Prof. Dr. Josef BECKER, Priv.-Doz. Dr. Karl zum WINKEL
and Dipl.-Phys. Eberhard JAHNS
Universitäts-Strahlenklinik, Heidelberg, Deutschland

The Collaboration of Physicists and Radiologists with Regard to irradiation planning in Supervoltage Therapy

In his topic Prof. *Cohen* has outlined the organisation of clinical dosimetry in megavoltage therapy. From the point of view of one, who has been familiar with this subject for years, Prof. *Cohen* has given us a detailed report on the optimal planning before irradiation. In this report we wish to outline our own experiences of supervoltage therapy from a clinical aspect, whereby a physicist and radio-therapist work in close collaboration.

Irradiation with 200 kV×rays, which was applied formerly, has for some years now, been replaced to a large extent by supervoltage therapy. The reason for this was among other things simply the less complicated dosimetry of the high energy radiation. For 11 years we have had experience with the 15 MeV-betatron and for 6 years we have applied a 2000 Curie Co^{60} source, and for 2 years a 2000 Curie $Caesium^{137}$ source. Since the Co^{60} source has been installed, the 15 MeV-betatron is applied exclusively for radiation with high energy electrons. Up to now 9105 patients in 353.780 single sessions were irradiated in the radiotherapy department of the Universitäts-Strahlenklinik Heidelberg. The table shows the specialized number of patients, treated with the several Instruments.

In this context it seems to us very important to point out, that the large number of patients were treated in our hospital with a team for each machine, a team consisting of a senior therapist, a young doctor and technical staff. A short time ago the whole hospital including furthermore, a large nuclear medical department, engaged only one physicist. In the meantime

TABLE I

Total number of radio therapeutic acts in the supervoltage department of the Universitäts-Strahlenklinik Heidelberg

Instrument	*Period*	*Patient*	*Single irradiations*	*Daily average*
Betatron	23.10.1953 31.12.1963	2940	117 394	80
Co^{60} - source . .	19. 2.1958 8. 8.1964	5562	222 218	140
Cs^{137} - source . .	15.11.1962 8. 8.1964	603	14 168	60
Total therapy department . . .		9105	353 780	280

there are two physicists. Moreover we have an electronics technician and a physical technical assistant. This minimum of physical staff compared with a maximum number of patients has forced us to look for more rational possibilities with regard to the organisation of radiotherapy. We could therefore some times accomplish the minimum requirements given by Prof. *Cohen*. These allow us to give a step by step illustration of how the work in our hospital is organized.

Let us start with the installation of new instruments, the beginning of all radiotherapeutic work of a hospital. Already with the development of these instruments a close relation with the physicists of the manufacturing firm is maintained which, among other things, has lead to the method of the excentrical rotation therapy and the sieve and grid radiation in megavoltage therapy. After installation of the machine the radiotherapist allows the physicist several weeks to carry out the measurements of the dose in air and water phantom. This dosimetry includes the depth dose curve of single field sizes in water or perspex phantom without consideration of the bone or air absorption, and similarly in the rectangular phantom the whole single — field — isodose charts for all usual field sizes and skin source distances. Moreover the absorption coefficient is especially determined by bone and lung tissue and correcting factors ascertained. The material obtained in this way enables one to make routine adjustments at the beginning of the irradiation treatment without continual measurement. Having finished, the therapist receives the results of the physical measurements as a scale for all members of the hospital. Then the instrument passes to the therapist, who during the first weeks, tries to treat simple cases suitable for stationary field radiation without heterogeneous tissues in the beam. The first treatments carried out in collaboration with the physicist whose results of the patient are permanently controlled thus enabling the therapist to learn how to handle the instrument and become acquainted with the dosimetry of this instrument.

As is usual, the control of a new big and expensive instrument is only given to an experienced radiotherapist and we do not think that a permanent consultation with the physicist about each patient is necessary. We have made the experience that a lot of new irradiation plannings of a definite indication, including dosimetry, can be elaborated by experienced therapists or given as a subject to young doctors, who are still studying. Therefore the therapist knows very well the dose distribution of his instrument and is able to carry out the normal radiation alone.

In this way the therapist is in the position to plan and carry out with the Co^{60} unit the stationary field irradiations of deep situated tumours with his standard method. The same applies to the half depth therapy with the caesium instrument, and to the radiation of soft tissues with the 15 MeV-betatron, which with the limited range of high energy electronics is given about 5 cm depth. At this point we want to define the position of the therapist in the megavoltage therapy. Just as the whole medicine is in part biology, radiotherapy is in part radiobiology, whose task it is to give an explanation with scientific methods of the phenomen of the actions of radiation on living cells. This calls for the necessary medical, physical and biological union in radiotherapy. In the same way that the physicist in a radiotherapy department must have a medical basis, a knowledge of dosimetry, the technique of setting up instruments and irradiation planning are indispensable requirements for the radiotherapist, who is then in the position to carry out the routine irradiation himself.

