Management of diagnostic x-ray radiation in developing countries

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ABSTRACT
The purpose of this study is to provide a simple, inexpensive, and effective method to prevent the scattering of x-ray radiation by using a lead apron in the x-ray rooms of developing countries.

In developed countries, the scattering of x-ray radiation among patients and radiographers in diagnostic x-ray rooms has been minimized by various methods. However, in some developing countries, scattered x-ray radiation has not yet been adequately contained. The policy of As Law As Reasonably Achievable (ALARA) requires that patients who are waiting for their examinations must be protected from scattered x-ray radiation. However, from the author’s experience, protection from scattered x-ray radiation in x-ray rooms is often insufficient in developing countries.

In addition, major public hospitals in big cities are overwhelmed with patients because radiology resources in developing countries are concentrated in the big cities. Moreover, the situation is made worse by short working hours in public hospitals. Hours from 10 a.m. to 3 p.m. are typical. Because of the circumstances, radiographers, who are in a rush to finish all of the examinations within their normal working hours, sometimes allow patients to enter the x-ray rooms while they are waiting for their examinations.

Chest and abdominal x-rays are the most common kinds of diagnostic x-ray examination in developing countries. Thus, in this study, anthropomorphic chest and abdominal phantoms were x-rayed for measuring the scattered x-ray radiation with and without protection using a 0.25mmPb lead apron at specific points from the anthropomorphic phantoms in the x-ray room. The lead apron was hung on a mobile apron-hanger and placed next to the anthropomorphic phantom. The scattered radiation dosimetry for chest x-rays proves that this simple method reduces scattered x-ray radiation to 15% at one-meter point and to almost 0% at the two-meter point from the anthropomorphic phantom in the x-ray room. Lead aprons are generally available in most developing countries, and the method described is simple and effective to reduce scattered x-ray radiation in the x-ray rooms.

INTRODUCTION
In modern hospitals of industrialized countries, the demand for diagnostic radiology has recently increased dramatically, and techniques have become more sophisticated along with the development of electronics and computer technology. In contrast, there is a great discrepancy in the availability of radiological services and equipment in developed and developing countries. The World Health Organization (WHO) reports that about two-third of the population in developing countries has no access to essential radiological services. On the other hand, regarding the increasing number of people who are dying of circulatory diseases, the demand for diagnostic radiology is expected to increase in developed countries as well as in developing countries (1). Consequently, medical exposure to the population is expected to increase gradually (2).

As far as the safe use of x-rays in developing countries is concerned, Ghana could be used as an example. In Ghana, there were no institutional performance checks following major repairs of faulty equipment, nor were there routine checks at regular intervals to ensure the consistent performance of the equipment. Moreover, quality assurance for providing the radio diagnostic information at the lowest possible cost with the least possible exposure is not always available (3). This situation may oppose the policy of ALARA. One reason for this problem may be simply lack of money. The data shows that a comparison of the expenditure on medical equipment per capita is just 0.5 U.S. dollars in Sub-Saharan Africa. In contrast, the UK and USA spent 21 U.S. dollars and 66 U.S. dollars, respectively (4). However, in the author’s experience in developing countries as an expert with the Japan International Cooperation Agency (JICA), radiation protection management has not always had a high priority in hospitals. Some other reasons for this problem in developing countries are as follows:
1) Enthusiastic managers for radiation protection are not always available.
2) Measuring devices for radiation exposure are not always available.
3) Radio diagnostic equipment is much more complicated than general medical equipment.
As a consequence, protecting patients in developing countries from unnecessary x-ray radiation must be organized and accomplished with achievable techniques. Based on this concept, the goal of this study is to provide an easy method for preventing the scattering of diagnostic x-rays among patients in developing countries.
METHOD

The concept of this preventative method is fairly easy to manage. The necessary materials are one lead apron and a mobile apron-hanger. Reduction of scattered radiation among exposed subjects may be achieved by placing a lead apron on the mobile apron-hanger next to the person being x-rayed. The experimental set-up used for chest x-rays and abdominal x-rays is shown in Figures 1 and 2 (a) and (b), respectively.

