ORIGINALARBEIT

Impact of radiation protection means on the dose to the lens of the eye while handling radionuclides in nuclear medicine

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Abstract

The human eye lens appears to be more radiosensitive than previously assumed. The reduction of the limit for the dose to the lens of the eye to 20 mSv per year has been passed in the current Euratom Directives (2013).
Therefore, in this work the impact of laboratory glasses and X-ray protective goggles was investigated and reciprocal attenuation factors (i.e. transmission factors) for different nuclides (Tc-99m, I-131, Y-90, F-18 and Ga-68) were determined. The radionuclides in typical geometry (syringe, applicator) were positioned at a distance of 50 cm to the eyes of four Alderson-Head-Phantoms. Different dosemeters measuring $H_p(3)$ *respective* $H_p(0.07)$ *were fixed to the eyes of the phantoms, either behind the glasses or without any protection means, respectively.*
The mean reciprocal attenuation factors were determined to be between unity for F-18 and I-131 using laboratory glasses (no attenuation effect) and < 0.01 for Y-90 using X-ray protective goggles. All other results were between these extremes. It has been shown, that prospective doses to the lens of the eye can be reduced significantly by

Wirkung von Strahlenschutzmitteln auf die Augenlinsendosis beim Umgang mit Radionukliden bei nuklearmedizinischen Anwendungen

Zusammenfassung

Die menschliche Augenlinse scheint strahlensensibler zu sein als bisher angenommen. Die Absenkung des Dosisgrenzwertes für die Augenlinse auf 20 mSv pro Jahr wurde in der aktuellen Euratom-Richtlinie (2013) festgelegt.
Aus diesem Grund wurde im Rahmen dieser Arbeit die Wirkung von Laborschutz- sowie Röntgenschutzbrillen untersucht und reziproke Schwächungsfaktoren (d.h. Transmissionsfaktoren) für unterschiedliche Nuklide (Tc-99m, I-131, Y-90, F-18 und Ga-68) ermittelt. Die verwendeten Nuklide wurden in ihren typischen Geometrien (Spritze, Applikator) in einem Abstand von 50 cm zu den Augen von vier Alderson-Kopf-Phantomen positioniert. Verschiedene Dosimeter für die Messgröße $H_p(3)$ *bzw.* $H_p(0,07)$ *wurden auf den Augen der Phantome positioniert*

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using appropriate radiation protection means, especially for those dose-relevant beta radiation emitting nuclides such as Y-90.

Keywords: Ocular lens, nuclear medicine, cataract, radiation protection means

und entweder hinter dem jeweiligen Schutzmittel oder ohne Schutzmittel exponiert.

Die ermittelten mittleren reziproken Schwächungsfaktoren liegen zwischen 1 für F-18 sowie I-131 für die Verwendung einer Laborschutzbrille (d.h. kein Schwächungseffekt) und < 0,01 für Y-90 bei der Verwendung einer Röntgenschutzbrille. Die anderen Ergebnisse liegen zwischen diesen Werten. Es wurde gezeigt, dass potentielle Augenlinsendosen mithilfe von geeigneten Schutzmitteln deutlich reduziert werden können, insbesondere beim Umgang mit hochenergetischen Betaemittern wie Y-90.

Schlüsselwörter: Augenlinse, Nuklearmedizin, Katarakt, Strahlenschutzmittel

Introduction

Recent epidemiological studies suggest that the human eye lens is more radiosensitive than previously assumed: The induction of cataract in the lens appears to have a significant lower dose threshold of about 0.5 Gy whereas the cataractogenesis might also be a stochastic radiation damage implicating no dose threshold at all [1–4].

As a consequence, the reduction of the dose limit for the eye lens from currently 150 mSv per year [5] to 20 mSv per year, or 100 mSv in any five consecutive years not exceeding a dose of 50 mSv per year has been passed in the current Euratom Directives (2013) [6] – and will have to be adopted in national legislation of the member states by the beginning of 2018.

As the eye lens is located in a tissue depth of about 3 mm, $H_p(3)$ is the most appropriate dose equivalent quantity for an estimation of the dose to the lens of the eye[1] [7]. Furthermore it has been shown that the properly calibrated $H_p(0.07)$-dosemeters available alternatively overestimate the eye lens dose for high-energy beta radiation ($E_{ß,max} \gtrsim 0.7$ MeV) up to a factor of 550 [7].

First measurements with $H_p(3)$-dosemeters (as an estimate for the eye lens dose) showed that dose rates depend on the nuclide used [8]. Handling especially high-energy beta-emitters such as Y-90 may induce quite high eye lens doses with respect to the new dose limit, so that special care has to be taken to avoid any exceedance.

The estimation of the expected annual doses to the lens of the eye of the staff in a nuclear medicine facility requires a detailed analysis of the department's working environment with regard to the kind of medical exams performed (diagnostics and/or therapy), nuclides used, and frequency of procedures. These configurations vary significantly between different nuclear medicine units, e.g. when comparing a facility providing standard diagnostic examinations using low energy gamma emitting radionuclides such as Tc-99m at a low dose rate with institutions offering internal radionuclide therapies utilising high energy beta emitters such as Y-90 at a high dose rate. In the latter case the number of therapies attended by a certain physician or nurse may be limited. The use of proper radiation protection means might prevent such limiting conditions. Therefore, in this work, the influence of appropriate radiation protection means for the reduction of the eye lens dose while handling radionuclides is investigated under well reproducible laboratory conditions.

Materials and Methods

For a most realistic experimental simulation of the eye lens exposure while handling radioactive sources, the Alderson head phantom (slices 0 – 12) was positioned in a source to eye distance of 50 cm. Using the anthropomorphic phantom, the geometry of the human head and possible scattering effects were simulated. To allow for measurements in parallel and to maintain symmetric conditions for the comparison with and without protection means, four Alderson phantoms were arranged on a circular arc, see figure 1 top.

The different dosemeters measuring $H_p(0.07)$, an estimate for the local skin dose, or $H_p(3)$, an estimate for the eye lens dose, and their corresponding characteristics are listed in table 1.

For each dosemeter type two exemplars were exposed during each measurement simultaneously. One dosemeter was fixed to the eyes behind the glasses, the other without any protection means in a symmetric alignment (with respect to the middle axis of the circular arc) in order to prevent possible geometry-dependent scatter effects. The protection means used were laboratory glasses (B-Safety, made of about 2 mm

[1] In the following 'eye lens dose' is used instead of 'dose to the lens of the eye' for convenience.