EDITORIAL

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PREFACE: How Dangerous Are X-ray Studies That We Undertake Every Day?

The editors of the *New England Journal of Medicine* presented the eleven most important medical developments of the past thousand years in the first issue of the year 2000 (1). Internal imaging of the human body was selected as one of those developments. Since Wilhelm Conrad Roentgen discovered x-rays in 1895, medical applications of x-rays have been accepted worldwide as essential tools for protecting and improving human health. On the other hand, they also represent by far the largest human-made source of radiation exposure.

X-ray is one of ionizing radiations that carry enough energy to free electrons from molecules. When biologic tissue is exposed to ionizing radiations, hydroxyl radicals can be created from their interaction with water molecules; these radicals in turn interact with nearby DNA to cause strand breaks. It can lead to induction of mutations which are linked to carcinogenesis (2). People are exposed to radiation on a daily basis from various sources, such as natural radioactive materials in water, food and stones, cosmic rays, nuclear power generation and x-ray diagnosis or treatment. Radiation dose limit for individual members of the public is 1 mSv per year, i.e. one-hundredth of the maximum limit for radiation workers. On the contrary, the guiding principle is: the dose should be as low as reasonably achievable. This is called the "ALARA Principle" and is central to all radiation safety.

X-rays have been used in the medical field for almost 130 years, but the introduction of computed tomography (CT) in the 1970s was revolutionary. The use of CT has increased rapidly and it now became one the most popular examinations owing to recent technical advancements, such as multi-detector CT and hybrid imaging. According to the OECD Health Data 2015, Korea had a large number of CT scans hitting 37.7 per million, which is the sixth-largest among the OECD members. It is estimated that more than one in Koreans underwent CT scans in each year and they are increasing 20% per year since 2005. CT emits a powerful dose of radiation, in some cases equivalent to hundreds of plain radiographs, resulting in a marked increase in radiation exposure in the population. Radiation exposure by CT scan per person was more than half of total radiation exposure by diagnostic x-ray.

It is very difficult to calculate how many cancers will result from medical imaging. Even though no large-scale epidemiologic studies of the cancer risks associated with CT scans have been reported; a commonly quoted estimate for excess cancer mortality from radiation exposure is 1 death per 2,000 scans. It was estimated that 1.5%-2% of all cancers in the United States may be attributable to the radiation from CT studies (2).

According to recommendations of International Commission on Radiological Protection (ICRP), radiation protection (RP) is based on three fundamental principles: justification, optimization and dose limitation (3). The principle of justification requires that any decision that alters the radiation exposure situation should do more good than harm. The principle of optimization requires that the likelihood of incurring exposures, the number of people exposed and the magnitude of their individual exposure should all be kept as low as reasonably achievable, taking into account economic and societal factors. The third principle of dose limitation requires that the dose to individuals from planned exposure situations, other than medical exposure of patients, should not exceed the appropriate limits recommended by the Commission.

RP represents a substantial part of the quality management system in our clinical practice. It could be achieved in several ways, including decreasing the number of unnecessary procedures as well as the dose per procedure. Rigorous effort should be paid to build-up evidence-based guidelines that offer guidance as to when imaging study of ionizing radiation is indicated. Healthcare providers should fully understand the fundamental principles of RP, and have to inform patients of risks before imaging. The industry, the standardization organizations as well as many professional medical societies are also dedicating significant effort to radiation safety aspects in medicine. The best outcome will only be accomplished when all the actors manage to work together.

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