

# Metastasi scheletriche

Fattibilità e ruolo dello studio dosimetrico nei trattamenti con  $^{223}\text{Ra}$ -chloride



The poster features the AIMN logo at the top, which consists of a stylized atom symbol with the letters 'AIMN' in a blue, italicized font. Below the logo, there is a grid of small squares and text identifying the organizing institution: 'SERVIZIO SANITARIO REGIONALE EMILIA ROMAGNA Azienda Ospedaliera di Reggio Emilia' and 'Assessorato D. Maria Rossi'. A line of text mentions 'Istituto di tecnologia avanzata e metodi innovativi in oncologia Istituto di Ricerca e Cura a Carattere Scientifico'. The main title is '7° Meeting Imaging Metabolico PET per una moderna Radioterapia', followed by 'Corso per Medici, Fisici, TSRM e Infermieri' and 'Responsabile: Dott. Annibale Versari'. A photograph of a large, modern brick building with many windows is shown in the center. A blue curved banner at the bottom left contains the text 'Corso d'Esellenza AIMN'. The date and location 'Reggio Emilia 10 novembre 2016' are printed at the bottom right.

SERVIZIO SANITARIO REGIONALE  
EMILIA ROMAGNA  
Azienda Ospedaliera di Reggio Emilia  
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Istituto di tecnologia avanzata e metodi innovativi in oncologia  
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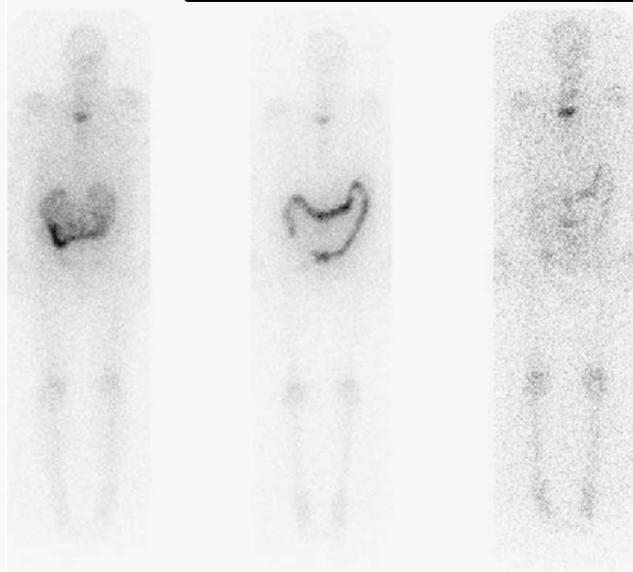
**7° Meeting**  
**Imaging Metabolico PET**  
**per una moderna Radioterapia**  
Corso per Medici, Fisici, TSRM e Infermieri  
Responsabile: Dott. Annibale Versari

Reggio Emilia  
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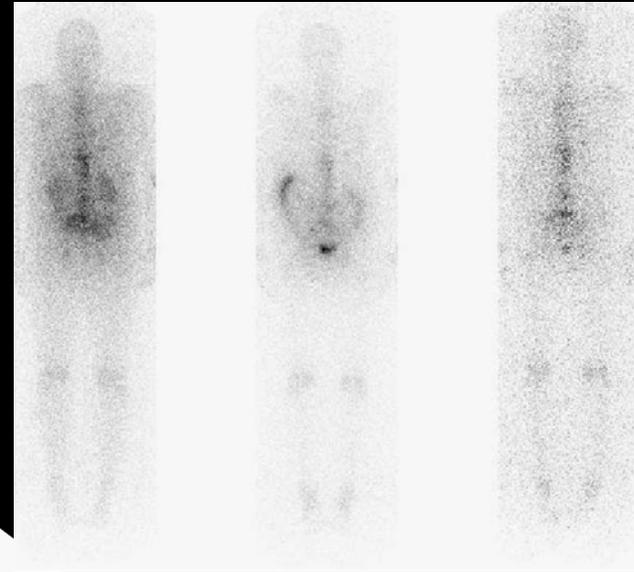
Corso d'Esellenza AIMN

