Elementary photobiology and photophysics biology essay

Science, Biology

Table of ContentsPhotodermatology

Introduction

Over the last 3 decades, there were improvements on the study of biological effects of visible light and ultraviolet through the skin, recognising the clinical presentation of light sensitive skin disorders which this study is known as Photodermatology. There are more additions nowadays under the study of photodermatolgy such as photodynamic and laser therapies while doctors as well as nurses have an essential role in the administration of phototherapies and also in the diagnosis of the photodermatoses. First, we should know the meaning of photobiology which is the study of non-ionizing radiation on living systems and as such reflects all types of interaction of light with plants and animals. However, photomedicine deals with therapeutic and diagnostic photobiology. This essay is interested in presenting the clinical area of photodermatology. There are more ranges of ultraviolet sources such as sunlight and artificial light such as fluorescent, electric discharge and other types used in our homes and work however sunlight is the most important UV source which is responsible for the most of our energy and has an essential role for growing plants and so for our food chain. Indeed, sunlight has a range of benefits and risks of biologic effects. The positive biological effects are vision, warmth, Vitamin D synthesis, photosynthesis, killing pathogens and the treatment of disease. However the negative effects are sun burning, damaging of the skin, photodermatoses, photosensitization and mutations. The UV region subdivided into three regions UVA, UVB and UVC wavelengths on the basis of optical filters however these bands describe only the numerical subdivisions not define

limits of biological effect, it is important to know which band is used when you read a particular article. Since the wide range of the biological effects produced by different wavelengths, there are some people are sensitive to sunlight that are prone to skin diseases which depend on some environmental factors such as time of year, time of date, altitude, latitude, environmental pollution and reflectant factors as snowing.

2. Elementary photobiology and photophysics

The spectrumG: photodermatologyoutil_bleu16_img01[1]. jpgFigure The electromagnetic spectrum The (em) spectrum is the range of all possible frequencies of electromagnetic radiation[1]which from very short wavelength X-rays, γ rays, ultraviolet (UV), visible, infrared to radiofrequency as shown in " Fig. (1)". The difference between these bands is the different in their wavelengths. UV, visible and IR radiations are types of optical radiation. Hence, light is defined as an em radiation within the visible range. EM waves can be described by three different physical properties:
the frequency (f), wavelength (λ), and photon energy (E). Since the relation between the frequency and the wavelength is : $\lambda = c/f$ (1)The ultraviolet region is subdivided into three regions according to (Commission International de l'Eclairage, CIE), which is: UVA 315– 400 nm, UVB 280– 315 nm and UVC 100– 280 nm. Since if λ (radiation) > 200nm it will have less significant biologic effect. On the beginning of 19th century, the quantum theory is introduced by Max Planck and examined the em radiation that emitted like quantized packets of energy which were known as photons. He proved that the frequency (f) was proportional to the energy (E), according

to the relation: E = hf = hc/ λ (2)Where: c = 299, 792, 458 m/s is the speed of light in vacuum and h = 6. 62606896(33) ×10−34 J s = 4. 13566733(10)×10−15 eV s is Planck's constant[2]. Using this relation, it is easy to determine the energy of photons corresponding to their wavelengths across the spectrum. The unit of the energy is electron volts eV. Obviously, from (2) the inversely relationship between the wavelength of a photon and the energy it emits so the photon that has short wavelength has more energy. For example, if a photon has λ = 100 nm the photon energy it carries is 12. 4 eV, and if λ= 400 nm it is 3. 1 eV.

Radiometric quantities

Radiometric quantities are used to measure the optical radiation within the visible region. The energy unit is joule (J). Power is defined as the energy delivered in joule per second and its unit is watts (W) according to Eqn. (3). The relation between these two quantities is: Energy (J) = power (W) x time (s) (3)And, similarly: W = J/s. Dose is defined as energy per unit area (J/) however irradiance (W/) is expressed as the rate of energy delivered per unit area. Therefore: dose (mJ/) = irradiance (mW/) x time(s). The spectral irradiance is expressed in the irradiance per unit wavelength (mW//nm). The meaning of spectral is the dependency of λ on the quantities.

