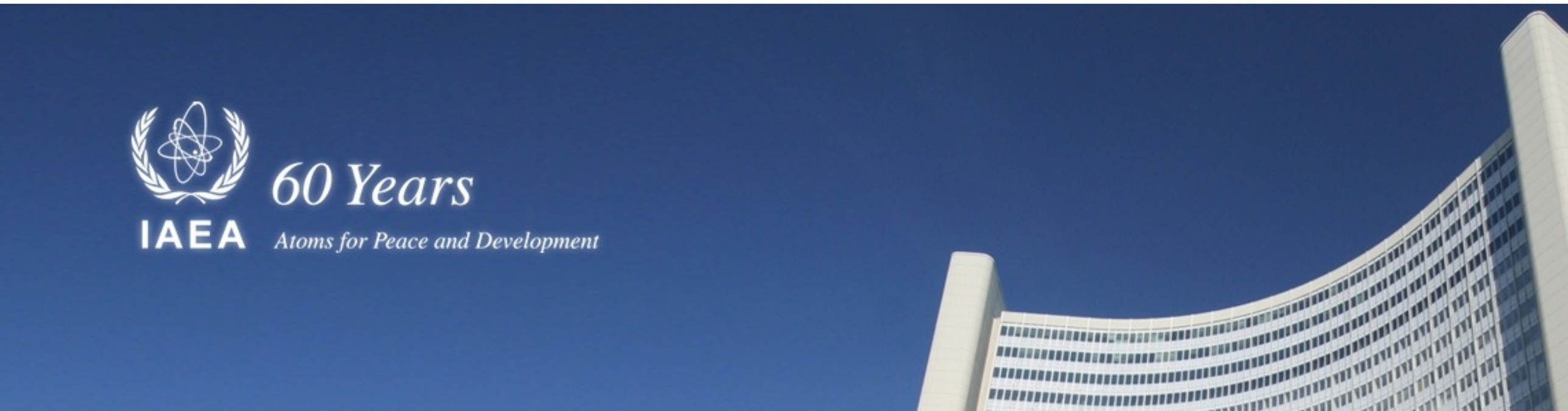
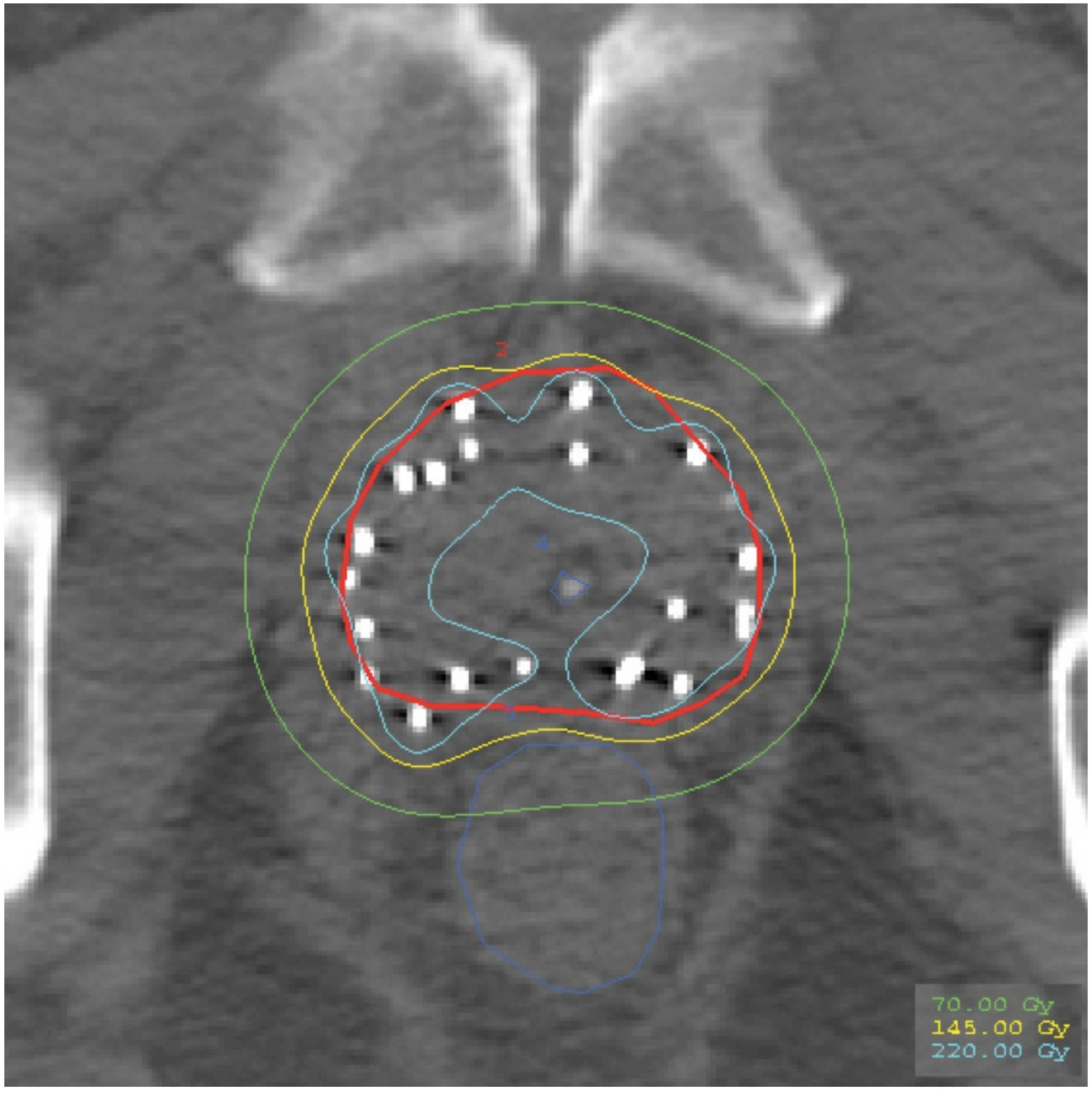
SYSTEMS IN BRACHYTHERAPY

Alfredo Polo MD, PhD
Division of Human Health
International Atomic Energy Agency



SYSTEMS IN BRACHYTHERAPY: WHAT IS IN A NAME?



SYSTEMS FOR DOSE PRESCRIPTION IN BRACHYTHERAPY: GENERAL ASPECTS

Any dosimetric system is a set of rules for arrangement of a specific set of radioisotopes in a specialised applicator to deliver a designated dose to a designated point, surface or volume.

BALLISTICS

Within any system, specification of treatment in terms of dose, timing, and administration is necessary so as to implement prescription in a reproducible manner.

1. Intervienen dos jugadores cada uno provisto de tres fichas del mismo color, que es distinto para cada jugador.

2. Las jugadas son alternas, efectuándose por sorteo para empezar.

3. El jugador que inicia la partida coloca su ficha en el círculo central, de donde ya no puede moverla mientras dure el juego. Todas las demás fichas pueden moverse en cualquier dirección, pudiendo ocupar los círculos que estén libres.

4. Es ineludible mover ficha cada vez que se está en turno de juego.

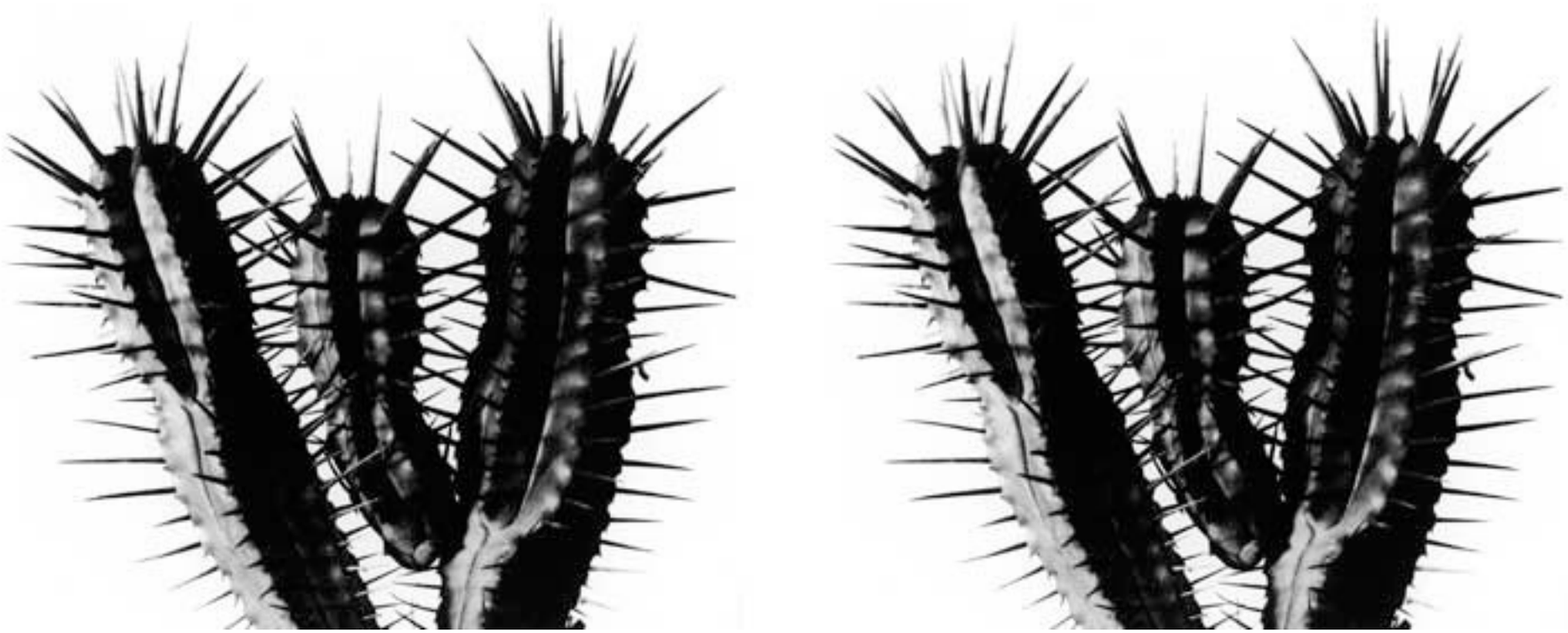
5. Gana el que consigue colocar sus tres fichas en línea recta, lo cual debe impedir el jugador contrario con sus propias fichas.

