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BENEFIT AND RISK IN BREAST SCREENING

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Abstract

Justification of breast screening in radiation protection terms both for the screened population and on an individual basis is necessary. In this paper the number of cancers detected, and the number of cancers potentially induced by radiation, in the UK National Health Service Breast Screening Programme (NHS BSP) are compared. Detection rates reported up to 1998 are used, with x-ray doses for 1997 and 1998 and breast cancer induction risk factors, stratified by age, recommended by the National Radiological Protection Board in 1994. Cancers detected exceed those potentially induced at all ages from 50 – 64. The relationship between these cancer numbers and the associated benefit and risk, in terms of breast cancer deaths avoided and induced, is then investigated. Improved values of the Nottingham Prognostic Indicator (NPI) attributed to screening provide one means of doing this. Using this strict criterion the breast-screening programme is also justified in radiation protection terms.

1. Introduction

It is widely considered that breast cancer can be induced by high doses of ionising radiation, such as X rays. The probability or risk of induction is believed to be dependent on dose. The time lapse between exposure to ionising radiation and development of breast cancer is generally agreed to be at least 10 years for women in the screening age group. Breast cancer induction decreases with increasing age at exposure [1]. In a breast-screening programme, the benefits achieved in the form of lives saved or prolonged should clearly exceed the risks arising from any breast cancers that may be induced from the associated radiation exposure. In this context both benefit and risk can only be estimated statistically, so that it is the probability of each which must be compared. Many attempts to consider the balance between radiation risk and benefit have been published. Most have considered only the numbers of cancers detected and induced, both of which can be estimated with relative confidence (e.g. [2]). Assessing benefit from treatment outcome is a much harder task. Treatment outcome is statistically more difficult to predict, especially in breast cancer, for which 5-year survival is a less reliable indication of "cure" or final outcome than in many other cancers [3].

This paper will consider the latest cancer detection rates and dose estimates, and hence the relative numbers of cancers detected and induced. It will then use treatment outcome data in an attempt to relate those numbers to the balance of benefits and risks.

2. Breast doses in the NHS BSP

The mean dose to breast glandular tissue (MGD) is generally considered to be the dose quantity most relevant to the risk of radiation induction of breast cancer. Average values of MGD for the NHS BSP have recently been reported by Young and Burch [4], who have found mean dose levels *per film* of 2.03 ± 0.02 mGy for lateral oblique views and 1.65 ± 0.02 mGy for craniocaudal (CC) views. The mean dose *per woman* is slightly higher because a small minority of women have more than one film per view, especially where the larger film size of 24 x 30cm is not available. The corresponding mean doses per woman for single view and two-view screening are 2.14 ± 0.04 and 3.65 ± 0.07 mGy respectively.

Current routine practice in the NHS BSP is to perform two view screening on the first round (ages 50 – 52) and single view screening on subsequent rounds. In the calculations that follow later in this paper, the dose levels for both single and two-view screening will be used for the 50 – 64 year age band.

The highest doses are likely to be received by women with the thickest breasts (around 10cm). These women also require more than one film per view, possibly up to four such films. However, the number of women in this subgroup is extremely small and difficult to predict. Young and Burch [4] report that for oblique films only, one film per thousand exceeded 8.6mGy, and they describe this as the maximum dose per film that may normally be expected. The corresponding dose level for CC films was 7.1mGy, giving a combined normal maximum dose for two-view screening of 15.7mGy at one film per view. Even for the 0.1% of the screened population receiving the highest doses (mainly those having the thickest breasts), the dose should not exceed 20 mGy.

3. Radiation risk factors for breast cancer induction

The risk of radiation induction of breast cancer decreases with increasing age of the woman at time of exposure (e.g. [1]). Numerical values for the magnitude of this risk factor are based on work by the National Radiological Protection Board (NRPB), with further subdivision from 10 to 5 year age bands following discussion with NRPB [2]. Although this data is 5 years old, these estimates of the risk factors are considered to remain the best available for the UK population. They refer to all breast cancers in a female population, not fatal cancers in a mixed population as in some earlier studies, and are given in Table I.

Table I. Radiation Risk Factors For Breast Cancer Induction – UK Female Population

Age Band	Breast Cancers Induced per Million women per mGy
50-54	13.2
55-59	11.5
60-64	9.4

Screening detection rates in the NHS BSP are reported at annual intervals. Those for the last four years for which figures are available are given in Table II and refer to England rather than the UK [5].