Sunlight

Figure Ultraviolet penetration to ozone layerMore than 60% of the sun energy outside the earth’s atmosphere could penetrate to the earth which carries only 5% of UV radiation s shown in fig. (2). The stratospheric ozone layer absorbs λ less than 320 nm which mainly responsible for absorbing 70–

90% of UVB from the sun. There were widespread concerns on the depletion of ozone which followed by observations of the ozone hole. Hence, there are protocols which aim to eliminate the production and use of chlorofluorocarbons and other gases that result in ozone depletion. The UV levels from sunlight are strongly dependent on proximity to the equator, season of the year, and time of day since all of these factors contribute to the effective path length of sunlight through the absorbing layers of the earth’s atmosphere.[3]https://encrypted-tbn3. gstatic. com/images? q= tbn: ANd9GcRkAAbLoQ3BA65UbZfmI2Ne1cZLMurpBPeJcHWSE02oCiSPC_26

Absorption of radiation

First Law of Photochemistry describes the principle that radiation must be absorbed before a photochemical event can occur is fundamental to understanding photochemistry and photobiology since each molecule has owns its absorption spectrum properties which can be presented as a graph between the wavelength and the probability of the photon to be absorbed. The shape of this spectrum is determined by the electronic configuration and the surroundings. Since a photon has been absorbed, there is a conversion of the energy and the molecule is excited or, if an electron is removed, then photo-ionization occurs.

Fluorescence and phosphorescence

Figure 3Absorption, fluorescence and phosphorescence spectra of a molecule Molecules that are in the electronic excited states lose its energy returning to the ground state which means that it drops from a low vibrational level of an excited electronic state to a high vibrational level of

the lower electronic state which loses its excess energy by collision in the form of heat. Then, the spectrum of the fluorescence is moved to longer wavelengths compared to the absorption spectrum. It is called Stokes' Law, since the excited singlet state is short-lived but the excited triplet state is more stable. Typical fluorescence occurs in nanoseconds, the lifetime of triplet may be in several seconds. The long-lived triplet emission is called phosphorescence. The phosphorescence spectrum lies at longer wavelengths than the fluorescence spectrum (but lower photon energy) as shown in " Fig. 3". http://chemwiki. ucdavis. edu/@api/deki/files/2711/= spectra%20for %20phenanthrene%20(2). png

3. Photoprotection

Behavior, clothing and sunscreens are the essential parts for a photoprotection strategy in order of priority. Since, there are some precautions for protecting and avoiding this problem, for example, when one wears proper clothing that can make a barrier to the covered areas; also using sunscreens is designed to protect the skin. Unfortunately, the general public tends to rank these three components in reverse order since the sunscreens being the primary source of photoprotection. This is due to some reasons, for examples – advertising, the pleasant feeling (for some) of sun on skin, and the desire for personal freedom of action.

Behavioral changes for sun avoidance

There are high levels of sunlight in some countries which lead to UV reduction in personal exposure. It can reduce that personal exposure by a factor of 10 UV radiation levels which are influenced by a number of factors:

Sun elevation: The rays of the sun pass through the atmosphere which is the cause of attenuating the ultraviolet radiations. Also, these radiations vary according to the time of day and also to the time of year. Latitude: It increases or decreases according to its location from the equator. Cloud cover: Ultraviolet radiations are attenuated to high degree because of clouds. Altitude: Ultraviolet radiations levels increase with altitude which in every 1 Km , it rises by 10 %. Shade: It has the role to remove ultraviolet radiation directly from the sun. Windows: The glass of windows (double glazing) can absorb the UVB component from the sunlight. Blind: Using plastic blinds is helpful in the management of patient with sever photodermatoses.

