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Review Article

The road to radiation safety and ALARA: A review

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ABSTRACT

The rapid progress of medical and dental science with the invention of various drugs have benefited the mankind. The proper and correct diagnosis of diseases is the primary necessity before the treatment. The different imaging modality plays an important role in clinical diagnosis, teaching and in the field of research. With advent of modern technology in imaging medical imaging has also greatly influenced. A diagnostic radiograph has become a hotspot in diagnosis and the clinical applications. The technology advancement has greatly influenced the medical imaging in many ways even in the aspect of storage of images. Oral and maxillofacial radiography is the art of recording images of a patient's oral and associated structures. Radiographic examinations play an essential part of dental practice.

1. Introduction

Health physics and biology are involved in benefiting the man from the deleterious effects of radiation while benefiting in medicine by unrevealing the different diseases.[1]

It was also was beginning of a new era and revolutionary change in our understanding of the physical world.[2]

The discovery of x-rays by Wilhelm Conrad Roentgen in 1895 has crossed the field of into another milestone.

The news of this amazing breakthrough caused a major leap in the medical and scientific communities. The news has spread across the world. Doctors soon picked up on the beneficial uses of the x-ray photography and started using them as an aid and support in clinical diagnosis.[3]

However, the safety regarding their use was a point of discussion from time in memorial even though the users were unaware of the serious biological effect caused due to the radiation and had no means to measure it. So this has led to new information about the adverse effects of radiation and their wide acceptance.

The initial biological effect was as skin ulcerations that appeared after intense exposure to radiation fields. So in the early period limits of exposure was based on delayed defect like cancerous change. However, more adverse effect happen only on intense exposure, which are usually less. Due to the early ignorance of adverse effect, the scientist, physicians suffered a great loss, and well documented, which led some researches to publicize the dangerous effect. Soon after this clinical reports started coming, regarding the adverse injury caused due to radiation.

However first protection recommendations were given by the American engineer Wolfram Fuchs. Make the exposure as short as possible; do not stand within 12 inches (30 cm) of the X-ray tube; and coat the skin with Vaseline (a petroleum jelly) and leave an extra layer on the most exposed area.[4]

Dentist are more prone for radiation since they advise more number of radiographs of different types when compared to others health professionals. Even though standards are set up for the use still are not under regulations. Even the dose is very low when compared to medical modalities, the cumulative effect should be taken into consideration.[5]

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So initially in 1902, the previous days a dose limit of 10 rad per day was recommended which was based on the fogging caused on the photographic plate and not on the biological effect. But an year later 1903, animals studies conducted showed that x-rays be used for diagnostic and therapeutic effect, because it kills even living cells, while causing mutations to the normal cells causing cancer. This causes damage to the DNA, which result in mutations. Thus most susceptible organs are blood forming, and reproductive organs and lymphoid organs.[6]

In 1915, the British Roentgen Society had put forth resolutions to protect people from overexposure to X-rays in hospitals.[7]

A dose range was formulated by Arthur Mutscheller during A meeting held by the American Roentogen society in 1924 called "Tolerance". He called this range as safe after conducting a study on different personnel's working with x-rays. He defined this dose as a dose "assumed to be a radiation dose to which the body can be subjected without production of harmful effects" F. M. Sievert also arrived at about the same dose limits in his study. 1934 the US advisory committee on x-ray and radiation protection layed down the first formal standards for protecting people from adverse effect of radiation and hence the recommended dose was calculated and it was implemented. But the dose limit for external dose was augmented by 1941 by a limit on the amount of radium a person could tolerate inside the body. This finding was based on radium study held on 27 subjects. This was again used 1944 to study other radioactive materials like plutonium. But in 1945 this limit was again reduced based on animal studies held during that time with plutonium. All the previous limit was based on the distribution of radioactive materials over the tissues, but this was modified by another method of accounting for whole a year was implemented. International Commission on Radiation Protection (ICRP) translates to a body burden that is about the same as the working-lifetime limit set at Hanford during World War II.

