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ACCURACY OF COMPUTERIZED RADIATION TREATMENT PLANNING

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Application of minicomputers to dose planning has increased during the past few years. Several programmed systems based on the use of a small computer are available on the market. The devices compete for speed, versatility and ease of operation, while the accuracy of the system is often largely ignored. The present experiment was made to assess the accuracy only.

The accuracy of a dose plan depends on two factors: the input data and the program of the computer. In the program, the results of empirical measurements have been replaced with mathematical formulas, which are not completely the exact counterparts of observed values (VAN DE GEIJN 1975, GELL 1977). The accuracy of the program used in the present experiment was tested by comparing the dose distribution calculated by the computer with that measured. The tests are also applicable to other dose planning systems.

Material and Methods

The device tested was RADPLAN (Radiation Treatment Planning System), which includes the following main components: one central unit (PDP 8/e, 16K), two disk units, one tape reader, and one terminal comprising a control console and a 28 cm display monitor.

In addition a graphic input translator records patient data and an electrostatic

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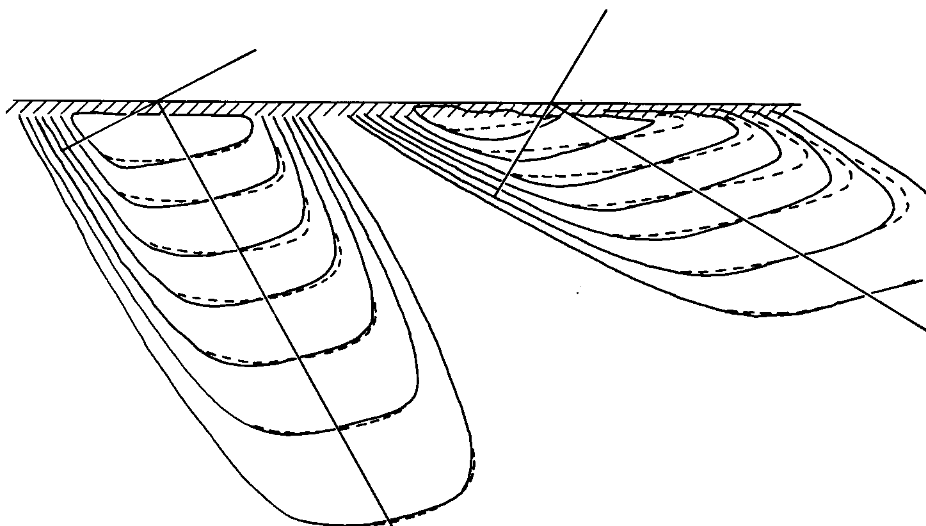

Fig. 1. Inclination of the field incidence causes a difference between the calculated and the measured isodoses. The greater the angle of inclination, the greater the difference.

plotter writes out the computed plans. The technique of calculating the dose distribution has been described by MILAN & BENTLEY (1974).

Both film (Kodak type M) and thermoluminescence dosimetry (LiF rods) were applied for measuring the dose distribution. The deep dose curves were assessed using a SHM Nuclear automatic isodose plotter, which has a small semiconductor as the indicator. The latter measurements were made in water, while the others were performed in a plexiglass phantom.

A betatron (BBC) and two cobalt units (Rocus and Jupiter) were used in the experiment.

Measurements. All the dose distribution data in the computer memory were based on measurements carried out in simplified conditions, i.e. using a square field and an even homogeneous medium with perpendicular irradiation.

Since the beam incidence in stationary radiation therapy is often oblique relative to the skin, the accuracy of the computer program calculating the curvature and angle correction is of importance.

The deep dose curve is changed if either the source-to-skin distance (SSD) or the field shape is altered. The effect of both these alterations on the deep dose curve calculated by the computer was compared with measured curves. The nominal SSD was altered by ± 5 cm. The effect of the field shape in a cobalt unit and a betatron was determined using the field sizes (in cm) 5×5, 5×10, 5×15 and 6×6, 6×12, 6×18, respectively.

