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Are we being exposed to radiation in the hospital?

Yeonghee Kim

Sunflower-Korean Association of Lawyers Against Nuclear Power Plants Representative

Unconsented Harms of Medical Radiation Need to Be Explained

X-rays or computed tomography (CT) scans are performed frequently in the hospital for health examination or treatment purposes. Medical radiation involves applying radiation such as X-rays, gamma-rays, or beta rays, injecting radioactive isotopes into the body, or administering them orally to take imaging studies or treat diseases such as cancer.

When the human body is exposed to radiation, cells can die, become malignant, or even mutate. If cells die, it can be harmful to tissues or organs. If DNA inside a cell is damaged, the cell can turn to cancer. If DNA damage occurs in a sperm or egg, it can lead to genetic problems such as congenital anomalies in the offspring.

Over-the-counter painkillers or cough medicines provide a detailed description of their side effects. In comparison, in Korea, when you undergo X-ray or CT imaging, you are not given an explanation of the harms of radiation exposure or how much radiation you would be exposed to.

The rooms in the hospital where radiological exams such as X-rays, CT scans, or angiograms are performed display a sign "Radiation Zone" or "Caution: X-ray Radiation." However, no explanation on the dose each patient would be exposed to or effects of radiation on health is offered. Moreover, when you undergo a radiological examination multiple times, you cannot learn how much radiation you had been exposed to over a certain period of time (cumulative dose). No one informs you, nor do you have any way to figure it out on your own.

According to a case evaluated by the Supreme Court of Korea, when a doctor performs a medical practice on a patient, the doctor is responsible for providing an explanation of the treatment method, its necessity, and expected risks, so that the patient can weigh the benefits and risks sufficiently before deciding whether to receive the treatment. Such a principle also applies to the case of radiation studies.

Significant Radiation Can Be Exposure by Imaging Tests

The millisievert (mSv) is a unit indicating the effect of radiation on living organisms and 1 millisievert is the annual dose limit for the general public. Though the amount of radiation varies depending on the test and device, the radiation doses produced from diagnostic radiological exams are as shown in Table 1 according to the data of United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

Use of Diagnostic Medical Radiation in Korea

As of 2011, the number of CT scanners in Korea is 35.9 per

Table 1. Effective dose from diagnostic radiological examinations

Exam type	Effective dose per exam (mSv)
General X-ray	
Chest PA	0.1
Lumbar PA	1.2
Abdomen	0.8
Mammography	0.3
Fluoroscopic imaging techniques	
Upper GI series	2.6
Colonography (lower GI series)	7.4
Angiography	
Cardioangiography	11.2
Computed tomography (CT)	
Head CT	2.4
Thorax CT	7.8
Abdomen CT	12.4
Pelvic CT	9.4
Nuclear medicine diagnostic tests	
Bone Tc-99m	4.74
Cardiovascular Tl-201	40.7
Thyroid scan Tc-99m	3.75
Thyroid scan I-131/I-123	30.5
PET	6.42
PET-CT combined	7.88

From United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). UNSCEAR 2008 report to the General Assembly, with scientific annexes (http://www.unscear.org/unscear/en/publications/2008_1.html).
PA, posterior-anterior; GI, gastrointestinal; PET, positron emission tomography.

Table 2. Radiological exams and exposure doses in Korea, 2007-2011

Year	No. of annual diagnostic medical imaging studies of the total population	Annual per capita radiological imaging exams (times)	Annual per capita diagnostic radiation exposure dose (mSv)	Radiation exposure dose from CT scans out of the annual radiation exposure dose (%, mSv)
2007	$160x10^6$	3.3	0.93	49.30 (0.46)
2008	$180x10^6$	3.7	1.06	49.90 (0.53)
2009	$190x10^6$	4.0	1.17	52.1 (0.61)
2010	$210x10^6$	4.3	1.28	54.70 (0.7 mSv)
2011	$220x10^6$	4.6	1.4	56.4 (0.79)
2007/2011 Increase ratio	35%	39%	51%	7.1% p

From Korea Ministry of Food and Drug Safety. National implementation of patient dose monitoring system for CT scan; 2014 Jan 22 (http://www.mfds.go.kr/index.do?seq=22654&mid=675).
CT, computed tomography.

one million people, which is the third greatest prevalence among the Organization for Economic Cooperation and Development countries, after Iceland (42.2 units) and the US (40.7 units). According to an analysis by the Korea Ministry of Food and Drug Safety (MFDS) of a big data set consisting of one billion cases of radiological exams performed for diagnostic purposes in hospitals from 2007 to 2011, over this five-year period, the annual number of diagnostic radiological exams of the total population increased by 35%, the annual number of radiological exams per capita by 39%, and the annual per capita diagnostic radiation exposure dose by 51% (Table 2). CT scans accounted for 56.4% of all annual diagnostic radiation exposure.

