

PRELIMINARY STAFF DOSE ASSESSMENT FOR COMMON FLUOROSCOPY GUIDED PROCEDURES AT KORLE-BU TEACHING HOSPITAL, ACCRA, GHANA

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Received 13 November 2018; revised 23 January 2019; editorial decision 29 January 2019;
accepted 1 February 2019

Preliminary studies on effective and eye lens doses of six Radiologists, four Cardiologists have been conducted for a period of 3 months. Electronic dosimeters positioned under and over lead apron of staff were used for the dosimetry. The estimated effective dose per month to Cardiologist and Radiologist were 0.01–0.07 mSv and 0.03–0.14 mSv, respectively. The estimated eye lens doses per month to Cardiologists and Radiologists were also 0.15–0.30 mSv and 0.53–3.39 mSv, respectively. The effective doses per month to staff were below the ICRP acceptable limit of 1.67 mSv/month but the upper limit of the range of estimated eye lens dose exceeded the ICRP acceptable limit by a factor of 2. Regular use of protective goggles and consistent eye lens dose monitoring is encouraged at the hospital for dose optimization.

INTRODUCTION

Staff performing fluoroscopically guided procedures is likely exposed to high radiation exposure among all medical occupational staff. Due to the nature (i.e. real time viewing) of procedures, long exposure times are recorded and the presence of the staff in the room is required^(1, 2). The continuous and systematic use of adequate protective equipment such as protective apron, thyroid shield can significantly reduce exposure to the workers directly involved in interventional procedures. The eye lens (when not shielded) could result in high radiation exposure leading to lens opacities and cataracts^(3–5). Therefore, International Commission on Radiological Protection (ICRP) reduced the recommended eye lens dose limit from 150 to 20 mSv per year⁽⁶⁾. Additionally, ICRP has recommend the use of two dosimeters for fluoroscopy staff (one dosimeter placed inside lead at waist level and another outside lead at neck level) in order to consider the unshielded parts of the body⁽⁷⁾.

Some studies on occupational exposure in fluoroscopy guided procedures have been done in Europe and America^(8–10) and none published to give the perspective of Ghana practices. Currently, studies performed in the country have focussed largely on patient dosimetry^(11, 12) and a study by Botwe *et al.*⁽¹³⁾ suggested an

unsatisfactory radiation monitoring of staff at Korle-Bu Teaching Hospital (KBTH). Also, procedure statistics from the Cathlab at KBTH indicates an increase from 15 to 20 procedures per year to 22–24 procedures per month.

Therefore, this study aimed to estimate effective and eye lens dose to staff performing common fluoroscopy guided procedure for a duration of 3 months. The knowledge of staff dose level and factors in this preliminary study is important requirement for optimization of radiological protection.

MATERIAL AND METHODS

A Shimadzu/Flexavision (Model: Collimator type R-30H and serial number 3Z0FF7D22045) over-couch and Siemens (model no. 10144181 and serial no. 640041673) under-couch fluoroscopy machines in different rooms were considered for the study. The study focused on the radiation monitoring of six Radiologists performing retrograde urethrogram, hysterosalpingogram, fistulogram, barium meal, and myelogram, biliary drainage, biliary stenting; and four Cardiologists performing coronary angiogram (CA), percutaneous coronary intervention (PCI) and right heart catheterization (RHC) for a period of 3

Table 1. Cumulative effective dose and eye lens dose to Radiologist and number of procedures per month for the considered procedures.

Type of procedures	No. of procedures per month	Effective dose (mSv)	Eye lens dose (mGy)
Rad 1 Retrograde uretrogram	32	0.03	0.55
Rad 2 Hysterosalpingogram	69	0.03	0.57
Rad 3 Hysterosalpingogram	69	0.03	0.53
Rad 4 Fistulogram, barium meal, myelogram	8	0.14	3.39

Table 2. Cumulative effective dose and eye lens dose to Cardiologist and number of procedures per month for the considered procedures.

Type of procedure	Fluoroscopy time (min)	No. of procedures per month	Effective dose (mSv)	Eye lens dose (mGy)
Card 1 CA, PCI	177.0	10	0.03	0.30
Card 2 CA, PCI, RHC	129.0	12	0.02	0.25
Card 3 CA, PCI, RHC	77.1	7	0.01	0.15
Card 4 CA, PCI, RHC	109.2	12	0.02	0.20

months. The fluoroscopy time for each procedure and the number of procedures were recorded. The required ethical clearance was sought for this study.

Personnel dose measurements

Four calibrated electronic personal dosimeters of type EPD MK 2.3 manufactured by Thermo Electron Corporation with corresponding serial numbers 00179975, 00178174, 00070491, 00179958 were used in this study. Two were issued to each staff to be used at the neck on the thyroid collar (surface dose) and one at the waist level inside the lead apron (deep dose) according to ICRP recommendation⁽¹⁴⁾. The deep dose equivalent at a depth of 10 mm [$H_p(10)$] and 0.07 mm [$H_p(0.07)$] were recorded after each procedure.

