Radiothérapie stéréotaxique

Généralités

Pr D. PASQUIER

Université de Lille, Centre Oscar Lambret

Pôle de radiothérapie

CRIStAL UMR CNRS 9189

Plan

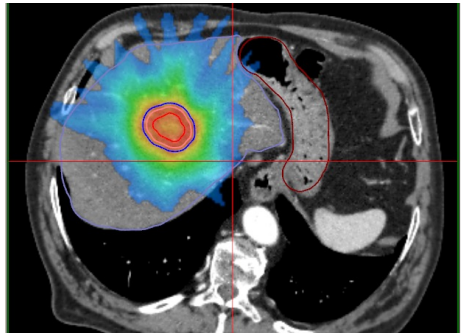
Définitions

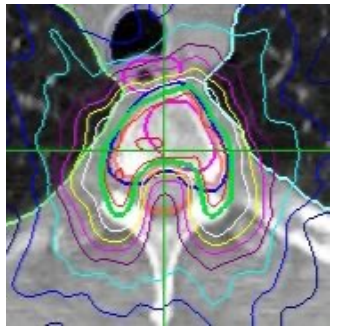
Modes de réalisation

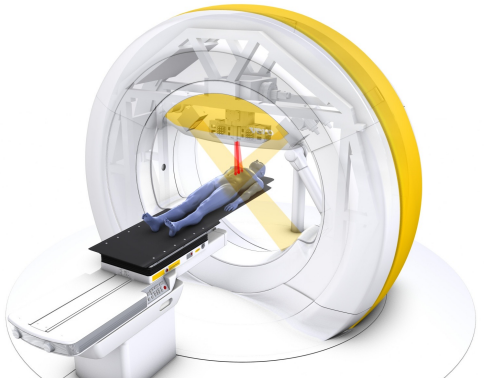
Localisations

Protection des OAR

Evaluation radiologique







Historique

Lésions intra crâniennes → lésions extra crâniennes

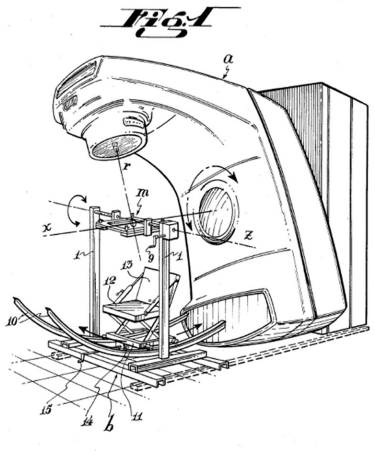
2010 – 2020’

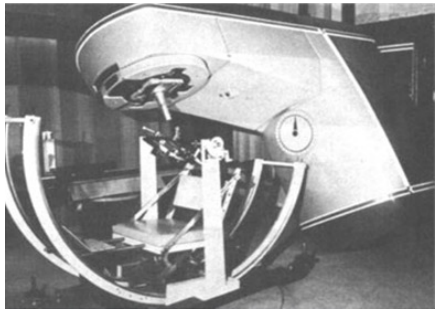
Gamma knife 1960’

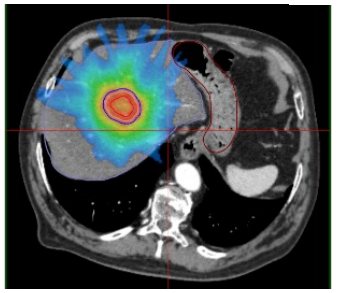
(Leksell et Larsson)

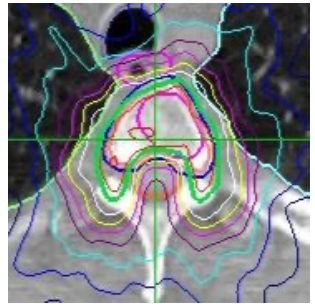
Cobalt-60

Chaise de Betti, cadre de Talairach









Définition(**s**)

Pas de définition vraiment consensuelle…

HAS 2016

- « une **stéréotaxie rigoureuse** qui permet d'identifier le plus précisément possible le volume lésionnel (…) par l'utilisation de techniques **d'imagerie moderne »**

- « une technique d'irradiation qui au moyen d'une collimation permet la **convergence de multiples «mini-faisceaux»** de photons de haute énergie (rayons X) et de **petites dimensions vers un foyer unique**, repéré préalablement par la méthode stéréotaxique. (…) »

Définition(**s**)

2010

TABLE I. Comparison of typical characteristics of 3D/IMRT radiotherapy and SBRT.

Characteristic	3D/IMRT	SBRT
Dose/fraction	1.8–3 Gy	6–30 Gy
No. of fractions	10–30	1–5
Target definition	CTV/PTV (gross disease+clinical extension): Tumor may not have a sharp boundary.	GTV/CTV/ITV/PTV (well-defined tumors: GTV=CTV)
Margin	Centimeters	Millimeters
Physics/dosimetry monitoring	Indirect	Direct
Required setup accuracy	TG40, TG142	TG40, TG142
Primary imaging modalities used for treatment planning	CT	Multimodality: CT/MR/PET-CT
Redundancy in geometric verification	No	Yes
Maintenance of high spatial targeting accuracy for the entire treatment	Moderately enforced (moderate patient position control and monitoring)	Strictly enforced (sufficient immobilization and high frequency position monitoring through integrated image guidance)
Need for respiratory motion management	Moderate—Must be at least considered	Highest
Staff training	Highest	Highest+special SBRT training
Technology implementation	Highest	Highest
Radiobiological understanding	Moderately well understood	Poorly understood
Interaction with systemic therapies	Yes	Yes

Définition(**s**)

- “Stereotaxy historically refers to the use of a 3-dimensional (3D) coordinate system to localize intracranial targets”

