ULTRAVIOLET RADIATION (UVR)

INTRODUCTION, PRODUCTION, PHYSIOLOGICAL, THERAPEUTIC, INDICATION, CONTRAINDICATION, PRECAUTION & DANGERS.
Ultraviolet radiation (UVR) covers a small part of electromagnetic spectrum lying between the violet end of the **VISIBLE LIGHT** and **X-RAY REGION**.
UVR are **INVISIBLE** to the human eyes.

Natural source of UVR is **SUN**.

UVR provoke **CHEMICAL CHANGES** & not simply heat at sites where they are absorbed.
The radiations introduced to the tissues through 1. subcutaneous tissue, 2. hair follicles, and 3. sebaceous glands.
GENERALIZED RESPONSE TO UVR EXPOSURE

1. Sunburn (UVB) / Erythema (Reddening of the skin)
2. Tanning of the skin / Pigmentation
3. Decrease in sensitivity of the skin (Increased Epidermal thickness)
4. Premature aging of the skin (UVA)
5. Skin cancer (UVB)
6. Exposure to the eye causes photokeratitis (UVB)
7. Photosynthesis of vitamin D
1. Reflection
2. Refraction
3. Absorption
4. Penetration
1. UVA (Long UV) - 400 - 315nm. {penetrates to dermis, Responsible for development of slow natural tan}

2. UVB (medium UV, erythemal UV) - 315 - 280nm. {Produces new pigment formation, sunburn, Vitamin D synthesis. Responsible for inducing skin cancer}

3. UVC (short UV, germicidal UV) - 280 - 100nm {Does not reach the surface of the earth}
1. High pressure mercury vapor lamp - Air cooled.

2. High pressure mercury vapor lamp - Water cooled (Kromayer lamp).

3. Fluorescent lamps
The therapeutic UVR are produced by mercury vapour lamp which consists of a QUARTZ BURNER TUBE evacuated from air and containing traces of argon gas and mercury under reduced pressure.

An electrode is inserted at each end of burner tube. The current is applied to the electrodes, the mercury vapour and the passage of electrons through the vapour establishes the UVR.
UVR LAMPS
The UV apparatus is grouped as follows:

1- **Air-cooled lamps**: Hanovia Alpine Sun Lamp, {High pressure vapour lamps} wavelength 253nm (short wavelength) used in treatment of **GENERALISED SKIN CONDITIONS AS ACNE AND PSORIASIS**.
Emit ultraviolet, infrared, and visible light

UVR produced falls within UV-B range

Mainly used to produce erythema and accompanying photochemical reactions
The heat produced inside the Burner or Quartz tube causes some of it to change to another form of silica called **TRIDYMITE**.

- Tridymite is **OPAQUE** to UVR. So output of the rays tends to **FALL**.

- A **variable resistance** is included in the burner circuit to increase the potential difference across the burner & intensity of the current.
The photochemical action of UVR shorter than 250nm in wavelength on atmospheric oxygen is to form OZONE.

Ozone is a toxic gas for inhalation & partly prevented by good ventilation.

Levels of ozone can be detected by smell.
Water-cooled lamps:
Kromayer lamp, wavelength at 366nm give both **UVA and UVB**, used for treating localised lesions as **pressure areas**, **ulcers**, and **sinuses** in open areas.

It is a water cooled mercury vapor lamp.

Eliminates the danger of an IRR burn.
UVR APPARATUS
- The distilled water is circulated in the jacket.
- The purpose of which is to absorb the IRR.
- After the use of the lamp, the water circulation should be continued for 5min after the burner is switched off in order to cool the lamp.
- Tap water has the disadvantage, that it contains SALTS & OTHER IMPURITES which may deposit on the quartz window.
1. It must be kept dry.
2. It should not be turned on & off more frequently.
3. After 1000hrs of use the burner must be renewed.
4. The burner of an air cooled lamp should be cleaned regularly with absolute alcohol.
5. The burner should not be touched with fingers.
6. After every 8hrs of use the distilled water should be renewed.
It used for GENERAL UV IRRADIATION.

The spectrum contains a large proportion of short UVR which are undesirable for the general treatment.
FLUORESCENT TUBES:

The modern treatment methods often require the use of Long UV without short UV.

So to meet this criteria the fluorescent tubes are used.

These are similar to the tubes used for lighting.
UVR APPARATUS
Each tube is about 120cms long.

It is made of a type of glass which allows long UV to pass.

The output proportion of this is mainly of Long UV, Few IRR & some Short UV.

It is mainly used for General Irradiation for individual or in Group.
Theraktin lamp consists of a number of fluorescent tubes each with a parabolic reflector incorporated into a semicircular tunnel.

The wavelength between 290 and 350nm (UVA long) used in treating affecting large areas.
This provides an even irradiation to patients.