Clothing

Clothing comes in the second step after sun avoidance that uses for photoprotection from UV. The level of protection afforded by clothing depends on several factors:[4]Weave: It plays an important role that affects the ultraviolet radiation’s transmission since the high closely woven a fabric is, the low UV radiation is transmitted. Colour: The fabrics that are dark in colour release higher UV absorption, thus increasing the Ultraviolet protection factor (UPF). Weight: It is another factor since if the materials have the same colour and weave, it is important to know its weight which the weightier, the higher ultraviolet absorption. Stretch: There are some fabrics like Lycra has the ability to stretch which the amount of the transmission dependent on this property. Water: This factor is depending mainly on the fabric since when it presents in the spaces of the fabrics it

reduces the scattering of the radiation. Washing: After the first wash of cotton, UPF will increases significantly. One study reported a mean UPF of 20. 2 ± 2. 5 when new, which increased to 38. 3 ± 4. 2 after one wash, and was 39. 9 ± 3. 1 after 36 washes. Most fabrics undergo a combination of relaxation and shrinkage that reduces the spaces between the yarns. UV absorbers: There are more improvements for using UV absorbers for laundry rinse which for example, there is an application of UV absorbers that significantly improves the UV protection of a garment.

Sunscreens

The use of sunscreens is the third and final step after clothing step in a practical photoprotection strategy which is considered as the most important measure for sun protection since sunscreens are highly marketed. Over the last four decades the products of cosmetic sun were started designed to be used for tanning and then for enhancing the products of sun protection. These were improved to examine the protection level of burning. Active ingredients: They are usually divided into physical and chemical compounds. Chemical sunscreen are organic which absorb over narrow wavebands which in UVA and UVB however physical ones are inorganic which scatter as well as reflect both visible radiation and ultraviolet. Sun protection factor (SPF): It is expressed as the dose ratio of UV radiation that results in minimal erythema in unprotected skin to that ratio in skin protected by the sunscreen. Thickness of application: The sun protection factor is measured using a uniform application thickness of 2 mg/. In practice, however, only between 0. 5 and 1. 5 mg/is used[5], mainly due to its high cost which describes the

strong relation between thickness and light absorption. Substantivity: Throughout the day, sunscreen could be removed by water, sweat, towelling, clothing, and sand. Therefore, nowadays the most products of sunscreens are designed to be resistible against water and sand.

Sunscreens for photosensitive patients:

Patients who are suffering from the photodermatoses use sunscreens to provide photoprotection and many of them are sensitive to ultraviolet as well as visible radiation. Unfortunately, commercial sunscreens are designed mainly to protect ultraviolet radiation but little protection against visible region. For further protection into UVA region, products are developed using microfine Ti-dioxide and Z-oxide particles.

4. Polymorphic light eruption

PLE is the major of the idiopathic photodermatoses which is provoked by UV light. It is delayed type of hypersensitivity. EpidemiologyG: photodermatology 0000000. jpgG: photodermatology 00000011. jpgPrevalence: The higher figure of prevalence was 21% which was obtained amongst employees of a Swedish company.[6]Age of onset: According to a series from Tayside, Scotland, shows that two-third of patients experienced the beginning of their symptoms in the first three decades of their life but could be occurring later. G: photodermatology 0001212. jpgG: photodermatology 010120. jpgSex distribution: The ratio of male to female patients is halved in a Swedish group however it is t 1: 6. 7 in a Scottish group.[7]Figure 4 Different types of PLEClinical presentationThis happens usually in spring or in the early of the summer as a pruritic, erythematous,

papular rash on exposed sites. It accompanies rash and it could be preceded by burning . It usually develops within half an hour to more hours of the exposure of sun; rarely, this latency period extends to 1– 3 days. It is possible to spare the exposed sites like the hands and face however the rash is affecting mostly the sites that subjected to sun in summer, such as the forearms, neck and legs. Frequently, the papules are just 1– 2 mm in diameter but can be larger, hence it can form plaques. Several morphologic types have been described: popular, plaque, papulovesicular, vesicobullous, hemorrhagic, and erythema multiform-like. Currently, there are some forms which know as " PLE sine eruptione" which describe a sunlight-induced pruritus without rash and also there is one knows as pinpoint which is described in the dark skin. There is limiting forms of PLE which present papulovesicular eruption on the helices of the ears, usually in boys in springtime, is called juvenile spring eruption. The term PLE reflects these different forms, but, for the individual, a particular morphology leads to more monomorphic pictures, which is usually consistent between attacks as shown in " Fig. 4".