Grassi Elisa  
S.C. Fisica Medica  
ASMN-IRCCS Reggio  
Emilia

# Imaging of $^{223}\text{Ra}$ -Chloride



Anterior view



Posterior view

Images acquired at 4, 48 and 144 h post injection of 10,01 MBq

Imaging and image-based planar dosimetry  
are feasible

# Characteristics of $^{223}\text{Ra}$

Radium 223 is primarily an  $\alpha$ -emitter

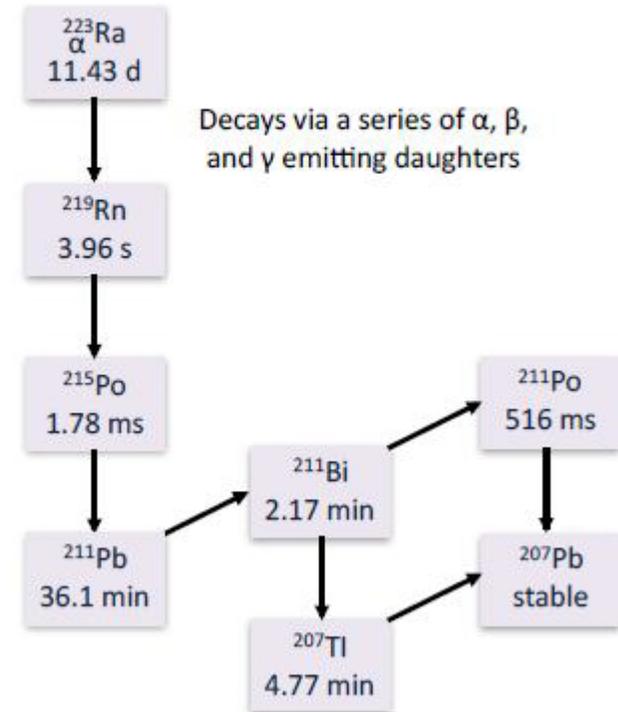
$t_{1/2} = 11.43$  days

Of the total decay energy

- » 95.3% emitted as  $\alpha$  particles
- » 3.6% emitted as  $\beta$  particles
- » 1.1% emitted as  $\gamma$  or X-rays

Easily measured on standard dose

## Radium 223 Decay Chain

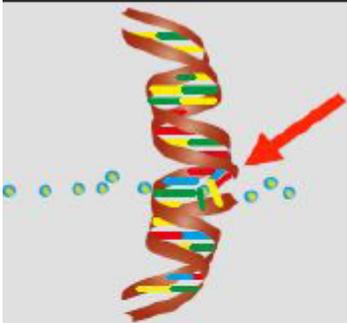


### $\beta$ -emitters

- Low-LET  $\beta$ -radiation  $\rightarrow$  single-strand DNA breaks
- Single-strand breaks: easily repaired using the opposite strand as a template
- Single-strand breaks  $\rightarrow$  less likely to induce cell death

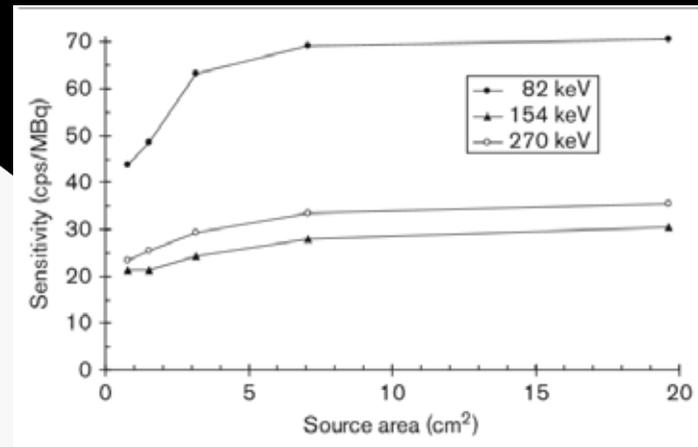
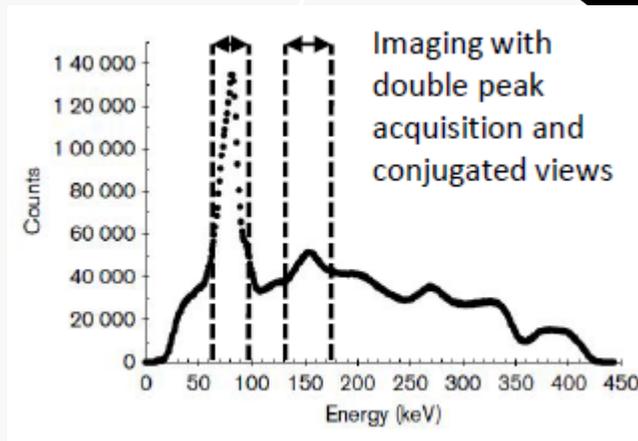
### $\alpha$ -emitters

