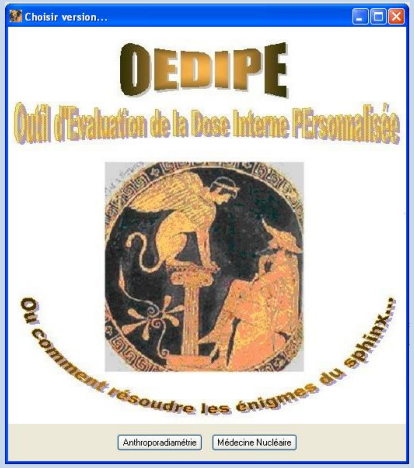
IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

PERSONALIZED DOSIMETRY IN ^{90}Y-MICROSPHERES THERAPY OF LIVER CANCER USING THE ŒDIPE SOFTWARE AND SPECT-CT IMAGES

PETITGUILLAUME Alice [1], BERNARDINI Michela [2] and DESBRÉE Aurélie [1]

[1] IRSN, Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-Aux-Roses, France
[2] HEGP, Hôpital Européen Georges Pompidou, Paris XV, France



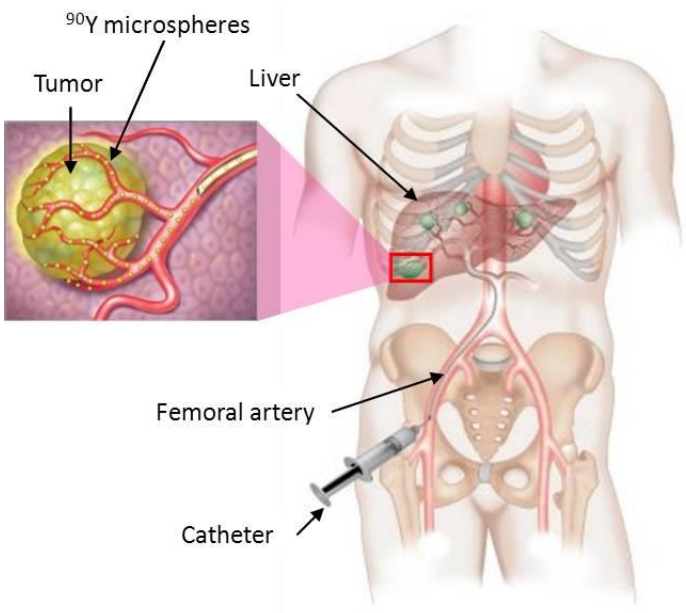
HEGP
Hôpital Européen Georges-Pompidou

Contents

- *The Selective Internal Radiation Therapy (SIRT)*
  - *General principle*
  - *Treatment steps*
  - *Predictive dosimetry*
- *The personalized 3D dosimetry*
  - *General principle*
  - *MCNPX input file generation*
  - *Results - Application to a patient study*

The Selective Internal Radiation Therapy (SIRT)

General principle



ALTERNATIVE THERAPY FOR THE TREATMENT OF UNRESECTABLE LIVER CANCERS

- **Transfemoral catheterization under fluoroscopic guidance**
- **Injection of ^{90}Y-microspheres in the hepatic artery**

SELECTIVE IRRADIATION OF TUMORAL TISSUE

- **Resulting from differences in the blood supplies of tumoral tissue and healthy liver**
- **Depending on the type of disease**
  (hepatocellular carcinoma or hepatic metastases)

A radiopharmaceutical being injected, the optimization principle must be respected to ensure the patient's radiation protection and the efficiency of the treatment.

