Mid TERM

**RADIATION PROTECTION PAPER**

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## 

**Question No.1**

**Ans:**

**Law of bergonie and Tribondeau :**

* This law was theorized by **two French scientist bergonie and tribondeau** in **1906**.
* They were observed that the **radiosensitivity** was a function of the metabolic state of the tissue being irradiated.

**Statement:**

* This low states that the radiosensitivity of living tissue varies with **maturation and metabolism**
* This law also state that the radiosensitivity of a living tissue is **directly proportional** to the by mitotic activity greater the mitotic activity grater will be the length of time that they are actively proliferating a **inversely proportional** to the degree of differentiation of its cells

**Explanation:**

* Its means that radiosensitivity varies of living tissue varies with maturation and metabolism
* It depend on durability and **rapidly** of response
* This law also says that:
* **Fetus** are more sensitive to radiation exposure then **mature adult**
* **Younger tissue** are more **radiosensitive** then **mature tissue**
* Tissue which have **high metabolic activity** are more radiosensitive then the tissue which have **low metabolic activity**

**Radiosensitivity:**

* It is the response of cell are tissue to the **low dose of radiation**
* Some to cell or tissue response more **quickly** to the lower dose of radiation.

**For example:**

* **Spermatogonia and erythroblast epidermal stem cell**

**Physical factors that effect radio sensitivity:**

* There are some Physical factors that affect radio sensitivity which are follow :
* **Linear Energy Transfer (LET)**
* **Relative Biologic Effectiveness**
* **Protraction and Fractionation**

1. **Linear Energy Transfer (LET):**

* LET is the **amount of energy** transfer from ionizing radiation to soft tissue
* The value of radiation quality is determined by **radiation weight factor** **(wr)**
* Its units is also expressed in **electron volt** **energy transferred per micro** **meter** of track length in soft tissue
* **Kev/um**
* When LET of radiation increase so the ability of ionizing radiation to produces **biological response** also increases
* It means when LET is **high ionization** will be occur frequently
* Ionization of molecule is a **directly proportional** to LET

1. **Relative Biologic Effectiveness**:

* It is the **ratio** **of dose** between the radiation to give a certain biological affect
* When the LET of radiation increases the ability to produce biological damage also increases

**RBE = Dose of stander radiation necessary to produce a given affect**

**Dose of test radiation necessary to produce the same effect**

* The RBE of diagnostic X ray is one
* RBE is **directly proportional** to LET
* It means radiation with higher LET have higher RBE.

1. **Protraction and Fractionation:**

**Protraction:**

* The **time** in which the **total dose** is to be delivered is called **protection.**
* When the **lower dose** is continuously delivered then this is called **protracted.**

**For example:**

* When **6 gray dose** is delivered in **3 minute** at a dose of **2 Gyt/min** is lethal for mouse, and then the dose delivered at a rate of **10 mGyt/hr** for total time of **600 hrs.**

**Fractionation:**

* When a dose of radiation is given for **long period** of time it dose not effect then the dose given **quickly** (for a short period of time)
* When a radiation is given for long period of time then higher dose is required to produce the **same effect**
* When a **6 GYt**is delivered at the same dose rate

But when it divided into **12 equal parts of 500 mGYt**then this is called **fractionated.**

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**Question No:2**

**Ans:**

1. **Effect Of Irradiation Of Macromolecules:**

**MACROMALECULE:** A macromolecules is very large molecules composed of **polymerization of smaller subunits called** **monomers**. Macromolecules are:

* **Proteins**
* **Carbohydrates**
* **Lipids**
* Irradiation of macromolecules is quite different from irradiation of water
* When macromolecules are irradiated in**:**

1. **In Vitro:**

* **Out side** the body or out side the cell
* **Tolerate less** **radiation**

1. **In Vivo:**

* **Within** the cell
* **In natural environment**
* **Tolerate lot of radiation**

**Effect Of Radiation Of Macromolecules:**

* When macromolecules irradiated then three major effects occurs

1. **Main chain scission**
2. **Cross linking**
3. **Point lesion**
4. **Main chain scission:**

* Breaking the **backbone** of long chain macromolecules
* Reduction of long ,single molecules into many smaller molecules
* **Reduce viscosity**
* When main chain scission occurs it **reduce the viscosity** of macromolecules