It allows treatment of the whole body in 2 halves.

2 IRR elements are included in order to keep the patient warm during treatment.

All of the lamps should be positioned at least 18” from the patient.
- **UVA** - Dermis level.
- **UVB** - Deep Epidermis
The UVR physiological effects may be divided into 2 groups;
1. Local - Effects which produced locally in the area.
2. General - Results from a widespread Irradiation.
1. **ERYTHEMA** - It is reddening of the skin.

First observable effect of UV Irradiation.

It cause chemical action which result in **IRRITATION & DESTRUCTION** of cells. This causes liberation of “H”-substance which produce the **TRIPLE RESPONSE**.

The erythema is regarded as an inflammatory reaction stimulated by the UVR.
1. Dilation of capillaries - H-substance

2. Dilation of arterioles - Axon reflex

3. Exudation of fluids into the tissues - Increased permeability of the capillary walls.
It is thought that the UVR stimulates MELANOCYTE & ACCELERATES the production of MELANIN PIGMENT.

Pigmentation commonly follows an erythematernal reaction.

It varies with the dosage of UVR & the different individuals.
The mechanism of skin pigmentation after UV irradiation.

**a** Immediate pigment darkening (IPD)
- Melanin in melanosome
- Basal cell
- Basement membrane
- Epidermis
- Single UV
- Dermis
- Distributed melanin forms a ‘nuclear cap’

**b** Delayed tanning (DT)
- Melanocyte
- Keratinocyte
- Single UV
- Increased activity of melanocyte
- Repeated UV
- Accelerated melanin transfer to keratinocytes
- Melanocyte dendrites elongate and branch
- Increased number and size of melanosomes
- Increased number and activity of melanocytes
Sometimes immediate tanning occurs as a result of effects of **PRE-EXISTING melanin**. This may occur within minutes of exposure.

- Sun / Carbon arc  ➔ Brown color
- Mercury Vapor lamp ➔ Grayish

The pigmentation **REDUCES** the penetration of UVB.
UVR provokes an increased reproduction of KERATINOCYTES.

This leads to thickening of epidermis which acts a PROTECTION AGAINST THE RAYS.

So longer doses are required to repeat an ERYTHEMAL reaction.
4. DESQUAMATION / PEELING

- It is the CASTING OFF of dead cells from the surface of the skin.
- The desquamation is proportional to the intensity of the erythema.
- The peeling results in REDUCTION / LOSS OF THE INCREASED RESISTANCE TO THE RAYS.
5. ANTIBIOTIC EFFECT

- Destructive effects of ultraviolet radiation include the destruction of viruses, bacteria, and other small organisms on the skin surface such as FUNGI commonly found in wounds. (effect of UVB).
1. Vitamin D Production

In the presence of UVB, converts **7-Dehydrocholestrol** into **Vitamin - D through chemical reaction**.

Vitamin D is required to assist in the **absorption of calcium and phosphorous** from the intestine to blood stream.
2- THE ESOPHYLACTIC EFFECT

General UVA Irradiation

Stimulation of reticulo - endothelial system

Ingest bacteria & produce ANTIBODIES against BACTERIA & TOXINS.

- So the resistance of the body to infection is increased & this being known as ESOPHYLACTIC EFFECT.
Its being claimed that because of General UV Irradiation has a "GENERAL TONIC EFFECT, APPETITIE & SLEEP BEING IMPROVED NERVOUSNESS & IRRITABILITY DECREASED"
The principle therapeutic uses of UVR are for skin diseases.

1. **Psoriasis**:
   - It is a skin condition which presents localized thick pink/red plaques, sharply demarcated & covered with silvery scales.
   - In this state, the aim of UVR irradiation is to decrease the DNA synthesis in the cells of the skin & to improve the skin condition.
HEALTHY & PSORIASIS SKIN

Healthy Skin

Psoriasis

- scales
- plaques
- inflamed skin

keratin layer
epidermis
sweat gland
hair follicle
dermis
subcutaneous layer

Infographic: FDA/Renée Gordon
2. ACNE VULGARIS

- Acne is also a skin condition which presents **PUSTULES, PAPULES** formed by **blocking of sebaceous pores & hair follicles affecting mainly the face, chest & back.**

- The more severe & long lasting forms cause **disfiguring & serious distress.**

- Using UVR is aiming to produce **desquamation to open** the blocked pores and hair follicles.

- E2 dose is given to the face, chest and neck.
3. **ECZEMA**

- It is an **INFLAMMATORY RESPONSE** in the skin associated with **OEDEMA**.

- The patient suffers marked **ITCHING** with **REDNESS, SCALING, VESICLES** & exudation of serum on the skin.

