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Effects of Radiation on Patient's Health during Imaging Diagnostics.

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ABSTRACT: Radiation from imaging diagnostic had caused many detrimental effects to patients. Imaging diagnostic is the largest manmade source of radiation exposure. Dose- response models have aided the study of effects of radiation from imaging diagnostic. Certain imaging tools have caused more radiation hazard towards patients such as computed tomography. Non-ionizing radiation imaging modalities have represented safer alternative. Medical practitioners should adopt as low as reasonably achievable principle during imaging diagnostic to avoid health hazard to patients.

KEYWORDS: Radiation, Imaging diagnostics, Dose-response models, Modality specific effects

I.INTRODUCTION

The use of imaging diagnostic has develop since Wilhelm Roentgen image of his wife‘s hand in 1895 towards four dimensional digital imaging in this era [1]. Radiation from the imaging diagnostic had causes many detrimental effect to the patients. Human are exposed to both man-made radiation and background radiation. Studies shows that approximately 83 percent of the population's radiation exposure is from the natural resources while the remaining 17 percent is man-made and medical radiation is the most prominent man-made radiation which accounts 15 percent of radiation received by the public [2]. What is habitually referred as radiation is better phrased as ionising radiation. Ionisation is a process by which electrons are removed from the atoms. Ionising radiation in imaging diagnostic focuses more on x-rays, γ-rays and radionuclide [3]. Ionising radiation is known to cause harm where the high radiation doses have a tendency to kill cells, while low doses tend modify the Deoxyribonucleic acid (DNA) of irradiated cells [2]. Ionising radiation interact with the human cells in two ways that is direct and indirect interaction mechanism. In direct interaction, the human cell's macromolecules which is the DNA and protein are hit by ionising radiation which effects the cell either by killing the cells or mutating the DNA whereas the indirect mechanism act in way when radiation energy is deposited in the cell, the radiation interacts with cellular water which results in hydrolysis of the water molecule consequently the free radicals are formed [4, 5]. Ionising radiation can cause two types of effect namely deterministic effect and stochastic effect. Deterministic effect results in radiation induced cell death and need a dose that exceeds the threshold. This effect can be

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apparent soon after receiving radiation dose [1]. Examples of deterministic effects are hematologic suppression and skin erythema [6]. The stochastic effect where it results in a genetic effect and long term cancer induction at such there is no definitive threshold is safe. Stochastic effect is a probabilistic event and there is no known threshold dose [7]. In imaging diagnostic, type of ionizing radiation involves is the low dose ionizing radiation [8]. Extent of radiation produced by the imaging device is expressed in mSv which is quantified as kinetic energy released in matter. Substantiation has correlated exposure to low dose ionizing radiation with the progression of malignancy if the exposure exceeds certain levels and with each imaging diagnostic that uses radioactive agents and x-rays can increase exposure to radiation. Estimated exposure ranges from in the region of 10-20 mSv per procedure, depending on the type of imaging diagnostic used. Numerous imaging can result in cumulative exposure of more than 100 mSv [9]. In short, an individual should be only exposed to maximum of 20 mSv per year to radiation and this includes the health care professionals that are involved in the imaging diagnostic [8].

II. DOSE-RESPONSE MODEL

Hypothetical dose response models are used to explain the effects of radiation exposure. Different models propose different possibilities of response to radiation exposure. There are five types dose response model used to study radiation effects namely linear no threshold, linear threshold, linear quadratic, hypersensitivity models and lastly hormesis model. Linear No Threshold (LNT) suggest that any exposure including the background radiation is harmful [2]. In contradictory, radiation hormesis also known as radiation homeostasis stated that low dose radiation exposure is not harmful infact it is beneficial [10]. The hormesis model explains that low dose radiation exposure stimulates the activation of repair mechanisms which is capable of protecting against diseases, where it cannot be activated when there is an absence of ionizing radiation [11]. Opposing to LNT and hormesis, hypersensitivity model suggest that radiation induces DNA repair pathway in non-irradiated cells and also in irradiated cells which eventually increase the number of damaged cells. As a result, hypersensitivity model foresees the extent of harm from radiation which exceeds the amount predicted by LNT model [9]. Linear threshold dose response model consists of known threshold and effects of radiation are not seen below the threshold. At the threshold level, effects are obvious and rise linearly as the dose increases. This model is generally accepted because it more rational since there no clinical effects seen from radiation exposure below the threshold. Linear quadratic dose response model is used in general human response to radiation exposure where no threshold is applied. The model suggests that responses at low levels of radiation exposure are linear whereas at high doses radiation exposures are quadratic [5]. However, the only dose response model that is accepted is the LNT which suggest that any radiation exposure is harmful [12]. LNT can be a useful model but current radiation exposure effect concepts should be focused more on facts and on current scientific results and not on opinions based [11].

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III. ASSESSMENT OF THE CATEGORY OF RISK

Few categories were assessed to study the radiation risks. First, is the foetus where the potential effects are prenatal death, organ malformation, and reduced intelligence quotient. However these effects rely on the radiation dose towards conceptus and stage of conceptus development at which the exposure occurs [13]. Following foetus, radiation risk towards pregnant women was assessed. Radiation risk increases especially during the pregnancy period due to imaging diagnostic procedure such as abdominal radiography usually conducted during the early pregnancy period [14]. Another category were assessed is the children. They are at high risk because the pediatric tissues are more radiosensitive [15]. The children also have a longer life expectancy to express stochastic effects [1]. Trauma patients are also at risk of radiation. This is due to rapid diagnosis is needed and prioritized treatment of injuries is essential for trauma management [6]. Computed tomography (CT) scanning has become the screening test of choice for the most injuries where CT examinations results in significantly higher radiation doses than the plain radiography [16]. BMI is another criteria that is also assessed during the study of radiation risk. Low Body Mass Index (BMI) patients are more exposed to radiation risk because there is less tissue mass shielding an organ. Based on another study high BMI patients often receive a greater dose due to the thickness of the area being imaged increases therefore greater penetration is needed to create a satisfactory image [4]. Last category was studies were the gender. The studies show that the female patients are more vulnerable towards radiation-induced cancer. The rate of extreme radiation risk was higher in females which relates to higher risk of thyroid cancer and high radio sensitivity of breast tissues [17].