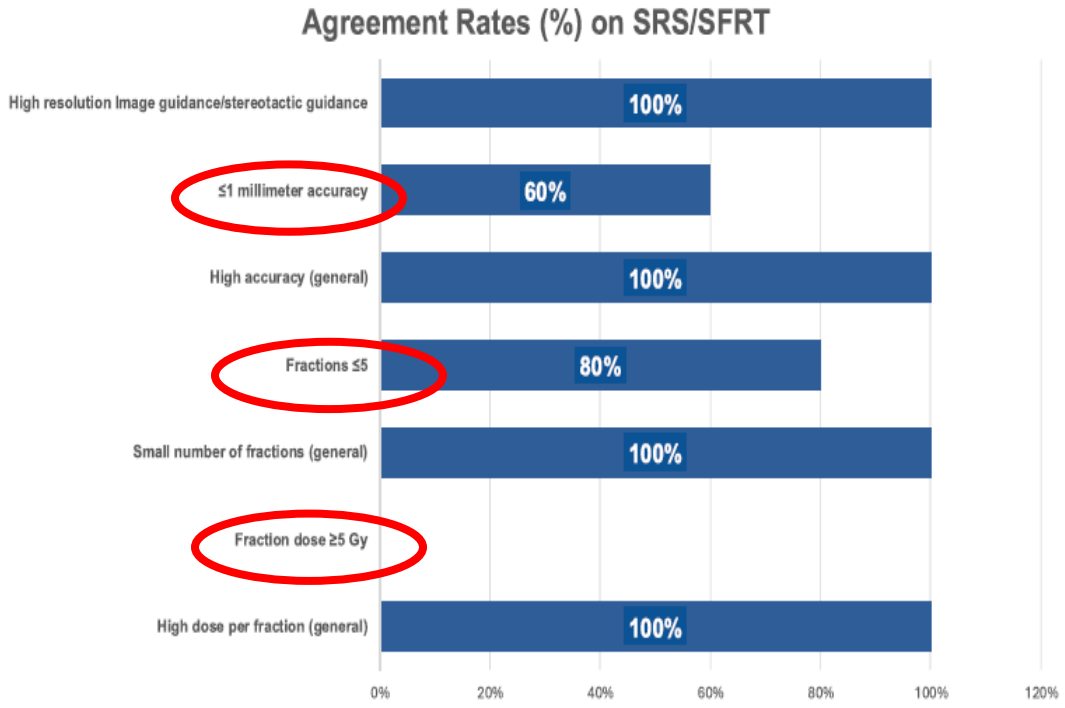
- “As of the time of publication of this report the concept of stereotactic treatment has been expanded to refer to the **accurate and reproducible localization of the clinical target in space** (i.e., at the mm level) **and in time**”

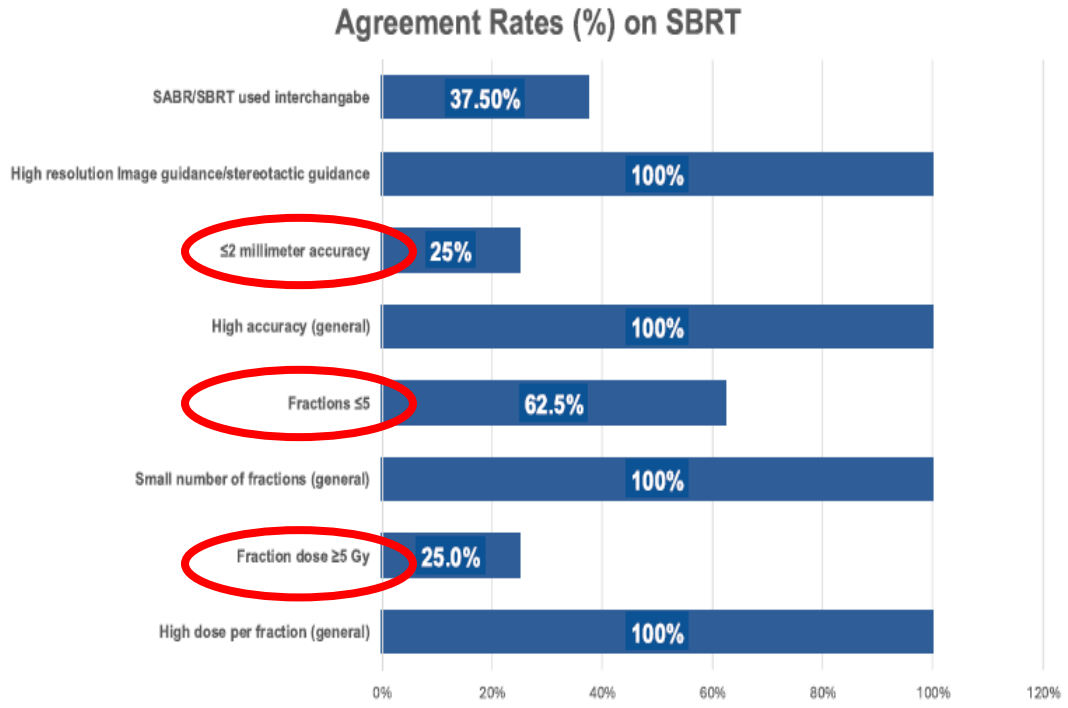
Definition and requirements for stereotactic radiotherapy: a systematic review

Radiotherapy and Oncology 211 (2025)

Łukasz Kuncman [a,b,*], Carolina De la Pinta [c], Maaike T.W. Milder [d],

51 articles définitions et guidelines → 22 articles de définitions





"Although stereotactic radiotherapy is broadly adopted in daily routine practice, **substantial variability exists in its definitions and implementation**"

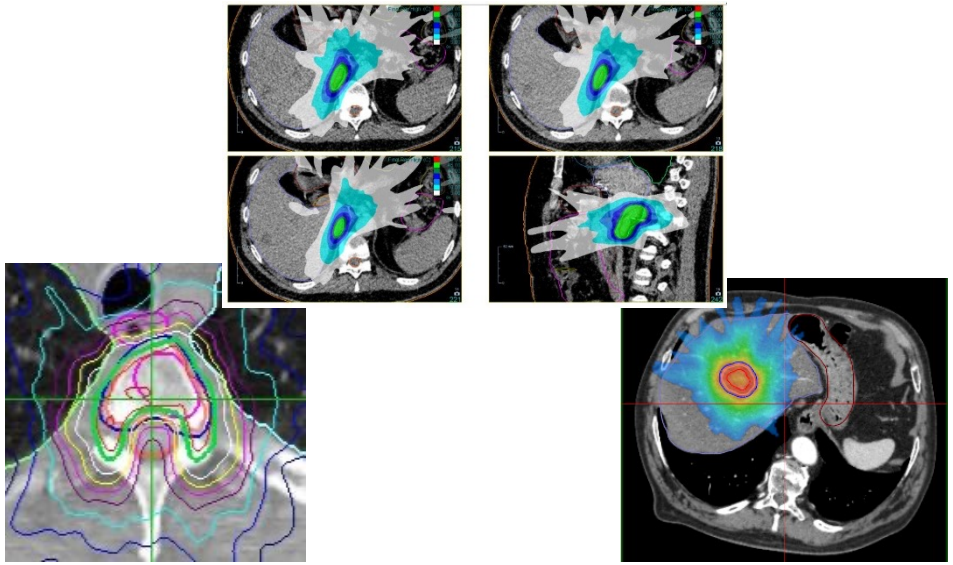
Définition(**s**)