1. **Cross Linking:**

* Small **spur-like structure** that extend off main chain ,**link** with another molecule or part of itself.
* The side structure behave that the have **sticky substance** on end
* And they attach to another **segment of same** molecule
* **Viscosity** of macromolecule **increases.**

1. **Point Lesion:**

* **Disruption of** **single chemical bond or loss of base**
* They are not **detectable**
* They cause **minor modification** of molecules which turn cause the malfunction in the cell
* **Effect** observed at whole body level

**For Example:**

**Radiation Effect ON DNA:**

* DNA is the **most important** molecule in the human body
* It contain **genetic information** for each cell
* The nucleus contain DNA with other molecule in the form of **chromosomes**
* Radiation **damage** DNA
* **Chromosomes** **aberration or cytogenetic damage**
* It can lead to **cell death**

**Radiation Response to DNA:**

* **Main chain scission with only one side rail severed**
* **Main chain scission with both side rail severed**
* **Main chain scission and subsequent cross linking**
* **Rung breakage causing a separate of bases or loss of bases.**

1. **RADILYSIS OF WATER:**

**Meaning:**

* Radio means radiation

**&**

* Lysis means BREAK DOWN

**Definition:**

* It is the **breakdown** of molecules by ionizing radiation

**Explanation:**

* Human body consist of **80%** of water
* When water molecule is irradiated it breakdown into **two ions**
* **H2O + HOH+ + e-**

There is a lot of reaction happen. When their **pair re-join** they form stable water molecule then no damage will be occur. But when the pair not join the a **lot of reaction will be occur**

* When electron ( e-) with water molecule
* **H2O + e- HOH**-
* This electron is received by **hydroxyl ion** so the **HOH+ and HOH-**are **unstable** because of the **positive** and **negative ion** on OH. So it Dissociate.

**Dissociation:**

* **HOH+ H+ + OH\* + e-**
* this will taken e- from H ion To become **stable**
* **HOH- H + OH\*-**
* **So it become free radical**
* It is **uncharged** molecule which have single unpaired electron in outer shell

**Hydrogen Peroxide formation:**

* When**OH\* and OH\***come together they **form hydrogen peroxide.**
* **OH- + OH-  H2O2**

**Hydroperoxyl Formation:**

* The **H\* free radical** combine with **molecular oxygen** to form the **hydroperoxyl radical**
* **H\* +O2  HO\*2**

**Organic Free Radical Formation:**

* Some organic molecules, **symbolized as** **RH** can become **reactive free** **radical** as fallow
* **RH + RH\* H\* + R\***
* When **oxygen** is present , yet another free radical is possible
* **R\* + O2 RO\*2**

1. **EFFECT OF RADIATION ON CELL:**

* **Chromosomes** **breakage** Effect of radiation on cell result from an ionizing event changes the **targeted molecule DNA**
* **Cellular transformation** can result in late **stochastic effect** at human level
* **Mitotic delay**
* **Cell death** can result early **deterministic effect** on human level
* **Cell death**
* **Instant**
* **Reproductive**
* **Interphase death**
* **Genetic death**

**Target Theory:**

* According to targeted theory **cell die** after radiation exposure its target molecule must be **inactivated**
* Critical target in the cell **no replacement**
* Cell death occur if **critical target is destroy**
* **DNA** is targeted molecule
* Hits occur through both **direct and direct hit**
* **O2** present with **low LET**

**Cell Survival:**

* The **lethal effect** of radiation is determined by observing cell survival, not cell death.
* **It has two methods**

1. **Single Target-Single Hit:**

* This models applies to **biological target** such as **:**
* **Enzymes**
* **Bacteria**
* **Viruses**
* Due to **random nature** of x-rays
* Equal number of **x-rays** **does not mean** equal number of damage
* Radiation **interact randomly** with matter
* If there were uniform irradiation **D37 would** sufficient to kill **100%** of cells.

1. **Multi-Target, Single Hit:**

* This model applies more **complicated biological system** such as human cells.
* Cell has more than **one critical target 2 or more hit** required to cell death.

**Cell Cycle:**

* Human cell replicate by **mitosis**
* **G1** is the most time variable of cell phases
* Human cell are most radiosensitive in **M** and most radioresistant in **lates**
* Next most sensitive phase of the cycle occur at **G1-S.**

**Radiation Effect Modification:**

* Irradiation of mammalian cell with high- LET radiation fallow the **single target, single hit model**.

