

Effects of Electrical Stimulation on Treatment of Pressure Sores in Subjects with Spinal Cord Injuries: A Case Series Study

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Abstract

Introduction: Unsatisfactory results of conventional medical treatment methods for pressure sores in patients with spinal cord injury (SCI) have instigated the use of non-medical treatments, such as electrotherapy. However, the risk of burning in exposure to direct current (Galvanic) and contradictory propositions on the best applicable electrotherapeutic current during the method have prevented widespread application of electrotherapy. The purpose of this study was to show the effects of High-Voltage Pulsed Current (HVPC) on the treatment of pressure sores resistant to routine medical treatment practices. **Materials and Methods:** The case series study involved the analysis of 8 SCI subjects with grade III and IV pressure sores around the pelvic area. All the subjects received HVPC electrotherapy for 12 daily sessions, during which The negative electrode placed on the wound and the positive electrode was placed 20 cm distal to the negative electrode. The intensity increased gradually until muscle contraction was observed. The treatment time was kept at 20 minutes per treatment session. Single session was performed each day for 12 consecutive days. The wounds were photographed at day 1 before starting the treatment, on day 6, and finally, on day 12 after the treatment. The area of wound on each of these days was calculated with the help of the AutoCAD Software. **Results:** The results obtained after 12 consecutive days of electrotherapy indicated that the wound size of the studied SCI subjects reduced by 56, 87% of wound size (the wound surface) has been reduced. **Conclusion:** The results confirmed positive effects of HVPC electrical stimulation for healing SCI associated pressure sores in patients resistant to the routine medical approaches of treatment. Moreover, HVPC application was found to accelerate the healing process in these subjects.

Keywords: Electrotherapy, Electrical Stimulation Current, High-Voltage Pulsed (UVP), Pressure Sore, Spinal Cord Injury, Wound Healing

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Introduction

Pressure sores are serious secondary complications of spinal cord injuries (SCI). Although, pressure sores are preventable in many cases, they exert detrimental impacts on the rehabilitation of the patient. They prevent the patient from going to work and resume their normal daily routine. In general, these ulcers pose a problem for the effective presence of the individual in the community and lower their quality of life [1-4]. If the pressure sores cluster together, they may even cause disability, immobility, deadly infections, loss of independence and the need for surgical interventions [3, 5].

Pressure sore is a lesion on the skin surface which is usually caused by some reasons such as friction, pressure, or a combination of pressure and shear force. [5-8]. About 85% of patients with SCI suffer from pressure sore in their lifetime. [9-11]. According to the reports published by the SCI System Statistical Center, the prevalence of pressure sores is about 14.7% in the first year after injury, but its prevalence increases in the subsequent years [12]. Furthermore, pressure sores are a serious detrimental factor for the social healthcare system. In Britain, the treatment cost of pressure sore varies from about 1214 pounds (grade I ulcer) to 14108 pounds (grade IV ulcer). When considered



Figure 1. The electrotherapy device used in the study

together, the entire cost of the treatment of such sores ranges from 1.4 to 2.1 billion pounds per annum. This accounts for about 4% of the annual national healthcare budget of Britain [13-15]. When considered on an individual basis, it is estimated that the cost of pressure sore treatment accounts for about 25% of the total cost incurred for the treatment and rehabilitation of SCI patients [16, 17].

These sores (ulcers) may appear on the skin surface (Its surface and depth is not determined yet) several weeks after its development [18]. Pressure reduces blood supply of tissues under pressure and muscles show higher sensitivity to the reduced blood supply under pressure rather than the skin. Muscles show higher sensitivity to the reduced blood supply under pressure rather than the skin [1]. The most contemporary modes of treatment and management of these pressure sores involve the administration of conventional nursing treatments, such as removal of pressure from the area, improvement of nutrition, revascularization, and debridement (if necessary). It is generally said that if the size of the non-infectious pressure sores is reduced by 50% within four weeks, then the ulcer will be fully repaired. Conversely, if the size does not reduce within four weeks, then it is likely that the ulcer will enter the chronic phase. The treatment of such chronic sores requires the administration of advanced methods, such as negative pressure build-up devices, oxygen therapy, skin replacement by bioengineering techniques, ultrasound treatments, and electrical stimulations. Choosing each method depends on the availability of the treatment as well as financial constraints and timing conditions [19].