PRESCRIBING, RECORDING AND REPORTING

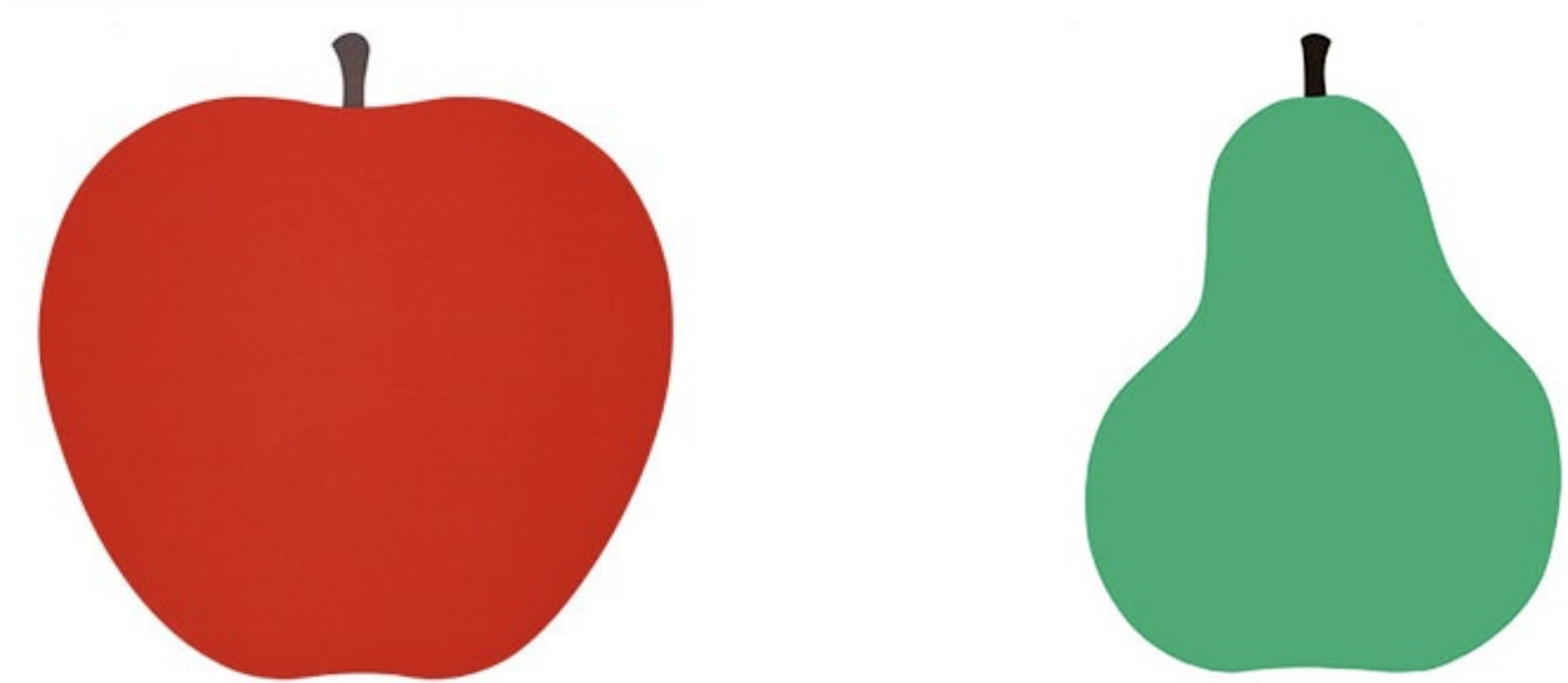
REPORTING	RECORDING	PRESCRIBING
• General harmonization of reporting patient data and treatment conditions • It requires uniformity and agreement on dose levels, methods used to determine the doses and points and/or volumes where these doses are delivered.	Accurate and complete recording of the treatment parameters is necessary for several reasons: • to ensure further care and follow-up of patients • to keep the treatment conditions reproducible, safe and constant • to continuously develop clinical experience in the department and systematically improve the techniques • to be able to exchange information on treatment conditions with other centres • to be able to "reconstruct" the treatment conditions when needed	• The prescription should remain the responsibility of the radiation oncologist in charge of the patient. • However, it is obvious that using the same approach and the same definitions of terms and concepts for prescribing and reporting facilitates the procedures and reduces the risk of confusion and errors.

THE THREE LEVELS FOR REPORTING

LEVEL 1	LEVEL 2	LEVEL 3
• Reporting at Level 1 implies reporting the minimum of data required to perform the treatment effectively and safely.	• Reporting at level 2 must include the information given at level 1 but, in addition, all information necessary to perform a treatment in a state-of-the-art manner. • Reporting at level 2 implies the availability of modern imaging techniques, typically a series of CT and MRI sections to delineate the relevant volumes and Organs At Risk. • Positron Emission Tomography (PET) and ultrasound (US) may provide additional relevant information in some situation.	• Reporting at level 3 usually applies to complex treatments and/or new and evolving complex irradiation techniques. • Reporting at level 3 must include the information given at level 1 and 2, and the current definitions of terms and concepts should be used whenever possible. • Since level 3 reporting is used for complex or evolving techniques, no requirements are formally established yet, but comprehensive and carefully verified information (QA) should be reported.



Applicator-based dose prescription



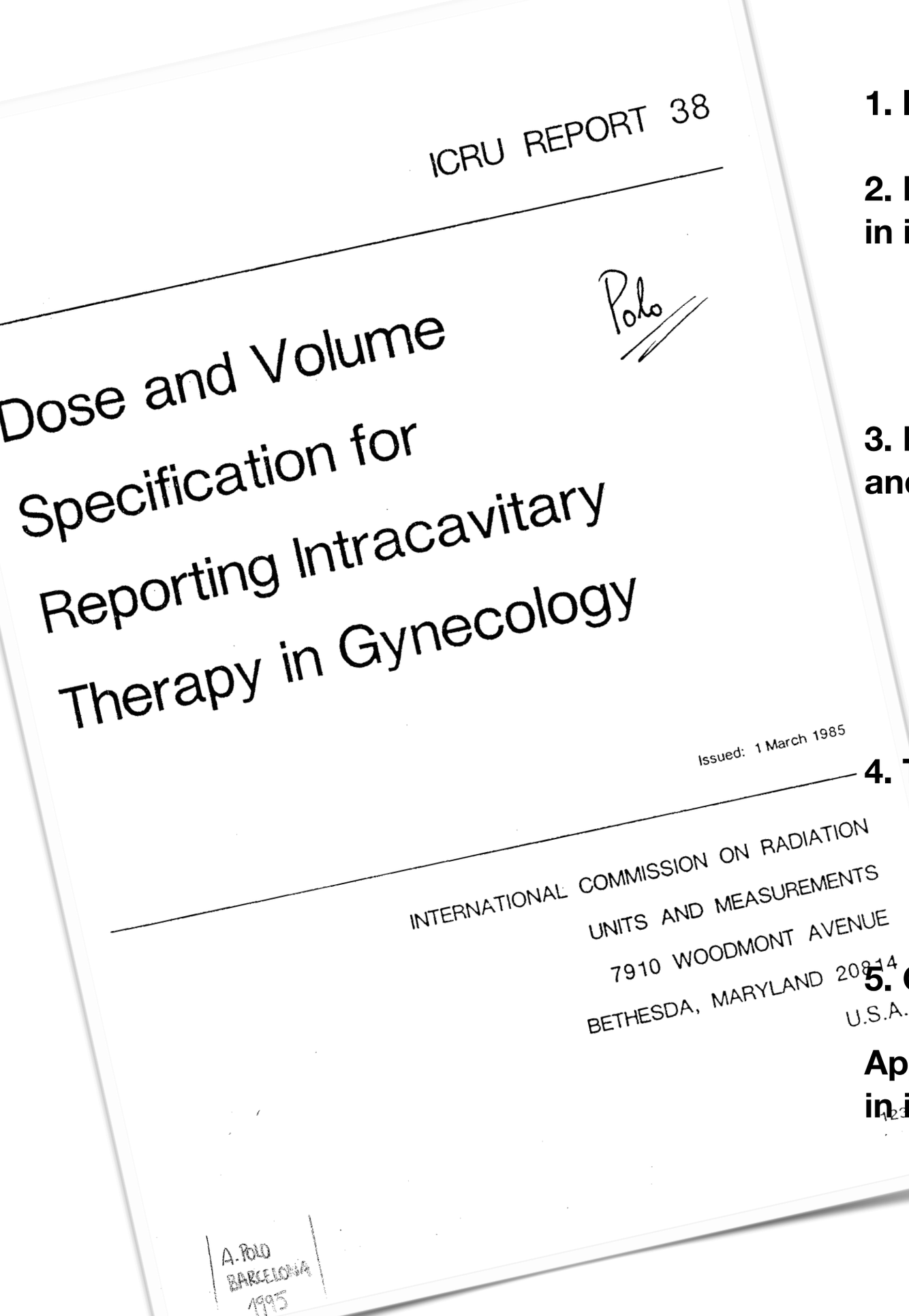
Volume-based dose prescription

SYSTEMS FOR DOSE PRESCRIPTION IN ENDOCAVITARY BRACHYTHERAPY

CLASSIC SYSTEMS FOR ENDOCAVITARY BRACHYTHERAPY

- Paris system
- Stockholm
- Manchester (Tod-Meredith)
- Computer system (no system)
- ICRU-38 revision
- GEC-ESTRO recommendations

PARIS	STOCKHOLM	MANCHESTER
• Radium sources • Single application (5 days) • Almost equal amounts of Radium were used in uterus and vagina • Intrauterine tube contained three sources in the ratio of 1:1:0.5 • Two cork intravaginal cilinders (copostats) had one source each of almost the same strengh as the top intrauterine source • Total mg-h were 7200-8000	• Radium sources • Fractionated (2-3 applications) devivered within about a month • The amount of Radium was unequal in uterus (30-90mg in linear tube) and in vagina (60-80mg, in shielded silver or lead boxes) • Vaginal and uterine applicators were not fixed together • Total mg-h were usually 6500 to 7100 out of which 4500 mg-h were in vagina	• Radium sources • Fractionated delivery from the Stockholm system (2 fractions of 72h, delivered with 4-7 days gap) • Source loading technique from the Paris system • Intrauterine tubes and vaginal ovoids containing fixed Radium units • Radium unit: 2.5mg of 1mm Pt filtered radium • Optimal dose: 8000 R to point A


ICRU REPORT 38

Polo

Dose and Volume Specification for Reporting Intracavitary Therapy in Gynecology

Issued: 1 March 1985

INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS
7910 WOODMONT AVENUE
BETHESDA, MARYLAND 20814
U.S.A.