1. **FRACTIONATION AND PROTRACTION:**

**FRACTIONATION:**

* When a dose of radiation is given for **long period of time** it dose not effect then the dose given quickly (for a short period of time)
* When a radiation is given for long period of time then higher dose is required to produce the **same effect**
* When a 6 GYt is delivered at the same dose rate
* But when it divided into **12 equal parts of 500 mGYt**then this is called **fractionated.**

**Types of Fractionation:**

* **Conventional Fractionation**
* **Altered Fractionation**
* **Hyper fractionation**
* **Accelerated fractionation**
* **hypo fractionation**

**Advantages of Fractionation:**

* **acute effects** of single dose of radiation can minimized
* **patient’s** tolerance improves with **fractionated radiation**
* provides time for repair of **sublethal damage** of normal cells
* Provide time for **reoxygenation** of tumor cells**.**

**PROTRACTION:**

* The time in which the **total dose** is to be delivered is called **protection**
* When the **lower dose** is continuously delivered then this is called **protracted.**

**For example:**

* When **6 gray dose** is delivered in **3 minute** at a dose of **2 Gyt/min** is lethal for mouse, and then the dose delivered at a rate of **10 mGyt/hr** for total time of **600 hrs.**

**NOTE:**

* Protraction in fractionation cause **less effect** because there is a lot of time is allowed for **intracellular repair and tissue recovery.**

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**Question No. 3**

**Ans:**

**Summary Of Early Effect Of Radiation On Human Body:**

Early radiation response is described as diministric; by increasing radiation dose severity will be increase. The producing radiation response in the human within a few dose to month, the dose must be substantial such response is called early effect of radiation exposure. Radiosensitivity is very in deterministic. Acute radiation lethally is only academic interest in diagnostic radiology because diagnosis x-ray beam are neither intense enough and nor large enough to cause death. Such death will be occur when person expose to nuclear energy. In acute radiation high level of radiation exposure occurs. There are three separate syndromes. Prodromal period appear within minutes to hour and effect of is dose dependent on varies in time onset, severity and duration. Manifest stage the syndrome depend on the specific syndrome and last from hours up to several months. Most patients do not recover and will die within few to several months of exposure and the recover process last from several weeks to two years. Hematologic syndromes have two phases i.e. prodromal phase and latent phase. When person exposure to 200-1000 rad after 1 hr to 24hrs later symptoms of vomiting, nousea, and diarrhea develops and may persist for several days. Latent phase is a symptomatic of hematologic syndrome. The manifest illness phase is characterized by neutropenic fever, systemic and localized infection. Recovery phase begin in2 to 4 weeks about long as up to 6 weeks. Death may also occur due to generalized infection. Mean survival time is 10 to 60 days. Gastrointestinal syndrome occurs with the exposure of 1000- 5000 rad, which damage the living of GI tract. Intestinal bacteria get free access to the body. In prodromal phase nausea, diarrhea occurs, latent period show no symptoms. And in manifest diarrhea become severe and if untreated cause death. Survival time is 4 to 10 days. Latent period last up to 12hrs in manifest symptoms return but severe difficulty in breathing, convulsive seizures, loss of equilibrium; and the mean time is 0 to 3 days. The LD50/60 is the dose of radiation to whole body that cause 50% of irradiated subject to die within 60 days. For it is appearing 350 rad after whole body radiation. The whole body radiation dose increases the average time and death decreases. Skin, gonads and bone marrow are affected immediately. Skin is the most common effected tissue. Erythema within few hours after single dose excess of about 200rad/ 2 Gy. Second hyperemic phase the main erythematic reaction begin about 10 days after dose of about 600 rad. Dose in excess of 700rad may irreversibly damage hair follicle and permanent epilation occur. Most desquamation occurs when radiation is even higher i.e. 1500-2000 rad it occur within 20-28 days. The blister formation occurs when the radiation dose excess is about 1500-2500 rad. At radiation dose 2500 rad necroses develop in 3 weeks. Human gonads are sensitive to radiation because these organ control fertility and heredity. Testicular dose 10-30 rad temporary oligospermia. 200-300 testicular dose 100%aspermia beginning at 1-2 month post-exposure and no recovery observed. Radiation dose effect the hematopoietic system like lymphocytes, granulocytes, thrombocytes and erythrocytes. The radiation dose also effects the cytogenetic. Single hit effect produce by radiation during G1 phase in which the chromatid deletion occur.

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