Immobilization

SOPHIE BOISBOUVIER, RADIATION THERAPIST, MSC, PHD STUDENT

CENTRE DE LUTTE CONTRE LE CANCER LEON BERARD

Learning objectives

01. Describe the objectives and the impact of positioning and immobilization
02. Discuss types and causes of set up errors and describe their evaluation
03. Identify the fundamental principles of the patient positioning and immobilization in radiation therapy
04. Outline the differences in positioning and immobilization for photon and particles
05. Discuss the challenges of upright positioning and immobilization

Introduction

The goal of radiation therapy:

- Deliver a therapeutic dose of radiation to the target
- Limit radiation dose delivery everywhere else espacially to Organs At Risk (OARs)

But many uncertainties …

Chapter 11

Accuracy and Uncertainty Considerations in Modern Radiation Oncology

Jacob Van Dyk, Jerry J. Battista, and Glenn S. Bauman

And each patient is unique

Table 11.3

Examples of human- and technology-related uncertainty components in the radiation treatment process. Note that these are not comprehensive lists but only some examples for illustration.

Human-related uncertainties	Technology-related uncertainties
Target and organ-at-risk segmentation	Absolute dose determination
Patient repositioning	Machine calibration
Organ/tumour motion	Beam profiles
Interpretation of on-line image matching	Imaging quality/resolution
Deformation	Dose calculation
Couch position	Electron density
Organ full/empty	Beam energy
Weight change	Machine isocentricity
Contour change	Tissue inhomogeneity corrections
Source-to-surface distance	Beam modifiers
Immobilization devices	Leaf transit times
Accuracy of laser setup	Uncertainty in leaf position
Skin tattoo movement	Partial leaf transmission
Breathing motion	Optimization algorithm

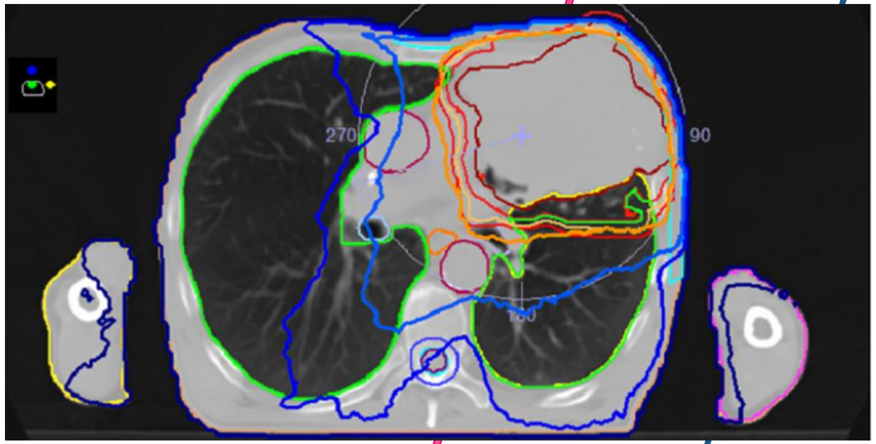
The objectives of P&I

To avoid:

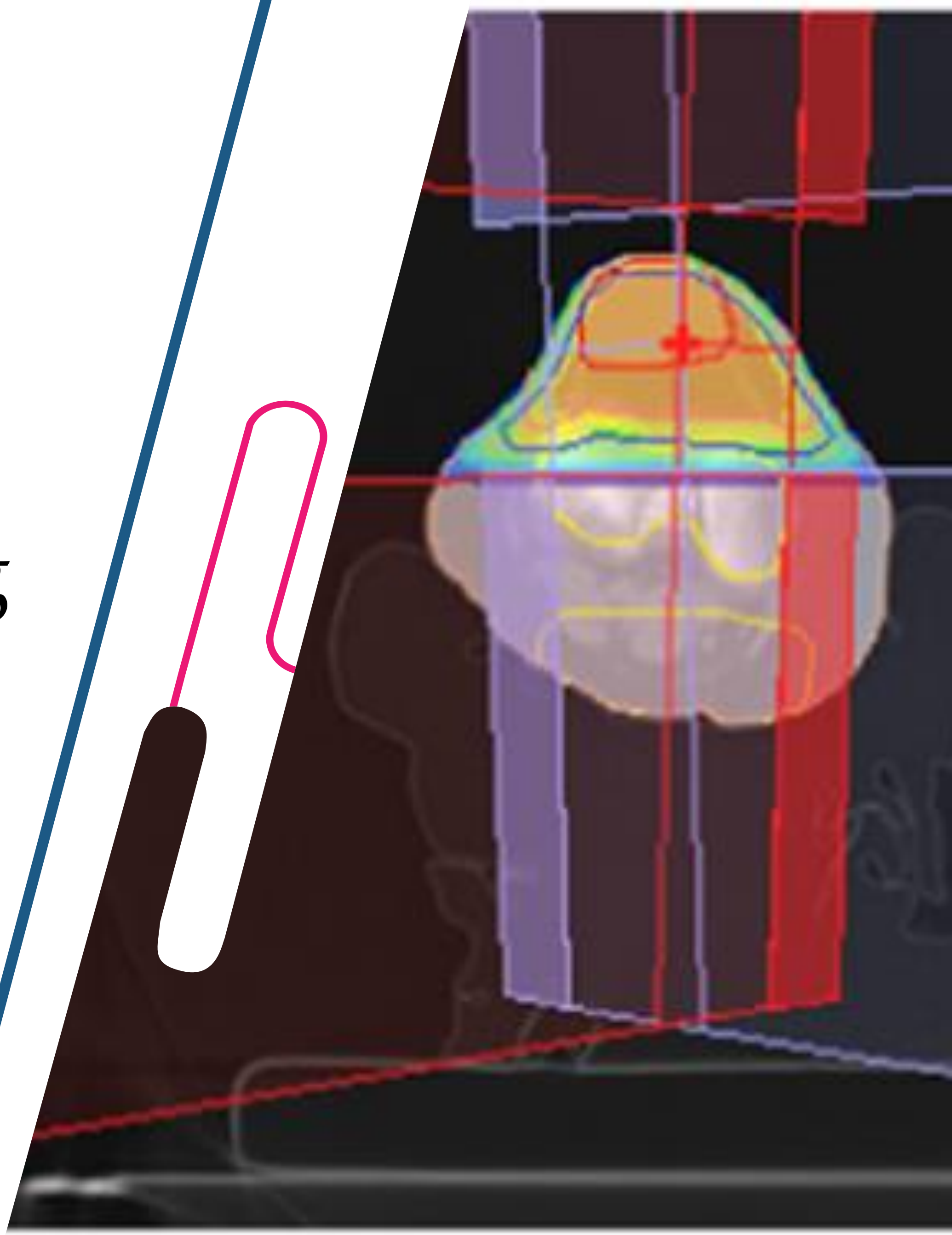
- Under dosage of the target
- Over dosage of the OARs

Positioning and immobilization impact:

- Treatment planning
- Margins
- & clinical outcomes

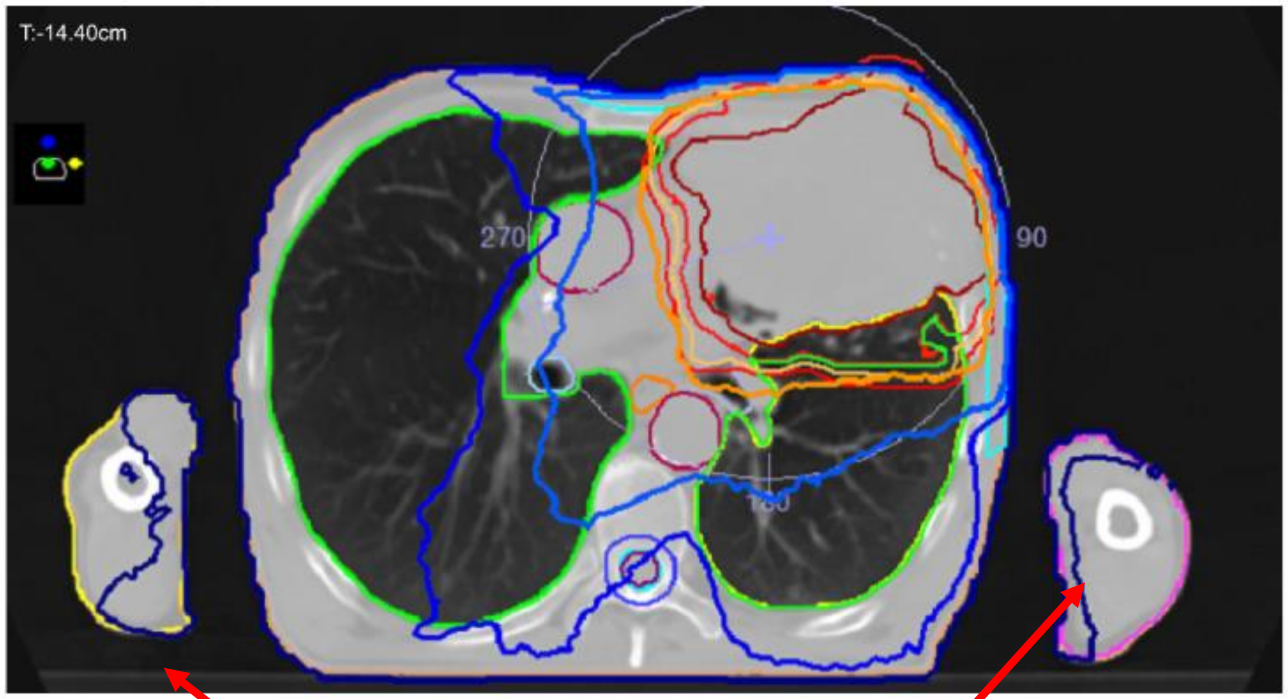


Impact on treatment planning



Impact on treatment planning

Prescription: Upper lung lobe 30 fractions of 2 Gy, Vmat plan



Color	Dose (cGy)
	6420.0
	6300.0
	5700.0
	3000.0
	2000.0
	500.0

Color	Structure Name
	Moelle
	Oesophage
	Coeur
	Trachee
	PoumonD
	PoumonG
	Canal_Medullaire
	patient
	BSG
	BSD
	Aorte
	CTV T
	CTV N
	GTV T
	GTV N
	PTV
	PRVCM
	peau
	BrasD
	BrasG
	poumonsMoinsCT
	PTV3

Arms up position would have been better

A part of his arms received 5 Gy.

