

# Action Potential Simulation Therapy: Self Assessment by 285 patients with chronic pain

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It is believed that A-beta fibres (low threshold mechanoreceptors from the skin) give off collaterals as they pass upwards in the spinal cord, which impinge on the nociceptor cells of the A-delta and C-pain fibres, effectively reducing the excitability of these nociceptor cells. Thus, electrical impulses which stimulate these A-beta fibres are effective in reducing pain perception. Electrotherapy has therefore been used as a treatment modality for pain and swelling.

*Dit word voorgestel dat A-beta vesels (lae drempel meganoreseptore vanaf die vel) kolateraál versprei soos wat dit deur die rugmurg opwaarts beweeg en inbreuk maak op die nosiseptorselle van die A-delta en C-pyn vesels, en sodoende die eksiteerbaarheid van die nosiseptorselle verlaag. Elektriese impulse wat die A-beta vesels stimuleer verminder pynwaarneming effektief en word dus as behandelingsmetode vir pyn en swelling gebruik.*

*In hierdie studie is pynverligting gemeet deur gebruik te maak van 'n visuele pyn analoog skaal (VPAS) en mobiliteitsindeks (MI) in 285 pasiënte met 'n verskeidenheid van kliniese diagnoses met betrekking tot pyn. Pasiënte is evalueer vir basislyn op dag een en dan op dag vyf na vyf dae van behandeling met elektroterapie (Aksiepotensiaal Simulasie, APS). Die gemiddelde VPAS en MI het betekenisvol verbeter in die groep as totaal sowel as in groepe wat verdeel is in onder 50 jaar oud en ouer as 50 jaar. Op kliniese gronde en deur pasiënte selfevaluering was*

*APS terapie suksesvol. APS gebruik perifere senuwee stimulasie om pyn te verlig. Daar word gebruik gemaak van die vinniger A-beta vesels wat stimulasie van die C-vesels belemmer (nosiseptore) en dus pyn waarneming blokkeer. Die rol van opoëde moet ook nie onderskat word nie. Verdere navorsing is nodig om die positiewe effekte van ekelroterapie op die gesondheid van persone te verklaar.*

In this study pain relief was assessed in 285 patients with varying clinical manifestations of pain, using the visual analog pain scale (VAPS) and mobility index (MI). Baseline measurements were taken on day one and then after five days of electrotherapy treatment (Action Potential Simulation, APS). The mean VAPS and MI improved significantly in the patient group as a whole, as well as in the two age-related groups, namely, below and above 50 years of age. Both on clinical grounds and by patient self assessment, APS therapy appeared to be most beneficial. This mode of treatment utilises peripheral nerve

stimulation to relieve pain using the faster A-beta fibres which intercept stimulation from the C-fibres (nociceptors) and therefore, according to the gate theory, blocks pain perception. The role of opioids should also not be underestimated. Further research is warranted to fully understand the positive effects of electrotherapy on the health of the individual.

Nociception is defined as the neural response to noxious stimulation, pain as the conscious perception of nociception, and pain expression as the verbal coupled to behavioural signals that allow the clinician to assess the severity of the nociceptive stimulus<sup>1</sup>. The outward expression of pain is influenced by a variety of biopsychosocial factors including culture, mood and psychological state, and physical function. In addition, as the brain is actively involved in modulating and processing nociceptive stimuli, cognitive function is also likely to influence pain expression<sup>2,3,4</sup>.

Excitable tissues, muscles and nerves, can be stimulated by suitable currents. This may lead to many

effects such as muscle contraction and modification of pain perception through the stimulation of the motor or sensory nerves. All sensations recognised at a conscious level, can be altered by the central nervous system. Chronic pain, which is recognised as slow pain, as opposed to acute pain (carried by small myelinated A-delta fibres and recognised as fast pain), is equated with tissue damage and is carried by small unmyelinated C-fibres<sup>5</sup>.

The gate control theory suggested by Melzack and Wall in 1965, proposed that pain perception is regulated by a physiological "gate" which may be opened or closed, thus increasing or decreasing the pain perceived, by means of other inputs from peripheral nerves or from the central nervous system.<sup>6</sup> The A-beta fibres, low threshold mechanoreceptors from the skin, travel without synapsing, up the posterior columns of the spinal cord. These fibres give off collaterals, which impinge on the nociceptor cells of the A-delta and C-pain fibres in different laminae of the substantia gelatinosa of the spinal cord. It is believed that input from these mechanoreceptors effectively reduces the excitability of the nociceptor cells to pain-generated stimuli<sup>7</sup>.

