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J G Russell and R Fawcitt

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Commentary

New Risks, New Doses

J. G. B. Russell[1] and R. Fawcitt[1]

Our perception of the risks of ionizing radiation has substantially increased over the last decade (1–3). This change has been required by study of the survivors of the atomic bombs dropped on Japan in 1945. The bomb survivors are the largest group combining exposure to substantial excess radiation, good dosimetry, and careful follow-up. Studies of this population dominate our assessment of the hazards of ionizing radiation, although numerous other studies of radiation workers and other groups exposed to more than average radiation confirm (2) the estimates of the hazards derived from the studies of the bomb survivors. The increase in the assessed risk arises from two causes. First, the dosimetry of the bomb survivors; the estimates of the doses of ionizing radiation the survivors received have been downgraded by the new dosimetry (4) so the effect per unit dose is proportionately increased. Second, the longer follow-up discloses more fatal cancer cases than predicted earlier, and of a different pattern of primary site. In particular, a substantial excess number of gut fatal cancers have appeared than predicted earlier. This different pattern of the sites of origin of fatal cancers has in turn demanded an amendment (1) of the weighting factors used in calculating the effective dose. The term "effective dose" has replaced the old "effective dose equivalent" (1), and this allows distinction between doses calculated with the old weighting factors, and the new ones.

Table 1 gives the new and old (5) weighting factors. As can be seen, the organs in the head included in "remainder" are now weighted less heavily. Table 2 gives the new effective doses found for some examinations and indicates the variations when using the old and new weighting factors (6, 7). The effective dose estimates made by Feygelman et al in this issue of *AJNR* (8) were obtained using the old weighting factors: to obtain the current assessment of effective dose from their results requires a new computation, but some estimates can be made bearing in mind Table 2. The fluoroscopy is likely to include the abdomen, thorax, and neck, as well as the head. Recomputed effective doses for this part of the examination are likely to show little change, and the parts of the examination involving the head will show a reduction of around 50%. This means that the recomputed effective doses for carotid angiography are likely to show a reduction, perhaps of around 20%, from the figures given by Feygelman et al. Applying the new weighting factors rather than the old ones has led to a reduction in the new effective dose in examinations of the head, but an examination using ionizing radiation involving the abdomen, eg, myelography, will be likely to show little change in the effective dose.

It must be stressed that Feygelman et al give a mean value for their hospital. They found in their small series a range of 23.4–2.7 mSv (uncorrected). Studies of different radiographic examinations show similar large variations in radiation dose (9). Any radiologist wishing to discuss risks of an examination should have available radiation doses assessed in his or her hospital.

An important factor in assessing risk is the age of the patient. Figure 1 indicates the variation in the risk of fatal cancer by age and sex from exposure of ionizing radiation at low doses and low dose rate (1). It should be noted that our perception of the probability coefficient for the development of fatal cancer as an average for the whole population increased from the 1977 estimate of 1.2% Sv^{-1} (5) to 5% Sv^{-1} now (1). The genetic injury risk also varies with age. It is estimated (1) at 1.3% Sv^{-1} per child to be born. At birth, the risk of injury to future generations is about twice this (as about two children is the expectation for reproduction) and falls to zero as the expectation of parenting children falls to nothing.

[1] Department of Radiology, Royal Infirmary, Manchester, M13 OJH, United Kingdom.

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TABLE 1: Organ weighting factors

	1977 (6)	1991 (1)
Red bone marrow	0.12	0.12
Bladder		0.05
Bone surface	0.03	0.001
Breast	0.15	0.05
Colon		0.12
Liver		0.05
Lung	0.12	0.12
Esophagus		0.05
Skin		0.01
Stomach		0.12
Thyroid	0.03	0.05
Gonads	0.25	0.20
Remainder	0.30	0.05

TABLE 2: Ratios of mean doses between 1991 and 1977 weighting factors, and current effective doses (6, 7)

	Effective Dose/Effective Dose Equivalent $\frac{1991}{1977}$	Typical Effective Dose (mSv)
Radiography		
Skull PA	0.31	}0.2
Lateral	0.27	
Chest PA	0.92	0.05
Abdomen AP	1.8	1.4
Nuclear medicine		
Brain—Tc-99m gluconate	0.62	5
Computed tomography		
Head	0.5	1.8
Cervical spine	1.5	2.9
Chest	0.9	7.9
Abdomen	0.9	7.1
Lumbar spine	0.8	3.6
Pelvis	0.8	7.3

The possibility of radiation injury may be an important factor in deciding if ionizing radiation is to be used. An exposure of 10 mSv effective dose will carry a risk of promoting a fatal cancer of one case in 1000 examinations for a female teenager (perceived cancer risk 10% Sv^{-1}) or one case in 10,000 in a 70-year-old (perceived cancer risk 1% Sv^{-1}).

Costing the harm done by ionizing radiation in medicine can be assessed (10) and, in the United States, $30,000/Sv ($30/mSv) for an adult is a reasonable figure to use in this context, and five times this for children. More should be spent in a richer country, less in a poorer country, to avert exposure to ionizing radiation. It may be that the additional cost of magnetic resonance (11) imaging over other imaging techniques can be justified on purely financial grounds, by reason of the value of the averted ionizing radiation.

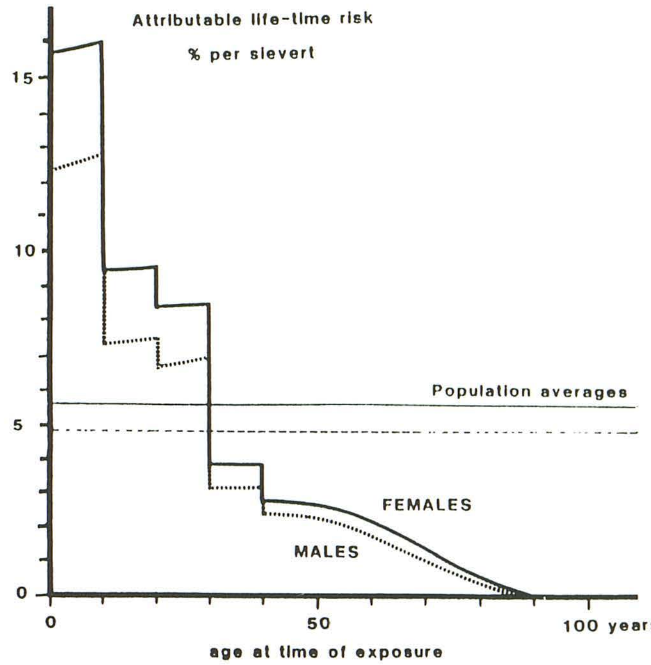

Fig. 1. The attributable lifetime risk from a single small dose at various ages at the time of exposure.

Feygelman et al (8) briefly discuss reducing the dose to the patient in cerebral angiography. It must be stressed that there are many more approaches available other than reducing screening time and field size. A recent review (12) noted 21 headings of methods of dose reduction. In this context, some of these may be stressed. Much of the dose arises from fluoroscopy. If an image intensifier is poorly adjusted, it may give a radiation dose four or more times than necessary (13). A quality assurance programme (14) is essential. The use of carbon fiber components (CFM) can allow substantial reductions (15)—for instance a CFM-faced grid with fiber interfaces can lead to a 20% reduction in dose for fluoroscopy and radiography. It must always be remembered also that if the use of ionizing radiation can be avoided, this will lead to a dose reduction of 100%, and if the dose to patient is reduced, the dose to staff is also reduced.

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