Points communs

- **Convergence** de multiples «**mini-faisceaux**» de **petites dimensions**
- Précision **millimétrique**
- **Gradient** de dose important, conformation +++
- Prise en compte stricte des **mouvements** des organes
- **Faible nombre** de séances

→ Dose **élevée** par séance

→ **Dose à visée ablative délivrée avec une précision millimétrique**



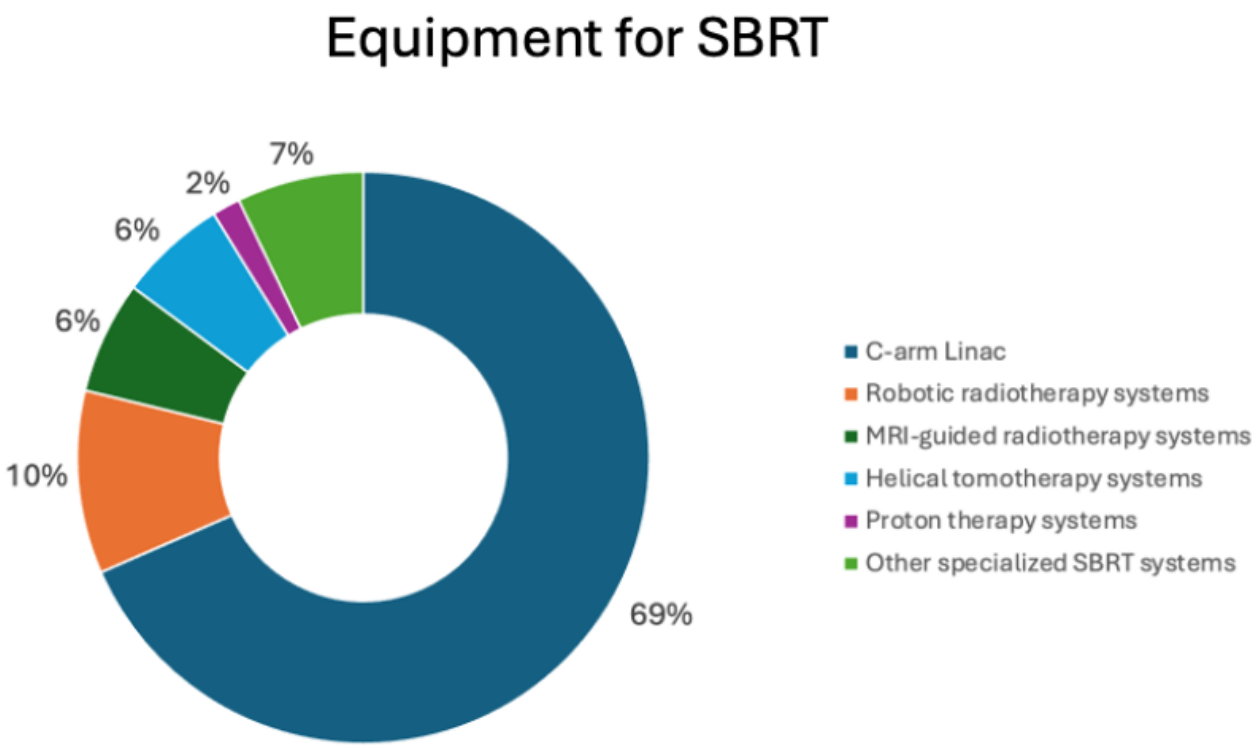
HAS, ICRU 91, AAPM, DEGRO, Kuncman…

Modes de réalisations

Lésions extra crâniennes

Clinical practice, barriers to implementation, and priorities for equitable access of Stereotactic Body Radiation Therapy: an analysis of the ESTRO SBRT focus group

289 participants; 59 pays



ESTRO SBRT focus group Franzese submitted

Modes de réalisations

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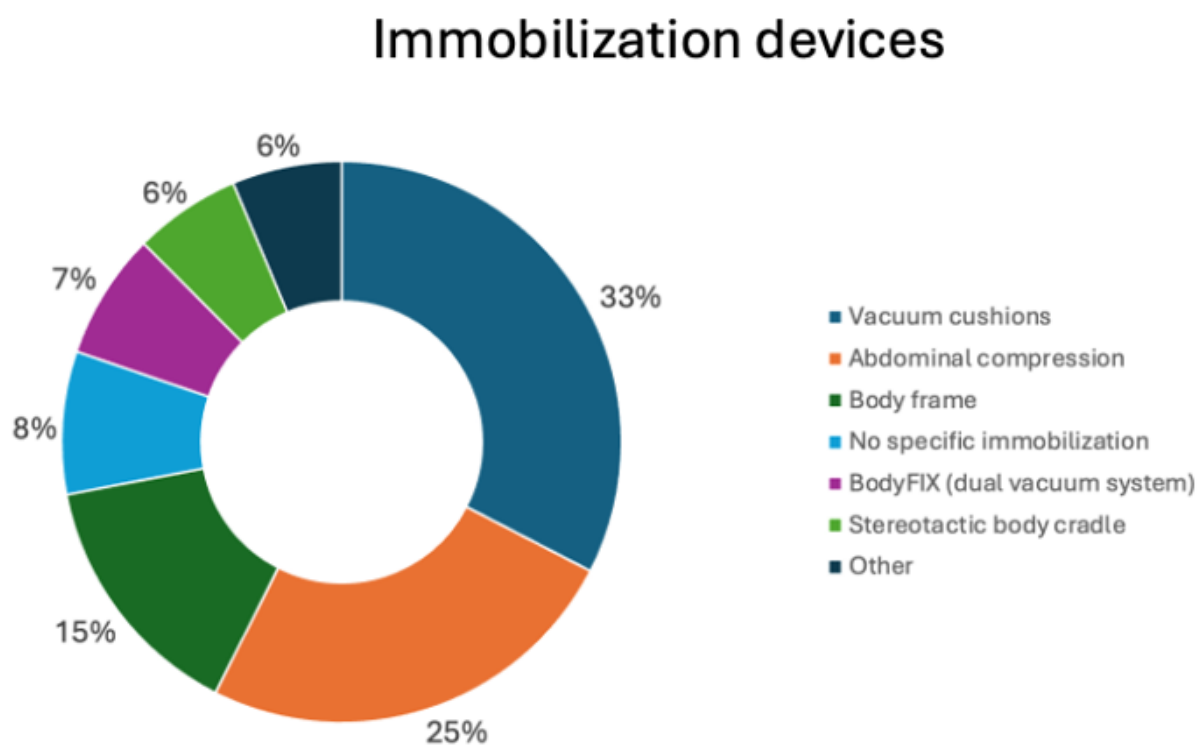