123

A. POLO
BARCELONA
1995

GEC-ESTRO RECOMMENDATIONS

ELSEVIER

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Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group☆ (I): concepts and terms in 3D image based 3D treatment planning in cervix cancer brachytherapy with emphasis on MRI assessment of GTV and CTV

Christine Haie-Meder[a,*], Richard Pötter[b], Erik Van Limbergen[c], Edith Briot[a], Marisol De Brabandere[c], Johannes Dimopoulos[b], Isabelle Dumas[a], Taran Paulsen Hellebust[d], Christian Kirisits[b], Stefan Lang[b], Sabine Muschitz[b], Juliana Nevinson[e], An Nulens[c], Peter Petrow[f], Natascha Wachter-Gerstner[b]

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www.thegreenjournal.com

ESTRO project

Recommendations from gynaecological (GYN) GEC ESTRO working group (II): Concepts and terms in 3D image-based treatment planning in cervix cancer brachytherapy—3D dose volume parameters and aspects of 3D image-based anatomy, radiation physics, radiobiology

Richard Pötter[a,*], Christine Haie-Meder[b], Erik Van Limbergen[c], Isabelle Barillot[d], Marisol De Brabandere[c], Johannes Dimopoulos[a], Isabelle Dumas[b], Beth Erickson[e], Stefan Lang[a], An Nulens[c], Peter Petrow[f], Jason Rownd[e], Christian Kirisits[a]

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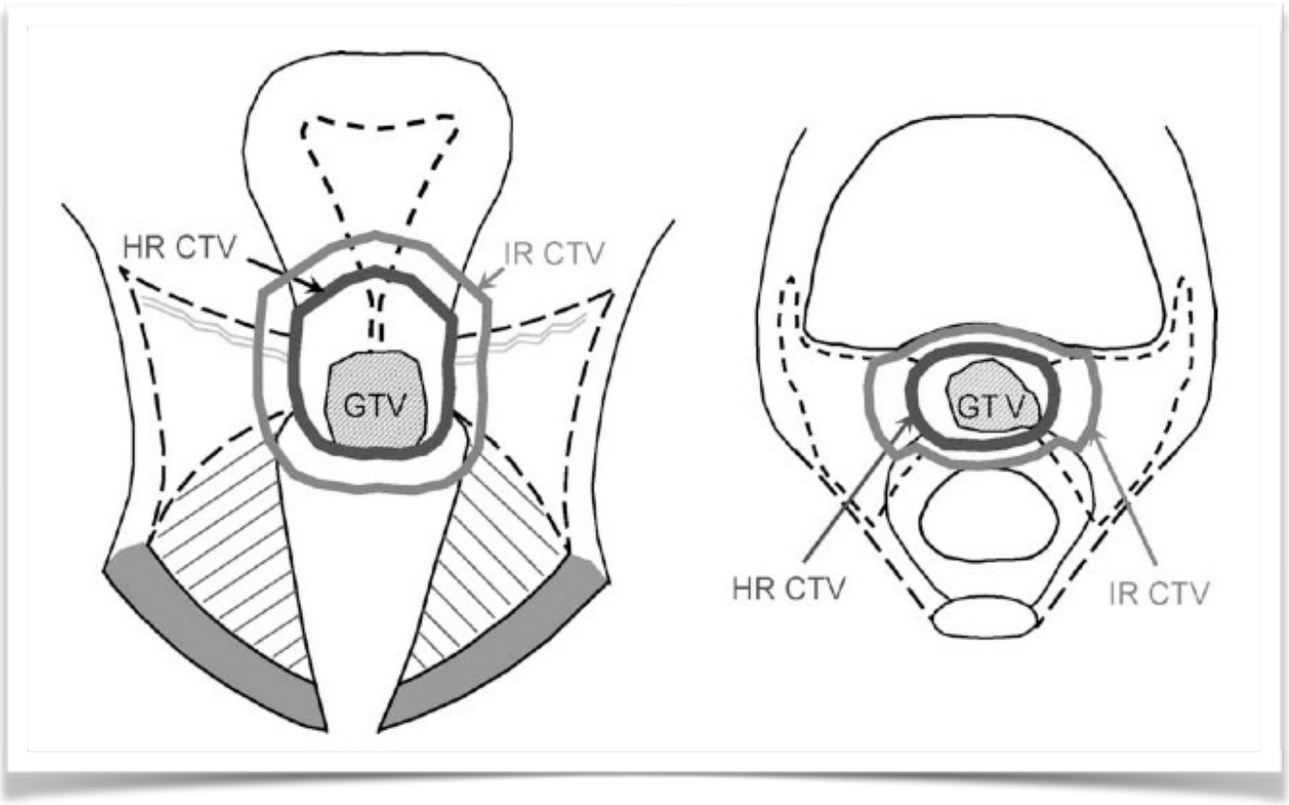
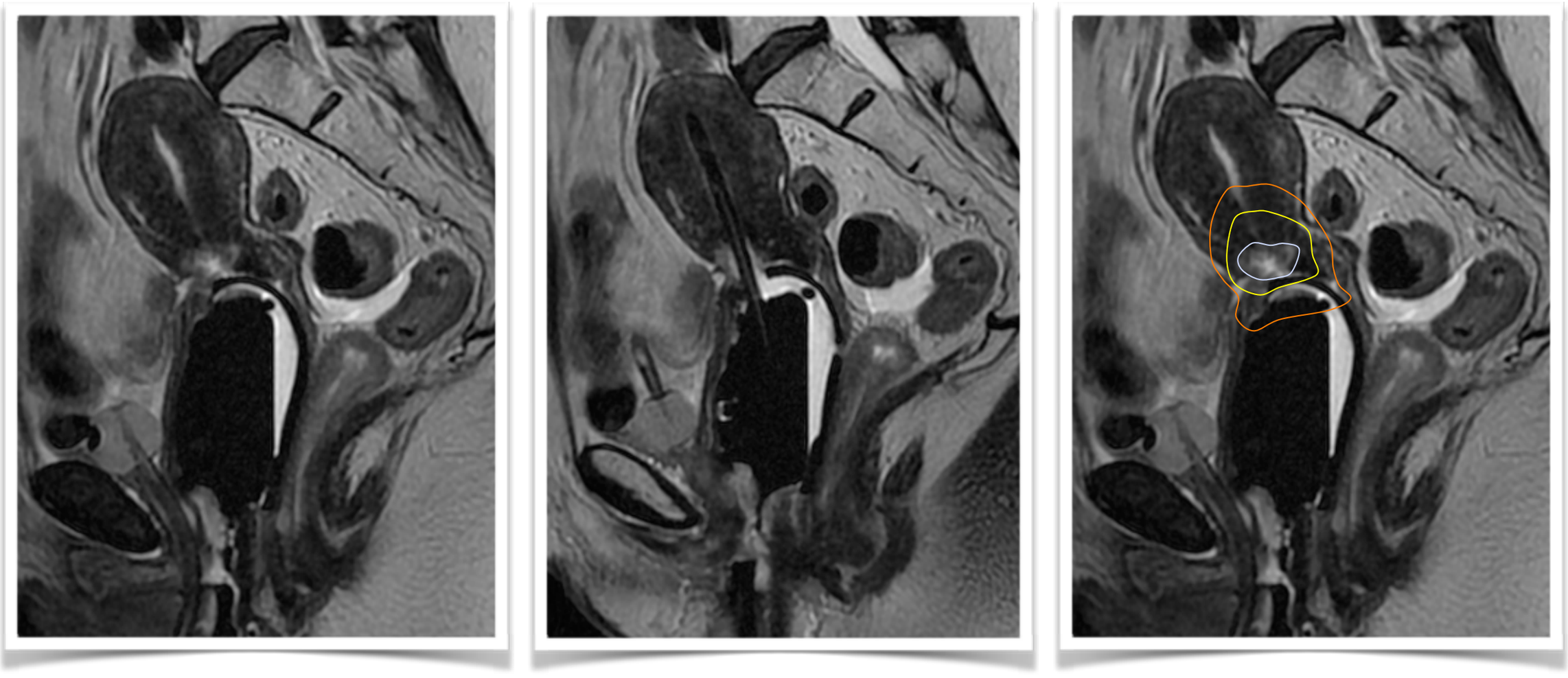

HR CTV
IR CTV
GTV
GTV
HR CTV
IR CTV



Courtesy Dr. Haie-Meder

	OLD SYSTEMS (Paris and Stockholm)	MANCHESTER	COMPUTER-BASED (Image-based)	IMAGE-GUIDED
DOSE PRESCRIPTION AND SPECIFICATION	Intracavitary therapy, specified in mg-hrs, is used combined with external beam therapy, specified in terms of absorbed dose, overall radiation treatment cannot be adequately defined	Doses in R (roentgen) Define treatment in terms of absorbed dose to a point.	Absorbed doses (Gy) DVH	Absorbed doses (Gy) DVH
ANATOMY	Dose prescription in terms of mg-hrs ignored anatomical targets and tolerance organs	Define treatment in terms of dose to a point representative of the target (point representative of the target), more or less reproducible from patient to patient.	Knowledge of anatomy is limited to organs at risk	Full knowledge of the anatomy (target and OAR)
REPRODUCIBILITY	Dose distribution is fixed and reproducible	Dose distribution can be slightly adapted and modified	Dose distribution is flexible, can be adapted mainly to account to doses to organs at risk	Tailored treatments

ICRU RECOMMENDATIONS

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Journal of the ICRU

ICRU REPORT 89

Prescribing, Recording, and Reporting Brachytherapy for Cancer of the Cervix

OXFORD UNIVERSITY PRESS

INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS

SYSTEMS FOR DOSE PRESCRIPTION IN INTERSTITIAL BRACHYTHERAPY

CLASSIC SYSTEMS FOR INTERSTITIAL BRACHYTHERAPY

- Patterson - Parker
- Quimby
- Memorial
- Paris
- Computer system (no system)
- ICRU-58 revision

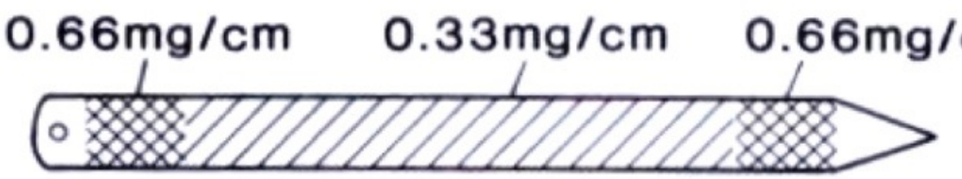
PATTERSON-PARKER	QUIMBY	PARIS
• Radium needles • Developed to deliver an uniform (10%) dose • Planar or volume implants • Crossing ends • Differential loading • Dosage tables	• Radium needles • Non-uniform dose distributions (hot center) • Planar or volume implants • Parallel array • Uniform activity • Dosage tables	• Developed for Ir-192 • Non-uniform dose distributions • Planar or volume implants • Parallel distribution • Uniform linear activity • Equal distances • Centres of the sources are in the same plane perpendicular to the directon of the lines • Dose specification is based on an isodose surface called reference isodose

RADIUM NEEDLES

Uniform

"Indian Club"

"Dumbbell"



Tube

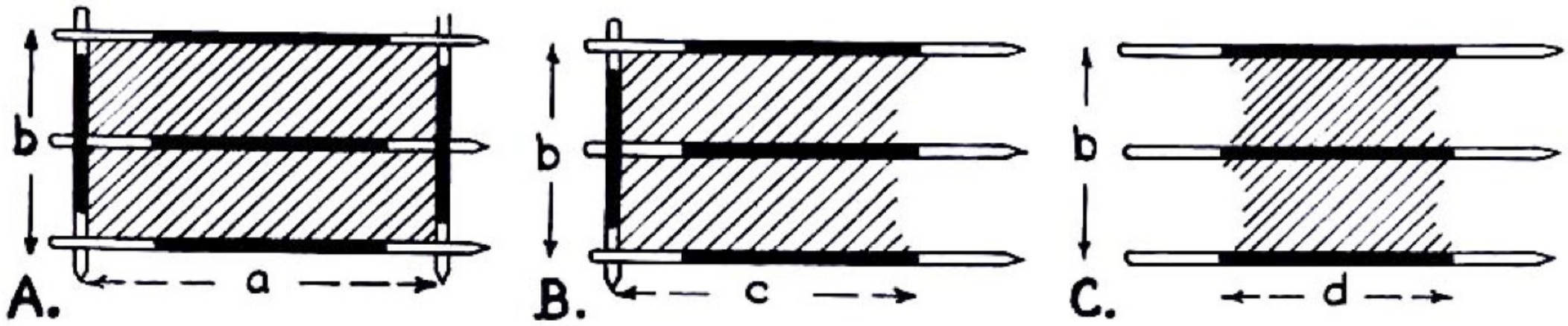


FIGURE XIV-6. Diagram illustrating the method of calculating the treated area for a rectangular implant. A, both ends crossed. B, one end crossed. C, neither end crossed.

