

DATE NO.

Enact 2

DATE Sep. 2, 2024 NO.

Radiobiology

- The study of the effect of ionizing radiation on biological tissue

Ultimate goal: to accurately describe the effects of radiation

on human

Dose response relationships: develop to predict the effect and manage

accidental exposure

Diagnostic Radiology: concern with stochastic effect of radiation

Human Population in whom radiation effect have been observe

POPULATION

Effect

- American radiologists

- Leukemia, reduced life span

- Atomic bomb survivors

- Malignant disease

- Radiation accident victim

- Acute lethality

(e.g Chernobyl)

- Marshall Islanders

- Thyroid cancer

- Uranium miners

- Lung cancer

- Patients treated with ^{131}I

- Thyroid cancer

- Radium watch-dial painters

- Bone cancer

- Children treated for enlarged

- Thyroid cancer

Thymus

- Children of Belarus

- Thyroid cancer

(downwind from Chernobyl)

- Patient with ankylosing spondylitis

- Leukemia

- Patient who underwent

- Liver cancer

- Irradiation in utero

- Childhood malignancy

- Volunteer convicts

- Fertility impairment

- Cyclotron workers

- Cataracts

Seven notes

Seven notes

Biologic Effects

Deterministic

- Early effect
- Occur within days after radiation exposure
- Response increase in severity with increasing radiation doses

Stochastic effect

- Late effect
- not observe for months or years
- Response increase in incidence with increasing radiation doses

1. Acute radiation syndrome

a. Hematologic syndrome

b. Gastrointestinal syndrome

c. Central nervous system syndrome

2. Local tissue damage

a. Skin

b. Gonads

c. Extremities

3. Hematologic depression

4. Cytogenetic damage

1. Leukemia

2. Other malignant disease

a. Bone cancer

b. Lung cancer

c. Thyroid cancer

d. Breast cancer

3. Local tissue damage

a. Skin

b. Gonads

c. Eyes

4. Shortening of life span

5. Genetic damage

a. Cytogenetic damage

b. Doubling dose

c. Genetically significant dose

Fetal Irradiation

- Prenatal death
- Neonatal death
- Congenital malformations
- Childhood malignancy
- Diminished growth

radiolysis of water

- Dissociation of water result of irradiation
- The principal radiolysis final result:

- Ion

- Two

- Atom of water (H₂O)

• H₂O + radiation

• HOH + 4 e⁻

- The ion pair may occur

• HOH⁺

- If the ions do not react to another water

• H₂O + e⁻

- HOH⁺ & HOH⁻ are the smaller molecule

• HOH⁺ = H⁺

• HOH⁻ = OH⁻

NO.

stochastic effect

late effect

to observe for months

or years

response increase in incidence

with increasing radiation

dose

leukemia

other malignant disease

a. Bone cancer

b. Lung cancer

c. Thyroid cancer

d. Breast cancer

Local tissue damage

a. Skin

b. Gonads

c. Eyes

Shortening of life span

Genetic damage

a. Cytogenetic damage

b. Doubling dose

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significant dose

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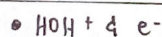
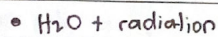
Fetal Irradiation

- Prenatal death
- Neonatal death
- Congenital malformation
- Childhood malignancy
- Diminished growth and development.

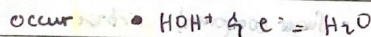
radiolysis of water

- Dissociation of water into other molecular products as a result of irradiation
- The principal radiation interaction in the body: (indirect effect)
- Final result:
 - Ion pair (H^+ & OH^-)
 - Two free radicals (H^* & OH^*)

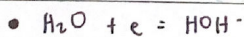
- Atom of water (H_2O) is irradiated



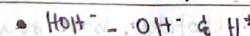
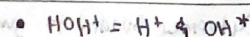
- The ion pair may rejoin into a stable water and no damage occur



- If the ions do not rejoin, the negative ion (e^-) will be attached to another water molecule



- HOH^+ & HOH^- are very unstable and can dissociate into smaller molecules



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Hydrogen Peroxide (H_2O_2)

- the principal damaging product of radiolysis of water
- Poisonous to the cell & therefore acts as a toxic agent.
- Formed by combination of two OH^*
 - $OH^* + OH^* = H_2O_2$

Hydroperoxyl Radical (HO_2^*)

- The principal damaging product of radiolysis of water
- Poisonous to the cell & therefore acts as a toxic agent.
- Formed by combination of H^* and Oxygen (O_2)
 - $H^* + O_2 = HO_2^*$
- May produce H_2O_2
 - $HO_2^* + HO_2^* = H_2O_2 + O_2$