After World War II 1949, different animal studies were carried out to study further on the adverse effects and developed new concepts regarding protection. On such was calculating the permissible dose. These included absorbed dose (measured in rad), dose-equivalent (measured in rem), relative biological effectiveness (RBE), which relates the rad to the rem for different types of radiations, the absorbed dose as a function of photon energy and depth in tissue. These were accepted by ICRP and NCRP in 1953 and 1954 respectively. In the early 50's studies were done on fruit flies and mammals demonstrated that genetic changes could be induced from very high radiation exposures. Thus radiation-induced genetic changes became a main concern. This led the scientist to study about the early assessment of the atomic-bomb survivors and found it was incorrect or it was never observed. However a fear of future genetic effects had taken a heat wave through the scholars.

Hence, ICRP and NCRP modified the dose limits to 5 rem per year in the 1957 and 1958 respectively or a limit of 235 rem for someone who works from ages 18 to 65. An annual limit to the public of 500 millirem per year. Recommended by NCRP at this same time. But By 1960 the Federal Radiation Council recommended an annual limit of 500 millirem per year and an average of 170 millirem per year.

As the time passed 1961, the observers noted that delayed adverse effect were beginning to show its effect on the humans as cases of leukemia had increased amount he survivors. This with other studies showed that different cancer ha different latency periods, or elapsed times, between irradiation of the individual and clinical observation of a malignancy. Leukemia has a latency period of 2 to 25 years.

This unmistakable appearance of different cancers led the scientist to rethink about the protection norms and paved the way to think that even a small low dose radiation can induce cancerous changes or mutations. Nevertheless there were no data exited to show a threshold dose for radiogenic cancers so that a small risk group can be compared with large persons working with x-rays receiving the above said dose.

These considerations made the organization to rethink in different way and move in a philosophical manner rather just observing the adverse effect alone and calculation the dose limits. The ICRP defined a system of dose control consisting of three parts:

1.1. Justification

No new methods has to be tried until it benefits wholly for the benefit of the patient.

1.2. Optimization

All doses should be kept as low as reasonably achievable (ALARA), considering the financial and social status of patient.

1.3. Limitation

That any individual dose should not exceed the limits set for appropriate circumstances.

By 1977 the philosophy changed but the limit set previously was unchanged. As 5 rem per year, ICRP adopted a more formal risk-based approach to setting standards.

By 1980 new estimates were calculated based on the ratio of neutrons to gamma rays in the radiation produced by the bomb, in the atomic- bomb survivors. The ICRP released a new set of international recommendations in 1990. The new recommended were limiting the radiation exposure to 10 rem over any 5-year period and 5 rem in any one year. The public limit was set at a 100 millirem per year averaged over any 5-year period. But by 1993 NCRP came with new recommendations based on stochastic and deterministic effect. The limit for deterministic effect were 50 rem per year to any tissue or organ and 15 rem to the lens of the eye to avoid cataract formation. Whereas the limit for stochastic effect or whole body radiation were 5 rem in any one year and a lifetime average of no more than 1.5 rem per year.[8]

Hence these developments can be grouped into different eras:

Predormant Era (1895-1905), in which no much dermal or internal hazard were observed among the workers. However the delayed effects were overlooked.

Dormant Era (1905-1925), in which the dose limit was put forth based on the delayed effects and other adverse effects. The dose limit was named as Tolerance dose.

Active era (1925-1945), during this time the dose limit was modified based on different studies, and different organizations came in to being. This era makes its importance as many radogrolgiva; protecting act was layed down by different organizations the manhatten engineer district reduced considerably the tolerance dose along with the production of plutonium in The Hanford Site.

Post active era (1949-1993) during this period various dose limits were reviewed based on different criteria. Different organizations came forward with different dose limits based on different aspect.

By 1993 the NCRP came out with final recommendations as to the dose limits which can be safely received by a personnel, even though many questions were still to be answered.

So by 1994 the dose limit of 5 rem became a parameter and limitation for the total estimated risk which resulted from both external and internal exposures.

Eventhough the first protection advice was given earlier in 1896, but different bodies came into being later.

