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Workplace Monitoring During Interventional Cardiology Procedures

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Abstract**—**Interventional cardiologists are at greater risk from radiation exposure as a result of the procedures they undertake than most other medical specialists. A study was performed to evaluate operator dose during interventional cardiology procedures and to establish methods of operator dose reduction with a radiation protective device. Different procedure technique and use of protective tools can explain big difference in the annual equivalent dose received by the professionals. Strategies to prevent and monitor radiation exposure, advanced protective shielding and effective radiation monitoring methods should be applied.

Keywords**—**absorbed dose rate measurements, annual equivalent dose, protective device.

I. INTRODUCTION

INTERVENTIONAL cardiology is recognized as a high-radiation- risk practice, and evaluation and follow-up of occupational doses should be considered an important part of quality assurance programmes [1].Cardiovascular interventional therapy is effective therapeutically for cardiovascular diseases and reduces the morbidities of coronary artery disease, peripheral vascular disease, cardiac arrhythmia, and congenital heart disease. However, interventional cardiologists working in high-volume cardiac catheterization laboratories are exposed to significant occupational radiation risks of developing certain diseases, including hematopoietic cancers, thyroid diseases, skin diseases, cataracts, or upper respiratory disease [2].Scatter radiation levels in the vicinity of the patient may be quite high under normal working conditions [3]. If protection tools and good operational measures are not used, and if several complex procedures are undertaken per day, the professionals will be exposed to significant occupational radiation risks. To reduce and prevent radiation-associated diseases, the amount and duration of radiation exposure that may be harmful to the interventional cardiologist should be well defined. Strategies to prevent and monitor radiation exposure, including new fluoroscopic equipment with lower radiation doses, advanced protective shielding, and effective radiation monitoring methods, should be applied by current interventional cardiologists [2]. Awareness of radiation dose levels can be maintained by providing regular education about the radiation dose and radiation protection as part of an ongoing educational programme.The wide variation and lack of reduction in operator doses strongly suggests that more attention must be paid to factors influencing the operator dose. Numerous patient, physician and shielding factors influence the operator dose to different degrees [4].

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Since the operator dose is proportional to the patient dose, optimizing the patient dose benefits both the patient and the operator.

Studies of radiation doses received during X-ray procedures by cardiologists and other clinical staff have been reviewed. The number of interventional procedures is steadily increasing together with the potential for staff to receive high doses, and it is important that appropriate protection measures are in place for interventional operators and that their doses are monitored [5] .

II. EXPERIMENTAL PROCEDURE

Interventional cardiologists are exposed to significant occupational radiation risk. It is necessary to determine their exposure so that the risk can be managed in the context of ALARA programs. The ALARA principle, which emphasizes utilizing techniques and procedures to keep exposure to a level *a*s *l*ow *a*s *r*easonably *a*chievable, should be followed to minimize the risk of radiation exposure to medical professionals. A study was performed to evaluate operator dose during interventional cardiology procedures and to establish methods of operator dose reduction with a radiation protective device.

Absorbed dose-rate measurements around operator exposed during the interventional cardiology procedures were performed. Measurements were done by the calibrated Universal Monitor LB 123 "UMo", made by Berthold, Germany. LB 123 "UMo" is a versatile instrument for contamination, dose rate and activity measurements in radiation protection. It has been tested and approved by the German Office of Standards (PTB).

Absorbed dose-rate measurements around X-ray devices performed once in year, which is regulated by Law on Protection Against Ionizing Radiation and Nuclear Safety [6]. The Laboratory of Nuclear Physics in the Department of Physics, Faculty of Sciences, University of Novi Sad has a long-term experience in dosimetry measurements. Laboratory is Accredited by Accreditation Board of Serbia, and meets requirements of SRPS ISO/IEC 17025/2006, thus being competent for performing test of dose-rate measurements.

III. RESULTS AND DISCUSSION

Studies of radiation exposure in interventional cardiology laboratories have usually focused on the primary operator because the exposure of other medical personnel is lower. There are limited data pertaining to the exposure of physicians who assist during cardiac catheterizations and for technologists and nurses. The attending physicians generally have lower exposure levels than physicians-in-training who often spend more time in the position of the primary operator and work more slowly [7]. It should be recalled that the inverse square law is a potent factor influencing non primary operator and support staff exposure. The results of absorbed-dose rate measurements during interventional cardiology procedures are presented in Tables 1-3. All measurements were performed in real conditions, during the interventional procedures. Level of the background radiation is 0.12 μSv/h.

