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SURVEY OF REGIONAL CALIBRATION FACILITIES FOR
BIOMEDICAL RADIATION DOSIMETRY IN THE UNITED STATES

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INTRODUCTION

This panel concerns itself with intercomparison measurements of exposure and absorbed dose in medical and industrial applications. However, I plan to confine my remarks to medical applications, since most of my experience has been in this area and in industrial accident dosimetry.

Over the last 20 years, our group at Argonne Cancer Research Hospital has been engaged in various activities concerning exposure and absorbed-dose intercomparisons with X rays, gamma rays, and electrons. The term "intercomparison" and "intercalibration" have different meanings. For the purpose of this discussion, I suggest that the variance of a series of measurements in an intercomparison be considered a measure of the precision among the items compared, and the variance of a series of measurements in an intercalibration, a measure of the accuracy among the items being calibrated.

I would like further to limit my discussion to beams of radiation used in teletherapy, and to exclude those from beta, gamma, and neutron sources used in intracavitary and interstitial work.

I shall consider the following topics:

(1) Organizational arrangement and implementation of intercomparisons or intercalibrations; (2) Types of instruments and techniques employed; and (3) Intercomparison of exposure and absorbed dose in generalized as well as specific geometries.

1. ORGANIZATION AND IMPLEMENTATION

In the United States we have a single governmental agency, The National Bureau of Standards, which has official responsibility for certain calibration and test services. For X-ray and gamma-ray exposure determinations,

Individuals from institutions within the United States are permitted to mail, freight, or hand-carry certain ionometric instruments to the Bureau's laboratory near Washington, D.C. After calibration, the instruments, together with a calibration report, are returned to the institution of origin. For electron beams, an intercalibration service¹ is presently available in which Fricke chemical dosimeters are prepared at the Bureau and then mailed to the user institutions where they are irradiated under the conditions outlined in a protocol set up by the American Association of Physicists in Medicine for dosimetry of high-energy electrons². Following irradiation in a standard geometric arrangement (generalized case - not a specific tumor site) each dosimeter is returned to the Bureau for analysis, after which a report is sent to the user giving the results for all Fricke dosimeters employed by participants in an intercomparison for a given period. This intercomparison service is available only at certain times during the year.

Through the years, groups of medical physicists in the United States have carried out informal intercomparisons using ionometric methods, thermoluminescent detectors, and the Fricke dosimeter. Some of these have been reported in the literature³.

About two years ago the National Bureau of Standards made plans to change its policy regarding the exposure calibration of certain instruments⁴. When this change is implemented, an instrument very commonly used in the United States, namely, a Roentgen condenser chamber together with a string electrometer, will probably be no longer acceptable for Bureau of Standards calibrations. In place, the Bureau is encouraging the establishment of regional, or secondary, calibration laboratories where such field instruments may be calibrated. Because of this pending policy, the Scientific Committee⁵

of the American Association of Physicists in Medicine (AAPM) has established a task force to set standards for and to accredit the establishment of regional calibration laboratories⁶. These laboratories would be able on comparatively short notice to provide exposure calibrations for institutions in their vicinity. They should be considered as secondary centers whose range of calibration activities and whose facilities need not be as comprehensive as those of a primary calibration laboratory like the Bureau of Standards.

There are at least two models of operation under which such a regional laboratory can function:

a) Within the region which it serves, the laboratory can assemble the medical physicists and their instruments, e.g., ionometric dosimeters. Following brief instructions by the laboratory coordinator, each person will use and calibrate his own instrument in a beam of the appropriate radiation whose exposure in air or whose dose in an appropriate medium is previously or simultaneously determined with primary calibration instruments carrying Bureau of Standards calibrations. This type of secondary laboratory is functioning successfully in the state of Texas⁷ and has worked successfully on a trial basis in the Illinois and Wisconsin region of the United States⁸.

b) In the second model, calibrations are carried out by the regional calibration laboratory much in the same way as at a primary center. The medical physicist sends his instrument to the regional laboratory, where it is calibrated and returned with a certificate of calibration. The secondary laboratory in this case assumes complete technological and legal responsibility for the calibration. In model (a), limited legal liability is assumed because the medical physicist who himself is the user has performed much of the calibration work.

Another type of organization has developed in several parts of the United States under a government-sponsored arrangement referred to as Regional Medical Programs (RMP). Under RMP, which were set up to implement institutional programs on heart disease, cancer, and stroke, several medical physics programs have been initiated⁹.