- A mild UVR treatment will help. *(Sub acute & Chronic stage)*
Infected wounds such as
1. **ULCERS**
2. **PRESSURE SORES**
3. **SURGICAL INCISIONS** are often treated with HIGH DOSES of UVR.

The aim of UVR irradiation is to destroy the surface bacteria, remove the (SLOUGH) infected material & promote repair.

**E3 dose** is sufficient, the dose is may be given daily and is not being applied to normal skin.
5. VITILIGO

- It is a condition in which destruction of **MELANOCYTES** in local areas causes **WHITE PATCHES** to appear on the skin.

- Both UVA & UVB stimulate melanocyte activity.

- UVA seems to provoke a **DARKER & LONGER LASTING TANNING.**

- UVB provokes **more THICKENING.**
The aim of UVR is to stimulate the **GROWTH of GRANULATION TISSUE & SPEED UP REPAIR**.

- **UVA** stimulates **GROWTH**.

- Example for non infected wounds are - **Venous / Arterial ulcers**.
It is used to produce a strong counter irritation effect over the site of DEEP SEATED PAIN.

E4 dose is given to cause discomfort and producing mask of pain.
1. **DERMATOLOGICAL CONDITIONS** - Psoriasis, Acne, Sub acute & Chronic Eczema.

2. **Calcium / Phosphorus disease** - Osteomalacia

3. **Non pulmonary tuberculosis**

4. **Local Ulceration** - Ulcers, Pressure sores, Surgical incision
5. Upper respiratory condition management - Common Cold.

6. Counter Irritant Effect.
CONTRAINDICATION OF UVR

1. Pulmonary Tuberculosis

2. Severe cardiac disturbances

3. Systemic Lupus Erythematosus

4. Severe Diabetes

5. Dermatological Conditions
6. Known Photosensitivity.

7. Photosensitizing medication.


9. Acute Febrile illness

10. Recent skin grafts.
- Porphyrias
- Pellagra
- Sarcoidosis
- Xeroderma pigmentosum
- Acute psoriasis
- Renal and hepatic insufficiencies
- Hyperthyroidism
- Generalized dermatitis
- Advanced arteriosclerosis
- Acute eczema
- Herpes simplex
- Hypersensitivity to sunlight
1. **Shock**

2. **Eyes** - UVR may produce conjunctivitis, iritis or cataract.

3. **Over Dosage** - UVR burn can occur. Mainly E4 reaction

4. **Ozone** - Important to ensure adequate Ventilation in the area.
SAFETY PRECAUTIONS AGAINST SUNLIGHT (UVR)

1. Eyes protection.
2. SKIN DAMAGE / TANNING PROTECTION

- Sunscreen doesn’t offer 100% protection.

- SPF (Sun Protection Factor) 30+: sunscreen blocks 96% of UV; SPF 15+: blocks out 93%.

- In addition to sunscreen, wear a hat, sunglasses, more clothing, and seek shade.
GUIDELINES FOR PROTECTION

Tanning Protection
Most cotton and cotton/polyester fabrics protect against 95% of UV, but are less effective if wet, faded, or aged.
It is used to assess the individual patients (ERYTHEMAL) reaction to uvr irradiation.

The basis for any calculation of any UVR dosage is the MED (MINIMAL ERYTHEMAL DOSE).

This MED refers to the response of erythema for the dose to be given.
The patient must understand that the purpose of the MED test is to DETERMINE just how much EXPOSURE TIME is necessary based on their skin sensitivity.

Proper patient education should be given:-
1. Wear Goggles
2. Observe & monitor the skin condition
3. Keep skin moisture following exposure to UVR
4. Pigmentation changes are to be expected & are a normal response.
5. Prolonged & repeated exposure leads to premature aging.
1. The area chosen for the test is of importance.
2. Because the patient is to inspect at regular intervals a convenient, visible site is essential.
3. It should be clear of skin disease.
4. The FLEXOR SURFACE of the FOREARM is the most usual site. (Other sites are - Abdomen, Medial aspect of arm / thigh)
5. The selected site should be cleaned with soap & water to remove surface grease.
6. Cover the patient other areas leaving only the forearm exposed to UVR.
7. Three to Five holes of at least 2cm² & 1cm apart are cut in a piece of lint/paper/cardboard is taken for irradiation of UVR along with a slide cover - to pull up to reveal one opening at a time.
8. This cutting is fixed to the forearm with adhesive plaster.

9. The cuttings are of different sizes & shapes in-order to make **IDENTIFICATION OF THE ERYTHEMA EASIER** for the patient.

10. Allow the lamp to warm up according to the manufacturer instructions.

11. Place the lamp PERPENDICULAR to the area being tested (Forearm) & a DISTANCE of 60 to 90cms from the site.

12. Expose the 1\textsuperscript{st} opening for 30sec, then expose the 2\textsuperscript{nd} opening for another 30sec & go on till the last opening
13. So the 1\textsuperscript{st} opening would receive the longest exposure time & the last opening would receive the least amount of exposure time.