TABLE I
RESULTS OF ABSORBED DOSE-RATE MEASUREMENTS IN CARDIAC CATHETERIZATION LABORATORY.

	LOCATIONS	Fluorocopy [μSv/h]	Flurography [μSv/h]
1.	Control room	0.12	0.12
2.	Corridor - wall	0.12	0.12
3.	Intervention room-cardiologist Behind shield In the beam (hands)	 46 356	tube directed to the doctor 983 1583
4.	Intervention room-nurse	41	
5.	Intervention room-technician	2.8	

* Number of patents per day per team are from 8 to 10.

TABLE II
RESULTS OF ABSORBED DOSE-RATE MEASUREMENTS IN THE ROOM FOR HEMODYNAMICS

	LOCATIONS	Fluorocopy [μSv/h]		Flurography [μSv/h]	
1.	Control room	0.12		0.12	
2.	Corridor - door	0.12		0.12	
3.	Intervention room-cardiologist	without shield 211	with shield 32	without shield 335	with shield 170
4.	Intervention room-nurse	without shield 18	with shield 12	without shield 129	with shield 65
5.	Intervention room-technician	3.3		80	

Radiation received by specialists is mainly the scattered radiation from patients. The distribution of scattered radiation around the patient is non-uniform and asymmetric. The effective dose received by an operator within a 1.5-m radius from the edge of the table can vary by a factor of 40 depending on the operator's position. Generally, radiation doses are higher on the left side of the operator's body because the left side is closer to the X-ray beam when the cardiologist is standing at the patient's right side [4].

As shown in Tables1-3, the exposure of a staff stationed a few feet from the primary beam was less of the exposure for the primary operator, depending on the angulation of the beam relative to the staff's position. Effective dose for total body received by cardiologist worked in Laboratory for electrophysiology-radiofrequency ablation for one procedure is 0.973 mSv, Table 3. For a specific organ or body area the effective dose is calculated, Table 5. The effective dose received by nurse is 0.28 mSv, and for technician is 0.03 mSv per procedure. All kind of protection tools are available in laboratories. During the procedure staff did not use the protection screen. Maximum recommended annual effective dose for professionals is 20 mSv in Serbia, based on the Law on Protection Against Ionizing Radiation and Nuclear safety [6], so the cardiologist will receive this dose after 20 procedures.

TABLE III
RESULTS OF ABSORBED DOSE-RATE MEASUREMENTS IN THE LABORATORY FOR ELECTROPHYSIOLOGY-RADIOFREQUENCY ABLATION

	LOCATIONS	Fluorocopy [μSv/h]
1.	Control room	0.12
2.	Corridor - door	0.12
3.	Intervention room-cardiologist	without shield 973
4.	Intervention room-nurse	without shield 280
5.	Intervention room-technician	3.3

* Number of the patients per day 4-5. Duration of fluoroscopy per patient 50-60 min. During the procedures staff did not use movable shield.

It is extremely noteworthy that during the training with new X-ray devices, sellers (or service providers) of equipment did not have enough sensitive dosimeters, so the values of absorbed dose-rate measurements are not valid. Because of that, staff did not informed correctly about the real radiological risk. To reduce or prevent radiation risk, the amount and duration of radiation exposure that may be harmful to the interventional cardiologists should be well defined. Strategies to prevent and monitor radiation exposure, advanced protective shielding and effective radiation monitoring methods should be applied by current interventional cardiologist. Awareness of radiation dose levels can be maintained by providing regular education about the radiation dose and radiation protection as part of an educational program.

IV. Conclusion

Occupational doses of radiation in interventional cardiology are the highest doses registered among medical staff using x-rays. Radiation shielding is one of the most efficient and easiest methods to protect staff during interventional cardiology operation. One of the most important factors is that protection tools are available in catheterization laboratories and are used appropriately. The question is why these tools are not used in all catheterization laboratories and in all procedures. One likely reason is the lack of information and training in radiation protection. Further, the use of protective tools may be sometimes self defeating for the patient [3]. In these situations, the cardiologist should have sufficient knowledge of the radiation protection fundamentals to act in the most conscientious way for both doctor and patient. The most successful action to reduce occupational doses has been training in radiation protection.

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