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An in Vivo Study of High Voltage Pulsed Current on pH in the Healing Wound Bed

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– ABSTRACT –

The purpose of this study was to determine the effect of High Voltage Pulsed Current on pH in the healing wound bed. Seven adults, four males and three females, were studied with a total of fifty-five viable treatment sessions.

Using a Cardy Digital pH meter, we measured the pH in the wound bed following saline rinse both prior to treatment and after a forty-five minute treatment. Analysis of all viable records(n=54) did not show a significant change in pH(p=0.82). The mean pH change in NoN-Smokers(-0.14) was more acidic when compared to the mean pH change in smokers(0.27) which was more alkaline.

Key Words: Wound; High voltage pulse current; pH; Smokers.

Since 1968, several human clinical studies have demonstrated the effectiveness of electrical stimulation when used to promote the healing of dermal ulcers. one study that is often quoted is Assimacopoulos report[1] on three venous stasis ulcer patients whose wounds had healed after being treated with direct current. In 1972, Gault and Gatens[2] reported a study of 150 patients treated for ischemic skin ulcers with direct current. Untreated ulcers from fourteen patients with bilateral ulcers served as controls. The treated ulcers healed 28.3% per week versus 8.3% per week for the controls. In 1976, Gault and Gatens[3] published a second report on 100 ischemic skin ulcers. Of this group, the treated ulcers healed 30.05% per week versus 14.7% per week for untreated ulcers from six patients with bilateral ulcers serving as controls.

The efficacy of various forms of electrical current in augmenting tissue repair gas been studied both on human subjects and in animal models. Recent anecdotal reports indicate that crater-type wounds (e.g. decubitus ulcers) have responded favorably to electrical stimulation with high voltage.[4-14] Aders and Gabrielson[15] studied the rate of decubitus wound healing in human subjects using three different procedures. Fourteen patients with decubitus ulcers were assigned to one of three treatment groups: (1) whirlpool bath once a day, (2) combination of whirlpool bath and high voltage stimulation(HVS) twice a day, and (3) HVS twice a day. The distribution of patients between groups, duration and number of treatments, and stimulus characteristics were not reported. Aders and Gabrielson indicated that patients who received only HVS treatment experienced the greatest rate of change in wound size followed by patients who received both whirlpool and HVS treatments. Patents who received whirlpool treatment alone experienced the least change. Kloth and Feedar[16] reported that high voltage monophasic pulsed current accelerates the healing rate of stage IV decubitus ulcers in human subjects. Sixteen patients ranging in age from 20 to 89 years with stage IV decubitus ulcers participated in the study. The patients were assigned randomly to either a Treatment Group (n=9) or a Control Group (n=7). Patients in the Treatment Group received daily electrical stimulation from a commercial high voltage generator. Patients in the Control group had the electrodes applied daily but received no stimulation. The ulcers of patients in the Treatment Group healed at mean rate of 44.8% a week and healed 100% over a mean period of 7.3 weeks. The ulcers of patients in the Control Group increased in area an average of 11.6% a week and increased 28.9% over a mean period of 7.4 weeks.

It has been postulated that a slightly acidic wound environment favors granulation in the healing wound, and that the healing wound goes from a slightly alkaline state in its infected stage to a slightly acidic state as it

heals.[19] Since the above research suggested that HVPC produces a substantial increase in wound healing rate, it would be of interest to know if the HVPC is associated with a change of pH in the wound bed.

The purpose of this study was to determine the effect of HVPC on pH in the healing wound bed. The null hypothesis was that a 45 minute HVPC treatment would not significantly alter pH in the wound bed.

Methods

The sample consisted of adults with wounds, who were patients at an outpatient problem wound clinic. Subjects were excluded if they gad wounds that were healing by primary intent. Data on smoking status and whether or not the subjects had diabetes was collected since these variables were thought to be potential confounders to the outcome of our study.

To Measure the pH in the wound bed, a sterilized strip of pH neutral filter paper was placed on the wound bed following a saline rinse and allowed to absorb the fluid within the wound. The paper strip was then placed in a Cardy digital pH meter and a reading was taken. In order to insure consistency and allow for some of the wounds which were quite dry, one drop of de-ionized water was added to each sample to be read. After 45 minutes of electrical stimulation another pH measurement was taken with a new paper strip and the pH reading sequence was repeated.

Results

Seven adults, four males and three females, were studied with a total of sixty-two treatment sessions. All subjects completed this study, however, data from seven treatment sessions were unavailable due to damage of the testing strips. This left fifty-five viable records for analysis.