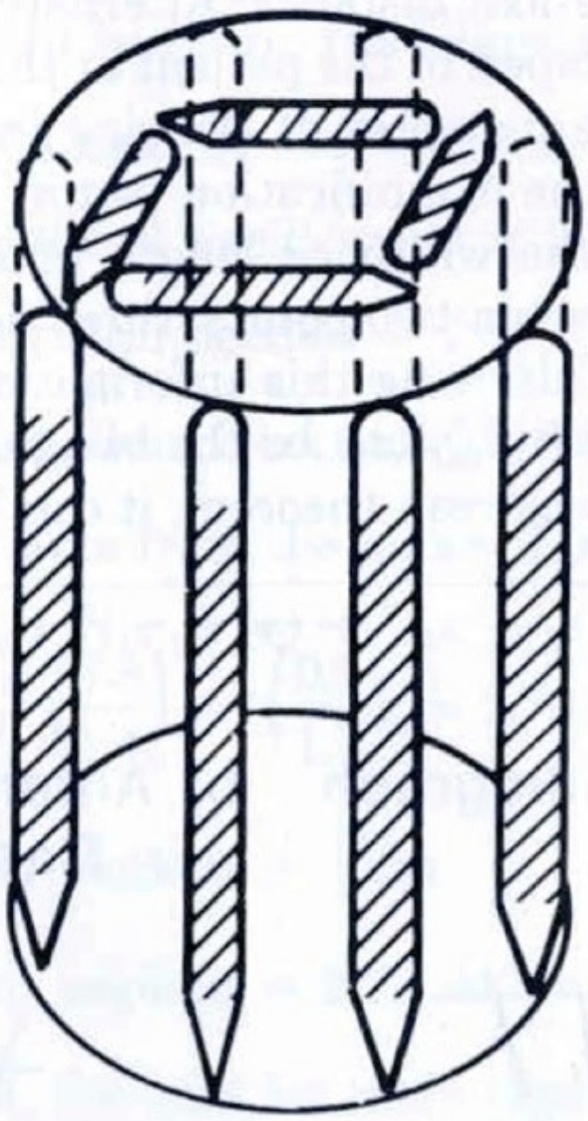


Figure 15.12. Example of a volume implant with one end uncrossed. The implant has 8 needles in the belt, 4 in the core (not shown), and 4 at one end. Whereas the needles in the belt and core are 1 mg each, the crossing needles at the end are 0.5 mg each, thus satisfying the Paterson-Parker rule of radium distribution.

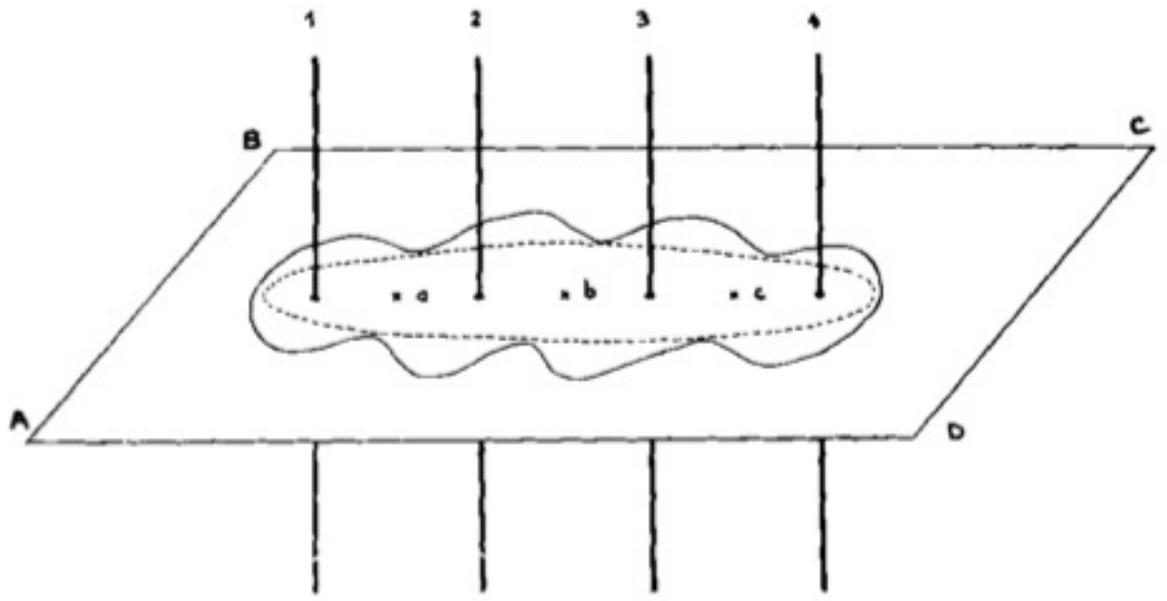
B. PIERQUIN, A. DUTREIX, C. H. PAINE, D. CHASSAGNE, G. MARINELLO
and D. ASH

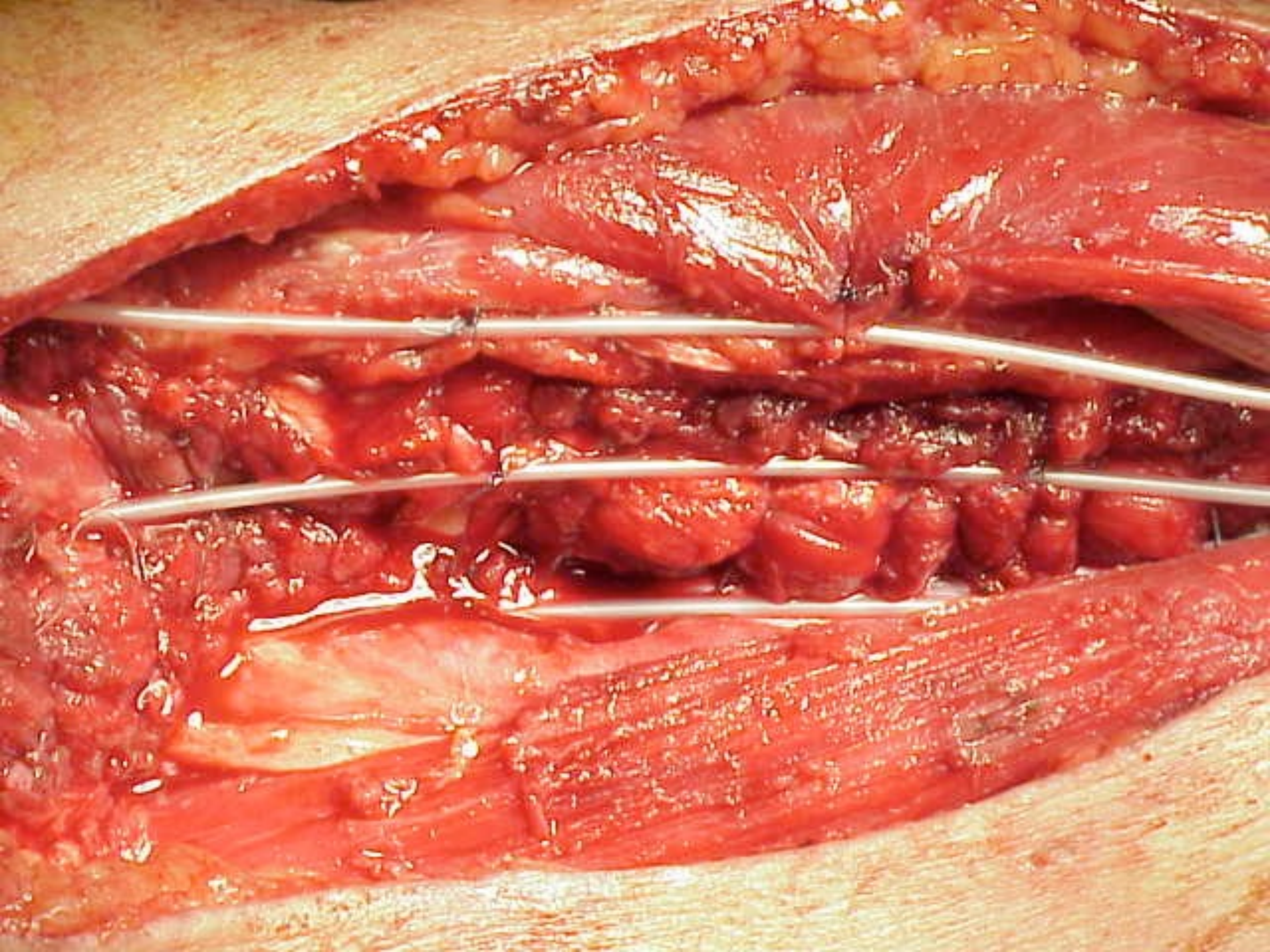
The introduction of after-loading methods for flexible ^{192}Ir wires in interstitial therapy has brought renewed interest in this modality of radiation therapy throughout the world (cf. HILARIS 1975). While a major advantage to the therapist and the staff has been the improved radiation protection, the use of these techniques has also allowed a new dosimetry to be evolved, the 'Paris System', better suited to the characteristics of flexible wire implants than the previous dosage systems which were associated with rigid sources of finite length (PIERQUIN 1971, DUTREIX et coll., in press). The techniques for the use of these methods have been described previously (PIERQUIN 1964, PAINE 1972, PIERQUIN et coll. 1977). The purpose of this article is to describe the system of dosimetry, which has now been found satisfactory in clinical use for over 15 years, and to show the current practice in day to day implant construction, dose calculation and prescription.

Although some 90 per cent of the applications are calculated easily by the methods to be described, it seems right to say that in a very small number it is not possible to distribute the sources in such a way that this system can be accurately applied, usually

Submitted for publication 31 May 1977.

Fig. 1. Four lines (1, 2, 3, 4) transecting the central plane (A, B, C, D) on which dose-calculation is carried out. The basal dose rate (BD) is the mean of the dose rates at a, b and c. The reference dose rate (85 % BD) has an irregular contour (wavy solid line) and totally encloses the target volume (dotted line).