The collaboration of the radiotherapist with the physicist is absolutely necessary for each moving field irradiation and multiple field irradiation and for each irradiation with high energy electrons in inhomogenuous medien. Furthermore it is indispensable with regard to large atypic tumors and in the case of a new irradiation of an irradiated field of the body or by the combination of several kinds of irradiation.

This applies especially to work in our hospital, when for example, a field radiated with a Co^{60} source is to be irradiated with high energy electrons up to a full tumor dose. Another indication for the close collaboration between physicist and therapist is the combination of local application of radioisotopes and an additional percutanous teletherapy with gamma radiation. These cases are presented to the physicist, who either measures or calculates the distribution of dose corresponding to the individual situation.

Some characteristics with regard to the collaboration between physicist and radiotherapist in the dosimetry are due to the conditions in Germany. As you already know, there are only few places for physicists. But it is our aim to change these conditions and to create more permanent appointments for physicists in the future, offering, of course, the stimulus demanded, but this situation will probably not change in the immediate future. Nevertheless the number of doctors must be greater than that of the physicists. But we do not intend to reach the anglo-saxon conditions. This attitude is due to the fact, that our successes do not lay behind on the international scale. Today the boundaries of modern radiation therapy lie not only in the technical field, but also in the biological field. It is one of the physicists duties to give all the therapists of a hospital comprehensive instructions with regard to the dosimetry so that he needs only be consulted for abnormal irradiation.

He is there to give information in cases where his specialised knowledge is required for treatment planning. Moreover the physicist's duty is to work continuously in the technical development of radiology and its biophysical basis. From the medical point of view we should like to add the following: Although it is necessary to carry out the treatment planning with care, yet — and it may sound trivial — the patient is by no means a subject who can be calculated exactly. He is not only a biological subject, he is a psychological one too, which must be considered during the therapy. Consequently each patient must undergo medical care with each radiotherapy. During the irradiation both patient and radiation instrument must be controlled. To fix the patient during this period, is not only unnecessary but also detrimental. Quite often we had the experience that in spite of accurate planning and reconsideration the radiation field was not exactly aimed at the point of disease. As you have heard of the method of the transverse tomography, the tomography of the internal organs is dependent upon the body position. Moreover some organs such as kidney, spleen and liver vary in their position during respiration which in turn varies with the psychic factors.

On the other hand we want to mention the filling state of some organs in the body like oesophagus and bladder which must be considered during irradiation. For all these reasons we either carry out a setting up of the irradiation field with the x - ray localisation equipment with video amplifier prescribed by *Becker* and *Werner*, or a direct field control by means of photos with the telecobalt — source or telecaesium — source in irradiation position which has been prescribed and developed by *Frischbier, Harms* and *Kuttig*.

Corrections are not infrequent. Further modifications result during the irradiation provided that a progressive growth of the tumor or a diminution demand an increase or decrease in the size of the irradiation field. A continuous photographic documentation can be carried out in superficial tumours or in the other cases by x-ray controls means as a dire.

The collaboration between physicist and therapist is of special importance when the individual tumor disease and the state of the patient stipulate situations differing from the usual disease. Inspite of the most accurate treatment planning and most careful dosimetry it is possible that haematological complications or a continuous cachexia lead to a state, whereby a complete tumor dose is only allowed over in long periods. These medical points of view often demand modifications of the irradiation field during the treatment planning, medical interests taking absoluty priority in radiotherapy.

However, we do not expect longer survival times of our patients solely because of a perfected physical technique, but rather by means of better and more refined diagnosis. For years therefore, we have made extensive tests with our carcinoma patients before and during treatment to determine the presence of metastases. Apart from the usual x-ray pictures of the lung and bone system, we examine the lymphatic system by means of radioisotop scan and x-rays. Moreover we check intensively tumor complications of the urogenital tract of the gastro-intestinal tract, and the lungs. Indication of metastases either leads to an increase of the irradiation field or to a formation of several fields making an additional burden for the patient. Tumor complications require careful consideration, because complications could increase with a high dosis and menace the life of the patient more than the tumor disease. As it is possible for us to determine metastases more often than was the case formerly, and as we find a considerable frequence of complications in our carcinoma patients, we often are confronted with complicated situations, requiring consultations between the therapist and the physicist. The purpose of these consultations is to find out whether a curative or a palliative radiotherapy is required, according to the individual tumor situation. We have received the impression, that the so - planned radiotherapy improves to a large extent the prognosis of carcinoma patients capable of being treated and enables us on the other hand to refrain from radiating the patients unsuitable for treatment.