Thus electrical impulses which stimulate these A-beta mechanoreceptor fibres, are effective in reducing pain perception. "From the spinal region, transmission proceeds onward to supra-spinal levels, where pain perception is altered through the release of endogenous opioids." These and other substances are released at many other key regions in the brain and spinal cord, and through efferent discharge in local regions too.

Evidence has also shown that various forms of electrotherapy are capable of restoring normal cell membrane potential, thus affecting tissue growth and repair<sup>8</sup>.

Opiates exert their action in the central nervous system by binding to specific receptors, and it has been discovered that there is an increased density of receptors in regions where electrical stimulation has an antinociceptive effect. An intense

search for the natural ligand to these receptors led to the isolation of a number of endogenous opioid peptides, e.g., the enkephalins and the endorphins. It has also been discovered that they exert an inhibitory modulation on the transmission of pain impulses. Furthermore, the electrical stimulation which leads to pain control and relief, sometimes correlated with the release of endogenous opioids.<sup>9,10,11</sup>

Electrotherapy is the use of electricity to cause a specific physiological response, and is a well-known and accepted treatment modality used by physiotherapists.<sup>5</sup> There are many different electrotherapy modalities available, each defined by different parameters such as frequency and intensity. Electrotherapy is considered to be an effective way of treating clinical conditions such as pain and swelling, by causing peripheral vasodilatation, which results in better perfusion of the affected areas.

The potential advantage of electrical stimulation as an adjunct to other pain therapies, is that this treatment modality is non-invasive and relatively safe. Such treatments have minimal side effects, assist in the reduction of medication and may improve the quality of life of the patient, permitting return to normal working and social activities.<sup>12</sup>

In 1992, a new electrotherapy modality was designed and brought onto the South African market - known as Action Potential Simulation (APS) Therapy. It was developed specifically for use in pain relief and pain control and for the improvement of mobility of stiff joints and muscles.<sup>13</sup> The device uses an electrical current that supposedly mimics the normal physiological action potential of nerve conduction. This may be a unique concept to electro-physics. The device is said to produce action potentials that are four times stronger than those naturally occurring in the neuron.<sup>8</sup> When swelling, inflammation, poor circulation and pain occur due to mechanical, chemical or electrical disturbances, by stimulating the body's natural regenerative processes (as in depolarisation), these

conditions are encouraged to resolve.

Various instruments have been designed for the actual measurement of the degree of pain; for example, the verbal rating scale, McGill pain questionnaire, pain drawings and descriptor pain perception profile, to name a few.<sup>14,15</sup> Each measuring instrument has its own degree of reliability and validity.<sup>14</sup> The word pain tends to be confusing. For some it is merely a pinprick, while for others it is an unbearable sensation. This makes it difficult to compare individuals' experiences of pain.<sup>15,16</sup> Thus the clinician, in order to evaluate the efficacy of pain intervention, due to lack of more substantive methods, must surely rely on self assessment of pain relief and control by patients. Use can be made of a pain intensity scale where each patient acts as its own control.

The aim of this study then was to allow self-assessment, before and after APS therapy of:

1. Pain relief
2. Improvement in mobility by patients with chronic pain and stiffness.

## SUBJECTS AND METHODS

Approval for the study was obtained from the combined Ethics Committee of the University of Pretoria and the Gauteng Provincial Health Authorities.

Patients, who routinely attended two pain clinics for therapy, were used in this study. The total number of patients were 285. The clinical diagnosis varied considerably and was anatomically 'classified' as back, neck, knees, hands, hips, etc.

After a thorough physical examination, all patients were asked to fill in a visual analogue pain scale (VAPS) and mobility index (MI). Every patient gave a VAPS value for their specific pain condition. This value represented a combined impression of their pain for the previous week and was the baseline on which the whole study was built.