Dose estimation algorithms proposed by Carinou *et al.*⁽¹⁴⁾ and Swiss ordinance⁽¹⁵⁾ were used to estimate eye lens and effective dose, respectively. The chosen algorithms meet ICRP⁽¹⁶⁾ criteria of no underestimation and minimum overestimation of dose. Equation 1 is the effective dose estimation algorithm proposed by Swiss ordinance⁽¹⁵⁾.

$$E = H_p(10)_{\text{under}} + 0.05H_p(10)_{\text{over}} \quad (1)$$

Equations 2 and 3 are the eye lens dose estimation for under-couch and over-couch fluoroscopy tube respectively proposed by Carinou *et al.*⁽¹⁴⁾.

Under-couch fluoroscopy tube:

$$\text{Eye lens dose} = 0.75 \times H_p(0.07)_{\text{over}} \quad (2)$$

Over couch fluoroscopy tube:

Table 3. Comparison of effective dose per procedure of Cardiologists with other studies.

	Effective dose (μSv)		
	CA	PCI	RHC
This study	0.05–21.1	0.8–57.6	0.1–2.8
Morrish and Golstone ¹⁷	0.02–30.2	0.17–31.2	—
Fardid <i>et al.</i> ¹⁸	0.3–14.3	1.3–27.5	—

$$\text{Eye lens dose} = 1.46 \times H_p(0.07)_{\text{over}} \quad (3)$$

RESULTS AND DISCUSSION

Table 1 illustrates the number of procedures, cumulative effective doses and eye lens doses received by each Radiologist (rad) monthly. Rad 1, 2 and 3 received comparable effective and eye lens doses although the number of procedures and type of procedure are different. Rad 1 performed approximately half of the procedures of Rad 2 and 3 but their cumulative effective and eye lens doses are comparable. This could be attributed to the difference in the procedures and hence examination protocol. Rad 4 received doses in excess of a factor of 4.6 and 6.2 for effective and eye lens dose respectively. It could be seen that Rad 4 performed the least number of procedures but recorded the highest effective dose and dose to the eye lens. Again, this could be attributed to difference in the procedures performed and hence different examination protocols (i.e. staff position,

Table 4. Dose records of interventional radiology procedures using different configuration of the x-ray tube.

Procedures	Fluoroscopy time (min)	Equipment	Effective dose (mSv)		Eye lens dose (mSv)	
			IR	Ass. IR	IR	Ass. IR
Biliary drainage	14.3	Over couch	0.04	0.02	0.53	0.22
Biliary stenting	76.4	Under couch	0.05	0.01	0.67	0.11

use of protective devices, fluoroscopy time, radiographs taken) engaged.

Effective dose, eye lens dose, number of procedures and fluoroscopy time for each Cardiologist performing CA, PCI and RHC is illustrated in Table 2. It could be seen that Card 1 recorded a high fluoroscopy time and hence high effective and eye lens dose comparatively. Cardiologist doses are not dependent on the number of procedures performed but rather on the fluoroscopy time. Comparison of Cardiologist effective dose per procedure has been done with other studies in Table 3. The range of effective dose to Cardiologist published by Morrish and Goldstone⁽¹⁷⁾ had an upper limit more than that of this study by a factor of 1.4 for CA procedures but less by a factor of 1.84 for PCI procedures and those published by Fardid *et al.*⁽¹⁸⁾ was within the range of this study for both CA and PCI procedures.

The cumulative effective dose and eye lens dose to Radiologists and Cardiologists per month were all below the ICRP recommended dose limit of 1.67 mSv/month except Rad 4 whose eye lens dose was more by a factor of ~2. It must be mentioned that the amount of radiation received by each worker in this study depends on the frequent use of protective measure, i.e. thyroid shield and protective goggles.

Table 4 shows the influence of different x-ray tube orientation on the doses received by staff [interventional radiologist (IR) and assistance IR (Ass.IR)] performing what was otherwise the same procedure. The IR received more doses (effective and eye lens) than the Ass.IR by a minimum factor of 2. This could be attributed to the proximity of the IR to the source of radiation than the Ass.IR. The doses (effective and eye lens) to IR and Ass.IR for the different procedures are comparable although the fluoroscopy time for the under-couch tube orientation was more than the over-couch tube orientation by a factor of 5.

CONCLUSION

Assessment of preliminary Cardiologist and Radiologist doses has been conducted. Effective and eye lens dose of Radiologist performing different procedures were observed to vary due to different examination

protocols. Fluoroscopy time of Cardiologist has strong influence on staff doses irrespective of the number of procedures performed. Cardiologist and Radiologist cumulative doses per month compared well with other studies except one staff with eye lens dose greater than ICRP recommended dose limit by a factor of 2. Under-couch tube orientation for procedures is recommended due to low dose delivery to staff.