IV. MODALITY SPECIFIC EFFECT

Computed tomography has the highest radiation effect followed by nuclear medicine and radiography [1, 18]. For instance, studies on radiation risk of CT imaging and nuclear medicine fall in the range shown by direct epidemiological evidence which is connected with increased risk of cancer [4]. Radiation doses received from CT may vary between institutions. Risk from radiography fall in the range for which no epidemiological evidence exists to be connected with increased risk of cancer. Yet there is controversy on radiography risk where it is stated that a slight increased cancer risk may occur if the LNT hypothesis is correct. Apart from that, results of radiation may vary if different parts of the body are involved. Example radiography of abdomen and spine has higher radiation risk than radiography of the chest [2].

V. OCCUPATIONAL EXPOSURE

Effects of ionizing radiation doses to health care professions depend on the type of work being undertaken and the effectiveness of working procedures that are being followed. An enhanced DNA damage in hospital workers exposed to chronic low doses of ionizing radiation was reported following a data from cryptogenic studies. Concern also directed to physicians who perform invasive procedures requiring ionizing radiation exposure. The occupational dose of electro

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physiologists and interventional cardiologists tend to be higher compared to other health care profession due to the current increase use of interventional techniques. Potential adverse effects of occupational radiation exposure are closely associated with an increased incidence of cancer and cataracts. Pregnant women in the health care profession working in radiation environment are advised to alter the working practice due to the radiation risk that can harm the fetus [19].

VI. DISCUSSION

Technological advances of imaging diagnostic have certainly improved the physician's perspectives for better understanding of diseases and treating the patients. Unfortunately, few ethical issues have been raised due to the technological advance which creates uncertainty that may be harmful to the patients due to overuse of imaging diagnostic. Increased detection afforded by imaging diagnostic and overestimation of disease prevalence can confuse the evaluation of therapeutic effectiveness. Regardless of clinician's objective, many patients may have been diagnosed with disease they do not really have and many have been given therapy that they do not really need. Overestimations on disease prevalence may lead to traumatic evacuation such as suicide and abortion [26].

Utility of imaging diagnostic have been growing rapidly while overlooking the effect of radiation. As an example two review on imaging in pulmonary embolic disease in scientific journals did not refer to chest radiography however as an alternative recommended CT pulmonary angiography as the preliminary examination [17, 20, 21, 22]. This is due to the advancement of imaging diagnostic which facilitate doctor to examine images without difficulty. The advancement includes enhanced spatial resolution of images that has upshot finding of previously unknown relevance and undetected abnormalities [17]. The occurrence of radiation exposure from imaging diagnostic will grow exponentially since more physicians lay a greater trust on imaging diagnostic for patient management. In turn patients also are demanding more testing for reassurance of accurate diagnosis and treatment [9]. The diagnostic workups of hip bone deformity call for 3-dimensional rendering of bony structure but in certain country where the resources is concern and when there is limited access to the advanced imaging diagnostic, pelvic CT scans were used to obtain these images where greater radiation dose applied to obtain the image. On the other hand, medical malpractice such as equipment failure or human error causes the number of patients who had undergone imaging diagnostic was overexposed to high doses of radiation. Though the truth of negligence is apparent, the nature of the injury suffered by the patients' remains to be established [23]. Even though the emergence of non–ionizing imaging modalities represents safer alternatives such as Magnetic Resonance Imaging (MRI) and ultrasound which is capable of being substituted with CT scan often CT scan is preferred due to limitations of MRI which includes limited availability, high cost, contraindications and the difficulties connected with functioning the MR machine [24, 25].

The future research should be focused towards reducing ionizing radiation as much is clinically practical. Research and development of new technology should have the potential to achieve advanced image resolution with the smallest radiation

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dose. The new technology used should minimize excessive radiation exposure using a dose as low as reasonably achievable to obtain proper resolution and thus preventing the need for imaging to be repeated. In addition future area of research on imaging diagnostic should include accessible methods of image portability. A universal accessible electronic medical record would get rid of the need for the imaging to be repeated. The universal accessible electronic medical record should contain a complete log of cumulative year to date and lifetime radiation exposure that would allow patients and physicians to make more informed decisions regarding the risk benefit ratio of further imaging that would be undertaken [31].

VII. CONCLUSION

Modern medicine depends on medico-nuclear and radiological procedures and they are essential tools and thus form the basis for many therapeutic decisions [27, 28]. Radiation exposure nevertheless is an unavoidable risk of imaging diagnostic and must be considered in isolation when it is ordered [29]. Increased consciousness among both health care professions and patients would help to reduce the number of inappropriate imaging diagnostic and the biological burden on future [4]. In most cases the benefits of imaging diagnostic will overshadow the radiation hazard and patient's management should not be changed on the basis of radiation risk [30]. Conversely, for certain subsets of patients, radiation hazard should be placed greater concern on the health care professions who have been constantly exposing themselves to radiation.

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