Government funds for RMP have been made available for a limited time in the hope that the programs will become self-supporting after three or four years. Areas in the United States where such programs have been established include Wisconsin, Upper California, Washington and Alaska, Texas, and Philadelphia. Not all of these programs are identical; therefore, only a broad outline of the type of activities carried out is given here. In each case a center of operation is selected in a major clinical institution which is the headquarters for needed equipment and physics staff. From this center a staff physicist travels with field equipment to the cooperating institutions for the purpose of making exposure and, in some cases, dose measurements. In addition, the visiting physicist verifies by actual measurements that items such as charts of depth dose distributions, field size, etc. are correct. A centralized computer facility is sometimes available to cooperating institutions for the determination of dose distributions. The dose distribution turn-around time for any given patient can be small when telecopying instrumentation is available to send and receive graphic information over ordinary telephone lines⁷.

The last type of organization to be described is the Radiological Physics Center (RPC) sponsored by the American Association of Physicists in Medicine. This center, which is presently located at M. D. Anderson Hospital in Houston, Texas, has the function of assuring the correctness of physical

data on patients entering into certain nationwide interinstitutional clinical trials which involve radiation therapy. In addition to simple checks on exposure and dose determinations, all calculative methods for dose determinations of those diseases undergoing trials are reviewed by the Center. The establishment of the RPC was mutually agreed upon by the Committee on Radiation Therapy Studies (CRTS) of the United States National Cancer Institute and the American Association of Physicists in Medicine, following the signing of a memorandum of agreement by both organizations on March 24, 1967. The function of in-depth review of the determination of absorbed tumor dose in specific cases has resulted in a complete review of clinical dosimetry in the studies undertaken so far. For example, in the determination of absorbed dose for patients with Hodgkins disease, procedures have been agreed upon for calculating the dose, taking into account the exposure measurement initially, and then Roentgen-to-rad conversion factors, the primary and scattered radiation beam from irregular fields, non-normal and irregularly shaped surfaces, and use of various types of compensating filters.

In the particular case of Hodgkins disease, the RPC together with the CRTS decided that the dose at several specified points within the tumor should be accurate within $\pm 5\%$. In a given practical situation a physicist from the RPC visits a cooperating institution and joins the institution's physicist in making direct comparisons of exposure measurements, using ionometric techniques with instruments both from the center and from the institution. In addition, an anthropomorphic phantom¹⁰ filled with thermoluminescent dosimeters from the center is exposed at the institution and the results are analyzed following appropriate measurements at the RPC. A complete report on all aspects of the dosimetry, together with

an error analysis, is then filed with the cooperating institution.

The work of the RPC is steadily expanding and the number of different types of tumors under study is increasing. The RPC has made 82 dosimetry review visits to 71 institutions in the past 2 1/2 years¹¹. Sixty-three per cent of the radiation machines checked meet the criterion of $\pm 3\%$ for correctness of calibration measurements. At 65% of the institutions visited all machines and types of treatment were found to be within the $\pm 5\%$ criterion. Considering machines and types of treatment separately, 80% met the $\pm 5\%$ criterion for absorbed-dose accuracy. Differences in radiation measurements for all of the machines checked ranged from -9% to +8.5%, while fulfillment of the dose prescription ranged from -29% to +21%.

Two workshops on the dosimetry of Hodgkins disease have been held by the RPC. A volume entitled Workshop Notes is available from the Center.

11. INSTRUMENTS AND TECHNIQUES

In general, ionometric measurements are used in the United States with orthovoltage and supervoltage radiations for the determination of exposure. Since, however, the United States National Bureau of Standards does not offer a calibration service for X- or gamma-ray energies higher than those of cobalt, an instrument calibrated for cobalt may be used for higher energies only when certain correction factors are applied. A protocol recently published by the Subcommittee on Radiation Dosimetry of the AAPM¹² outlines these correction factors in detail.

The protocol recommends that the Fricke dosimeter be used in certain situations as a backup instrument. The Fricke dosimeter can be considered in a sense to be an absolute instrument for which previous calibration is

unnecessary; it should be kept in mind, however, that the techniques for its use are very intricate. As previously pointed out, the Fricke dosimeter is also used in the intercomparison service provided by the National Bureau of Standards for electrons (for energies from 5 to about 50 MeV).

Thermoluminescent dosimeters, which have been used successfully by the International Atomic Energy Agency's radiation intercomparison service, have also been employed in the United States. Workshop¹³, for example, used them in a precursor study for those now being carried out by the RPC. In certain of the U. S. Regional Medical Programs previously mentioned thermoluminescent dosimeters are also the instrument chosen for measurements.

X-ray film is used in a variety of programs for checking depth dose distributions¹⁴ and beam alignment.