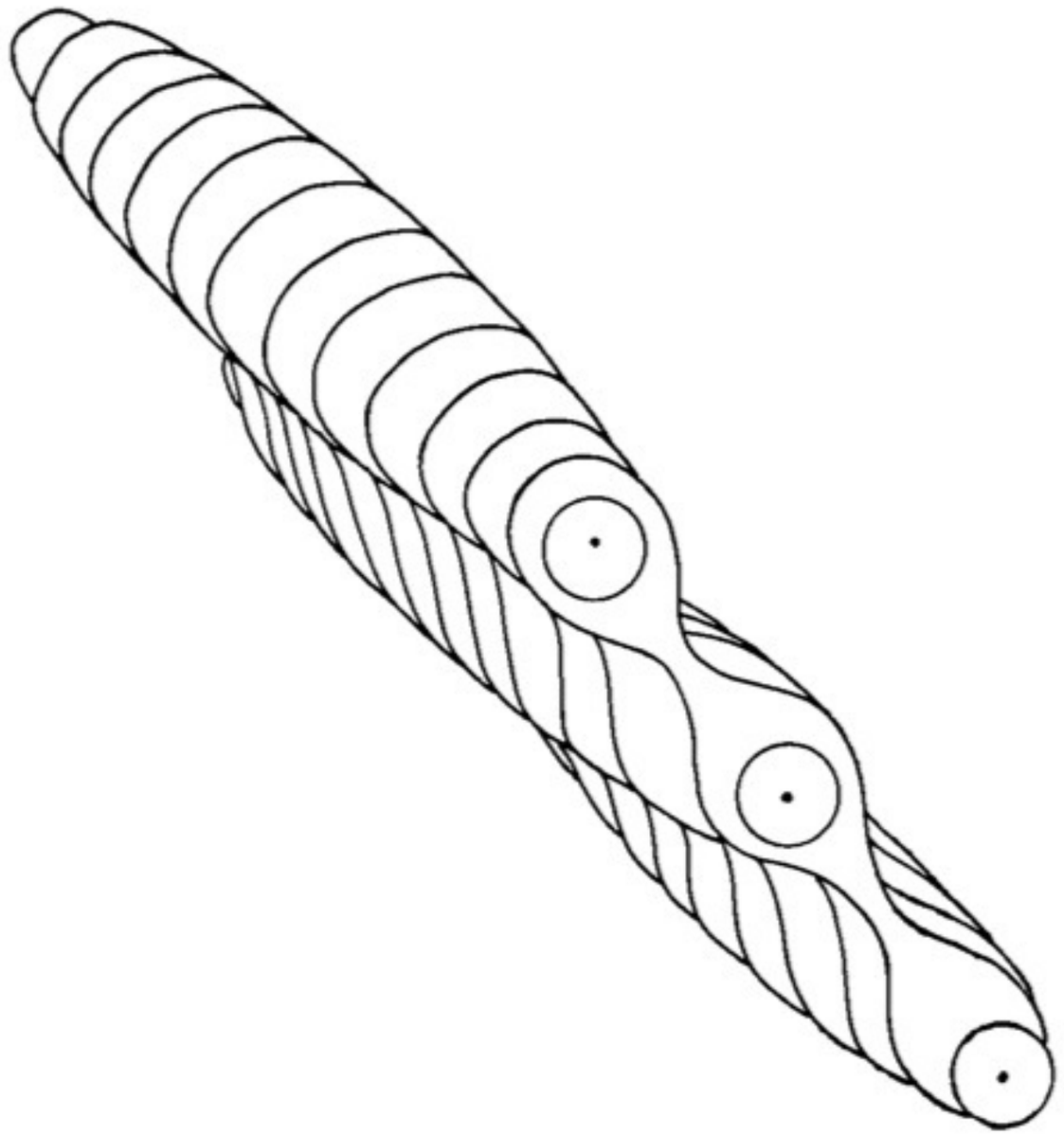
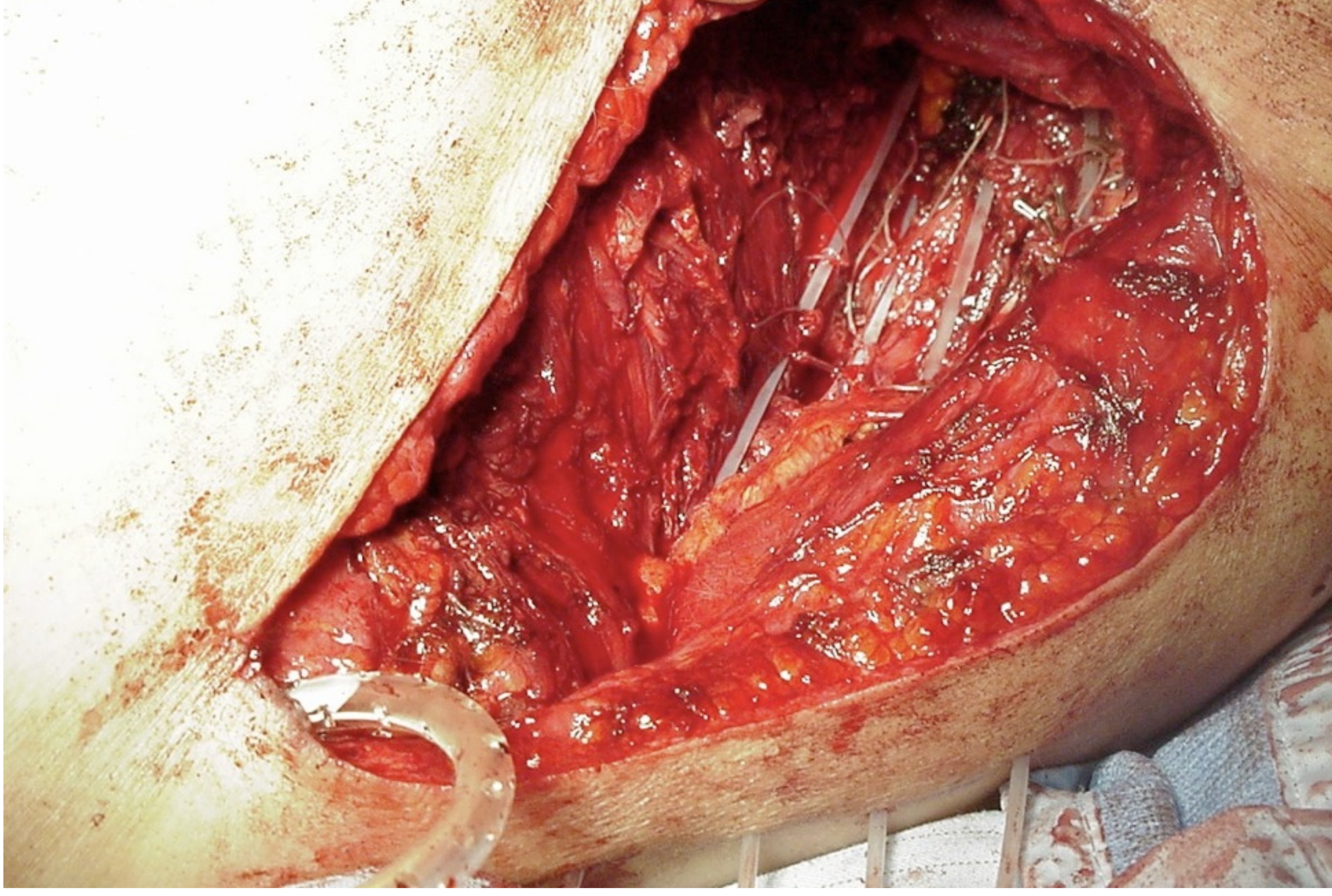
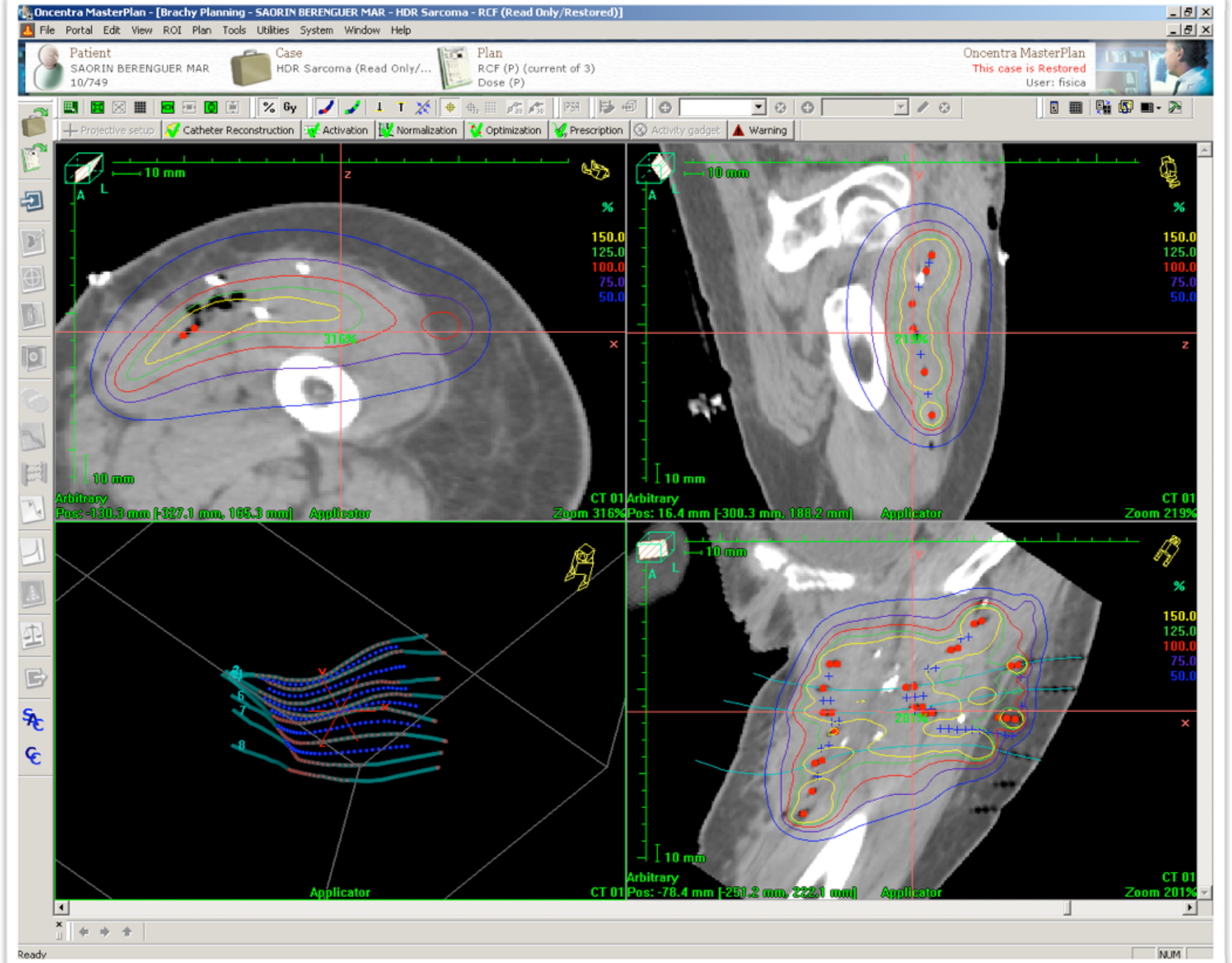


Fig. 2. The actual 3-dimensional form of the reference isodose (treatment volume) is that of coalescing, cigar-shaped volumes surrounding each line source. This overall structure satisfactorily encloses the usual biologic shape of the tumour and hence target volumes. (Courtesy of L. BOUSQUET.)




