Effect of Ultraviolet Radiation (UVR) on Gunshot Wounds: Clinical Case Reports in a Tertiary Health Facility in northwest Nigeria

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Abstract

Wound care is benefitting from contemporary technological advancements; one of which is the use of ultraviolet therapy. This report focuses on the use of ultraviolet therapy. This case report Aimed to ascertain the efficacy of Ultraviolet Radiation (UVR) in the healing of gunshot wounds in a tertiary health facility in northwest Nigeria, to stimulate more interest in an integrated approach to wound management in our care environment. The case summaries are two patients with gunshot injuries selected from a female orthopedic ward of the hospital. They had been on antibiotics and wound dressing with little results. Following a consult sent to the Physiotherapy Unit of the hospital, after due assessment, an ultra-violet therapy was commenced using a cold quartz UV generator. Following some specific steps, the Minimal Erythemal Dose (MED) was performed on the 1st session to determine the dosage level, using an erythemometer. Baseline measurements of the wounds were taken and documented. Patient 1 and Patient 2 had 14 and 12 treatment sessions respectively over four weeks. The wound dimensions were measured every week for four weeks and these were noted. Results showed that there was a gradual but significant decrease in the size of the wounds for both Patients 1 and 2 within four weeks of commencement of the therapy. Surrounding skin remained intact. it is concluded UV radiation therapy in the treatment of gunshots wounds has great potential for traumatic wound management and this can be further explored. More studies should be conducted to establish its place in wound management in our health facility. A multidisciplinary approach among clinicians and physical therapists should improve wound care particularly those that respond poorly routine treatments. Collaborative research will therefore provide such opportunity.

Keywords: Gunshot Wounds • Wound management • Wound care • Ultraviolet therapy

Introduction

Wound care is a major component of medical care, often managed by a team of health professionals such as nurses, doctors, and physical therapists (physiotherapists). In recent times, there have many recent technological advances in wound care, among these is the light-based technology comprising a wide range of modalities. Wounds of different types have benefitted from such innovations and collaboration. Wounds that are heavily infected can be managed with the use of UVC, while low-level laser (or light) therapy and photodynamic therapy both have such wide applications in wound care (Gupta, et al., 2013). Ultraviolet (UV) radiation (200–280 nm) has been directly applied to the wounded tissue to stimulate wound healing, restore skin homeostasis and selectively inactivate micro-organisms (Gupta, et al., 2013).

Several reports indicate the efficacy of the use of UVR in the treatment and management of different types of wounds and ulcers. For example, the effective use of UVR in managing varying degrees of pressure ulcers has been established in Nigeria and elsewhere (Onigbinde, et al., 2010; Nussbaum, 2013).

In other infected wounds, evidence abounds on the effectiveness of UVR in their treatments. Recently, Yarboro, et al., (2019) reported the effect of of Ultraviolet Radiation (UVR-C) irradiation in treating chronic wounds and found that radiation therapy was a useful adjuvant therapy for chronic wounds. They reported healing in 62.1% of venous wounds, and 76.7% diabetic foot ulcers.

The efficacy of UVR in treating burn wounds with sepsis has also been reported. Exposure of the wounds for 6 – 8 hours daily for 8 days to ultraviolet phototherapy resulted in improvement in wound healing and sepsis significantly (Aleema, et al., 2014). The effect on sepsis has been associated with the elimination of various micro-organisms infecting wounds.

The antimicrobial efficacy of UVR against certain bacteria has also been documented. Several studies (Thai, et al., 2002; Gupta, et al., 2013; Onigbinde, et al., 2010; Kaleshtari, et al., 2015) have reported the effectiveness of UVR against methicillin-resistant Staphylococcus aureus (MRSA) and Pseudomonas aeruginosa. Aleema, et al., (2014) also reported its efficacy in burn wounds infected with MRSA.

The ultraviolet radiation has other applications such as in the prevention of surgical site infections. Buonanno et al., (2013) reported using UVR (207mm) effectively for surgical site infection control. They found that UVR killed bacteria efficiently without any significant cytotoxic or mutagenic effect on humans.