- High-LET  $\alpha$ -particles  $\rightarrow$  double-strand DNA breaks
- Double-strand breaks: difficult to repair
- Failure to repair  $\rightarrow$  to apoptosis
- Misrepaired double-strand breaks  $\rightarrow$  chromosomal aberrations  $\rightarrow$  mitotic cell death



# How is dosimetry of $^{223}\text{Ra}$ possible?

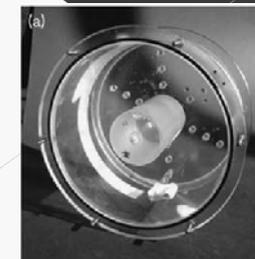
- Energy windows set at: 82keV (20%), 154keV(15%), 270keV (10%)
- Medium-energy collimators
- Accurate scanner calibration
- PVE analysis



- Attenuation correction

Energy window (centre, width)	Sensitivity (cps/MBq)	FWHM (cm)	$\mu_{\text{eff}}/\phi$ (Perspex) (cm <sup>2</sup> /g)
82 keV, 20%	69	1.07	0.071
154 keV, 20%	31	1.13	0.048
270 keV, 20%	34	1.12	0.046

- Quantification test with phantoms



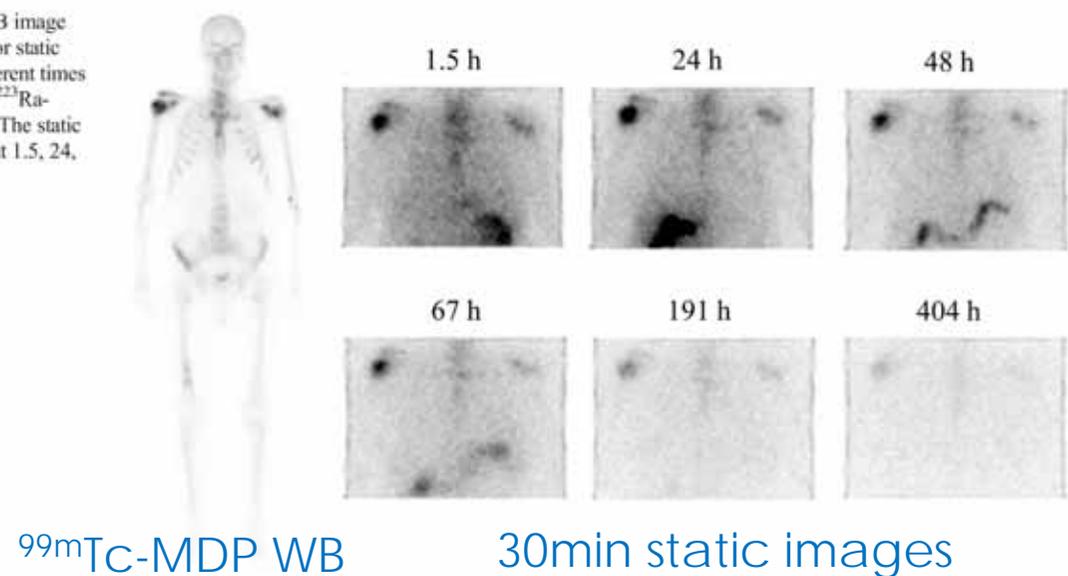
Data from: Hindorf et al. Nucl Med Comm 2012; 33:726-732

# How is predictive dosimetry possible for $^{223}\text{Ra}$ ?

Skeletal scintigraphy (and/or SPECT-CT) images before therapy are usually performed.