These experiences gained in practice should in no way lessen the physical efforts to achieve as exact a dosimetry as is possible. They may only serve to show that in the radiotherapy no claims should be made resulting from the dosimetry. In our opinion, for example, the supervoltage therapy has the essential advantage to spare the skin tissue of the patient. Therefore we are not prepared to renounce this sparing of the skin in favour of a proportionate distribution of dose in the tumor and to geometrise the patient's body with moulage and wedge filters, if they disturb the build up facture.

Taking into consideration all that planning or dosimetry and the progress of radiotherapy can influence, we come to the conclusion that the collaboration between physicist and therapist is not based on a priority, but to the contrary it must be determined essentially by compromises from both sides. With reference to the special position of each carcinoma patient the collaboration should aim at applying a tumor dose to all diagnosed tumor tissue offering the greatest saving of the healthy tissue, and should consequently guarantee an optimum of success.

LITERATURE

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INTERVENTI SULLA RELAZIONE

J. F. FOWLER

Dr. zum Winkel and Prof. Becker's paper was interesting in this respect, i.e. for providing the opportunity of individual variations. It should be noted that the percent variation of dose at the centre of the body will be only about half that of the variation in exit dose.

F. ELLIS

1 - Dr. zum Winkel seemed to think that the tissue compensation method described might lose the skin sparing advantage. I can assure him that this is not the case. The compensator is at least 12 cm. from the end of the applicator and so electrons from it do not reach the skin in any effective quantity.

2 - I think that while the clinical and radiotherapeutic wash of Dr. Becker and Dr. zum Winkel clearly of the highest order it will be a mistake if they do not use physicists for physical work. At the lowest it must be uneconomic and at a different level they may find themselves in danger of committing serious and systematic errors if they try to dispense with their services and advice.

RISPOSTA DEI RELATORI

K. zum WINKEL

Zur Diskussion von Herrn Professor Ellis, der uns heute morgen in seinem hervorragenden Referat ausführlich über die Verwendung von Keilfiltern in der Strahlentherapie berichtet hat, möchte ich sagen, daß sich unsere diesbezügliche Bemerkung nur auf die Benutzung von Moulagen und Keilfiltern in unmittelbarer Nähe der Haut bezogen hat. Wir benutzen in unserer Klinik auch Kompensationssysteme, doch war es uns wichtig, außerdem die Möglichkeit der Dosisangleichung durch Aenderungen des Bestrahlungsfeldes unter der Therapie wenigstens zu erwähnen. Herrn Professor Meldolesi bin ich dankbar, dass er gleichfalls die Bedeutung der Radiodiagnostik für die Strahlentheraphie betont hat. Zugleich im Namen von Herrn Professor Becker darf ich die unabdingbare Einheit von Radiotherapie, Radiodiagnostik und Klinik unterstreichen, die zusammen mit den Bestrebungen der Physiker nach unserer Auffassung zweifellos die Ergebnisse der Strahlentherapie bei den Krebskranken verbessern wird.

CONCLUSIONE DEI MODERATORI

A. VALLEBONA

Non è mia intenzione, e non ve ne sarebbe la possibilità, di riassumere le interessanti relazioni dei prof.ri Cohen, Dutreix, Massey, Becker (letta da Zum Winkel). I relatori hanno assolto il loro compito nel modo migliore.

Mi limiterò a fare qualche considerazione di ordine generale sul tema « *Applicazione pratica della fisica in radiologia* » argomento trattato nelle tre ultime sedute.

L'interessante argomento svolto nella seduta di ieri mattina, la radioprotezione, ha dato luogo ad una animata discussione sulle reciproche competenze tra fisico e radiologo.

Io credo che non si debba drammatizzare su tali competenze; è bene che se ne discuta, e siamo qui per questo; io ritengo, e credo che non mi si possa contraddire, che ciascuno debba esplicare quel compito che è in condizione di fare nel migliore dei modi.

Sono convinto che il tempo farà giustizia ponendo ciascuno nella posizione che gli compete per forma mentis, per preparazione e per capacità in quel campo specifico.

Stamane sentimmo trattare dal prof. Marinelli dei problemi tecnici generali nella fisica radiologica.

I prof.ri Perussia, Ellis, De Giuli entrarono nei particolari della dosimetria.

Tutti siamo convinti dell'importanza fondamentale di questo argomento. Nessun medicamento in genere potrebbe essere impiegato se non vi fosse il modo di dosarlo esattamente.