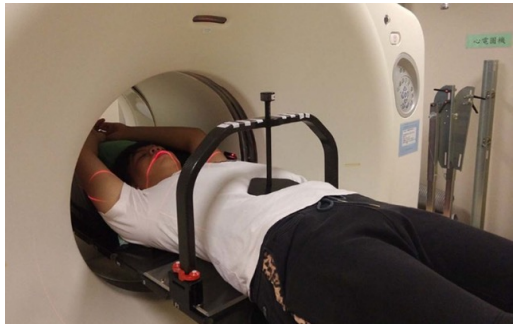

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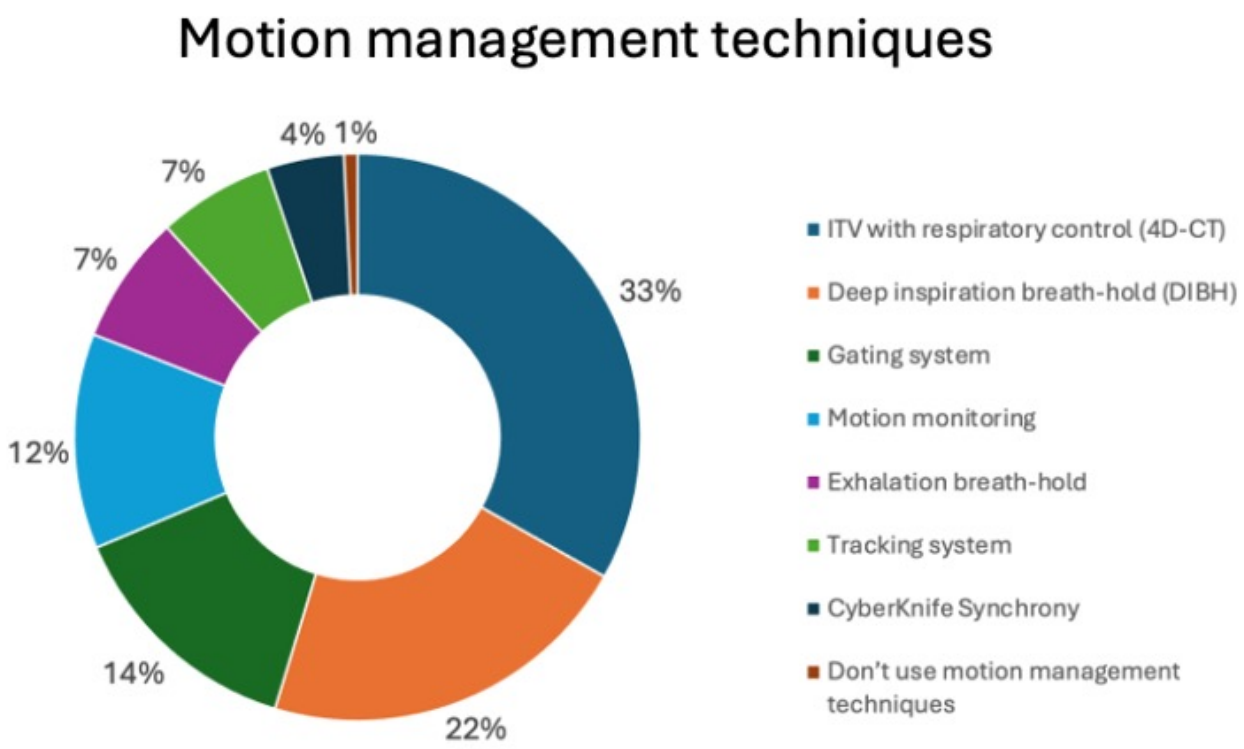
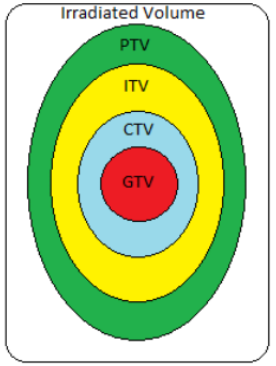
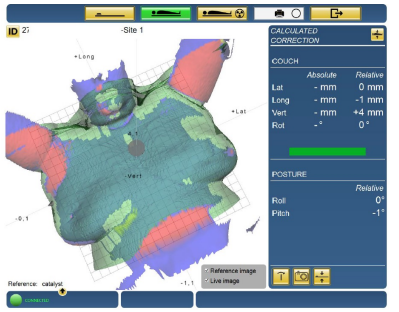
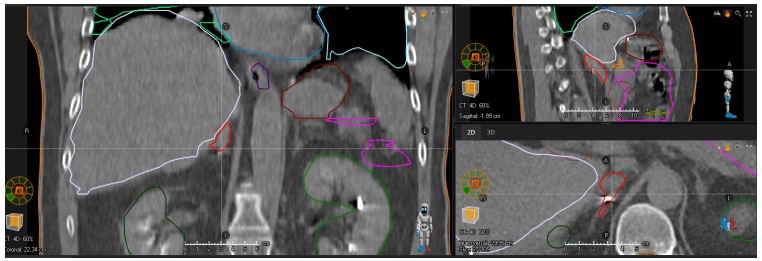