III. INTERCOMPARISON IN GENERALIZED AND SPECIFIC GEOMETRIES

For many years it has been recognized by medical physicists that it is necessary for the sound practice of radiotherapy to have both primary and secondary calibration laboratories available to all institutions where radiotherapy is carried out. The frequency with which medical beams should be calibrated has been discussed in many reports.

Considerable progress has been made in some countries and regions of the world in standardizing exposure and/or absorbed dose for general situations. The problem of determining the specific tumor dose from a calibrated beam is often left to the physician or the medical physicist. Since the steps involved in determining absorbed dose for specific tumor sites can introduce substantial uncertainties, it would be well if an

Institution were to give information on specific uses of its irradiation facility. If a majority of institutions had certain specific-dose determination problems in common, the intercomparisons could be expanded to include such cases.

Various studies, some of which have been referred to in this paper, confirm that, in medical situations, the secondary dosimetry laboratories should include wherever possible, as part of their function, programs to minimize the uncertainty of absorbed dose in specific tumor sites. A model for this activity, which is as important as the mere determination of exposure or absorbed dose in a generalized system, is the work of the RPC on tumors such as Hodgkins and lymphoma, carcinoma of the prostate and of the oral cavity, pharynx and larynx.

SUMMARY

The World Health Organization presently has regional calibration laboratories that are associated with the International Atomic Energy Agency. I would like to recommend that consideration be given to the setting up of regional laboratories for the instruction of personnel and for providing consultants to radiation therapy centers. Such a system would help to assure that the dose to specific tumor sites is accurately determined through the extensive use of intercomparisons and intercalibrations.

REFERENCES

1. Lanzl, L. H., N.B.S. High-Energy Electron-Beam Dosimetry Program. Radiology, Vol. 88, No. 3, p. 595, March 1967.
2. Laughlin, J. S., Almond, P., Cameron, J. R., Feldman, A., Hale, J., Holt, G., Lanzl, L. H., Loevinger, R., Ovadia, J., Robinson, G., Schulz, R. J., Shalek, R. J., Webster, E. W., Wootton, P., Worsnop, R., Wright, K. A., "Protocol for Dosimetry of High-Energy Electrons", Physics in Medicine and Biology Vol. 11, No. 4, p. 505, October 1966.
3. For an example of an intercomparison done on an informal basis see: Adams, H. E., Andrews, G. D., Lanzl, L. H., Laughlin, J. S., Sinclair, W. K., Clinical Dosimetry. Radiology, Vol. 70, No. 1, p. 96, January 1958.
4. Private communication from R. Loevinger.
5. AAPM Scientific Committee: John S. Laughlin, Chairman, Cameron, J. R., Lanzl, L. H., Meurk, M. L., Shalek, R. J., executive members, J. R. Cunningham, F. O'Foghluudha, E. Gregg, C. J. Karzmark, J. G. Kereiakes, J. Ovadia, R. Worsnop.
6. Recommendations of AAPM Task Force on Regional Calibration Laboratories.
7. Shalek, R. J., Moran, J. M., Golden, R., Stovall, M., Cundiff, J. H., "Cooperative Programs and the Status of Medical Physics". Advances in Medical Physics, publ. by Second International Conference on Medical Physics, Boston, Mass., U.S.A., 1971.
8. Personal communication from M. L. Rozenfeld.
9. Lanzl, L. H., Report on Manpower Needs in Medical Physics. Quarterly Bulletin of the American Association of Physicists in Medicine, Vol. 4, No. 3, p.109, September 1970.
10. Alderson, S. M., Lanzl, L. H., Rollins, M., Spira, J., An Instrumented Phantom System for Analog Computation of Treatment Plans. The American Journal of Roentgenology, Radium Therapy and Nuclear Medicine, Vol. 87, No. 1, p. 185, January 1962.

11. Golden, R., Cundiff, J., Grant, W., Shalek, R. J., A Review of the Activities of the Radiological Physics Center in Interinstitutional Trails Involving Radiation Therapy. Submitted for publication.
12. The Scientific Committee on Radiation Dosimetry (SCRAD):
Schulz, R., Holt, J. G., Loevinger, R., Shalek, Suntharalingam, N.
(Ad Hoc subcommittee for this protocol), Almond, P., Karzmark, C. J.,
Lanzl, L. H., Laughlin, J. S., Ovadia, J., Wootton, P., Worsnop, R.,
Wright, K., Protocol for the Dosimetry of X- and Gamma-Ray Beams with
Maximum Energies Between 0.6 and 50 MeV. Physics in Medicine and Biology
Vol. 16, No. 3, p. 379, July 1971.
13. Workshop, R., "Phantom TLD Comparison for Cooperative Radiotherapy
Trial." Radiology Vol. 91, p. 545 (1968).
14. L. Stanton, Private Communication.