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Enact 2 DATE Sep. 2, 2022 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 (e.g Chernobyl)	Acute lethality
- Marshall Islanders	- Thyroid cancer
- Uranium miners	- Lung cancer
- Patients treated with ^{131}I	- Thyroid cancer
- Radium watch-dial painters	- Bone cancer
- Children treated for enchanged Thymus	- Thyroid cancer
- Children of Belarus. (downwind from Chernobyl)	- Thyroid cancer
- Patient with ankylosing spondylitis	- Leukemia
- Patient who underwent	- Liver cancer
- Irradiation in utero	- Childhood malignancy
- Volunteer convicts	- Fertility impairment
- Cyclotron workers	- Cataracts.

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Biologic Effects

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

1. Acute radiation syndrome
   a. Hematologic syndrome
   b. Gastrointestinal syndrom
   c. Central nervous system syndrome
2. Local tissue damage
   a. Skin
   b. Gonads
   c. Extremities
3. Hematologic depression
4. Cytogenetic damage

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

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

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Fetal Irradiation
- Prenatal death
- Neonatal death
- Congenital malforma
- Childhood malignanc
- Diminished growth

Radiolysis of Water
- Dissociation of wate
  result of irradiatio
- The principal radiati
  final result: - Ion
  - Two
- Atom of water (Hy
  - H_2O + radia
  - HOH + 4 e⁻
- The ion pair may
  occur • HOH
- If the ions do not re
  to another water
  - H_2O + e =
- HOH^+ & HOH - are re
  smaller molecule
  - $HOH^+ = H^+$
  - $HOH^- = OH$

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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
  - H_2O + radiation
  - HOH + & e^-
- The ion pair may rejoin into a stable water and no damage occur
  - HOH^+ & e^- = H_2O
- If the ions do not rejoin, the negative ion (e^-) will be attached to another water molecule
  - H_2O + e = HOH^-
- HOH^+ & HOH - are very unstable and can dissociated into smaller molecules
  - HOH^+ = H^+ & OH^*
  - HOH^- = OH^- & H^*

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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 thymines
- Cytosines bonded to guanines
- Nucleotides: base sugar Posphate combination
- Condon: three-base pair

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Cell Proliferation

- The act of a cell
  multiply in num
- Mitosis and me

Mitosis

- Somatic cell divis
- a parent cell d
  to the parent

Meiosis

- Genetic / germ c
- Cell division that
  to half the nu
- Occur only in

Cell Cycle time

- Cell generation
- Average time fr
  four phases -

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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

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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

G1 Phase

- Pre-DNA synthesis phase
- Earliest phase
- Most time variable
- Approximately 11 hrs
- the gap in cell growth between M & S
- DNA: double helix form

G2 phase

- Post DNA synthesis phase
- Approximately 4hrs
- Cell growth continues

S phase

- DNA synthesis phase (8hrs)
- DNA: replicated
- Chromosome: from 2 to 4 Chromatid structure.

M phase

- Division phase
- last phase of cell cycle
- Approximately 1hr
- Most radiosensitive phase
- Subphases: PMAT

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Prophase

- First phase
- Nucleus: swe
- Chromosomes
- Nuclear me
- Centrioles

Meta phase

- Nucleus elo
- Chromosome
  - appear
- Mitotic sp
  - Form
- Chromatid

Anaphase

- Duplicated
  - Mig
  - Can
- Number of

- Chromosome
  - Each
  - New
  - Two

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Prophase

- First phase of cell division
- Nucleus: swells / enlarges
- Chromosomes: become more prominent / visible (enlarge)
- Nuclear membrane: disappear
- 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 & Centromes: attaches to the spindle fibers.

Anaphase

- Duplicated Centromes:
  - 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.

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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 (dumbell 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.

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Physical factors that affect Radiosensitivity

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

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