Purtroppo nel campo nostro, per mancanza di mezzi idonei, abbiamo dovuto per molti anni accontentarci di mezzi di dosaggio imprecisi; lo sa bene chi, come il sottoscritto, ha adoperato i primitivi apparecchi di misura (radiometro di Holzknecht, ecc.).

Oggi siamo nella condizione di potere esattamente dosare il mezzo fisico che adoperiamo, e di ciò dobbiamo essere grati ai fisici.

E' necessaria una precisa dosimetria; né vale dire che poi la risposta biologica possa essere diversa anche per la stessa dose; questo dovranno valutarlo i biologi ed i radiologi.

Il poter partire da una dose precisa semplifica enormemente il compito al biologo ed al clinico.

Nelle parole introduttive da me pronunciate all'inizio di queste tre sessioni, a proposito della precisione della dose, ho portato l'esempio del cannone dal tiro preciso e del bersaglio il più spesso indefinito; fanno bene i fisici a perfezionare il tiro del cannone, ed hanno già fatto molto, come abbiamo visto; faranno bene i medici, ed in particolare i radiologi, a perfezionare le notizie sul bersaglio e cioè sul tumore da irradiare.

Ha ragione Marinelli quando dice che le incertezze sulla neoplasia non rappresentano una seria obiezione allo studio della precisione della dose.

In conclusione si deve dire che se esistono delle cause di errore, che non possono essere evitate, cerchiamo di eliminare almeno quelle che sono nella nostra possibilità.

Nelle tre giornate precedenti, a proposito della localizzazione del tumore, si è parlato della tomografia assiale trasversa (Meredith, Marinelli, Ellis ed il Cohen, il quale si è dilungato sul metodo).

Aggiungerei che la radiodiagnostica in genere è di notevole importanza nella localizzazione di molte neoplasie, come ho riferito nelle parole introduttive e come giustamente il Meldolesi ha riaffermato.

Tutti sono d'accordo che si debba distruggere la cellula neoplastica rispettando al massimo i tessuti circostanti; ancora stamani lo hanno affermato Marinelli ed Ellis.

Quindi è necessario conoscere la sede e la estensione del tumore.

La tomografia assiale trasversa consente di raggiungere questo scopo, almeno nel campo dei tumori polmonari.

La tomografia assiale trasversa, nata nel 1947 e derivata dalla tomografia convenzionale del 1930, ha già dato i suoi frutti sia nel campo chirurgico, sia in quello radiologico.

Sono d'accordo con Meredith che occorre, in tomografia assiale trasversa, grande precisione dello strumentario ed accuratezza della esecuzione tecnica.

Dovendo utilizzare il tomogramma assiale trasverso per la terapia radiante (sia per la terapia convenzionale, sia per la terapia con alte energie) è necessario ridimensionare l'immagine portandola alle sue dimensioni reali; la cosa è abbastanza facile, poiché basta porre un indice centimetrato sul paziente e riportare poi fotograficamente questo indice alle sue misure reali; avendo tutte le immagini dello strato fisso subito eguale ingrandimento (cosa che avviene solo in tomografia e non avviene nella radiografia standard) esse saranno tutte riportate alle misure reali.

L'osservazione di Cohen, Becker (Zum Winkel) è esatta; infatti, mentre la tomografia assiale trasversa viene eseguita a paziente in posizione eretta o seduta, il trattamento viene poi invece praticato a paziente in decubito; è naturale che ciò comporti uno spostamento della neoplasia, il che non accade quando si fa il trattamento a paziente in posizione seduta, come nella terapia rotatoria.

In realtà il metodo giapponese, che consiste nel far ruotare tubo e pellicola radiografica attorno al paziente in decubito, sarebbe vantaggioso sotto questo punto di vista; ma si tratta di un metodo molto complesso, che richiede uno strumentario complicato e non facilmente realizzabile.

L'istrumentario di Manzi, citato dal Meldolesi, non raggiunge una rotazione completa di 360°, consentendo solo una rotazione parziale, la quale, come hanno dimostrato numerose ricerche, tra cui quelle fondamentali di Oliva, non è sufficiente per ottenere una precisa tomografia assiale trasversa.

Ad ogni modo la tomografia assiale trasversa, come oggi viene abitualmente eseguita, pur riconoscendo le riserve avanzate, viene sempre ad avere una notevole importanza nella localizzazione delle neoplasie polmonari, contribuendo a perfezionare le nostre conoscenze sul bersaglio, che è rappresentato dal tumore da irradiare.

Concludendo le tre sedute « sulla applicazione pratica della fisica in radiologia », anche a nome del collega moderatore, desidero esprimere il mio compiacimento agli organizzatori di questi colloqui e ringraziare i relatori e tutti coloro che, prendendo parte alla discussione, hanno contribuito ad accrescere l'interesse di questo convegno.

Argomento precedente
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