Photosensitization Induced by Exposure to Colour Cathode Ray Tube Monitor Following Topical 5-Aminolaevulinic Acid-based Photodynamic Therapy: A Case Report

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Acne vulgaris is a common skin disorder that affects 80–85% of teenagers and may continue into adulthood. Clinical studies suggest that 5-aminolaevulinic acid-based topical photodynamic therapy (ALA-PDT) is a potentially useful modality for inflammatory acne and for patients who are unable to tolerate isotretinoin or antibiotics (1). ALA is a prodrug that can be converted intracellularly by the haem biosynthetic pathway into the active photosensitizer protoporphyrin IX (PpIX). ALA degrades in the skin with a half-life of 24 h and endogenous PpIX-mediated photosensitization can last for up to 48 h, although it can be prevented by strict avoidance of exposure to light (2). The common acute adverse events of topical ALA-PDT are pain during exposure to light and mild acute inflammatory response (e.g. erythema) after exposure to light (3). In general, complete healing with good to excellent cosmetic outcome occurs within 2 weeks post-PDT. However, the potential risk of cutaneous photosensitization associated with light sources other than sunlight and bright electric lights may be underestimated. We describe here a case of persistent erythemal reaction after topical ALA-PDT due to long exposure to light from a cathode ray tube (CRT) monitor.

CASE REPORT

A 19-year-old male with 5 years' history of intractable acne was referred for evaluation and treatment. The patient had used topical antibacterial cream, and oral isotretinoin and minocycline in the past. Physical examination revealed severe acne vulgaris involving the forehead, nose, temple and cheek areas, characterized as reddish follicular papules, pustules and cysts accompanied by diffuse erythema. The patient was recruited into an ongoing ALA-PDT clinical trial (split-face study of ALA dose effect, three-course PDT at 2-week intervals). Informed consent was obtained from the patient.

ALA cream of different concentrations (3, 5 and 10%, w/w) were freshly prepared using ALA powder (Shanghai Fudan-Zhangjiang Bio-Pharmaceutical Co., Ltd, Shanghai, China) and applied evenly to acne lesions; 3% ALA was applied to the right side of the face plus the nose, 5% ALA to the left side of the face plus the chin, and 10% ALA to the forehead. The ALA-treated areas were occluded with cling film and covered with thick gauze for light protection. After 3 h of incubation, the lesion surface was cleaned with wet cotton gauze to remove residual ALA (3). Superficial PpIX distribution was examined with a fluorescence camera (PD Imager, Curalux, Munich, Germany) showed the typical red fluorescence of PpIX on the left side of the face, which received 5% ALA. Visually there was no marked difference in terms of superficial fluorescence intensity between areas that received 3%, 5% or 10% ALA. The lesions were then irradiated with a red light-emitting diode (LED) panel (633 ± 6 nm; Omnilux Revive, Photo Therapeutics Ltd, Manchester, UK) at 55 J/cm^2 at a power density of 66 mW/cm^2. After light irradiation, superficial fluorescence diminished due to photobleaching. The patient was advised to avoid bright light after the treatment.

Oedema, thin crust formation and scattered erosive and exudative lesions appeared the day after PDT. The erosive and exudative lesions disappeared around day 5 after PDT, but the severity of erythema remained unchanged although the patient did not expose himself to strong sunlight or electric light. The erythema was still visible 2 weeks after the first course of PDT. The distribution of erythema correlated well with the area that had received ALA cream, showing distinct red colour under ultraviolet (UV) illumination. The erythemal reaction was thought to be related to the topical ALA-PDT and/or secondary to the patient's acne. An identical ALA-PDT procedure was prescribed as planned, except the light dose was reduced to 35 J/cm^2 due to concern about erythema. However, similar skin responses and persistent erythema were seen after the second course of ALA-PDT, even though the patient stated that he had adhered strictly to the advice about light avoidance.

Two weeks after the second course of PDT, the patient's acne lesions were partially cleared, but the erythema was still clearly visible. The patient was asked to provide a detailed list of possible sources of light exposure, and he reported that he had stayed indoors all the time, but played computer games for approximately 10 h daily under dimmed ambient lighting before and after PDT. Typically, his face was 50–60 cm away from a 16-inch standard CRT computer monitor (800 × 600 resolution). It therefore became clear that long exposure to a colour CRT monitor might be the major cause of the persistent erythema. The patient received the third course of ALA-PDT at 35 J/cm^2 and was advised to stop playing computer games after the treatment. The erythema gradually subsided within 7 days. Subsequently the patient began to play computer games again (1–2 h/day). Two weeks later, the patient returned for follow-up. Examination showed clearance of the acne, although mild hyperpigmentation and residual erythema were visible.