Impact on treatment planning

- Consequences of poor or non-adapted immobilization:
  - Difficulties for patient repositioning
  - Risk of patient motion
  - Loss of CTV coverage & increase of dose to OARs

- Dosimetric effect of immobilization devices (and treatment couch) is a combination of:
  - Skin dose increase
  - Tumor dose reduction
  - Dose distribution alteration

Neubauer et al. Radiation Oncology 2012, 7:19
http://www.ro-journal.com/content/7/1/19

RADIATION ONCOLOGY

RESEARCH Open Access

Assessment of shoulder position variation and its impact on IMRT and VMAT doses for head and neck cancer

Emily Neubauer[1], Lei Dong[1], David S Followill[1], Adam S Garden[2], Laurence E Court[1], R Allen White[3] and Stephen F Kry[1*]

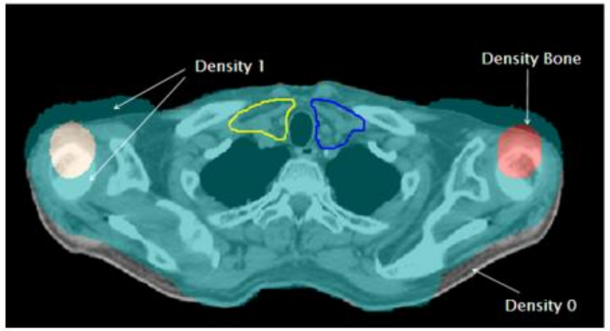


Figure 1 15 mm anterior shift. Body contours are shifted, and the appropriate density is set.

Dosimetric effects caused by couch tops and immobilization devices: Report of AAPM Task Group 176

Arthur J. Olch[a)]
Radiation Oncology Department, University of Southern California and Children's Hospital Los Angeles, Los Angeles, California 90027

Lee Gerig
Department of Physics, Ottawa Hospital Regional Cancer Centre, Carleton University, Ottawa, Ontario K1S 5B6, Canada and Faculty of Medicine, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada

Heng Li
Department of Radiation Physics, UT MD Anderson Cancer Center, Houston, Texas 77030

Ivaylo Mihaylov
Department of Radiation Oncology Department, University of Miami, Miami, Florida 33136

Andrew Morgan
The Beacon Centre, Musgrove Park Hospital, Taunton TA1 5DA, England

(Received 10 January 2014; revised 22 April 2014; accepted for publication 27 April 2014; published 27 May 2014)

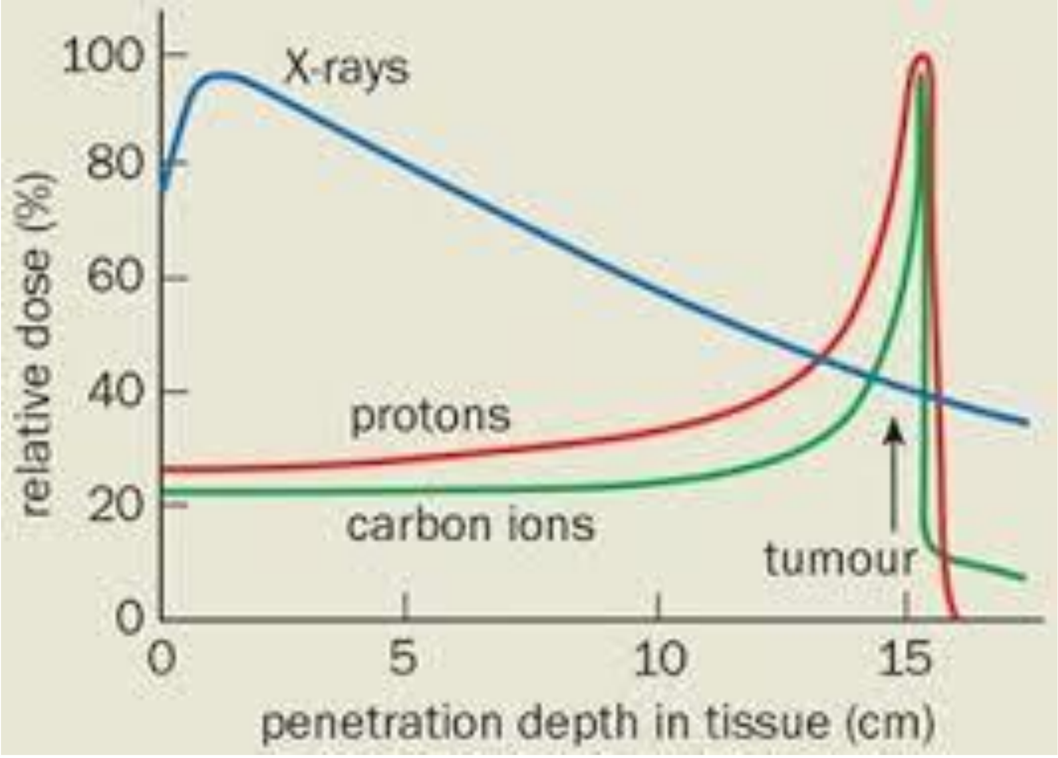
Impact on treatment planning in particle therapy

Protons / carbon ions stop at a finite distance within the tissue

Particles are sensitive to the density variations in the beam path

Movements of high-density structures, air pockets in the beam path during treatment could create a shift in the particle range and hence the Bragg peak

Affect the dose distribution



Published in final edited form as:
Radiother Oncol. 2019 May ; 134: 101–109. doi:10.1016/j.radonc.2019.01.028.

Effect of setup and inter-fraction anatomical changes on the accumulated dose in CT-guided breath-hold intensity modulated proton therapy of liver malignancies

Zhiyong Yang[1], **Yu Chang**[2], **Kristy K Brock**
C Koong[4], **Joseph M Herman**[4], **Peter C Par**
Wu[2], **Brian Anderson**[3], **Andrea N Ohrt**[3], **Yu**
Heng Li[6]

[1]Cancer Center, Union Hospital, Tongji Medic
Technology, Wuhan, China; Department of Ra
Anderson Cancer Center, Houston, United St

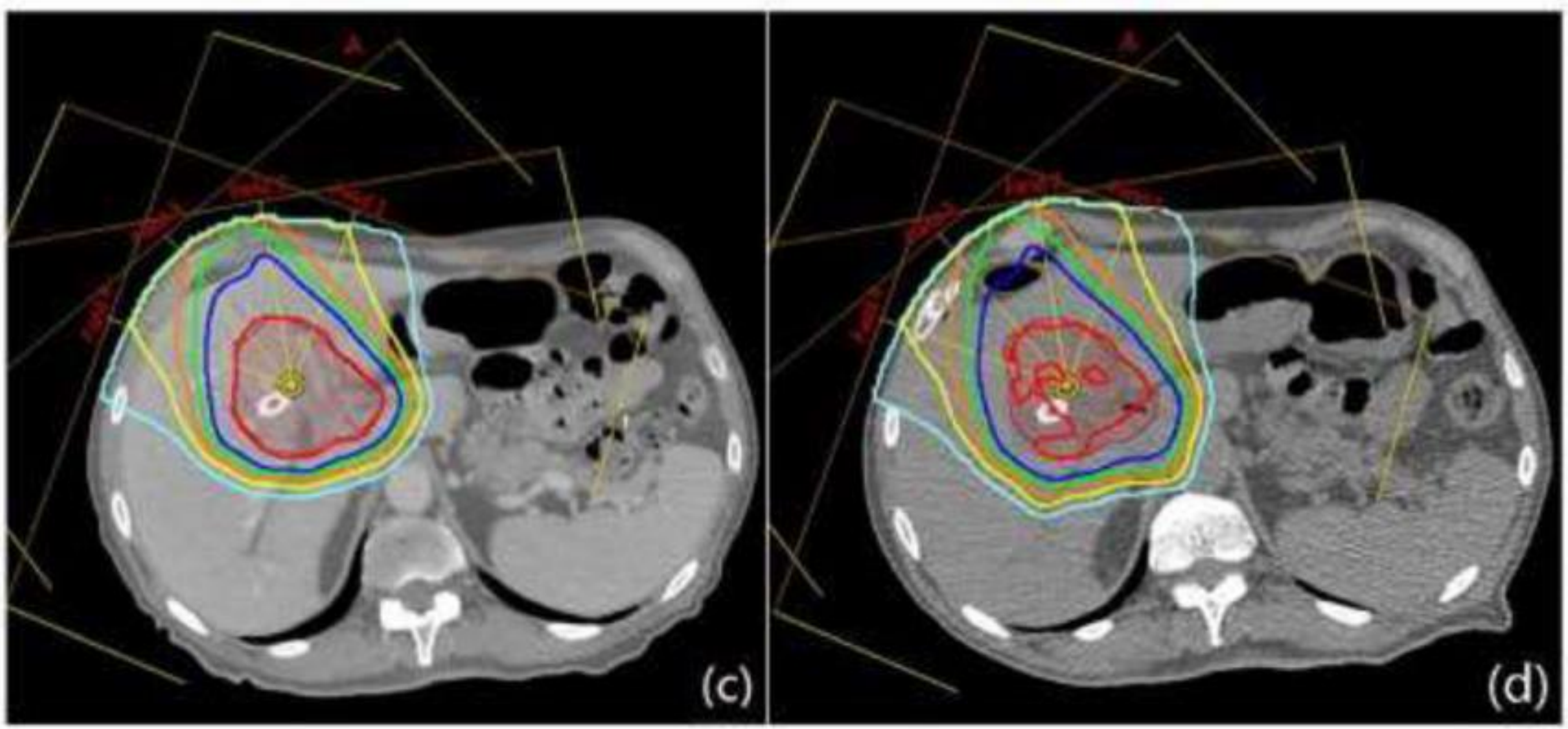
[2]Cancer Center, Union Hospital, Tongji Medic
Technology, Wuhan, China.

