



Proper Use of Radiation Dose Metric Tracking for Patients Undergoing Medical Imaging Exams

Frequently Asked Questions

Introduction

In August of 2021, the American Association of Physicists in Medicine (AAPM), the American College of Radiology (ACR), and the Health Physics Society (HPS) jointly released the following position statement advising against using information about a patient's previous cumulative dose information from medical imaging exams to decide the appropriateness of future imaging exams. This statement was also endorsed by the Radiological Society of North America (RSNA).

It is the position of the American Association of Physicists in Medicine (AAPM), the American College of Radiology (ACR), and the Health Physics Society (HPS) that the decision to perform a medical imaging exam should be based on clinical grounds, including the information available from prior imaging results, and not on the dose from prior imaging-related radiation exposures.

AAPM has long advised, as recommended by the International Commission on Radiological Protection (ICRP), that justification of potential patient benefit and subsequent optimization of medical imaging exposures are the most appropriate actions to take to protect patients from unnecessary medical exposures. This is consistent with the foundational principles of radiation protection in medicine, namely that patient radiation dose limits are inappropriate for medical imaging exposures. Therefore, the AAPM recommends against using dose values, including effective dose, from a patient's prior imaging exams for the purposes of medical decision making. Using quantities such as cumulative effective dose may, unintentionally or by institutional or regulatory policy, negatively impact medical decisions and patient care.

This position statement applies to the use of metrics to longitudinally track a patient's dose from medical radiation exposures and infer potential stochastic risk from them. It does not apply to the use of organ-specific doses for purposes of evaluating the onset of deterministic effects (e.g., absorbed dose to the eye lens or skin) or performing epidemiological research.

The position statement specifically addresses stochastic risks from radiation exposure – i.e., the potential for increased risk of developing cancer. It does not address deterministic tissue effects such as radiation-induced skin damage, for which it is known that radiation effects are cumulative over a period of a few months. This document is intended to provide answers to frequently asked questions about radiation exposures from medical imaging.

Frequently Asked Questions

Target Audience: Healthcare Professionals

1. The facility where I work uses a dose management software program to monitor dose metrics from imaging exams. Why should we not use this to add up the doses from all of a patient's imaging exams?

Over the past decade, many medical imaging facilities have incorporated dose monitoring software programs to collect and analyze information about radiation doses from medical imaging exams. Dose metrics reported by the imaging device at the time of an exam – such as CT Dose Index (CTDI), CT Dose Length Product (DLP), Reference Air Kerma, and Kerma Area Product (KAP) – are sent to these dose monitoring programs. Some software will also estimate values such as absorbed doses to specific organs or tissues or effective dose.

None of these dose metrics quantifies the biological effect of radiation to an individual patient. Further, possible stochastic effects (including potential increases in cancer risk from radiation) due to a current exposure are independent of previous exposures. Consequently, while dose monitoring software tools have the ability to sum dose metrics and estimate a patient's cumulative imaging radiation dose, it is inappropriate to consider estimated cumulative risks from past exposures when evaluating the need for a new medical imaging exam. Rather, only the potential risks from the imaging exam under consideration should be compared to the potential benefit from that exam.

Importantly, effective dose is not a measure of radiation dose or individual risk but rather a radiation protection quantity that estimates radiation *detrimment* to a population consisting of all ages and both sexes. As such, effective dose does not represent the radiation risk to any individual patient, even if the dose monitoring software provides a calculated value for a specific patient.

2. Even if cumulative doses are not perfect representatives of total radiation risk, they still give a general idea of the total radiation the patient has received. What is wrong with using this information when ordering a medical imaging exam?

Considering cumulative dose or effective dose values when deciding which medical imaging exam to order may be detrimental to a patient's care. For example, using a patient's cumulative dose as a reason to *not* perform a medically indicated imaging exam that uses ionizing radiation, or as a reason to substitute an imaging technique that uses ionizing radiation with one that does not, ignores many other important considerations. These include overall diagnostic performance, variability in diagnostic performance based on operator or reader, equipment availability, need for sedation, exam time, contraindications based on renal function or presence of metal or implanted devices, and cost.

3. If tracking a patient's total radiation dose from imaging exams is not valuable in medical decision making, what is dose monitoring software good for?

Monitoring dose metrics is helpful for quality assurance, protocol optimization, and compliance with accreditation and regulatory programs. Analyzing dose data in aggregate across patients can identify exam protocols that may benefit from further optimization, perhaps by changing pre-set exposure parameters. Outliers among the aggregate data can be scrutinized for opportunities to improve consistency of image quality or patient positioning. Such analyses can also be used to compare protocols across scanners and institutions. On a large scale, these data can be pooled to help establish updated Diagnostic Reference Levels (DRLs) for specific exam types and by patient size. In the future, these data, considered together with patients' health outcomes, may aid in epidemiological studies of radiation risk from medical imaging.

4. My facility's dose management software adds up the dose metrics it has for a patient's previous imaging exams. If this information is not appropriate for medical decision making, how can we avoid making this information available?

You can contact the manufacturer of your dose monitoring software and ask if this functionality can be turned off. Another important task is to have your Radiology Information System stop sending the DICOM modality worklist to the dose monitoring software. This is because access to the modality worklist is what allows dose monitoring programs to trigger prospective alerts or cumulative dose alarms.

5. Should we track a patient's total organ doses, especially for parts of the body that we know are more sensitive to radiation, such as the thyroid?

