Minutes of the Fifth Ordinary Meeting

Held on Thursday 7th February 2019

Joint Meeting with the Institute of Physics

'Photodermatology – Lighting Up Skin'

Dr Ewan Eadie, Head of Scientific Services, Photobiology Unit, Ninewells Hospital, Dundee

Dr Eadie was introduced by Dr Steve Ryan, President-Elect, Liverpool Medical Institution.

Dr Eadie graduated with First Class Honours from the University of Strathclyde in 2005 with a Masters in Physics and Mathematical Finance. Following this, he embarked on a PhD with Professor Harry Moseley at the Photobiology Unit in Ninewells Hospital. During his PhD, he worked closely with the National Physical laboratory and published several papers including his work on the sunburn potential of energy saving lightbulbs.

Having completed his PhD in 2009, he moved to the Nuclear Medicine Department at Ninewells as a Route 2 Trainee Clinical Scientist and he successfully obtained Clinical Scientist status in 2013. Whilst there, he was involved with editing the IPEM Report 111 Quality Control of Gamma Cameras and Nuclear Medicine Computing Systems.

Dr Eadie returned to the Photobiology Unit in 2015 as the Head of Scientific Services for Photobiology. Currently, his interests are in the use of innovative technology and how this can be used to improve patient care when using optical radiation. His research has focussed on the use of LEDs in phototesting and improving patient dosimetry in daylight Photodynamic Therapy.

Dr Eadie began his talk by explaining that Photodermatology is the study of light interaction with skin, noting that:
Photo – meaning light from the Greek phos,
Dermatology – from the Greek dermatos meaning skin and logia meaning the study of.

He listed the four aspects of photodermatology practised at Dundee, namely: photosensitivity testing; UV phototherapy; photodynamic therapy (PDT) in the treatment of superficial skin cancers and pre-cancerous lesions and laser therapy.

He noted that Dundee was home to the Scottish national service for investigating and treating skin interactions with sunlight. Dundee provided clinical services with multidisciplinary staff with specialist knowledge and he noted the small number of patients involved. Within the UK and Ireland, there are nine similar centres with Salford being the nearest to Merseyside.

He indicated that he would focus on two areas; namely, photosensitivity and PDT.

As an introduction to photosensitivity, he invited the audience to close their eyes and imagine their favourite spot on a hot summer's day. He then talked the audience through the initial delight of the warmth of the sun's rays to the pain of sunburn. Such is the power of sunlight on skin!

In a question to the audience, he showed six images of patients who were suffering from reddened skin features and asked which of the images they thought to be "routine sunburn". Unsurprisingly, the audience's opinions were varied. A handful of the audience chose the correct image for sunburn but many were unsure or just simply wrong in attempting to pick out routine sunburn.

He noted that sunburn only affected skin that was exposed to sunlight but he noted a case of an individual showing skin reddening when visible and ultraviolet light passed through a thin shirt. Also, that the effect on the skin was lessened by two layers of shirt material and lessened further by the diagonal strap of a car seat belt being worn by the individual.

He pointed out that photosensitivity was the reaction of the skin to exposure to light, resulting in physical symptoms on the skin. The effects of this sensitivity can be severe and can impact on the quality of life – in some extreme cases, requiring the patient to cover from head to toe to eliminate exposure to sunlight. He described other examples such as a baby crying in a buggy simply because of photosensitivity; xeroderma pigmentosum (a recessive genetic disorder of DNA repair after UV exposure); photoallergic reactions to a lime juice marinade and the chemicals in a sunscreen. In many such cases, the cause of the reaction was unknown.

He showed a graph of the relative intensity against wavelength of sunlight, noting that the visible part of the spectrum ranged from wavelengths of about 400 nm at the "blue" end up to about 760 nm at the "red" end. He noted also that the spectrum extended at wavelengths shorter than 400 nm into ultraviolet and beyond the red end to longer wavelengths, the infrared.

He emphasised that photosensitivity was wavelength-specific.

Ultraviolet is responsible for sunburn, for skin cancer, for wrinkles but also has beneficial effects such as the production of Vitamin D and he noted that most photosensitive individuals are sensitive to UV but that this sensitivity can extend into the blue end of the visible spectrum.

The first step in investigating an individual's sensitivity is phototesting. This is done by exposing the patient's skin (usually the back since it won't have been regularly exposed to sunlight previously) to light of a particular wavelength and noting any immediate skin reaction (reddening or swelling) and later after 7 and 24 hours. To achieve an individual wavelength of light, a monochromator based on a diffraction grating is used. By changing the angle of the diffraction grating, different wavelengths will be emitted and then shone along a light tube onto the patient's skin.

He showed an illustration of the clinical set-up in Dundee describing the application process and the recording of the exposure of the light at different wavelengths at various sites on the patient's back.

The dose (strictly, radiant exposure) received by the patient can be quantified by knowing the irradiance of the light source and recording the exposure time.

