High Voltage Pulsed Current (HVPC)

OVERVIEW :

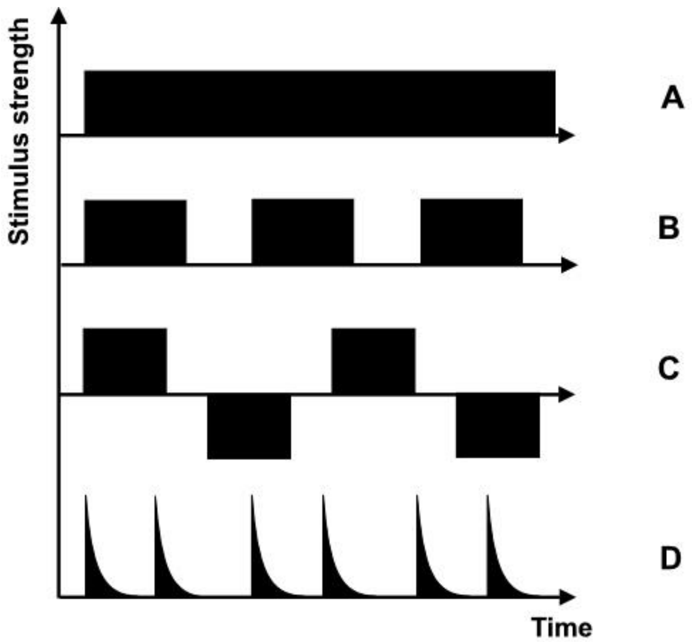
High Voltage Pulsed Current (HVPC) has been used in therapy for many years (machines have been available since the 1940's), yet while in many countries it is highly popular, in other countries its use is minimal. It is sometimes called 'Twin Peak Monophasic' which is more like a description of the machine output, and some authors include it in the Microcurrent group on the basis that the average current flow is almost certainly in the microcurrent range. HVPC will be used here as the preferred term for this modality.

Essentially, this stimulation modality employs a monophasic pulsed current, the pulses being delivered in a doublet (hence the 'twin peak' term). Each pulse is of short duration (typically less than 200µs), but, as the name implies, at a high peak voltage (up to 500V, typically 150-500V). By virtue of the fact that each pulse is very short, the current flow through the tissue will average to a very low level - thus the links with microcurrent type therapies.

There is an evidence base for its application in a range of clinical presentations, mainly relating to the stimulation of wound healing, pain relief and facilitated oedema resolution.

HVPC WAVEFORM AND STIMULATION PARAMETERS

There are several variations on the specific waveform employed in machines from different manufacturers. Some machines allow very little control over the pulse parameters whilst others enable variation of several key parameters.



In Figure 1 (Watson, 2008) HVPC is shown in relation to other common current forms.

Figure 1 : Representation of basic stimulating current forms.

(A) direct current (B) monophasic pulsed DC (C) symmetric biphasic pulsed (D) twin peak monophasic

Some devices allow the operator to adjust both the pulse duration, the interval between the 'twin peaks' and the interval between the pulse pairs.

A 'typical' HVPC set of parameters are illustrated in Figure 2 below. In this case the pulse duration is set at 200µs, the interpulse interval is set at 9800µs and therefore 1 cycle will take 10000µs to deliver (which is 10ms - milliseconds). If 1 cycle takes 10ms to deliver, the stimulation frequency will be 100Hz.

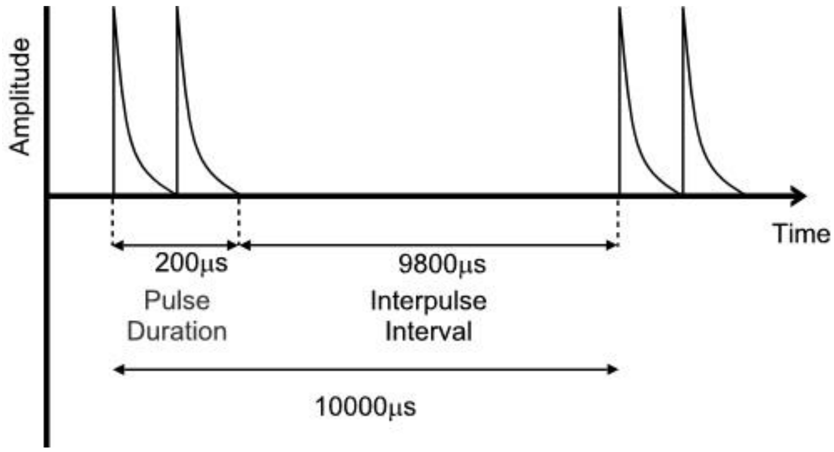


Figure 2 : Basic parameters with example settings for HVPC

If the therapist has the option to adjust the pulse frequency, the machine will automatically adjust the Interpulse Interval to enable the right number of (twin) pulses to be delivered per second.

It is argued (see figure 3 below, from www.nervestudy.com) that although the pulses are high voltage (typically 150-500V), they are of very short duration (microsec) and thus the actual (averaged) current flow through the tissues will be low - in the microcurrent range (microamps).