Oncentra MasterPlan - [Brachy Planning - SAORIN BERENGUER MAR - HDR Sarcoma - RCF (Read Only/Restored)]
File Portal Edit View ROI Plan Tools Utilities System Window Help
Patient
SAORIN BERENGUER MAR
10/749
Case
HDR Sarcoma (Read Only/...
Plan
RCF (P) (current of 3)
Dose (P)
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User: fisica
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Catheter Reconstruction
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Prescription
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Warning
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150.0
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100.0
75.0
50.0
316%
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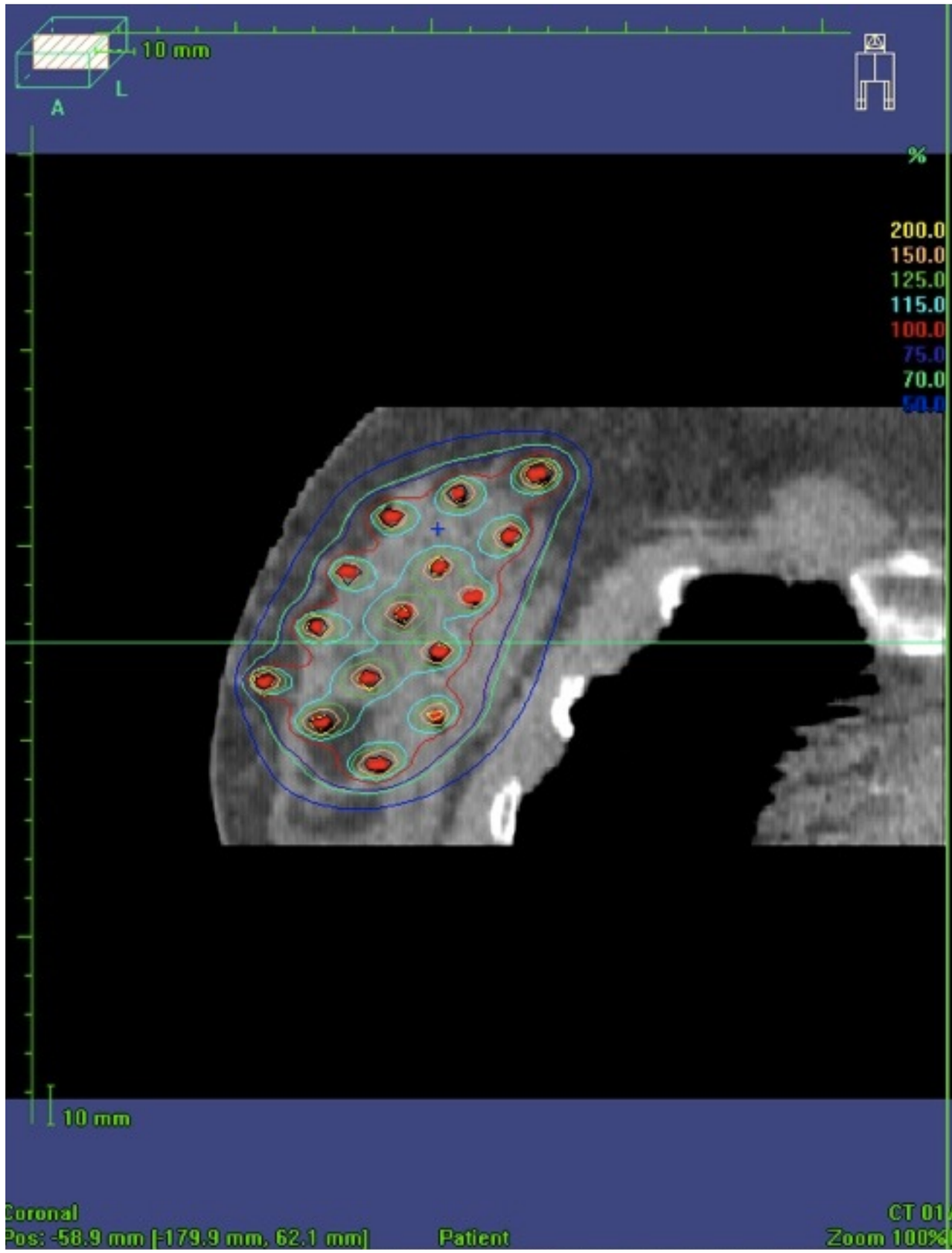
Pos: -130.3 mm [-327.1 mm, 165.3 mm]
Applicator
CT 01
Zoom 316%
219%
Pos: 16.4 mm [-300.3 mm, 188.2 mm]
Zoom 219%
201%
Pos: -78.4 mm [-251.2 mm, 222.1 mm]
Zoom 201%
Ready
NUM


10 mm
A
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%
200.0
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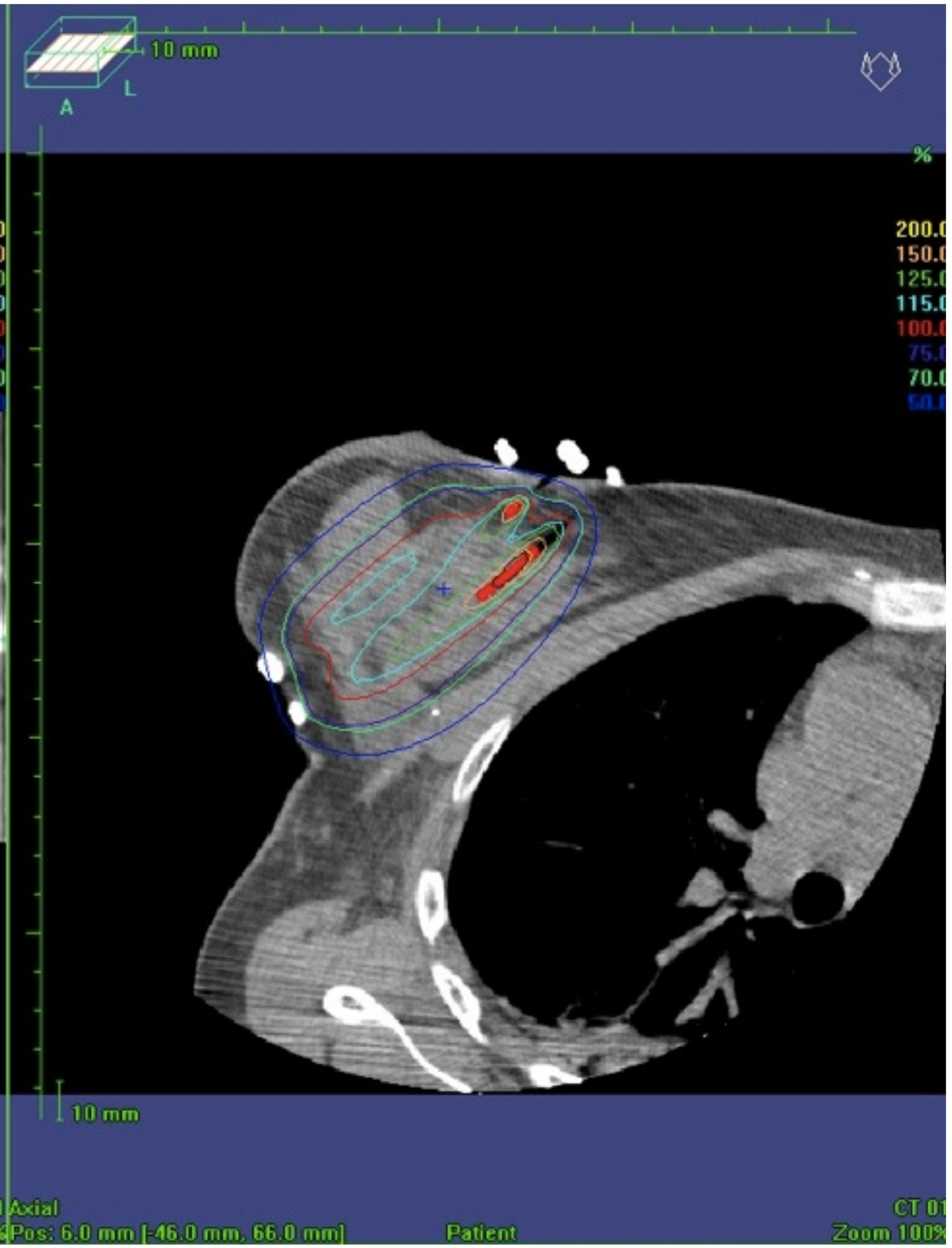
Patient
CT 01
Zoom 100%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CT 01
Zoom 100%

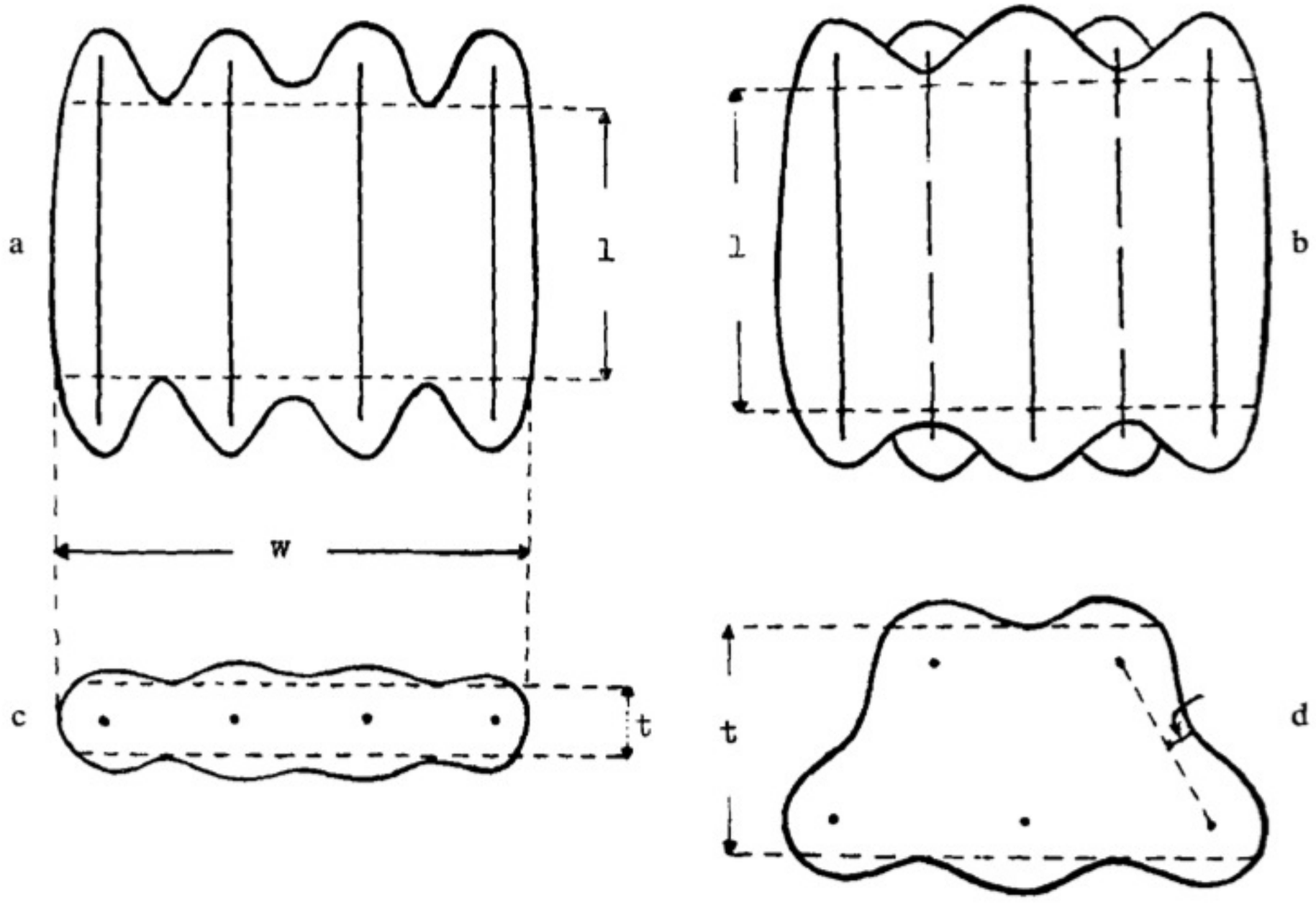


Fig. 3. a, b) Definition of dimensions of length (l) of the treatment volume for a single-plane implant. a, c) show width (w); c, d) thickness (t). In the case of a 2-plane implant, the correct definition of length is the minimum distance between reference isodose invaginations between the planes (b). d) Thickness (t). The concept of lateral margin (arrow). For the 2-plane implant illustrated, it is the least distance between the reference isodose and a line joining the points at which any two sources intersect the central plane.

