UNIT IV

RADIATION DOSE AND ITS EFFECTS

4.2.DOSIMETRIC QUANTITIES

Dosimetric quantities used in medical imaging and interventions for reporting patient doses and establishing diagnostic reference levels (DRLs).

Dosimetric quantities are

1) kerma

2) cema

3) Absorbed dose

KERMA

Kerma is an acronym for Kinetic Energy Released per unit MAss. It is a non- stochastic quantity applicable to indirectly ionizing radiations such as photons and neutrons.

It quantifies the average amount of energy transferred from the indirectly ionizing radiation to directly ionizing radiation without concerns to what happens after this transfer.

Energy of photons is imparted to matter in a two-stage process. In the first stage, the photon radiation transfers energy to the secondary charged particles (electrons) through various photon interactions (photo-effect, Compton effect, pair production, etc.). In the second stage, the charged particle transfers energy to the medium through atomic excitations and ionizations.

In this context, the kerma is defined as the mean energy transferred from the indirectly ionizing radiation to charged particles (electrons) in the medium dEr per unit mass dm:

The unit of kerma in joule per kilogram (kg).

CEMA

Cema is the acronym for Converted Energy per unit MA. It is a non-stochastic quantity applicable to directly ionizing radiationssuch as electrons and protons

The Cem C is the quotient of df, by dm, where d*F is the energy lost by charged particles in electronic collisions in a mass dm of a material:

U = d/dm

The unit of cema is joule per kilogram (kg)The special name for the unit of cem is the gray (Gy)

ABSORBED DOSE

Absorbed dose is a non-stochastic quantity applicable to both indirectly and

directly ionizing radiations,

For indirectly ionizing radiations, energy is imparted to matter in a two-step process

In the first step (resulting in kerma) the indirectly ionizing radiation transfers energy as kinetic energy to secondary charged particles.

In the second step these charged particles transfer some of their kinetic energy to the medium (resulting in absorbed dose) and loss some of their energy in the form of bremsstrahlung losses.

The absorbed dose is related to the stochastic quantity energy imparted. The absorbed dose is defined as the mean energy & imparted by ionizing radiation to matter of mass m in a finite volume V

The energy imparted & is the sum of all energy entering the volume of interest minus all energy leaving the volume, taking into account any mass-energy conversion within the volume. Pair production, for example, decreases the energy by 1.022 MeV, while electron-positron annihilation increases the energy by the same amount. • The unit of absorbed dose is joule per kilogram (Jk * g ^ - 1) . The special name for the

unit of absorbed dose is the gray (Gy)

RELATIONSHIP BETWEEN THE DOSIMETRIC QUANTITIES

The energy transferred to electrons by photons can be expended in two distinct ways: 1) through collision interactions (soft collisions, hard collisions),

2) through radiative interactions (bremsstrahlung, electron-positron annihilation). Therefore, the total kerma is usually divided into two components: the collision kerma K_{col} and the radiative kerma K_{rad}

Collision kerma K_{col} is that part of kerma that leads to the production of electrons that dissipate their energy as ionization or near the electron tracks in the medium, and is the result of Coulomb-force interactions with atomic electrons.

Thus, the collision kerma is the expectation value of the net energy transferred to charged particles per unit mass at the point of interest, excluding both the radiative energy loss and energy passed from one charged particle to another.

kerma K_{rad} is that part of kerma that leads to the production of bremsstrahlung as The secondary charged particles are decelerated in the medium. It is the result of Coulomb field interactions between the charged particle and the atomic nuclei.

Generally, the transfer of energy (kema) from the photon beam to charged particles a particular location does not lead to the absorption of energy by the medium (absorbed dose) at the same location. This is due to the non-zero (finite) range of the secondary elections released through proton interactions.

As a high energy photon beam penetrates the medium, collision kerma is maximal at the surface of the irradiated material because photon fluence is greatest at the surface. Initially, the charged particle fluence, and hence the absorbed dose, increases as a function of depth until the depth of dose maximum zur is attained.

Exposure X is the quotient of dQ by dm, where do is the absolute value of the total charge of the ions of one sign produced in air when all the electrons and positrons liberated or created by photons in mass dm of air are completely stopped in air:

$$X = dq/ dm$$

The unit of exposure is coulomb per kilogram (C/kg). The special unit used for exposure is the roentgen R, where 1 R = 2.58 × 104 C/kg.

The relationship between total kerma and exposure is given by

$$Kair = X (War) 1 - 9 e 1$$

Where,

Wair - Average energy expended in air per ion pair formed.

X - Exposure

g-Bremsstrahlung fraction depending on the electron