The use of ultraviolet (UV) radiation in traumatic wounds such as gunshot wounds (GSWs) could be of immense benefit just like its use in many infected wounds. Gunshot wounds are caused by firearms; one of the most destructive and readily available weapons in modern society (Itodo, et al, 2015). Ogunlusi, et al, (2006) reported that the incident of civilian gunshot injuries and their ensuing fatalities have been on the increase worldwide, with the burden of firearms violence being borne more by the most productive segment of the society, i.e. those aged between 16-45years (Odatuwa-Omagbemi, et al, 2013). Relative to the other weapons, guns tend to be associated with greater long term physical sequel resulting in suffering, wound, and disfigurement disability as in the case of our two patients in this case reports. This makes GSWs quite life-threatening especially when they are to the head, chest, abdomen, and the spine (Ogunlusi, et al, 2006). These have led to grave complications such as hypovolaemia, haemorrhagic shock, sepsis, and paralysis/paresis (Onuminya, et al, 2005).

The most common sites of gunshot injuries are the extremities, usually accompanied by fractures and soft tissue damage, requiring debridement, sterile dressing, and surgery usually closed by primary or secondary intention. In many situations, these modalities have not brought about effective wound healing in GSWs (Onuminya, et al, 2005), necessitating other interventions.

This study consisted of observations made on two patients brought to the study setting whose gunshot wounds failed to heal after several weeks of daily wound dressing and antibiotic therapy. Isolated micro-organisms were found to be resistant to the available antibiotics. A consultation request was then sent to the Physiotherapy Unit of the hospital by the attending orthopaedic surgeon. An ultra-violet therapy was then prescribed and added to the line of managing the wounds.

These case reports are presented to disseminate findings on the effect of the UVR therapy in the healing of the gunshot wounds in a tertiary health facility in northwest Nigeria. This is with a view to stimulating more interest and research in this mode of wound management as an adjunct treatment.

Materials and Methods

Setting

The two cases were obtained from the Female Orthopedic Ward of Ahmadu Bello University Teaching Hospital, Shika-Zaria, Northwest Nigeria.

Participant selection

Two patients were purposively studied, following consults sent to the Physiotherapy Department from the Orthpaemic Surgical Unit of the Hospital.

Patient 1

A 21-year old female patient, was admitted through Accident and Emergency Department of Ahmadu Bello University Teaching Hospital Zaria in December 2015. The patient was later to Female Orthopaedic Ward for comminuted fracture of the left radial bone associated with an open wound on the left forearm secondary to a gunshot to the left upper limb. The left upper limb was placed in an elbow cast and a sling. The initial measurement of the wound surface area was 14cm by 6.5cm on the posterior and 14cm by 3cm on the anterior aspect of the forearm (see Table 1).

Patient 2

An 18-year old female patient admitted through Accident and Emergency Department of Ahmadu Bello University Teaching Hospital Zaria in December 2015. The patient was later transferred to Female Orthopaedic Ward for comminuted fracture of the left tibial bone associated with an open wound on the left leg secondary to a gunshot. The left leg was placed in an above-knee cast with a window on the anterior aspect of the leg. The initial measurement of the wound surface area was 15.4cm by 7.5cm (see Table 1).

The two participants were on antibiotics therapy, and patients' wounds were being dressed daily with honey but with little response. A consult was then sent to the Physiotherapy Unit, requesting for UV therapy. Patients were then started on UV radiation therapy.

Procedure

A cold quartz UV generator was used. The Minimal Erythemal Dose (MED) was performed on the 1st session to determine the dosage level, using an erythemometer. The method of determining the MED involved the following steps:

1) The use of erythemometer that was cut in about ¾ inches of holes of various shapes about ¾ inches apart.

2) The area to be tested should not be previously exposed to UVR such as the inner part of the thigh or inner part of the arm

3) The erythemometer was taped to the area to be tested

4) The other part of the body was covered except the area where the erythemometer was placed.

5) The UVR lamp was positioned perpendicular to the exposed area about 2-3 inches away.

6) When the generator was ready, the 1st hole was turned on and exposed for 15seconds and then other holes at 15 seconds interval for a total of 60 seconds.

7) The generator/lamp was turned off when the 60 seconds was up.

8) The patients were instructed to check the area every 2 hours while awake.

9) The area which appeared first with the highest pink color was recorded.

10) The 1st hole 60 seconds, 2nd 45seconds, 3rd 30 seconds and 4th 15 seconds

Dose

The minimal erythemal dose (MED) (E1) appears to be mildly pink and takes 6-8 hours to develop but just visible at about 24 hours/less. E2 DOSE (2.5 x MED) appears definite pink-red that blanches on pressure. It takes 4-6 hours to develop and last for as long as 48 hours. E3 (5 x MED) appears very red and does not blanch on pressure. It takes 2-4 hours to develop and last for as long as 72 hours. E4 DOSE (10 x MED). It appears angry red and takes less than 2 hours to develop and last for up to a week (Sreeraj, n.d).

