Radiation-Induced Cataract in a Vascular Surgeon with Occupational Health and Safety Management: A Case Report

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Abstract

Background: Radiation-induced cataract is a recognized occupational disease among healthcare workers exposed to ionizing radiation, particularly those involved in image-guided procedures.

Case Report: This case report describes a 32-year-old male vascular surgeon who was notified that his lens radiation dose exceeded recommended limits and was subsequently diagnosed with early bilateral posterior subcapsular cataracts (PSC) during ophthalmologic examination conducted as part of the institution's medical surveillance program. Occupational history revealed 40 months of radiation exposure, with reliable dosimeter records over six months estimating a cumulative lens dose of approximately 0.15 Sv [Hp(3)]— within a range in which increased risk has been reported. Inconsistent use of lead eyewear during earlier practice periods was noted, and no significant nonoccupational risk factors were identified, supporting a probable occupational radiation-associated cataract. Following diagnosis, radiation-protection measures were strengthened by upgrading lead eyewear from 0.07 to 0.75 mm Pb and implementing administrative and work-practice controls, in coordination with the occupational health team, to reduce exposure duration. These interventions were associated with a measurable reduction in lens dose from an average of 3.8 to 0.6 mSv per month.

Conclusion: This case of probable occupational radiation-associated PSC in a young vascular surgeon highlights the importance of routine ophthalmologic examination as part of medical surveillance for early detection of radiation-induced lens changes. It also adds to the limited literature on the development of cataract among vascular surgeons and underscores the value of integrating personal protective equipment with systematic radiation control measures to help reduce ocular exposure.

Keywords: Radiation-induced cataract; Radiation protection; Occupational health

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Exposure to ionizing radiation can cause both deterministic and stochastic health effects. Cataracts, particularly posterior subcapsular cataracts (PSC), are among the most clinically relevant deterministic outcomes due to the radiosensitivity of the ocular lens[1,2]. Globally, cataract remains a leading cause of visual impairment[3]. Of the three main anatomical subtypes—cortical, nuclear, and posterior subcapsular—PSC is most strongly linked to ionizing radiation. A recent review reported an association between PSC and low-dose radiation exposure[4]. This may result from both short-term and long-term radiation exposure[5], with occupational concerns primarily related to long-term, low-dose exposure that accumulates over time.

What is already known about this topic?

Radiation exposure has been associated with cataract formation, particularly PSC.

What does this study add?

This case suggests that radiation-induced PSC may occur in HCWs with chronic low-dose occupational exposure. It highlights an important occupational health concern and underscores the need for early ophthalmologic surveillance, standardized eye-level dosimetry, and consistent use of PPE.

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Healthcare workers (HCWs) exposed to ionizing radiation face a risk of developing PSC, especially among interventional cardiologists (IC), who show the highest prevalence in systematic reviews (RR 3.85,

95% CI 2.79 to 5.30)[6]. Recognizing this, regulatory agencies have introduced stricter exposure limits and emphasized consistent personal protective equipment (PPE) use[7]. However, recent evidence shows that for surgeons and other non-cardiology physicians, the association remains uncertain (RR ~2.29, 95% CI 0.26 to 19.97)[8]; not statistically significant, possibly leading to under-recognition of risk and less rigorous implementation of safety controls in these groups. We present a case of probable occupational radiation-associated cataract in a vascular surgeon with chronic fluoroscopy-related radiation exposure, highlighting persistent gaps in occupational health protection and the need to re-examine current safety management protocols.

Case Report

Patient information

A 32-year-old male vascular surgeon was referred for ophthalmologic evaluation after being notified through occupational radiation surveillance of elevated radiation exposure to the eye lens. He had approximately 1 year of professional experience in vascular surgery and had been involved in fluoroscopy-guided endovascular procedures. In accordance with the institutional occupational health protocol, the examination was performed to document his lens status following this exposure alert. At the time of evaluation, he was asymptomatic and denied blurred vision, glare, decreased visual acuity, eye pain, or other visual disturbances.

His past medical history was unremarkable, with no known diabetes mellitus, long-term corticosteroid use, previous ocular trauma, prior eye surgery, or other recognized risk factors for early cataract formation. He was a non-smoker, drank alcohol socially, and had no family history of cataracts.