The small inaccuracies arising from the modification of the different fields may

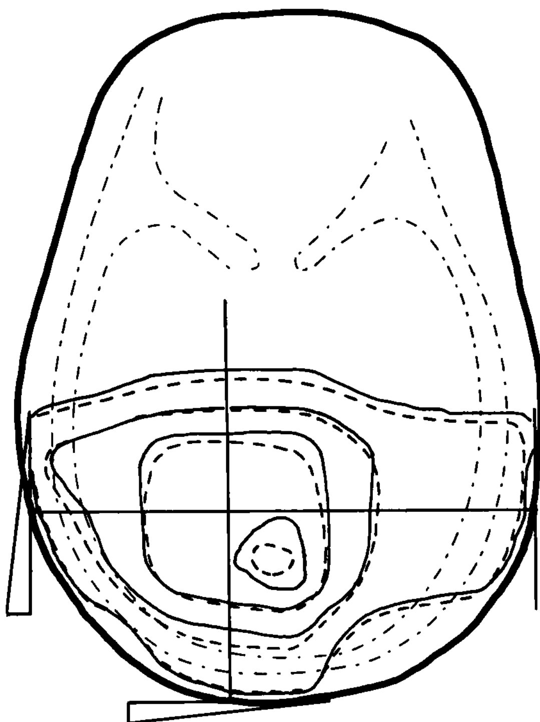

Fig. 2. Calculated (——) and measured (–––) dose distributions in brain therapy.

cumulate in a dose plan of several fields, thereby resulting in a notable error. A few computerized dose plans were produced for Alderson's anatomic phantom and the distribution was compared with that obtained in measurement during therapy. The following therapeutic regions were chosen: brain, larynx, lung and bladder.

Results

The curvature correction is accomplished fairly accurately in the computer program. However, when the beam hits the skin obliquely, differences exist between the distribution calculated by the computer and the film-measured one: the more oblique the beam the greater the difference (Fig. 1). A mere 30° inclination demonstrates the inadequacy of the correction, and at greater angles the error is considerable.

An examination of the deep dose curve dependence on the SSD demonstrated that the computer modification of the original deep dose curve is perfect. This does not mean that any given set of isodose data might be used at arbitrary source-to-skin distances—it must always be assumed that the field dose is calculated for the original nominal SSD. The computer always calculates the relative dose with reference to the original SSD.

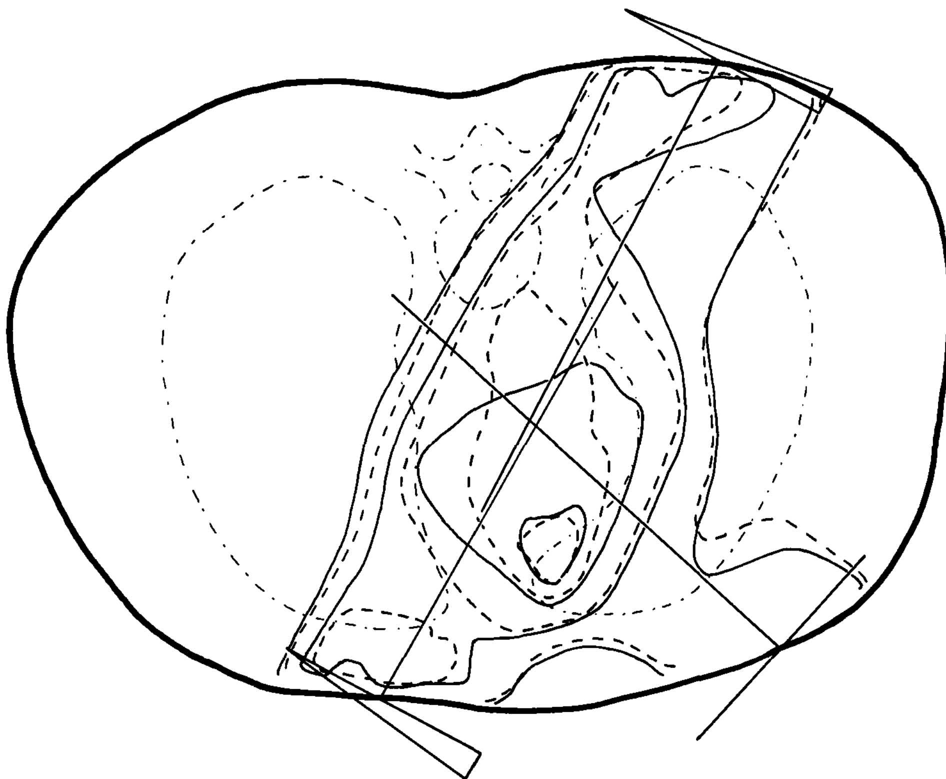

Fig. 3. Calculated (——) and measured (---) dose distributions in lung therapy.