ICRU 50/62/83



- Gross tumor volume (GTV): Tumor visible
- Clinical target volume (CTV): GTV and microscopic tumor
- **Internal tumor volume (ITV): CTV including internal movement**





ESTRO SBRT focus group Franzese submitted; ICRU 62

Modes de réalisations

Lésions extra crâniennes

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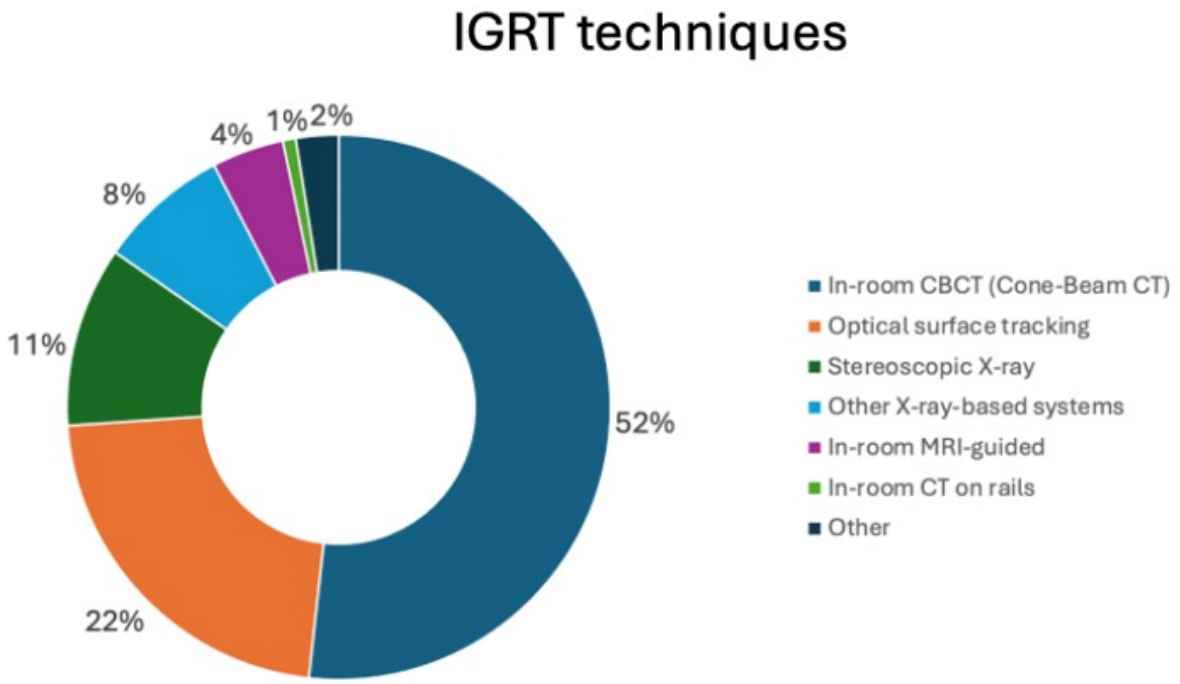
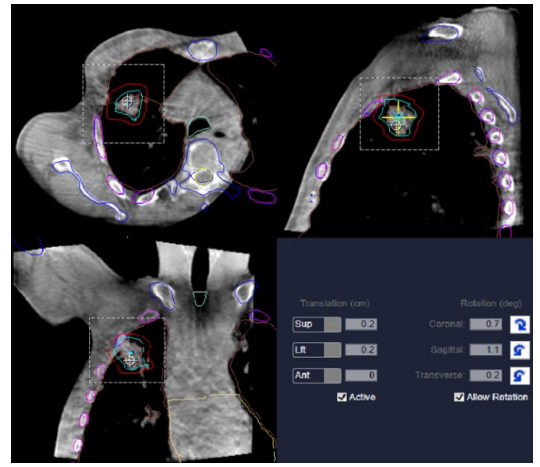
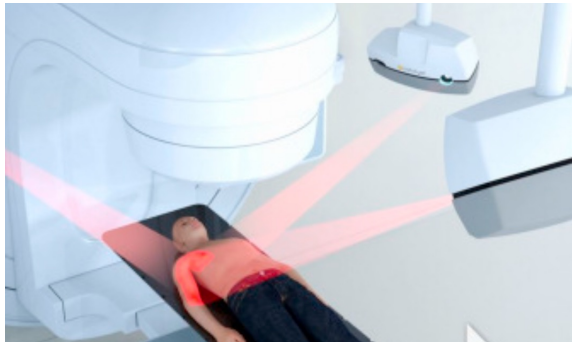
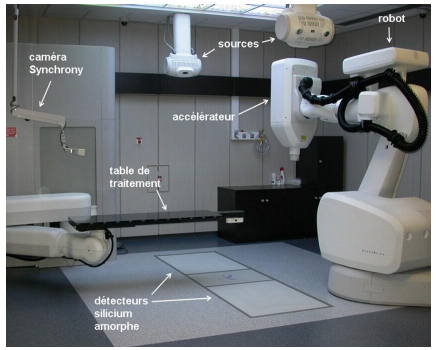
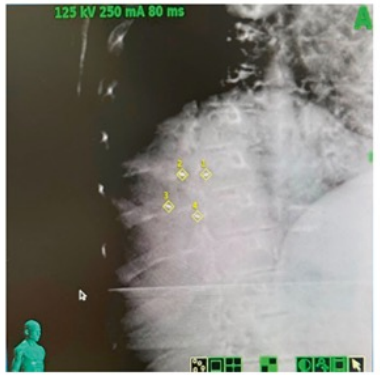




