



The effects of polarized light therapy in pressure ulcer healing

Uticaj terapije polarizovanom svetlošću na zarastanje dekubitusne ulceracije

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Abstract

Background/Aim. Neglecting polarized light as an adjunct therapy for pressure ulcers and methodology distinctions in the trials engaging polarized light are the reasons for many dilemmas and contradictions. The aim of this study was to establish the effects of polarized light therapy in pressure ulcer healing. **Methods.** This prospective randomized single-blind study involved 40 patients with stage I-III of pressure ulcer. The patients in the experimental group (E) were subjected, besides polarized light therapy, to standard wound cleaning and dressing. Standard wound cleaning and dressing were the only treatment used in the control group (C). A polarized light source was a Bioptron lamp. Polarized light therapy was applied for six min daily, five times a week, four weeks. The Pressure Ulcer Scale for Healing (PUSH) was used in the assessment of outcome. Statistic analysis included Mann Whitney Test, Fisher Exact Test, Wilcoxon Signed Rank test. **Results.** There were significant differences between the groups at the end of the treatment regarding the surface of pressure ulcer (E: 10.80 ± 19.18 ; C: 22.97 ± 25.47 ; $p = 0.0005$), rank of pressure ulcer (E: 5.90 ± 2.48 ; C: 8.6 ± 1.05 ; $p = 0.0005$) and total PUSH score (E: 7.35 ± 3.17 ; C: 11.85 ± 2.35 ; $p = 0.0003$). The patients in the experimental group had significantly better values of the parameters monitored than the patients in the control group. **Conclusion.** After a four-week polarized light therapy 20 patients with stage I-III ulcer had significant improvement in pressure ulcer healing, so it could be useful to apply polarized light in the treatment of pressure ulcers.

Key words:

pressure ulcer; therapeutics; physical medicine; phototherapy; wound healing; treatment outcome.

Apstrakt

Uvod/Cilj. Zanemarivanje polarizovane svetlosti kao pomoćne terapije za dekubitusne ulceracije i metode u trijažama izaziva dileme i kontradiktornosti. Cilj ovog rada bio je da se utvrde efekti primene polarizovane svetlosti na zarastanje dekubitusne ulceracije. **Metode.** Ova prospektivna randomizovana jednostruko slepa studija uključila je 40 bolesnika sa dekubitusnom ulceracijom faze I-III. Bolesnici eksperimentne grupe (E) bili su podvrgnuti, pored terapije polarizovanom svetlosti, i standardnom čišćenju i premazivanju rane. U kontrolnoj grupi (C) jedina primenjena terapija bilo je standardno čišćenje i premazivanje rane. Kao izvor polarizovane svetlosti korišćena je lampa Bioptron. Terapija polarizovanom svetlosti trajala je šest minuta dnevno, pet puta nedeljno, tokom četiri nedelje. Za određivanje efekata polarizovane svetlosti korišćena je skala zaceljivanja dekubitusnih ulceracija (*Pressure Ulcer Scale for Healing* – PUSH). Za statističku analizu primenjeni su testovi Mann Whitney, Fisher Exact i Wilcoxon Signed Rank. **Rezultati.** Nađena je značajna razlika između grupa na kraju tretmana. Naime, bolesnici eksperimentne grupe, kod kojih je osim standardne terapije primenjena i polarizovana svetlost, imali su značajno bolje zarastanje od bolesnika kontrolne grupe kod kojih nije primenjena polarizovana svetlost, u odnosu na površinu dekubitusne ulceracije (E: $10,80 \pm 19,18$; C: $22,97 \pm 25,47$; $p = 0,0005$), na grupu dekubitusne ulceracije (E: $5,90 \pm 2,48$; C: $8,6 \pm 1,05$; $p = 0,0005$) i ukupni skor PUSH (E: $7,35 \pm 3,17$; C: $11,85 \pm 2,35$; $p = 0,0003$). **Zaključak.** Posle četiri sedmice terapije polarizovanom svetlosti 20 bolesnika u fazi I-III dekubitusne ulceracije imalo je značajno bolje zaceljivanje dekubitusnih ulceracija, te je poželjno primenjivati polarizovanu svetlost u lečenju dekubitusnih ulceracija

Ključne reči:

dekubitus; lečenje; medicina, fizikalna; fototerapija; rana, zarastanje; lečenje, ishod.