A survey of the effect of the field shape on the deep dose curve demonstrated that cobalt unit isodoses were well corrected by the computer, no errors being revealed by the measurements. The betatron isodoses, however, were provided with no field shape corrections. This is remarkable, considering that the original cobalt unit and betatron data were fed into the computer memory in precisely the same way, using the same technique.

Figures 2 and 3 illustrate some dose plans calculated by the computer and the corresponding measured dose distribution. The incorrectness of a plan is difficult to measure or express numerically. The figures show that differences exist, occasionally in great numbers, but they cannot all be attributed to the computer program. Irradiation and dose measurement also involve errors, and the measured dose distribution is an unreliable point of reference. The heterogeneity of the irradiated tissue is difficult to estimate, which means that the computer uses incorrect approximations in its calculations. Dose plan information thus does not provide a reliable basis for estimating the accuracy of the computer system.

Discussion

The computer program examined only treats the dose distribution in a 2-dimensional space. Changes in the profile perpendicular to the plane of interest do not influence the distribution. This deficiency may result in significant errors of the distribution in plans pertaining, for example, to the region of the neck.

The system tested gives inadequate attention to the build-up region. The shape of the dose distribution in the build-up region has been defined fairly well with one expression (MILAN & BENTLEY), but the starting-point in that calculation is wrong, as the dose at the skin level is assumed to be 0.

Pendulum treatment plans have not been included in this account, because they are little used and needed in this hospital. However, the computer system can be used for making such plans. Within the given angle range, it will place similar fields directed to the same point of the axis at 12° intervals and calculate their sum distribution.

Even when accurate, a computerized dose plan does not yeild a dose distribution completely identical with a measured one, because the isodoses in the computer memory are, for practical reasons, smoothed and lack the small irregularities and minor asymmetry present in reality.

Film measurements always involve well-known uncertainties. The operation of the cobalt unit diaphragm frequently results in a field asymmetry, the extent of which depends on the device and the duration of irradiation. If measurements are made on sensitive films, this effect is emphasized at the plane of diaphragm motion. The present measurements were therefore conducted at a plane not affected by this phenomenon.

The minicomputer dose planning system described has turned out both durable and reliable in calculating dose plans. Although the accuracy of the system could still be improved, the speed and accuracy of this system well exceed the level reached in manual calculations.

SUMMARY

The accuracy of computerized dose planning depends essentially on the computer program. The quickest and simplest way to assess the accuracy of a commercial program is to compare the results of the computer calculations with measured values. The present report deals with the accuracy of the RADPLAN dose planning program in different situations easy to control. The test methods are also applicable to other corresponding systems.

ZUSAMMENFASSUNG

Die Genauigkeit einer Computerunterstützten Dosisplanierung hängt wesentlich von dem Computerprogramm ab. Die schnellste und einfachste Weise, die Genauigkeit eines kommerziellen Programms festzustellen, ist die Resultate der Computerberechnungen mit gemessenen Werten zu vergleichen. Der vorliegende Bericht behandelt die Genauigkeit des RADPLAN Dosisplanierungsprogramms in verschiedenen leicht zu kontrollierenden Situationen. Die Testmethoden sind ebenfalls anwendbar für andere entsprechende Systeme.

RÉSUMÉ

L'exactitude du plan de dose calculé par ordinateur dépend essentiellement du programme d'ordinateur. La façon la plus rapide et la plus simple de déterminer l'exactitude d'un programme commercial est de comparer les résultats du calcul de l'ordinateur avec les valeurs mesurées. Le présent travail concerne la précision du programme de plan de dose RADPLAN dans différentes situations faciles à contrôler. Les méthodes de test sont aussi applicables aux autres systèmes correspondants.

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