Radiation eye injuries in medical staff working with fluoroscopy guided procedures in Bulgaria

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Purpose

Occupational radiation doses in fluoroscopy guided (FG) procedures are the highest in the medical sector [1], varying among procedures, facilities and physicians [2-4].

The eyes of the physicians are mostly exposed to radiation. As Vano et al. demonstrated, the scattered radiation doses to the eye lens of the interventional radiologist in typical working conditions can exceed 10 mSv/h in high-dose fluoroscopy modes and 50 mSv/h during image acquisition in cardiology laboratories when radiation protection tools are not used [5]. The current literature demonstrates wide variations (up to more than 1000-fold) in the radiation dose to the eye lens of medical staff per procedure, depending on a range of technical, patient-related and operator-related factors [4-6]. There are evidences that the annual dose limit of 150 mSv for occupational exposure for the eye lens [7] can be exceeded and radiation-induced cataract could be developed if non-optimized practice is used [8, 9].

Radiation induced cataract has been classified by the International Commission on Radiological Protection (ICRP) as a deterministic effect with a threshold of 2 Gy for acute and 5 Gy for protracted exposure [7]. A number of epidemiological studies with radiation workers [10, 11], patients undergoing radiotherapy [12] and computed tomography examinations [13], the astronauts [14], atomic bomb survivors [15] and Chernobyl accident clean-up workers [16], demonstrate that the threshold for cataract development is certainly less than was previously assumed. New observation even suggest a stochastic basis for radiation cataractogenesis, with an absence of a dose threshold and described by a linear, no-threshold model [17, 18]. In its latest recommendations, ICRP states that "new data on the radiosensitivity of the eye with regard to visual impairment are expected ... because of the uncertainty concerning this risk, there should be particular emphasis on optimization in situations of exposure of the eyes" [19].

The purpose of this study is to detect opacities in eyes of medical and paramedical staff involved in interventional procedures in Bulgaria, as a part of the RELID study, initiated in 2008 by the International Atomic Energy Agency (IAEA). The aim is to learn whether long-term chronic low-dose occupational exposure to x-rays is associated with development of lens opacities.

Methods and Materials

Methodology developed by the IAEA for its RELID (Retrospective Evaluation of Lens Injuries and Dose) project [20] was used.
Every participant in the study signed an informed consent form, describing:

- The purpose of the study
- The study procedure
- The study risks
- The study benefits
- Confidentiality statement and
- Principle of voluntary participation.

Every participant filled in a detailed questionnaire having information on:

- Profession and personal demographic data
- Models of the X-ray systems used in the past and at present
- Short description of the work inside the interventional room, location in the room and percentage of time inside the catheterization lab during a typical procedure
- Pattern of practice - use of ceiling suspended screen, led glass eye wear
- Personal dosemetry - use of dosemeter, number and location of dosemeters
- Typical workload currently and in the past
- Relevant medical history - diabetes, heart disease, cancer / chemotherapy, MRI, nuclear medicine procedures, phototherapy, skin disease, use of drugs; history of autoimmune disease or use of systemic corticosteroids, etc.
- Radiation examination of head as a patient (head CT, skull X ray)
- Ocular history - personal and family history of eye diseases, previous examinations for lens opacity for eye/ cataract, surgery for cataract, etc.
- Other factors - work with radiation, exposure to the sun, smoking, alcohol

Comprehensive slit lamp examination of both eye lenses was performed by experience ophthalmologists after a papillary dilation (Fig. 1 on page 4).

Each eye was tested separately for posterior subcapsular opacities, known to be the sign of radiation induced opacities [17, 21, 22]. The found opacities were scored using Merriam-Focht scale (Fig. 2 on page 5), assuming that the radiation cataracts develop sequentially with the earliest lens changes consisting of development of an opalescent sheen to the posterior capsule followed by the appearance of dots, vacuoles or diffuse opacities centered around the posterior lens suture. Continued cataract development leads to progression of these posterior changes, the involvement of the anterior subcapsular region and, ultimately, total lens opacification [21, 22].

A total 66 voluntaries were included in this study - 18 cardiologists, 24 paramedical staff (19 nurses and 5 radiographers) and a control group of 24 non-radiation workers (Fig. 3 on page ).
The study was performed in two phases. The first was performed in July 2009 in two cities by an international team of two ophthalmologists and three medical physics experts. Each ophthalmologist scored the opacities staging independently. A total of 25 people working in interventional rooms and a control group of 20 people not working with radiation were tested. The control group consisted of cardiologist, not involved in FG procedures and other voluntaries of different non-radiation professions.

The second round of eye testing was performed during the Annual Symposium on the Bulgarian Society of Interventional Cardiology when 17 radiation workers and 4 cardiologists not working with radiation were tested. The same methodology was applied but the eye testing was performed by only one local ophthalmologist, who participated in the first phase of the study.

Images for this section:

**Fig. 1:** Testing with biomicroscope (slit lamp)
Fig. 2: The Merriam-Focht scoring scale for radiation cataract staging [21]
Results

The distribution of the participants in the study by occupation and gender is presented in Table 1. The age of participants varied between 26 and 64 years and the experience of work in interventional cardiology - between 1 and 25 years.

