ACTA RADIOLOGICA

OFFICIAL ORGAN OF THE RADIOLOGICAL SOCIETIES OF
DENMARK, FINLAND, NORWAY AND SWEDEN

Vol. 7
Fasc. 6

THERAPY PHYSICS BIOLOGY

1968
December

DETERMINATION OF TUMOUR DOSE BY TRANSMISSION MEASUREMENTS IN ROENTGEN ROTATION TREATMENT OF THE OESOPHAGUS

by

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Determination of the tumour dose in conventional roentgen irradiation is very uncertain because of tissue inhomogeneity especially in the region of the thorax. This inhomogeneity is due essentially to the presence of lung tissue, the density of which varies from patient to patient as well as within the same patient.

Attempts to measure depth doses in lung tissue have been made several times by FAILLA (1921), WEATHERWAX & ROBB (1930), QUIMBY et coll. (1934), NAHON & NAIDORF (1952) and DAHL & VIKTERLÖF (1955), and others. The conditions under which the measurements were made have been very different, however, and so the results show no great agreement. NEUMANN & WACHSMANN (1942) introduced a method for the calculation of the target dose in rotation treatment, based on the measurement of transmission, in principle on the conception of tissue-air ratio (TAR). ROBBINS & MESZAROS (1954) determined the TAR-value of homogeneous media of different shapes and sizes by phantom measurements for 250 kV roentgen rotation irradiation. LIDÉN (1948) described dose determination directly in the oesophagus; this method has been employed

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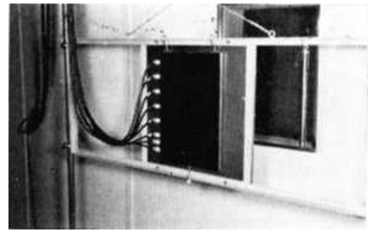


Fig. 1. Transmission chamber placed on the tube side of the fluoroscopic screen.

by GYNNING (1951). O'CONNOR (1956) as well as JACOBSSON & KNAUER (1956) have discussed two modifying, mutually counteracting factors: reduced attenuation, which increases the dose to the tumour within a region of lower density, and reduced scattering, which decreases the dose to the tumour in such a region. O'CONNOR attempted to estimate the influence of each of these two factors, and he has confirmed his calculations in three patients by measurements with small Sievert chambers, placed directly in the oesophagus. JACOBSSON & KNAUER made measurements in a heterogeneous phantom for some special treatment techniques and obtained correction factors due to reduced scattering as well as reduced absorption. DICKSON & MORGAN (1961) employed NEUMANN & WACHSMANN'S method of calculation and correlated their calculations with four measurements in patients. The measured values were not very accurate but they nevertheless indicated some agreement with the calculations. KELLER & ROK (1963) published a collection of tissue factors for different depths in the thorax and abdomen based on measurements of exit exposure. DAHL & VIKTERLÖF (1960) measured the cranio-caudal variation in transmission with several small condenser chambers and then constructed compensating filters to make the target dose homogeneous along the oesophagus.

The individual ability of the thorax to absorb and to scatter radiation varies considerably. NAHON & NAIDORF indicated that there is a variation of 250 % in exit exposure for comparable regions of the same thorax thickness in patients. JACOBSSON & KNAUER indicated that the exit exposure may vary considerably when measured with opposite beam directions. Measurements directly in the tumour region are, of course, the most reliable ones. However, even if the tumour is situated in the oesophagus such measurements are not always possible; in six out of the 50 cases included in the present investigation such measurements could not be made.

Calculation of target dose based on water-equivalent thickness, determined by means of transmission measurements, does not take into account the variation in the dose contribution of scattered radiation at the site of tumour. With the rotation technique one is for practical reasons limited to measuring the transmission.

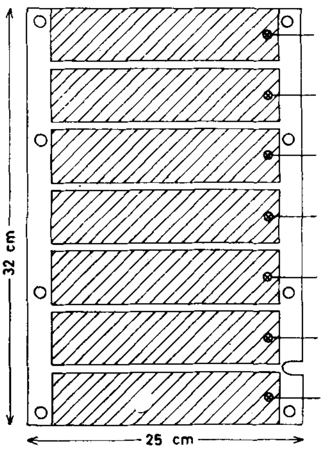


Fig. 2. Inner electrode with the seven graphite sections of the transmission chamber.