Introduction

Pressure ulcer, sometimes referred as decubitus ulcer or pressure sores, is a localized area of cellular necrosis^{1,2}. The National Pressure Ulcer Advisory Panel (NPUAP) in the United States, defines pressure ulcer as an area of unrelieved pressure resulting in ischemia, cell death, and tissue necrosis. It

is usually localized over a bony prominence³. The most common sites of pressure ulcer formation are the ischium, the sacrum, the trochanter and the heel⁴. From the aspect of pathophysiology a local external pressure can cause hyperemia (skin redness), blue demarcation of the skin, necrosis and ulceration. The incidence of pressure ulcers varies widely by hospitalized population. In acute care hospitals the incidence ranges from 1

to 29%, with prevalence of 3 to 69%^{3,5}. Within geriatric sub-population, incidence rates as high as 24% with prevalence of 17, 4%⁶. These conditions are responsible for physical, social and vocational costs, as well as the economic cost of treating ulcer. A total cost of pressure ulcer treatment in the USA, for example, ranges from \$ 1, 3 to \$ 6 billion annually³. Medical providing of pressure ulcers implies their prevention and treatment. Prevention means skin inspection, skin care and pressure reduction modalities². The measures of treatment are: education and nutrition of patients, prescribing the support surfaces, wound care in terms of its cleaning and dressing, surgery and the physical modalities as an adjuvant therapy¹⁻¹⁸.

Polarized light therapy, a kind of phototherapy, is a linearly polarized and polychrome light therapy. This light therapy contains a whole spectrum of visible rays, infrared A and B rays as well. Polarized light comes from refraction of common light through the specific laminated mirrors and admitted this light through photo filter system. Biologic effects of this physical modality are well known: enhancement of the cell membrane activities, acceleration of the production of the adenosine triphosphate (ADP) in mitochondria, return to normal cell membrane potential which was disturbed, stimulation of the regenerative processes. Additionally, fibroblast proliferation and deposition of collagen could be accelerated by this kind of physical therapy¹⁹. These, so-called cellular and sub-cellular polarized light effects are the base of systemic polarized light effects: improving microcirculation, diminishing inflammation, improving tissue oxygenation, enhancing of the wound healing, accelerating epithelialisation of wound and improving quality of early scar tissue formation¹⁹. Wounds and pressure ulcers befall to the most important indications for using polarized light therapy. There are no absolute contraindications for this kind of physical therapy⁷.

Regarding pressure ulcers prevention and treatment, there are many dilemmas and contradictions. These are, connected with the physical modalities, so-called adjuvant therapies, which have long been described in the pressure ulcer literature. Among these therapies the authors suggest positioning and exercise therapy, hydrotherapy, ultrasound, pressure reduction measures, serial casting, low energy laser therapy, low-frequency current, electrical stimulation, hyperbaric oxygen therapy or new adjuvant therapies such as vacuum assisted therapy, normothermia and constant tension approximation^{2, 3, 5, 6, 13, 20-26}. Of all the physical therapy options ultraviolet light is the most frequently recommended^{3, 5-7, 13, 15, 16}. Today, physical therapy is an obligatory part of the protocols for the successful treatment of pressure ulcers²⁷. In spite of that, dilemmas and contradictions exist and can be divided into three categories: unbelief in efficiency of physical therapy for the patients with pressure ulcers; negligence of polarized light as a relative new adjuvant therapy; methodology distinctions in the trials engaging of polarized light therapy^{1-6, 8-10, 12-14, 19, 28-30}. All these facts give evidence of necessity for the replication of some studies, taking into account that a whole methodology and study design would be precise as more as possible. We are especially interested in wound characteristics, as the authors engaged with polarized light therapy were checking almost wound healing rate^{19, 29}.

The aim of our study was to establish the effects of polarized light therapy in the healing process of pressure ulcer.