Clinical findings

On ophthalmologic examination, best-corrected visual acuity was 20/20 in both eyes. Slit-lamp examination revealed early bilateral posterior subcapsular lens opacities (Figure 1). The remainder of the anterior segment examination was unremarkable. Visual field testing using Goldmann perimetry was normal, and fundus photography showed no abnormalities. Optical coherence tomography (OCT), including retinal nerve fiber layer analysis, was within normal limits in both eyes. No other significant systemic physical examination abnormalities were noted. In view of the patient's young age, the bilateral posterior subcapsular pattern, and the absence of major conventional risk factors, a detailed review of occupational radiation exposure was undertaken.

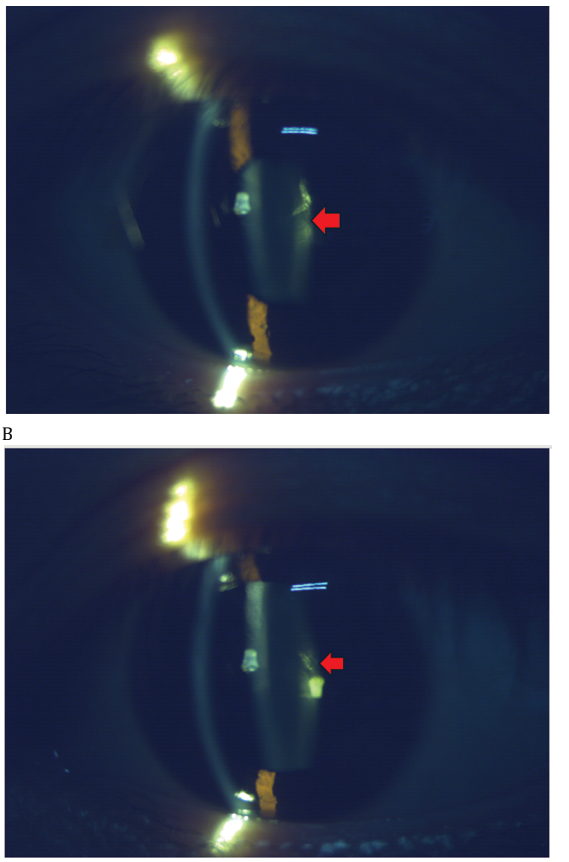

Figure 1. (A) PSC in the right eye of this patient, (B) PSC in the left eye of this patient.

Occupational exposure history

A comprehensive occupational history was obtained to characterize cumulative exposure to ionizing radiation across different stages of his surgical career. The patient reported fluoroscopy-guided procedural exposure during residency (approximately 0.5 hours/week for 4 months), fellowship training (approximately 10 hours/week for 2 years), and his first year as a faculty vascular surgeon (approximately 12 hours/week for 1 year), corresponding to a total exposure period of approximately 40 months. All procedures were performed in a hybrid operating room using standard fluoroscopic equipment, and he was typically positioned on the side opposite the C-arm (Figure 2).

During radiation procedures, he routinely wore a lead apron and thyroid shield throughout training and early practice. Radiation-protective eyewear (0.07-mm

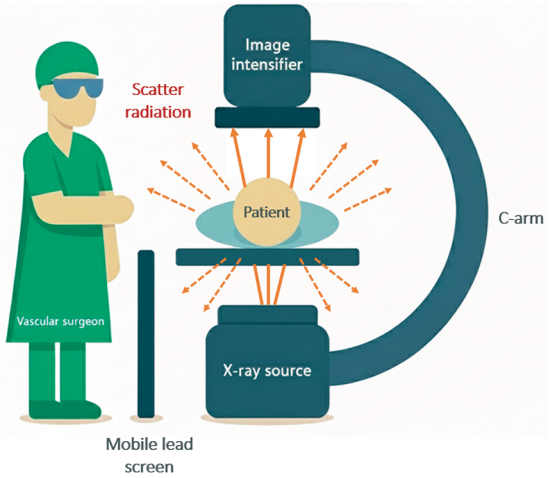

Figure 2. Position during the surgical procedure using the angiogram machine.

lead equivalent glasses) was introduced during the latter half of the fellowship following occupational health recommendations. Additional exposure-reduction practices included minimizing fluoroscopy time, using available shielding, and employing indirect imaging techniques whenever feasible.