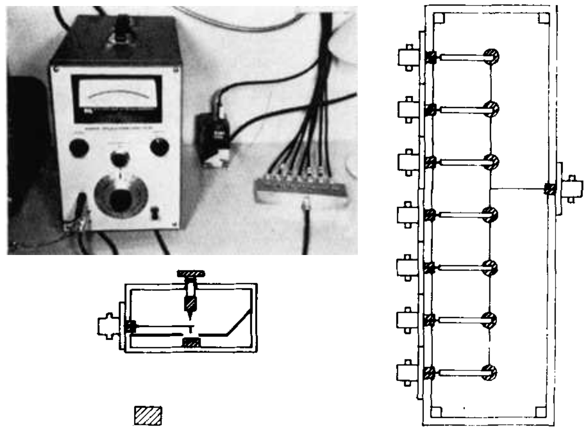


Fig. 3. Switch to 7-sectioned transmission chamber. The striped areas indicate the insulator.

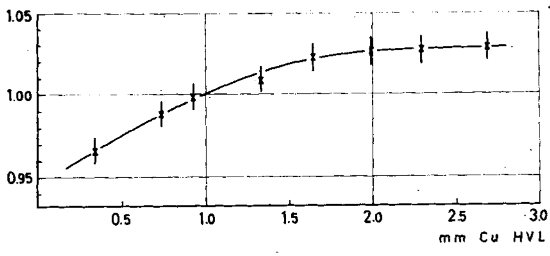
The oesophagus is surrounded by tissue of variable thickness with an average density of 1 g/cm^3. Deviations from calculations by the TAR-method thus ought to be of somewhat less importance than for a tumour situated in the lung parenchyma. However, the investigation has shown that this decrease in the dose, due to reduced scattering, is still quite observable.

Mathematical calculations for each treated patient would be time-consuming and uncertain. Often a relatively long cylinder, extending through most of the thorax of the patient and including varying amounts of lung parenchyma, is irradiated. The heart and the diaphragm may be included in the radiation beam.

The aim of this investigation has been to calibrate different transmission values by simultaneous measurements in the oesophagus and in the transmitted beam. These calibrations can then be used to calculate the target dose in roentgen rotation treatment of oesophageal tumours, and to estimate the variation of the dose in the cranio-caudal direction. In this way the unevenness of the dose can be eliminated by means of compensating filters.

Transmission (T) is here defined as the ratio between the exposure rate of the primary radiation transmitted through a patient, measured at some point beyond him, and the exposure rate of the primary beam itself at the same point.

The *treatment technique* includes the following technical data: focus-axis distance 60 cm; focus-fluoroscopic screen distance 120 cm; beam quality 200 kV, external filter 0.2 mm copper, which means a first HVL of 0.7 mm Cu. The patient is treated in a sitting position with arms raised over his head.



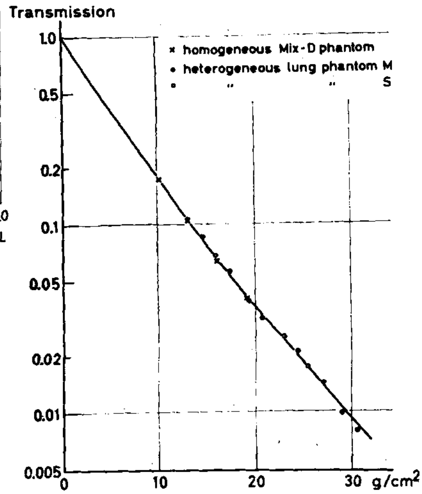


Fig. 4 (above). Energy response of the transmission chamber normalized to 1.0 for HVL=1.0 mm Cu. Vertical lines indicate the spread for different sections of the chamber.

Fig. 5 (right). Transmission as a function of phantom thickness in g/cm^2, for a solid mix-D phantom and for two heterogeneous lung phantoms. HVL=0.65 mm Cu for the primary radiation.

Measuring equipment

The ionization chamber which is used to measure the transmission has an area of 25 cm×32 cm and is placed in contact with the tube side of the fluoroscopic screen (Fig. 1). The construction of this chamber has been previously described (NORDBERG 1962). The walls and the central electrode are made up of 2 mm thick perspex sheets. The inside walls of the chamber are covered with a thin conducting layer of graphite and serve as the other electrode of the chamber. The design of the central electrode is shown in Fig. 2. The graphite layer is divided into 7 separate sections, each one having a separate lead through the surrounding metal frame. The chamber has a thickness of about 15 mm and is completely roentgen transparent except for the frame. The outside walls of the chamber are covered with graphite and grounded. The seven leads are joined to a switch situated in the roentgen control room (see Fig. 3 for the design of the switch). In the chamber, condensers of 50 000 pF are joined parallel to each section. The total capacity of each section and its corresponding cable is about 200 pF. An electrometer with a low input capacity (5 pF) is used as measuring instrument. A power supply in the control room keeps the inside walls at 300 V, and the central electrode is grounded before starting the measurements.