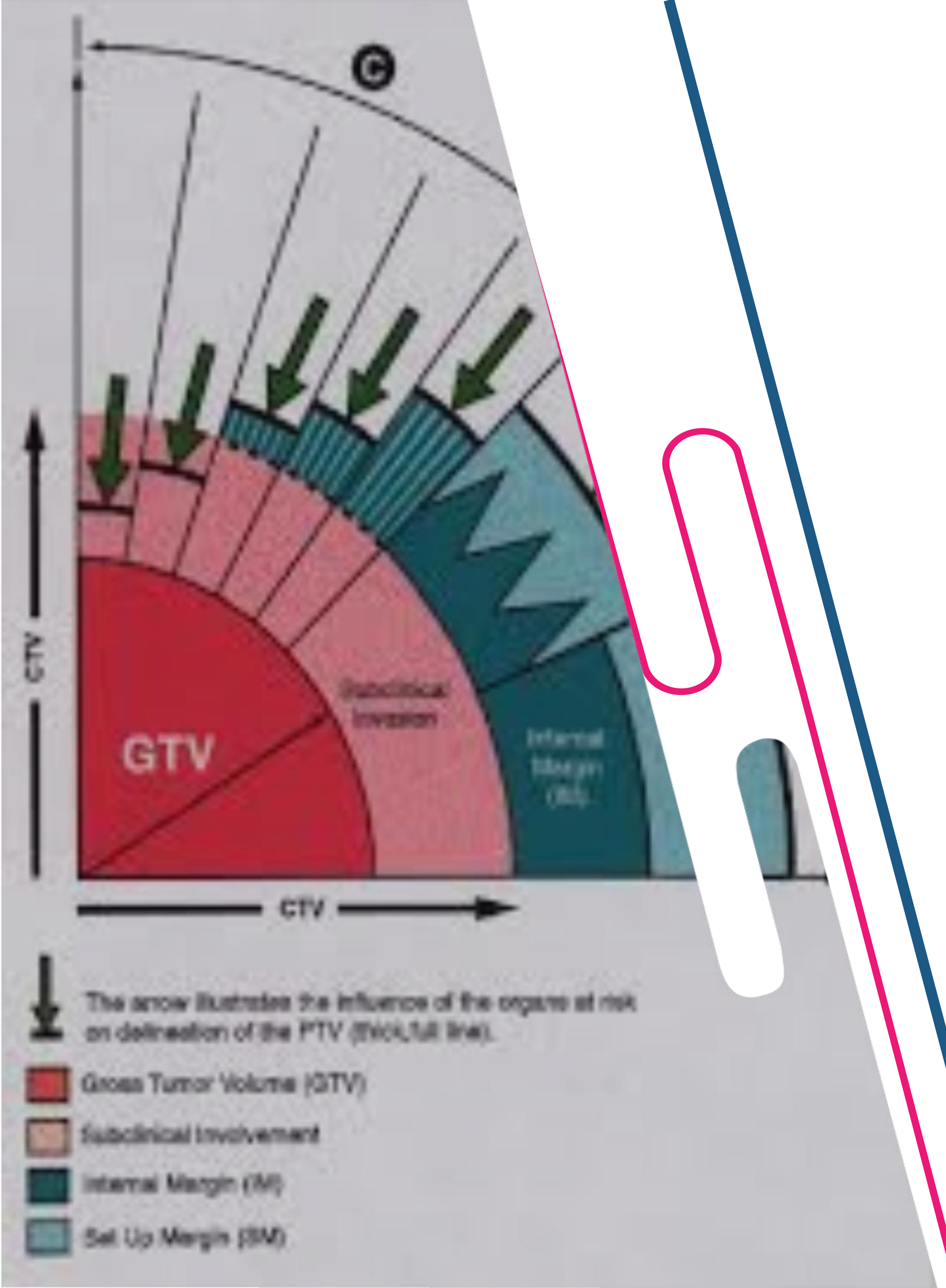
[3]Department of Image Physics, The Universit
United States.

[4]Division of Radiation Oncology, The Universi
United States.

[5]Department of Radiation Physics, The Unive
Houston, United States.

[6]Department of Radiation Physics, The Unive
Houston, United States.





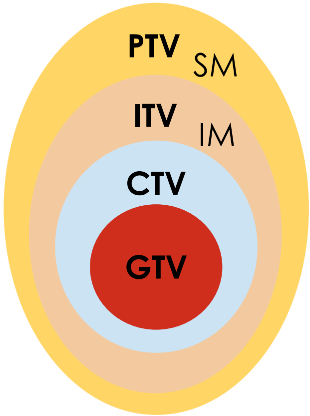
Impact on margins

Impact on margins

ICRU 50 : Gross Target Volume (GTV) - Clinical Taget Volume (CTV) – Planning Target Volume (PTV)

ICRU 62:

- Internal margin (IM): variation in size, shape and position of the CTV relative to anatomic reference points (e.g. bladder filling, movement due to breathing,…)
- Setup margin (SM): uncertainties in patient positioning, mechanical uncertainties of the equipment (ICRU 62)



GTV and CTV cannot be reduced

PTV can be reduced by:

- Decreasing IM (e.g. use of compression belt)
- Decreasing SM (e.g. better immobilization devices)

Sphere 3 cm of diameter
Volume = 14,4 cm^3
With a marge of 5 mm
Volume = 33,5 cm^3
With a marge of 7 mm
Volume = 44,6 cm^3

Verellen, D., et al (2007). Innovations in image-guided radiotherapy. Nature Reviews Cancer

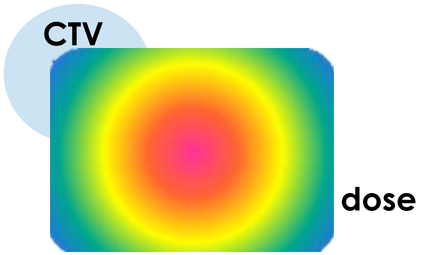
IAEA. Accuracy Requirements and Uncertainties in Radiotherapy. Vienna: IAEA; 2017. 1 p. (IAEA Human Health Series No. 31).
On target 2: updated guidance for image-guided radiotherapy |

Impact on margins

To determine margins: systematic errors and random errors from the various uncertainties need to be taken into account

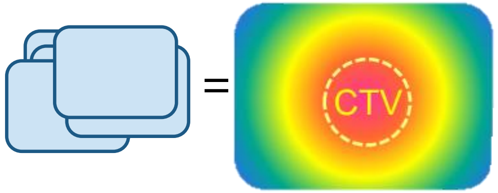
Systematic error Σ

Reproductible inaccuracies that are consistently in the same direction (e.g. incorrect documentation of patient setup)



Random error σ

statistical fluctuations (in either direction) in the measured data (e.g. organ motion, setup error)



van Herk M, Remeijer P, Rasch C, Lebesque JV. The probability of correct target dosage: dose-population histograms for deriving treatment margins in radiotherapy. Int J Radiat Oncol Biol Phys. 2000 Jul 1;47(4):1121-35.

Impact on margins

Setup error vary by treatment site & according to each immobilization device

	Systematic errors (in mm)	Random errors (in mm)
Delineation		
Organ motion		
Setup error		

Total of Σ and σ errors:

$$\Sigma = \sqrt{\Sigma_{del}^2 + \Sigma_{mot}^2 + \Sigma_{setup}^2}$$

$$\sigma = \sqrt{\sigma_{del}^2 + \sigma_{mot}^2 + \sigma_{setup}^2}$$

Simplified PTV margin recipe based on probability:

To cover the CTV for 90% of the patients with the 95% isodose: PTV margin = 2.5 Σ +0.7 σ

	patient 1	Patient 2	patient 3	Patient 4	
Day 1	2	4	1	3	
Day 2	1	-2	-1	-3	
day 3	1	2	2	-2	
day 4	1	0	2	1	
					Mean = M = 0.75
Mean	1.25	1	1	-0.25	SD = Σ = 0.68
SD	0.50	2.58	1.41	2.75	RMS = σ = 2.03

Fig 1. Estimation of the SD of random and systematic errors based on measurements in a population of patients. The numbers in this table could represent, for instance, a shift of the patient in millimeters in the left-right direction determined using electronic portal imaging. For each patient, the mean and SD of measurements of several fractions is determined. Different combinations of these values give an estimate of the errors for a population of patients.

Errors and Margins in Radiotherapy

Marcel van Herk

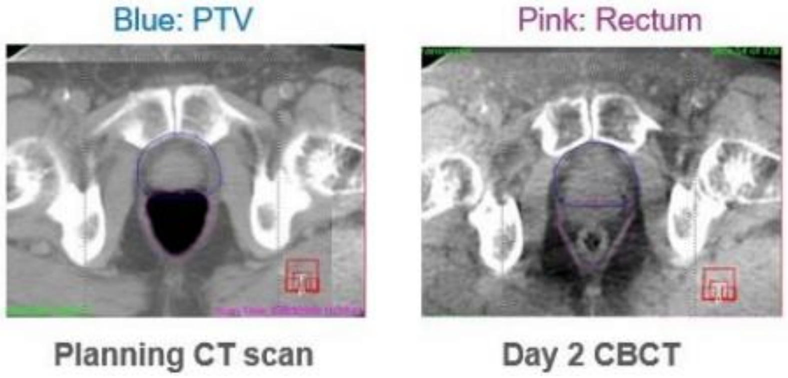
Seminars in Radiation Oncology, Vol 14, No 1 (January), 2004: pp 52-64

Impact on clinical outcomes

Impact on clinical outcomes

Prostate case

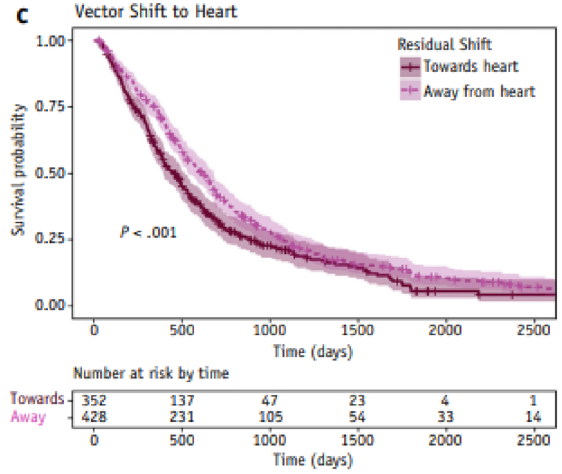
Increased risk of biochemical and local failure in patients with distended rectum on the planning CT for prostate cancer RT



(De Crevoisier et al. IJROBP 2005)

Lung & oesophagus case

Shifts toward the mediastinum have a negative effect on survival for lung and esophageal cancer patients



(Johnson-Hart et al. IJROBP 2018)

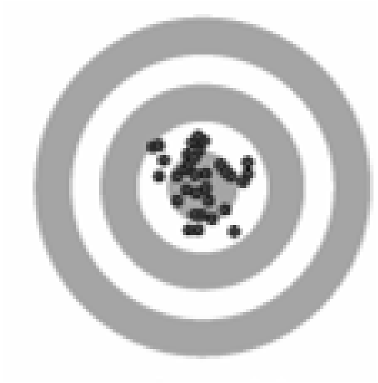
Impact on clinical outcomes: skin folds increase skin toxicity (Fordes et al. Radiation Oncology 2025)

Key principles of the positioning and immobilization

Safety

Stability

Reproducibility



Safety

Respect of the hygiene rules (e.i. cleaning the equipment between patients, hand hygiene, …)