In 2011, CT scans, which accounted for a mere 2.8% of the total number of radiological exams, was the source of 56.4% of the annual per capita radiation exposure dose. The radiation exposure dose from a CT scan ranges between 100 times and 500 times that of a general radiology study, depending on the body part. Moreover, as more radiation in CT scans enhances the quality of the image, if the device operator lacks awareness of the risks of radiation exposure, he or she may apply a higher dose of radiation to obtain better image quality than is needed.

According to the Korea Health Insurance Review and Assessment Service (HIRA), as much as 20% of CT scans were duplicates taken within 30 days of a previous CT scan from 2007 to 2011, typically when patients transferred between hospitals for re-examination. The author has personal experience with just this situation: The author was told to have a CT scan retaken, in spite of having the result of one, taken immediately before from another hospital. Despite the author's expertise on this subject, as a patient, the author still had no choice but to undergo a second scan as required by the hospital. As expected, no one offered an explanation of the risks of radiation exposure that the unneeded second exam posed.

Health Exams and Radiation Exposure

The MFDS's study was on radiological exams for both health checkup purposes as well as treatment purposes for patients with diseases. However, many radiological studies are being performed for cases of health examination alone. The 2011 Korea Health Statistics showed that 51.8% of the population aged 19 or older in Korea had undergone a health checkup within the previous two years, among whom 9.2% had comprehensive health examinations.

A research team at Seoul Medical Center conducted a survey on a total of 296 health screening institutions, including health screening centers of university hospitals and general hospitals as of 2013. The results showed that the minimum radiation dose that individuals can be exposed to through comprehensive health exams was 2.49±2.50 mSv on average. Moreover, depending on the addition of optional exams, the maximum dose reached as high as 14.82±9.55 mSv on average. As many as 31 institutions (10.5%) yielded 30 mSv or higher maximum exposure doses. The exposure dose of the institution with the highest dose was up to 40.1 mSv. The contribution to the total exposure was comprised largely of CT scans (72%), contrast radiography (16%), positron emission tomography (PET, 9%), and X-rays (3%). In short, one health checkup can expose a person to radiation 2.5 times higher than the annual dose limit for the general public (1 mSv), or on average 14.8 times, if an abdominal CT or PET CT is added.

According to Korea Radiation Watch, more expensive health checkups are associated with higher effective doses. For examinations that cost below 1 million Korean won (KRW, approximately US$1000), the average effective radiation dose is 1.43 mSv. In comparison, for exams that cost between 1 and 2.99 million KRW, the dose was 6.5 mSv; exams that cost 3 to 4.99 million KRW, it was 16.42 mSv; and for exams higher than 5 million KRW, the dose rose to 25.46 mSv. This demonstrates a very strong correlation between the increase in health checkup costs

and effective dose. Those who pay high fees for their checkup may have higher expectations for their care, but in fact, they are exposed to more radiation.

Secondary Consequences of Radiation Therapy

Besides radiation used in health examinations or diagnostic imaging, radiation for treatment conditions such as cancer also poses risks following radiation exposure. According to the cancer registry analysis data in the US, it is suspected that about 8% of all cancer cases are caused by radiation therapy. While secondary cancer accounts for about 14% of all cancer cases, radiation therapy to treat primary cancer is thought to be a major cause of secondary cancer. In cases in which radiation was applied for breast cancer treatment, the risk of secondary cancer occurring in the unaffected breast was reported to be proportional to the dose of radiation given. For pediatric patients in particular, whose cell division is active, the risk of secondary cancer following radiation therapy is a critical issue.

Radiation Exposure Risk to Medical Staff

Medical institutions without proper awareness or accurate information on the harms of radiation exposure might overuse radiological studies for patients because they can increase profitability by using costly radiological imaging modalities. Nonetheless, one study reported that the awareness of referring physicians (who order radiation-based studies) or radiologists (who perform the studies) about the risk of radiation is low. Another report showed that 76% of radiologists, 73% of emergency department doctors, and 100% of patients underestimate the radiation exposure dose from CT scans. Such lack of awareness of the risk of radiation may not only increase the radiation exposure to patients but also to medical professionals.