The sections of the central electrode are orientated in a vertical row and each section is 4 cm high and 24 cm wide, thus corresponding to an area of 2 cm×12 cm at the place of the rotation axis. The field size at the axis can vary between 4 and 8 cm in width and 10 and 17 cm in height, i.e. along the oesophagus.

Table 1

Response per unit field width for different field widths and phantom thicknesses

Field width cm	Equiv. square area cm²	A. Measurements without grid Phantom thickness, in cm				B. Measurements with parallel grid Phantom thickness, in cm			
		10	13	16	19	10	13	16	19
4	37	1.22	0.76	0.46	0.29	0.87	0.53	0.33	0.21
5	50	1.26	0 76	0.47	0.29	0.88	0.54	0.33	0.21
6	64	1.29	0.77	0.48	0.30	9.89	0.54	0.34	0 24
8	92	1.29	0 79	0.48	0.30	0.89	0.54	0.33	0.21

The irradiated area of each section is directly proportional to the width of the field. When short treatment fields are used the outer sections of the chamber will be hit only by the penumbra of the radiation beam. The charge that each section accumulates during the treatment of a patient is the measure of the exposure caused by the energy fluence from a horizontal cross-section of the patient, approximately 2 cm thick, during a certain number of full revolutions, a presumption being that scatter contribution from other sections can be neglected.

The quality of the primary radiation corresponds to a first half-value layer of about 0.7 mm Cu. The first half-value layer of the transmitted radiation measured in broad beam geometry is between 1.5 and 3 mm Cu, depending on the thickness of the patient. The response of the chamber (normalized to 1 for the mean value of the response of the sections, for a half-value layer of 1 mm Cu) is shown in Fig. 4 as a function of the quality of the irradiation. The energy dependence is negligible within the quality range of interest; for all practical purposes the variation in the response between the different sections (indicated by a vertical line in Fig. 4) can also be neglected. The variation in sensitivity from one section to another is probably due to the slightly varying height of the graphite sections.

For the low exposure rate at the place of the chamber, less than 2 R/min, no loss takes place because of the recombination for a field strength of about 700 V/cm. For accurate measurement of the transmission, the chamber must not be hit by scatter radiation from the patient. The ionization chambers usually have a distance of between 40 and 50 cm to the patient. After the beam has passed through 10 cm of water the ratio between the fluence of scattered photons leaving the phantom in directions aiming at a given point in the chamber, and the fluence of primary photons towards this same point, is about 0.06. The variation of the secondary contribution from the smallest to the largest field used is

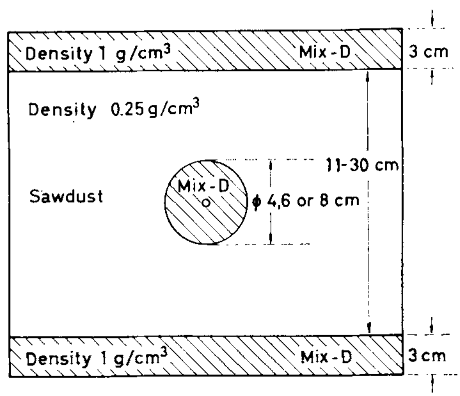


Fig. 6. Cross section of the lung phantom used for the calibration.

within $\pm 30\ \%$. After the beam has passed through 15 cm of water, this ratio is twice as much as for 10 cm. The influence of the variation in area is the same (BJÄRNGARD & HETTINGER 1961, LÉGARÉ 1964).

If the chamber is hit only by primary radiation the response per unit field width should be constant for different field sizes provided the exposure rate is constant all over the cross-section of the roentgen beam. This quotient, determined for 4 different field widths and 4 different thicknesses of a homogeneous mix-D-phantom, is given in Table 1-A. The values for each size of the phantom lie within $\pm 2\ \%$. This experimental series was repeated with a parallel grid (62 lamellae/inch, ratio 1 : 5.5) in front of the transmission chamber (Table 1-B). In this case the spread is within $\pm 1.5\ \%$. The influence of the grid, measured as the relation between the quotient with grid and the quotient without grid, for all field widths and all phantom sizes, lies within 0.69 and 0.72. This reduction corresponds approximately to the grid attenuation of the primary photons. This variation in sensitivity and grid effect for different areas and phantom sizes is so small that the contribution from scattered photons can be considered negligible.

