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Ultraviolet Phototherapy for Skin Diseases

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Ultraviolet phototherapy for skin diseases

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The foundation of modern-day ultraviolet (UV) phototherapy began with the work of the Danish physician Niels Finsen who is best remembered for his successful treatment of cutaneous tuberculosis, and in 1903 was awarded the Nobel Prize for Medicine in recognition of this work. The first sources of artificial ultraviolet radiation were carbon arc lamps of the type developed by Finsen at around the turn of the century. These lamps were unpopular in clinical practice because of their noise, odour and sparks, and were superseded by the development of mercury arc lamps. Fluorescent lamps were developed in the late 1940s and, since then, a variety of phosphor and envelope materials have been used to produce lamps with different emissions in the ultraviolet region such that today there exists a wide range of arc and fluorescent lamps which are used for the phototherapy of skin diseases.

Treatment of skin disease by exposure to UV radiation alone is termed *phototherapy.* When treatment with UV is combined with a photosensitizing agent, the term *photochemotherapy* is used. The most common type of photochemotherapy involves the combination of the photoactive psoralen with UVA, so-called PUVA therapy.

Treatment Units Patient exposure is achieved in a number of ways:

- single medium pressure mercury arc lamp eg Alpine Sunlamp
- several metal halide lamps stacked in a vertical column and housed behind an optical filter to remove shortwave (<290nm) UV
- semi-cylindrical or cylindrical cubicles incorporating up to 48 fluorescent lamps 2m in length mounted vertically around the inner circumference
- bed and canopy incorporating fluorescent lamps for simultaneous anterior and posterior irradiation with patients lying supine
- small units incorporating 30-60 cm fluorescent lamps designed for treating hands and feet

Some cylindrical cubicles incorporate a mixture of UVB and UVA fluorescent lamps. The advantage of such a cubicle is that the one machine can be used for either phototherapy (when the UVB lamps are switched on) or PUVA therapy (when the UVA lamps are switched on).

UV measurement

There are two principal reasons why ultraviolet radiation should be measured in phototherapy:

- to allow consistent radiation exposure of patients over many months and years within a local department;

- to allow the results of irradiations made in different departments to be published and compared.

It is important to distinguish between these two objectives. The first requires *precision,* or reproducibility. The dosemeter is used as a monitor to give a reference measurement and so it needs to be stable. *Accuracy,* that is, absolute calibration against some accepted standard, is not essential. The second objective requires both precision and accuracy. Here the dosemeter must not only be stable from one day to the next, but also the display (normally in milliwatts per square centimetre) must be traceable to absolute standards. Routine measurement of spectral output is not necessary since any change in relative spectral emission of UV lamps is so small that the clinical impact is non-significant.

Although spectroradiometry is the fundamental way to characterize the radiant emission from an optical source, radiation output is normally measured by techniques of broad band radiometry. Broad band radiometers combine a detector (eg photodiode) with a wavelength-selective device (such as a colour glass filter or interference filter) and suitable input optics.

It is now clearly established that long-term PUVA treatment results in an increased risk of skin cancer. This risk has shown to be dose-dependent: a cumulative UVA dose received through PUVA of < 500 Jcm^{-2} is unlikely to result in significant risk; above 1000 Jcm^{-2} is associated with definite risk, and around 50% of patients who have received > 2000 Jcm^{-2} will have pre-malignant or malignant skin changes. For this reason accurate dosimetry in PUVA photochemotherapy is important for two reasons:

- To ensure that patients receive the correct prescribed dose of UVA, thus allowing treatment regimens to be optimally effective.

- To maintain accurate records of patients' lifetime UVA exposure received during PUVA treatment, which is important when the risk of PUVA-related malignancy is considered.

Calibration

Users of broad band radiometers often gain the impression from commercial literature that instruments are readily available to measure UVA, UVB, or UVC. In order to meet the criterion for a UVB radiometer, say, the sensor should have a uniform spectral response from 280 to 315 nm (the UVB waveband) with zero response outside this interval. In other words, the electrical output from the sensor should depend only on the total power within the UVB waveband received by the sensor and not on how the power is distributed with respect to wavelength. In practice no such sensor exists with this ideal spectral response (neither does one exist that measures UVA or UVC correctly for that matter). All radiometers which combine a photodetector with an optical filter have a nonuniform spectral sensitivity within their nominal spectral band. This means that broad band radiometers need to be calibrated for every type of source spectrum with which they will be used. The method we use is to measure the spectral irradiance [$E(\lambda)$] from the appropriate lamp using a spectroradiometer whose spectral sensitivity is calibrated with standard lamps provided by national standards laboratories; determine the irradiance within the waveband of interest [$\Sigma E(\lambda)$]; place the entrance aperture of the broad band radiometer at the same point as the input optics of the spectroradiometer and adjust the radiometer display so that it reads the correct irradiance.