

THE ORGANIZATION OF CLINICAL DOSIMETRY. II

Some special topics in treatment planning

by

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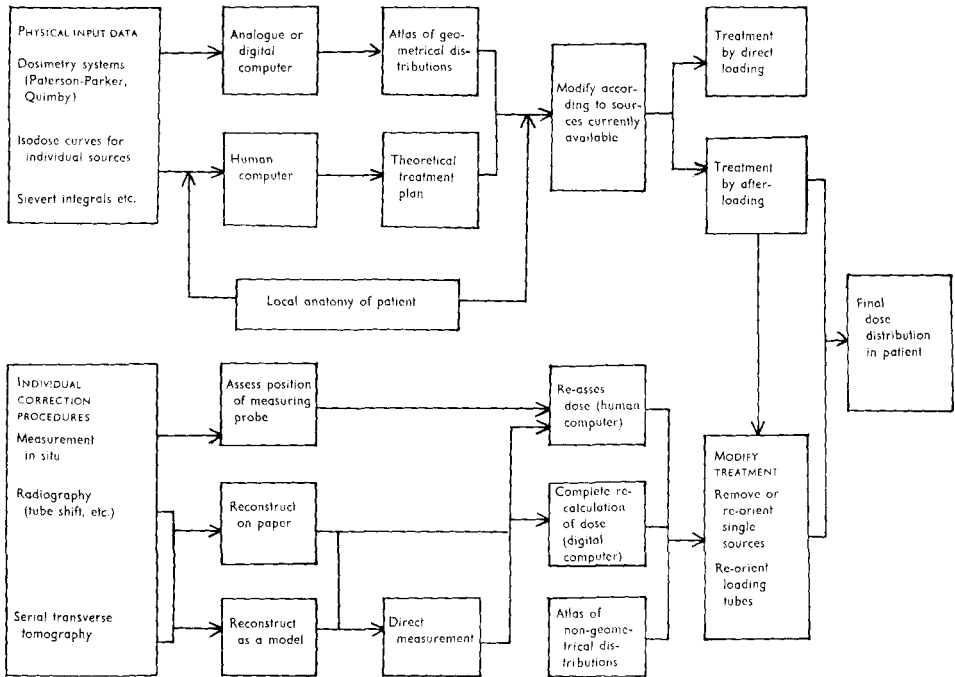
In part I of this review, the four stages of clinical dosimetry — topography, planning, treatment and reconsideration — were described in relation to teletherapy. In the course of the discussion a number of topics concerned with treatment planning were mentioned but were not described. In the present paper, these topics — transverse tomography, pre-calculated treatment plans, atlases of isodose charts, and the rapid assessment of treatment plans — will be discussed in more detail. Firstly, however, the general consideration of the four stages of clinical dosimetry will be concluded by applying the same principles to surface, interstitial and intracavitary therapy using sealed sources. (These forms of therapy are sometimes collectively known as ‘brachytherapy’.)

Dosimetry in brachytherapy

The organization of clinical dosimetry in surface, interstitial and intracavitary therapy is shown in block form in Table 1. The general plan is the

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Table 1

Treatment planning in interstitial and intracavitary therapy

same as in teletherapy: physical data must be combined with information on the local anatomy of the patient and his disease to produce a theoretical treatment plan which is in turn corrected according to the individual conditions prevailing when the actual treatment is carried out. There are, however, important differences in emphasis which arise from the fact that brachytherapy is usually applied to tumours of limited volume in fairly accessible sites. Correction procedures depending on, for example, the thickness of lung tissue traversed by a beam of radiation, are therefore unnecessary. On the other hand, the re-assessment of the dose on the basis of the actual treatment, as distinct from the planned treatment, is perhaps even more important than in teletherapy, and is certainly more widely practised. It is easy enough to plan an implant or gynaecological application according to a strict geometrical pattern, but it is not so easy to carry out the plan in a living patient. Dosage control through radiography of the implant is therefore essential (MEREDITH & STEPHENSON 1945, NUTTALL & SPIERS 1946, MEREDITH 1951, FARR 1953). A number of methods whereby implants can be reconstructed, either on

paper or as a model, have been described (KLIGERMAN et coll. 1956, MUSSELL 1956, SMITH 1958, DEVOIS et coll. 1958, VAETH & MEURK 1963). The use of multisection transverse tomography for visualizing implants is particularly worth mentioning (EGAN & JOHNSON 1960, PIERQUIN & FAYOS 1960, PIERQUIN, CHASSAGNE & GASIOROWSKI 1960).

The 'physical input data' shown on the top left on Table 1 correspond to the isodose curves and output measurements which are a prerequisite of clinical dosimetry in teletherapy. As was pointed out in part I of this review, it is the physicist's responsibility to obtain, by direct measurement or otherwise, full data on all sources of radiation used in therapy. In the case of the small sealed sources used in brachytherapy, an accurate measurement of the activity of each source is usually made by the manufacturer. It is advisable, however, for the user to check the distribution of activity within the source by autoradiography and to check all radium sources for leakage at 6 or 12 monthly intervals. The strength of short-lived seeds, including radon, ^{198}Au and ^{90}Y , should also be measured before use, at least on a sampling basis to check the values quoted by the supplier, and the same applies to radioisotopes used in wire form (^{182}Ta and ^{192}Ir) which may be supplied as 'hairpins' or alternatively as long wires which have to be cut to length before use.