Determination of the transmission through homogeneous mix-D-blocks and heterogeneous lung phantoms (mix-D, sawdust) of different thicknesses with a beam aperture of 5° (Fig. 5) gives a first half-value layer for the primary radiation of about 3.7 cm mix-D, corresponding to a mono-energetic radiation of about 80 keV. The first half-value layer of copper determined with narrow-beam geometry and with an ionisation volume of 1 cm^3 gives a value of about 70 keV. The sixth half-value layer is about 5 cm of mix-D. The HVL limit of the primary beam is 5.1 cm of water. Since mix-D and water are supposed to have the same linear absorption coefficient, the measurements cited give the actual transmission values. Fig. 5 also shows that the attenuation curve is the same for a homogeneous absorber when the thickness is measured in g/cm^2.

The transmission chamber is placed directly in contact with the tube side of the fluoroscopic screen which consists of a Pertinex plate (0.4 g/cm^2) causing backscatter radiation to the chamber. This contribution has been experimentally determined to be about 9 % for the transmitted beam, which is approximately independent of the various radiation parameters employed. For the primary quality the contribution is 12 %. These values agree with calculations made from published data (QUIMBY & LAURENCE 1940, WACHSMANN & DIMOTSIS 1957). Therefore the backscatter contribution merely necessitates a constant correction factor in the determination of the transmission.

The electric charge released during the irradiation is stored in the section itself, the cable, and the condenser of the switch. The polarization voltage of the chamber is 300 V, and the voltage change of a section will never exceed 30 V. This gives constant sensitivity during the whole irradiation. After irradiation the sections are successively connected with the electrometer by means of the corresponding buttons of the switch. The switch is constructed so as to prevent rubbing of the insulators, and as a result it does not contribute to the charge.

Calibration of transmission

Determination of the TAR-values corresponding to different transmission values has been made by measurements with heterogeneous lung phantoms of different constructions and by simultaneous measurements in the patients' oesophagi and in the transmitted beam.

1. Calibration by means of phantom measurements. The design of the lung phantom is shown in Fig. 6. It has a central, circular mix-D cylinder with a measuring channel of about 6 mm diameter. This cylinder is surrounded by sawdust compressed to a volume weight of 0.25 g/cm^3 (DAHL & VIKTERLÖF 1960) between two parallel mix-D blocks, each 3 cm thick. The diameter of the mix-D cylinder was 4, 6 or 8 cm. For each diameter the total phantom thickness varied from 17 to 36 cm. (The phantoms, designated S, M and L have diameters of 4, 6 and 8 cm, respectively.) In another series the thickness of the two outer mix-D blocks varied from 3 to 11 cm (the phantom being designated by Sa), while the parameters inside the phantom were kept constant. Measurements have been made simultaneously with the transmission chamber and with several condenser chambers in the phantom channel. The phantom was not rotated. The whole series has been repeated for different field widths.