Available occupational dosimetry records consisted of data from a single optically stimulated luminescence (OSL) dosimeter worn beneath the lead apron at chest level for routine occupational monitoring. The dosimeter was submitted for reading at 3-month intervals, and dose reports were provided by the Thailand Institute of Nuclear Technology. As dosimeter use and record availability outside these periods were not sufficiently complete for reliable analysis, only two consecutive 3-month monitoring intervals were included. Based on these records, the eye lens dose was retrospectively estimated and expressed as Hp(3). The cumulative estimated eye lens dose over this 6-month period was 22.78 mSv, comprising 7.73 mSv during the first 3 months and 15.02 mSv during the latter 3 months.

Diagnosis assessment

To provide a rough estimate of long-term occupational exposure, the 6-month cumulative estimated eye lens dose of 22.78 mSv was extrapolated over the 40 months of his surgical career, assuming a broadly similar average exposure pattern during periods without reliable dosimetry data. This yielded an approximate cumulative estimated eye lens dose of 151.88 mSv (0.152 Sv). Although this estimate should be interpreted cautiously because the precise cumulative dose could not be directly measured, its magnitude lies within or above the range of lens dose levels reported in the literature to be associated with radiation-related cataract formation, including reports suggesting thresholds as low as approximately 0.1 Gy (equivalent to 0.1 Sv for X-rays, for which the radiation weighting factor is 1).

In the context of the patient's young age, bilateral PSC morphology, prolonged fluoroscopy-related occupational exposure, estimated dose, and absence of major alternative risk factors, these findings support the diagnosis of a probable occupational radiation-induced cataract. The patient also reported less consistent use of shielding during fellowship training, which may have increased per-procedure eye lens exposure, whereas the total number of procedures during that period may have been lower than during his staff practice. Thus, while the extrapolated cumulative estimate may either underestimate or overestimate the true lifetime occupational eye lens dose, it remains an important component of the overall occupational disease assessment.

Management and follow-up

Following the diagnosis of early bilateral PSC, the surgeon's radiation-protective eyewear was upgraded from 0.07 to 0.75 mm lead equivalence. In response, the surgeon and occupational health team implemented administrative controls and work-practice modifications to reduce further eye lens exposure. These included increasing distance from the radiation source whenever possible, minimizing time spent close to the operative field during fluoroscopy, and adjusting procedural responsibilities within the team to reduce his direct exposure. Eye lens monitoring was intensified using an OSL NanoDot dosimeter (MicroStar reader) positioned near the left eye. During one month of follow-up after these interventions, the measured left eye lens dose was 0.6 mSv, suggesting lower monitored exposure. He remained asymptomatic, and no surgical treatment was indicated at that time. Continued ophthalmologic follow-up and enhanced occupational radiation surveillance were recommended. A timeline of his radiation exposure and clinical course is presented in Figure 3.

Discussion

This case highlights early bilateral PSC in a young vascular surgeon with prolonged occupational exposure to fluoroscopy-guided procedures. While previous systematic reviews have emphasized the increased risk of PSC among IC, radiation-induced

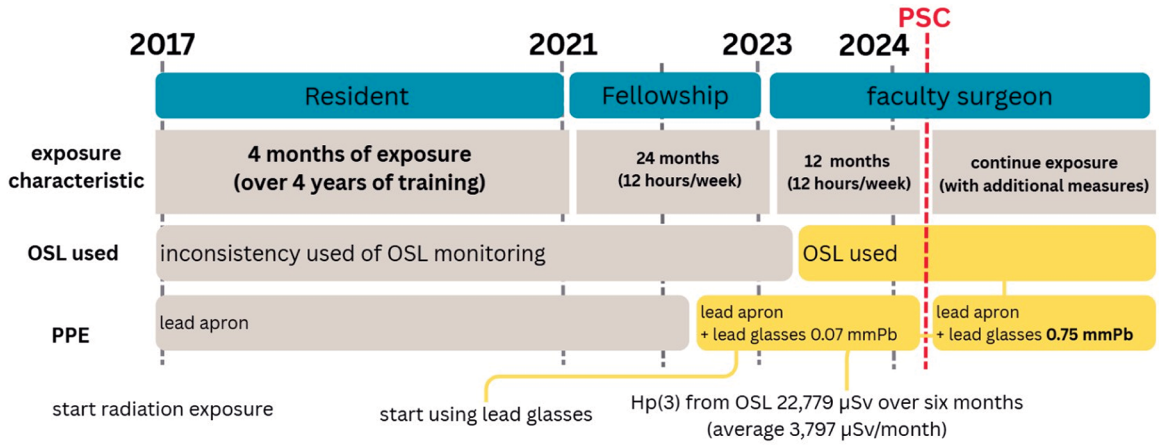

Figure 3. A timeline summarizing radiation exposure and cataract development.