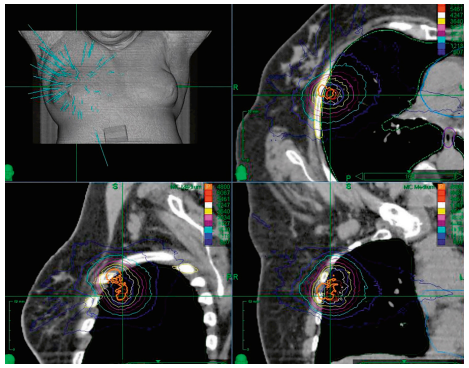




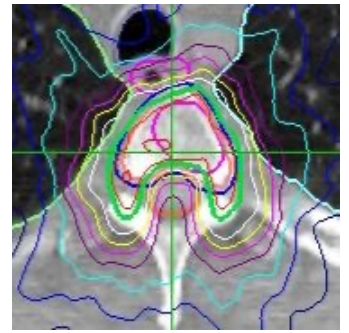


Localisations

Lésions extra crâniennes (% de centres)



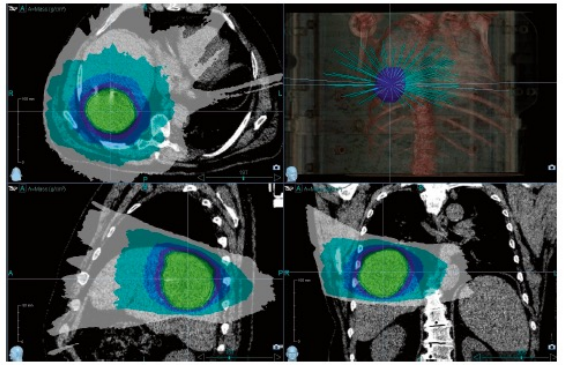
Tumeurs primitives et secondaires du poumon 92 %



Métastases vertébrales 86 %

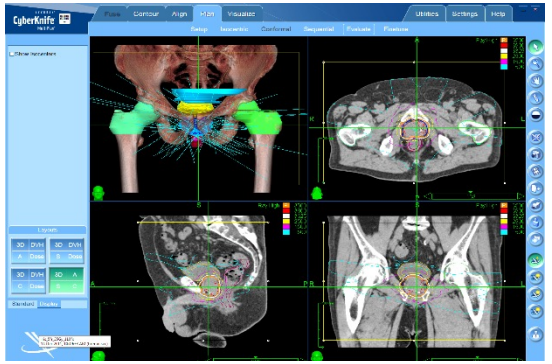
Métastases osseuses 82 %

Adénopathies pelviennes 79%



Métastases hépatiques 79%

Prostate 60%



Hépatocarcinome 51%,…

Freins

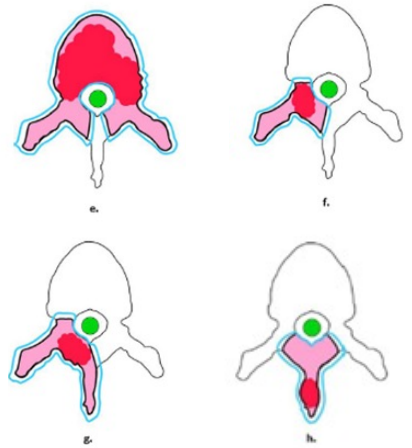
289 participants; 59 pays

Clinical practice, barriers to implementation, and priorities for equitable access of Stereotactic Body Radiation Therapy: an analysis of the ESTRO SBRT focus group

Manque de financement pour les essais	37%
Disponibilité du personnel	36%
Coût de l'équipement	36%
Manque de remboursement	30%
Défaut d'orientation de patients	28%
Manque de personnel formé	27%
Complexité de la planification	13%

RT stéréotaxique extra crânienne





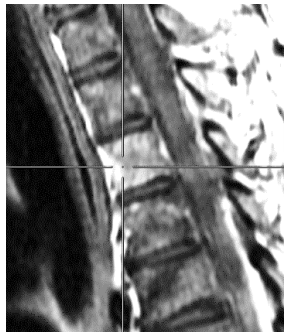
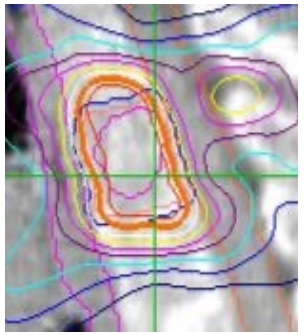
Métastases vertébrales

IRM obligatoire pour la délinéation

OAR = moëlle épinière, œsophage,..

Dose 27-37 Gy 3 à 5 fr. (27-30 Gy 3 fr +++)

16-24 Gy 1 fr.

5600 patients, 55 séries

Contrôle local à 2 ans # 75 - 80 %

Toxicité: fracture vertébrale # 10% (1 fr., lésion lytique,…)

Cox IJROBP 2012; Glicksman Jama Oncol 2020

RT stéréotaxique extra crânienne

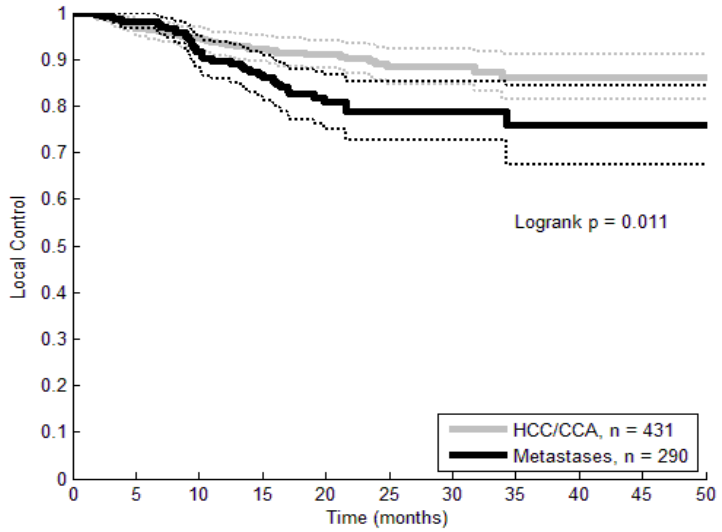
Métastases hépatiques

45-60 Gy en 3-5 fractions

2 méta analyses

CL à 2 ans : 84% (IC95:78-88)

