AGE AS A FACTOR IN ASSESSING RISKS TO PATIENTS FROM THE USE OF X-RAYS

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INTRODUCTION

Any use of ionising radiation carries with it a risk of harm, and it is often necessary to estimate this risk for groups of irradiated persons, or for individuals. Such persons include patients in diagnostic radiology. In diagnostic radiology effective dose has become widely used as the preferred index of patient dose. This is primarily for two reasons - effective dose is linked to a useful definition of radiation detriment and, because it converts an actual irradiation into an equivalent uniform whole body dose (in terms of detriment), it is able to cope with the partial body irradiations characteristic of diagnostic radiology. But while effective dose has these attractions, it is based on assumptions that could impose limitations on its use for risk assessment. Effective dose is an index that has been averaged over populations and risk projection models, and its application to individuals or specialised groups of the population may not be appropriate.

In this paper the collective risk from the use of diagnostic radiology in a large New Zealand teaching hospital is assessed using an age-specific approach, and this is compared with the collective risk assessed using the coefficients given in ICRP Publication 60 (1) for the general public.

METHOD AND RESULTS

Age- and sex-specific risks of stochastic radiation effects have been calculated by using the health effects model developed at NRPB for a UK population (2) . In applying the model, ICRP 60 values were used for cancer lethality fractions and for weighting factors associated with hereditary effects. These age- and sex-specific lifetime risks of total radiation detriment were then used to derive age- and sex-specific tissue weighting factors. The age- and sex-specific tissue weighting factors vary considerably since the relative contributions of the tissues to total detriment strongly depend on age at exposure and to a lesser extent sex. For example, the gonads, while dominant early in life, assume little significance later on. Conversely the lungs' relative importance increases dramatically in the middle years, while the red bone marrow's importance increases throughout.

The age- and sex-specific tissue weighting factors were used to derive age- and sex-specific "effective doses" for x-ray examinations that were considered significant in terms of contributing to collective dose. These "effective doses" were derived from the Monte Carlo based normalised organ dose data of the NRPB, UK (3,4). "Effective doses" for most x-ray examinations were smaller than the ICRP values, generally reflecting the reduced significance of the gonads at older ages. Notable exceptions were examinations of the chest region, where "effective doses" exceeding twice the ICRP value were obtained for some adult age bands. Differences between males and females were small compared with the differences due to age at exposure, hence a sex averaged age-specific "effective dose" was assigned to each x-ray examination.

Assessment of lifetime risk from an x-ray procedure was performed by multiplying the age-specific "effective dose" by the age-specific total risk coefficient. When these results were compared with the estimate of risk obtained by using effective dose and the risk coefficient for the general public significant differences were obtained. For example, with skull x-rays, the age-specific risk was about two to three times greater than the ICRP estimate for children, but fell to below the ICRP estimate for older adults. For chest examinations the age-specific risk was above the ICRP value for ages at exposure up to about 60 years. And for the abdomen, the age-specific risk was about double the ICRP risk for children, but less than half for most of adulthood.

X-ray examination statistics were obtained for a large New Zealand hospital for a six month period, giving patient numbers for males and females in 5 year age bands. To illustrate the very different make up of the patient population compared with the New Zealand population, a comparison of proportions of patients in age bands versus the general population is presented in Figure 1 for three x-ray examinations.

Age-specific collective risk to the patient population was determined using age-specific "effective dose", age-specific risk coefficients and the age-specific frequencies of the x-ray examinations. For comparison the ICRP estimate was obtained using effective dose, the risk coefficient for the public and total frequencies for the x-ray examinations. The relative results are presented in Figure 2 for simple radiographic examinations, barium studies, IVUs and CT examinations. The age-specific collective risk assessment for each of these examinations is about one-half that of the ICRP estimate, with the exception of chest and skull examinations (both conventional and CT). In the case of the chest age-specific risk estimates, this is a result of the relative importance of lung doses in the older age groups, for the skull examinations, it reflects the relatively large number of these examinations performed in the younger age groups and the higher risks at these younger ages.