Table 1. Radiation dose levels associated with lens opacity or cataract

Source	Dose	Type of radiation	Description
ICRP 2012[9]	0.5 Gy	Radiation	Eye cataract
IAEA[5]	>0.1 Gy/a	Ionizing radiation	Detectable opacity in the lens of the eye (chronic exposure)
	>0.15 Gy/a	Sparsely ionizing radiation	Visual impairment (cataract) in the lens of the eye (chronic exposure)
Nakashima et al. 2006[15]	0.6 Sv (90% CI <0.0 to 1.2)	Gamma and neutron	Cortical cataract
	0.7 Sv (90% CI 0.0 to 2.8)	Gamma and neutron	Posterior subcapsular cataract
Neriishi et al. 2007[13]	0.1 Gy (non-significant 95% CI <0 to 0.8 Gy)	Gamma and neutron	Postoperative cataract
Worgul et al. 2007[14]	0.34 Sv (95% CI 0.19 to 0.68)	Gamma and beta	Stage 1 cataract
	0.35 Sv (95% CI 0.19 to 0.66)	Gamma and beta	Stage 1 posterior subcapsular cataract
Wilde et al. 1997[10]	0.1 Gy	Gamma	Subcapsular punctate opacities and vacuoles in the lenses
Little et al. 2018[11]	0.1 Gy	Ionizing radiation	Cataract
Su et al. 2021[12]	100 mGy (OR 1.73, 95% CI 1.05 to 2.85)	Gamma	Posterior subcapsular cataract
Azizova et al. 2018[16]	0.25 to 0.50 Sv (RR 1.37, 95% CI 1.14 to 1.64)	Gamma	Posterior subcapsular cataract
Jacobson 2005[17]	0.2 Sv	Actinide	Posterior subcapsular cataract occurs in 15% of workers
	0.2 to 0.6 Sv	Actinide	Posterior subcapsular cataract occurs in 37.5% of workers

ICRP=International Commission on Radiological Protection; IAEA=International Atomic Energy Agency; CI=confidence interval; OR=odds ratio; RR=risk ratio

cataract in other proceduralists, including vascular surgeons, remains less well characterized[8]. This report adds to the growing literature suggesting that chronic low-dose occupational radiation exposure may also be relevant to cataract risk in a broader range of image-guided specialties.

Current evidence has prompted reassessment of the radiation dose at which lens injury may occur. In the International Commission on Radiological Protection (ICRP) Publication 118, the threshold for radiation-induced lens opacities was revised downward compared with earlier assumptions[9], and several studies have suggested that PSC may develop at cumulative lens doses lower than previously recognized, in some reports approaching 0.1 Gy[10-12]. Table 1 summarizes radiation dose levels associated with lens opacity or cataract reported in the literature[5,9-17]. In the present case, the retrospectively estimated cumulative eye lens dose was approximately 0.15 Gy. Although this estimate was derived from limited dosimetry data and should be interpreted cautiously, it falls within a range that has been discussed as potentially relevant to cataractogenesis. This interpretation is further supported by the patient's young age and the lack of major alternative risk factors identified in the available clinical evaluation. Therefore, the dose reconstruction is supportive of a possible occupational association, but it does not permit definitive inference regarding dose threshold or causality in this individual case.

In this case, the occupational exposure assessment also highlighted limitations in radiation protection practice, particularly the delayed and inconsistent use of leaded eyewear during earlier training and the absence of standardized long-term eye-level

dosimetry. These gaps are not unique to this patient; prior studies have described persistent barriers to effective radiation safety, including inconsistent PPE use and reliance on indirect or incomplete monitoring of eye lens dose[18,19]. Importantly, the lens changes in this patient were identified through occupational health surveillance while he remained asymptomatic and maintained normal visual acuity. This finding emphasizes that early radiation-induced lens changes may be clinically silent and supports the value of structured surveillance programs, particularly for HCWs with prolonged fluoroscopy exposure. It also reinforces the need for standardized dosimetry to improve exposure monitoring, along with enhanced technical measures, strengthened administrative controls, and improvement of ocular protection to reduce preventable lens exposure among procedural specialists[6,20,21].