GTV (1)
PTV (2)

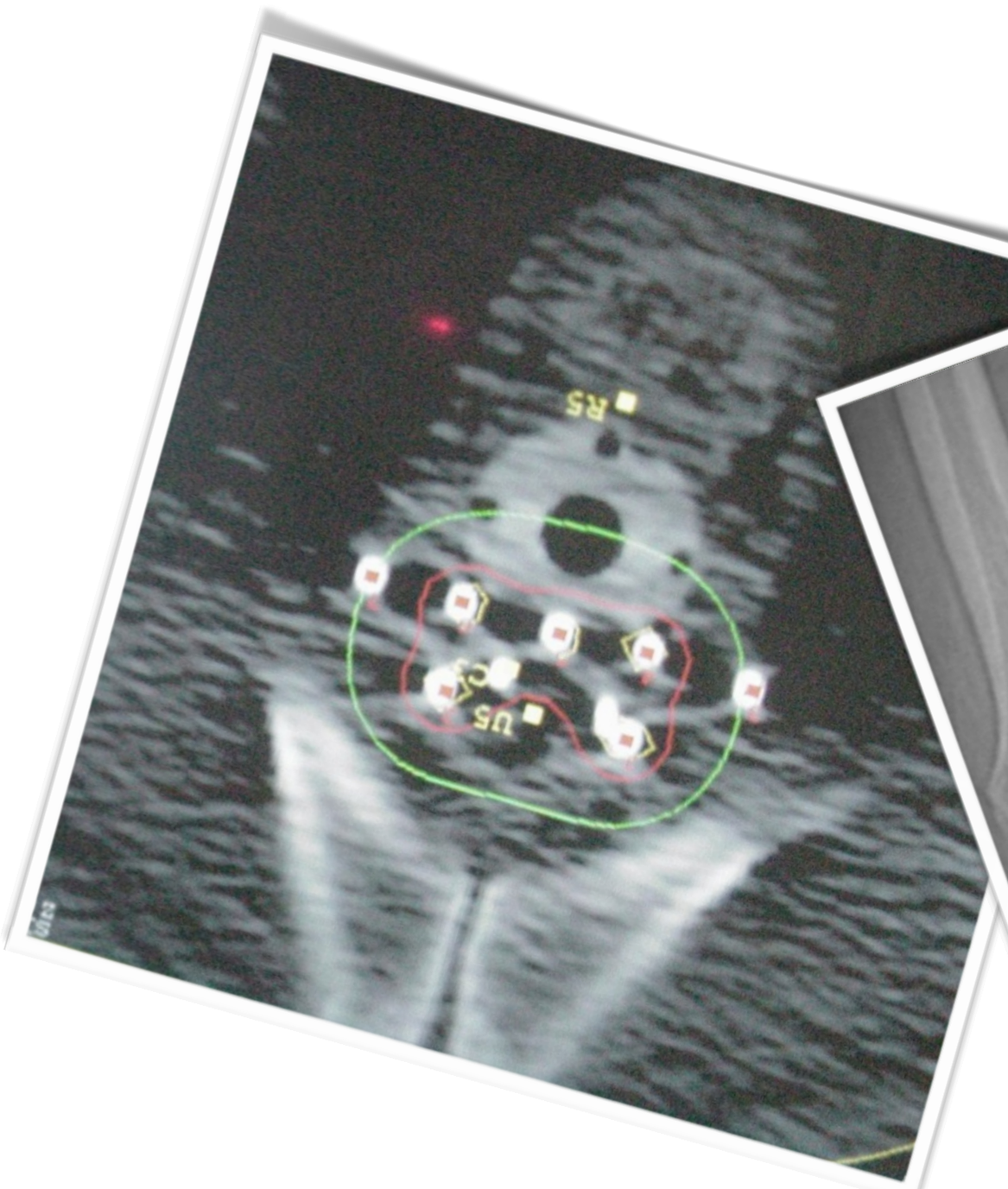
Slice : 12 of 24
Z(CT) : -1057.0

50 %
70 %
100 %
130 %
200 %

3D

5
3
2
1

Applicator


R5
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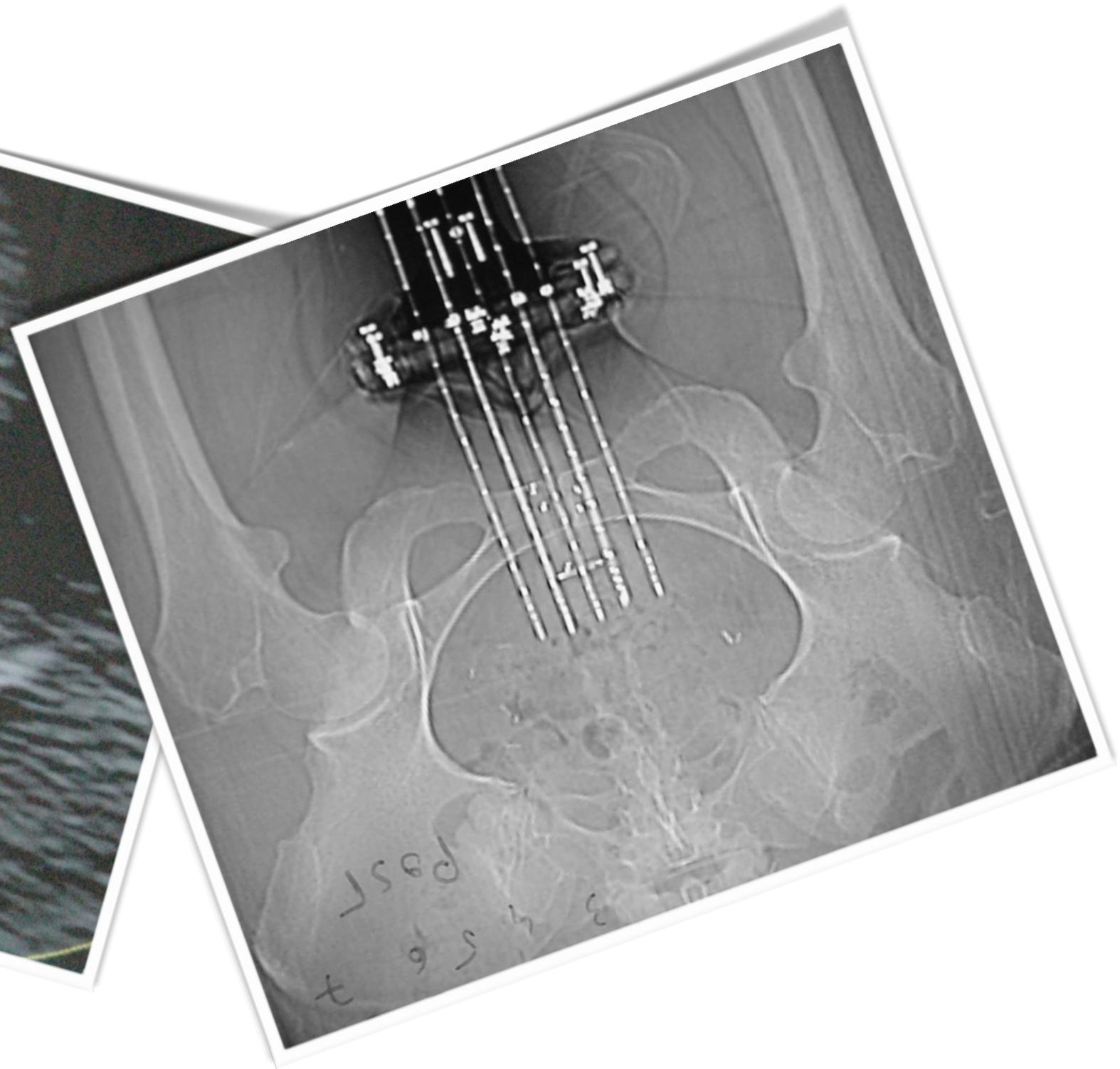
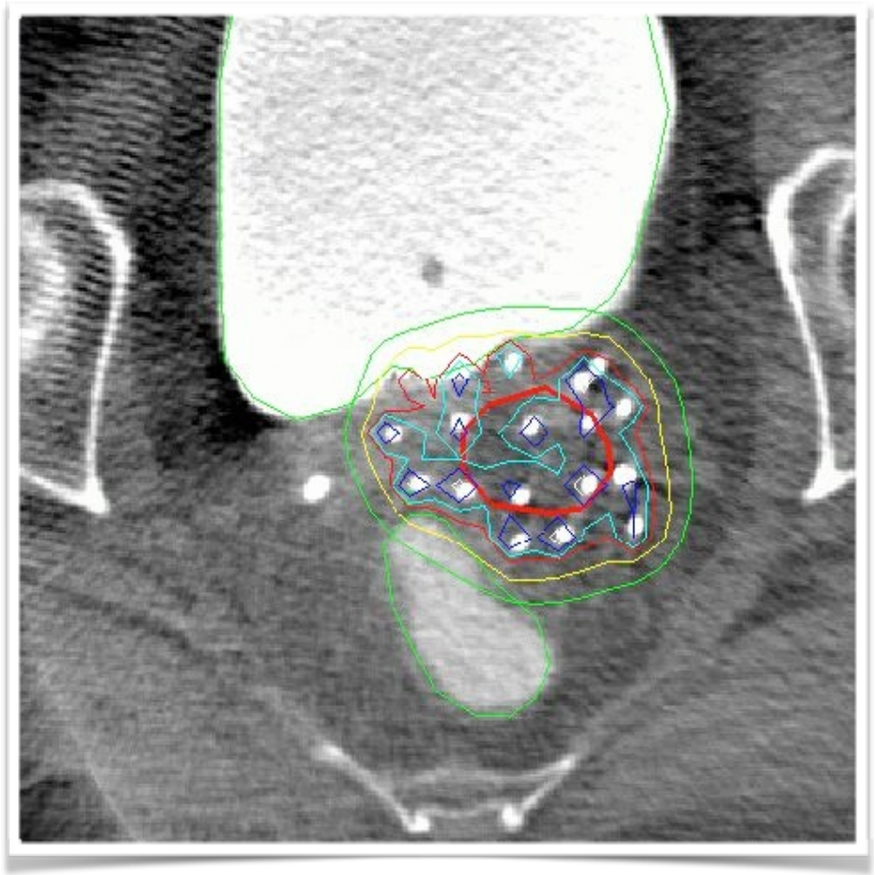
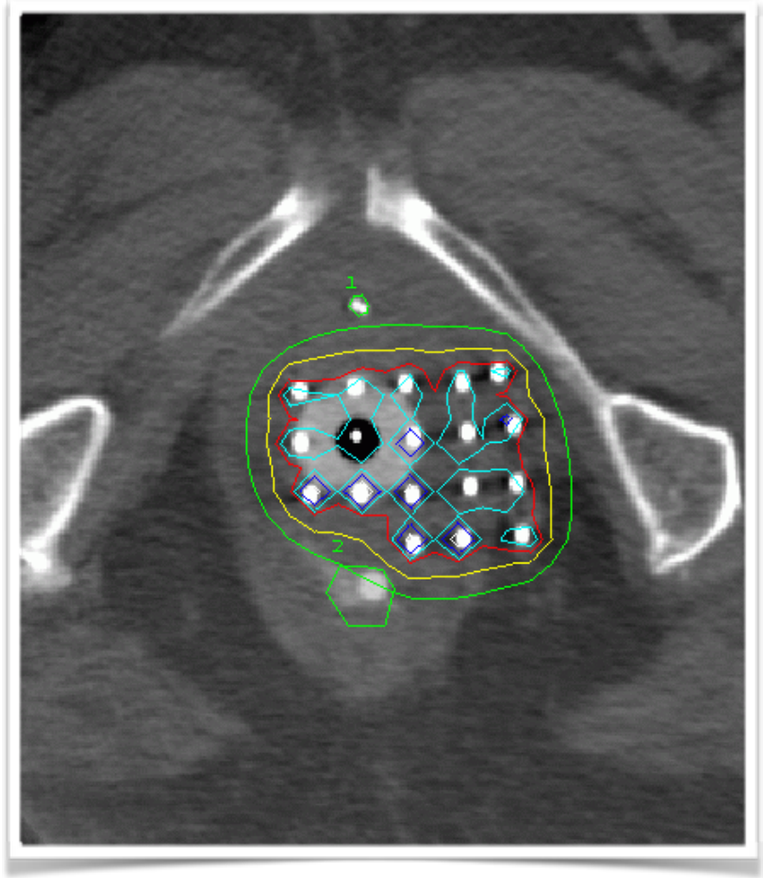




