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ACCURACY IN RADON WORK

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General

In a recent paper (Ellis, Jennings and Russ, 1947) in this Journal, a discussion was given of accuracy in making glass radon seeds. It may be of interest to record, for comparison, some results with gold seed technique as adopted in Queensland. Since the particular technique used depends on the rather unusual organisation for radon application which has been evolved in this State, this is outlined in the next section.

Organisation

Apart from occasional consignments from the Commonwealth X-ray and Radium Laboratory (Melbourne), all radon used in Queensland is prepared at the Radiation Physics Laboratory, University of Queensland, Brisbane, under an arrangement with the Queensland Radium Institute and other interested authorities. Needles, if used, are prepared according to the methods of the Commonwealth X-ray and Radium Laboratory. Apart from β-ray applicators, however, radon is used almost exclusively in the form of gold seeds with wall thickness of 0·5 mm. and lengths about 3, 4, or 8 mm.

The shorter seeds are used both for permanent implants and for external applicators (moulds), while the longest seeds are used exclusively for moulds. Most implants are designed in consultation with a physicist from the Radiation Physics Laboratory and practically all moulds are designed and constructed by the physicists to administer the dose prescribed by the radio-therapist. An organisation has been evolved which has permitted the carrying out of radon treatments, under these conditions, at country hospitals as far north as Cairns (over 1000 miles from Brisbane).

Method of working

Orders for radon are usually framed in terms of the approximate dimensions of the lesions being treated, and their types. (From the type of lesion the physicist can gauge approximately what dose the radio-therapist will eventually prescribe.) For implants, the length of gold capillary tube to be filled with radon is usually adjusted so that a seed between 3 and 4 mm. long will contain about 0·8 mc. (occasionally 0·6 mc.) at the proposed time of use. The anticipated total amount of radon is computed on the basis of the average yield of the purification plant—at present about 80 per cent. (The plant is similar to that described by Oddie (1937) except that a three-stage mercury vapour pump is used, instead of Toepler pumps, for the transfer of the gases.)

Immediately after filling, part or all of the gold capillary is subdivided into seeds of length calculated to give an average strength of 0·8 mc. After an interval of two to three hours, the seeds are all measured individually. It is usually found that the strengths tend to be concentrated around some value, usually somewhat different from 0·8 mc., but that a proportion of the seeds have widely different strengths. As they are measured, the seeds are sorted into groups, each group containing seeds varying over a 10 per cent. range ($\pm$ 5 per cent. from the centre of the group). The largest group is then usually used for implants, unless the mean for the group is markedly different from 0·8 mc. Often several implants can be completed with this one group, the number of seeds in each implant being adjusted in accordance with Paterson and Parker's (1934) methods. Although individual seeds may deviate from the mean by as much as 7 per cent. in extreme cases, the chance of the total number of millicuries in a particular implant, and therefore the dose, being more than 2 per cent. from the calculated value, is rather remote; this error is swamped in the errors due to difficulty in exact location of the seeds in the tissues.

With this method, the work of the Radiation Physics Laboratory is considerably simpler than if exact seed strengths were specified and no sacrifice in accuracy or in uniformity of dosage is implied.

Among the smaller groups of seeds sorted out during measurement, some may be suitable for other implants; the remainder are used for external applications of radon, *i.e.*, radon moulds. In such applications the strength of individual seeds can differ widely from the mean without leading to marked non-uniformity of dosage.

The small size of gold radon seeds and ease of handling make them particularly suitable in constructing moulds for areas less than 3 cm. in diameter. Seeds cut for interstitial work (3 to 4 mm. long) are normally suitable for moulds of 5 and 10 mm. distance, but for greater distances and larger areas, seeds of 8 mm. length are more convenient. These are made with a similar technique (often part of the capillary is used for 3 mm. and part for 8 mm. seeds) and are sorted into groups, each with a $\pm$ 5 per cent. range, during measurement. Usually strengths of 2 to 3 mc. per seed, at time of use, are most convenient.

Checks have been made of the dosage received by the radon technician as the result of the preparation and measurement of the radon seeds; they indicate considerably below the tolerance dose. The total number of seeds prepared weekly at the Radiation Physics Laboratory is nearly 300, and the average strength per seed at the time it is measured is about 2 mc. (It has been found advantageous to prepare each day—except Saturday and Sunday—as many radon seeds as the available radon will permit, even if this involves a considerable excess over anticipated requirements.) Developments now in progress (including pneumatic transfer of seeds) are expected to result in further reduction of dose received by the technician during measurement.

Results of measurements

Figs. 1 and 2 show the results of measurements of a few selected batches of radon, and Table I summarises analyses of a fairly representative sample of the results obtained.

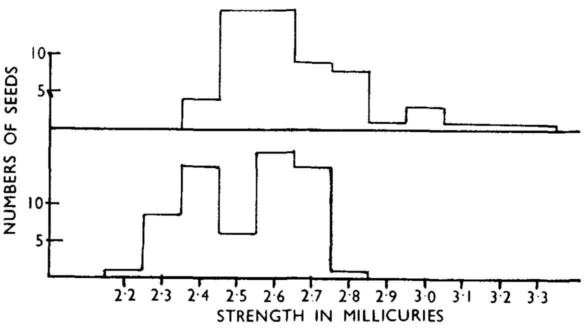

FIG. 1.
Distribution of strengths in batches 2 and 3 (reading downwards). Length 8 mm.