In contrast to teletherapy, isodose curves and dosimetry systems in brachytherapy are usually based on calculation rather than measurement, although it is fairly common practice to check the calculated dose-rate in situ by means of a scintillation or photoconductive (usually CdS) probe, for example placed in the rectum in the case of radium treatment of the cervix uteri. Isodose curves for many individual needles and tubes are available through the 'Radiation data for medical use' — scheme (1964) of the International Atomic Energy Agency. It must be remembered that nearly all clinical experience with small sealed sources is based on dosimetry in air, i. e. the effect of tissue absorption and scattering is neglected. This is unimportant for nearby points (say up to 2 cm from a source) but the correction becomes appreciable for more distant points, and it is precisely at such points that the dose needs to be known if supplementary external irradiation is planned. (For correction factors see: WOOTTON, SHALEK & FLETCHER 1954, BATHO & YOUNG 1964.)

It must further be borne in mind that the most commonly used dosimetric system, the Paterson-Parker system, is based on a dose-rate in air of 8.4 R/hour at 1 cm from a point-source of 1 mg of radium (filtration, 0.5 mm Pt), although the correct value of this constant is now generally considered to be 8.25 R/hour. Indeed, there is an interesting group of related problems which remains to be resolved in brachytherapy: (a) the conversion of Paterson-Parker roentgens to rads (SHALEK 1963), (b) the relationship between the stated dose, according

to a formalized dosimetric system such as Paterson-Parker and the dose assessed by detailed study using a computer, and (c) the relationship between the dose delivered to a given volume of tissue by implanted sources and that delivered to the same volume by external irradiation — an important matter when 'combined' therapy is to be given, as in cancer of the cervix uteri.

It is not proposed to discuss Table 1 in detail since most of the procedures included in the table are well known. We shall therefore conclude this section on brachytherapy by referring briefly to four developments in this field.

1. Recently there has been a considerable interest in, and development of, afterloading techniques. By afterloading is meant the insertion into the tissues, or into a body cavity, of empty tubes or containers representing the radioactive sources. The actual sources are loaded into the empty tubes later on, under much more favourable conditions of radiation protection. Afterloading is not only advantageous from the protection point of view, but is also conducive to accuracy since it is easier to insert, or re-insert, inactive containers into the body than active sources (MOWATT & STEVENS 1956, HENSCHKE 1960, BRASFIELD & HENSCHKE 1961, SUIT *et coll.* 1961, WALSTAM 1962, PIERQUIN & CHASSAGNE 1962, RIDINGS 1963, CHASSAGNE, RAYNAL & PIERQUIN 1963, HENSCHKE, HILARIS & MAHAN 1964, 1965.)

2. Another recent development is the use of computers in the dosimetry of small sealed sources. The analogue computer of KEMP (1950) has been used for many years, but digital computers are now being brought into this field, both for the calculation in advance of treatment arrays and for the assessment of implants which have already been inserted into the patient (SHALEK & STOVALL 1961, STOVALL & SHALEK 1962, LAUGHLIN *et coll.* 1963, MEURK & ADAMS 1963, ADAMS & MEURK 1964, HOPE *et coll.* 1964).

3. The replacement of radium by artificial radioisotope sources is gathering momentum. (The use of gold-198 seeds in place of radon for permanent implants is well established.) The isotope most favoured as a radium substitute, particularly for gynaecological work, is caesium 137 (HORSLER, JONES & STACEY 1964, HORWITZ *et coll.* 1964). This isotope has a reasonably long half-life (30 years) and its gamma ray energy (0.66 MeV) is significantly lower than that of radium, so that shielding problems (both external and within body cavities) are simplified. Until recently, caesium sources were considered unsuitable for use within the body since the active material was available only as a soluble salt, but this difficulty has now been overcome. Another isotope of great promise is tantalum 192 (half-life 74 days; effective gamma ray energy 0.34 MeV) which is available in wire form, particularly suitable for afterloading techniques (HENSCHKE 1958, PIERQUIN 1964, 1965, SIMON 1965).

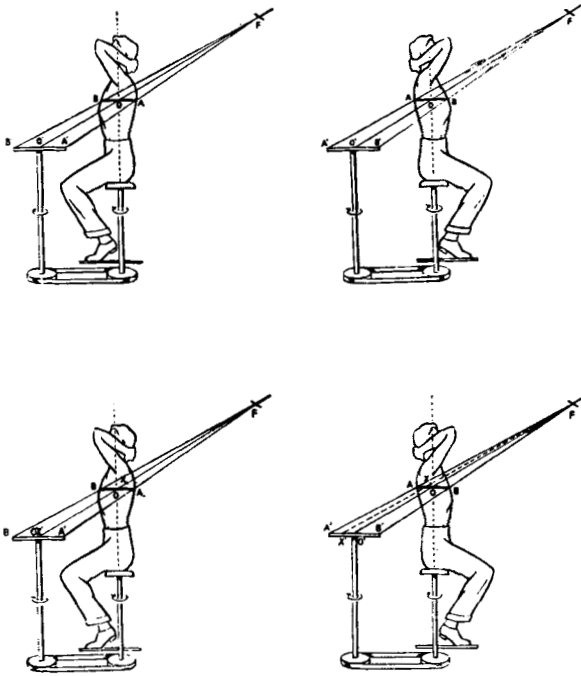


Fig. 1. Principle of transverse tomography. From STEVENSON (1950). By courtesy of the author and the editors of Brit. J. Radiol.

The use of radium substitutes does not, in itself, introduce any fundamental change in the dosimetric procedures and calculations, provided that due account is taken of differences in half-life, specific gamma ray emission constant, oblique filtration and tissue absorption. If, however, the geometry of the sources is greatly different from that of radium needles or tubes — for example, if a number of flexible iridium wires are implanted — it may be difficult to utilize the usual dosimetric tables, and another system may be needed, such as the ‘point technique’ of PIERQUIN & FAYOS (1960).

