

ICRU 89: Changes over GEC-ESTRO guidelines for cervical cancer



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Learning Objectives

Understand the concepts and learn the terms for planning, prescribing, recording and reporting the target volumes and OARs for 3D IGABT

Use dose volume and dose point parameters for planning aims and dose prescription

Learn changes in ICRU 89 over GEC-ESTRO

Margaret Abigail Cleaves (1848-1917)





September 16, 1903: Treated a case of carcinoma cervix initially treated with Intracavitary X-rays: Radium vials applied to fornices 10 min Day 1 and 5 min Day 2 [Intracavitary radium for gynecological malignancies Med Rec 1903;64:601-606]

Early applicators: 1903-1913



Figure 1 : Wickham and Degrais; St. Louis hospital, Paris

Figure 2&3: Carl Josef Gauss ('Inter-cervical tubes' and Portio plates): Mostly used in Germany

Dawn of a new era: 1910-1930

Stockholm System: Gosta Forssell (1910)

Paris System: Claude Regaud (1912)

Manchester System : Todd and Meredith (1930)



M.C.Todd Manchester System

Point A & B

The work of T. F. Todd, already referred to, supports the contention that the initial lesion of irradiation necrosis is always due to high dose effects in this paracervical region, and not a direct effect on the rectum. It therefore seems reasonable to regard tolerance here as the limiting factor of normal tissue tolerance in the irradiation of the uterine cervix, and it is on this assumption that the principles to be outlined are based. The area described will be

- Classic definition : fixed point 2cm lateral to the center of uterine canal and 2 cm above from the mucosa of the lateral fornix
- Revised definition #1: 2 cm
 above the external cervical os
 and 2 cm lateral to midline
- Revised definition #2 (1953, Tod & Meredith): 2 cm above the distal end of the lowest source in the tandem and 2 cm lateral to the tandem
 - Common variation: use flange at cervical os



TREATMENT OF CANCER OF THE CERVIX UTERI-A REVISED "MANCHESTER METHOD"

By MARGARET TOD, M.B., Ch.B., F.R.C.S.E., F.F.R., and

W. J. MEREDITH, M.Sc., F.Inst.P.

The Christie Hospital and Holt Radium Institute, Manchester

(Accepted for publication March, 1953)

TABLE III.	PROPORTIONS IN	WHICH	RADIUM I	S PLACED	IN	VAGINAL
1.1.1	OVOIDS	AND UT	TERINE TUP	BES		1 - 1

Ov	oids	Diameter -	Units	Total radium
Large		 3 cm.	9	$2.5 \times 9 = 22.5$ mg.
Medium	·	 2.5 cm.	8	$2.5 \times 8 = 20.0$ mg.
Small		 2.0 cm.	7	$2 \cdot 5 \times 7 = 17 \cdot 5$ mg.

Uterine	tubes	Diameter	Units	Total radium $(2.5 \times 6 = 15 \text{ mg.})$
Long .		6.0 cm.	{4	$2 \cdot 5 \times 4 = 10$ mg.
Medium		4.0 cm.	4 6	$\begin{cases} 2:5 \times 4 = 10 \text{ mg.} \\ 2:5 \times 6 = 15 \text{ mg.} \end{cases}$
			4	$2 \cdot 5 \times 4 = 10$ mg.
Short .		2.0 cm.	8	$2 \cdot 5 \times 8 = 20$ mg.

ICRU-38: Dose-Volume specification for reporting intracavitary Therapy in Gynecology [1985]

- Definition of terms and concepts for ICBT
 - Treatment techniques
 - Absorbed dose pattern and volumes
 - Specification of radioactive sources

Recommendations for reporting absorbed doses and volumes in ICBT

TRAK

- Reference volume
- Absorbed dose at reference points
- Calculation of dose distributions

Time-Dose pattern

- Radiobiological considerations
- Recommendations for reporting time-dose pattern

ICRU 38: Target volume





ICRU 38: Target volume









ICRU 38: Bladder and Rectal points



2D Brachytherapy: ICRU



Time to move from points to profiles

- Point A &B are not anatomical sites. The variation in position and distribution of sources significantly changes the anatomic structures in which points A & B are located.
- No one point is representative even of a small volume.
 - It is viewed as a treatment reference point.