Despite increasing regulatory attention to occupational eye lens exposure, important gaps in radiation safety persist, particularly outside traditionally recognized high-risk specialties. The use of leaded eyewear remains inconsistent in many settings, and eye lens dose monitoring is often sporadic or inferred indirectly rather than measured at eye level[22,23]. In addition, baseline and follow-up ophthalmologic assessments may be underused, limiting opportunities for early detection of lens changes. These systemic shortcomings highlight the need not only for improved technical and administrative controls, but also for comprehensive surveillance systems that integrate exposure monitoring with timely ophthalmologic evaluation for workers with substantial or prolonged occupational radiation exposure[24].

For occupational health teams, systematic dose monitoring and periodic health surveillance are important for identifying HCWs who may be at increased risk from chronic occupational radiation exposure[24]. When surveillance indicates elevated exposure or early lens changes, this should prompt a more detailed ophthalmologic assessment, reinforcement or upgrading of PPE, renewed radiation safety training, and structured follow-up monitoring. In the present case, replacing 0.07-mm lead-equivalent eyewear with 0.75-mm lead-equivalent protection, together with work-practice modifications, was associated with a lower monitored eye lens dose during short-term follow-up. When appropriate, temporary adjustment of radiation-intensive duties may also be considered as part of an individualized occupational health plan. Such measures may help reduce ongoing exposure while supporting safe continuation of clinical practice.

This report has several limitations. First, the cumulative eye lens dose was retrospectively estimated from incomplete dosimetry records and extrapolated across periods lacking reliable monitoring data, rather than being directly measured over the entire exposure period. Second, routine occupational monitoring relied on the inconsistent use and placement of a single dosimeter worn beneath the lead apron at chest level—rather than a standardized eye-level dosimeter—which may have led to an underestimation of the actual lens exposure. Third, part of the occupational exposure history was based on self-reports, introducing the possibility of recall bias. Additionally, temporal variations in workload, procedure complexity, fluoroscopy time, operator position, and adherence to PPE could not be fully quantified. Furthermore, individual susceptibility to radiation-related cataract formation was not assessed. Finally, as a single case report, these findings are not generalizable and cannot establish a definitive causal relationship or a dose–response association. Nevertheless, this case provides a clinically relevant signal supporting the importance of dedicated eye lens monitoring and occupational surveillance for fluoroscopy-exposed proceduralists.

Conclusion

This report presents a probable occupational radiation-associated PSC in a young vascular surgeon with prolonged fluoroscopy-related exposure. Radiation-induced cataract remains an important occupational health concern among HCWs exposed to ionizing radiation, and this case highlights the value of routine ophthalmologic examination for early detection of lens changes. It also illustrates that consistent use of PPE, together with systematic radiation control measures and occupational surveillance, may help reduce ocular exposure. Strict adherence to radiation protection principles, including the ALARA (as low as reasonably achievable) principle, is essential to safeguard long-term ocular health in radiation-exposed workers.

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Authors' contributions

SK collected clinical data, performed a literature review, and drafted the manuscript. CN assisted in data collection, contributed to the literature review,

and revised the manuscript. OT provided patient care, offered academic consultation, and revised the manuscript. CT verified the accuracy of patient information and reviewed the manuscript. All authors read and approved the final manuscript.

Clinical trial registration

Not applicable. This manuscript is a case report of an individual patient and does not report on a clinical trial.

Conflicts of interest

The authors declare no conflict of interest.

Data availability statement

The datasets generated and analyzed during the current study are not publicly available due to patient confidentiality and privacy restrictions. However, the data are available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

This case report was reviewed and approved by Khon Kaen University Ethics Committee for Human Research (Reference No. HE681258). Written informed consent was obtained from the patient for the publication of this case report and any accompanying images.

Use of artificial intelligence

The authors used ChatGPT (version 4o) solely for English language editing, including grammar, vocabulary, syntax, and punctuation. This tool did not generate scientific content, analyze data, or influence the interpretation of results. Additionally, Gemini (version 1.5 Flash) was utilized to assist in the preparation of Figure 2, illustrating the surgical positioning relative to the angiogram machine, to enhance visual clarity and presentation quality. The authors maintain full responsibility for the content of this manuscript.

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