4. The International Atomic Energy Agency is currently preparing an ‘Atlas of dose distributions’ for brachytherapy, which will include both geometrically perfect arrays of sources and illustrations of the effect of errors and variations in the geometry. It is hoped to be able to publish this atlas in 1966 or 1967.

Transverse tomography

Transverse axial tomography has been mentioned several times in this review in connection with planning the treatment, assessing the effect of body

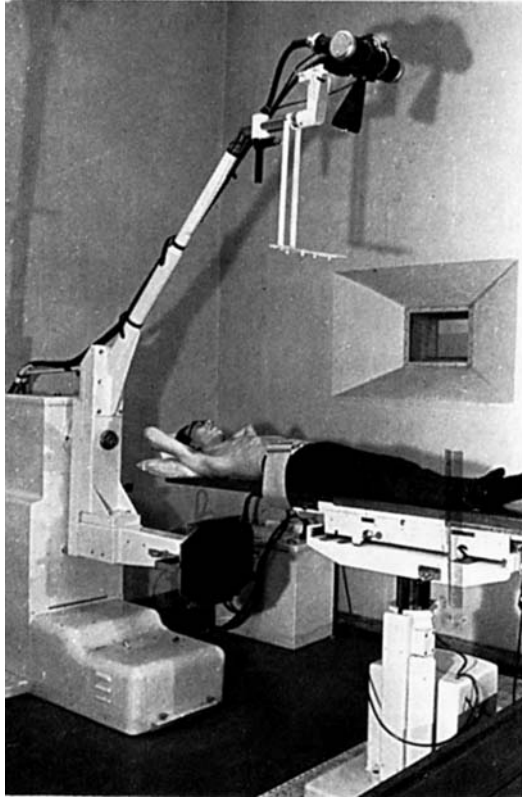


Fig. 2. Apparatus for axial transverse tomography with patient in horizontal position. Courtesy Dr S. TAKAHASHI and Toshiba Nucleonics Co, Tokyo.

composition and reconstruction of an implant. The method was developed largely in Italy and in France, whereas in the Anglo-Saxon countries the technique has, on the whole, been neglected, at least until quite recently. This is in spite of the fact that the theory was first expounded in an American journal (KIEFFER 1938) and one of the earliest papers was in the *British Journal of Radiology* (STEVENSON 1960) from which Fig. 1 is taken. This diagram shows the working principle: when the film and the patient are simultaneously rotated, in the same direction, about parallel axes, only points lying in a single plane of the body, less than 1 mm thick, remain stationary on the film and therefore in focus. All other points are blurred out.

The literature on this subject is abundant, and only a few of the papers will be mentioned: VALLEBONA 1948, 1950, FRAIN & LACROIX 1948, FRAIN

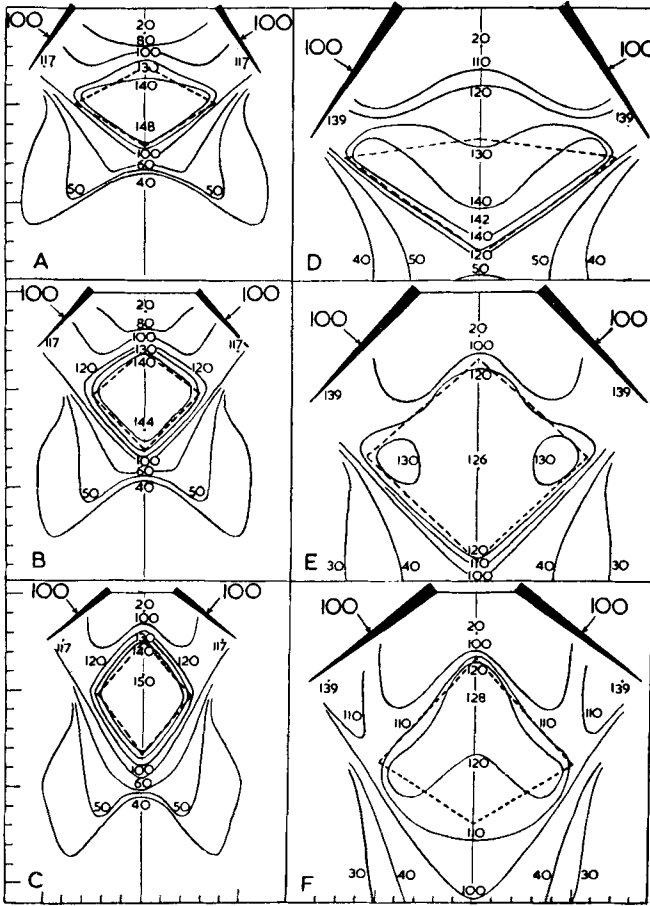


Fig. 3. Precalculated wedge-field isodose charts. From COHEN, BURNS & SEAR (1960 b).

et coll. 1955, ROSWIT et coll. 1959, PIERQUIN 1961, OLIVA 1963, FARR 1964. Papers on the use of transverse tomography for the reconstruction of implants have already been mentioned.