Methods

We performed a prospective randomized single-blind study which involved 40 patients with several kinds and locations of pressure ulcers. Inclusion criteria were: 1) patients with stage I-III ulcer according the Pressure Ulcer Classification System; 2) absence of relative contraindications for using of polarized light; 3) absence of deterioration of a common disease or attack of new disease; 4) a patient's agreement to participate in the study^{6, 7}. Before randomizing, subjects were excluded if: 1) they were previously in the study to treat their current pressure ulcer; 2) skin grafting was planned within one week; 3) nutrition was poor, as indicated by albumin levels below 3.0 g/dL; 4) presence of local or general infection, particularly the sacral (pylonidal) sinus or the sacral osteomyelitis; 5) necessity for drugs that can affect the skin and delay in healing, specially steroids, immunosuppressive agents, antineoplastic drugs and anticoagulants¹¹.

The patients who met inclusion criteria were randomly divided into the experimental (E) and the control group (C). The random divide was performed by the random numbers table³¹. The patients in the experimental group were treated using standard cleaning and dressing and polarized light therapy. The standard cleaning and dressing only were used in the control group. A linear polarized light source (Bioptron lamp) with the following technical characteristics was used: wavelength: 400-2000 nm; degree of polarization: > 95%; power density: 40 mW/cm²; light energy: 2,4 J/cm². Polarized light therapy was performed for six min daily, at a distance of 10 cm, five times a week (Figure 1). Before the polarized light



Fig. 1 – Polarized light therapy

therapy, we splashed each wound by oxygen spray. All therapies were performed between 2 and 4 h p.m. The whole treatment lasted four weeks. All wounds were cleaned using 2% hydrogen peroxide. The standard dressing implied application of a gauze with normal saline (NaCl), then a dry gauze, next it a cotton wool and adhesive strip.

The Pressure Ulcer Scale for Healing (PUSH) was used in assessment the effects of polarized light therapy. Toward this scale all wounds were described through the surface area measurement, exudates amount and surface appearance³². According to the statistical circumstances we divided these points into the surface of wounds, rank of wounds, exudates amount, tissue type and total PUSH score. Wound healing process was evaluated in a standard manner (centimeter ruler and some kind of callipers) by two independent blinded observers. Measurement was performed at the start and the end of the treatment.

Statistic analysis included Kolmogorov-Smirnov test, Shapiro-Wilk test, Mann Whitney Exact test, Exact Wilcoxon signed rank test and Fischers Exact test. Statistical significance was set up $p < 0.05$. The data were assessed by SPSS 10.0 for Windows.

Results

A total of 48 patients were recruited by a physiatrist, surgery specialist and physiotherapist. Out of them four patients refused to participate to the study. Two patients from

the experimental group were withdrawn. One of them had deterioration of consciousness after stroke. Another was withdrawn because of anticoagulants drug administration. Two patients from the control group died in the second and third week of the treatment. A total of 40 patients participated to the study.

The groups were homogenous in terms of age and sex of patients, and duration of polarized light therapy. At the start of the treatment, there was no significant difference between groups regarding surface of pressure ulcer, rank of pressure ulcer and total PUSH score (Table 1).

The majority of the patients in both groups had pressure ulcers in the sacral area, the left hip and both heels (Table 2).

At the start of the treatment, there were significant differences between the groups regarding exudates amount and tissue type. Half of the patients in the experimental group (50%) had light exudates; the majority of the patients in the control group had no exudates (65%); epithelial tissue dominated in the experimental group (55%); in the control group half of the patients (50%) had completely covered wounds (Table 3).

Table 1
Subjects characteristics

Characteristics	Group		P
	Experimental (n = 20)	Control (n = 20)	
Age (years); ($\bar{x} \pm SD$)	61.85 \pm 16.11	68.65 \pm 19.87	0.06
Sex; n (%)			
– male	11 (55)	11 (55)	
– female	9 (45)	9 (45)	
Duration of a polarized light therapy (days); ($\bar{x} \pm SD$)	20.15 \pm 3.57	21.0 \pm 0	0.48
Surface of the pressure ulcers (cm ²); ($\bar{x} \pm SD$)	15.10 \pm 17.61	19.15 \pm 22.73	0.18
Rank of the pressure ulcers; ($\bar{x} \pm SD$)	7.40 \pm 1.96	8.20 \pm 1.51	0.20
Total PUSH* score of the pressure ulcers; ($\bar{x} \pm SD$)	10.65 \pm 2.25	10.45 \pm 2.74	0.79

