RECENT CONTRIBUTIONS TO PLANNING THERAPEUTIC IRRADIATIONS*

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The computerized treatment planning programs, indispensable for up-to-date irradiation of deepseated malignancies, must take the influence of ever-greater numbers of physical factors into consideration and they make necessary the specification of ever-more optional factors. For this reason, we have attempted to develop a program also including optimization, on the one hand, and have checked with direct measurements whether the generally used methods in determining dose distribution take the surplus doses (produced by inclined irradiation) correctly into consideration, on the other.

Among the earliest fields of interdisciplinary research works, the cooperation of radiological physicians and radiation physicists is of particular importance. The investigations performed have often led to practical results of great significance and have opened up new vistas in the use of ionizing radiation both in diagnostic and therapeutic applications. A problem dating back half a century and coming to light in these works will be examined, and some new results of our investigations in this province are presented below; we refer here to the planning of irradiations.

One of the current ways to remove malignant tumours is the destruction of the tumour by ionizing radiation by means of a tumour-destroying dose. For over 80 years, side-by-side with special purpose radium sources, X-ray tubes, at a peak voltage of several hundred kV have been used as radiation sources.

With these X-rays of relatively poor penetration power even tumours seated at only 8–10 cm could hardly be reached by beams coming from a single direction. As the dose required for the destruction of the tumour was applied, the body tissues in the path, primarily the skin, suffered heavy irreversible damage.

The problem could be handled by either of two approaches. The first, viz. the application of photon radiations of significantly greater quantum energy, could not be implemented in practice for half a century mainly because of difficulties in the insulation of high voltages. The literature gives an account only of a single piece of X-ray equipment of 1 MV in which the X-ray tube was 10 m long and therefore unfit for routine therapeutic irradiations.

It was not until 1942 that Kerst discovered the principle of circular acceleration: electrons revolving in an annular vacuum tube of not more than 60 cm diameter can be

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accelerated to an energy of many MeV and either the electrons themselves or the X-rays generated by their collisions can be used for radiotherapy.

These betatron devices, however, were much too expensive and because of their poor dose intensity and other drawbacks did not become widespread in practice. All the more so since, in the last few years, cobalt units charged with $^{60}$Co radio-isotope, having parameters more favourable in many respects, have appeared. The 1.25 MeV photon energy is equivalent with the bremsstrahlung of a conventional X-ray machine with about 2500 kV peak voltage.

It should be mentioned here that Hungary has nine cobalt units for therapeutic purposes and one 29 MeV betatron device, but a further ten supervoltage units, in the first place linear accelerators, would be needed; in possession of these, all the old X-ray machines could be scrapped.

The other method to prevent over-irradiation of the tissues surrounding the tumour uses more beams from several different directions, or a moving radiation source rotating around the tumour in such a way that the beam is permanently centred upon the tumour. This technique results in the reduction of the dose upon the skin to half or a third of that applied to the tumour and so there is no risk of the tissues being overexposed.

The aim of the technique can be defined unequivocally: the tumour should be exposed to uniform irradiation as it receives the total irradiation coming from the different directions, while the resultant dose-field around it should drop as abruptly as possible.

The main physical factors influencing the requirements are:
- the energy spectrum of the photon radiation,
- the source – body surface distance,
- the dimensions of the fields of irradiation,
- inhomogeneities in the body (bones, lungs),
- location of the fields,
- directions of the irradiations,
- geometry of the body surfaces under the field,
- dimensions of the wedge filters,
- shape and dimensions of lead blocks shielding the body parts requiring special radiation protection,
- the relative doses delivered to the individual fields.

It goes without saying that the taking into account of the factors listed above, or even a rough estimation of their effects, cannot be done by mental arithmetic. Physicists are required who are familiar with the laws of physics governing the absorption and scattering processes, who are versed in the specialized calculations, and who have adequate knowledge of the relevant equipment, instruments, dosimeters, etc.

Despite these requirements, the physicians involved have no fundamental training in such matters and they cannot even be reasonably expected to acquire them.