The disadvantage of transverse tomography, as shown in Fig. 1 and described in the papers so far quoted, is that the roentgenograms must be obtained with the patient in the vertical position, whereas radiotherapy is usually given with the patient lying down. This introduces the possibility of a change in the shape of the body, and in the relative positions of internal structures, as mentioned in part I of this paper. In order to overcome this difficulty, TAKAHASHI & MATSUDA (1960) devised a new form of tomograph which they called

Table 2

*Example of dosage table for 8 cm wedge to be used in conjunction with pre-calculated treatment plans
— From Cohen, Burns and Sear (1960b)*

θ	s (cm)	Plateau dimension (cm)		Mean tumour dose (per cent)	
		Max. width	Depth below base line	4 cm field length	16 cm field length
70°	4.0		5 —11.2	158	161
	6.0		6 —11.9	144	149
	8.0	14	7 —12.6	132	137
	10.0		8 —13.3	121	126
	12.0		8 —14.0	110	116
80°	2.0		3 —11.2	158	161
	4.0		4 —12.1	144	148
	6.0	13	5 —12.9	131	136
	8.0		5 —13.8	119	125
	10.0		6 —14.6	108	114
90°	2.0		1.7—11.9	143	147
	4.0		2.7—12.9	129	134
	6.0	12	3.7—13.9	116	122
	8.0		4.7—14.9	105	111
	10.0		5.7—15.9	94	101
100°	2.0		1.9—12.6	132	137
	4.0		3.1—13.8	118	124
	6.0	11	4.3—15.0	105	112
	8.0		5.5—16.2	94	101
	10.0		6.7—17.4	84	91
110°	1.0		1.4—10	139	144
	3.0		2.8—11	123	128
	4.0	10	3.6—12	115	121
	5.0		4.3—13	108	114
	7.0		5.7—14	95	102
Hot spot (per cent)				139	135

the 'universal rotatograph'. TAKAHASHI has since improved the apparatus so that it can be used either for fluoroscopy or for radiography, and the latest commercial version (Toshiba Nucleonics Co Ltd, Tokyo, Japan) is shown in Fig. 2. (See also TAKAHASHI 1965.)

Pre-calculated treatment plans

It is sometimes said, when a pre-calculated treatment plan is used, that the patient is made to fit the plan instead of adapting the plan to fit the patient. This is fortunately only a half-truth, since the rationale of the pre-calculated

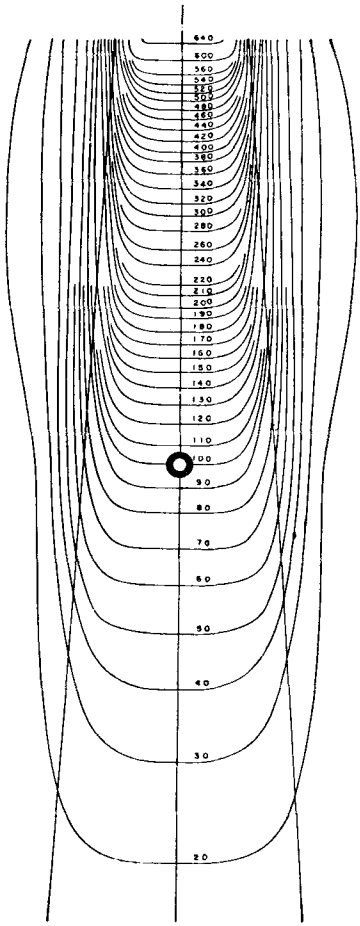


Fig. 4

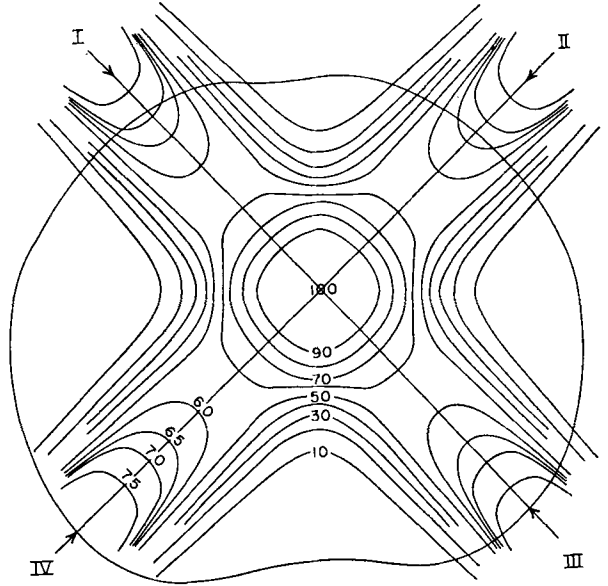


Fig. 5

Fig. 4. Single field isodose curve based on 100 % at a depth in tissue (^{60}Co , SCD 75, 10×10). From DU SAULT (1959). By courtesy of the author and the editors of Radiology.

Fig. 5. Four-field isodose charts (^{60}Co , fields 6×6 at right angles) with contour of patient added. From DU SAULT (1959). By courtesy of the author and the editors of Radiology.

plan is that it should be independent of the contours of individual patients, or, at least, readily adaptable to any patient. Nevertheless it must be stated that a single pre-calculated plan is unlikely to be applicable to all patients and tumours, and the method is useful only if a series of such plans is available to cover a broad range of conditions.

One of the best examples of the method is for two oblique wedge fields. This technique was first used by ELLIS & MILLER (1944) for 200 kV roentgen rays and was further developed by ELLIS et coll. (1950). The method was systematized by COHEN (1959), who analysed the effect of the different parameters of the system. A similar analysis was carried out by COHEN, BURNS &