Figure 2. Fixing electrodes before the application of electric current

In spite of recommendation and training to the SCI patients on the preventing, managing, healing of these sores by the rehabilitation group and public health professionals but, pressure sores are still common in SCI patients. [20]. Previous studies have shown that the use of electrical stimulation contributes to sore healing and also helps in saving the medical expenses incurred for its management and treatment [21]. Electrical stimulation had been used for the treatment of pressure sores, especially for the sores that do not respond to routine medical treatments, including pressure sores of patients with sensation and patients with SCI, ever since the 1960s [16, 22, 23]. However, there has always been a controversy over the type of electrical current that can produce the best therapeutic results without causing any further complications [24]. The importance of the study and exploration of such alternative treatment methods is further highlighted by the increasing number of people with SCI due to car accidents. Therefore, the medical treatment and rehabilitation teams are even more interested in finding more effective and cost-efficient methods of treatment. In this regard, they must be well aware of the primary and secondary complications arising out of SCIs and the most appropriate methods for the prevention and treatment of the complications [25].

The present study aims to investigate one such method that involves administration of electrical stimulation for the treatment of pressure sores in spinal cord injured patients, those who were found resistant to the conventional therapeutic and nursing methods.



Figure 3 - Sore surface changes in subject 6

Materials and Methods

Study subjects

The experimental subjects were selected from the patients taken care of by the "home care team" of the Kahrizak Disability and Elderly Charity foundation, Tehran. The selection was based on the inclusion criteria. According to which SCI patients with grade III or IV pressure sores (identified on the basis of the specifications made by National Pressure Ulcer Advisory Panel [NPUAP]) that have persisted for at least 6 months (routine medical treatments for at least six months did not show a positive effect) since the time of diagnosis were included in the study. The exclusion criteria specified that diabetic and psychotic patients who were unable to follow the instructions or patients whose sores were infected and patients who expressed their unwillingness to participate in the study were not included in the study. The methodology of the experiment was explained to the selected subjects as they entered the study after signing a consent form. For people with more than one sore, the larger sore was used in the study.

As a case series study, 8 selectively chosen patients were treated with Pulsed Electric High-Voltage current and routine nurse care. HVPC stimulation applied for 20 minutes each day and in 12 consecutive days.

A trained physiotherapist was chosen to administer the treatment. The changes in sore area were then examined with the help of a digital camera. The camera photographed the sore before the start of the treatment, after the end of the sixth treatment session and finally after the end of the treatment period, i.e., 12th treatment session.

The device used for the administration of electrotherapy was an electric stimulator (WinStim, manufactured in India under the license of Johari Digital Healthcare Company, USA) (Figure 1). The electric current used in treatment was

high-voltage with twin pulses of 75 μ s duration. The adjustable voltage used in the treatment was kept between 0-500 volts while the frequency was maintained at 1 to 120 pulses per second.

In the present study, the electric current was set at the frequency of 100 pulses per second. The cycle selected was of 5 seconds on and 5 seconds off while the current gradient was kept at 2 seconds.

Before applying the electric current, the sore was washed with 0.9% normal saline serum. If deemed necessary, the sore was even mechanically debrided the necrosis tissue with sterile gauze. Before placing the electrode, the sore was covered with 0.9% normal saline soaked gauze while deep sores were filled with the soaked gauze. The negative electrode was placed on the gauze and fixed in place with plastic glues. The positive electrode was fixed on a wet gauze layer below the negative pole (20 cm) over the hip area (Figure 2).