- Cancer patients have reduced immunity
  - Cleaning equipment
  - Hand Hygiene

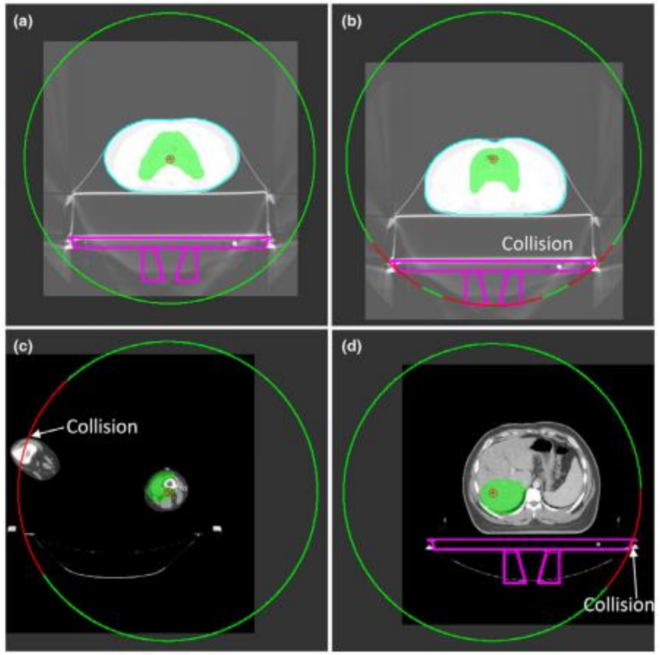
https://www.cdc.gov/healthcare-associated-infections/hcp/prevention-healthcare/outpatient-oncology.html

https://www.who.int/publications/m/item/five-moments-for-hand-hygiene

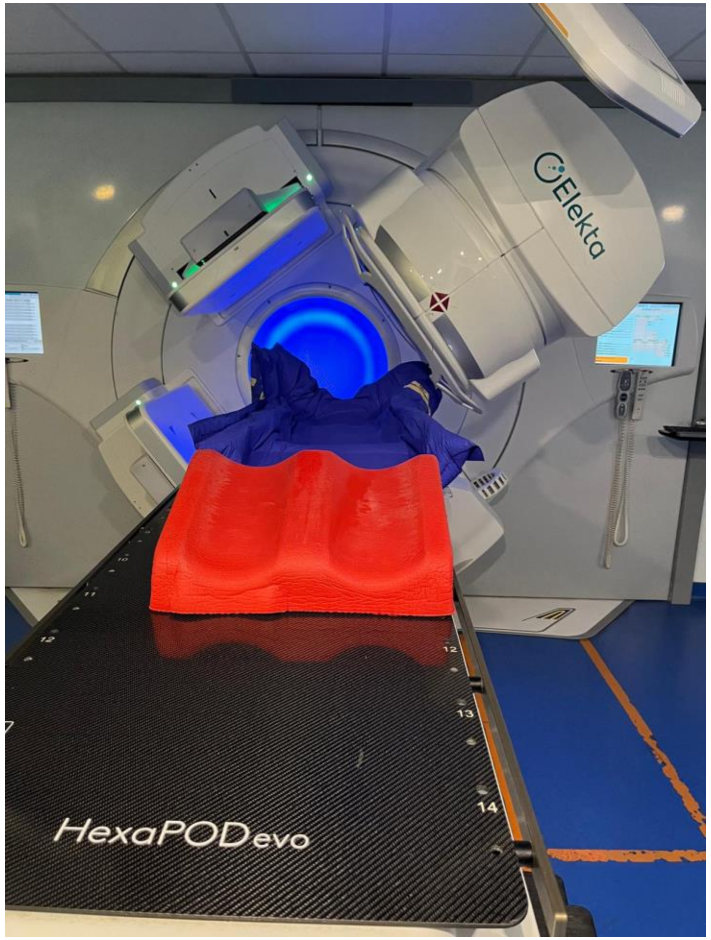
Safety

Avoid collision risk

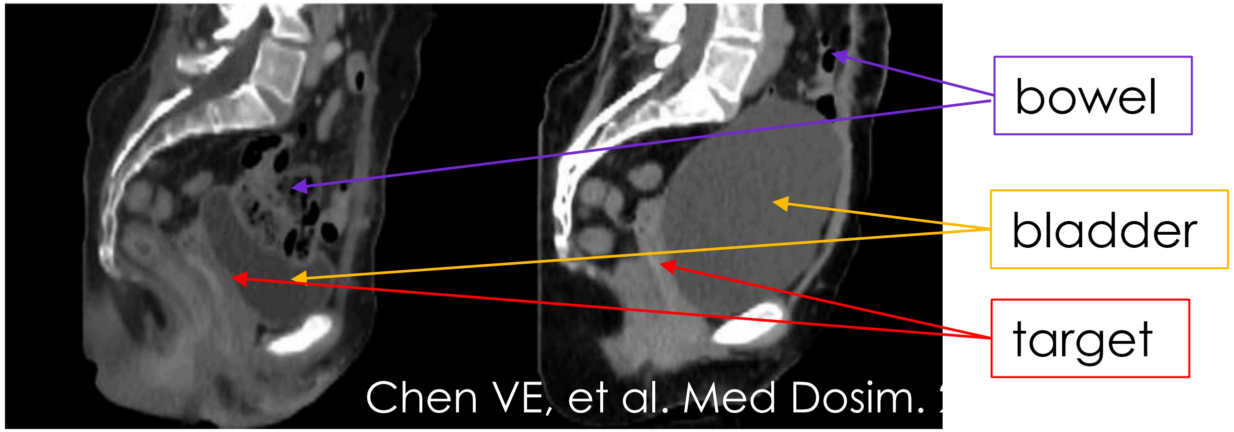
- Constrains between patient positioning system (i.e. treatment couch with immobilization device,…) & the other equipment (i.e. onboard imagers,…)



Miao J, et al. J Appl Clin Med Phys. 2020



Safety



Respect radiation safety

- As Low As Reasonable Achievable especially on the OARs:
  - Treatment modalities (fixed beam, IMRT, photon, proton,…) and beam angle selection (tangential fields, partial arc,…)
  - CTV position (lymph nodes included?)
  - OAR position
  - Maximisation of the distance between the target and the OARs:
    - External anatomy : expose the target (arms up/ arms down)
    - Internal anatomy : change the relationship between organs, reduce the size of the treatment area

Stability

A comfortable patient might be a stable patient (Bayley AJ et al. Radiother Oncol 2004, . Bartlett FR et al. Radiother Oncol 2015) :

- But assessment of the comfort based on a non-validated patient-reported scale

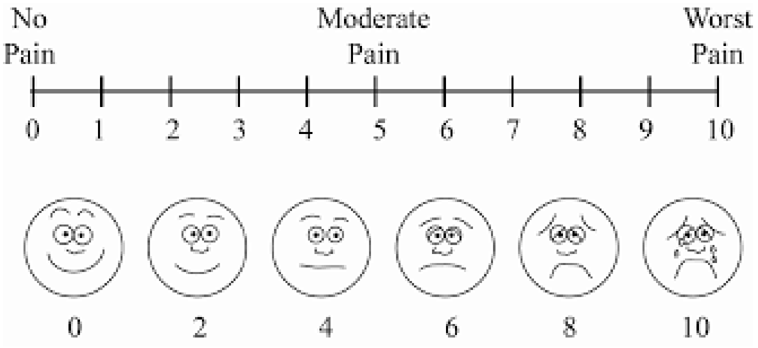
Patient comfort:

- Complex concept
- Not limited to physical comfort / pain … often measured with numeric rating scale (NRS) or visual analog scale (VAS)

TAXONOMIC STRUCTURE OF COMFORT

	Relief	Ease	Transcendence
Physical	pain		
Psychospiritual	anxiety		
Environmental			
Sociocultural			

Kolcaba, K. (1991). A taxonomic structure for the concept comfort: Synthesis and application. Image: Journal of Nursing Scholarship, 23, 237 240



Stability

Patient comfort:

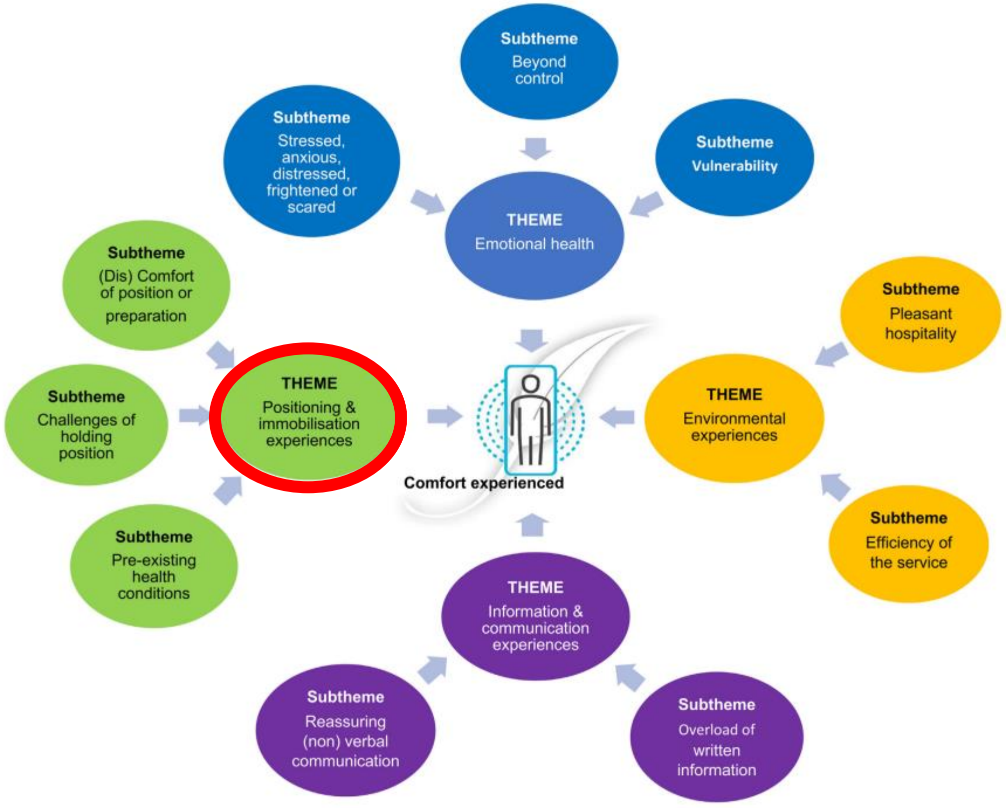


Figure 1. Patient comfort experience themes.