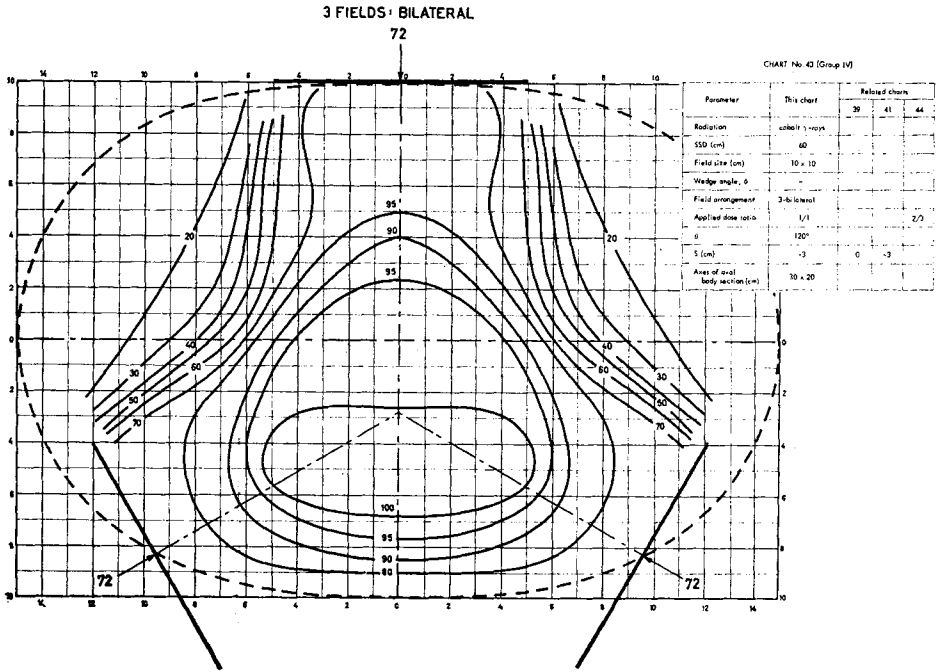


Fig. 6. Sample page from 'Atlas of multiple-field isodose charts'. From COHEN (1966). By courtesy of IAEA, Vienna.

SEAR (1960), for wedge filters used with cobalt 60 radiation, and Fig. 3 shows some examples of isodose charts taken from this paper. The complete set of charts is, of course, much larger, and the charts have to be used in conjunction with tables such as that illustrated in Table 2.

The purpose of the wedge method is to treat tumours located near the surface of the body but extending to some depth below the surface by means of 2 fields on one side of the body only. Thus the size of the individual patient does not matter, and the only aspect of the patient which comes into the picture is the necessity of fitting the curved entrance surface of the patient into the space defined by the two oblique fields. In the case of 250 kV roentgen rays this problem is solved by irradiating through a wax block which fills the space between the applicator end and the patient's skin. For high energy radiation, however, it is desirable to use a compensating filter. The difference between these techniques was illustrated in Fig. 3 of part I.

Wedge filters are now very widely used in radiotherapy, especially with high energy radiation, and an extensive literature exists. Only those papers will be mentioned here which have made an important contribution, not

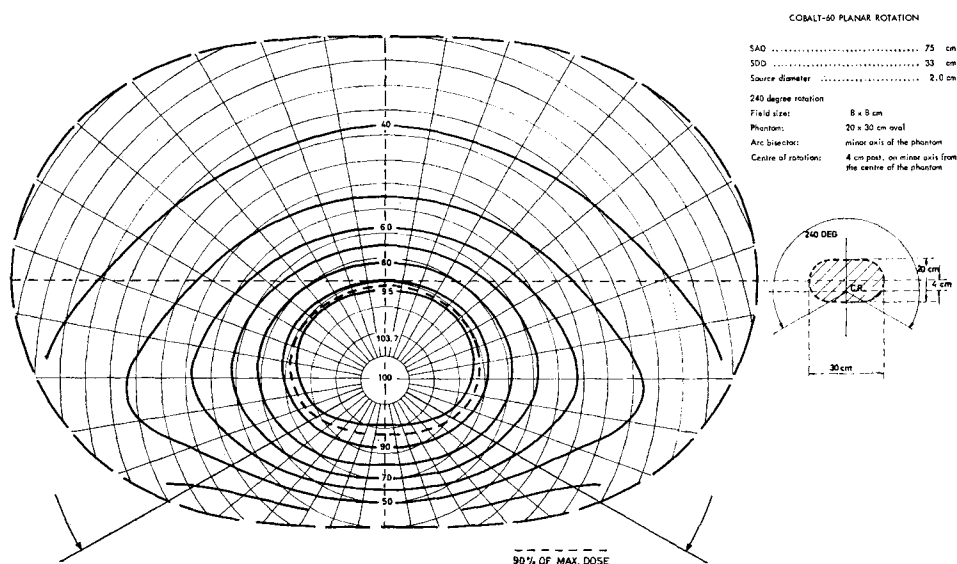


Fig. 7. Sample page from 'Atlas of moving-field isodose charts'. From TSIEN, CUNNINGHAM & WRIGHT (1966). By courtesy of IAEA, Vienna.

merely to the design and construction of the filters but to the concept of pre-calculated plans: MICELI, BONO & RIMONDI 1964 (^{137}Cs); CAVINA et coll. 1962 (^{60}Co); STEWART 1960 (4 MV roentgen rays); VAN ROOSENBECK & GRIMM 1961 (22 MV roentgen rays); SEAR 1959 (general analysis).

Another important type of pre-calculated plan is derived from the method of BRAESTRUP & MOONEY (1955) which was further developed by DU SAULT (1959). The basis of the method is the single-field isodose curve referred to 100 % at a depth in tissue instead of at a point at or near the surface. The isodose curves are supposed to extend indefinitely both above and below the reference point (Fig. 4). When a number of such fields converge at the reference point, a multiple field isodose chart is obtained which is independent of the contour of the individual patient. This contour may, in fact, be drawn on the chart, and the dose which has to be applied to each field to ensure equal contributions at the centre point may be calculated (Fig. 5). In these circumstances, the dose distribution in the centre of the chart is exactly reproduced, and errors are incurred only near the surface, where in general the dose is not critical. The method has been further extended and improved by MACDONALD (1961), PFALZNER (1962), GIAUX et coll. (1964) and LEGARÉ (1964).