* The Pressure Ulcer Scale for Healing

Table 2
Location of pressure ulcers

Location	Group			
	Experimental (n = 20)		Control (n = 20)	
	n	(%)	n	(%)
Low part of back	0	0	1	5
Righ-low part of back	1	5	0	0
Right buttock	1	5	0	0
Left buttock	1	5	1	5
Both buttocks	0	0	2	10
Sacral area	10	50	5	25
Right sacral-buttock area	1	5	0	0
Right iliac spine	0	0	1	5
Left hip	3	15	3	15
Right hip	0	0	1	5
Right heel	1	5	4	20
Left heel	2	10	2	10

Table 3

Characteristics	Group				<i>p</i>
	Experimental (n = 20)		Control (n = 20)		
	n	(%)	n	(%)	
Exudate amount					
– None	5	25	13	65	0.04
– Light	10	50	5	25	
– Moderate	5	25	2	10	
– Haevy	0	0	0	0	
Tissue type					
– Closed	2	10	10	50	0.01
– Epithelial	11	55	5	25	
– Granulation	7	35	4	20	
– Slough	0	0	1	5	

There were significant differences in the experimental group at the end of the treatment regarding the start of the treatment. A significant improvement was registered. Namely, surface of pressure ulcers, rank of pressure ulcers and total PUSH score were significantly smaller at the end of the treatment (Table 4).

There were significant differences in the control group at the end of the treatment as compared to the start of the treatment. A significant aggravation was registered. Namely, surface of pressure ulcers, rank of pressure ulcers and total PUSH score were significantly bigger at the end of the treatment (Table 5).

There were significant differences between the groups at the end of the treatment. The patients in the experimental group had significantly higher improvements in the surface of pressure ulcers, rank of pressure ulcers and total PUSH score than the patients in the control group (Table 6, Figures 2 and 3).



Fig. 2 – Pressure ulcer stage I–III before treatment with polarized light therapy

Table 4

Characteristics of the pressure ulcers at the start and the end of treatment in the experimental group

Characteristics	Start	End	<i>p</i>
Surface of the pressure ulcers (cm ²) ($\bar{x} \pm SD$)	15.10 ± 17.61	10.80 ± 19.18	0.01
Rank of the pressure ulcers ($\bar{x} \pm SD$)	7.40 ± 1.96	5.95 ± 2.48	0.0004
Total PUSH* score of the pressure ulcers ($\bar{x} \pm SD$)	10.65 ± 2.25	7.35 ± 3.17	0.0001

* The Pressure Ulcer Scale for Healing

Table 5

Characteristics of the pressure ulcers at the start and the end of treatment in the control group

Characteristics	Start	End	<i>p</i>
Surface of the pressure ulcers (cm ²) ($\bar{x} \pm SD$)	19.15 ± 22.73	22.97 ± 15.69	0.001
Rank of the pressure ulcers ($\bar{x} \pm SD$)	8.2 ± 1.51	8.6 ± 1.05	0.01
Total PUSH* score of the pressure ulcers ($\bar{x} \pm SD$)	10.45 ± 2.74	11.85 ± 2.35	0.003

* The Pressure Ulcer Scale for Healing

Table 6

Characteristics	Group		<i>p</i>
	Experimental (n = 20)	Control (n = 20)	
Surface of the pressure ulcers (cm ²) ($\bar{x} \pm SD$)	10.80 \pm 19.18	22.97 \pm 15.69	0.0005
Rank of the pressure ulcers ($\bar{x} \pm SD$)	5.95 \pm 2.48	8.6 \pm 1.05	0.0005
Total PUSH* score of the pressure ulcers ($\bar{x} \pm SD$)	7.35 \pm 3.17	11.85 \pm 2.35	0.00003

*The Pressure Ulcer Scale for Healing



Fig. 3 – Pressure ulcer stage I–III after treatment with polarized light therapy

Discussion

Prevention and treatment of pressure ulcers is a serious clinical problem. Variations in patient's characteristics and ulcer management make difficult systematic clinical observation. There is a clear accord in requiring further research^{29,33}. Our study showed that patients with stage I–III ulcers, treated with polarized light therapy, had significant improvement after a 4-week treatment (Figures 2 and 3). Contrary to the control group, without polarized light, the patients in the experimental group had diminishing majority of PUSH tool parameters: surface of pressure ulcer, rank of pressure ulcer and total PUSH score. It is estimated that the PUSH tool will become the dominant wound healing tool in the future in the United States³². We could not compare other two PUSH parameters, exudates amount and tissue type because of a significant difference in these parameters between the groups at the start of the treatment (Table 3).