Nucleic Acids

DNA

- Location: nucleus
- Sugar component: deoxyribose
- Base component: thymine
- Configuration: double helix

RNA

- Location: cytoplasm; nucleus (some)
- Sugar component: ribose
- Base component: uracil
- Configuration: single helix

DNA bases

- Nitrogen-containing bases
- attached to each deoxyribose
- Purines: adenine & guanine
- Pyrimidines: thymine & cytosine

Base Bonding

- adenine bonded to thymine
- Cytosine bonded to guanine
- Nucleotides: base sugar phosphate combination
- Codon: three-base pair

Seven notes

Cell Proliferation

- The act of a cell multiply in number
- Mitosis and Meiosis

Mitosis

- Somatic cell division
- a parent cell divides to the parent

Meiosis

- Genetic / germ cell
- Cell division that halves the number of chromosomes
- Occur only in eukaryotes

Cell Cycle time

- Cell generation time
- Average time for a cell to divide
- Four phases: Prophase, Metaphase, Anaphase, Telophase

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Cell Proliferation

- The act of a single cell or group of cells to reproduce & multiply in number

- Mitosis and Meiosis

Mitosis

- Somatic cell division

- a parent cell divides to form two daughter cells identical to the parent cell.

Meiosis

- Genetic / germ cell division

- Cell division that reduces the chromosomes in each daughter cell to half the number of chromosomes in parent cell.

- Occur only in reproductive cells.

Cell Cycle time

- Cell generation time

- Average time from one mitosis to another (24 hrs)

Four phases - G1 phases

- S phase

- G2 phase

- M phase

nucleus (some)

acid

double helix

to thymine

to guanine

sugar

nation

a pair

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Interphase

- the period of growth before the actual mitosis
- Comprises G₁, S, G₂ phases
- No cell division yet
- Chromosomes: not visible

S phase

G₁ Phase

- DNA synthesis phase (8hrs)
- DNA: replicated
- Chromosome: from 2 to 4
- Chromatid structure.
- Pre-DNA synthesis phase
- Earliest phase
- Most time variable
- Approximately 11 hrs
- the gap in cell growth between M & S
- DNA: double helix form

M phase

G₂ phase

- Division phase
- last phase of cell cycle
- Approximately 1 hr
- Most radiosensitive phase
- Post DNA synthesis phase
- Approximately 4hrs
- Cell growth continues
- Subphases: PMAT

Prophase

- First phase
- Nucleus: seen
- Chromosomes
- Nuclear membrane
- Centrioles

Meta phase

- Nucleus: elongated
- Chromosome
- appear
- Mitotic spindle
- Form
- Chromatid

Anaphase

- Duplicated
- Migration
- Carcinoma
- Number of

- Chromosome
- Each
- New
- Two

Prophase

- First phase of cell division
- Nucleus: swells / enlarges
- Chromosomes: become more prominent / visible (enlarge)
- Nuclear membrane: disappears
- Centrioles - Begin to migrate on opposite sides of cell
- Begin to regulate formation of spindle fibers

Meta phase

- Nucleus elongates
- Chromosomes:
 - appear & line up along the center or equator to the cell
- Mitotic spindle
 - form between two centrioles
- Chromatid & Centromeres: attaches to the spindle fibers

Anaphase

- Duplicated centromeres:
 - Migrate in opposite direction
 - Carry the chromatids to opposite side of the cell
- Number of centromere and chromatids is reduced by half.
- Chromosomes
 - Each splits at the centromere
 - New chromosome migrates toward to the spindle
 - Two complete sets of chromosomes.

telophase

- last phase of cell division
- separates the two set of genetic materials.
- 46 chromosomes in each new somatic cell
- Chromatids
 - Change in appearance
 - become long, loosely spiraled thread
- Chromosomes: structure disappears
- Nuclear membrane: forms two new nuclei (dumbbell like)
- Cytoplasm: divided into near the equator.

Law of Bergonie & Tribondeau

- Jean Bergonie & Louis Tribondeau (1906)
- Radiosensitivity depend on:
 - Type of cell and tissue
 - Tissue metabolic activity
 - Cell proliferation rate
 - Tissue growth rate

High Radiosensitivity Low Radiosensitivity

- | | |
|-----------------------------------|-----------------------------------|
| - Stem cell | - mature cells |
| - Younger tissue and Organ | - Mature tissue and organs |
| - Tissues with high rate of cells | - Low proliferation rate of cells |
| - High growth rate for tissue | - Low growth rate for tissue |

Physical factors

- Linear e
- relative
- Protraction
- fraction

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Physical factors that affect radiosensitivity

- Linear energy transfer (LET)
- Relative Biologic Effectiveness (RBE)
- Protraction
- Fractionation

bell like)

Seven
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