INTRODUCTION

As interventional radiology (IVR) has advanced and spread in recent years, there has been more and more exposure of patients and medical staffs to X-rays, and this has become a major problem. Alexander R. Margulis, who had first used the term "interventional radiology", referred to the problem of radiation exposure as early as 1967, when he discussed problems related to IVR in his paper entitled “Interventional diagnostic radiology - A new subspeciality”(1). This means that techniques which belong to the field of IVR were already available in those days, but at that time these techniques involved radiation exposure as a significant hazard. Subsequent advances in the design and specifications of radiological devices reduced radiation exposure, resulting in greater use of therapeutic techniques using fluoroscopy. Margulis said that this kind of radiological technique would be established as a subspeciality of radiology and would be carried further. In fact, IVR later spread more extensively than expected, but radiation exposure has become highlighted again. This paper will report on the present status of the problem of radiation exposure related to IVR and measures to prevent or reduce it.

PRESENT STATUS OF RADIATION EXPOSURE

One factor responsible for increasing radiation exposure related to IVR is the increasing number of patients who undergo IVR. The development of new IVR techniques and expansion of indications for their use have resulted in a rapid increase in the number of patients who undergo IVR. Furthermore, as the techniques of IVR have become more sophisticated and complex than ever, the time required to complete an interventional procedure IVR has been prolonged, resulting in a tendency for fluoroscopic exposure time to last longer. These factors are all responsible for the increasing exposure of patients and medical staffs to X-rays.

The frequency of radiography and the duration of fluoroscopy were compared between diagnostic angiography and IVR administered at the Osaka University Hospital. The average frequency of radiography and the average duration of fluoroscopy were 20 times and 43 minutes for cardiac IVR and 8 times and 32 minutes for abdominal IVR, respectively. These frequencies and durations were approximately double those for diagnostic angiography. The average absorbed radiation dose was calculated to be 1.14Gy for patients undergoing cardiac IVR. This dose level does not cause practical radiation injuries, but the duration of fluoroscopy needed for IVR is sometimes prolonged by inability to insert the catheter smoothly at the target point or for other reasons.

We analyzed the data concerning abdominal vascular IVR conducted in 1997 at the Osaka University Hospital. Fluoroscopy, lasting for more than 60 minutes, was performed on 51 cases (7.2%). Among these 51 cases, the most frequently used IVR technique was transcatheter chemoembolization for hepatocellular carcinoma (39 cases), and the second most frequent IVR technique was catheter placement for the treatment of metastatic liver cancer (9 cases). Angioplasty of peripheral arteries, arterial stenting and TIPS were used on one case each. The average skin dose level, calculated for these 51 cases, was evidently higher than 3 Gy. In 6 cases (0.85%), fluoroscopy lasted for more than 120 minutes. The average skin dose for these 6 cases exceeded 6 Gy. No patient, however, developed skin damage after IVR. This is probably because the area of skin irradiated is not fixed but changes during fluoroscopy.

RADIATION EXPOSURE OF INTERVENTIONISTS

Vascular IVR usually involves fluoroscopy using an under-the-table X-ray tube (under-tube fluoroscopy). It is not uncommon for an over-the-table X-ray tube fluoroscopy (over-tube fluoroscopy) to be used for non-vascular IVR. In a phantom experiment conducted by Hayashi et al. (Fukui Medical University), radiation exposure of the interventionalist after 30 minutes of under-tube fluoroscopy was 0.75 mSv, 0.95 mSv and 0.24 mSv tube at the height of the patient's level, 50 cm above the patient and 50 cm below the patient, respectively. The exposure of the assistant, who stood at a point 50 cm distant from the interventionalist, was less than half the exposure of the interventionalist. This means that the exposure of the interventionalist's eyes is unlikely to reach 150 mSv per year when using under-tube fluoroscopy.

When an over-tube fluoroscopy was conducted for 30 minutes, the exposure of the interventionalist was 0.66, 1 and 0 mSv at the height of 0, +50 cm and -50 cm relative to the patient's level, respectively. The exposure of the assistant was less than half that of the interventionalist. This means that if non-vascular IVR using an over-tube fluoroscopy, lasting for 30 minutes, is performed 3 times a week, the exposure of the
interventionalist's eyes will exceed 150mSv per year. Although the average duration of fluoroscopy for non-vascular IVR at the Osaka University Hospital is shorter (about 17 minutes), we see necessity for interventionalists to wear protective glasses if using an over-tube fluoroscopy (2).

HOW TO REDUCE THE EXPOSURE

Two points are important when discussing how to reduce radiation exposure during IVR.

1. “The interventionalist should have adequate knowledge concerning radiological protection and should always be aware of the fact that the patient and the staff (including the interventionalist himself/herself) are exposed to radiation during IVR.”

   Awareness of exposure of the patient will guide the interventionalist to minimize unnecessary radiography and fluoroscopy and pay adequate attention to the irradiation field. Awareness of exposure of the interventionalist will ensure that the interventionalist will wear protective clothing and glasses and remain as distant as possible from the source of radiation. The awareness of these possibilities will also encourage the interventionalist to become skillful and make efforts to complete the IVR in as short a time as possible.

2. “X-ray devices used for IVR need to be improved to minimize exposure and display the X-ray dose on a real-time basis.”

   First, the under-tube fluoroscopy should be used even for non-vascular IVR. At our facility, an X-ray device which can be used for both over-tube fluoroscopy and under-tube fluoroscopy (a product made by SHIMADZU) is used. We use the over-tube fluoroscopy only when its use is unavoidable (the percentage is very low). Another problem with X-ray devices is deterioration of the image intensifier (I.I). For the 9 X-ray devices that were investigated at 5 facilities, the relative Gx of the I.I. had decreased by approximately 50% after about 5 years. This suggests that the quality of fluoroscopic images becomes markedly reduced after about 5 years have passed since the X-ray device has begun to be used. The X-ray dose needs to be increased to compensate for this quality deterioration. It is therefore advisable to replace the X-ray device after adequate intervals of use.

   Regarding the radiation dose display function, the DSA devices used at our facility are equipped with a PEMNET system, capable of always displaying the total radiation dose of fluoroscopy and radiography. This system allows the interventionalist to ascertain the cumulative procedural radiation dose at any time on a real-time basis. Such a system should be adopted as soon as possible as a standard requirement.

REFERENCES