Multimodal Imaging for Radiotherapy and its Benefit.

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Myths and facts in Oncology: the challenge of local therapies

- Chemotherapy: 37%
- Surgery: 22%
- Surgery + radiotherapy: 18%
- Radiotherapy: 12%
- Not cure (local recurrence): 6%
- Not cure (distal recurrence): 5%

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• Multimodality imaging
• Future prospects
From X-rays …

Discovered in 1895 and immediately used for the treatment of cancer…

Why so quickly?
Surgery was the only option but it was not armless…
Evolution of Radiation Delivery

Chart A: Various imaging and treatment technologies over time.

Chart B: Graph showing the increase in number of patients treated with different radiation delivery methods:
- Conventional 2D
- Conventional 3D
- IMRT
- SBRT/SABR
- Particle-beam therapy

Timeline: 1950 - 2015

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Q-T Le, CCR, 2015
Arc therapy: the linac is constantly rotating while the coach is moving.
Protontherapy
Protontherapy
Target volume: clinical examination

T1a glottic larynx

T3 supra-glottic larynx
Evolution of Target Volume/normal anatomy definition

- Clinical judgment
- Planar imaging
- Single-modality anatomic imaging
- Multi-modal anatomic imaging
- Molecular imaging
3D- Reconstruction

- Small intestine
- Bladder
- Target Volume
IMRT for Head and Neck Tumors

Oropharyngeal SCC
T2-N0-M0
SIB-IMRT: 30x2.3 Gy
30x1.85 Gy

PTV 55.5 Gy
PTV 69 Gy
PRV Spinal cord
Larynx
Right parotid
Left parotid

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Target volumes in Radiation Oncology: ICRU 50, 62 and 83:

- Gross Tumor Volume: GTV
- Clinical Target Volume: CTV
- Internal Target Volume: ITV
- Planning Target Volume: PTV
- Organ at Risk: OAR
- Planning Organ at Risk Volume: PRV
Multimodality imaging for target visualisation

Gadolinium-enhanced T1 FatSat
Contrast-enhanced CT (bone window)

Courtesy of Th. Duprez
Multimodality imaging for target visualisation

CE T1-W (fat Saturated)  T1-W (fat Saturated)  ConeBeam CT scanner

Courtesy of Th. Duprez
Multimodality imaging for target visualisation
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Multimodality imaging for target visualisation

- T2w MRI
- DCE MRI
- $^{11}$C-Choline PET-CT
- DW MRI: $b_{1000}$
- DW MRI: ADC map
- MRS

Courtesy of K. Haustermans
Multimodality imaging for target visualisation

A. T2w
B. $K^{\text{trans}}$
C. ADC

D. H&E original
E. H&E registered
F. Tumor and contours

Courtesy of K. Haustermans
FDG-PET based target volume delineation

R/ PET-based IMRT treatment  ↔  CT-based IMRT planning

No difference in target volume conformity: $p = \text{ns}$

Leclerc & Grégoire, R&O, 2015
Imaging the target: intra-tumour heterogeneity

SCC oropharynx: T4b-N0-M0 – FDG-PET-CT
Target volumes in Radiation Oncology: ICRU 50, 62 and 83:

• Gross Tumor Volume: GTV

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• Internal Target Volume: ITV

• Planning Target Volume: PTV

• Organ at Risk: OAR

• Planning Organ at Risk Volume: PRV
Of 88 slides from 10 patients with oral cancers, 44 (50%) had signs of microscopic extension. The maximum distance from the border was 7.8 mm. Ninety-nine percent of all MD was within 4.75 mm and 95% was within 3.95 mm of the GTV.
From macroscopic \( (GTV_p) \) to microscopic \( (CTV_p) \) target volumes
CT-based delineation of lymph node levels in the neck (revised version 2013)
Imaging the Organ at Risk
Multimodality imaging for Organ at Risk visualisation
Thirty years of progresses: the Danish example

DAHANCA Database
Stage 3-4 Larynx and Pharynx

Loco-regional control

Time after treatment (months)

201 pts
201 pts
84% 6 fx/wk + NIM + cis-P + Zalu
83% 6 fx/wk + NIM + cis-P

645 pts
713 pts
411 pts
255 pts
62% 6 fx/wk + NIM
44% 5 fx/wk + NIM
27% 5 fx/wk

IMRT 2013
2D 1985

Courtesy of Overgaard 2015
Clinical Impact of Radiotherapy Compliance (TROG 02.02)

- Compliant ab initio
- Made compliant
- No major TCP impact
- Major TCP impact

\[ P < .001 \]
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And in the “foreseeable” future…
Augmented reality?
Clinical Impact: Endoscopic Contouring

Contour tumor visible in endoscopic image

Project onto 3D “Virtual Image”
Radiomics for treatment individualization

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From care to the “average” …

Multidisciplinary Tumor board
... to personalized care
"Here's my sequence..."

One patient …
One disease …
One treatment …