VOLUME BASED DOSE PRESCRIPTION



IMPLANT BASED DOSE PRESCRIPTION

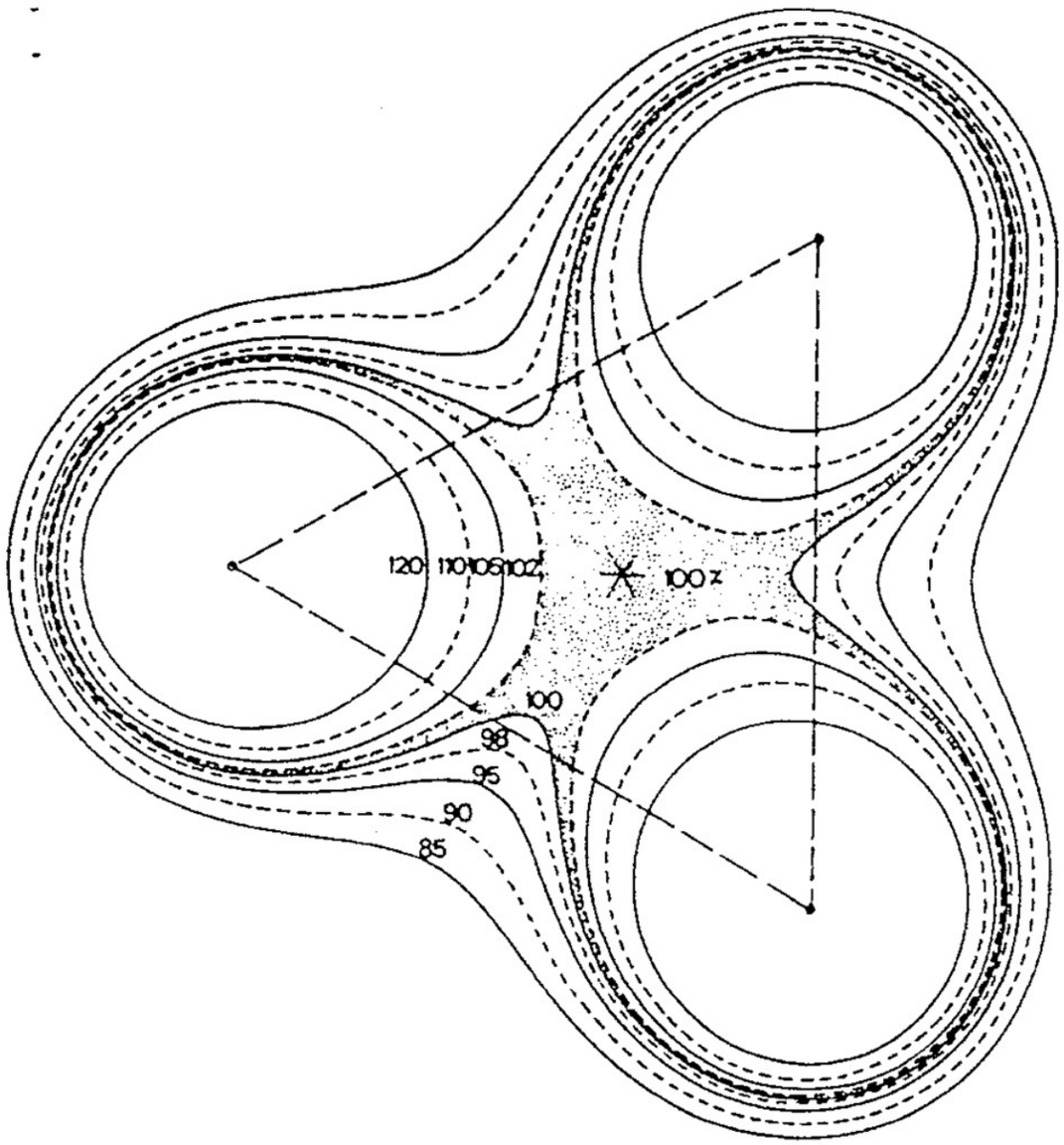
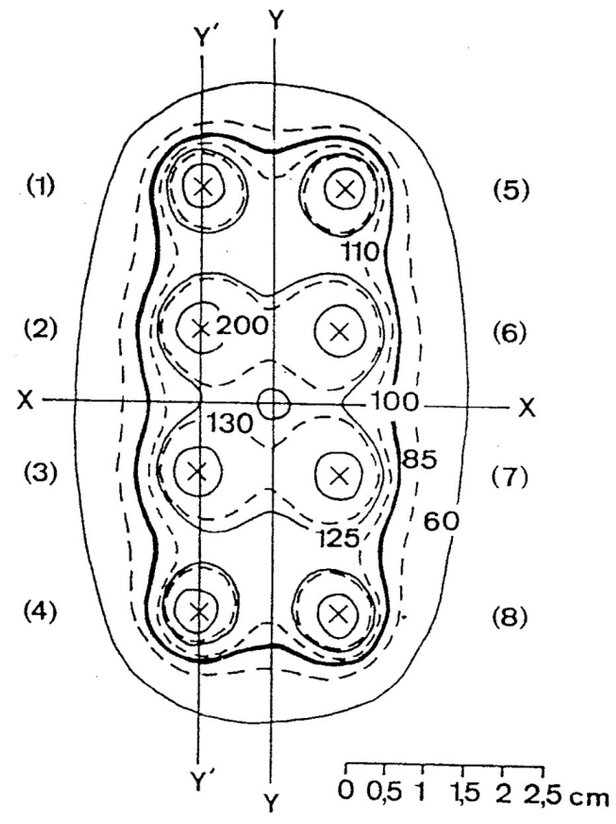
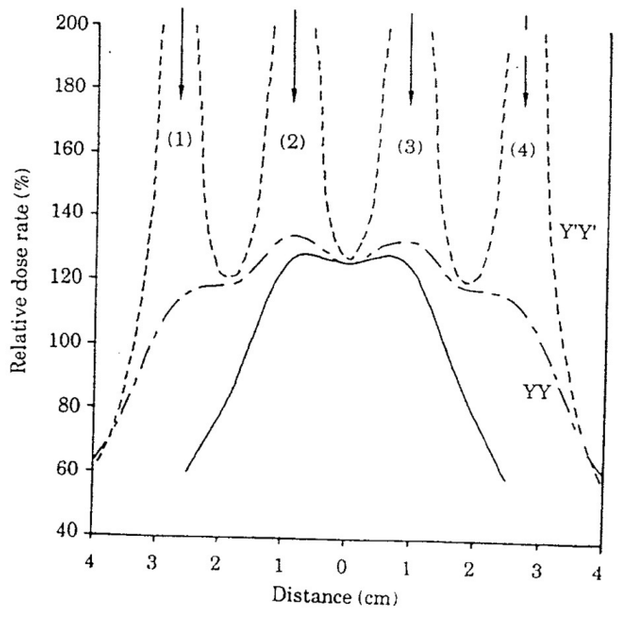


Fig. 2.2. Plateau dose region between radioactive sources. The dose distribution in a plane perpendicular to linear and parallel sources, shows a plateau dose region of low dose gradient. In this example of three sources 6 cm long and with 1.5 cm spacing, the dose varies by less than 2% in the gray region between the sources. (After Dutreix et al., 1982).



(a)



(b)

ICRU REPORT 58
MILANO 2000

Dose and Volume Specification For Reporting Interstitial Therapy

Issued: 30 December 1997

INTERNATIONAL COMMISSION ON RADIATION
UNITS AND MEASUREMENTS
7910 WOODMONT AVENUE
BETHESDA, MARYLAND 20814
U.S.A.

	OLD SYSTEMS (Patterson-Parker and Quimby)	Paris	COMPUTER-BASED (Image-based)	IMAGE-GUIDED
DOSE PRESCRIPTION AND SPECIFICATION	Interstitial therapy, specified in mg-hrs, is used combined with external beam therapy, specified in terms of absorbed dose, overall radiation treatment cannot be adequately defined	Define treatment in terms of absorbed dose to a surface.	Absorbed doses (Gy) DVH	Absorbed doses (Gy) DVH
ANATOMY	Dose prescription in terms of mg-hrs ignored anatomical targets and tolerance organs	Define treatment in terms of dose to isodose surface representative of the target, more or less reproducible from patient to patient.	Knowledge of anatomy is limited to organs at risk	Full knowledge of the anatomy (target and OAR)
REPRODUCIBILITY	Dose distribution is fixed and reproducible	Dose distribution can be slightly adapted and modified	Dose distribution is flexible, can be adapted mainly to account to doses to organs at risk	Tailored treatments

CONCLUSIONS

IMAGE GUIDANCE

TUMOUR COORDINATES

IGBT

PHYSICAL OPTIMIZATION

RADIOBIOLOGY PREDICTIVE ASSAYS


SEGWAY
Hollandsch
Fabrikaat
R.S. STOKVIS & ZONEN LTD.
AFDEELING RIJWIELEN.
ROTTERDAM