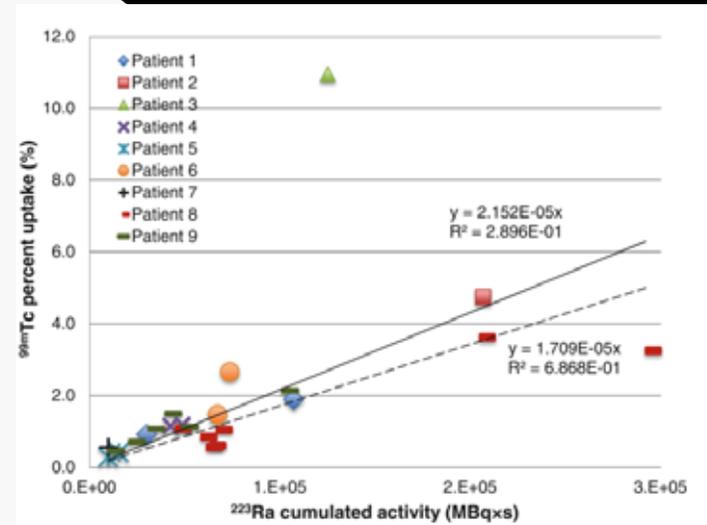
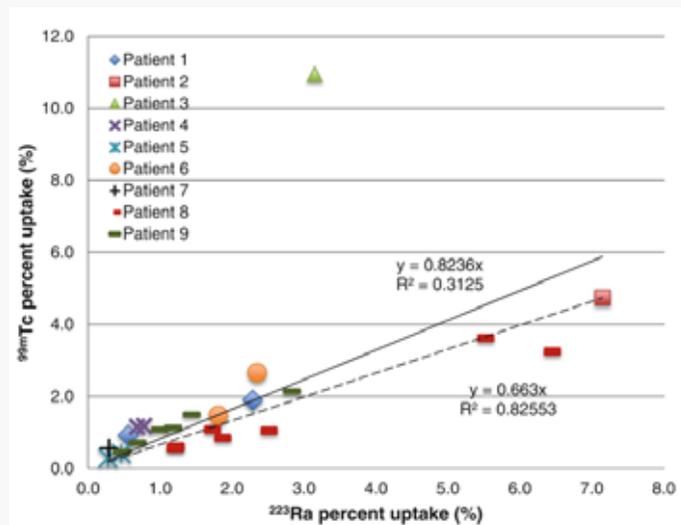
- ◎  $^{99\text{m}}\text{Tc}$ -MDP whole body scan (740MBq)
- ◎ Energy window at 140keV (20%)
- ◎ LEHR collimators

**Fig. 2**  $^{99\text{m}}\text{Tc}$ -MDP WB image and the series of anterior static images obtained at different times after administration of  $^{223}\text{Ra}$ -dichloride in patient 1. The static images were acquired at 1.5, 24, 48, 67, 191 and 404 h



# How is predictive dosimetry possible for $^{223}\text{Ra}$ ?

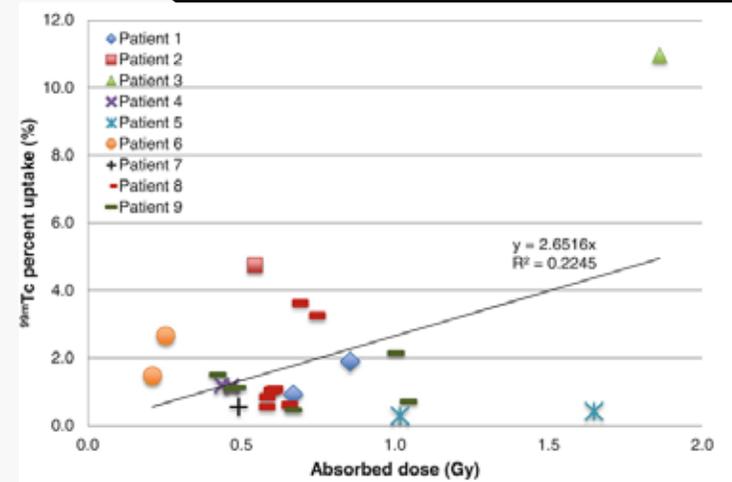
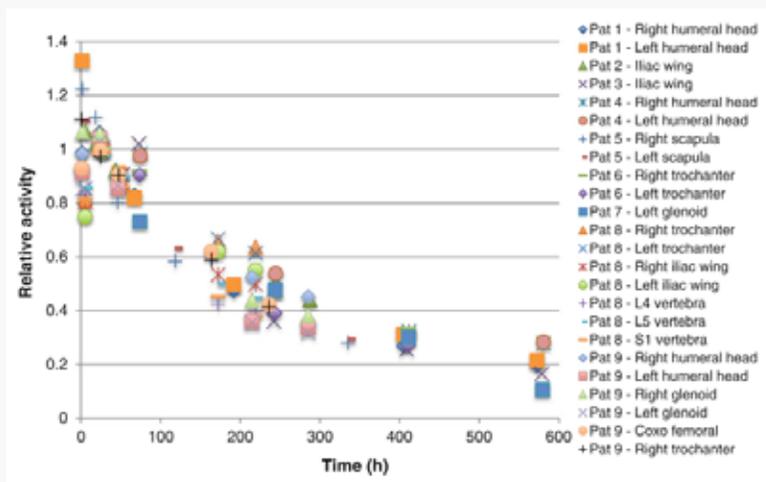
- Good correlation between  $^{99\text{m}}\text{Tc}$  and  $^{223}\text{Ra}$  uptake:
  - > Lesion delineation on MDP WB images, unlikely impossible on  $^{223}\text{Ra}$  images.
  - > %uptake of  $^{223}\text{Ra}$  is slightly higher than that of  $^{99\text{m}}\text{Tc}$  probably because of differences in biodistribution