The E1 DOSE was used on both patients, Patient 1 was exposed for 60 seconds while Patient 2 was exposed for 45 seconds

The therapy

Both patients were given a test dose before the commencement of the treatment and minimal erythemal (MED) dose was determined. The MED used for both patients was the E1 dose. They were on alternate days of wound dressing and treatment of the wound area was carried out after exposure and cleaning of the wound area. For Patient 1, the wounds were exposed for 60 seconds while Patient 2 wound was exposed for 45 seconds.

Patient 1 received a total of 14 treatment sessions and Patient 2 received 12 treatment sessions over four weeks.

Measurements and Data Analysis

The wound dimensions were noted as a baseline and subsequently measured every week for four weeks.

Ethical considerations

Patients gave their informed consent to the case report. The Head of Department had earlier permitted to undertake the case report.

Results

The initial wound surface area was 14cm by 6.5cm on the posterior and 14cm by 3cm on the anterior aspect of the forearm for Patient 1, while for Patient 2 wound surface area was 15.4cm by 7.5cm. At the end of the period of four weeks, there were gradual but significant decreases in the sizes of the wounds for both Patients 1 and 2 (as shown in Table 1).

For example, for Patient 1, it decreased from 14cm x 3cm (anterior) and 14cm x 8cm (posterior) to 10cm x 2.7cm (anterior) and 11cm x 7.1cm (posterior) within the first week of therapy.

By the 4th week, it had almost completely healed (6.2cm x 1.0cm) (see Fig.1).

Patient	Initial	1st Week	2nd Week	3rd Week	4th Week
1	Ant: 14cmx3cm	10.8cmx2.7cm	8.7cmx2cm	7.5cmx1.5cm	6.2cmx1.0cm
	Post: 14cmx8cm				
2	15.4cmx7.5cm	12.5cmx5.8cm	13.5cmx8cm	12cmx5.9cm	11.0cmx3.8cm

Table1: Results of the Wound Healing for Patients 1 and 2

Similarly, from Table 1, Patient 2, it is shown that the initial wound surface area of 15.4cm x 7.5cm reduced to 11.0cm x 3.8cm in four weeks. These decreases are shown in Figure 2.