Many other examples of pre-calculated plans could be given, for example for tangential irradiation of the breast and for parametrial irradiation by

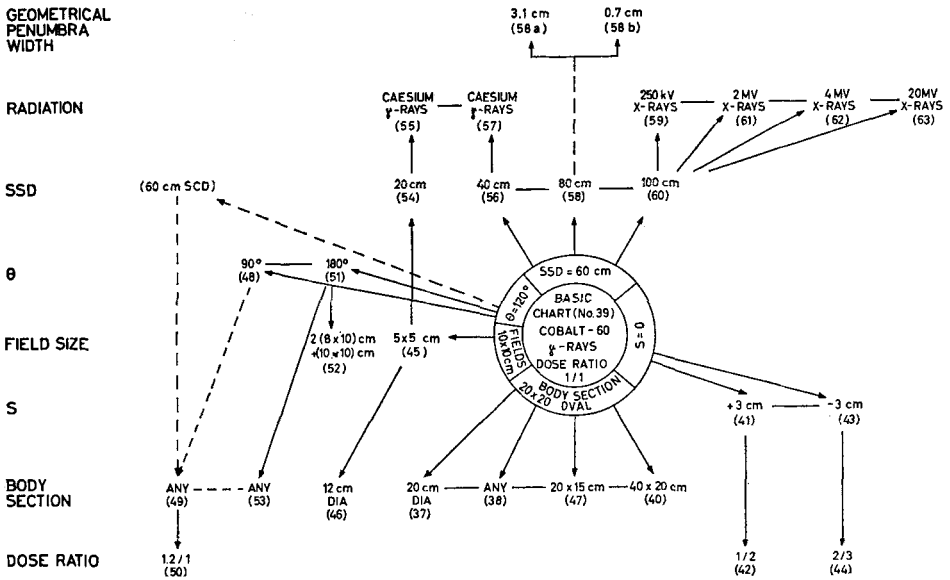


Fig. 8. 'Radial' arrangement of 3-field charts in group IV of the 'Atlas of multiple-field isodose charts'. From COHEN (1966). By courtesy of IAEA, Vienna.

means of opposed fields following intracavitary radium treatment. The essential feature of the method is that only one or two parameters of the individual patient are relevant so that a set of plans covering all sizes of patients can be prepared and systematized.

Atlases of isodose charts

An atlas of isodose charts is, superficially, similar to a set of pre-calculated plans but in fact differs from such plans in that the charts in an atlas are not confined to situations which are independent of the individual patient. In a sense, every radiotherapy department builds up its own atlas over a period of time, but these collections (which of course derive from treatment plans produced for actual patients) differ from a true atlas in that they lack the two essential elements of systematization and analysis. Indeed, to turn a collection into an atlas is a formidable task, as the author and his colleagues in the International Atomic Energy Agency discovered when they decided to prepare such atlases for high energy radiation (including cobalt and cesium gamma rays).

These atlases are for multiple fields (COHEN 1965) and moving beams (TSEIEN, CUNNINGHAM & WRIGHT 1966); sample pages are shown in Figs 6

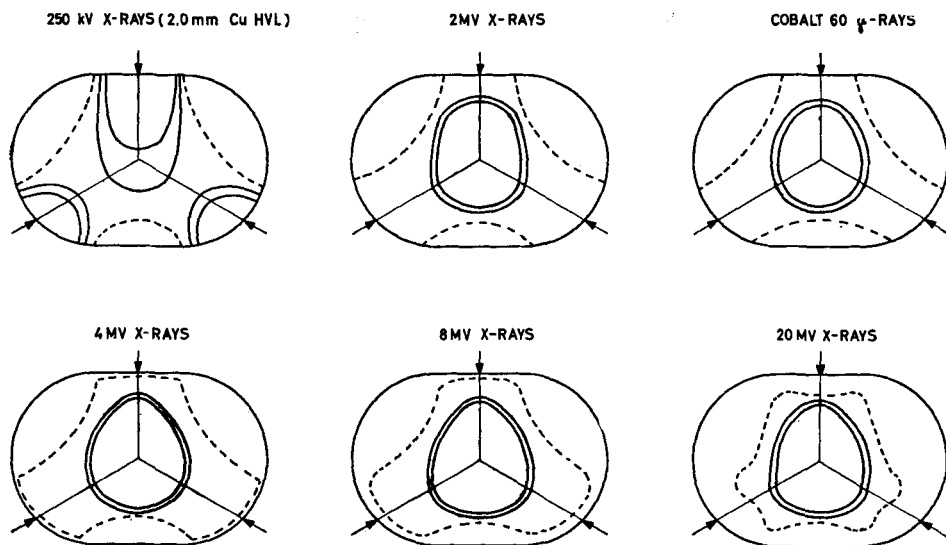


Fig. 9. 'Plateau diagrams' for 3-field irradiation with different beam energies (10×10 cm fields, 100 cm SSD). The lines represent 90 %, 80 % and 50 % isodoses, where 100 % is the maximum in the target region. (See also fig. 11.) From COHEN (1966). By courtesy of IAEA, Vienna.

