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Short Review

Ultraviolet blood irradiation: Is it time to remember "the cure that time forgot"?

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ABSTRACT

Ultraviolet blood irradiation (UBI) was extensively used in the 1940s and 1950s to treat many diseases including septicemia, pneumonia, tuberculosis, arthritis, asthma, and even poliomyelitis. The early studies were carried out by several physicians in USA and published in the American Journal of Surgery. However, with the development of antibiotics, the use of UBI declined and it has now been called "the cure that time forgot." Later studies were mostly performed by Russian workers, and in other Eastern countries, and the modern view in Western countries is that UBI remains highly controversial. This review discusses the potential of UBI as an alternative approach to current methods used to treat infections, as an immune-modulating therapy and as a method for normalizing blood parameters. Low and mild doses of UV kill microorganisms by damaging the DNA, while any DNA damage in host cells can be rapidly repaired by DNA repair enzymes. However, the use of UBI to treat septicemia cannot be solely due to UV-mediated killing of bacteria in the bloodstream, as only 5–7% of blood volume needs to be treated with UV to produce the optimum benefit, and higher doses can be damaging. There may be some similarities to extracorporeal photopheresis (ECP) using psoralens and UVA irradiation. However, there are differences between UBI and ECP in that UBI tends to stimulate the immune system, while ECP tends to be immunosuppressive. With the recent emergence of bacteria that are resistant to all known antibiotics, UBI should be more investigated as an alternative approach to infections, and as an immune-modulating therapy.

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1. Historical Introduction

Ultraviolet (UV) radiation is part of the electromagnetic spectrum with a wavelength range (100–400 nm) shorter than that of visible light (400–700 nm), but longer than x-rays (<100 nm). UV radiation is divided into four distinct spectral areas including vacuum UV (100–200 nm), UVC (200–280 nm), UVB (280–315 nm), and UVA (315–400 nm).

In 1801, Johann Wilhelm Ritter, a Polish physicist working at the University of Jena in Germany discovered a form of light beyond the violet end of the spectrum that he called "Chemical Rays" and which later became known as "Ultraviolet" light [1]. In 1845, Bonnet [2] first reported that sunlight could be used to treat tuberculosis arthritis (a bacterial infection of the joints).

In the second half of the 19th century, the therapeutic application of sunlight (known as heliotherapy) gradually became popular. In 1855, Rikli from Switzerland opened a thermal station in Veldes in Slovenia for the provision of heliotherapy [3]. In 1877, Downes and Blunt discovered [4] by chance that sunlight could kill bacteria. They noted that sugar water placed on a window-sill turned cloudy in the shade but remained clear while kept in the sun. Upon microscopic examination of the two solutions, they realized that bacteria were growing in the shaded solution but not in the one exposed to sunlight.

In 1904, the Danish physician Niels Finsen was awarded the Nobel Prize in Physiology or Medicine for his work on UV treatment of various skin conditions. He had a success rate of 98% in thousands of cases, mostly the form of cutaneous tuberculosis known as lupus vulgaris [5]. Walter H Ude reported a series of 100 cases of erysipelas (a cutaneous infection caused by *Streptococcus pyogenes*) in the 1920s, that were treated with high cure rates using UV skin irradiation [6].

Emmett K Knott (Fig. 1) in Seattle, WA, reasoned that the beneficial effect of UV irradiation to the skin might (at least partly) be explained by the irradiation of blood circulating in the superficial capillaries of the skin. With his collaborator Edblom, an irradiation chamber was constructed to allow direct exposure of the blood to UV light. The irradiation chamber was circular and contained a labyrinthine passage connecting the inlet and outlet ports underneath the quartz window that formed the top of the chamber. The irradiation chamber was so designed as to provide maximum turbulence in order (a) to prevent the formation of a film of blood on the chamber window that would absorb and filter out much of the UV; (b) to insure that all the blood passing through the chamber was equally exposed to UV [7].

Knott and co-workers then carried out a series of experiments using UV irradiation of blood extracted from dogs that had been intravenously infected with *Staphylococcus aureus* and hemolytic *Streptococcus*, and then the treated blood was reinfused. They found that it was unnecessary to deliver a sufficient exposure to the blood to kill all the bacteria directly. It was also found unnecessary to expose the total blood volume in the dogs. The optimum amount of blood to be irradiated was determined to be only 5–7% of the estimated blood volume or approximately 3.5 mL per kg of body weight. Exceeding these limits led to loss of the benefits of the therapy. All the treated dogs recovered from an overwhelming infection (while many dogs in the control group died), and none showed any ill effects after four months of observation [7].

The first treatment on a human took place in 1928 when a patient was determined to be in a moribund state after a septic abortion complicated by hemolytic streptococcus septicemia. UBI therapy was commenced as a last resort, and the patient responded to treatment and made a full recovery [7]. She proceeded to give birth to two children.

Hancock and Knott [8] had similar success in another patient with advanced hemolytic streptococcal septicemia. These workers noted that in the majority of cases, a marked cyanosis was present at the time of initiation of UBI. It was noted that during (or immediately following) the treatment, a rapid relief of the cyanosis occurred with improvement in respiration accompanied by a noticeable flushing of the skin with a distinct loss of pallor.

These observations led to application of UBI in patients suffering from pneumonia. In a series of 75 cases in which the diagnoses of pneumonia were confirmed by X-rays, all patients responded well to UBI with a rapid fall in temperature, disappearance of cyanosis (often within 3–5 min), cessation of delirium if present, a marked reduction in pulse rate and a rapid resolution of pulmonary consolidation. A shortening of the time of hospitalization and convalescence occurred regularly.

Fig. 1. Emmett K Knott of Seattle, WA.

Fig. 2. The Knott Hemo–Irradiator.