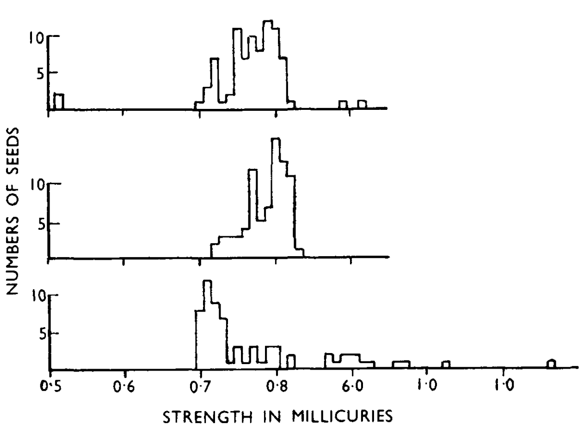

FIG. 2.
Distribution of strengths in batches 8, 9 and 10 (reading downwards). Length 3 mm.

TABLE I

Ref. No.	Length of seed (mm.)	Linear density mc./cm.	No. of seeds	Standard deviation per cent.	No. of groups from sorting	Gas pressure cm. Hg.	Notes
1	8	2·7	32	5	3	12	
2	8	3·0	60	7	3	5	
3	8	3·0	63	6	3	4	
4	8	2·9	37	4	3	10	
5	8	4·3	26	6	4	1	double condensation
6	3	3·1	93	25	8	10	triple condensation
7	3	2·3	79	6	4	8	
8	3	2·6	85	7	4	5	
9	3	2·5	80	3	2	4	
10	3	2·6	68	11	5	9	
11	4	2·8	80	7	4	10	
12	3	2·5	71	19	8	10	
13	3	2·5	90	6	3	13	
14	3	3·1	103	16	8	20	

It will be noted that while the results for the 8 mm. lengths show roughly the same variation in strength on all occasions, there is a wide divergence between the mean errors (standard deviations) for the 3 mm. lengths in different lots. So far, no definite correlation has been discovered between the standard deviation and any circumstance attending the purification. Thus, although in batch 6, a hitch in the purification process demanded a double repetition of the condensation of the radon, a similar hitch in batch 5 (with 8 mm. lengths) did not lead to a large standard deviation.

It has been noted that if the radon has to be "frozen" into the capillary, owing to extra high content of impurities, the seeds are exceedingly irregular in strength. In conformity with this, there is a slight suggestion that higher impurity content generally leads to higher standard deviation, but this is not true in every instance.

With the subdivision method used, one would expect the seeds to show a gradual (exponential) increase in strength as the tube is progressively shortened. This may explain some of the irregularities (particularly batch 10, *vide* Fig. 2). Measurements that have been made of strengths of successive seeds have, however, shown that other factors predominate in most instances.

Included in the table (column 6) is a record of the number of groups of seeds actually prepared for use from each batch. Each group is selected, as mentioned earlier, to give no more than $\pm$ 5 per cent. variation from the centre value of the group. Consequently the standard deviation within a group is unlikely to exceed 3 per cent. The number of groups runs parallel, of course, with the standard deviation for the whole batch.

Comparison of Queensland results for 3 mm. seeds with those of Ellis, Jennings and Russ (1947) shows that in some batches our standard deviation is somewhat smaller than those reported by the English authors and that in all instances the standard deviation within each group of seeds, as finally supplied, is distinctly smaller. The methods in use here thus permit a greater accuracy in dosage. Wastage of radon, except the unavoidable wastage due to fluctuations in the demand, is not involved.

SUMMARY

A short account is given of the organisation of the radon service in Queensland (Australia). Using a gold seed technique for both interstitial and external application of radon, and measuring all seeds as a routine procedure, accuracy of dosage can be maintained at as high a level as factors outside the control of the radon laboratory will permit. A method of grouping seeds is described which reduces wastage to a minimum.

ACKNOWLEDGMENTS

The methods of radon application in use in Queensland have been developed, on the physical side, jointly by Mr. D. F. Robertson, M.Sc., and the writer. The radon purifications and measurements recorded in this note were mostly carried out by Mr. R. G. S. Taylor, B.Sc. This analysis was suggested by Dr. C. E. Eddy, Physicist-in-charge, Commonwealth X-ray and Radium Laboratory, whom I wish also to thank for helpful comments. Thanks are also due to Dr. A. G. S. Cooper, Director, Queensland Radium Institute, for his friendly co-operation.

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CORRESPONDENCE

SIR,

Readers will be glad to have Dr. Webster's account of their experiences with Radon in Queensland University and of the ways in which they have met some of the inaccuracies to which we drew attention in our article "Accuracy in Radon Work".

It will not pass unnoticed that the range of error in seed content is least with gold seeds, but users must then forgo the advantage of glass-in-platinum seeds that can be threaded, thus allowing for their easy withdrawal from the tissues. The choice lies with the radiotherapist; if he chooses gold seeds he sacrifices a point of technique, while if he chooses the glass-in-platinum seed his range of radon content per seed is larger because of the necessity for the fusing of glass by heat in the final stages of their production.

We look forward to the time when these seeds are all mechanically filled, thus ensuring greater safety in handling and increased accuracy in the result.

Yours, etc.,

F. ELLIS,
W. A. JENNINGS, and
S. RUSS.