Radiography xxx (xxxx) xxx

Contents lists available at ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

Patient and therapeutic radiographer experiences of comfort during the radiotherapy pathway: A qualitative study

Simon Goldsworthy [a, b, *], Jos M. Latour [c, d], Shea Palmer [e], Helen A. McNair [f], Mary Cramp [b]

[a] Beacon Radiotherapy, Musgrove Park Hospital, Somerset NHS Foundation Trust, Taunton, United Kingdom
[b] Faculty of Health and Applied Sciences, University of the West of England, Bristol, United Kingdom
[c] Faculty of Health, University of Plymouth, Plymouth, United Kingdom
[d] School of Nursing, Midwifery and Paramedicine, Faculty of Health Sciences, Curtin University, Perth, Australia
[e] Centre for Care Excellence, Coventry University and University Hospitals Coventry & Warwickshire NHS Trust, Coventry, United Kingdom
[f] Royal Marsden NHS Foundation Trust and Institute of Cancer Research, Sutton, United Kingdom

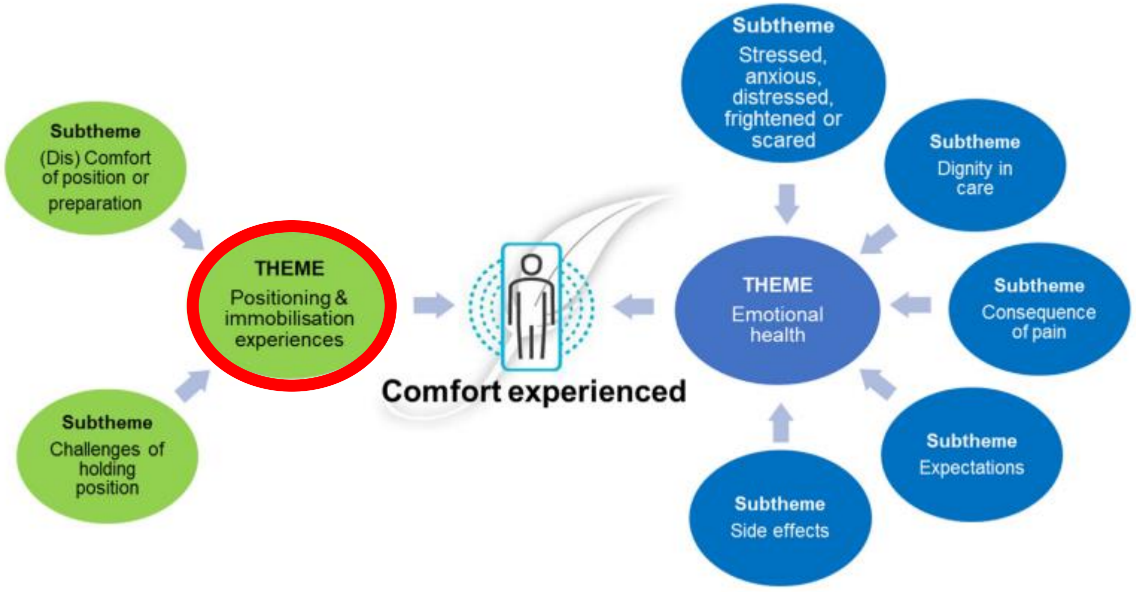


Figure 2. Therapeutic Radiographer comfort experience themes.

Stability

Patient comfort:

Journal of Medical Imaging and Radiation Sciences 54 (2023) 603–610

Journal of Medical Imaging and Radiation Sciences
Journal de l'imagerie médicale et des sciences de la radiation

www.elsevier.com/locate/jmir

Research Article

A thematic exploration of patient and radiation therapist solutions to improve comfort during radiotherapy: A qualitative study

Simon Goldsworthy[a,b,*], Jos M. Latour[c,d], Shea Palmer[e], Helen A. McNair[f] and Mary Cramp[b]

[a] Beacon Radiotherapy, Musgrove Park Hospital, Somerset NHS Foundation Trust, Taunton, United Kingdom
[b] Faculty of Health and Applied Sciences, University of the West of England, Bristol, United Kingdom
[c] Faculty of Health, University of Plymouth, Plymouth, United Kingdom
[d] School of Nursing, Midwifery and Paramedicine, Faculty of Health Sciences, Curtin University, Perth, Australia
[e] School of Healthcare Sciences, Cardiff University, Cardiff, NSW, United Kingdom
[f] Royal Marsden NHS Foundation Trust and Institute of Cancer Research, Sutton, United Kingdom

Fig. 1. Patient comfort solutions.

Stability

Treatment couch or chair are insufficient to immobilize a patient:

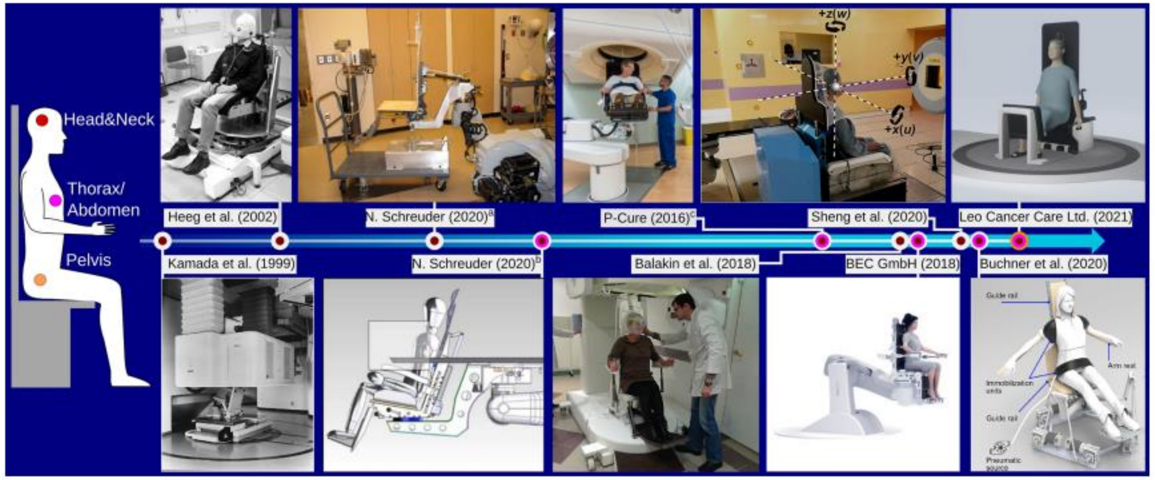


FIGURE 1 | Overview over different chair designs targeted for particle therapy found in literature, focusing on those that were constructed as prototype. The color of the time line connectors indicates the chair's intended use with respect to different treatment sites, as shown on the left. [a]The chair was installed at the Indiana University Health Proton Therapy Center prior to 2006, as described by Schreuder (30). [b]The device was installed at the Oklahoma Proton Center as described in (30). The figure shows the couch overlayed on the chair. [c]The chair system is installed at Northwestern Medicine Chicago Proton Center and was designed by P-Cure[1]. Image reprinted with kind permission by Dr. M. Pankuch (Northwestern Medicine Chicago Proton Center). Images [a],[b], and the Leo Cancer Care Ltd (2021). were reprinted with kind permission by Dr. N. Schreuder (Leo Cancer Care Ltd.). Kamada et al. (1999): Reprinted from Kamada et al. (5) with permission from Elsevier. Buchner et al. (2020): ©2020 IEEE. Reprinted, with permission, from Buchner et al. (35).

Volz L, et al. Front Oncol. 2022

Stability

Use of various immobilization devices:

- Universal solution : used for multiple patients, adjustable settings and reusable
  - Breast board
  - Chest board
  - Knee and feet devices
  - Prone devices
- Personalised: customized to a patient reusable or not:
  - Thermoplastic mask
  - Vacuum cushion

Many vendors, many solutions

orfit Klarity macromedics SOLUTIONS IN RADIOTHERAPY CDR Systems CQ MEDICAL Formerly CIVCO RT and Qfix

Monarch by CQ medical

Kneefix and Feetfix by CQ medical

A thermoplastic mask by Orfit

Stability

During the beam delivery:

- Motion management technologies:
  - Passive: try to quantify the motion prior to delivery with a respiration correlated CT
  - Active: monitor motion in real time and adapt during treatment with tracking, gating, breath hold or mecanical ventilation techniques

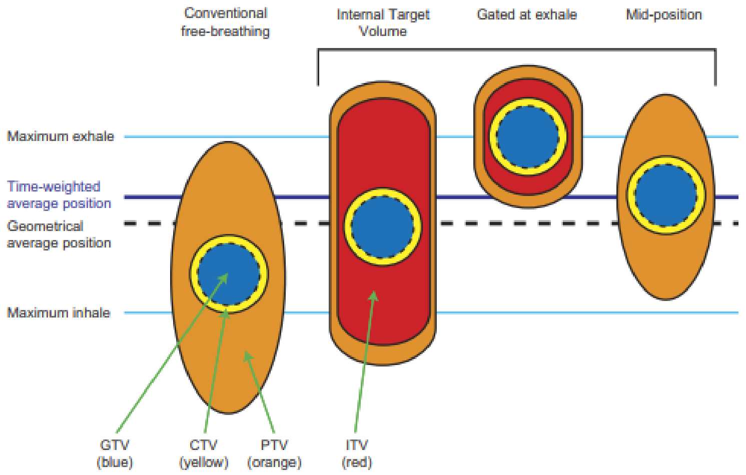
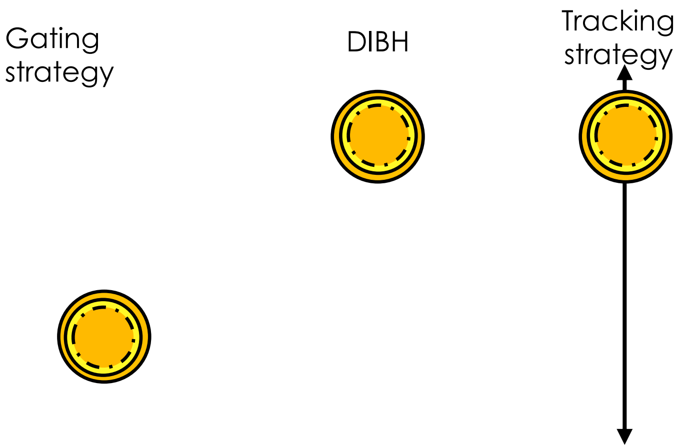


Fig. 1. Schematic overview of different treatment-planning concepts: conventional free-breathing, internal target volume (ITV), gating (at exhale), and mid-position. GTV = gross tumor volume; CTV = clinical target volume; PTV = planning target volume.



Wolthaus JW, et al. IJROBP 2008

Reproducibility

P&I must be documented for each patient

Lock the immobilization devices used to reduce systematic errors (Goldworthy et al. conference College of Radiographers radiotherapy weekend 2013)

External localization:

- Anatomical landmarks
  - Skin marks
  - Tatoos
  - Surface Guided Radiation Therapy

Alignement of anatomical landmarks in three planes of the body

- Ensure straightness
- Laser

CQ medical

According to treatment site in recumbent position

Brain

Consider whether brain or brain plus central nervous system

Looking for

- An immobilization
- Or immobilization with verification system

Ensuring a sub milimetre accuracy

Frameless

Practical Radiation Oncology® (2023) 13, 183–194

practical radiation oncology
pro
www.practicalradonc.org

Physics Contribution

ISRS Technical Guidelines for Stereotactic Radiosurgery: Treatment of Small Brain Metastases (≤1 cm in Diameter)

Diana Grishchuk, MSc,[a,*] Alexis Dimitriadis, PhD,[a] Arjun Sahgal, MD,[b] Antonio De Salles, MD, PhD,[c] Laura Fariselli, MD,[d] Rupesh Kotecha, MD,[e] Marc Levivier, MD, PhD,[f] Lijun Ma, PhD,[g] Bruce E. Pollock, MD,[h] Jean Regis, MD,[i] Jason Sheehan, MD, PhD,[j] John Suh, MD,[k] Shoji Yomo, MD, PhD,[l] and Ian Paddick, MSc[a]

Patient treatment	• Sub-millimeter geometric accuracy must be achieved during treatment. To comply with this requirement the choice of immobilization device and in-room imaging should be made based on the achievable accuracy of patient positioning and target localization. Patient immobilization and localization techniques are critical in this regard. • Lower energy beams may reduce dose to normal tissue.

