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COMMENTARY

Should the justification of medical exposures take account of radiation risks from previous examinations?

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ABSTRACT

With the growing availability of dose histories for patients, the question of whether previous diagnostic radiation exposures should affect decisions on future examinations is coming into sharper focus. This article discusses ways in which cumulative dose information may affect our thinking in justifying exposures. Based on a common tendency to see a connection between past and future events even where we know them to be independent—the gambler's fallacy—we may find ourselves treating past risks as if they contribute to the present risk. We take the example of two patients scheduled for CT scans, one with no previous diagnostic radiation exposures, the other with a history of previous CT scans, to show that the risks, and justification process, are equivalent in both cases. For the patient with a history of diagnostic exposures, there are only two possibilities: either harm has been caused or there has been no effect. If previous CT examinations have not caused harm, then, as past risks, they are irrelevant. The patient is in precisely the same position with regard to risk as a patient with no dose history. If harm has been caused, avoiding further diagnostic exposures does not change this outcome; again in this case, a justified radiation examination should proceed. We argue that bringing dose history into the decision process for justifying examinations is contrary to our understanding of risk for low-dose radiation and, rather than improving patient safety, would unnecessarily restrict access to radiation-based diagnostic examinations.

With the growing availability of dose histories for patients, the question of whether previous diagnostic radiation exposures should affect decisions on future diagnostic radiation examinations is coming into sharper focus. Durand et al,¹ in a recent article, highlight the danger of cumulative dose estimates affecting the justification of future exposures, emphasizing that histories have no place in a rational decision-making process. The argument that justification should not take account of past exposures follows from the stochastic risk model described by the linear no threshold (LNT) hypothesis. According to this model, the probability of a low-dose exposure causing cancer is proportional to the radiation dose and, crucially for the argument being made here, each exposure is a statistically independent event.^{2,3} However, despite the logical difficulties Durand et al describe, there can be a strong temptation to include cumulative exposures in the decision-making process. In this article, we look at how cumulative dose information might erroneously affect our thinking in justifying exposures and, taking an example of CT scans, set out the counter argument. The argument refers to risks that are modelled

stochastically and follows the LNT hypothesis for low-dose exposures. Cumulative dose in high-dose procedures, where repeat exposures in a short time frame may accumulate to exceed a deterministic threshold for a tissue or organ, follows a different risk process and are not considered as part of this discussion.

It is important to draw a distinction between the imaging information and the radiation exposure from past radiographic examinations. The justification process includes careful consideration of the benefit of the examination and how it will contribute to a patient's clinical management. A key step in this process is the consideration of previous imaging to establish whether the clinical question can be answered without recourse to further radiation exposure or with a lower dose diagnostic examination. In the examples outlined in this commentary, it is assumed that this part of the justification process has been completed.

There can be a tendency, however, to treat past dose information in the same way as previous imaging and assume

that it should play a role in whether or not the patient should have further imaging with ionising radiation. We know, for example, that five CT scans carry a greater risk than one CT scan. It may seem reasonable to take the risks of the previous four scans into account when justifying the fifth scan. As our thinking subtly shifts towards consideration of the previous scans, the fifth CT scan begins to seem a different proposition to the first CT scan. In the back of our minds, the risk associated with the fifth scan becomes, notionally at least, somehow conflated with the risks from the previous four scans.

Part of the thinking here is based on a logical error, sometimes referred to as the gambler's fallacy. We have a strong tendency to assume that past events have an influence on future events, even when we know that each event is independent. A common example used to illustrate this point is the toss of a coin. Assuming it is a fair coin, the chances of getting tails on a coin toss is 50–50. However, if we get tails, there can be an inclination to believe that on the second toss of the coin, the probability of tails coming up again is less than 50–50. But this is not the case. The coin has no “knowledge” of past events, and its chance of coming up heads remains 50–50, so long as it is a fair coin, regardless of the history. The fallacy of believing we are due heads after several throws resulting in tails (*i.e.* that the odds of getting heads has changed) is also a factor when we consider further radiographic exposures.

Take the situation of a patient who is scheduled for a fifth CT scan. The gambler's fallacy leads us to believe that patients getting their fifth CT scan are in a different position with regard to the risk for that scan than they were for their first CT scan. We are, in a sense, considering the risk of all five scans together, although four of those scans were in the past and have no bearing on the risk for the fifth scan that we are being asked to justify. Of course, if we were actually comparing the risk of all five scans to the risk of one scan, then five scans carry the higher risk. But we are not in this position. Justifying a fifth CT scan should not be confused with justifying five CT scans. A previous scan is relevant if it provides the diagnostic information we are looking for, thus abrogating the need for a new scan; there is no basis under LNT for considering a previous radiation exposure as a modifier to the risk for the current scan.

The argument can be brought out more clearly with an example. Assume we have two patients of equal size who have been scheduled for the same examination on the same CT scanner using the same technique factors. The scan has been properly justified for each patient. Patient A is to have their first CT scan. Patient B has had four previous CT scans. For the purpose of this argument, we take the risk of inducing cancer from a CT scan to be a standard value for each scan, say 1 in 2000.

For Patient A, who has not had previous scans, we have justified the CT scan, and the examination goes ahead.

What about Patient B? The scan has been clinically justified, but there is hesitancy because of the previous scans. Should we

consider these? Is it correct to treat these two patients differently because of the previous radiation dose to Patient B?

There are two possible outcomes in terms of the radiation risk for Patient B after four CT scans. Treating each outcome in turn with regard to its relevance to the fifth scan, we get the following:

The first possibility is that Patient B has not had cancer induced by the previous CT examinations. The patient's chance of getting cancer from the new scan is entirely unaffected by this history (the patient might have got cancer from the previous scans, but in this case did not: those four CT scans and their attendant risks are now past). Just as on a fair die, all previous rolls have no bearing on the probable outcome of future rolls, so too with stochastic cancer induction: the past scans where cancer was not induced have no affect one way or the other on the new scan. The risk probability for the fifth scan is not altered. Patient B is at precisely the same risk as Patient A. Given that the risks are equivalent for both patients, we have no basis for proceeding differently on each patient.

The second possibility is that Patient B has had cancer induced by one or more of the previous scans. The new CT scan has no impact on this outcome. If we proceed, there is a chance of causing harm as before; if we do not scan the patient, then they still have cancer from the previous scan, and they lose the benefit from the CT scan that we have not given them. So in this case, we should also proceed with the scan.

We do not know which of the two situations pertains to Patient B, but according to the LNT model, it is one or the other of the two cases. And as we have shown, we should proceed with a justified CT in either case. Thus, under the present understanding of risk as a stochastic process for low-dose radiation, previous dose history should not influence the justification of future radiographic exposures.

The example above is intentionally artificial. We assume that each CT scan delivers the same dose and that it carries the same simplified risk quoted. This allows us to concentrate on the point in question—whether the history of risk is relevant—without getting sidetracked by the complexities of dose calculations. It also keeps the point general. Our argument attempts to show that, as a general rule, taking account of risk from previous scans should not affect the justification process. The justification process already includes risk–benefit analysis and the consideration of alternate strategies, and rightly focuses on the particular examination in question.

This article makes the case that including the history of radiation risks in the justification process is contrary to our understanding of risk for low-dose radiation. Allowing cumulative dose estimates to influence whether a patient should get a scan would be tantamount to introducing dose limits for patients and, rather than improving patient safety, would unnecessarily restrict access to radiation-based diagnostic examinations.

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