ACKNOWLEDGEMENTS

The authorship of this article acknowledges with gratitude the support of the radiologists and cardiologists for agreeing to participate in the study.

FUNDING

This work was supported by the International Atomic Energy Agency (CMR/16019) in collaboration with the University of Ghana.

REFERENCES

1. Davros, W. J. *Fluoroscopy: basic science, optimal use, and patient/operator protection*. Tech. Reg. Anesth. Pain Manag. **11**(3), 44–54 (2007).
2. Vanhavere, F. *Personal dose monitoring in hospitals: global assessment, critical applications and future needs*. Radiat. Prot. Dosim. **124**(3), 250–259 (2007).
3. Vano, E., Kleiman, N. J., Duran, A., Rehani, M. M., Echeverri, D. and Cabrera, M. *Radiation cataract risk in interventional cardiology personnel*. Radiat. Res. **174**(4), 490–495 (2010).
4. Vano, E., Kleiman, N. J., Duran, A., Romano-Miller, M. and Rehani, M. M. *Radiation-associated lens opacities in catheterization personnel: results of a survey and direct assessment*. J. Vasc. Interv. Radiol. **24**(2), 197–204 (2012).
5. Ciraj-Bjelac, O., Rehani, M., Minamoto, A., Sim, K. H., Liew, H. B. and Vano, E. *Radiation-induced eye lens changes and risk for cataract in interventional cardiology*. Cardiology **123**(3), 168–171 (2012).
6. International Commission on Radiological Protection (ICRP). *The 2007 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 103. Ann. ICRP **37**(2–4), 1–332 (2007).
7. International Commission on Radiological Protection (ICRP). *Avoidance of radiation injuries from medical*

- interventional procedures*. ICRP Publication 85, Ann. ICRP **30**(2), 7–67 (2000).
8. Clerinx, P., Buls, N., Bosmans, H. and de Mey, J. *Double-dosimetry algorithm for workers in interventional radiology*. Radiat. Prot. Dosim. **129**, 321–327 (2008).
 9. Covens, P., Berus, D., Buls, N., Clerinx, P. and Vanhavere, F. *Personal dose monitoring in hospitals: global assessment, critical applications and future need*. Radiat. Prot. Dosim. **124**(3), 250–259 (2007).
 10. Chida, K., Kaga, Y. and Haga, Y. *Occupational dose in interventional radiology procedures*. AJR Am. J. Roentgenol. **200**(1), 138–141 (2013).
 11. Gyekye, P. K., Schandorf, C., Boadu, M., Yeboah, J. and Amoako, J. K. *Patient dose assessment due to fluoroscopic exposure for some selected fluoroscopic procedures in Ghana*. Radiat. Prot. Dosim. **136**(3), 203–208 (2009).
 12. Gyasi, E., Schandorf, C., Boadu, M., Gyekye, P. K. and Yeboah, J. *Patient organ dose estimation due to some selected fluoroscopy procedures using kerma area product meter*. J. Appl. Phys. Sci. Int. **6**, 74–79 (2016).
 13. Botwe, B. O., Antwi, K. W., Adesi, K. K., Anim-Sampong, S., Dennis, M. E., Sarkodie, B. D. and Opoku, Y. S. *Personal monitoring of occupationally exposed radiographer in the biggest tertiary referral hospital in Ghana*. Saf. Health **1**–7 (2015). DOI:10.1186/s40886-015-0009-y.
 14. Carinou, E., Ferrari, P., Bjelac, O.C., Gingaume, M., Merce, S. M. and o'Connor, U. *Eye lens monitoring for interventional radiology personnel: dosimeters, calibration ad practical aspects of Hp (3) monitoring. A 2015 review*. J. Radiol. Prot. **3**(35), 17–34 (2015).
 15. Swiss Ordinance. Eidgenossisches Departement des Inneren und Eidgenossisches Departement fur Umwelt, Verkehr, Energie und Kommunikation: Verordnung uber die Personendosimetrie (Dosimetrieverordnung). vom 07.10.1999. SR 814.501.43. Swiss Ordinance, Bern (in German), 2008.
 16. International Commission on Radiological Protection (ICRP). *Occupational radiological protection in interventional procedures*. ICRP Publication 139. Ann. ICRP **47**, 1–118 (2018).
 17. Morrish, O. W. and Goldstone, K. E. *An investigation into patient and staff doses from X-ray angiography during coronary interventional procedures*. Br. J. Radiol. **81**, 35–45 (2008).
 18. Fardid, R., Mirzadeh, F. and Rezaei, H. *Occupational doses of cardiologists in cath labs and simulation method*. J. Cancer Res. Ther. **13**, 901–907 (2017).