14. Switch off the lamp

15. Instruct the patient to MONITOR the forearm every 2hrs & note which opening or shape appeared pink / red first & when it faded / disappeared.

16. The patient is also given a card similar to the opening to make a note.
It is a slight reddening (erythema) of the skin which takes from 6 - 8hrs to develop & which is still just visible at 24hrs.
<table>
<thead>
<tr>
<th>Degree of Erythema</th>
<th>Latent period In HRS</th>
<th>Appearance color</th>
<th>Duration of Erythema</th>
<th>Skin Oedema</th>
<th>Skin discomfort</th>
<th>Desquamation of skin</th>
<th>Relation to E1 Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>6-8</td>
<td>Mildly pink</td>
<td>&lt;24hrs</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>E1</td>
</tr>
<tr>
<td>E2</td>
<td>4-6</td>
<td>Definite Pink Red. Blanches on Pressure</td>
<td>2 Days</td>
<td>None</td>
<td>Slight Soreness, Irritation</td>
<td>Powdery</td>
<td>2.5% of E1</td>
</tr>
<tr>
<td>E3</td>
<td>2-4</td>
<td>Very red, Does not blanch on pressure</td>
<td>3-5 Days</td>
<td>Some</td>
<td>Hot &amp; Painful</td>
<td>In thin Sheets</td>
<td>5% of E1</td>
</tr>
<tr>
<td>E4</td>
<td>&lt;2</td>
<td>Angry Red</td>
<td>A Week</td>
<td>Blister</td>
<td>Very Painful</td>
<td>Thick Sheets</td>
<td>10% of E1</td>
</tr>
</tbody>
</table>
The skin response to UVR depends on:

1. The quantity of UVR energy applied to unit area of the skin. (Depends on):
   a) The output of lamp - Make, Type, Aging
   b) Distance between the lamp & the skin - Inverse square law
   c) Angle at which radiations fall on the skin - cosine law
   d) Time for which radiations are applied

2. The sensitivity of the skin
**CALCULATION OF DOSAGE**

- E1/MED is the basic of UV calculation which is determined for each individual patient by performing a skin test.

- From this point all other doses of UVR can be calculated.

- \( E_2 = 2\frac{1}{2} \times E_1 \)
- \( E_3 = 5 \times E_1 \)
- \( E_4 = 10 \times E_1 \)
EXAMPLE:

If the E1 dose of the patient is 25sec, calculate the E3 dose?

- E1 dose = 25sec
- E3 dose = 5 x E1
- E3 dose = 5 x 25 = 125sec
The dose at different distances from the lamp to skin can be calculated by formula:

\[ \text{NEWDOSE} = \frac{\text{OLD DOSE} \times \text{NEW DISTANCE}^2}{\text{OLD DISTANCE}^2} \]
An exposure to UVR should not be repeated until the erythema caused by a previous dose has faded.

- Thickening of the epidermis

Necessary to increase the exposure in order to repeat the erythematic reaction at each successive dose.

- Doses are progressed as follows:
  - To repeat an E1 25% of the preceding dose is added
  - To repeat an E2 50% of the preceding dose is added
  - To repeat an E3 75% of the preceding dose is added
  - To repeat an E4 100% of the preceding dose is added
Examples of progression of dosage

- If E1 is 30sec, find the second progression (P2E1)?

- E1 = 30sec

- P1 (Day one progression) E1 = E1 + 25% of E1 = 30 + 30/4 = 30 + 7.5 = 37.5sec

- P2 (Day two progression) E1 = P1E1 + 25% of P1E1 = 37.5 + 37.5/4 = 46.9sec

- P2E1 = 47sec
1. An E1/MED - Given to the total body area (Whole body)

2. An E2 - May not be given to up to 20% of total body area

3. An E3 - May not be given to up to 250cm² of normal skin

4. An E4 - May only be given to an area up to 25cm² of normal skin.
1. An E1 / MED may be given DAILY

2. An E2 - Should be given every second day

3. An E3 - Should be given every 3 or 4\textsuperscript{th} day (Twice Weekly)

4. An E4 - may only be given once a week or even once a fortnight.

\textbf{N.B.} when treating non-skin areas such as pressure areas or ulcers, all doses may be given daily as there is no erythema reaction produced.
SENSITIZATION / SENSITIZING DRUGS

- A number of drugs & some foods in a few patients are known to sensitize patients to the effects of UVR.

- Commonly seen sensitizing groups are:
  1. psoralens - Sensitizer
  2. Sulphonamides - Antibiotic
  3. Phenothiazine - Tranquilizer
  4. Barbiturates
  5. Gold therapy
  6. Aspirin & Derivatives