The Selective Internal Radiation Therapy (SIRT)

Treatment steps

PATIENT ELIGIBLE FOR SIRT

2 - 4 weeks

EVALUATION

- **TUMOR CARTOGRAPHY :**
  - High resolution CT scan
  - ^{18}F-FDG PET/CT scan
- **VASCULAR CARTOGRAPHY :**
  - Hepatic angiography with prophylactic embolization
  - ***SPHERE 1*** = ^{99m}Tc-MAA injection followed by a SPECT/CT scan and a whole body scintigraphy

DETECTION OF POSSIBLE EXTRA-HEPATIC FIXATIONS
(LUNGS, GASTRODUODENAL ARTERY, …)

PREDICTIVE DOSIMETRY FOR ACTIVITY PRESCRIPTION
(BSA METHOD OR PARTITION MODEL)

< 4 weeks

TREATMENT

SPHERE 2

^{90}Y-microspheres injection

followed by a SPECT/CT scan

and

a whole body scintigraphy

The Selective Internal Radiation Therapy (SIRT)

↗ Pre-dosimetry – Clinical practice

BSA method (Body Surface Area)

The activity to inject depends on :

- Tumor burden (%)
- Patient's height and weight
- Pulmonary fixation

$$A_{injected}\ (GBq) = \left[(BSA - 0.2) + \frac{V_{tumor}}{V_{whole\ liver}}\right] +$$

Correction factor depending on the pulmonary fixation

HYPOTHESIS : PERFECT SELECTIVITY OF THE THERAPY

⇒ Overestimation of the tumor absorbed dose and underestimation of the healthy liver absorbed dose

⇒ Optimization principle non respected

Partition model

The activity to inject depends on :

- Pulmonary fixation
- Healthy liver fixation
- Tumor fixation

3 compartments :

- Lungs
- Healthy liver
- Tumor

+

2 limiting criteria :

- D_{lungs} < 15 Gy
- $D_{healthy\ liver}$ < 30 Gy

⇒ More realistic consideration of the therapy selectivity

⇒ LIMITATION : Absorbed doses calculated considering a uniform activity distribution within the compartments

➡ ***NEED FOR A PRECISE AND REALISTIC DOSIMETRY***

The personalized 3D dosimetry

General principle

...ch combines :

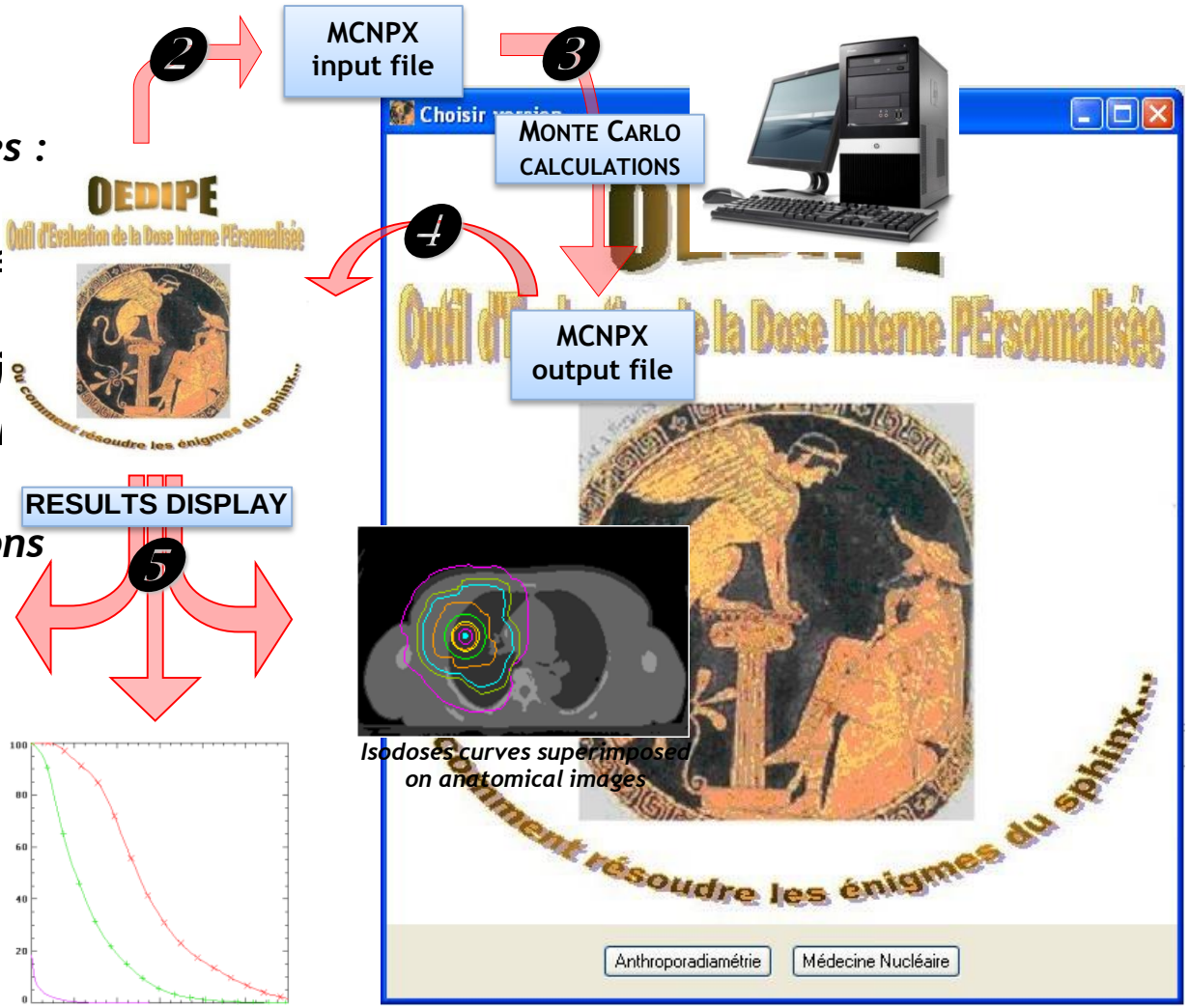
- Geometry (Patient's anatomy)
- Activity at the voxel scale (Patient's biodistribution)
- Physical characteristics - radionuclide - tissues