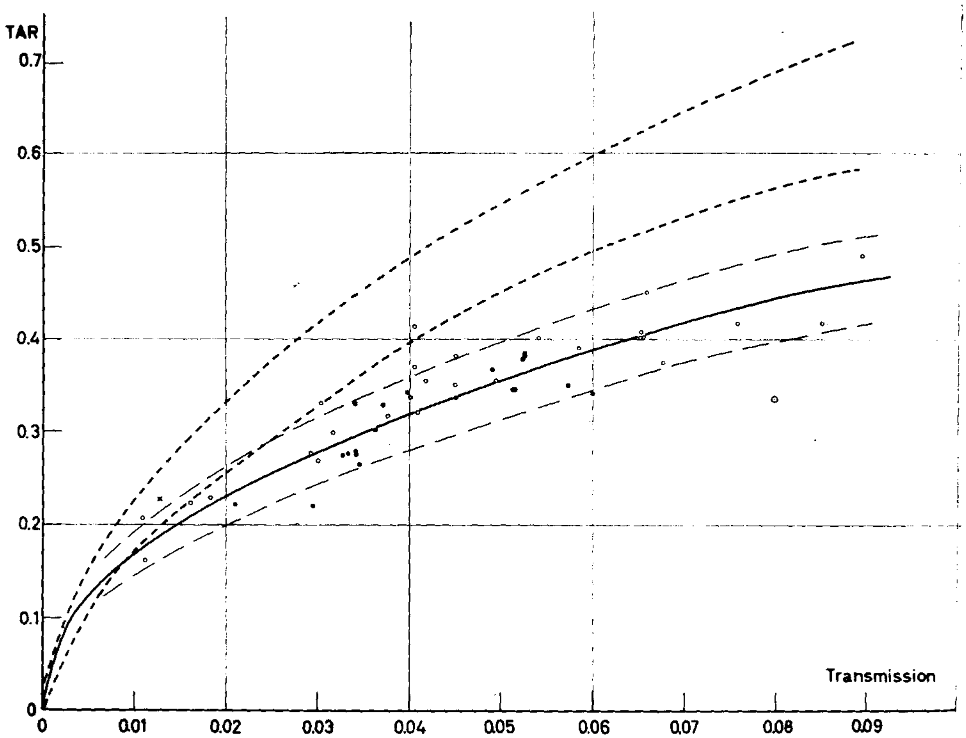


Fig. 7. TAR as a function of the transmission, indicating patient's measurements, field sizes equivalent to square areas of: 40 to 60 cm^2 (●), 60 to 80 cm^2 (○), $>$ 80 cm^2 (×), $<$ 40 cm^2 (⊙). The full-drawn curve, $T = 0.44\ (TAR)^2 - 0.014\ TAR$, has been calculated to fit the measurements. Curves indicated by short dashes have been calculated for homogeneous material and for equivalent square areas of 40 cm^2 (lowest curve) and 80 cm^2, respectively. The curves indicated by long dashes have been calculated to give the same relative spread for field size variation of 'experimental' full-drawn curve.

2. *Calibration by means of patient measurements.* Calibration measurements have been made for all the patients during a continuous period of about 2 years (1960—1962), except in six patients in whom oesophageal measurements could not be made. At least three reliable measurement values are recorded for each patient. The catheter normally contains 8 small condenser chambers and 3 indicators, permitting localization of the measuring catheter on the fluoroscopic screen. Sometimes even a roentgen film has been exposed to check the position of the catheter. Only those measuring values have been used where the oscillation of the catheter was small and the measuring points could be localized within ± 0.5 cm. In this way the dose distribution along the whole treated region of the

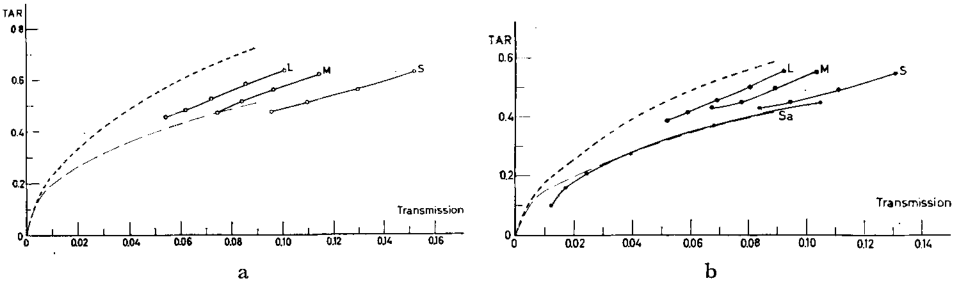


Fig. 8. a) The curves indicated by long and short dashes correspond to those in fig. 7 calculated for an equivalent square area of 80 cm². The full-drawn curves illustrate phantom measurements for an equivalent square area of 74 cm². L, M, and S indicate different phantom constructions. b) The curves indicated by long and short dashes correspond to those in fig. 7 calculated for an equivalent square area of 40 cm². The full-drawn curves illustrate phantom measurements for an equivalent square area of 42 cm². L, M, S, and Sa indicate different phantom constructions.

oesophagus was determined. The condenser chambers are designed for an exposure of about 300 R. Their sensitivity as a function of energy is almost constant (±1 %) within the energy interval used. The effective energy of the secondary radiation corresponds to a HVL of about 0.3 mm Cu for the actual irradiation conditions (HETTINGER & LIDÉN 1960). The scattered radiation irradiates the chamber almost isotropically. The chamber has a slight radiation direction dependence, which causes an increase of the calibration constants of less than 2 % (LIDÉN 1961).

Results and Discussion

The TAR as a function of the transmission is shown in Fig. 7. The measurement values correspond to the middle part of the treated region of the patients. The values are marked differently for two different intervals of the field size: one interval equivalent to a square area of 40 to 60 cm² (●) and the other 60 to 80 cm² (○), with 19 and 28 points for each interval, respectively. One patient had a field size smaller than 40 cm² (○) and another had a field size larger than 80 cm² (×). The full drawn line in Fig. 7 is a second degree curve, with coefficients calculated from the point lattice by means of the least square method ($T = 0.44 \cdot (TAR)^2 - 0.014 \cdot TAR$). The two curves indicated by short dashes have been drawn with TAR-values calculated from the British Journal of Radiology, Suppl. 10, for field sizes of 40 and 80 cm², respectively (ref. 5). The relative spread of these two curves for different values of transmission has been transformed to the full-drawn curve and is indicated by long dashes on either