and 7, respectively. (A third atlas, for single fields, has also been prepared: WEBSTER & TSIEN 1965.) Space does not permit a detailed discussion of these atlases and their use, but one or two important features of the multiple-field atlas will be mentioned. Classification is based on the number of fields and their arrangement, for example, 2 opposed fields, 3-field bilateral irradiation, and so on. Within each main section there is a basic plan, with average or typical values of all parameters, and the other charts in the section are linked to this chart on an approximately radial basis, as illustrated in Fig. 8. Each isodose chart is related to at least one other chart, and often to several other charts, by a change in one parameter only. The body contours are necessarily idealized, and for this purpose the 'oval' outline proposed by HAYNES & FROESE (1957) has been adopted. In this atlas, and in the moving-beam atlas, the isodose charts are supplemented by a detailed analysis of the effect of the various parameters on the dose distribution. This analysis takes the form both of graphs and of so-called 'plateau diagrams', which are abbreviated and simplified isodose charts produced by the method to be described below. An example of a group of six of these diagrams for three fields, converging at the centre of an 'oval' of axial dimensions 30×20 cm (10×10 cm fields, 100 cm SSD), for various beam energies, is shown in Fig. 9. Such groups of plateau

diagrams provide an effective means of illustrating the effect of a given parameter. A detailed graphical analysis is also given in the moving-beam atlas.

While the IAEA atlases are the most comprehensive of their type yet published, mention should also be made of the important sets of dose distributions for moving-beam therapy published by DAHL & VIKTERLÖF (1958) (250 kV roentgen rays) and by HULTBERG et coll. (1959) (cobalt 60 radiation).

Rapid assessment of treatment plans

As was pointed out in part I of this paper, it is difficult for a human computer to produce isodose charts for individual patients quickly enough to enable the final treatment plan to be chosen from a number of alternative charts. The author has therefore devised a method whereby this choice can be made on the basis of data which are intermediate between a full isodose chart and the dose at one or two points only. At present, the method has been fully worked out only for symmetrical field arrangements but it is being extended to asymmetrical arrangements. The following is intended only as a summary, since a detailed description of the method will be published elsewhere. Two operations are involved:

1. The combined dose distribution is plotted along the axis of symmetry. This is rapidly done, without combining isodose curves, by drawing a line at the appropriate position on the single-field isodose chart. From the axial distribution curve may be read off (i) the maximum percentage depth dose, which is called 100 %, and (ii) the positions of the 90 %, 80 % and 50 % dose levels.

2. The edges of the various beams are drawn on the outline representing the patient. Except for very short SSD's, beam divergence may be ignored. The area in which all the beams overlap represents the area enclosed by the 80 % isodose curve, except that this area may be extended into certain areas in which some, but not all of the beams overlap (e. g. 2 out of 3 beams, or 3 out of 4). Simple rules may be propounded for these extensions. The envelope of the beam edges (excluding the exit positions of each beam) represents the 50 % isodose curve, except in certain cases (for which, again, there is a simple rule) for which this envelope represents instead the 40 % or the 30 % curve (Fig. 10).

3. Combining (1) and (2), it is possible to sketch an abbreviated isodose chart (plateau diagram) which shows only the 90 %, 80 % and 50 % isodose curves. Such a diagram contains in fact all the information needed to assess the suitability of a treatment since it shows the position, size and shape of the region of uniformity (as depicted by the 90 % line), the rapidity of the fall-off

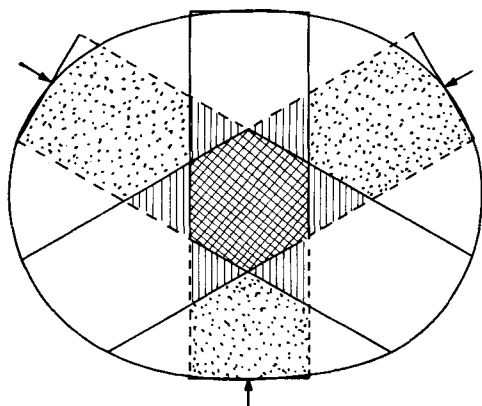


Fig. 10. Method of rapid assessment of multiple-field distributions by considering area of beam overlap.

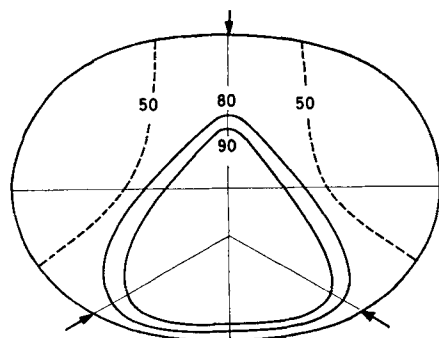


Fig. 11. Abbreviated isodose chart ('plateau diagram') of field arrangement shown in fig. 6. The 100% point (maximum in target region) not shown.

outside this region (as shown by the relationship between the 90% and 80% lines), and finally some information about the dose outside the tumour region (as represented by the 50% line). In Fig. 11 the plateau diagram for a 3-field arrangement is shown and this may be compared with the full isodose chart for the same field arrangement shown in Fig. 6.

However, even if a full isodose chart is available, it is doubtful if we make use of much more information than this in assessing the value of the chart; in fact, a full isodose chart contains so much data that we are bound to extract the salient features before it can be comprehended. All that the proposed method does is to examine the nature of the extracted data and to produce this information, but no more, by a short cut.

Conclusions

Clinical dosimetry today is in a most interesting stage of development. A few years ago, the main pre-occupation in radiotherapy was the switch-over to high energy radiation. This process is, of course, continuing, but the centre of interest has moved towards more exact dosimetry with high energy units whose existence is taken for granted. Two problems must now be solved, not simply in a few large and advanced radiotherapy centres but in centres all over the world: firstly, how can we ensure that an optimum treatment plan is prepared for each patient in accordance with the individual characteristics of the patient and his tumour; and, secondly, how can we take into account,

on a routine basis, the obvious fact that a patient is not exactly the same as a rectangular tank of water.