The irradiance is the power per unit area (milliwatts per square metre) and the patient dose is the energy per unit area received by the patient (millijoules per square metre). It is critical that the measurement of the irradiance emitted by the light source is accurate and much time and effort goes into ensuring that the clinician can have confidence in the exposure parameters.

At Dundee, all of the phototesting and light exposure on patients is performed by clinical technologists within Medical Physics. They all have a scientific background although not necessarily in physics and this provides for an excellent synergy between physical science and clinical medicine. They perform all of the procedures not just light based procedures but also things like taking blood and preparing the skin for treatment.

Turning to the therapeutic role, Dr Eadie turned to his particular interest, namely, photodynamic therapy (PDT). PDT is a drug therapy where the drug is activated by the absorption of light and Dr Eadie mentioned its use in treating superficial non-melanoma skin cancers such as basal cell carcinoma and Bowen's disease and to treat pre-cancerous lesions.

He showed four examples of outcomes of PDT which provided excellent clinical outcomes together with pleasing cosmetic appearances. He noted that, for older patients with reduced skin healing properties, PDT provided a clear benefit for the patient.

Dr Eadie then described the basics behind PDT. Initially, using gentle abrasion, the skin is de-crusted. Following this, the drug (e.g., aminoleavulinic or its methyl ester) is applied to the skin surface and then the skin area is covered for three hours, during which time the drug accumulates in the diseased cells and metabolises.

Prior to shining red light onto the affected area, the dressing is removed. He showed a slide describing the physical process involved and these involved photon absorption, internal energy conversion, and energy transfer via singlet oxygen to destroy the affected tissue and to regenerate the normal tissue.

There are some drawbacks to this treatment – it can only be carried out in a hospital setting, takes between 3½ to 4 hours and the patient can experience moderate to severe pain which may need intervention. The extent of the pain depends on the size of the area being treated with larger treatment areas producing greater pain. He cited a report where about 44% of patients required pain interventions. The pain is believed to be neurological and topical analgesics are generally ineffective. Reducing the applied irradiance to the affected area can help to reduce pain but the treatment time becomes longer and this may mean multiple treatment sessions.

He commented on the incidence of pain in a cohort of Dundee patients (n = 909 with 2,188 lesions and 4,717 treatments) with just over half reporting moderate pain and about 30% reporting no or mild pain and about 16% reporting the pain as severe.

He went on to describe the increasingly common approach to PDT of using natural daylight as the light source. As with the hospital-based treatment, the treatment area is de-crusted and following the application of a sunscreen, the PDT drug is applied. Following a short wait time (~ 30 minutes), the patient goes outside for a couple of hours and can do whatever they wish as long as it's outdoors.

Of course, there is one big problem – is the sun shining today? Patients obviously prefer to be outside getting the treatment from the sun's rays than being in a clinical setting and there is the added bonus of significantly less pain. So, physicists, being the pharmacists of light dosage, need to assess whether there will be enough sunlight to provide for successful daylight PDT. No problem with Perth, Australia but Perth, Scotland is a different matter.

Along with colleagues from NHS England, historical records of sunlight from nine different locations across the UK were studied. The results (British J Dermatology, 2017) showed that, surprisingly, there is enough sunlight through the year across the UK for daylight therapy to be successful BUT the limiting factor is not the amount of sunshine, it's the air temperature. Being outside without clothes on the treated areas in temperatures less than 10oC is hardly appropriate and this is the situation from about November to March in the UK. The obvious solution is to have the patients in conservatories or greenhouse but because of attenuation of the light by the glass, treatment times need to be extended, typically from two to two and a half hours. In Dundee, patients can be successfully treated outdoors from April to October as long as rainy days are avoided. As a comparison, daylight PDT sessions can be held almost all year round in the southern part of the UK.

The clinical outcome from these treatment in Dundee has been reported as:
73% of patients with "clearance or good response"; a median pain score of 1; and with 90% of the patients preferring daylight PDT (Scottish Med J, 62[2], 48-53, 2017). He showed four cases of excellent clinical improvement with obvious cosmetic improvement.

Apart from being preferred by patients, outside treatment does have an added benefit in that it frees up important clinical time.

Dr Eadie gave the clear "take home" message in favour of daylight PDT: (i) it's an effective treatment for cancer and pre-cancer skin lesions, (ii) the physics informs the clinical by innovation, safety and efficacy; & (ii) there is enough sunlight!!

In closing, Dr Eadie acknowledged several organisations including the NHS, local universities & other academic bodies and charitable bodies.

Dr Ryan invited questions for the audience and that the question time lasted more than a quarter of an hour indicated the audience's level of interest. Dr Stockdale (Institute of Physics, Merseyside branch) led the vote of thanks to Dr Eadie in the usual manner.

Following the formal end of the session and, as a mark of appreciation, Dr Ryan, on behalf of the LMI, presented Dr Eadie with a commemorative medal and Dr Stockdale, on behalf of the IOP, presented him with a book token.

Dr Harold Stockdale