Image based brachytherapy

- Newer imaging modalities are used to define target volumes
- ► USG, CT, MRI (preferred), PET
- Prescribed dose related to the target
- Shape the spatial dose to conform to the target volume
 - Reduce dose to normal tissues & hence reduce the normal tissue toxicity.
 - Escalate dose to the tumor to produce greater rates of local control





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

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





Pre-requisites for IGBT: GEC-ESTRO

Baseline clinical documentation MRI at diagnosis Clinical examination and MRI prior to brachytherapy MRI after ICBT application Advanced TPS: Delineation and planning HDR Brachytherapy after loaders







2 CTVs

A first target related to the extent of GTV <u>at time of BT</u>: corresponding to residual disease with a high dose prescribed to this target (80-90 Gy) *High risk CTV*

A second target related to the extent of GTV <u>at diagnosis</u> : with an intermediate dose prescribed to this target (60 Gy) Intermediate risk CTV







IR-CTV: for extensive disease

Complete remission

 \blacktriangleright HRCTV + GTV_D (No safety margin)

Partial response

► HRCTV + GTV_D + safety margin of ≥ 10 mm added in the direction of potential spread.

Stable disease

► HRCTV + GTV_D + safety margin of ≥ 10 mm to the initial tumour extension at diagnosis.







Delineation of OARs

- Rectum: Begin 1 cm above the anus, ended at the sigmoid flexure, and covered the outer wall of the organ.
- Sigmoid: Begin at the level of the recto-sigmoid flexure and ended at the anterior crossing of the sigmoid by the pubic symphysis.
- Bladder contour to include outer wall of the bladder and ended at the beginning of the urethra.

OAR specification with volumetric imaging

Three quantities to characterize the dose distribution for OAR.

- Minimum dose in the most irradiated tissue volume adjacent to the applicator (0.1, 1 & 2 cc) is recommended for recording.
- D_{2cc}: Useful during dose planning and for evaluating toxicities
 D_{0.1 cc}: Indicative of the maximum dose.



Potter et al. Radiother Oncol, 2006

Target dose specification for GTV, HRCTV & IRCTV

Minimum target dose D₁₀₀ & D₉₀: Minimum dose delivered to 100% & 90% of target

► V₁₀₀

Potter et al. Radiother Oncol, 2006

Dose prescription

Table 5	Recommended	dose to targets and	l dose constraints to	organs at risk
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Volume/point	ABS	EMBRACE trial
Point A	Variable	No recommendation
HR-CTV D90	≥80-90 Gy EQD2	According to institutional practice
IR-CTV D90	No recommendation	According to institutional practice
D2 cc bladder	\leq 90 Gy EQD2	<90 Gy EQD2
D2 cc rectum	\leq 75 Gy EQD2	<70-75 Gy EQD2
D2 cc sigmoid	<75 Gy EOD2	<75 Gy EOD2

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Journal of the ICRU

ICRU REPORT 89

Prescribing, Recording, and Reporting Brachytherapy for Cancer of the Cervix Integrated report of ICRU and GEC-**ESTRO** (260 page document)



OXFORD UNIVERSITY PRESS

INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS

Need for a new ICRU report in brachytherapy

- Previous report (ICRU 38) based on mostly on X-ray images
- Volumetric imaging (mostly CT) increasing in practice
- Development of specific concepts and terminologies like GEC-ESTRO
- Limited application of pure GEC-ESTRO guidelines (resource constrained settings)

GEC-ESTRO & ICRU-89



Radiograph based IGBT recommendations

GEC-ESTRO

Recommendations for IGBT

•Some new definitions & reporting

•Integrations with EBRT

Holistic/descriptive approach

ICRU/GEC ESTRO recommendations for gyneacological brachytherapy

- 1 INTRODUCTION
- 2 PREVENTION, DIAGNOSIS, PROGNOSIS, TREATMENT AND OUTCOME
- 3 BRACHYTHERAPY TECHNIQUES AND SYSTEMS
- 4 BRACHYTHERAPY IMAGING FOR TREATMENT PLANNING
- 5 TUMOR AND TARGET VOLUMES AND ADAPTIVE RADIOTHERAPY
- 6 ORGANS AT RISK-AND-MORBIDITY-RELATED CONCEPTS AND VOLUMES
- 7 RADIOBIOLOGICAL CONSIDERATIONS
- 8 DOSE AND VOLUME PARAMETERS FOR PRESCRIBING, RECORDING, AND REPORTING OF BRACHYTHERAPY ALONE AND COMBINED WITH EXTERNAL BEAM RADIOTHERAPY
- 9 3D VOLUMETRIC DOSE ASSESSMENT
- 10 RADIOGRAPHIC DOSE ASSESMENT
- 11 SOURCES AND DOSE CALCULATION
- 12 TREATMENT PLANNING
- 13 SUMMARY OF THE RECOMMENDATIONS
- APPENDIX EXAMPLES, SPREADSHEETS, DRAWINGS

