Understanding neuromuscular stimulation properties of the VST MyoDynamic® Device

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Abstract

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This paper focuses on neuromuscular electrotherapy, and in particular the factors which are addressed by the VST MyoDynamic Device from VCARE that provide treatment benefits. While many devices are prescribed for 15 or 30 minute treatment sessions, the VST is able to comfortably deliver treatment for 60 minutes. This is important because treatment times of this duration allow sufficient time for desirable electrochemical and electro-physical changes to impart their therapeutic benefits on tissues.

Apart from electrolytic burns, e-stim devices must overcome two problems that are in fact unique to their intended treatment benefits. The first problem is one of patient comfort as it relates to the forced, repetitive contraction of muscle tissue. E-stim devices are intended to work damaged muscle by forcing repetitions of controlled muscle contractions. This can be a painful experience, but as it turns out the waveform itself plays a role in dampening pain signals during muscle contraction. The other problem is that of sending enough current (without causing patient discomfort) to cause muscle contraction in the presence of a neuromuscular barrier known as inhibitory arc; a phenomena whereby the body puts up a nerve impulse roadblock that severely restricts the voluntary movement of injured muscle tissue.

An important capability of the VST machine is the ability to pass up to 50mA safely through a given channel. The 50mA ceiling of the VST is possible due to its use of a biphasic symmetrical waveform and the ideal low harmonics present. This allows each channel to carry this current with minimal discomfort and almost no risk of electrolytic burning.

Introduction

Electrotherapy is a generic term referring to a process in which an electrical current is passed through an area of the body in order to facilitate relief of pain, assist in the rehabilitation of muscle injury, or both. Electrotherapy has a stimulating effect on the tissue through which it passes; it activates different biochemical reactions in the body that would not otherwise occur. It is these reactions, and not the electrical current itself, which are responsible for achieving the objectives of a prescribed treatment. While many devices are prescribed for 15 or 30 minute treatment sessions, the VST is able to comfortably deliver treatment for 60 minutes. This is important because treatment times of this duration allow sufficient time for desirable electrochemical and electro-physical changes to impart their therapeutic benefits on tissues.

Electrotherapy can be roughly divided into two categories; transcutaneous and neuromuscular. Transcutaneous electrotherapy is primarily used to pass current through surface nerve tissue with the intent of interrupting pain signals transmitted by that tissue from a specific location. A device known as a Transcutaneous Electrical Nerve Stimulation unit, or T.E.N.S. unit, is the most common way this type of treatment is delivered. It is common for the phrase "TENS stimulation" or "TENS treatment" to be used as a means of referring to this type of treatment. In this paper, these phrases will be used interchangeably. Neuromuscular electrotherapy is different, in that it targets muscle tissue and the associated nerves that control muscle movement. This type of electrical stimulation is referred to by a number of terms, including "deep tissue stimulation", "neuromuscular electrical stimulation", "electrical muscle stimulation" (EMS), "neuromuscular electrical stimulation (NMES)" and more popularly, "e-stim".

It is important to recognize that for the purposes of this paper, "e-stim" will be used interchangeably with all of these terms, but that "e-stim" never refers to transcutaneous electrotherapy. The term "electrotherapy devices" will be used to refer to both TENS and e-stim devices.

Transcutaneous and neuromuscular electrotherapy devices work on the principle of passing electrical current through parts of a patient's body. In electrotherapy, "waveform" is used as a term that describes the current's wave shape, wavelength, frequency, amplitude, harmonics, polarity, and virtually all other characteristics common to electromagnetism wrapped up in one word. This is necessary because electrotherapy units are concerned with the delivery of electrical current with extremely specific properties. These current types need a common word for reference. That word is "waveform".

Keeping in mind the above definition of a waveform, both TENS and e-stim devices are bound by laws of physics that relate to the body's ability to tolerate different types of waveforms. The limit of this tolerance is primarily determined by waveform shape and waveform harmonics. When these two factors are effectively addressed, more current can be used with greater therapeutic benefit. We will discuss these two properties in detail, but for now know that the degree to which electrotherapy devices handle waveform generation and waveform harmonics is highly dependent on the quality of the onboard circuitry, and the amount of refined control over the waveform the device provides. These two aspects of control are primarily responsible for the differences in the quality of electrotherapy devices on the market today, and are what make the VST MyoDynamic Device® produced by VCARE® one of the most significant e-stim technology developments in over a decade.

Electrotherapy devices work by placing electrodes around the area to be treated, and then passing current between those electrodes. The current flowing between electrodes is known as a "channel". Patient discomfort during treatment can be caused by a number of factors within a channel. Common to all electrotherapy devices is the need to avoid a build up of electrolytes within the channel, which could result in electrolytic burns at the electrode sites. As we will later see, waveform quality plays a central role in preventing electrolytic burns.

Apart from electrolytic burns, e-stim devices must overcome two problems that are in fact unique to their intended treatment benefits. The first problem is one of patient comfort as it relates to the forced, repetitive contraction of muscle tissue. E-stim devices are intended to work damaged muscle by forcing repetitions of controlled muscle contractions. The reasons for this will be discussed later. This can be a painful experience, but as it turns out the waveform itself plays a role in dampening pain signals during muscle contraction.