Figure 1: Patient 1 wounds at commencement and 4 weeks later

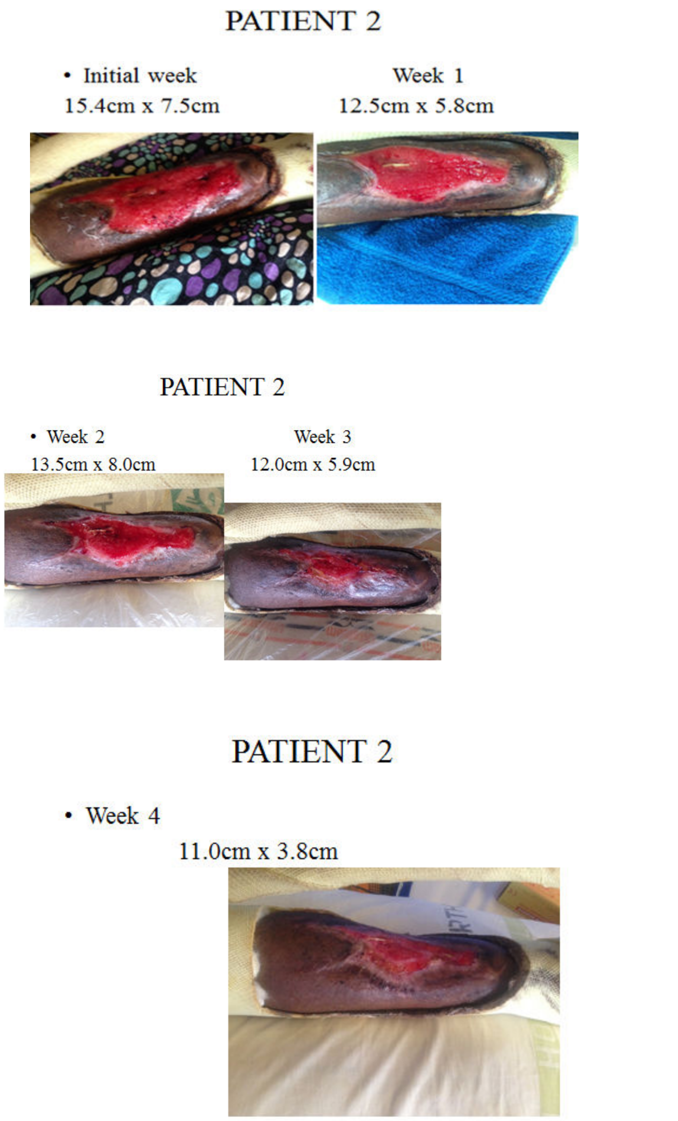

Figure 1: Patient 2 wounds at commencement to 4 weeks (Weeks 1-4)

Discussion

The gunshot wounds of two patients presented in this study healed significantly after four weeks of UVR. The gunshot wounds gradually reduced in surface area and wound volume over four weeks. This occurred after several weeks of antibiotic therapeutic regimens and wound dressings failed. Previous studies in pressure ulcers and chronic wounds, including venous and diabetic foot ulcers had confirmed the efficacy of UVR (Onigbinde et al., 2010; Nussbaum, et al., 2013; Yarboro, et al., 2019).

In terms of the duration of treatment, the gunshot wounds significantly healed in four weeks (about 30 days). Yarboro et al (2019) reported using UVR to successfully treat chronic ulcers including venous, diabetic foot, and traumatic wounds over an average of 45 days (range 4 – 260 days).

Although no previous study was accessed during the literature search on gunshot wounds as reported in this study, its wound healing and antimicrobial effects appear to have similar biological explanations: to promote wound healing, UVR is absorbed by extracellular fluids components and capillaries which promotes endothelial cell proliferation and induce expression of vascular endothelial growth factor (VEGF) (Parrish, 2002; Gupta, et al., 2013). This initiates proliferation and maturation involving erythema, epidermal hyperplasia, increased blood flow in microcirculation, and bactericidal effect (Guo and DiPietro, 2010; Feily, 2016).

UVR activity, after a few days, increases the rate of synthesis of DNA, RNA, and proteins that contribute to skin thickening as a late phase response and also bacterial cell inactivation (Thai, et al., 2002; Gupta, et al., 2013). It also enhances granulation tissue formation by the release of prostaglandin (PG-E) and histamine (Gupta, et al., 2013). The release of these mediators usually leads to early repair in the dermis and delay erythema response for a few hours which decrease a little (Feily, 2016).

The dose of the UVR used on the two patients did not result in any damage to the skin. The safety profile of UVR has been an issue of caution (Feily, 2016). Phototherapy UV irradiation effectiveness has been reported to depend on many factors such as the chosen irradiation parameters with maximal effective wavelength and lowest irradiation level (Feily, 2016). UVR (207mm) has been reported to kills bacteria efficiently without being cytotoxic or mutagenic (Buonanno, et al., 2013. Ultraviolet (UV) radiation (200–280 nm) has been directly applied to the wounded tissue to stimulate wound healing, restore skin homeostasis and selectively inactivate micro-organisms (Gupta, et al., 2013).

As cautioned by Kaleshtari, et al., (2015), in carrying out the therapy on patients, the doses (wavelength) were carefully measured against the time of exposure, the energy emitted, and other precautions. All the two patients were healed without any damage to the skin and at the two weeks after discharge follow up, both were doing well.

Limitations

The few patients included in this non-randomised, non-experimental study make the generalization of findings difficult. However, the case presentation has added some evidence to the effectiveness of UVR in wound healing. The study points to the potential of stimulating further widespread study of this as an adjunct therapy in the overall management of gunshot and other traumatic wounds.

Conclusion

The gunshot wounds of both patients significantly healed after four weeks of ultraviolent radiation therapy, contributing to the body of evidence on the possible widespread efficacy of ultraviolet radiation therapy in wound care. Previous evidences abound on its efficacy on pressure sore and other chronic wound treatments. However, results from this study have shown the effectiveness of UVR in the healing process with good tissue granulation and perfusion in wounds resulting from gunshots. Thus, the current report shows that the efficacy of UV therapy can be extended to the treatment of gunshot wounds in our locality.

Recommendations

Based on the results of these case reports, it is recommended that more studies should be conducted to establish its place in traumatic wound management. Similarly, the need for clinicians (nurses, physical therapists, surgeons, and physicians) to collaborate in both wound care and research is paramount.

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