Table II. Cancer Detection Rates in the English Breast Screening Programme (/1,000) [5]

Age Band	1994-95	1995-96	1996-97	1997-98	Mean
50-54	4.3	4.6	5.0	5.4	4.8
55-59	4.7	4.7	5.0	5.3	4.9
60-64	6.3	5.9	6.0	6.0	6.1
Mean 50-64	5.1	5.1	5.3	5.6	5.3

4. Cancers detected and cancers induced

Table III gives the ratios of cancers detected/induced, using the data from Table II, for three 5-year age bands of the NHS BSP, and for the various dose levels discussed earlier. These ratios are all in double figures, i.e. the cancers detected exceed the numbers induced even for almost all the women in the highest dose subgroup.

Table III. Ratio of Cancers Detected to Cancers Induced at Various Dose Levels

Age Band	Radiation Dose Levels (mGy)			
	2.14	3.65	11	20
50-54	170	100	33	18
55-59	199	117	39	21
60-64	303	178	59	32

5. Breast cancer treatment outcomes

In many types of cancer, 5-year survival is used as an indicator of outcome because, beyond this interval after initial treatment, life expectancy is restored to that of a normal population of the same age. With breast cancer, however, long-term recurrence is such that this position may not be achieved until 20 years after treatment or even longer.

To relate cancer detection and induction to benefit and risk, it is necessary to consider outcomes both with and without screening. Thus the benefit of screening is not the proportion of those with screen detected cancers who survive a given period, but the difference between that proportion and the corresponding proportion who would have been predicted to survive if they had been in a comparable unscreened population.

Thus one possible measurement of Benefit/Risk may be taken to be:

$$\text{Benefit/Risk} = \frac{\text{Detections} \times (A - B)}{\text{Inductions} \times M}$$

Where: A = % survival of screen detected cases, B = % survival of symptomatically detected cases and M = % mortality of symptomatically detected cases. M is defined here in terms of symptomatic detection because it must be assumed at present that the majority of induced cancers will appear in women over the age of 64 who do not refer themselves for screening. If screening of older age groups in future years could be assumed, the mortality of screen-detected cancers would replace that for cancers detected symptomatically.

5.1. Nottingham prognostic indicator (NPI)

Of the various sources of data to be considered, that based on the NPI appears to be the most firmly based, and the easiest to interpret and apply. The NPI is calculated as (0.2 x size in cm) + Stage + Grade. The lower the NPI, the better the prognosis. It was first derived empirically from observation and case records, and subsequently verified in a study of 1662 further cases.

The introduction of breast screening leads to the detection of smaller cancers which have a lower NPI value and hence a better chance of long-term survival. Table IV summarises the 15-year survival for different groups of women. The proportion of women presenting in each group before screening is taken from a symptomatic clinic, where as the screening data is based upon a large-scale survey of screen-detected cancers in the Northern and Yorkshire Region of England. (The 15-year survival of an age-matched population of women without breast cancer was 83%.)

Table IV. Nottingham Prognostic Indicator Data

NPI	15-Year Survival (%)		Proportion of Women Presenting	
	Actual	Age Corrected	Before Screening	After Screening
<3.4	80	96	29	76
3.4-5.4	42	51	54	20
>5.4	13	16	17	4

5.2. Benefit/risk ratio

The benefit risk ratio may be calculated using the above equation. Table V is a summary of the ratio of lives saved to the possible fatal cancers induced.

Table V. Benefit/Risk Ratio (Lives Saved/Possible Fatal Cancers Induced)

Age Band	Single View	Two Views	Highest Dose
50-54	105	62	11
55-59	123	73	13
60-64	188	110	20

6. Discussion

Justification is a fundamental concept in radiation protection legislation and in radiology. A practice is justified when it is beneficial and the benefit can be shown to exceed the associated radiation risk. Justification for a medical radiation procedure can properly be considered in terms of the average dose to all patients, without the need to allow for higher doses that may be received by sub-groups. Nevertheless it would provide added reassurance if it could be shown that benefit exceeded risk for all sub-groups or even for all individuals in a screening programme

In attempting to convert from detection/induction to benefit/risk, data from a variety of sources may be used. Of these data sources, those based upon the NPI may be the best for this purpose. The NPI is derived from parameters that are relatively easy to determine, and its relationship to survival has been established. Survival at 15 years is a much better basis than the 5 years survival widely used for other cancers.

7. Conclusions

For the NHS BSP as it is at present, there appears to be an ample margin of benefit over risk. This statement applies on the basis of the average MGD per woman, i.e. on a population dose basis. Radiological Justification can properly be based on this. At a dose level exceeded by only 0.1% of women screened this remains true. Newer designs of X-ray equipment should lead to further improvements in this position.

Thus, despite all the uncertainties and shortcomings of present information, it does appear that in the NHS BSP radiation hazards if they exist are quite small compared to the benefits. In these terms, the NHS BSP achieves radiological justification. Nevertheless, it remains essential that radiographic image quality, with its implications for cancer detection rates, and radiation dose levels continue to be closely monitored in the NHS BSP and in other breast screening programmes.

References

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