with the following protocols.

1. Current intensity should be very high, approaching a noxious level; muscular contraction is not desirable.
2. Pulse duration should be 10 msec.
3. Pulses per second should be 1-15.
4. On time should be 30 seconds to 1 minute.
5. Stimulation should be applied over trigger or acupuncture points.
6. Selection and number of points used varies according to the part treated.
7. A low-frequency, high-intensity generator is the stimulator of choice for central biasing.
8. If this treatment is successful, pain will be relieved shortly after treatment.
9. If this treatment is not successful, try different electrode setups by expanding the treatment points used.
Deep Aching / Chronic Pain
A large dispersive pad and a small pad or handheld probe point electrode are utilized in this approach. The point electrode is applied to the chosen site, and the intensity is increased until it is perceived by the patient. The probe is then moved around the area, and the patient is asked to report relative changes in perception of intensity. When a location of maximum-intensity perception is found, the current intensity is increased to maximum tolerable levels.

Beta-endorphin stimulation may offer better relief for the deep aching or chronic pain similar to overuse injury’s pain. Beta-endorphin production may be stimulated using the following protocols.

1. Current intensity should be high, approaching a noxious level: muscular contraction is acceptable.
2. Pulse duration should be 200 µsec to 10 msec.
3. Pulses per second should be between 1 and 5.
4. High-voltage pulsed current should be used.
5. On time should be 30 to 45 seconds.
6. Stimulation should be applied over trigger or acupuncture points.
7. Selection and number of points used varies according to the part and condition being treated.
8. A high-voltage pulsed current or a low frequency, high-intensity machine is best for this effect.
9. If stimulation is successful, you should know at the completion of the treatment. The analgesic effect should last for several (6-7) hours.
10. If not successful, try expanding the number of stimulation sites. Add the same stimulation points on the opposite side of the body, add auricular (ear) acupuncture points, add more points on the same limb.

LOW VOLTAGE CONTINUOUS DIRECT CURRENT

The therapeutic benefits are related to the polar and vasomotor effects and to the acid reaction around the positive pole and the alkaline reaction at the negative pole. Acidic or alkaline changes can cause severe skin reactions. These reactions occur only with low-voltage continuous direct current.

Protocols for continuous low-voltage direct current.

1. Current intensity should be to the patient’s tolerance; it should be increased as accommodation takes place.
2. Treatment time should be between a 15-minute minimum and a 50-minute maximum.
3. Equal sized electrodes are used over gauze that has been soaked in saline solution and lightly squeezed.
TREATMENT PRECAUTIONS WITH CONTINUOUS DIRECT CURRENTS

Skin burns are the greatest hazard of any continuous direct current technique.

References Consulted