Table 1
Inter- and intrafraction variability (mean shift ± standard deviation) measured by kV images for open face and closed masks. Statistically significant difference is in bold.

	Vertical [mm]	Longitudinal [mm]	Lateral [mm]	Pitch [°]	Roll [°]	Yaw [°]
Interfraction variability						
Open-face masks	1.27 ± 1.15	2.18 ± 5.76	0.68 ± 0.66	0.88 ± 0.74	0.80 ± 0.61	0.84 ± 0.73
Closed masks	1.24 ± 1.78	1.70 ± 1.72	1.99 ± 2.29	0.78 ± 0.62	0.70 ± 0.62	0.76 ± 0.64
P-value	0.34	**<0.01**	**0.03**	0.05	**<0.01**	**0.03**
Intrafraction variability						
Open-face masks	0.34 ± 0.63	0.56 ± 0.45	0.30 ± 0.22	0.30 ± 0.32	0.21 ± 0.19	0.27 ± 0.23
Closed masks	0.34 ± 0.46	0.44 ± 0.37	0.28 ± 0.22	0.24 ± 0.23	0.17 ± 0.16	0.23 ± 0.20
P-value	0.27	0.06	0.21	0.21	0.09	0.14

(<1mm or < 0.5°) for both masks (Table 2).

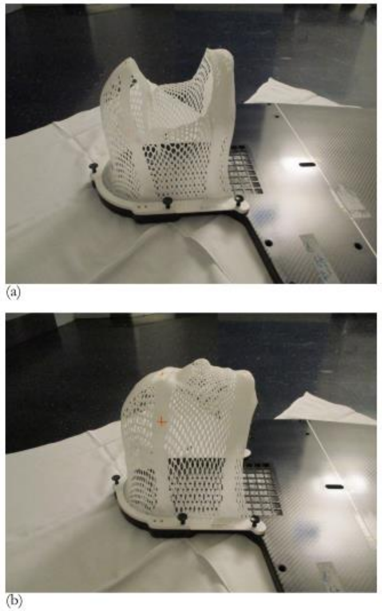


Fig. 1. Lateral views of open-face masks (a) and closed masks (b) used in

Radiotherapy and Oncology 196 (2024) 110314

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

ELSEVIER

Original Article

Randomized self-controlled study comparing open-face vs. closed immobilization masks in fractionated cranial radiotherapy

Michèle Keane[3], Nienke Weitkamp[1,3], Indira Madani, Jonathan Day, Riccardo Dal Bello, Mariangela Zamburlini, Antonia Schiess, Amanda Moreira[2], Sophie Perryck, Katja Tomuschat, Marilyn Spencer, Stephanie Tanadini-Lang, Matthias Guckenberger, Michelle Brown[*]

Department of Radiation Oncology, University Hospital Zürich and University of Zürich, Rämistrasse 100, 8091, Zürich, Switzerland

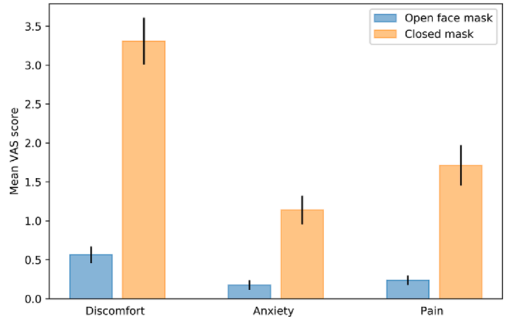


Fig. 2. Comparison of mean and standard errors of discomfort, anxiety and pain scores on a 0 to 10 Visual Analogue Scale reported by patients during treatment. All differences are statistically significant.

Head and neck

Supine position

Consider whether lymph nodes treated:

- Head thermoplastic piece or full head and shoulder piece

Follow the manufacturer's recommendations for the thermoplastic mask modelling and drying

Adequate neck rest: avoid any gaps

Open face mask with SGRT: a potential future solution that needs to be assessed

Technical Innovations & Patient Support in Radiation Oncology 1 (2017) 1–7

Contents lists available at ScienceDirect

Technical Innovations & Patient Support in Radiation Oncology

journal homepage: www.elsevier.com/locate/tipsro

Practice guidelines

ESTRO ACROP guidelines for positioning, immobilisation and position verification of head and neck patients for radiation therapists

Michelle Leech [a,*], Mary Coffey [a], Mirjam Mast [b], Filipe Moura [c], Andreas Osztavics [d], Danilo Pasini [e], Aude Vaandering [f]

[a] Applied Radiation Therapy Trinity (ARTT), Discipline of Radiation Therapy, School of Medicine, Trinity College, Dublin 2, Ireland
[b] Radiotherapy Centre West/Medical Center Haaglanden, The Hague, The Netherlands
[c] Hospital CUF Descobertas, Lisboa, Portugal
[d] Universitätsklinik für Strahlentherapie, Vienna, Austria
[e] USCU Policlinico A. Gemelli, Rome, Italy
[f] Radiation Oncology Department, Cliniques Universitaires St Luc, Brussels, Belgium

The update is in progress.

Fig. 3. Good immobilisation of forehead, nose and chin.

Fig. 4. Poor immobilisation of the shoulder and upper thorax.

Breast

Summary of recommendations.

Topic	Recommendations
Positioning	• For most breast cancer treatments supine is the standard position. For patients with larger breasts or patients that require a higher degree of lung sparing, prone can be considered if the equipment and expertise are available. • Both arms up are considered more stable; one arm up may be considered for patients that cannot tolerate both arms up. • When using supine positioning, both flat and elevated board positions are acceptable provided collision risks are managed and the patient is appropriately stabilised.
Immobilisation	• There is insufficient evidence to support the adoption of any specific immobilisation device of the breast. The pro and cons of specific immobilisation devices must be weighed carefully and evaluated by the local department prior to clinical implementation.
Setup	• In the absence of surface guided imaging, the use of skin marking is required. • The available options for skin marking should be discussed taking into account long-term patient experience and patient preference.

Technical Innovations & Patient Support in Radiation Oncology 28 (2023) 100219

Contents lists available at ScienceDirect

Technical Innovations & Patient Support in Radiation Oncology

journal homepage: www.sciencedirect.com/journal/technical-innovations-and-patient-support-in-radiation-oncology

ESTRO-ACROP guideline for positioning, immobilisation and setup verification for local and loco-regional photon breast cancer irradiation

M.E. Mast [a,*], A. Leong [b,c], S.S. Korreman [d,e,f], G. Lee [g,h], H. Probst [i], P. Scherer [j], Y. Tsang [g,h]

[a] Department of Radiation Oncology, Haaglanden Medical Center, Leidschendam, The Netherlands
[b] Department of Radiation Therapy, University of Otago, Wellington, New Zealand
[c] Bowen Icon Cancer Centre, Wellington, New Zealand
[d] Department of Clinical Medicine, Aarhus University, Denmark
[e] Department of Oncology, Aarhus University Hospital, Denmark
[f] Danish Center for Particle Therapy, Aarhus University Hospital, Denmark
[g] Radiation Medicine Program, Princess Margaret Cancer Centre, Toronto, Canada
[h] Department of Radiation Oncology, University of Toronto, Toronto, Canada
[i] Sheffield Hallam University, Sheffield, United Kingdom
[j] Department of Radiotherapy and Radio-Oncology, LKH Salzburg, Paracelsus Medical University Clinics, Salzburg, Austria

Deep Inspiration Breath Hold can minimize the dose to intrathoracic organs at risk

Pelvis

Consider whether prostate, cervix, endometrium, bladder, rectum, anal canal

Supine position for prostate, cervix, endometrium, bladder

Prone position can be considered for rectal cancer

With a knee / leg / ankle support

Hands on chest (arm up only if para aortic lymph nodes are treated)

Bladder and rectal filling

Radiotherapy and Oncology 141 (2019) 5–13

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Original Article

ESTRO ACROP consensus guideline on the use of image guided radiation therapy for localized prostate cancer

Pirus Ghadjar[a], Claudio Fiorino[b], Per Munck af Rosenschöld[c], Michael Pinkawa[d], Thomas Zilli[e], Uulke A. van der Heide[f,g,*]

[a] Department of Radiation Oncology, Charité Universitätsmedizin Berlin, Germany; [b] Department of Medical Physics, San Raffaele Scientific Institute, Milano, Italy; [c] Radiation Physics, Department of Hematology, Oncology and Radiation Physics, Skåne University Hospital, Lund, Sweden; [d] Department of Radiation Oncology, MediClin Robert Janker Klinik, Bonn, Germany; [e] Department of Radiation Oncology, Geneva University Hospital, Switzerland; [f] Department of Radiation Oncology, The Netherlands Cancer Institute, Amsterdam; and [g] Department of Radiation Oncology, Leiden University Medical Center, The Netherlands

Table 4
ESTRO ACROP recommendations on prostate IGRT:

1. IGRT for prostate cancer needs to be based on the position of the prostate itself, IGRT based on bony anatomy is considered inadequate for prostate only treatments
2. IGRT to account for interfractional prostate movement for conventionally fractionated and moderately hypofractionated EBRT as a minimum standard must be based on either fiducial markers or CT-based approaches with soft-tissue matching. A combination of fiducial markers with CT-based approaches is preferred
3. While US is a viable option for prostate IGRT, for now it must be considered less accurate compared to visualization of implanted fiducial markers or CT-based image guidance
4. Daily on-line correction is preferred for conventionally fractionated radiotherapy and recommended in case of hypofractionated radiotherapy.
5. For a treatment of both the prostate and pelvic lymph nodes (PLN), IGRT is preferentially based the position of the prostate. IGRT based on the bony structures may be considered but margins for prostate should then be enlarged compared to the sizes suggested in Table 3, in order to accommodate prostate organ motion
6. A distended rectum in the planning CT should be prevented as it may deform the prostate
7. Bowel regimens (including evacuation techniques, dietary interventions, laxatives, and enemas) are not recommended as routine practice. However, for patients with a high degree of intrafractional motion, they may be indicated
8. Bladder filling protocols have no clear effect on positioning stability of the prostate, but may ensure a dosimetric advantage in terms of bladder and bowel sparing as they move the bowel and parts of the bladder out of the high-dose volume
9. Monitoring and ideally tracking of intrafraction motion of the prostate may be considered for extreme hypofractionation
10. Margins for the three most popular IGRT scenarios have been suggested as examples in Table 3. Centers should however make an effort to estimate the residual error in their own institution and derive safe margins from these estimates

Bladder

Radiotherapy and Oncology 161 (2021) 95–114

ELSEVIER

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Original Article

Recommendations for planning and delivery of radical radiotherapy for localized urothelial carcinoma of the bladder