The other problem is that of sending enough current (without causing patient discomfort) to cause muscle contraction in the presence of a neuromuscular barrier known as inhibitory arc; a phenomena whereby the body puts up a nerve impulse roadblock that severely restricts the voluntary movement of injured muscle tissue. This term applies only to the inhibition of voluntary movement. Once inhibitory arc is established, muscle movement in the affected area can remain impeded even once the injury is healed. For lack of a better term, this paper will refer to this specific type of remaining impediment as "residual inhibitory arc".

To understand how the VST MyoDynamic Device solves some of the most vexing problems in e-stim treatment, a better understanding of the fundamentals of electricity is needed. Even if you

already know a lot about electricity, this will facilitate understanding of what makes the VST a step forward in the evolution of e-stim technology.

Properties of Electricity

There are five components that matter when it comes to understanding how electricity becomes a therapeutic, healing agent through its application with the VST MyoDynamic Device. These components are **current**, **voltage**, **resistance**, **distortion and the circuit**. All five components work in combination through the VST machine. How well these components are controlled and the manner in which they are used is a key determinant in therapeutic outcomes.

Electricity can be thought of as water running out of a faucet and through a hose. The water cannot flow unless it has somewhere to go. The water in our analogy must have both a place to start from and a place to which it will travel. When this is the case a complete path, or **circuit**, is said to exist. The electrodes used in treatment, and the area of the patient's body between the electrodes, complete a circuit.

Voltage is a property of electrical current that is similar to water pressure. The diameter of the hose and the amount of water that is attempting to pass through it determine the force of the water. Likewise, the voltage of an electrical current can be thought of in terms of water pressure. Voltage is the force that overcomes the body’s natural resistance to the flow of electrical current. Voltage measures the force that moves electricity between two points in a circuit. The VST machine regulates voltage to move charged particles between electrodes and through targeted cells in the body. Voltage is the force that pushes the current down a path (or the water through the hose).

The amount of voltage needed to push the current is dependent on the amount of **resistance** present. Resistance determines the rate of electrical flow. Using our analogy, the diameter of the hose determines the amount of resistance the flow of water encounters as it runs through it. A large diameter hose will have less resistance than a small diameter hose. Likewise, some materials are more conducive to the flow of electricity than others. Materials that block the flow of electrical current are called insulators (rubber, wood and glass are good examples of effective insulators). Materials that allow the flow of current are called conductors. Metals like copper and aluminum are good examples of very efficient conductors, presenting very little resistance to

electrical current. Most materials fall somewhere in between insulators and conductors, leaning to one side or the other depending on the material they are made of.

The electricity traversing the circuit is referred to as a **current**. The qualities of this current are what we are most interested in when using the VST machine. The volume or flow of water running through the hose is the amount of electricity, measured in amperes, flowing from one point to another. The amount of current flowing through the completed circuit depends completely on voltage applied and resistance to that voltage. Ohms Law is the equation used to show that relationship between the three properties of electricity discussed here. The amount of current through a body is equal to the amount of voltage applied between two points on that body, divided by the electrical resistance offered by the body between those two points.
The objective of VST treatment is to pass current through tissues that are deeper than subcutaneous. This is why the VST machine has controls to allow the body's natural resistance to be overcome. Although your body is a very good conductor of electricity, body resistance is not a fixed quantity. It does offer some resistance to the flow of current, with the greatest resistance located in the skin. Other variables to consider that affect electrical resistance in the body are:

1. Wet (conductive) or dry skin (resistive).
2. Percent of body fat
3. How contact is made with the skin: is it from hand-to-hand, hand-to-foot, foot-to-foot, hand-to-elbow, etc.
4. Sweat, being rich in salts and minerals, is an excellent conductor of electricity for being a liquid. So is blood, with its similarly high content of conductive chemicals. Thus, contact with a wire made by a sweaty hand or open wound will offer much less resistance to current than contact made by clean, dry skin.
5. Additionally, the conductive nature of water means that tissues with high water content (such as muscle and nerve tissue) allow higher currents at any given voltage.

The VST Waveform: Low Harmonics and Ideal Shape

Recall that a patient's comfort is regulated by waveform shape and waveform harmonics. These two properties of a waveform are highly dependent on the quality of the onboard circuitry that generates the current in the first place, and the amount of refined control over the waveform the device provides to the trained operator of the device. A discussion of what constitutes a waveform, including aspects such as harmonics and shape, will help to clarify what the VST Waveform actually is.

Characteristics of a waveform

The VST machine provides control over both the voltage required to reach deeper tissues and various qualities of that current. The VST delivers current through the body as waveforms with different shapes and sizes. How well defined or “clean” these waveforms are as they pass through the body is a property referred to as **wave distortion.** The less distorted (the more clean) the waveform, the better the electrotherapeutic effect and more pleasant the experience for the patient. With distorted or “noxious” waveforms, the body experiences localized system shock, and decreases blood flow to the injured area. The effect only gets worse with more noxious waveform stimulation. The VST uses a non-noxious type waveform and so has the opposite effect. The body's reaction in this case is to open (dilate) the vessels, improving blood flow to the injured area.

The therapy delivered by the VST is known as “Voltage and Current controlled electrotherapy” because of its focus on providing refined control over the various properties of electrical current. This is an important capability of the VST machine when compared to units that primarily provide control over the voltage itself. Such devices are focused on voltage controlled electrotherap**y** and do not provide the same quality of treatment as the VST machine.

To better understand distortion requires looking a little closer at the current itself. Current is best described as electrons moving in a specific direction, at a specific speed, and grouping themselves into specific patterns. These are in fact the waveforms themselves. Waveforms that are stable and well defined are the result of being generated by a high quality signal.

