Schweizerische Eidgenossenschaft
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Eidgenössische Kommission für Strahlenschutz
Commission fédérale de radioprotection
Commissione federale della radioprotezione
Federal Commission on radiological protection

SCM, 06.09.2025

Empfehlung der medizinischen Subkommission der KSR zur Verwendung der kumulativen Dosis in der diagnostischen Bildgebung

1 Ausgangslage

Die Medizinische Subkommission der KSR (im folgenden SCM genannt) erhielt die Anfrage der Arbeitsgruppe der SGSMP zum Thema Massnahmen der Verbesserung des Strahlenschutzes beim Patienten, bei wiederkehrenden radiologischen diagnostischen Bildgebungsverfahren, durch Verwendung der kumulativen Dosis. Die Arbeitsgruppe setzt sich zusammen aus den folgenden Mitgliedern: Luca Bellesi (EOC), Jonas Ekeberg (USZ), Marie Nowak (CHUV) Tobias Pahleln (Hirslanden-Gruppe), Natalia Saltybaeva, Elina Samara (USZ, Leiterin der Gruppe).

Die SCM hat die Unterlagen erhalten und anlässlich ihrer Sitzung vom 18.06.2025 besprochen.

2 Fragestellung

Seit der Einführung von Dosismanagementsystemen (DMS) ist die Erfassung von Patientendosisdaten einfacher geworden. Gemäss der Schweizer Gesetzgebung müssen die Bewilligungsinhaber technische Parameter im Zusammenhang mit der diagnostischen Exposition dokumentieren, damit die vom Patienten aufgenommene Strahlendosis zu einem späteren Zeitpunkt bestimmt werden kann (StSV, Art. 33 und Röntgenverordnung, Art. 20, Abs. 4). Obwohl gesetzlich nicht vorgeschrieben, bieten DMS die Möglichkeit, die kumulative effektive Dosis (CED) für Patienten zu berechnen, die sich radiologischen Untersuchungen unterziehen. Darüber hinaus haben viele Kantone in der Schweiz kürzlich das elektronische Patientendossier eingeführt, in der Informationen zu allen medizinischen Untersuchungen einschliesslich der CED erfasst werden können. Die Verwendung der CED und ihre Interpretation kann jedoch für verschreibende Ärzte, insbesondere für Hausärzte, eine Herausforderung darstellen.

Im Jahr 2021 veröffentlichte die Internationale Atomenergie-Organisation (IAEO) eine von anderen internationalen Organisationen unterstützte Stellungnahme zu Massnahmen zur Stärkung des Strahlenschutzes von Patienten, die sich wiederholenden radiologischen Bildgebungsverfahren unterziehen. Motiviert durch die aktuellen Trends, interne Diskussionen in Krankenhäusern und die zunehmende Zahl von Artikeln, die sich mit CED befassen, wurde innerhalb der SGSMP eine Arbeitsgruppe (AG) gebildet, deren Aufgabe es ist, eine Stellungnahme zu deren Verwendung vorzuschlagen. Die Stellungnahme basiert auf einer Literaturrecherche zu Artikeln und Empfehlungen zur Verwendung der CED und wiederholter Bildgebung, die von einzelnen Forschern, anderen Gesellschaften und Organisationen veröffentlicht wurden [1].

3 Stellungnahme der KSR

Die SCM stimmt der Notwendigkeit der Erfassung der Strahlendosen der Patienten zu. Diese Erfassung ist eine Voraussetzung zur Erstellung diagnostischer Referenzwerte und der Durchführung epidemiologischer Studien zu Strahlenrisiken in der medizinischen Bildgebung. Dosismanagementsysteme (DMS) bieten eine Erfassungsmöglichkeit der Patientendosen verschiedener Bildgebungsverfahren und liefern damit Schätzungen der effektiven Dosen aus verschiedenen dosimetrischen Methoden. Die SCM sieht bei der Verwendung der effektiven kumulativen Dosis Unsicherheiten, da diese einerseits die individuellen Patientenrisiken nicht einschliessen und andererseits das Risiko einer zusätzlichen unerwünschten stochastischen Strahlennebenwirkung gemäss dem LNT-Modell von der Vorgeschichte des Patienten unabhängig ist. Eine einfache Addition der effektiven Dosen zu einer Kumulativdosis birgt die Gefahr, dass dieses Prinzip nicht beachtet wird und die daraus resultierende Überschätzung des zusätzlichen Risikos dazu führt, dass eigentlich medizinisch notwendige und gerechtfertigte Untersuchungen nicht durchgeführt werden. Konsequenterweise sieht die Strahlenschutzverordnung auch keine Dosisgrenzwerte für Patienten vor (Art. 5), sondern fordert die Optimierung jeder Einzeluntersuchung (Art. 32 Abs. 1).