Radiation protection regulations were prepared in several countries, by the early years of 1920, but by 1925 only the first International Congress of Radiology (ICR) took place and considered establishing international protection standards. By 1950 the ICR was reconstituted to the present ICRP recommend that all interested countries establish, each for itself.[9,10]

The ICRP was formed officially by 1928.ICRP works closely with other bodies like the International Commission on Radiation Units and Measurements (ICRU), and has links with the World Health Organization, the International Atomic Energy Agency. Over the years ICRP has laid down many recommendations. All these are confined to protection against only ionizing Radiations. ICRP emphasizes on radiation protection for ionizing radiation which needs to be treated with care rather than fear. ICRP strongly believes that the standard of environmental control to protect man will ensure protection to other species. ICRP recommendations mainly provide guidance on the fundamental principles on which radiological protection can be based. Over the last three decades or so, there has been a significant change in the emphasis in the presentation and application of the system of protection recommended by ICRP. More emphasis has been put on the over-riding requirement to keep all exposures "as low as reasonably achievable.

Dental radiography contributes enormous diagnostic benefit to patients, the increased effective doses, especially from CBCT examinations, are high enough to warrant reconsideration of means to reduce patient's exposure. Justification and optimization of a procedure along with dose limitations are absolutely essential in clinical practice.[11]

Different studies conducted across the country showed varying result. But none had applied fully the protective measures. Many studies done were questionnaire based. Study conducted by Rathi Rela et al. on the topic named Knowledge, Attitude and Practice of Radiation Protection Protocols amongst Students of a Dental College, has the conclusion on the negative side.[12]

Similar study was conducted by Agrawal B et al. on the topic named Evaluation of Radiation Protection Awareness amongst General Dental Practitioners of Western Rajasthan in India where the author advised to conduct continuing education programs on the radiation protection aspect.[13]

In another study by Sumona Pal et al. got the result as the protective measures were not satisfactory and they reinforced the use of ALARA principle.[14]

In another review article by GD Crane namely - Radiation shielding in dentistry: an update, warrens the use of different protective shields in the radiology department during the procedures to ensure maximum safety to the patients.[15]

In different studies all authors are of the view that radiation dose and exposure should be reduced to the patient and dental personnel and radiation protection to be implemented effectively in diagnostic radiography.

The rules laid down by AERB (Atomic Energy Regulatory Board) in India is mandatory to be followed. The mission and principle of AERB is follow the principle of ALARA strictly.[16]

The rules laid down by the AERB insists on following this so that the various detrimental biological effects due to radiation can be avoided. "SMART" – a code for obtaining this can be followed.

Shielding is appropriate?

Marking of the film, ID etc. are appropriate?

Area collimation is appropriate?

Restriction on motion appropriate?

Technical setting is appropriate?

So as per the literature the operational goal of ALARA is to manage the radiation dose to the patient to be commensurate with the medical purpose. The goal is to use the appropriate dose to obtain the desired image or desired therapy. With the advent of CBCT the radiation dose has reduced to a great extent. Whatsoever the goal is to get a diagnostic radiograph with a minimum exposure to the patient by applying ALARA principle.[17]

In medicine, it is best understood as "management of the radiation dose to the patient to be commensurate with the medical purpose", with the goal of using the appropriate dose to obtain the desired image or desired therapy.[18]

Physicians and radiologists should be aware of the radiation risks and benefits associated with medical exposure, understand and implement the principles of radiation protection for each patients.[19]

2. Conclusion

Use of radiation protection with the strict emphasis on ALARA principle, in dentistry we can obtain a diagnostic radiograph. Unnecessary or casual referral to X-ray examination should be avoided by medical practitioners to avoid minimal radiation hazards.

The safety culture need to be established in the institution.

Awareness about radiation hazards and adherence with medical ethic should be made mandatory. The dental curriculum should also modify syllabus so it involves the emphasis on the use of radiation protection along with ALARA principle.

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None.

4. Conflict of Interest

The authors declare that there is no conflict of interest.

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