Table 1. Distribution of participants in the study by occupation and gender

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Phase 1 (July 2009)</th>
<th>Phase 2 (October 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interventional cardiologist</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>(4 men and 0 women)</td>
<td>(9 men and 5 women)</td>
</tr>
<tr>
<td>Nurse in interventional cardiology</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>(1 men and 15 women)</td>
<td>(0 men and 3 women)</td>
</tr>
<tr>
<td>Radiographer in interventional cardiology</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(1 men and 4 women)</td>
<td></td>
</tr>
<tr>
<td>Total staff working with FG procedures</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>(6 men and 19 women)</td>
<td>(9 men and 8 women)</td>
</tr>
<tr>
<td>Control group</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>(6 men and 14 women)</td>
<td>(4 men and 0 women)</td>
</tr>
</tbody>
</table>

In the Phase 1 of the study identical scores were given by both ophthalmologists and this good agreement let the further study in October to be performed by only one of the ophthalmologist from this team.

The positive cases found in Phase 1, Phase 2 and pooled data of the study are presented on Fig. 1 on page 8. Eye opacities were found in 4 of 18 (22 %) of interventional cardiologists, 10 of 24 (42 %) of paramedical staff, or in total 14 of 42 (33 %) of the staff and only 2 of 24 persons (8 %) in the control group. Of total 16 positive cases, 6 (43 %) are with bilateral changes, 4 cases are with opacities in only left eye and 4 # in only right eye.

Our results support the preliminary conclusion from the RELID testing exercise held in Colombia, Malaysia and Uruguay [20] demonstrated an increased incidence rate of eye opacities in medical staff working in interventional cardiology. The results are consistent with the overall picture from the RELID study in Bogota [20, 23] showing that 21 of 76 (28%) persons working in interventional cardiology rooms had posterior subcapsular lens
changes in one or both eyes consistent with radiation exposure and similar eye opacities in only 4 of the 42 in the control group (9.5 %). The difference in findings between both studies is in the distribution of positive cases among the cardiologists and paramedical staff - 22 % for the cardiologist and 42 % for the paramedical staff in our study against 43 % and 9 % respectively in the Bogota study.

It was found difficult to reconstruct the eye doses because of the practice in the country of using only one dosemeter worn under the lead apron at the chest level. That why the analysis of the questionnaires was used to explain the results from the study.

Only one of the cardiologists with posterior lens changes never in 22 years practice used protective screen, while other three were with shorter work experience (2 - 7 years) declared using protective screen in 30 - 70 % of cases, but only in last two years. All of them never or rarely use eye glasses.

Both of the radiographers with eye opacities have been working more than 20 years with FG procedures. One of them works in non-cardiac interventional room and most often on the left side of the patient. Both have family history of cataract.

From nurses with eye opacities one has been working more that 20 years with FG procedures, 2 have between 5 and 10 years and other 4 - less than 5 years professional experience.

Typical position of nurse is on the right side of the patient, next to the cardiologist (Fig. 2 on page 9), but most of participants indicated 20 % of time working on the left side of the patient and two of them # 100 % of time in this position. Our measurements showed that scatter dose in this position commensurate that in the typical position of cardiologist.

Most of the paramedical staff do not use eye glass wear and only few declared to use it but irregularly. One of the nurses with eye opacities declared a family history of cataract and two have had head CT scans in last years. Nine of 14 (64 %) of persons with opacities are smokers.

Among cardiologists without opacities only 2 rarely use protective screen and all others use it in 50 - 100 % of time. During the discussion with participants it was recognized that even when used, protective screen sometimes is not positioned properly between the patient and operator, which increases the scatter dose rate to the head of the cardiologist and other staff.

Eye glass wear were used in more that 50 % of time by 40 % of participating cardiologist. Contrary, only 12 % of the paramedical staff uses regularly eye glasses and 63 % never wear them.
Images for this section:

Fig. 1: Distribution of participants in the study by professional groups
**Fig. 2:** Distribution of positive cases in Phase 1, Phase 2 and total by occupation.
**Fig. 3:** Typical position of nurses in the room
Conclusion

1. Posterior subcapsular lens changes consistent with X-ray exposure were found in almost 22% for the cardiologist and 42% for the paramedical staff, against only 8% for a control group.
2. Higher frequency of eye opacities in nurses was found compared to other studies. This can be associated with the work 20% of time on the left side of the patient without eye protection.
3. Nurses are advised to use eye protection glasses, especially in departments with high workload and when radial access is frequently used. Work on the left side of the patient should be avoided but whenever necessary eye glasses should be used.
4. The ICRP recommendation to use a second dosimeter at the neck/head level should be promoted for staff performing interventional fluoroscopy guided procedures.
5. Eye testing is recommended to be included in the regular medical surveillance of staff working with interventional procedures.
6. The increased rate of lens injuries in staff working with fluoroscopy guided procedures indicates the need of strengthening radiation protection measures and training for staff in interventional rooms for proper use of available fluoroscopy equipment modes and all protective means.

References


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