Our results could be ascribed to biological effects of polarized light therapy. Wound healing process has three successive stages: reaction, regeneration and remodeling¹¹. Regeneration and remodeling are particularly important stages for pressure ulcer treatment. At regeneration stage capillaries bud and form new vessels; fibroblasts proliferate and secrete collagen, bacteria proliferate in dead tissue, macrophage activity increases, epithelial cells and myofibroblasts migrate, as well. On the contrary, in the remodeling stage, fibroblasts and macrophage activities are decreased, but the collagen starts to reorganize itself^{7,11}. Wound healing process is based on the

vascular and cellular activity. Vasomotion is the periodic constriction and dilatation of small blood vessels. It is attributed to local metabolic needs, vascular myogenic responses and neurogenic controls. Pressure ulcer develops due to insufficient blood supply and removal of metabolites when pressure exceeds capillary blood pressure for a sufficient time³⁴. Besides the fibroblast and macrophage activity, human wound-associated lymphocyte populations are modulated during a healing process³⁵. A role of proteoglycans (glypican and syndecan) during the inflammation and cell proliferation in chronic ulcers was also established³⁶. Protective function of human skin is well-known¹⁷. Additionally, significant time-dependent variation in cutaneous barrier was observed suggesting that there is a time-dependent variation in epidermal metabolism³⁷. Because of that we performed the therapy always in the same time. Polarized light was found to trigger human cellular and humoral defences. It is considered that polarized light rearranges the polar heads of a lipid bilayer in the cell membranes. This is an area where enzyme reactions take place, catalyzed by proteins. Due to this interaction, structural changes may occur in cell membranes, in consequence of which the surface features and lipid protein connections can be modified⁷. The authors have reported different biological effects after polarized light irradiation, including stimulation of cell proliferation (especially in fibroblasts), release of growth factors and enhancement of collagen synthesis. Additionally, it establishes accelerated wound closure, increased wound epithelialisation and improved tensile strength of scars^{19,30}. Polarized light therapy has influence on the nerve structures. This can diminish pain receptors stimulation and improving endorphin production^{7,38}.

The role of adjuvant therapies in pressure ulcer care has a long and controversial history. We also mention: positioning and exercise therapy, hydrotherapy, ultrasound, pressure reduction measures, special casting, low-energy laser therapy, ultraviolet therapy, low-frequency current, electrical stimulation, hyperbaric oxygen therapy^{2,3,5,6,9,10,13,14,20–26}. When treating pressure ulcer, a clinician should always keep in mind that the main external precipitating factors are pressure, shearing forces, friction and moisture and therefore has to focus treatment on minimization of these factors^{5,39,40}. Potential treatment complications exist for each therapy option in medical providing of pressure ulcer⁵. That applies to adjuvant therapies, as well. For example, in spite of serious recommendation for electrical stimulation^{2,6}, Priebe¹⁰ does not suggest this kind of adjuvant therapy in acute stage of pressure ulcer.

O'Connor³ truly doubts in efficiency of ultrasound, but do not renounce it; however, McBrier et al.⁴¹ demonstrated that therapeutic ultrasound may be detrimental to some of the pathways associated with skeletal muscle regeneration. Ultra-violet light is a well-known and powerful option for pressure ulcer adjuvant therapy, but it can affect intracellular redox state and increase the frequency of apoptosis in human melanocytes^{6,7,9,13,15,42}. There is no description of the potential treatment complications after polarized light therapy. In our study we did not record any side effect. Polarized light therapy was completely safe as a therapy option.