The estimate of total collective risk to the patients from the practice of diagnostic radiology in this hospital, using the age-specific risk approach, was approximately three-quarters of the ICRP estimate. The large proportion of CT examinations being performed in the hospital meant that the contribution from CT chest and CT head examinations had the effect of bringing the age-specific total collective risk estimate closer to the ICRP estimate.

DISCUSSION

The estimate of collective risk using the age-specific approach was less than the simple ICRP estimate. However the age-specific approach necessitates many sets of tissue weighting factors, and the potential confusion of age-specific "effective doses" for all the x-ray examinations. In addition, given the large uncertainties in the nominal risk coefficients for radiation detriment, it must be concluded that the additional "accuracy" of the age-specific approach to collective risk is not justified.

For estimating individual risks or risks to particular age groups it would be desirable, from a practical perspective, to retain the single ICRP set of tissue weighting factors but to obtain a more specific estimate of risk. NRPB have looked at this in the context of simple radiographic projections, and concluded that sufficient accuracy was obtained by adhering to the ICRP approach, but if a particular age group was of interest, then applying scalars of 1.8, 0.8, & 0.15 for paediatrics, adults and geriatrics respectively to the ICRP risk estimates would suffice (5). Applying this approach to the data in this study (which included CT examinations and fluoroscopic examinations) gave a collective risk estimate within 10% of the age-specific estimate, thus giving support to this simple solution.

CONCLUSION

While patients in diagnostic radiology may be unrepresentative of the general population, assessment of their collective risk can be assessed with sufficient accuracy using effective dose and the risk coefficients for the public given in ICRP 60.

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4. D. Hart, D.G. Jones, and B.F. Wall, *NRPB-SR279* (1995).
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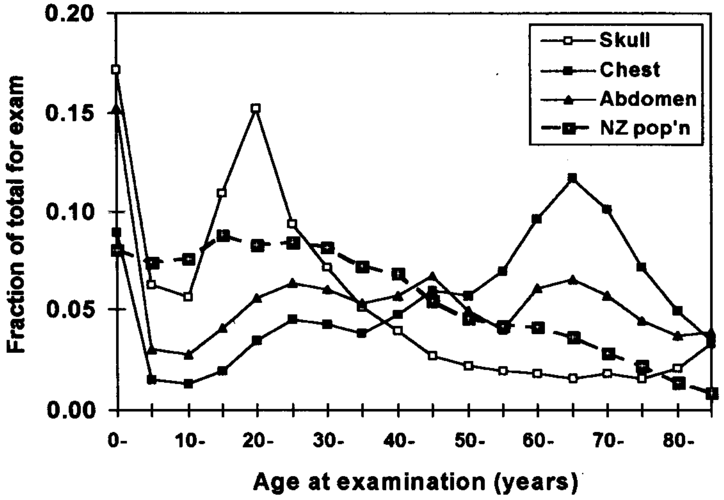

Figure 1. Relative proportions of patients for three x-ray examinations in age bands compared with the New Zealand population.

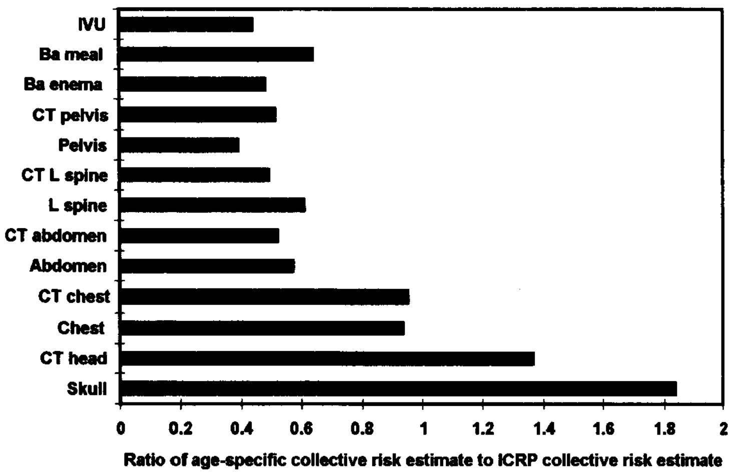

Figure 2. The ratio of age-specific collective risk estimate versus the ICRP estimate for specific x-ray examinations at a teaching hospital.