The VAPS consists of a 10cm horizontal line bounded by "no pain" on the left and "worst pain imagi-

**TABLE I: THE DEMOGRAPHICS OF THE STUDY POPULATION**

Total number of patients	285	Percentage
Male	161	56
Female	124	44
<b>Mean age</b>	50	
Male	42	
Female	60	
Oldest patient	94	
Youngest patient	9	
<b>Medication</b>		
Anti-inflammatory	48	17
Analgesics	4	1
No medication	233	82

nable” on the right end. Patients indicate their pain intensity on a 1-10 scale. The MI is a self-report and instrument to assess the degree to which chronic pain interferes with daily activities.<sup>17,18</sup> It has test-retest reliability and validity. As MI seems to be associated with levels of pain expression shown by patients,<sup>17</sup> VAPS and MI's were re-assessed in patients after five days of APS therapy. The average duration of treatment was 12 minutes with an intensity of between 1,1 and 1,3 mA.

**TECHNICAL SPECIFICATIONS OF THE APS THERAPY DEVICE**

Wave form: Simulated Action Potential  
 Wave Type: Monophasic Square Pulse with Exponential Decay  
 Amplitude: Adjustable, 0-24.4 mA peak into 500 ohm load  
 Pulse rate: 150Hz  
 Modulation: Variable pulse width; automatic adjustment depending on distance between electrodes  
 Burst: Continuous  
 Voltage: 0-46 Volts (open circuit)

**RESULTS AND DISCUSSION**

The demographics of our study population are shown in Table I. A relatively heterogeneous mixture of subjects - 56% male and 44% female with mean age of 42 for the males and

60 for the females. The mean age was 50. Our oldest patient was 94 and youngest 9. Seventeen percent of our subjects were taking anti-inflammatory drugs on a daily basis, while 1% were taking analgesics only on an ‘as needed’ (prn) basis. 234 subjects or 82% did not take any anti-inflammatories or analgesics.

The VAPS and MI before day 1 and after day 5 for all the patients as a whole are shown in table II. The mean VAPS and MI improved dramatically from 6,6 and 6,5 to 2,7 and 3,3 respectively.

The ‘anatomical’ classification of different injuries and conditions were as follows: The largest 2 groups (97 + 45) were classified as back and neck patients. These patients suffered mostly from back and neck pain due to spondilosis, disc degeneration with narrowing of the intervertebral disc spaces, paravertebral osteoarthritis,

previous back surgery, spondilolisthesis, spondilolysis and N.ischiadicus root irritation, postural and mechanical (functional) back and neck ache. Clinical diagnosis in the other groups included osteoarthritis, rheumatoid arthritis, gouty arthritis, menisci lesions, ligamentous injuries, malalignment, flat feet, plantar fasciitis, rotator cuff syndrome, bad circulation, varicose veins, migraine, carpal tunnel syndrome, osteoarthritis jaw, tennis elbow, muscle spasms, etc. The effect before and after treatment on the VAPS and MI are depicted in Fig 1 and 2. In all groups, except for those with arms and jaw pain, the changes in VAPS were statistically significant (P<0.001). The small number of subjects (3) in the arms and jaw group may explain their non-significant results.

The patients were also divided in an above 50 years of age group and a below 50 years of age group, for both the VAPS and MI (See Figures 3 & 4 on pg. 22). The average value as a whole for the VAPS for >50 years was 6,8 before treatment and 3,3 after treatment. In the <50 years age group, it was 6,3 and 2,2 respectively. Although both age groups improved dramatically there was a 15 % overall better response in the older age group.

The average value as a whole for the MI for >50 years was 6,7 before treatment and 3,4 after treatment. In the <50 years age groups it was 6,4 and 3,2 respectively. Both groups responded equally to treatment.

The best results were obtained in the elderly patients with neck

**TABLE II: THE VISUAL ANALOGUE PAIN SCALE AND MOBILITY INDEX BEFORE AND AFTER TREATMENT**

	Before Treatment		After 5 Treatments	
	Mean	STDev	Mean	STDev
<b>VAPS (total)</b>	6.6	1.4	2.7*	2
VAPS (male)	6.4	1.5	2.3*	2.1
VAPS (female)	6.8	1.1	3.3*	1.7
<b>Mobility (total)</b>	6.5	1.4	3.3*	1.8
Mobility (male)	6.4	1.5	3.2*	1.9
Mobility (female)	6.8	1.1	3.5*	1.7

*These changes are also depicted in fig 1 and II. \*P < 0.001.*