Jonathan Khalifa [a], Stéphane Supiot [b], Géraldine Pignot [c], Christophe Hennequin [d], Pierre Blanchard [e], David Pasquier [f], Nicolas Magné [g], Renaud de Crevoisier [h], Pierre Graff-Cailleaud [a], Olivier Riou [i], Morgane Cabaillé [j], David Azria [i], Igor Latorzeff [k], Gilles Créhange [l], Olivier Chapet [m], Morgan Rouprêt [n], Sarah Belhomme [o], Arnaud Mejean [p], Stéphane Culine [q], Paul Sargos [j,*]

[a] *Department of Radiotherapy, Institut Claudius Regaud, Institut Universitaire du Cancer de Toulouse Oncopole;* [b] *Department of Radiotherapy, Institut de Cancérologie de l'Ouest, Nantes Saint-Herblain;* [c] *Department of Urology, Institut Paoli Calmettes, Marseille;* [d] *Department of Radiotherapy, Hôpital Saint Louis, Paris;* [e] *Department of Radiotherapy, Institut Gustave Roussy, Villejuif;* [f] *Department of Radiotherapy, Centre Oscar Lambret, Lille;* [g] *Department of Radiotherapy, Institut de Cancérologie Lucien Neuwirth, Saint Priest en Jarez;* [h] *Department of Radiotherapy, Centre Eugène Marquis, Rennes;* [i] *Department of Radiotherapy, Institut du Cancer de Montpellier;* [j] *Department of Radiotherapy, Institut Bergonié, Bordeaux;* [k] *Department of Radiotherapy, Clinique Pasteur, Toulouse;* [l] *Department of Radiotherapy, Institut Curie, Paris;* [m] *Department of Radiotherapy, Hospices Civils de Lyon;* [n] *Department of Urology, Hôpital Pitié-Salpêtrière, APHP Sorbonne Université, Paris;* [o] *Department of Medical Physics, Institut Bergonié, Bordeaux;* [p] *Department of Urology, Hôpital Européen Georges-Pompidou, Paris; and* [q] *Department of Medical Oncology, Hôpital Saint-Louis, Paris*

Summary of guidelines from the working group for bladder radical radiotherapy.

Topics	Proposition of guidelines	Evidence strength	Grade of recommendation
1. TURBT preceding radiotherapy	A complete TURBT must be performed within 4–8 weeks before the start of radiotherapy.	A	1
	When TURBT has been performed more than 6 weeks before the start of RT, a second look should be performed to ensure that there is no tumor regrowth.	B	2
2. Planning CT-scan acquisition	When standard planning is performed (i.e. without adaptive strategy): – if single-dose level whole bladder radiotherapy is planned, patients have to stop any absorption of fluids within 30 minutes before the planning CT and to void bladder immediately before planning CT. – when index tumor irradiation is planned, patients have to void bladder then drink 250–500 ml of water approximately 30 minutes before the planning CT.	B	2
	Ideally, rectum should be empty as well, with the same local practices as those used for prostate planning.	C	2
	Patients must be supine in comfortable position with adequate immobilization devices (knee and/or ankle supports).	C	1

Cervix and endometrium

International Journal of Radiation Oncology biology • physics

www.redjournal.org

Clinical Investigation

NRG Oncology/RTOG Consensus Guidelines for Delineation of Clinical Target Volume for Intensity Modulated Pelvic Radiation Therapy in Postoperative Treatment of Endometrial and Cervical Cancer: An Update

William Small, Jr, MD,* Walter R. Bosch, DSc,† Mathew M. Harkenrider, MD,* Jonathan B. Strauss, MD,‡ Nadeem Abu-Rustum, MD,§ Kevin V. Albuquerque, MD,‖ Sushil Beriwal, MD,¶ Carien L. Creutzberg, MD,# Patricia J. Eifel, MD,** Beth A. Erickson, MD,†† Anthony W. Fyles, MD,‡‡ Courtney L. Hentz, MD,* Anuja Jhingran, MD,** Ann H. Klopp, MD, PhD,** Charles A. Kunos, MD, PhD,§§ Loren K. Mell, MD,‖‖ Lorraine Portelance, MD,¶¶ Melanie E. Powell, MD,## Akila N. Viswanathan, MD,*** Joseph H. Yacoub, MD,* Catheryn M. Yashar, MD,‖‖ Kathryn A. Winter, MS,††† and David K. Gaffney, MD, PhD‡‡‡

**Loyola University Stritch School of Medicine, Maywood, Illinois; †Washington University School of Medicine, St. Louis, Missouri; ‡Northwestern University, Chicago, Illinois; §Memorial Sloan Kettering Cancer Center, New York, New York; ‖UT Southwestern Medical Center, Dallas, Texas; ¶UPMC—Hillman Cancer Center, Pittsburgh, Pennsylvania; #Leiden University Medical Center, Leiden, The Netherlands; **MD Anderson Cancer Center, Houston, Texas; ††Froedtert and the Medical College of Wisconsin, Milwaukee, Wisconsin; ‡‡Princess Margaret Cancer Center, University of Toronto, Toronto, Ontario, Canada; §§National Institutes of Health, Bethesda, Maryland; ‖‖UC San Diego Moores Cancer Center, La Jolla, California; ¶¶University of Miami Miller School of Medicine, Miami, Florida; ##Saint Bartholomew's Hospital, London, United Kingdom; ***Johns Hopkins University/Sidney Kimmel Cancer Center, Baltimore, Maryland; †††NRG Oncology Statistics and Data*

Table 2 Computed tomography simulation steps

1. Immobilize the patient in the supine position with a comfortably full bladder that she will be able to reproduce for each treatment.
   - Possible bladder filling regimen: Instruct patient to void and then drink 500-750 mL of liquid 30-60 minutes before imaging.

4. Consider simulating patient with both a full and empty bladder scan, particularly if planning to have a vaginal internal target volume.

Rectum

Practical Radiation Oncology® (2021) 11, 13-25

CME ASTRO

practical radiation oncology® pro www.practicalradonc.org

Clinical Practice Guideline

Radiation Therapy for Rectal Cancer: Executive Summary of an ASTRO Clinical Practice Guideline

Jennifer Y. Wo, MD,[a] Christopher J. Anker, MD,[b] Jonathan B. Ashman, MD, PhD,[c] Nishin A. Bhadkamkar, MD,[d] Lisa Bradfield, BA,[e] Daniel T. Chang, MD,[f] Jennifer Dorth, MD,[g] Julio Garcia-Aguilar, MD,[h] David Goff,[i] Dustin Jacqmin, PhD,[j] Patrick Kelly, MD,[k] Neil B. Newman, MD, MS,[l] Jeffrey Olsen, MD,[m] Ann C. Raldow, MD, MPH,[n] Erika Ruiz-Garcia, MD,[o] Karyn B. Stitzenberg, MD,[p] Charles R. Thomas Jr, MD,[q] Q. Jackie Wu, PhD,[r] and Prajnan Das, MD, MS, MPH[s,*]

[a]Department of Radiation Oncology, Massachusetts General Hospital, Boston, Massachusetts; [b]Division of Radiation Oncology, University of Vermont Cancer Center, Burlington, Vermont; [c]Department of Radiation Oncology, Mayo Clinic, Phoenix, Arizona; [d]Department of General Oncology, MD Anderson Cancer Center, Houston, Texas; [e]American Society for Radiation Oncology, Arlington, Virginia; [f]Department of Radiation Oncology, Stanford University, Stanford,

The choice of patient positioning is an important consideration in the treatment of rectal cancer.[78-80] The belly board can position abdominal organs more superiorly, displacing some of the small bowel out of the treatment field. The superiority of prone treatment with a belly board has been established in terms of dosimetric indices and differences in overlap between the target and organs at risk, but not in terms of patient outcomes. The limitations of these studies notwithstanding, the evidence is sufficient to make a conditional recommendation of simulation in the prone position with a belly board. However, in patients treated with IMRT/VMAT or with a colostomy, a supine position may also be suitable, particularly for patients whose CTV includes the inguinal lymph nodes. Regardless of whether a patient is treated in the supine or prone position, treating with a full bladder may further decrease dose to the small bowel. Additional treatment-planning studies will further identify optimal radiation treatment-planning techniques to minimize treatment toxicity.

Anal cancer

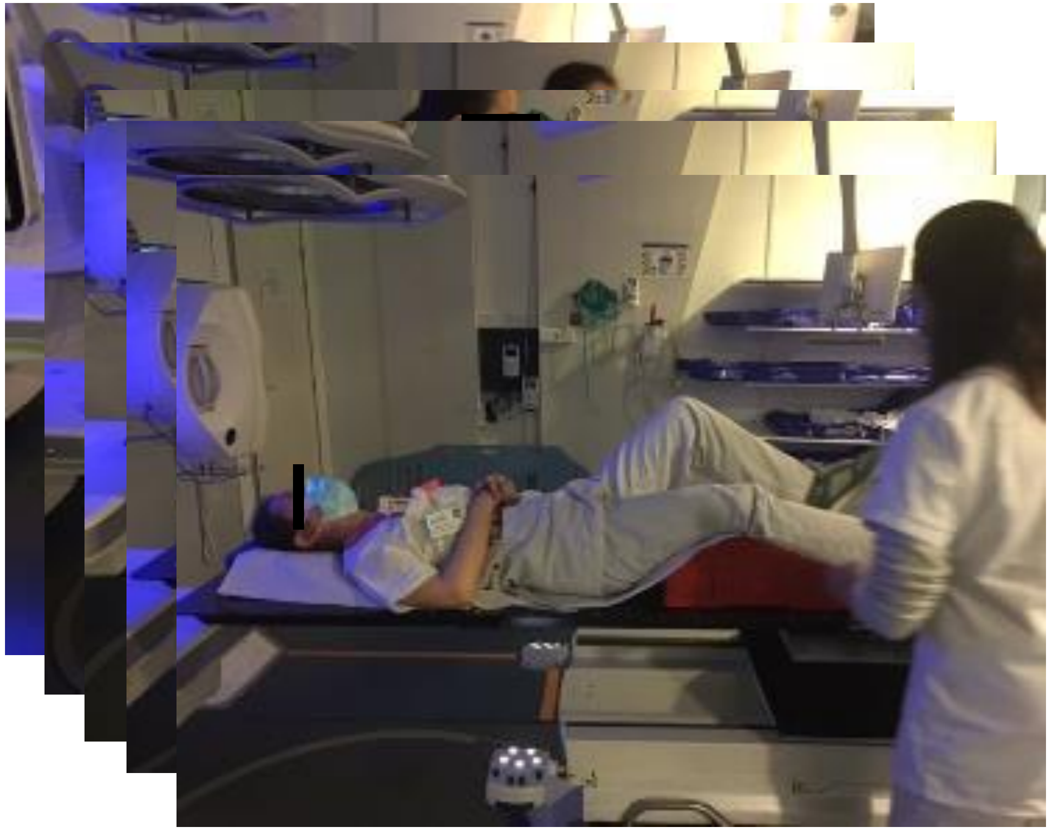
04 Pre-treatment

Patient simulation and immobilisation

- Standard position is supine with immobilisation for popliteal fossa and feet.
- Prior to pre-treatment scan, the clinician should assess the diagnostic imaging and ascertain whether the tumour is adequately bolused by the surrounding buttocks – 5 mm of tissue surrounding gross tumour volume (GTV). If there is not 5 mm of tissue around the whole GTV consider lying the patient on tailored wax or sheet bolus. It is suggested to avoid treating patients prone.
- In inguinal nodes, bolus should only be used if there is visible skin infiltration.
- The distal point of macroscopic disease or anal verge can be delineated with a radio-opaque marker prior to imaging, whichever is more inferior (optional).
- Following excision, a radio-opaque marker must be placed at the excision scar or anal verge.
- All patients must be scanned with a comfortably full bladder (>250 ml).
- The use of IV contrast to aid delineation of pelvic vessels is strongly recommended.
- The use of oral contrast is at the discretion of the site but may aid in delineation of small bowel.
- Once the patient is scanned, tattoo and document as per local protocol.