Committee:

Chairmen: Richard Pötter, Christian Kirisits B. Erickson, C. Haie-Meder, J. Lindegaard, E. van Limbergen, J. Rownd, K. Tanderup, B. Thomadsen

Continued emphasis on clinical documentation



Volume concepts: ICRU 89

	EBRT	Brachytherapy	Adaptive RT
GTV GTV-T res	GTV-T	GTV-Brachytherapy	GTV-T ini
CTV CTV-T1	CTV-T GTV-T+ Adjacent tissue+ Whole cervix	CTV-T HR	
CTV2 CTV3 CTV-Tadapt	CTVT1+Margin CTV2+Margin 	CTV-T IR CTV-T LR	GTV-T res + Residual pathological tissue
PTV-T	CTV + Margin	Not recommended (Research purpose)	

Volume terminologies

GTV init (GTV at diagnosis)
 GTV res (GTV at brachytherapy)
 CTV_{HR} (GTV res +residual pathological tissue + whole cervix)
 CTV_{IR}: GTV init and CTV-HR plus safety margins



Radiographic dose assessment



Point A Localization



Other volumes: Radiographic assessment

Pelvic wall point
Lymphatic trapezoid
Rectal point and bladder point
Vaginal point
Sigmoid reference point: No consensus as yet

Defining vaginal point







Organ wall/whole organ contouring



Vaginal point definition





Vaginal reference length (VRL)



Dose reporting for defined volumes based on volumetric imaging:

- D₉₈, D₉₀, D₅₀ for CTV_{HR}
- (D₉₈, D₉₀, D₅₀ for CTV_{IR} if used for prescription)
- D₉₈ for GTV_{res}
- D₉₈ for pathological lymph nodes
- D90: Minimum dose within most exposed 90% of volume of interest - reliable and reproducible, but 10% "neglected" (clin relevance)
- D 98: Minimum dose within most exposed 98% of volume of interest - reliable and reproducible, 2% not included
- [V100: Volume recieving prescribed physical dose (V150%/V200%)]
 - indicates target coverage;
 - only relevant within a specific dose (rate) and fractionation schedule
- D50: Minimum dose within most exposed 50% of volume of interest

D_{2cc} w x h:



30mm x 30mm







10mm x 10mm



3D-based Dose Volume Parameters for OAR

CLASSICAL MAX DOSE in 2D: in 3D a voxel is no clinical relevant endpoint

FIXED VOLUME: tolerance dose (total dose)-"minimum dose to the most exposed tissue"*



 2 cm^3



0.1 cc: 3D"maximum dose": ulceration(fistula)



*GYN GEC ESTRO Recommendations(II) Radiother Oncol 2006



Level 1 reporting: Target volumes

Volumetric-imaging approximation based on:

- · Comprehensive clinical gynecologic examination
- Volumetric imaging (MR, CT, US, PET-CT) at the time of diagnosis and brachytherapy

FIGO/TNM stage

Baseline morbidity and QoL assessment

Schematic 3D documentation on a clinical diagram indicating dimensions (width, thickness, height) and volumes for:

- GTV_{init} (the GTV at diagnosis)
- GTV_{res} (the GTV at brachytherapy)
- CTV_{HR} [the GTV_{res} (if present) plus residual pathologic tissue (if present) plus whole cervix]
- (CTV_{IR}: area of GTV_{init} and/or CTV_{HR} plus safety margin if used for prescription)

Radiographic approximation based on:

- · Comprehensive clinical gynecologic examination
- Radiographic imaging (plus additional volumetric 3D imaging if available)

FIGO/TNM stage

Baseline morbidity and QoL assessment

Schematic 3D documentation on a clinical diagram indicating dimensions [width, thickness, (height)] and volumes for:

- GTV_{init} (the GTV at diagnosis)
- GTV_{res} (the GTV at brachytherapy)
- CTV_{HR} [the GTV_{res} (if present) plus residual pathologic tissue (if present) plus whole cervix]
- (CTV_{IR}: area of GTV_{init} and/or CTV_{HR} plus safety margin if used for prescription)