Toxicité G3+: 0 - 5%

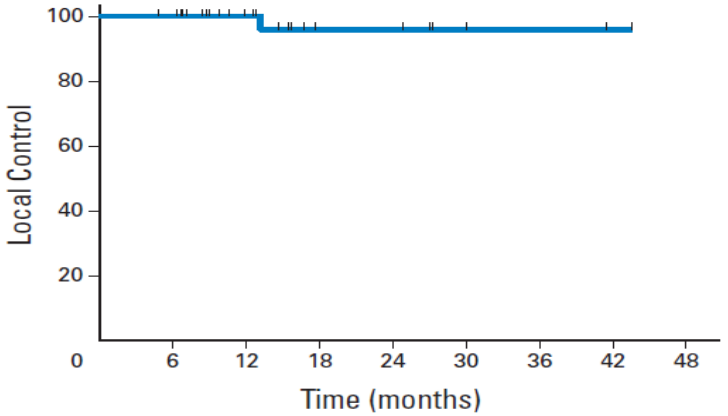


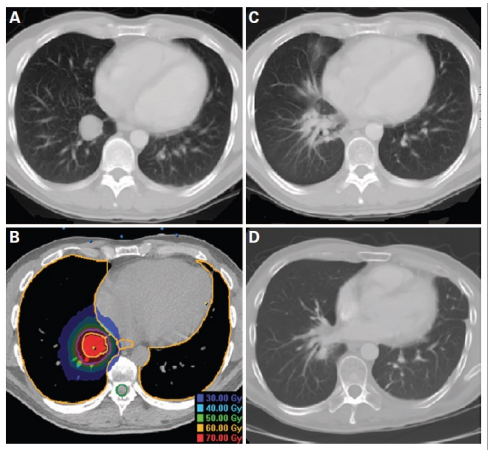
Métastases pulmonaires

45-50 Gy en 3-5 fractions

CL à 2 ans: 77 - 95%

Toxicité G3+ # 5%





Ohri IJROBP 2018; Lee Radiother Oncol 2020; Rusthoven JCO 2009

Protection des OAR

- Faut il une dose « homogène » # RCMI ?

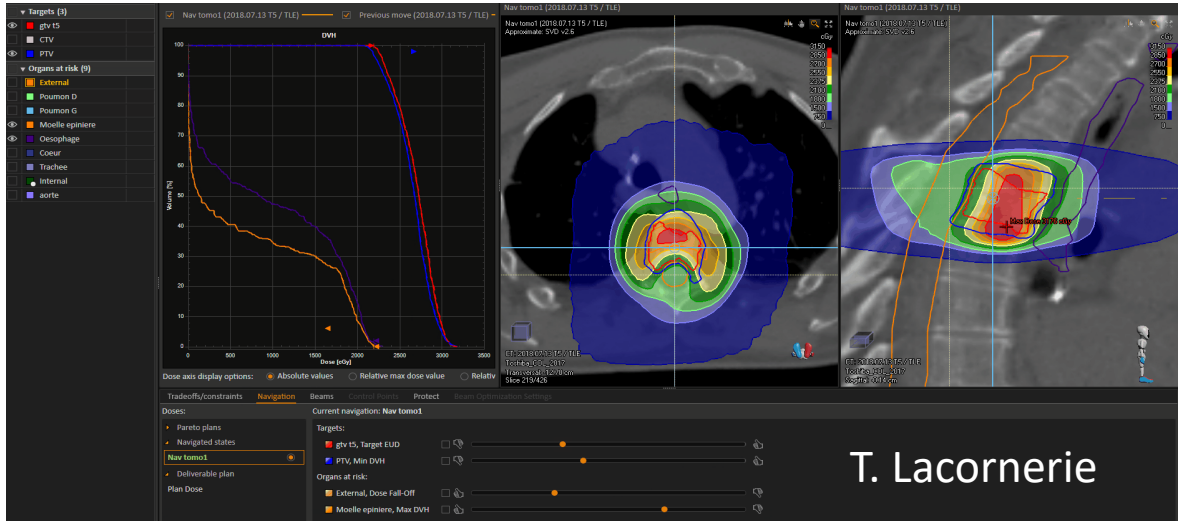
Dose « hétérogène » dans la cible

→ gradient plus proche

→ préservation accrue des OAR

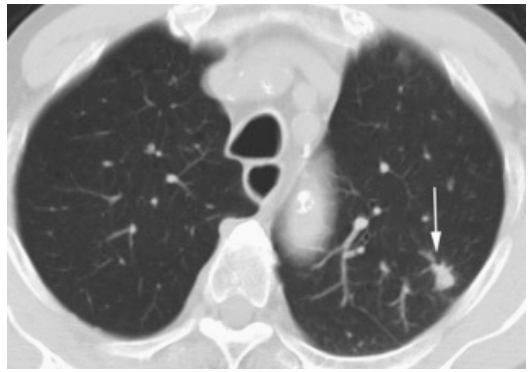
Poumon, foie, métastases osseuses, ADP,…