DISCUSSION

A major drawback of PDT is the prolonged skin photosensitization after systemic administration of hematoporphyrin-based photosensitizer and the need for the patient to avoid sunlight and bright ambient light for several weeks. Transient and mild erythema, oedema, and scaling can occur immediately after the topical treatment in some patients. These reactions might last a few days without the need for intervention (3).

The usefulness of ALA-PDT for treatment of a number of inflammatory disorders, such as acne vulgaris, has been under clinical investigation worldwide since the late 1990s (4–7). In general, topical short-contact (90 min or less) ALA or methyl-ALA using a non-coherent light source at 2–4-week intervals for a total of two to four treatments produces a satisfactory clinical effect

(8, 9). Adverse effects associated with ALA and endogenous PpIX are minimal (10). Short-term adverse effects are limited to erythema and peeling for up to a few days after treatment. Some of these acute responses may lead to hyperpigmentation that fades gradually over weeks to months (11). Although the current guidelines and (written or verbal) warnings mainly emphasize the avoidance of sunlight and bright electric lights, the potential risk of other common light sources (e.g. video-game, computer and television monitors) might be equally important for certain patient populations.

Colour CRT monitors have phosphor-coated screens. Phosphors are arranged as stripes and glow as dots of colour (i.e. emitting visible light) when exposed to a radiation beam generated from the CRT. Three beams are used in CRT colour monitors to excite the three colours (red, green and blue) in combinations needed to create the various hues that form the picture. Thus, a colour CRT monitor is a unique light source emitting a mixture of red, green and blue light, which coincidentally matches the light absorption spectrum of the PDT photosensitizer in the Q-band region. Typically, colour CRT monitors have a maximum luminance of 100–150 candela per square metre (cd/m^2) (12). Thus, long exposure to a colour CRT monitor can excite residual PpIX molecules and other endogenous porphyrins and, consequently, cause cutaneous photosensitization. Although the light spectrum and intensity change constantly during video-game playing and the actual light dose (spectrum- and time-dependent) is unknown in this case, it can be estimated that the 10 h of exposure at 0.66 mW/cm^2 (one hundredth of treatment power density) could deliver a total of 24 J/cm^2 to the face of a video-game player.

CRT monitors are gradually being replaced by liquid crystal display (LCD) flat panel monitors or displays. Although the light emitting mechanism of LCD monitors is different from that of CRT monitors, the light spectrum of LCD matches the visible absorption spectrum of photosensitizers and long exposure to a LCD monitor might pose the same risk to patients who have received topical PDT. Research is currently in progress to characterize light spectrum and intensity profiles during video-game playing, determine the potential risk of long exposure to CRT or LCD monitors, and propose guidelines regarding the prevention of such risk.

Although different concentrations (3–10%) of ALA were applied in a split-face fashion in this case, the severity of erythema on the different parts of the face appeared to be similar when examined visually. Typically, after 3 h of incubation excess ALA was cleaned off with wet cotton gauze and a significant amount of intracellular PpIX was photobleached by light irradiation (3). Although patients are advised to avoid bright light for a few days, residual ALA and PpIX regeneration can continuously cause skin photosensitization in some patients, since the metabolic rate of ALA and PpIX varies from patient to patient (13).

The photobleaching kinetics of a photosensitizer have been used as a PDT dosimetry tool (14). However, although PpIX photobleaching can be monitored by measuring *in situ* fluorescence and such measurement usually shows the rapid depletion of PpIX at the end of light irradiation (15), this depletion might not ensure the absence of skin photosensitization, since the residual ALA can continue to re-generate PpIX. Clearly, the complete removal of residual ALA on the skin surface might minimize the risk of potential phototoxicity, but the intracellular ALA may still pose a risk in post-PDT photosensitization.

Younger patients with a history of playing video-games daily for long hours may also often present with more severe facial acne lesions, sometimes accompanied by secondary erythema. The potential cutaneous effect of long exposure to colour monitors certainly deserves further investigation.

In conclusion, this case report demonstrates possible cutaneous photosensitization caused by long exposure to a colour CRT monitor after topical ALA-PDT. Future guidelines and patient warnings should include an explanation of the potential risk of photosensitization associated with exposure to visible light generated from computer, video-game or television monitors.

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