No, this information should not be used for clinical decision-making. Organ dose tracking is not currently helpful for guiding clinical care because there is no meaningful way to incorporate cumulative doses into actionable risk-benefit decisions. Specifically, there is no scientific or medical consensus on what to do when a specific cumulative organ dose is reached. From a research perspective, however, organ dose tracking in large populations of patients, when matched to a patient's development or absence of cancer in those organs, may be valuable for improving radiation risk models in the future.

6. Are there any standards that ensure that the cumulative dose or effective dose values provided by dose monitoring software are accurate?

No. There is no standard for calculating organ doses or effective dose from device-reported dose metrics. Tolerances for the accuracy and precision of such calculations also do not exist. Further, dose monitoring software may not include imaging exposures from independent facilities, meaning that any reported cumulative dose metrics may represent only a portion of a patient's imaging exposures.

7. Is there a lifetime limit to the amount of radiation that a patient can receive from medical procedures?

No. The foundational principles of radiation protection in medicine are justification and optimization. The International Commission on Radiological Protection² and others have consistently emphasized that, unlike for occupational exposures, exposure limits to patients are not appropriate in medicine. This same philosophy is applied to all other medical interventions, such as pharmaceuticals or surgeries. Every medical imaging exam should be clinically justified – the potential benefit to the patient should be higher than the potential risk. Since the stochastic risk associated with a medical exposure to ionizing radiation – be it the patient's 1st or 50th – does not change based on past exposures, then the radiation exposure from the 50th exam is justified as long as that exam is reasonably expected to provide a clinical benefit.

8. Shouldn't we at least track the total dose for pediatric patients, who we know are more sensitive to radiation?

Even though children are generally more sensitive to radiation, all of the points made here also apply to pediatric patients – each imaging exam should be justified on its own merit, regardless of previous exposures to medical radiation.

9. Is there any benefit to knowing a patient's medical imaging history, even if the cumulative dose or effective dose values are not known?

Yes. Knowing a patient's imaging history can help determine whether an additional imaging study is likely to be beneficial. If a previous study exists that already answers the clinical question, there may be no benefit from further imaging. For example, if a patient had a CT of the head in Hospital A and then travels to Hospital B on the same day, the benefit to repeating the same study might be small or non-existent, presuming the exam at Hospital A was technically adequate. If the physicians at Hospital B have access to the previous study, additional imaging to answer the same clinical question could be avoided.

10. Employees exposed to ionizing radiation as part of their job responsibilities wear personal dosimeters to monitor their job-related radiation exposure. These exposures are then summed over time. If a radiation worker's cumulative dose is above a certain limit, the employee must stop working (in the radiation environment) for a period of time. Why is it appropriate to use cumulative dose in that scenario but not with medical exposures to patients?

Unlike patients, radiation workers do not derive direct benefit from occupational exposures. The International Commission on Radiological Protection and numerous other radiation protection organizations have consistently endorsed exposure limits for occupational exposures to protect workers from unnecessary risk in the performance of their job. Current regulatory occupational exposure limits are selected to ensure that jobs involving exposure to ionizing radiation pose no higher risks than other professions.

11. Does this position statement apply to interventional radiology procedures? Aren't we encouraged to track radiation doses from these interventional procedures?

Radiation doses from interventional procedures should be tracked, but only for the purposes of determining a patient's risk of developing radiation-induced tissue reactions. This position statement specifically addresses *stochastic* risks from radiation exposure – i.e., the potential for increased risk of developing cancer. It does *not* address direct tissue reactions (i.e., deterministic effects) such as radiation-induced skin damage, where it is known that radiation effects are cumulative over a short period (hours to a few months). In medical imaging, radiation-induced tissue reactions are very rare and are typically only seen in prolonged fluoroscopy-guided procedures where the lengthy radiation exposure is necessary to address a serious medical situation. For patients undergoing fluoroscopy-guided procedures, it is reasonable to track and consider their recent dose history (e.g., the most recent 2 to 3 months) so the risks and benefits of the procedure can be appropriately considered and managed.

12. Does this position statement apply only to stochastic risks? Why doesn't it apply to deterministic risks, such as dose to the skin or dose to the lens of the eye?

Yes, this position statement only applies to stochastic risks. The biological mechanisms for stochastic effects (i.e., the potential increased risk of developing cancer) are fundamentally different from those involved in deterministic effects (i.e., damage to the skin, hair follicles, or lens of the eye.) Deterministic tissue effects are known to develop as the tissues undergo incremental damage that is not repaired prior to a subsequent exposure. For example, radiation exposure to the skin can cause small amounts of damage to outer layers of the skin. If there is additional radiation exposure to the same area before the outer layers of the skin have had time to undergo repair processes, the protection provided by these outer skin layers is compromised and can lead to additional damage to underlying tissues. In contrast, there is no known biological mechanism for previous radiation exposure to increase stochastic effects in subsequent imaging exams.

13. Does this mean that it doesn't matter how much radiation we use during imaging exams?

No. It is important that for any imaging exam, the use of radiation is both justified and optimized. It is essential that the amount of radiation used for an imaging exam is *optimized*, not *minimized*.

Achieving the image quality required for the clinical task should not be compromised, and the amount of radiation used should be dictated by the image quality needs. Optimization should include considerations of patient-specific factors that influence image quality, such as patient size.

References

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