The intensity of the applied electric current was slowly raised to 150–200 volts to avoid any discomfort or muscle contraction caused due to the abrupt administration of high-voltage electric current.

The patients were informed and trained beforehand to avoid putting pressure on the sore and refrain from sleeping or sitting on the sore during the treatment procedure. It was also ensured that the wave mattress on the beds or wheelchairs of the patients was not changed during the course of the treatment.

The pictures of the sores before and after treatment were captured with a Canon PowerShot SX 200 (12x and 28–336 mm optical zoom lens) from a distance of 20 cm from the surface of the sore. The dimensions of the sores were determined with the help of a ruler that was kept next to the sore. Total area of the sores was calculated using AutoCAD 2015.

Table 1. Demographic characteristics of SCI patients

	Gender	Age, y	Weight, kg	Height, cm	BMI, kg/m ²
Subject 1	Male	43	91	173	30.40
Subject 2	Male	47	88	180	27.16
Subject 3	Male	22	82	181	25.02
Subject 4	Male	36	75	168	26.57
Subject 5	Male	30	75	187	21.44
Subject 6	Male	57	84	170	29.06
Subject 7	Male	31	60	165	22.03
Subject 8	Male	39	78	176	25.18
Mean		38	79	175	25.85

Table 2. Characteristics of the subjects' ulcers

	Level of injury	1 st session	6 th session	Percentage changes of 1 st to 6 th	12 th session	Percentage changes of 1 st to 12 th	The mean percentage changes of 1 st to 12 th
Subject 1	T11	17.18	10.635	38%	9.385	45%	56.87%
Subject 2	T6	16.992	9.667	43%	5.094	70%	
Subject 3	T5	4.001	0.609	84%	0.500	87%	
Subject 4	C7	0.233	0.126	45%	0.115	50%	
Subject 5	T12	0.709	0.563	24%	0.314	56%	
Subject 6	T9	7.307	3.795	48%	2.173	70%	
Subject 7	T8	6.461	5.158	20%	4.432	31%	
Subject 8	T10	1.429	1.094	23%	0.770	46%	

Results

The effects of the therapy in the 8 selected SCI patients were evaluated as presented in Table 1. It also listed the demographic characteristics and individual profile of the subjects, including gender, age, weight, height and body mass index (BMI).

After specifying the level of the SCI, the sores of the subjects were shot before the first session, after the sixth and the twelfth sessions while the AutoCAD program measured the area of the sores. The percentage change in the total area of the sores before and after electrotherapy sessions was calculated (Table 2).

The findings showed that after two weeks of treatment, the mean size of sores was reduced by 56.86%.

Discussion

The results indicated 56.86% recovery of SCI associated grade III and IV pressure sores by using high-voltage stimulations. It was also shown that application of electrical stimuli helps increase blood flow in the skin and muscles, which further results in better tissue nutrition and healing of the sores [25, 25, 16]. In addition to increase in the blood flow, electrical stimulation enhances collagen synthesis in the affected area, strength of sore traction, and increase of epithelial growth rate in pressure sores.

It also reduces bacterial infections and duration of treatment. Electrical stimulation reduces the swelling and indirectly increases the oxygen supply to the tissue for better healing [22].

Hence, it is proposed that electric stimulation (electrotherapy) administered along with the conventional sore care techniques will bring about better results with lower costs. In fact, it is expected that 16.4% increase in healing of sore will reduce the cost of treatment of SCI associated sores by \$224 per year. Statistical analysis of pressure sores treatment by electrotherapy has shown that the use of a combination of conventionally applied sore care therapy with electric currents has reduced the total cost of treatment by \$50000 compared to the use of standard sore care alone [21].

Conclusion

Based on the study results, pulsed "high-voltage" electric current is effective in the repair of pressure sores that are resistant to medical and nursing treatment methods.

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Conflict of interest:

None

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Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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