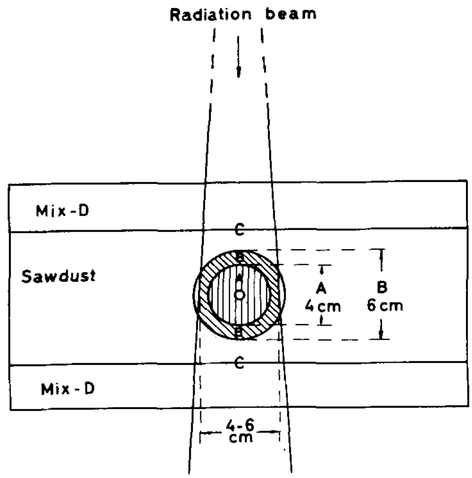


Fig. 9. Radiation geometry and different 'scatter compartments' used in the calculation of dose contribution of scattered radiation from different parts around the measuring channel in the phantoms.

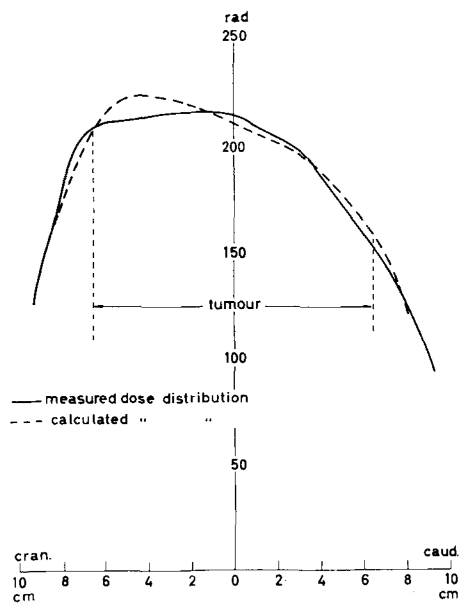


Fig. 10. Dose distribution along the oesophagus. The full-drawn curve is from measurements directly in the oesophagus and the dashed curve has been determined from transmission measurements.

side of the full-drawn one. Between these two curves lie 40 points. The total number of points is 47. The two extreme points lie outside this interval. As there is some displacement of the means of the values in the interval 40 to 60 cm^2 and 60 to 80 cm^2 towards smaller and greater TAR, respectively, greater accuracy can probably be achieved if the experimental calibration curve is considered valid for 60 cm^2 by correcting for areas different from 60 cm^2 in accordance with already tabulated TAR-values. Even without this correction, 85 % of the measuring points lie within ± 7 % of the curve of calibration.

The measuring points cover a transmission variation from 0.01 to 0.09 and the weights of patients vary between 35 and 95 kg. Attempts to correlate the individual spread in Fig. 7 to weight, age, sex and localization of the tumour have failed. The material is furthermore not large enough to arrive at a significant correlation.

A comparison of TAR-transmission curves calculated from the Table in ref. 5, and from patient measurements for the same size of area, clearly shows the loss of dose caused by the reduced contribution of scattered radiation from the thorax compared to the contribution from homogeneous material with a density of 1 g/cm^3 at the same water equivalent depth.

The phantom measurements have been drawn in Fig. 8a together with both curves for the maximal area in Fig. 7, and in Fig. 8b together with corresponding curves for the minimal area. The field sizes of the phantom investigations were 74 and 42 cm^2, respectively, which measurements approximately correspond with 80 and 40 cm^2, respectively. There are three phantom curves in Fig. 8a, indicated by L, M and S, corresponding to the diameters of 8, 6 and 4 cm of the mix-D cylinder. These curves were run before and during the same time interval as the calibration with patients was made and therefore the transmission interval later turned out to have been chosen too high. Nevertheless, it is easily seen that the M- and S-curves lie nearest to the patient curve, while, as would be expected, the L-curve lies nearest the curve of the homogeneous material. In Fig. 8b, another S-curve, designated Sa, is drawn in addition to the L-, M- and S-curves; this new curve corresponds to a series of investigations with a constant amount of lung tissue but with varying thicknesses of the outer mix-D blocks (Fig. 6). The S-curve and the Sa-curve should touch each other for a transmission of about 0.09; however, in Fig. 8b the curves run at a distance of 4 % of the TAR-value. This discrepancy can easily be attributed to experimental errors, e.g. repacking of sawdust between the two series.

The Sa-curve was determined when the actual transmission range was better known and is in agreement with the corresponding patient curve for a transmission of more than 2.5 %.

The TAR can be written as follows:

$$TAR_a = TAR_o \cdot B_D$$

where a = field size in cm^2 at measuring point P

TAR_a = TAR of point P with an irradiated area = a cm^2 at this point

TAR_o = TAR of point P with an infinitesimal irradiated area

B_D = dose buildup at point P.