Die SCM unterstützt auf Grund der vorliegenden Erkenntnisse somit die Stellungnahme der Arbeitsgruppe, dass der Einsatz medizinischer Diagnose-Untersuchungen auf Basis von anstehenden klinischen Überlegungen und ohne Berücksichtigung von früherer Strahlenexposition erfolgen sollte.

Beilage

[1] SSRMP: Position statement on the use of cumulative dose in diagnostic imaging

Position statement on the use of cumulative dose in diagnostic imaging

Working group members

Luca Bellesi (EOC), Jonas Ekeberg (USZ), Marie Nowak (CHUV), Tobias Pahlen (Hirslanden Group), Natalia Saltybaeva (LUKS), Elina Samara (USZ, chair of the group)

Introduction

Since the introduction of dose management systems (DMS), collecting patient dose data has become easier. According to the Swiss legislation, the license holders must document technical parameters related to the diagnostic exposure, so that the radiation dose received by the patient can be determined at later stage (StSV, art 33 and Ordinance of X-rays, Art. 20, al.4). Although not required by law, the DMS have the option to assess cumulative effective doses (CED) for patients that undergo radiological examinations. Moreover, many cantons in Switzerland recently implemented a unique patient file that can collect information on all medical examinations including the CED. However, the use of CED and its interpretation may be challenging for prescribing physicians, especially for family doctors [1].

In 2021, International Atomic Energy Agency (IAEA) published a position statement, endorsed by other international organizations, for actions on strengthening the radiation protection of patients undergoing recurrent radiological imaging procedures [2]. Motivated by the current trends, internal discussions in hospitals and the increasing number of articles discussing CED, a working group (WG) was formed within the SSRMP with the purpose to propose a position statement on its use. This document is based on literature review on articles and recommendations on the use of cumulative effective dose and recurrent imaging published by individual researchers, other societies and organizations.

It is important to note that the term “cumulative dose” often is used to describe the “cumulative dose at the reference point”, a metric provided by modern radiological equipment for the estimation of skin dose during interventional procedures. In this document, the acronym CED solely refers to the sum of the effective doses of different radiological procedures that patients undergo during a certain period.

Results and discussion

CED in the context of recurrent imaging have been studied since 1992 (search results from pubmed “cumulative effective dose” NOT cancer). Articles include cumulative doses for

patients undergoing recurrent imaging for cardiac, kidney and Crohn's diseases [3], patients in intensive care units with other causes for admission [4] or general discussions about the use of CED. There are both benefits and drawbacks by tracking CED.

First, it could increase awareness of radiation risks among referring physicians [2, 5, 6]. This is particularly important, as it has been shown that many radiological examinations are inappropriate [5, 7]. Tracking patients that have repeated non-justified examinations will allow reducing patient exposure without jeopardizing the patient's health. Secondly, the DMS could provide valuable information regarding population dose, by better defining typical radiation doses for radiological examinations, determining frequencies of radiological examinations and better estimation of the number of patients over the general population [6]. Finally, more information on high exposures is valuable when designing and revising imaging strategies for patients undergoing recurrent imaging [2, 6, 8-11].

However, we have identified five critical aspects, which will be further addressed:

1) the cumulative dose threshold was set either at 50 or 100 mSv
2) the age of patients varied from pediatric patients to a mean of 65 years old
3) the follow-up period varied from 1 to 20 years
4) the CED was associated with one medical condition
5) cumulative effective doses are based on effective dose estimations which are associated with huge uncertainties

The CED threshold of 50 mSv or 100 mSv is based on the assumption that a given effective dose is likely to imply a dose to the most exposed organ of at least the same magnitude [12]. Based on epidemiological data, there is good evidence of increased cancer risks in humans after an x-ray and gamma irradiation acute exposure at approximately 10 to 50 mSv and 50 to 100 mSv for a protracted exposure [13]. However, all effective dose estimations are based on the LNT model, meaning linearity and lack of threshold. The implication of linearity is that the absolute risk of cancer is the same for the first radiological procedure as for the last [14]. There are characteristics that increase radiosensitivity (age, gender, pregnancy, genetic diseases, etc.), but prior radiation exposure is not among them. Thus, patients with high CED are not in higher risks than patients with low CED [1, 14]. In other words, the added relative risk does not change based on the history of the patient and thus, the history should not play a role in the justification process.

Here, we need to further address the misuse of CED in medical exposure, as for example, making decisions about the appropriateness of medical procedures based on CED and its use as a dose limit for the individual patient [1, 6, 9, 14]. Misunderstanding of complex risk theory by referring doctors could have negative consequences for patients, as for example a) a necessary examination will not be performed at all, b) a necessary examination

will be performed at later stage, c) a necessary examination will be replaced with another one that gives less relevant information. In all cases, the correct diagnosis will be established only at a later point in time, if it all, leading to unnecessary patient suffering and a possible increased risk of death. In critical or emergency situations, the benefits of medical imaging tests far outweigh any radiation-associated risks and can save patient's life. Stochastic risks from previous imaging should not influence justification of further exposures [14]. For appropriately ordered procedures, the acute benefit is usually greater than the risk associated with the radiation [5]. CT scans can identify life-threatening injuries, allowing for immediate intervention. Repeated imaging studies over time provide a comprehensive view of a patient's condition, allowing healthcare providers to track changes and guide treatment decisions. This is particularly valuable for chronic diseases or cancer follow-up. Thus, the use of CED related to previous examinations in order to justify any radiological examination might seriously compromise patient health and well-being. A further risk in the use of CED is that the image quality may be sacrificed to reduce patient exposure. In that case, the examination results may also be compromised and the examination might need to be repeated, thereby increasing the total radiation dose.