...-specific ge...

...-specific bi...

...pharmaceu...

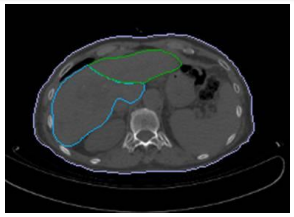
M...tions



The personalized 3D dosimetry

MCNPX input file generation

ORGANS CONTOURING
IsoGray – Dosisoft (France)



OEDIPE

PATIENT-SPECIFIC VOXEL PHANTOM

+

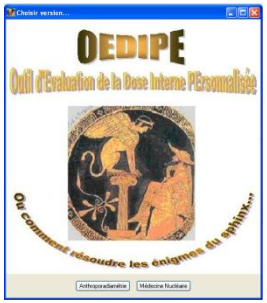
IMAGE REGISTRATION SPECT/VOXEL PHANTOM

OEDIPE

SOURCE DEFINITION AT THE VOXEL SCALE

+

PHYSICAL CHARACTERISTICS OF ^{90}Y AND TISSUES



MCNPX INPUT FILE

MCNPX CALCULATIONS

Tally F6 (Quantity of energy delivered per unit mass in a cell)
100 millions of particles

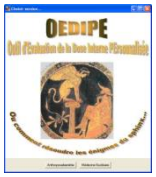
The personalized 3D dosimetry

↗ Results - Application to a patient study

HEGP Hôpital Européen Georges-Pompidou

TREATMENT : Woman - 70 yo - 1.61m - 55 kg - Whole liver treatment

APPLICATION : Biodistribution SPHERE 1 - ^{90}Y injected activity : 0.74 GBq

MCNPX output file → 

→

Mean absorbed doses to ROIs

Isodoses curves superimposed to the voxel phantom

Dose Volume Histograms (DVHs)

Mean absorbed doses (Gy)

	BSA method	Partition model	Personalized 3D dosimetry
Remaining tissue	-	-	0.52
Left lung	-	0.01	0.02
Right lung	-		0.59
Healthy liver	0.00	30.01	20.69
Tumor	644.62	60.42	44.23