As seen in Table 1, an analysis using a two-tailed paired t-test revealed that two of the seven subjects had statistically significant changes in pH. Patient 3, who was a non-diabetic smoker, had a wound which became more alkaline($p=0.01$), while patient 5, who was a diabetic non-smoker, had a wound which shifted toward acidity ($p=0.05$). Analysis of all fifty-five records, however, did not show a

Table 1. Analysis of pH differences following treatment (2 tailed paired t-test)

	Tx. Sessions	Mean	S.D	P-value
Total Txs.	55	-0.02	0.63	0.82
Patient 1	6	-0.13	0.39	0.44
Patient 2	7	-0.23	0.56	0.32
Patient 3	10	0.52	0.47	0.01
Patient 4	7	0.01	0.57	0.97
Patient 5	8	-0.38	0.45	0.05
Patient 6	14	-0.15	0.76	0.52
Patient 7	3	0.34	0.67	0.47

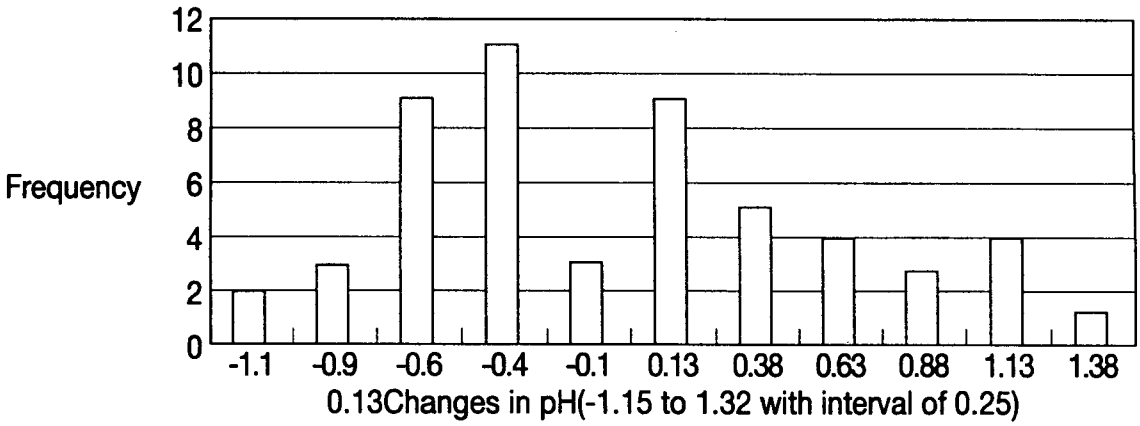

Figure 1. Frequency distribution of pH changes following treatment (n=54)

significant change in pH (p=0.82). Figure 1 shows that there was an almost equal distribution of pH changes, with 28 records shifting towards acidity, 26 records shifting towards alkalinity and one record with no shift in either direction.

The mean pH change in non-smokers (-0.14) was more acidic when compared to the mean pH change in smokers (0.27), which was more alkaline. The mean pH change in non-diabetics (0.07) was more alkaline while the mean pH change in diabetics (-0.20) was more acidic. None of these sub groups showed a significant mean change in pH (Smokers, p=0.06; Non-smokers, p=0.17; Diabetics, p=0.14; Non-diabetics, p=0.52).

Discussion

Many of the modalities which are used for wound care in physical therapy clinics are backed by empirical data with little or no scientific explanation as to why they work. In the case of High Voltage Pulsed Current, research has shown that the results are positive for the acceleration of wound healing even though the actual mechanism of operation is not clear. The purpose of this research project was to help delineate the effect of pulsed current on the healing wound.

Previous research by Szuminsky, et al.[17] stated that anodic current would produce an increase in the pH within the in vitro environment. This project has indicated that the actual change in pH within an in vivo environment is unpredictable. Because of high variability within the same patient among treatment sessions, the mean change in pH over the fifty-five treatments was not significantly different from zero. A decrease in pH of as little as 0.2 can increase oxygen perfusion approximately fifteen percent at the wound site and thus facilitate wound healing.[18]

The physiological ramifications of the patients day to day existence play a major role in the resulting effect of the HVPC on a

wound. A patient's eating, drinking, and smoking habits along with their health status, can produce changes in his response to treatment. One patient, who was a heavy smoker, had an increase in pH on virtually every treatment with the negative current. All the non-smokers had mixed results.

True pH was almost impossible to obtain due to the differing levels of desiccation in the different wounds. In order to compensate for this, each of the pre-treatment wound measurements were taken following saline rinse and the test strips were further wetted with one drop of deionized water, thus allowing enough liquid content on the paper strip to obtain a reading. One drop of deionized water was also added to the post-treatment sample. This wetting of the sample could have changed the pH reading. It was hoped that since every test was handled the same way, the differences between pre and post treatment would be accurate.

Although the number of treatments measured was substantial, there was a limited umber of patients in the study. Not all patients contributed the same number of treatments. This allowed for a potential bias especially when dividing the patients into subgroups.

Suggestions for further research would be to classify subjects according to criteria such as health status (e.g. diabetes vs. non-diabetes), smokers vs. non-smokers, and nutrition status. A reliability study of the method of data collection may also be appropriate. We hope this study will stimulate interest for future research on this topic.

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