THE CURRENT CONTRIBUTION OF DIAGNOSTIC RADIOLOGY TO THE POPULATION DOSE IN GREAT BRITAIN

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Twenty years have passed since the last national assessment of the radiological hazards to patients arising from medical practices in Great Britain (1). Only two local surveys of the contribution from diagnostic radiology have been carried out in the meantime, limited to the Sheffield region in 1964 (2) and the Yorkshire region in 1976 (3). Many other countries have conducted their own national surveys in recent years and some have managed to repeat them after a reasonable interval, so that trends in the pattern of use of medical radiology can be observed (4).

In view of the considerable changes in both the extent and techniques of medical radiology that have taken place in Great Britain over the past 20 years, the National Radiological Protection Board felt that a fresh look at the hazards to patients was long overdue. A reappraisal of the genetically significant dose (GSD) to the population of Great Britain from diagnostic radiology was recognised as one of a number of worthwhile objectives for the review. The absence of any direct benefit to the descendants of patients undergoing X-ray examinations argues for a close watch to be kept on the magnitude of the genetic risk, and diagnostic radiology was given priority because of the relatively large proportion of the fertile population who experience it in a year. Whilst an assessment of the somatic risks and the contributions from radiotherapy and nuclear medicine are currently underway, this paper concentrates on the survey that has recently been completed to establish a current value for the GSD to the population of Great Britain from diagnostic X-ray examinations.

SURVEY METHODS

Calculation of the GSD from diagnostic radiology requires knowledge of the number of people examined annually in Great Britain broken down by examination type, age and sex, the child expectancy of the population as a function of age and sex and the average gonadal dose delivered by each examination type as a function of age and sex.

Information on the frequency of X-ray examinations was obtained by sending questionnaires to a sample of about 100 hospitals spread throughout England, Scotland and Wales. The questionnaires asked for details of every X-ray examination carried out in a specified week in June 1977. The selection of the sample was based on the division of all the hospitals in the country into 8 strata depending on the workload of their X-ray departments. The proportion of the total sample to be allocated to each stratum was derived using the Neyman method of allocation (5) which minimizes the errors when extrapolating to the whole population. Individual hospitals were selected with probability proportional to their X-ray workloads. By this means the sample of hospitals that responded to the questionnaires was sufficient to achieve a standard error of 5% in the estimated total of examinations for the whole country. Annual totals were estimated by multiplying the weekly figures by 365/7 and then correcting for seasonal variations in workload based on film consumption data for Great Britain in 1977.

The child expectancy of the population was obtained from the official statistics provided by the Office of Population Censuses and Surveys.

Gonadal doses were measured directly on patients undergoing 13 selected diagnostic examinations at 21 hospitals. Thermoluminescent dosemeters were used that consisted of lithium borate powder contained in adhesive polythene sachets. They had been developed at NRPB specifically for use in medical dosimetry (6). For male patients they were attached to the inside of the thigh close to the scrotum and were assumed to receive the same dose as the testes. For female patients they were positioned so as to measure the entrance skin dose level with the ovaries. Skin doses were converted to ovarian doses using conversion factors obtained by exposing an anthropomorphic phantom to a range of typical diagnostic X-ray fields and measuring the doses at the ovary sites and on the skin. The 13 examination types selected for inclusion in the dose measurement survey were those that in previous surveys accounted for about 95% of the GSD. Doses for all other examination types were obtained from the current literature. The 21 hospitals visited came from all regions of the country and included a representative sample of X-ray department size and speciality. At the end of the survey the gonadal doses received by 4565 patients had been measured.

RESULTS

The frequency survey indicated that 21.3 million X-ray examinations were carried out in National Health Service (NHS) hospitals in Great Britain in 1977. This represents an increase of 64% over the estimate of 13 million from the 1957 national survey (1). The number of examinations per thousand of the population has risen by only 48%, since the population has increased during the period. This corresponds to an increase of 2.0% per annum in close agreement with estimates for other industrialised countries (4). In addition it was estimated that 1.5 million chest X-rays and 1.0

million other examinations (excluding dental) took place in institutions outside the NHS. This brings the total number of examinations up to 23.8 million, corresponding to 440 examinations per thousand of the population, which as the following table shows, is rather lower than in other industrialised countries.

TABLE 1. Frequency of X-ray examinations per thousand head of population for industrialised countries

Country	Year	Examinations per thousand
West Germany	1974	1658
Switzerland	1971	1350
Netherlands	1972	1186
Japan	1974	810
USA	1970	669
Sweden	1974-1976	650
Great Britain (this survey)	1977	440

Comparative data are from reference (4)

The relative frequency of particular examination types demonstrated some predictable trends. For example, chest X-rays have fallen from 48% of all examinations down to one-third, presumably reflecting the progress which has been made in controlling tuberculosis. The number of obstetric examinations per thousand live births has fallen from 114 in 1957 to 42 in 1977, no doubt as a consequence of the increased concern for possible foetal damage and the extensive use of ultrasound as an alternative to X-rays. There has also been a drop in the number of cerebral angiograms as a result of the advent of computerised tomography.

The gonadal dose measurement survey indicated that for some types of examination there has been an increase and for others there has been a reduction in the gonadal exposures delivered per examination. For example, the introduction of double contrast techniques in barium examinations of the gastro-intestinal tract has led to a doubling in the number of films taken per examination which in the case of barium enemas has more than doubled the gonadal dose. On the other hand simpler examinations involving only a few radiographs appear generally to be accomplished with lower gonadal doses than 20 years ago which is probably due to the trend towards faster films and screens. However, if the ratios of current to 1957 gonadal doses for each examination type and sex are weighted according to their relative contribution to the GSD, then the average of the ratios turns out to be about 1.07. Therefore there has been no overall reduction in the gonadal doses delivered by those types of examination of importance to the GSD.

Similarly there has been no reduction in the very large range of gonadal doses delivered throughout the country for the same examination type. Individual gonadal doses for the same examination ranged over 3 or 4 orders of magnitude throughout the country. Mean gonadal doses obtained at different hospitals for the same examination were found to differ by up to a factor of 10.

Our provisional estimate for the current value of the GSD to the population of Great Britain from all diagnostic examinations conducted both within the NHS and elsewhere is 17 x 10^{-5}Gy (17 mrad). This represents an increase of only 20% over the value of 14.1 x 10^{-5}Gy (14.1 mrad) found in 1957. Considering the errors involved in both surveys this is probably not a significant difference. Table 3 shows how the current value for Great Britain compares with recent estimates of the GSD in other countries.

TABLE 3. The GSD from diagnostic radiology estimated for various countries in the period 1970-1977 (10^{-5}Gy = 1 mrad)

Country	Year	GSD (10^{-5}Gy)
Sweden	1974-76	46
West Germany	1974	41
Italy	1974	30
Romania	1970	29
Netherlands	1972	28
USA	1970	20
Great Britain	1977	17
Japan	1974	17
Taiwan	1972	3.5
India	1967-72	1.1

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