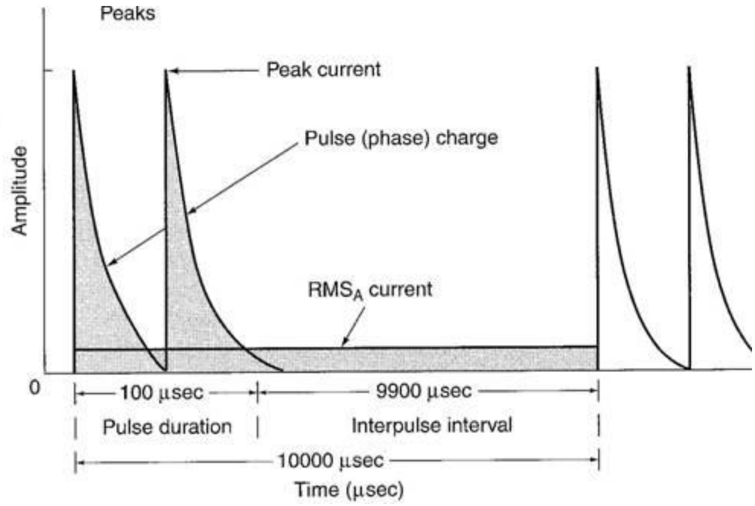


Figure 3 : Illustration of the low RMSA current flowing despite the pulses being delivered at high amplitude (from www.nervestudy.com)

MACHINES THAT DELIVER HVPC

As with other electrical stimulation modalities, most multifunction devices (examples of which are illustrated below) will include an HVPC mode somewhere in their menu system. Additionally, there are dedicated (some small and portable, some mains powered) HVPC devices available from several manufacturers (examples illustrated below).

		
Multifunction device from Gymna	Multifunction device from EMS Physio	Multifunction device from Chatanooga (DJO)
		
Portable HVPC stimulator from Prizm Medical	Portable unit (JACE TriStim) delivering HVPC	Portable unit (Chatanooga HV2) delivering HVPC

Figure 4: Examples of multimodal and dedicated machines that deliver HVPC stimulation

HVPC Effects and Clinical uses

There are several key areas in which HVPC is employed clinically. The main two of these are for **Wound Healing** and **Pain Management**. Additionally there are applications which have been advocated (and researched to a limited extent) for **Oedema Management** and **Muscle Strengthening**. Each is briefly summarised below with links to essential research and references.

HVPC for Wound Healing

This topic has been reasonably well researched (along with many other electrical stimulation options) and has been reviewed in Watson (2008) and Kloth (2005) to name but 2 papers.

A trial concerning the effects of HVPC was reported by Kloth and Feedar (1988). A group of 16 patients with stage IV decubitus ulcers were recruited for the trial and all had lesions that had been unresponsive to previous treatment. Patients were allocated randomly to a treatment group (n=59) or sham treatment)group (n=57). The ES consisted of monophasic twin-pulse stimulation at 105 pps. delivered at a voltage just below that required to achieve visible muscle contraction (typically 100–175V). These stimulation parameters are reported as being arbitrarily set. ES was given for one 45 minute session a day for 5 days a week. Sham group patients had electrodes placed in the same way, but the machine output was set to zero. Electrode polarity was set initially for the wound electrode to be positive, with the negative electrode placed on the skin surface proximally. If a healing plateau was reached during the trial, the wound electrode was made negative and the treatment continued. If a second plateau was reached, the electrode polarity was reversed daily thereafter. Whichever electrode was placed at the wound site, the relative arrangement was maintained in that the positive electrode was always placed cephalad in relation to the negative electrode.

All patients in the treatment group achieved complete healing of their ulcers (on average over 7.3 weeks at a mean healing rate of 44.8% per week). The control group patients did less well, with an increase in mean wound size of almost 29% between the first and last treatments. A subgroup of patients who were in the control group went on to complete a course of ES following the main trial; the three patients achieved full healing of their ulcers over 8.3 weeks with an average healing rate of 38% per week.

Griffin et al. (1991) assessed the effects of HVPC on pressure ulcer healing in a group of patients with spinal cord injury. Seventeen patients were assigned randomly to either a treatment or a control (sham treatment) group. ES treatments were carried out for 1 hour a day for 20 consecutive days with repeated wound assessments during this period. HVPC was delivered by means of a negative wound electrode with the stimulator delivering 100pps. at an intensity of 200 volts using similar twin pulses to the previous study. The percentage change (decrease) in ulcer size for the treatment group was significantly greater at days 5, 15 and 20 and the average change for all ulcers in the treatment group was an 80% size reduction compared with a 52% decrease for the control group.