Deterioration in the control group is a very interesting fact. Namely, the patients from this group, who had only wound cleaning and dressing, showed significant deterioration in all of comparable PUSH parameters at the end of the treatment (Tables 5 and 6). We can wonder if cleaning and dressing were appropriate. There are some controversies about pressure ulcer cleaning and dressing. A protocol for pressure ulcer care based on a stage and amounts of wound care¹². In this protocol, for example, normal saline is recommended as the best wound irrigant, but no hydrogen peroxide because of cytotoxic effects and damage of granulation tissue. In spite of that, Klipp et al.⁶ recommended hydrogen peroxide, among antiseptic solutions, with a note on appreciation of toxicity index and appropriate dilution. Jovičić et al.⁸ claim that there are no random control trials which proved that one kind of dressing was better than other. Opposite to that, Easton and O'Connor^{3,12} prefer occlusive or moisture-retentive dressing, using with success: films, hydrogels, hydrocolloids, copolymers and wound filters in the form of beads, gels, granules or pastes. Pressure ulcers in our patients were cleaned by 2% hydrogen peroxide and bringing a thin layer of appropriate fat. Dressing was performed by a gauze with 0,9% NaCl, dry gauze, cotton wool, and adhesive strip. This is a routine way of pressure ulcer care in our institution. It is possible that this kind of wound care was not appropriate. The questions are: how hydrogen peroxide in terms of its dilution and toxicity index was used; were wounds well protected with this kind of dressing; was the critical bacterial colonization of wounds a reason for such deterioration? Many authors emphasize the importance of careful cleaning of pressure ulcers and its dressing by the special kinds of bandage^{2-6,14}.

Our results are partially comparable with the results of other authors. In the available literature we have not found many articles engaging with polarized light therapy. Karadag at al.³⁰ for example, experimentally confirmed the clinical results of Monstrey et al.¹⁹ that polarized light therapy was effective in the treatment of burn wounds^{19,30}. Our results principally agree with the results of Iordanou et al.²⁸ and Verbelen²⁹, in spite of methodologic difference between our and their investigations. As compared to our study, Verbelen²⁹ did

not carry out a blind clinical trial, his sample size was smaller, polarized light therapy, in terms of application, lasted longer (10 min), and his main assessment parameter was the frequency of appearance of pressure ulcer grade II. Similarly to our study, Iordanou et al.²⁸ investigated stage I – III ulcer and they took the characteristics of wound for the assessment parameters; but their polarized light therapy, in terms of whole program, was shorter (2-weeks) and their sample size was bigger. Beside this, Verbelen²⁹ engaged with prevention of pressure ulcer and Iordanou et al.²⁸ with treatment of pressure ulcer. These authors concluded that this kind of physical therapy could be efficient in medical care of pressure ulcer. We tried to partially replicate Iordanou et al.²⁸ investigation, improving their methodology and contributing to physiatrist's body of knowledge. Toward our results and the results of other authors, we consider that polarized light therapy need to be obligatory in pressure ulcer prevention and treatment.

This study has some advantages and shortcomings. The problem is in methodology, in other words, using a tool assessment in the wound healing process. Besides PUSH used in our study, in the world clinical practice there are still six most useful wound healing tools³². All of them have good and less good features. In the available literature on pressure ulcers and polarized light therapy we have not found the authors who use these wound healing tools²⁸⁻³⁰. Monstrey et al.¹⁹, indeed, used a photographic method for assessment, but they observed burn wounds and we are not sure if they used the Photographic Wound Healing Tool (PWHT). The advantage of this study is the fact that the PUSH was used in our professional community first time. The PUSH, which has been used since 1997, incorporates three wound characteristics: surface area measurements, exudates amount, and surface appearance. It has a good validity which has been confirmed throughout two retrospective studies. The advantage of this assessment form is the possibility to note quickly any progress or degeneration of the wound. But its sensitivity in first version was not good enough. Some authors disputed its usefulness as assessment instrument for pressure ulcer. The PUSH tool does not include items that may be relevant for the treatment decision^{11,32}. We consider this as main shortcoming of our study. In further research of pressure ulcers and polarized light therapy, we should use other clinical tools for baseline and more comprehensive assessment.

Conclusion

The effects of polarized light as an adjuvant therapy for pressure ulcers were satisfactory. After a 4 week treatment, 20 patients with stage I-III ulcer showed a significant improvement in the wound healing process, so it could be useful to apply polarized light in the treatment of pressure ulcers.

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