Table 2

TAR-variation along a field and corresponding variation in dose contribution from scattered radiation for three different transmissions.

Distance from the centre of the field (field length 2a)	$\frac{TAR}{TAR_{centre}}$	$\frac{B_D-1}{(B_D-1)_{centre}}$ Transmission (equiv. square area 60 cm²)		
		0.01	0.04	0.09
1.00 a	0.70	0.6	0.4	0.4
0.75 a	0.91	0.9	0.8	0.8
0.50 a	0.97	1.0	0.9	0.9
0.25 a	0.99	1.0	1.0	1.0
0.00 a	1.00	1.0	1.0	1.0

TAR is calculated from The British Journal of Radiology, Suppl. 10 (ref. 5). In Fig. 5, TAR can be derived from the transmission for half the phantom thickness in g/cm², which gives the actual transmission. This curve, however, is not made with a perfect narrow-beam geometry and there are no measuring points in that region of the curve where the interpolation must be done. B_D, calculated from the patient curve (equivalent square area 60 cm²), lies between 2 and 3.

TAR_o is calculated to be 0.234 for transmission of 0.085 (from Fig. 5 about 0.25).

For a field size of 40 cm²:

$TAR_S = 0.430$ corresponding to $(B_D)_S = 1.84$
$TAR_M = 0.478$ « « $(B_D)_S = 2.04$
$TAR_{homogeneous} = 0.572$ « « $(B_D)_{max} = 2.44$

For a field size of 80 cm²:

$TAR_S = 0.467$ corresponding to $(B_D)_S = 2.00$
$TAR_M = 0.517$ « « $(B_D)_M = 2.21$
$TAR_{homogeneous} = 0.710$ « « $(B_D)_{max} = 3.07$

B_D-1 can be expressed (Fig. 9) as the sum of the contribution from (1) a cylinder of radius 2 cm around the measuring channel $(B_D\text{-}1)_A$, (2) a volume cut out by the geometrical limitation of the radiation beam from a shell one

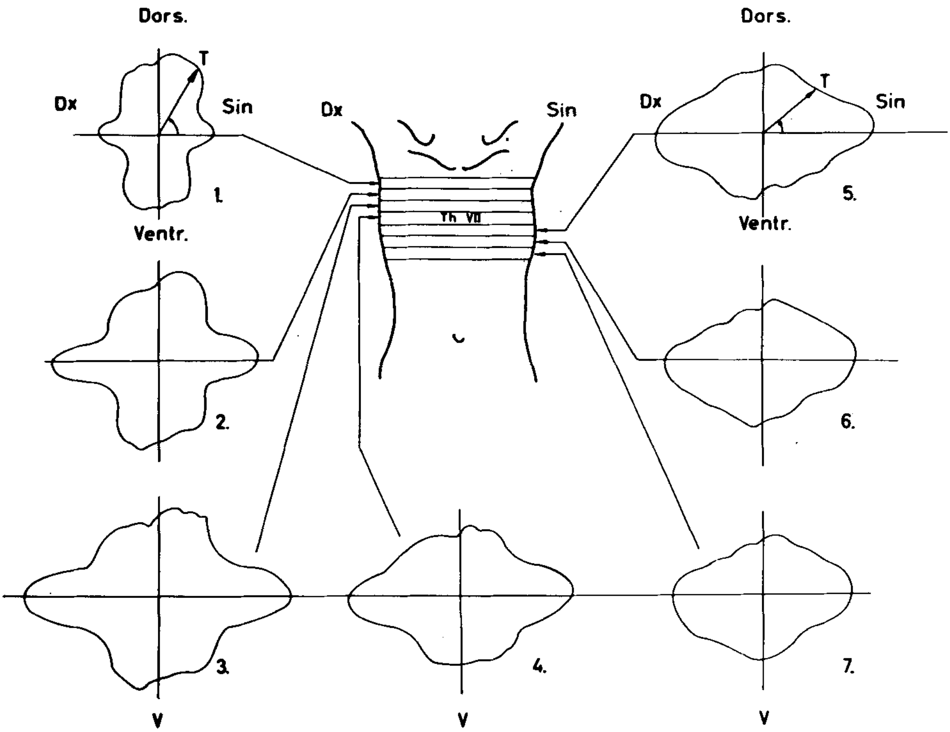


Fig. 11. Transmission variations during a full revolution shown as a polar diagram for each of the seven levels of the thorax indicated in the middle of the figure.

centimeter thick around the cylinder in (1) $(B_D\text{-}1)_B$ and (3) the remaining irradiated phantom volume $(B_D\text{-}1)_C$.