Upright positioning and immobilization

Upright positioning and immobilization



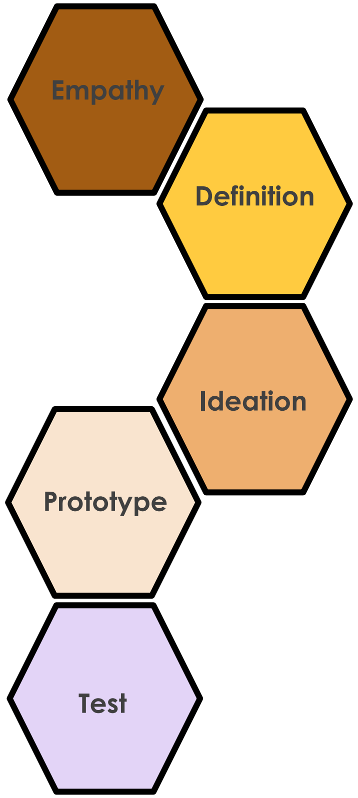
Sitting position
Perched position
Seat angle

Seat height
Backrest angle
Shin rest

Upright positioning and immobilization

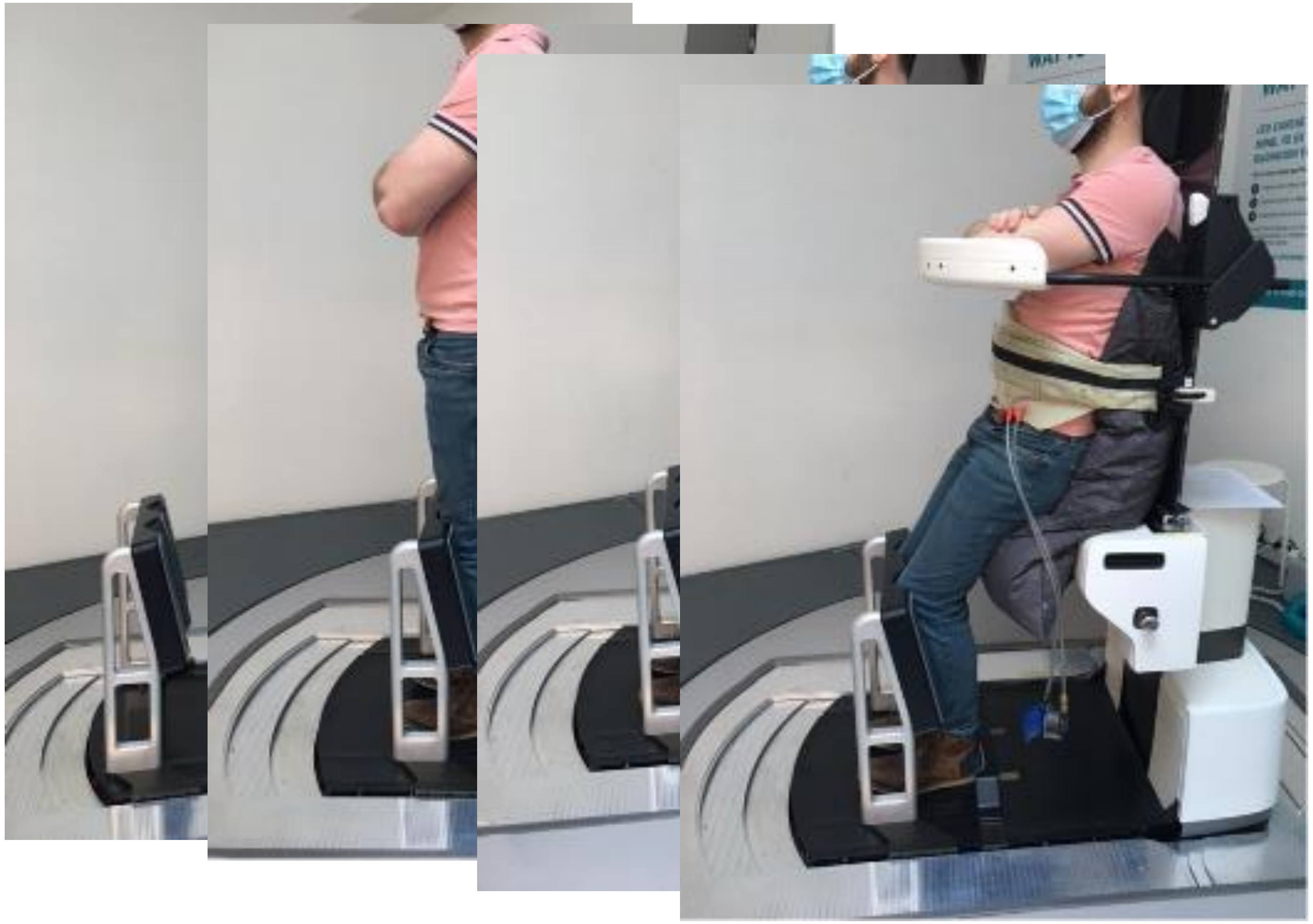
What about the workflow for patient setup?

- A context: pelvic treatment
- A first idea: ask patient to sit dow
- Results: observation and volunteer’s feedback



Design thinking in
Healthcare Ku et al, 2020

Upright positioning and immobilization



But what about the other treatment sites?

The other seat angles? The sitting position?

The other chair?

Upright positioning and immobilization

How gravity changes the patient P&I?

Fig. 2. A: view of the Chair with a patient seated on the vacuum cushion. B: view with the optical positioning system. The absence of green or pink light on the skin surface at the pelvic level illustrate the perfect patient repositioning. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Boisbouvier et al. TipsRO journal 2022

FIGURE 2
Body positioning for the patient cohort. **(A)** standing position with arms along the body, **(B)** standing position with arms behind the body, **(C)** standing position with one arm up, **(D)** sitting position with arms along the body, **(E)** sitting position with arm behind the body, **(F)** sitting position with one arm up.

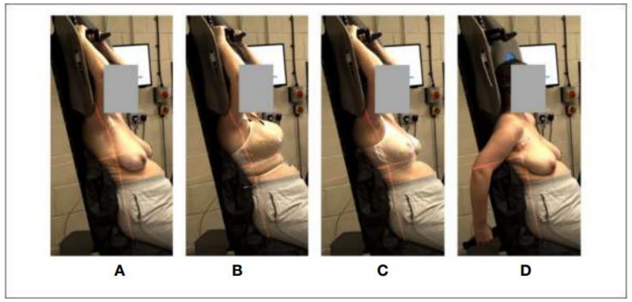


FIGURE 3
Body positioning for the healthy volunteer cohort. **(A)** arms-up, topless; **(B)** arms-up, S4A bra, **(C)** arms-up Chabner bra XRT, **(D)** arms-down behind the body, topless.

Boisbouvier & Underwood et al. Front Oncol 2023

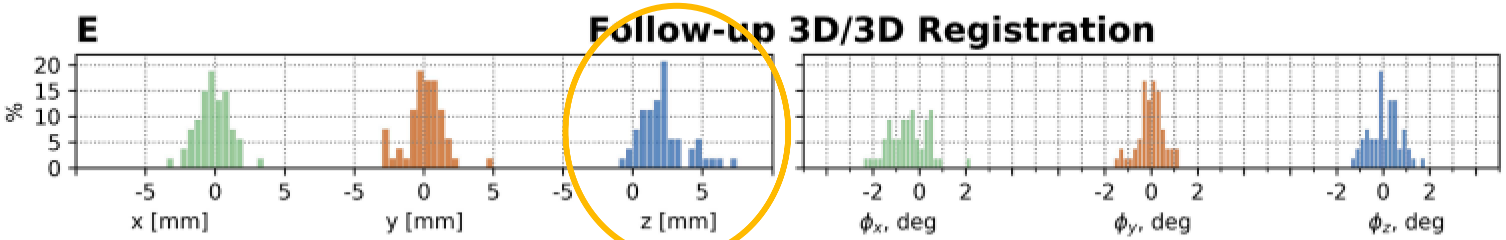
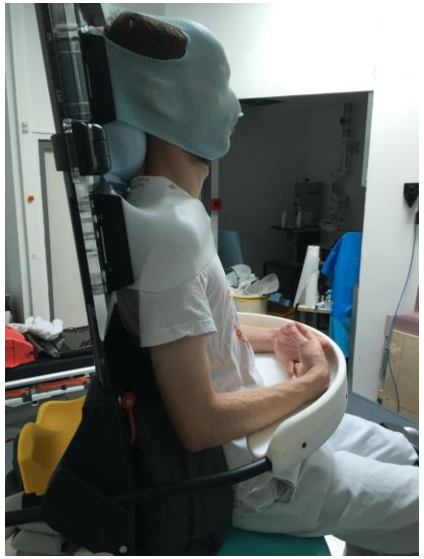


Fig. 4. Distribution of registered shifts for all imaging modalities.



For head and neck treatment site:

- Sitting position

Feldman et al. reported a tend to sag (Radiother Oncol. 2024)

My experience

- Main results:
  - One volunteer did not sag and the other one sagged.

⇒Hypothesis: the seating position was different

⇒"slump sitting" is associated with an increase of muscle activity compared to thoracic and lumbo-pelvic sitting. (Caneiro et al. Manual Therapy 2010)

New positioning of the volunteer

- Result: the volunteer did not sag

Perspectives and conclusion

Robust positioning and immobilization is still required

For upright position:

- Development of patient workflow for setting in upright
- Development of some specific immobilization devices (i.e. arm support, head rest,…)
- Assessment of setup uncertainties
- Assessment all the human aspects of the P&I
- Study of internal anatomy (reproducibility, relationship between target volume and OAR,…)

Thank you
Any questions?

Sophie Boisbouvier
RTT, Msc, PhD student
Radiation therapy department
Centre Léon Bérard
Lyon - FRANCE