The lead apron is a Kyokko UAB 0.25mmPb. The x-ray source is a Shimadzu Circlex 0.6/1.2 P38DE-80 tube coupled to a single-phase generator ED 150L. The bucky stand is a Shimadzu BR-1 for chest x-rays and the bucky table is a Shimadzu BK-1 for abdominal x-rays. The anthropomorphic phantoms are Kyoto Kagaku thorax phantom and lower torso phantom. The measuring devices for detecting scattered radiation are a radiation monitor controller, Radcal, Model 9015, and an ion chamber, Model 10×5-180.

The scattered radiation at the specific points for the chest and abdominal x-rays were measured by the ion chamber with and without the lead apron. The effectiveness of this easy method was evaluated by comparing the results of scattered radiation dosimetry.

For chest x-rays, the tube voltage, amperage, and exposure time were set at 120 kV, 100 mA, and 0.04 seconds, respectively. The focus film distance was 200 cm, and the rectangular exposure field of 35×35 cm was chosen. The height for ion chamber was on the centerline of the exposure field from the floor. For abdominal x-rays, the tube voltage, amperage, and exposure time were set at 80 kV, 300 mA, and 0.12 seconds, respectively. The focus film distance was 100 cm, and the rectangular exposure field of 43×30 cm was chosen. The height for ion chamber was on the centerline of the lower torso phantom from the floor as shown in Figures 2 (b).

![Fig.1: The experimental set-up of the lead apron.](image-url)
Fig. 2: The experimental set-up used for chest x-ray and abdominal x-ray.
RESULTS AND DISCUSSION

The scattered radiation dosimetry for chest x-rays has proved that this simple method reduces the scattered x-ray radiation to almost 15% at the one-meter point and to 0% at the two-meter point from the point of measurement in the x-ray room. The radiation reduction achieved by using a lead apron for chest x-rays and abdominal x-rays with standard exposure factors is shown in Figures 3 and 4, respectively.

Fig. 3: The results of radiation dosimetry for chest x-rays without using a lead apron (a) and using a lead apron (b).
Fig. 4: The results of radiation dosimetry for abdominal x-rays without using a lead apron (a) and using a lead apron (b).
There are more sophisticated options to prevent the scattering of diagnostic x-ray radiation in diagnostic x-ray rooms. However, the performance and cost of all the protection options must be assessed, and a comparison is needed to define the optimum protection options (5). The price for one standard lead apron in Japan is 38,000 yen or about 360 U.S. dollars. Comparing the prices for comparable lead curtain and glass lead, the cost of a standard apron is 1/7 and 1/9, respectively.

One more important factor is comfort for the radiographers. If discomfort is associated with this radiation protection method, the radiographers will not use it. This simple method is easy enough to use in routine daily work.

CONCLUSIONS

One of the most important tasks for the radiological technologist in hospitals is minimizing the radiation to which the patients and health service workers are exposed. Radiation exposure is inherently damaging at the molecular level. Radiation exposure is likely to be repaired by cellular mechanisms, or eliminated by defense mechanisms of the body; however, some may survive and lead to malignant conditions. It is also recognized that hereditary effects and the induction of cancer have no observable threshold radiation dose.

The genetic risks by medical radiation exposure in developing countries is smaller than it is in developed countries, possibly, because people have less access to x-ray diagnosis. However, the size of x-ray rooms and construction materials used, affecting such things as the thickness of the walls in developing countries, are not always sufficient compared to the recommended standards by WHO for protecting people from the scattering of diagnostic x-ray radiation (6). Consequently, the concept of keeping all doses as low as possible while giving consideration to economic and social factors is important (5).

This study verified that using lead aprons for protection could inexpensively reduce the scattering of diagnostic x-ray radiation to a reasonable and tolerable level. The required instruments are one lead apron and a mobile apron-hanger, which are readily available in developing countries. Moreover, the lack of complication permits radiographers to manage the method easily during their daily routines.

Because of economic factors, there is a great discrepancy in the development of medical technology in developed and developing countries. Consequently, the quality of diagnostic x-ray equipment in modern hospitals in developing countries is likely to be poorer than that in developed countries. Actually, quality assurance associated with the use of diagnostic x-ray equipment in developing countries is considered less important than the working condition of the equipment. Moreover, the role of the person responsible for radiation protection management in hospitals is not clearly defined, especially when compared to western countries that specifically define the role of medical physicists. For improving the situation in the near future, these problems and difficulties in developing countries must be overcome through technical cooperation with experts in developed and developing countries.

REFERENCES