If the contribution from a volume is supposed to be proportional to density, and if, furthermore, the change of filtration of the scattered contribution is neglected, homogeneous material will get $(B_D\text{-}1)_A$=0.6 for 40 and 80 cm^2; $(B_D\text{-}1)_B$ also remains approximately constant 0.3, while $(B_D\text{-}1)_C$ increases from 0.5 to 1.1 in agreement with the corresponding increase of the irradiated volume. This means that the dose contribution of scattered photons from a surrounding cylinder with a radius of 2 cm is between 20 and 25 % of the total dose.

Dose variation along the oesophagus. The relation between the transmission and TAR which has been shown in Fig. 7 is only valid in the middle of the irradiated field where B_D is at its maximum. This means that a transmission determined for a point outside the field center would not be directly transferred to

TAR, valid for this point, by using the curves in Fig. 7. For a homogeneous phantom the variation of the transit exposure along the field is relatively small and shows only the penumbra of the primary radiation which is independent of field length while the corresponding variation of dose inside the phantom is considerable. The influence of the penumbra is here the same as for the transit exposure and is therefore relatively small, but the variation of the scattered contribution is important. The TAR-variation along the field has been determined for different irradiation geometries and has been found to be very much similar if the distance to the central point is expressed in units of field length (Table 2).

The last columns of Table 2 show the variation of scattered contribution along the field for three different transmissions calculated from corresponding variations of TAR. When calculating the dose distribution, the variation of the primary beam intensity must also be considered.

If the target doses, thus determined, are correlated with simultaneously measured doses in the oesophagus of different patients, there is very good agreement. Fig. 10 shows a dose distribution with the accustomed agreement between calculation and measurement in the patient.

Target dose. The TAR-values valid for a homogeneous water-equivalent thorax have been calculated from cross sections drawn at different levels of the patients included in this investigation. This method results in an underestimation of the target dose, averaging 20 % (extreme values 0 and 40 %). Calculation of the target dose in homogeneous material by means of transmission measurements results, however, in an overestimation of the actual dose by between 20 and 40 %.

The measuring and calculation method now described for the determination of the target dose in rotation treatment has been used for about six years.

Daily measurements of the transmission along the treatment field constitute a more exact checking of the reproducibility of the treatment than the mere reading of an output monitor in front of the roentgen tube. The transmission is very sensitive to density changes in the patient. An increase of density corresponding to 1 cm of water gives a decrease in the transmission of between 15 and 18 %. The corresponding decrease in the tumour dose is between 7 and 9 %, as calculated from Fig. 7. A change in transmission of 10 % corresponds to a change in the target dose of 4 to 5 %. There is sometimes a continuous transmission change in a patient during a treatment session. This causes a corresponding continuous change of TAR, which change has been verified by direct measurements in the oesophagus of several patients. An investigation of these patients from a medical point of view has been performed in order to find some correlation between transmission changes and irradiation effects of different kinds (NORDBERG et coll. 1967).

Development of the method. The charge of a chamber section, accumulated during a treatment, gives an integrated average of the patient transmission in all beam directions through the oesophagus during a full revolution. Fig. 11 shows a considerable variation in the differential transmission for different angles, but the polar diagrams also illustrate the symmetry of opposite directions. The measurements are carried out with a heterogeneous lung phantom built on a real skeleton; corresponding recordings have also been made for patients. The calibration of this differential transmission must be made by continuously recording radiation detectors, introduced in the oesophagus (Benner et coll. 1959). The average transmission values for different directions through a patient and the transmission of the average thickness of the cross-section in the same directions agree within 7 % for the patients included in the group investigated.

The error caused by the integration can therefore be neglected.

SUMMARY

A device for simultaneous measurement of the transmission through a patient at different levels is described. Correlation between target dose and transmission is obtained by measurements in phantoms as well as in patients. The discrepancy in relation to conventional tissue-equivalent calculations are discussed.

ZUSAMMENFASSUNG

Eine Vorrichtung für gleichzeitige Transmissionsmessungen in verschiedenen Ebenen eines Patienten wird beschrieben. Korrelation zwischen der Herddosis und der Transmission wird durch Messungen in den Phantomen sowie in den Patienten erhalten. Die Diskrepanz im Verhältnis zu den gewöhnlichen gewebe-äquivalenten Bestimmungen wird diskutiert.

RÉSUMÉ

L'auteur décrit un dispositif de mesures simultanées à différents niveaux de la transmission du rayonnement à travers le malade au cours de la roentgenthérapie rotatoire des tumeurs de l'oesophage. Il obtient la corrélation entre la dose à la cible et la dose transmise par des mesures sur des fantômes et sur des malades. L'auteur examine les discordances avec les calculs faits au moyen des équivalents de tissus habituels.

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