Management

Many patients suffer from moderate PLE probably do not need medical advice and but the effective to manage their suffering is using sunscreens or avoiding the sun exposure. Therefore, they should avoid the sun from 10 am to 4 pm which this period is the maximum of ultraviolet exposure and also use protective clothing such as hats and woven fabrics in order to apply sunscreens before sun exposure. On the other hand, the sufferers should be

exposed gradually to the sun exposure in order to develop the natural tolerance.

5. Solar urticaria

Solar urticaria (SU) is an immediate-type hypersensitivity reaction, which is an uncommon photodermatoses. It is characterized by itching, erythema, and whealing over sun-exposed sites, which, when severe, cause significant lifestyle restriction. It is usually idiopathic but can be seen in association with porphyria, drugs, and topical tar. G: photodermatology1111111111111. jpgEpidemiology: Age of onset could be at any age but it is high between the third and fifth decades. A prevalence is estimated to be 3. 1 per 100, 000 of the population with 70% female predominance in the Tayside region of Scotland, but no variation in incidence with skin type[8]. SU can be seen in conjunction with chronic idiopathic and other physical urticarias as well as with other photodermatoses such as polymorphic light eruption. G: photodermatology11111. jpgG: photodermatology1111. jpgFigure5 Different types of Solar UrticariaClinical presentationThe onset of this disease is sudden which is preceded by itching and may be a burning sensation, then erythema and usuallywhealing over sun-exposed sites. Hence, most of them include the " V" of neck and arms, with less severe involvement of the more habitually exposed face and hands. Urticaria develops after only seconds of sun exposure in the most severely affected but after 5 minutes of exposure in approximately 50% and after 15 minutes in another 25%. In exposure times of an hour or more are necessary to provoke urticaria and can lead to confusion accompanying the onset of PLE, therefore it is important to

phototest it to determine other diagnosis. The time of exposure may vary in any one patient over time and be affected by season, altitude, latitude, and reflection. " Fig. 5" shows different types of SU.

Management

The majority of photosensitive patients should use proper sun avoidance as well as protective clothing and hats. On the other hand, a clear film is used for UVA patients to permit the transmission of small amounts of UVA radiation through for example car windows.

6. Photodynamic therapy

It is a treatment for cancer in which a drug is retained by tumour and then activated by light. The light absorption with proper wavelength is very important for the photodynamic therapy using a photosensitizer in an oxygen-dependent process, resulting in oxidative stress, tissue damage, and cell death. G: photodermatology222222222. jpgFigure 6 Before and after applying photodynamic therapyPhotosensitizer: The properties of an " ideal" photosensitizer include light absorption at clinically useful wavelengths, accumulation in the target tissue, efficiency, and rapid clearance. Currently, there are more developments for using topical photosensitizers in PDT, especially in the use of lipophilic ALA esters that may improve photosensitizer specificity. G: photodermatology222222. jpgLight sources: Most photosensitizers used in PDT absorb maximally in the visible waveband. The absorption spectrum of porphyrins is broad, with peak absorption around 410 nm (Soret band). For topical PDT, light delivery is a compromise which has the ability to improve tissue penetration to a maximum of approximately

6 mm, corresponding with one of the smaller absorption peaks of PpIX. New compounds are absorbing maximally in the 700– 800 nm wavelength range for future developments of photosensitizer, with enhanced tissue penetration, may facilitate the treatment of deeper lesions however at present both photosensitizer and light tissue penetration limit the depth of effective treatment using topical PDT.

7. Conclusion

On this study, I discussed photodermatology in terms of therapeutic and diagnostic aspects since within the diagnostic aspect, there are ranges of diseases exist. When one is considering a disease, it is important to have a simple schematic diagram which gives a lot of information according to understanding the current mechanism. Symptoms are also helpful in determines the diseases as is the patient’s description of morphology. The clinical presentation of photodermatology is great distinguish value since the morphology is described by two ways by examining the patients photograph or by direct clinical examine which are helpful to make the diagnostic straightforward.