In fact, a case was reported in an academic publication in which a doctor who had treated patients using medical radiographic devices for 20 years ended up having his finger amputated after it necrotized due to chronic exposure to radiation. With the increasing use of radiation modalities such as radiographic devices, the risk of orthopedic doctors' long-term radiation exposure is growing. Furthermore, according to the 2014 radiation safety management status audit report by the Board of Audit and Inspection of Korea, management of radiation exposure to radiation-related healthcare professionals including doctors or nurses exposed to radiation via mobile C-arms is substandard.

Risk of Low-dose Radiation Exposure

An international study reported important findings on the effects of low-dose (100 mSv or below) radiation exposure to the human body. The study was conducted on a cohort of about 300 thousand workers who had worked for more than one year in the nuclear industry in France, the UK and the US The results revealed that the group that had been exposed to radiation of around 1.1 mGy (milligray) on average per year had increased risks of leukemia or other types of cancer. This International Nuclear Workers Study drew an association between cumulative, external, and consistent exposure to low-dose radiation and various cancers including leukemia. In other words, it was clearly and epidemiologically demonstrated that even exposure to low-dose radiation of 100 mSv or below can linearly increase cancer mortality according to the radiation dose.

International Trends in Medical Radiation Exposure Regulation

In the UK, since 1992, patients' radiation exposure doses are calculated and mandatorily recorded in their medical records. Annual exposure doses of each patient are then taken into consideration before performing imaging studies. In the US, it has been mandated that radiological devices provide information on the size of the radiation dose being applied at the time they are given, and radiation doses from imaging modalities are displayed. The state of California stipulated in law that all providers using CT scans should record patients' radiation exposure doses, and provide the data annually when relevant organizations request them. Australia implements an authorization system for medical organizations for managing radiation exposure. The system is evaluated to help mandate radiation exposure management, by relating it with future insurance payments.

A Radiation Dose Monitoring System, Developed by Ministry of Food and Drug Safety Yet Not in Use

The Korea MFDS developed a patient dose monitoring system in 2012. The system is electronic software that converts radiation data generated from diagnostic radiation modalities into the effective dose in Sieverts and records and manages the data of individual patients. The MFDS announced that they would implement a CT radiation dose record and management program in medical organizations nationwide beginning in February 2014, which would enable patients to check their exposure dose online in real time whenever they receive CT studies.

Nonetheless, until as of the present (the end of December, 2015) the system has not been enacted into law. Initially, the scheme was intended to help doctors view patients' cumulative dose on a national patient radiation dose database in order to make decisions on radiological exams and provide sufficient explanation and information on exposure doses to patients before and after their exams.

After the MDFS announced their planned monitoring system, some political and medical societies expressed disagreement with notifying patients of this information. Their logic was that if radiation dose information is made available, patients may refuse to undergo needed examinations. However, patients have the right to decide which exams or treatments they undergo, and their right should be respected.

Necessity for Legalization and Implementation of a Medical Radiation Dose Management System

Radiation exposure management is done for medical professionals but not for the general public who receive medical radiation. Therefore, it is urgent to legislate the establishment of a medical radiation exposure management system. Radiation exposure management for individuals should be applied to all types of studies, including X-rays, CT scans, angiograms, radionuclide imaging, and fluoroscopy. Furthermore, radiation exposure doses that individuals receive from all medical institutions should be managed comprehensively, so that people know their data and risks. Hospitals need to view the cumulative dose of patients before ordering exams to recommend non-radiological studies that can replace magnetic resonance imaging or ultrasound studies, in case the patient's exposure dose is deemed high. They should also accept radiation studies taken at other hospitals and avoid duplicate studies.

Conflict of Interest

The author has no conflicts of interest associated with material presented in this paper.

ORCID

Yeonghee Kim *http://orcid.org/0000-0002-8411-9134*

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Correspondence: Yeonghee Kim
11 Seocho-daero 49-gil, Seocho-gu, Seoul 06596, Korea
Tel: +82-2-3477-2323
Fax: +82-2-3477-2324
E-mail: ilaw21@daum.net