Level 1 reporting: Minimum requirements

- Comprehensive clinical examination
- Volumetric imaging at the time of diagnosis and brachytherapy
- FIGO/TNM staging
 - **Baseline morbidity and QOL**
 - **3-D diagrammatic documentations**
 - GTV init (GTV at diagnosis)
 - GTV res (GTV at brachytherapy)
 - CTV_{HR} (GTV res +residual pathological tissue + whole cervix)
 - CTV IR: GTV init and CTV-HR plus safety margins

Level 1 reporting: Minimum requirements

Dose delivery pattern:

- Absorbed-dose rate/dose per fraction
- Number of fractions
- Time between fractions
- (Pulse number, size, time, if PDR)
- Overall treatment time
- Total EQD2 dose

- Source and dose calculation:
 - + Radionuclide and source model
 - + Source strength
 - † Dose-calculation algorithm

Level 2: Advanced standard of reporting

- 3D delineation of volumes (on volumetric imaging with applicator/Radiographic approximation
 - GTV res (GTV at brachytherapy)
 - CTV_{HR} (GTV res +residual pathological tissue + whole cervix)
 - With maximum width, height, and with volume
 - Dose reporting for defined volumes:
 - **D98** %, D90 %, D50 % for the CTVHR
 - ▶ (D98 %, D90 % for the CTVIR if used for prescription)
 - D98 % for GTVres
 - D98 % for pathological lymph nodes
 - Estimated dose to CTV HR, Pelvic wall point and L Trapezoid

Level 2: Advanced standard of reporting

- Dose reporting OARs:
 - Bladder reference point dose
 - D0:1cm3 , D2cm3 for sigmoid
 - D2cm3 bowel
 - Intermediate- and low-dose parameters in bladder, rectum,sigmoid, bowel (e.g., V15 Gy, V25 Gy, V35 Gy, V45 Gy or D98 %, D50 %, D2 %)
 - Vaginal point doses at level of sources (lateral at 5mm)
 - Lower- and mid-vagina doses (PIBS, PIBS+2 cm)

Level 3: Research-oriented reporting

- Volumetric-imaging approximation based on Tumor-related volumes:
 - GTV, CTVHR sub-volumes based on functional imaging (diagnosis, during treatment, and at brachytherapy)
 - PTV
- Isodose surface volumes: 60 Gy and 85 Gy EQD2 volume
- Dose reporting for tumor:
 - D98 % and D90 % for the CTVIR even if not used for prescription
 - ▶ D90 % for the GTVres
 - DVH parameters for the PTV
 - D50 % for pathological lymph nodes
 - DVH parameters for non-involved nodes (ext/int iliac, common iliac)

Level 3: Research-oriented reporting

- OAR volumes and points:
 - Additional bladder and rectum reference points
 - Anal canal (sphincter)
 - Vulva (labia, clitoris)
 - Sigmoid point
 - OAR sub-volumes (e.g., trigonum or bladder neck, sphincter muscles)
 - Vagina (upper, middle, lower)
 - Other volumes/sub-volumes of interest (e.g., ureter)
 - Remaining volume of interest akin to RVR
 - Dose-volume reporting for OAR:
 - Length of treated vagina
 - Dose-volume and dose-surface histogram parameters for additional OARs and sub-volumes
 - Vaginal dose profiles, dose-volume, and dose-surface histograms

Assessment and reporting of absorbed and equieffective EBRT and brachytherapy doses

Reporting of dose for relevant targets, OARs, and dose points:

- Planning-aim dose
- Prescribed dose
- Delivered dose

Absorbed dose and number of fractions assessed for target, OARs, dose points:

- Brachytherapy
- EBRT

Total equieffective dose (EQD2) calculated according to the linear-quadratic model through the following steps:

- (1) Brachytherapy EQD2 for each fraction
- (2) Total brachytherapy EQD2
- (3) Total EBRT EQD2
- (4) Accumulated total EBRT + brachytherapy EQD2 (based on current assumptions outlined in Sections 7.6, 8.5, 9.5.3)

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Take home message

- ICRU 89: Amalgamation of GEC-ESTRO and ICRU 38
- Continued emphasis on clinical documentation of disease
- Novel concepts of adaptive volumes, vaginal points, some changes in terminologies
- Three levels of reporting stratified as per resources available
- Integrated reporting of EBRT and brachytherapy
- Challenges in widespread application of these guidelines remain

Thank you!!