used to compare risks in one sort of situation does not invalidate its use in another.

2. Dr. Poston reminds us that the risk coefficients assigned to individual tissues (and thus the tissue-weighting factors) were assumed to be independent of the age and sex of the exposed individual. The pattern of coefficients might be very different for an individual patient than for the average occupationally exposed adult. This point was recognized by the ICRP in 1980 when they observed that the accuracy of the risk estimates themselves did not justify the use of different weighting factors for workers as distinct from the population as a whole. Age-specific and sex-specific risk coefficients have been developed in some detail by the National Radiological Protection Board (NRPB) (*7*). They conclude that, bearing in mind the large uncertainties in the analysis, it is reasonable to take one set of tissue-weighting factors for the whole population but to apply a different estimate of detriment to each of three broad age bands. (See our recommendation below.)
3. Dr. Poston notes that the calculation of EDE as originally recommended by the Commission only involved six different tissues with all others lumped into a category called "remainder." This is true. The new definition of effective dose involves 13 tissues. Clearly this is an area in which refinements will be made as knowledge advances. We cannot see this as an argument against the use of the concept for nuclear medicine patients. Perhaps the authors have in mind the idea that in some nuclear medicine applications an individual organ dose may be notably high and that this fact would be lost within the weighted calculation of an EDE. We would agree that in such cases the notably high individual organ dose should be quoted additionally.
   Stabin et al. (*8*) point out that the use of effective dose is certainly preferable to "total body dose, which is quite useless in almost all situations in medicine." However, they also recommend consideration of individual organ absorbed doses and we would not disagree. In any scientific assessment of dosimetry, it will always be important to define the model used, the methodology and the resulting calculations of individual organ doses. This does not detract from the advantages of a single figure when comparing risks from different procedures.
4. Dr. Poston states incorrectly that the ICRP has given little guidance on the use of effective dose equivalent as an indication of risk in medical exposures, and he quotes an irrelevant paragraph from ICRP 26 which refers to dose limits. In fact, the ICRP has stated clearly in its publication no. 52 (page 23):

   > "In order to facilitate a comparison between different types of radiological investigations, the effective dose equivalent is a convenient measure."

   On the same page, the Commission notes the dependency of risk coefficients on age and sex but concludes,

   > "However the weighting factors assigned are probably not very sensitive to changes in age of the population. Therefore the effective dose equivalent can be used in comparisons of the radiation exposure to a patient from different procedures used in diagnostic nuclear medicine and in research."

In summary, we conclude that Dr. Poston and the MIRD Committee have unfortunately failed to appreciate the significant advantages to be gained from the use of the concept of effective dose equivalent for nuclear medicine procedures. Furthermore, they have misrepresented the position of the ICRP.

We consider that the concept of representing nonuniform dose distributions by a single figure is invaluable in comparing different radiological procedures. We continue to recommend its use for medical diagnostic procedures and find an increasing general awareness of effective doses in millisieverts. For those who are not specialists in the science of radiation protection there really is no practical alternative. The conversion of effective dose values to risk estimates (essentially the concern of your correspondents) is rarely necessary. If, however, this is required, then we suggest the use of the ICRP's figure for detriment of 73 per million per mSv for the general population, applying a factor of 2 for pediatric patients and a factor of 0.2 for geriatric patients.

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## Use of the Effective Dose Equivalent

**TO THE EDITOR:** We were disappointed to read that the MIRD Committee believes that it is inappropriate to use the concept of the effective dose equivalent for patients undergoing nuclear medicine procedures (*1*). In the U.K., the use of the effective dose equivalent has been advocated for the intercomparison of the relative risks involved in nuclear medicine and radiological procedures (*2*). Over the last few years, the nuclear medicine community has made great progress in educating its users to put the risks of nuclear medicine procedures into perspective by the use of the effective dose equivalent. While understanding that the tissue-weighting factors may not be strictly accurate for a patient population and that the overall risk will depend on the age, sex and reproductive status of the individual patient, we do not believe that this invalidates the use of the effective dose equivalent in this context. We think that this point can be illustrated by an analogy with automobile fuel consumption.