It is fashionable nowadays to hail the digital computer as the answer to all dosimetric problems. The role of the computer in clinical dosimetry is by no means agreed, and it would be unwise to regard the computer as a universal panacea. On the one hand it is argued that the computer will enable an individual treatment plan to be tailored to the needs of each patient. But it is also said (e. g. SHALEK 1963) that this is not the ideal role for the computer: instead, computers should be used to produce a large number of treatment plans, of the pre-calculated type, as well as bigger and better atlases of isodose charts and analyses of the effect of each parameter. In the present author's opinion there will be need, and scope, for several types of application and, indeed, it is unrealistic to take a narrow view as to the application of computers.

At this point, a word of caution as to pre-calculated plans is perhaps necessary. There is no doubt that the judicious use of such plans is a god-send in a busy radiotherapy department. If half the patients are treated through pre-calculated plans, then the other half, for whom such plans are inapplicable, will have a better chance of the individual calculations which their conditions demand.

Now it is easy to conclude from this that the more pre-calculated plans a department has available the more patients can be treated by this method and the better the choice for the individual. This is true up to a certain point but beyond that the system can become self-defeating. Suppose, for example, one has 10, or even 20, isodose charts of pairs of wedge fields. These can be spread out side by side on the table and the choice for a given patient made by direct comparison. But if one has 200 such charts, a direct comparison is no longer so easy. The rapid choice of the correct chart now depends on the use of a system of classification; not, however, classification on the basis of the physical parameters, such as field size and angulation, but on the basis of the size and position of the tumour. The more treatment plans are produced, by computers or otherwise, the more urgent becomes the need for an acceptable analysis of the isodose charts themselves, so that a rational comparison of large numbers of charts becomes possible. This is the kind of analysis we have tried to undertake in the atlases and in the simplified method of assessing charts that has been described in this paper.

Finally, it may be inquired what the policy on treatment planning of a radiotherapy centre with limited resources and trained staff should be, e. g. a centre with only one physicist and perhaps a technician or two, and whether an optimum division of time and effort is possible between the different stages of clinical dosimetry and between the different types of treatment planning.

No universal answer is possible but we may conclude by offering a 5-point plan as a basis for further discussion:

1. During the first few months after his appointment, and again whenever new equipment is installed, the physicist must spend at least half his time on physical dosimetry.

2. For the first 2 or 3 years it is necessary to concentrate on 'water phantom' dosimetry. Simple corrections should be applied for lung tissue but no attempt should be made to assess these corrections individually. During this period the physicist must become thoroughly familiar with treatment planning.

3. Right from the start, simple corrections for field obliquity should be applied. Alternatively, compensating filters should be used routinely. Similarly, from the start, attention should be given to accuracy during the setting-up of the patient and delivery of the dose.

4. Routine treatment planning should eventually become the responsibility of either a technician specially trained for this purpose or of junior doctors who are training to be radiotherapists. In either case, overall supervision should rest with the senior radiotherapist in association with the physicist. It should be the aim of the physicist that after the first 2 or 3 years he should not need to spend more than 10—20 % of his time on routine planning. This will depend, of course, on the proportion of patients for whom pre-calculated plans are used. This proportion is a matter of individual preference and circumstances but, as a rough guide, 50 % of patients may be found suitable for this method. However, before this stage is reached the physicist must produce, or obtain, suitable plans.

5. Eventually more and more of the physicist's time should be devoted to the final ('reconsideration') stage of clinical dosimetry. This may be regarded as research in clinical dosimetry but the aim should be to produce a measurement and correction technique acceptable for routine use.

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SUMMARY

The organization of clinical dosimetry in four stages, which was described for teletherapy in part I of this review, is now discussed with reference to brachytherapy. Some recent developments are mentioned, including afterloading, computer evaluation of doses due to arrays of sealed sources, and the replacement of radium by other radioisotopes. Some special topics mentioned earlier in this review are described in more detail: axial transverse tomography, pre-calculated treatment plans, atlases of isodose charts, and the rapid assessment of treatment plans. A policy for treatment planning is suggested for developing radiotherapy centres.

ZUSAMMENFASSUNG

Die Einteilung der klinischen Dosimetrie in vier Stufen, wie im Teil I für die Teletherapie beschrieben worden ist, wird jetzt mit Hinsicht auf die Brachytherapie besprochen. Neuere Entwicklungen werden angeführt, einschliesslich 'afterloading', automatischer Berechnung von Dosen plombierter Bestrahlungsquellen und der Ersatz von Radium durch andere Isotope. Einige Spezialfragen, die früher in dieser Übersicht erwähnt wurden, werden im Detail beschrieben: axiale transversale Tomographie, vorberechnete Behandlungspläne, Atlasse von Isodosenkarten und die rasche Herstellung von Behandlungsplänen. Massnahmen für die Therapie-Planung in neuen radiotherapeutischen Zentren werden vorgeschlagen.

RÉSUMÉ

L'organisation de la dosimétrie clinique en quatre phases, décrite pour la téléthérapie dans la première partie de cette revue, est maintenant appliquée à la brachythérapie. L'auteur cite certains perfectionnements récents tels que 'afterloading', l'utilisation de calculatrice automatique pour évaluer la dose donnée par une série de sources scellées, le remplacement du radium par d'autres radio-isotopes. Certains sujets cités précédemment dans ce travail sont décrits de façon plus détaillée: la tomographie axiale transverse, les plans de traitement précalculés, les atlas de courbes isodoses, le choix rapide de plans de traitement. L'auteur propose comment procéder à l'organisation des traitements dans les centres de radiothérapie en développement.

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