→ pas de nécessité d'une presc. homogène

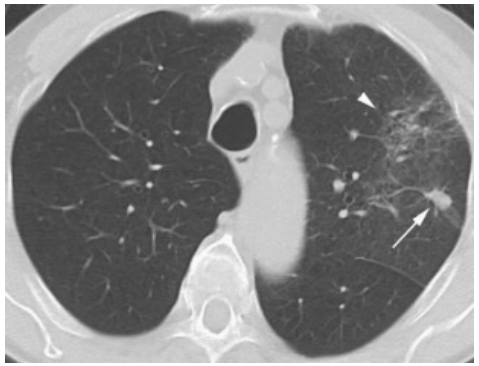


The Price of Target Dose Uniformity
Craft IJROBP 2016

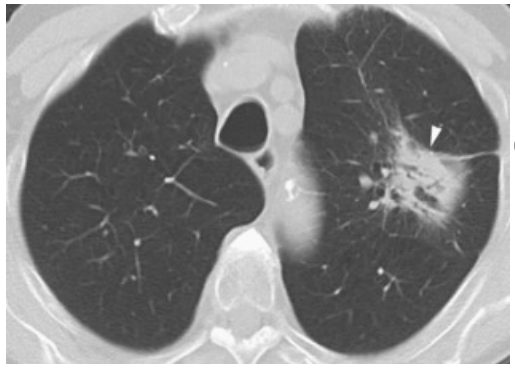
Evaluation radiologique complexe



T0

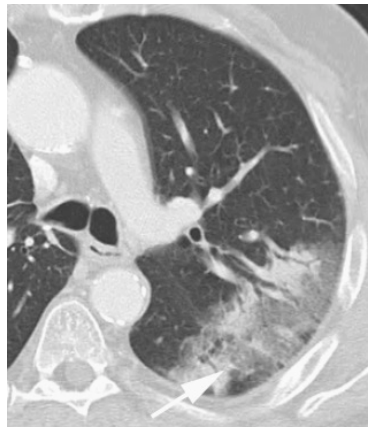


6 semaines

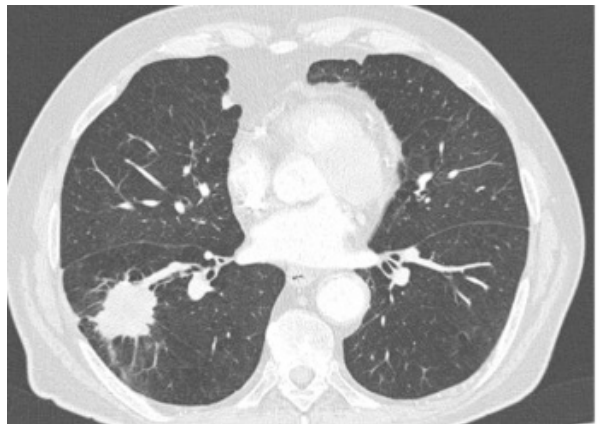


5 mois

Consolidation avec bronchogramme



Opacité en verre dépoli
5 mois



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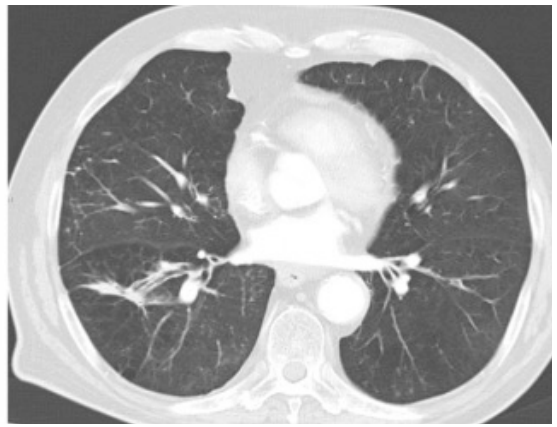


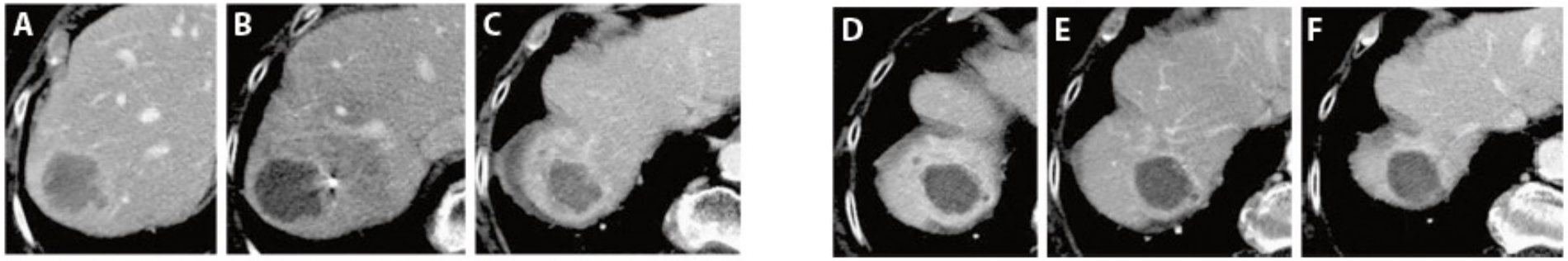
6 mois

Linda Eur J Radiol 2011; Bibault Diagn Interv Imaging 2013

Evaluation radiologique complexe

Nécrose centrale, stabilité ou pseudo progression, prise de contraste périphérique initiales

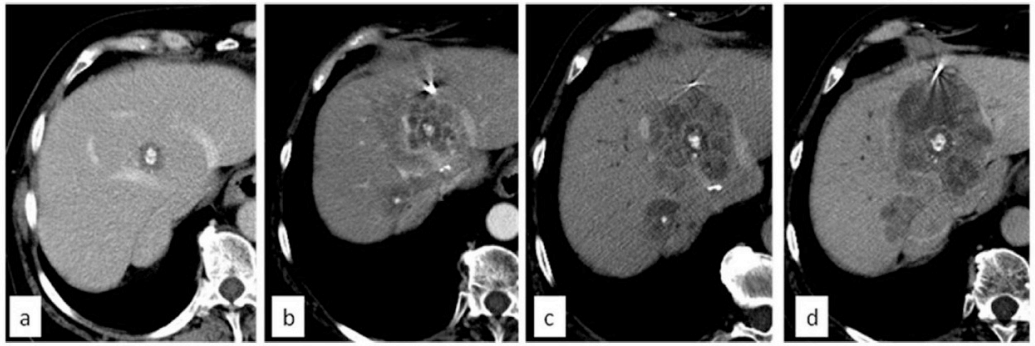
→ contrôle local



T0 2 mois 5 mois 9 mois 12 mois 24 mois

Prise de contraste lobulée

facteur pronostique d'échec



T0 4 mois 6 mois 9 mois

Taillez, Pasquier Radiothérapie oncologique 2025; Jarraya IJROBP 2015

Conclusion

- Progrès techniques: lésions intra crâniennes → extra crâniennes
- Définitions non consensuelles → gradient, précision mm, prise en compte mouvts,

  doses élevées par fraction,..
- Modes de réalisations variés (immobilisation, mouvts, IGRT,…)
- Taux de contrôle local +++, toxicité sévère rare
- Indications émergentes: primitif rénal, pancréas, re-irradiation, tachycardie ventriculaire…