Some practical cases of possible accumulation of radiation dose are examined below and may help illustrate other issues. In the first case, a patient suffering from a chronic disease implies a need to repeatedly irradiate the same body region. In that case, there is some concern for increased risk of tissue reactions or even for stochastic effects. However, there is no scientific or medical consensus on what to do when a specific cumulative organ dose is reached. What it is important in that case is to follow-up the patient and provide the best healthcare possible. In the second case, the patient does not suffer from one medical issue, but undergoes several radiological examinations for many diseases. In that case, the CED would be the simple sum of different examinations, but with no concern about a specific organ. In the third case, the DMS of an institute tracks the CED for the examinations that the patient underwent in the specific institute and over the period that the DMS was active. For the individual patient, the CED would probably be underestimated as the patients undergo radiological examinations in various institutes. Also, the DMS appeared only recently in the market, so earlier examinations would be omitted, and there are still many limitations in the DMS connectivity with modalities other than CT. The last case concerns specific studies, as we saw in the literature, where the follow-up period for patient doses varied from 1 to 20 years. These studies, however, only concern specific groups of patients, not individual patients, and were not and can not be routinely performed for all patients. The data from these studies remain very important for epidemiological and radiobiological research and for optimization purposes [6], but do not directly provide benefit for the individual patient.

Besides the above practical drawbacks, we need to address an important scientific gap. To start, let us examine the calculation of the CED, according to the following formula:

$$CED = \sum_i E_i = \sum_{i,T} w_T \cdot H_{i,T} = \sum_{i,R,T} w_T \cdot w_R \cdot D_{i,T,R} \quad \text{(Equation 1)},$$

where E_i is the effective dose of each medical procedure i, w_T is the tissue weighting factor, w_R is the radiation weighting factor, $Hi,_T$ is the equivalent dose for each organ or tissue T and $D_{i,T,R}$ is the absorbed dose for the different tissues and organs. The calculation of E is based on the ICRP recommendations 103 [15].

Since E is a derived quantity and not a physical dose quantity, there are several underlying uncertainties that need to be taken into account. These include uncertainties in the risk coefficients themselves, as well as uncertainties in the methods used to calculate the effective dose. The organ dose calculations ($D_{T,R}$) refer to physical or computational simulations of phantoms that mimic a reference patient and not the individual patients for whom we aim to estimate the exposure. Martin in his publication [16] listed the estimated standard errors in the quantities used for the estimation of the effective dose (e.g. dosimeter calibration and statistical error in Monte Carlo simulations) and concluded that the actual effective dose for the individual patient may differ up to 40% from the calculated effective dose. Regarding the weighting factors of Equation 1, it is important to note that the parameter w_T has been regularly revised in ICRP reports 26, 60 and 103, thus, the calculation of effective dose is subject to variation over time [15, 17, 18]. Furthermore, w_T bring huge uncertainties for the estimation of the individual patient dose, as they are population-averaged (age, gender) and based on a limited number of individuals and may not accurately represent diverse populations (other ethnicities). Moreover, the tissue weighting factors ignore individual differences in radiosensitivity. Although ICRP 103 recognizes that biological effects may depend on both total dose and dose-rate, the latter is not taken into account when estimating effective doses [15]. Thus, CED, being the sum over effective doses, also inherits all uncertainties and disadvantages of E.

Conclusion

In summary, tracking the radiation dose of the patient is necessary as it allows further optimization of the procedures, defining diagnostics reference levels and performing epidemiological studies on radiation risks from medical imaging. The DMS allow tracking of patient doses from different procedures and provide estimations of effective doses based on different dose metrics. However, effective doses are associated with large uncertainties and cannot express individual patient risks. As cumulative effective doses constitute a sum over dose contributions from various examinations, it suffers from the same kind of uncertainties.

Using cumulative doses for justification purposes and refraining from an indicated radiological procedure may be detrimental for the patient's health [19].

Proposed action

The WG proposes to endorse the content of the AAPM statement on the use of the cumulative dose for patients undergoing medical imaging examinations as it is addressed to healthcare professional and provides the necessary information in form of frequently asked questions (FAQ). The AAPM accepts that other societies may endorse the document (for instance, The Radiological Society of North America RSNA). The statement can be found online here: AAPM Position Statements, Policies and Procedures - Details

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