Fuel consumption will obviously depend on the manner in which a car is driven, and so in the U.K. manufacturers quote figures for several stated conditions; such as a constant 56 miles

per hr, a constant 75 miles per hr and for a standard urban cycle. However, in order to make a valid comparison of several models, a prospective purchaser needs a single figure that represents realistic driving conditions. Therefore many motoring publications calculate an average fuel consumption based on a weighted mean of the individual figures. It does not matter if the weights assumed do not exactly reflect an individual's driving pattern, the average fuel consumption is still a useful figure for comparing the *relative* efficiency of several models. It may also be used to give an idea of the running costs for an average driver, based on say 12,000 miles per yr. For a more accurate prediction of an individual user's *absolute* running costs, this can be scaled up or down to take into account whether the driver's annual mileage is more or less than average.

Returning to nuclear medicine, to say that it is inappropriate to quote effective dose equivalents for nuclear medicine investigations is just as unhelpful as it would be to say that it is inappropriate for motoring publications to quote an average fuel consumption figure for different cars. Effective dose equivalents allow the *relative* risk of several procedures to be compared prior to "purchase." The fact that the weighting factors might not have been quite right for this individual patient is a small error compared with uncertainties in the assumptions of the biodistribution which cannot be known accurately until after the test. If the *absolute* risk to an individual is important then the average figure for the risk per mSv can be adjusted to take account of whether the patient is older or younger than average.

We would urge the MIRD Committee to think again about their advice. They have led the way so admirably through the jungle of patient dosimetry in the past that it would be a pity for them to turn back now, just as we are emerging into a clearing where results can be understood by colleagues in other disciplines.

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# Application of the Effective Dose Equivalent to Nuclear Medicine Patients

**TO THE EDITOR:** A statement from the Medical Internal Radiation Dose (MIRD) Committee was recently published in *The Journal of Nuclear Medicine* (*1*), which concludes "... it is inappropriate to use the effective dose equivalent for individual patients undergoing nuclear medicine procedures," and recommends that dose calculations for such patients, "continue to be made in terms of radiation absorbed dose (in units of grays or rads)." We feel that we must disagree with both these conclusions.

It is certainly the case that the concept of the effective dose equivalent was developed by the ICRP (*2*) specifically for the purpose of providing comparative estimates of occupational radiation exposure, whether that exposure occurs in a uniform or nonuniform manner.

Nevertheless, in the publication *Protection of the Patient in Nuclear Medicine*, the ICRP itself comments on the usefulness of the effective dose equivalent (*3*). Paragraph 107 of this publication makes several salient points: "When radiopharmaceuticals are administered, individual organs may receive very different doses. In order to facilitate a comparison between different types of radiological investigations, the effective dose equivalent is a convenient measure." The same paragraph acknowledges the limitations of single-tissue weighting factors and the potential variation that may accrue from a patient population as opposed to an occupational one or from differing age and sex distributions. It is undoubtedly correct to say, as ICRP themselves acknowledge in the same paragraph; "... the effective dose equivalent can only be an approximate indicator of the risk to either the individual worker or the individual patient."

Nevertheless, the effective dose equivalent is the best method that we have had at our disposal for some time for estimating the relative risk to nuclear medicine patients from exposure, and the best way of comparing different nuclear medicine techniques with each other and with other radiological procedures.

There are several instances where different radiopharmaceuticals are used to image the same organ yet produce widely differing radiation dose distributions. The use of organ doses alone in such circumstances may make dose assessment and comparison difficult or even potentially misleading.

We would concur with ICRP, again quoting paragraph 107 (*3*): "the effective dose equivalent can be used in comparisons of the radiation exposure to a patient from different procedures used in diagnostic nuclear medicine and in research." We feel that not only can the effective dose equivalent be used in these circumstances, but that it is the most appropriate measure to use.

The effective dose equivalent is hardly a recent concept—its endorsement for use in nuclear medicine was published some 6 yr ago. Furthermore, the Committee makes no mention of *ICRP Publication 52* in their statement, nor do they mention the extensive data on the effective dose equivalent of nuclear medicine procedures in *ICRP Publication 53*. In *ICRP Publication 60* the concept has been refined and renamed "effective dose." This publication has now revised tissue-weighting factors to include total radiation detriment, and should prove a significant improvement in this dose assessment.

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