A more recent study by Houghton et al (2003) involved 27 patients with a total of 42 chronic leg ulcers of varying aetiology (diabetic, arterial, venous) and employed a placebo controlled RCT design. Following initial assessment, there was a stable (baseline) period during which only 'conventional' therapy was employed, followed by a 4 week treatment phase with the patients divided into treatment or sham groups. The high voltage pulses were delivered at 150V, 100pps and 100μsec duration, using 45 minute treatment periods, 3 times a week for the 4 weeks. The wound electrode was made negative throughout the treatment period i.e. no polarity reversal. Assessment included a one month follow up period. The treatment group wounds significantly reduced in size (mean 44% of original) compared with the sham group (mean 16%). The significant differences were not maintained at the 1 month follow up assessment, though there was a clear trend seen in the results.

Goldman et al (2002) aimed to evaluate the ability of high voltage pulsed current (HVPC) to increase microcirculation in critically ischemic wounds and, as a result, to improve wound healing. The diabetic patients presented with maleolar ischaemic lesions and serial measures were made of wound parameters, including oxygen tension. The results indicated that the use of electrical stimulation with these patient objectively improved tissue oxygenation and improved the anticipated wound healing profile.

In addition to the wound healing / wound closure studies, HVPC has been shown (with other stimulation modalities) to have both a germicidal and antibacterial effect. Papers include Kincaid et al, 1989; Weiss et al, 1989; Guffey et al, 1989.

There are many trial like those reported above. There is little doubt that HVPC has the capacity to influence wound healing in the clinical environment. There are several other forms of electrical stimulation which have also been demonstrated to have such an effect, and whilst they are 'supportable' from the published evidence, what is lacking is the critical comparative trial which directly compares different forms of stimulation with a common research method in order to establish whether a particular modality is superior to the others, or indeed, whether they are all as effective as each other.

HVPC FOR PAIN MANAGEMENT

There is generally less evidence available relating to the use of HVPC as a pain management tool, though it is certainly practiced (i.e. supported by the anecdotal evidence). One of the few studies which concludes that it is not effective as a pain management intervention was pblished by Akarcali et al (2002) who evaluated its use for patellofemoral pain. Patients were managed with either exercise alone or exercise together with HVPC over a 6 week period. There was a significant advantage the the HVPC group in terms of pain management early in the treatment phase (at 3 weeks), but there were no significant differences by the 6 week (end of treatment) assessment point. There was a quads strength increase in both groups, but not significantly different by the end of the trial period. HVPC therefore makes a significant contribution to early pain relief in this patient group.

Tanrikut et al (2003) evaluated the use of HVPC at trigger points for patients with myofascial pain syndrome, comparing the real (HVPC) therapy with placebo and control group outcomes. Whilst there was pain relief achieved in all groups, it was significantly greater in the HVPC group than in placebo or controls.

Holcomb et al (2007) used HVPC combined with an NMES stimulation in healthy subjects in order to see whether the addition of the HVPC make any significant difference to the outcome. The authors suggest that the HVPC did not make any significant difference to the outcome in terms of quadriceps strength, but that it might make a useful contribution if pain and/or oedema were clinical issues, e.g. post reconstructive surgery.

The Stralka et al (1998) study (in Oedema section below) also suggests that HVPC can make a useful contribution to pain management issues.

HVPC FOR MUSCLE STRENGTHENING

There has been a range of research over the years looking to see if muscle strengthening can be achieved with EStim - ranging from Interferential therapy, through Russian Stimulation to NMES based interventions. Yakut et al (2001) compared different e stim applications alongside an exercise programme, evaluating strength and pain changes. The HVPC was demonstrated to be the stimulation modality which provided best pain relief along side a strengthening effect (which was found with all groups)

HVPC FOR OEDEMA MANAGEMENT

There have been several studies looking at the potential for HVPC to influence oedema formation post trauma and also oedema management once it has formed. Several of the papers are based on animal experimentation, and thus may not be directly applicable in the clinical environment until transfer of effect has been verified. Stralka et al (1998) did employ HVPC as a means to resuce chronic hand oedema, using a wrist splint with HVPC or splint alone. Treatment for 20 minutes daily resulted in significantly reduced pain and reduced oedema in the HVPC group.

The work of Bettany et al (1990), although based on animal model work, demonstrated a clear reduction in the volume of oedema formation following trauma when HVPC was applied, and this may be useful as an early intervention option post injury.

Michlovitz et al (1988) tested an ice protocol against and ice plus HVPC intervention following acute ankle sprain. They failed to demonstrate a significant pain perception difference between the groups. The treatment was applied on three occasions with the HVPC at 28Hz, negative polarity once daily for 30 minutes. Whether this is a treatment 'dose' effect (i.e. stimulation at a different dose may have been effective) or whether HVPC is ineffective in the management of acute pain remains to be shown.

Summary

HVPC has a varied popularity around the world, with pockets of high activity, and areas of minimal or even absent use. It does have an evidenced efficacy, though at the present time, this is most strongly associated with wound healing activity. It has been evaluated for pain relief effects, muscle strengthening and oedema management, all of which has some supportive evidence. Whether it should be considered as a form of microcurrent therapy or as a type of classical electrical stimulation (like NMES, Russian Stimulation, Faradism etc) has yet to be resolved. It certainly has similarities to both, and may turn out to be more (or less) effective - time and research will tell.

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