The personalized 3D dosimetry

↗ Results - Application to a patient study

HEGP — Hôpital Européen Georges-Pompidou

TREATMENT : **Woman - 70 yo - 1.61m - 55 kg - Whole liver treatment**

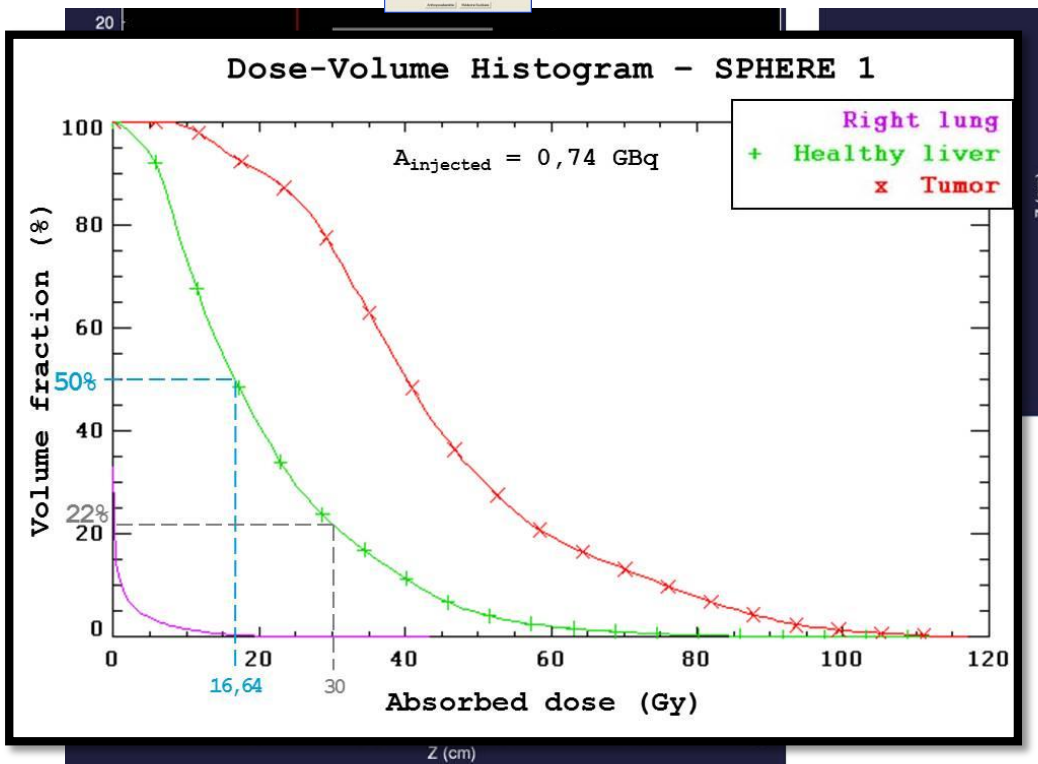
APPLICATION : **Biodistribution SPHERE 1 - ^{90}Y injected activity : 0.74 GBq**

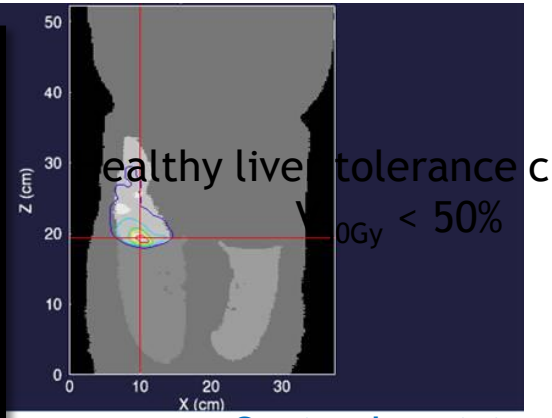
MCNPX output file → OEDIPE

Mean absorbed doses to ROIs

Isodoses curves superimposed to the voxel phantom

Dose Volume Histograms (DVHs)





Healthy liver tolerance criterion : $V_{70Gy} < 50\%$

Optimal activity : $A_{injected} = 1.33$ GBq

Remaining tissues
Right lung
Left lung
Healthy liver
Tumor

Conclusions

- ***Feasibility of a personalized 3D dosimetry using :***
  - *Patient's anatomy*
  - *SPECT/CT images*
  - *Monte-Carlo calculations*
- ***Different types of results :***
  - *Calculations of mean absorbed doses*
  - *Display of isodoses curves superimposed to the geometry*
  - *Generation of DVHs*
- ***Optimization of the treatment maximizing treatment efficiency while ensuring patient's radiation protection***

THANK YOU