Data from: Pacillo M et al Eur J Nucl Med Mol Imaging (2016) 43: 21-33

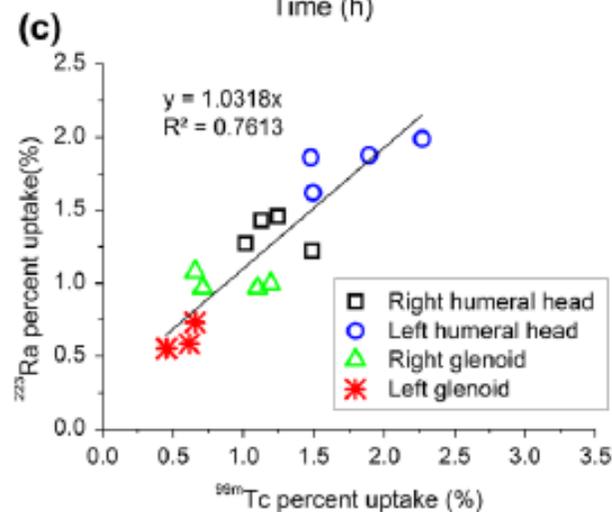
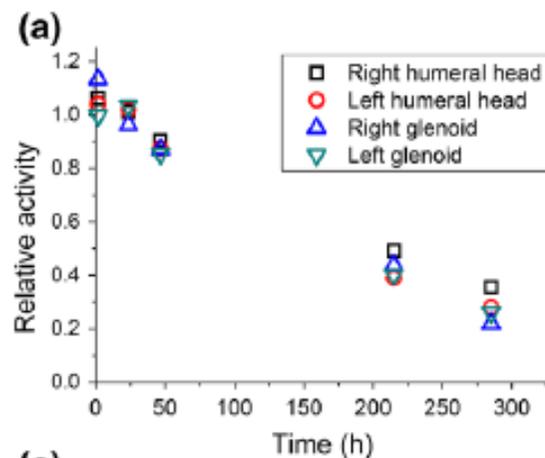
# How is predictive dosimetry possible for $^{223}\text{Ra}$ ?

- Poor correlation between  $^{99\text{m}}\text{Tc}$  uptake and absorbed dose from  $^{223}\text{Ra}$ :
  - Absorbed dose depends on uptake, biokinetics, lesion mass
  - Biokinetics and lesion mass vary independently from uptake.

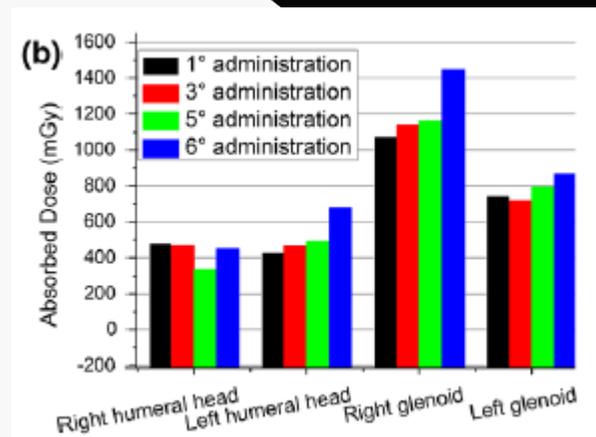


Data from: Pacilio M et al Eur J Nucl Med Mol Imaging (2016) 43: 21-33

# An Italian case report of image-based dosimetry



- Very good correlation of  $^{99\text{m}}\text{Tc}$ -MDP and  $^{223}\text{Ra}$  uptake in a single case study
- Similar kinetics of lesions
- Dose assessments in serial administrations



# Conclusions

- Data confirm the feasibility of quantitative  $^{223}\text{Ra}$  imaging with the aim to assess the absorbed dose to bone lesions.
- Optimal timing for  $^{223}\text{Ra}$  imaging is: 1-5h, 18-24h, 48-60h 7-15 d.
- The uptake of  $^{99\text{m}}\text{Tc}$ -MDP correlates significantly with  $^{223}\text{Ra}$  uptake
- The follow-up of the uptake level of  $^{223}\text{Ra}$  can be efficiently quantitatively performed by  $^{99\text{m}}\text{Tc}$ -MDP (to check for symptomatic skeletal event-free survival or overall survival)
- The macrodosimetry of bone metastasis is feasible, but its predictive value in clinical outcomes must be still demonstrated.
- At present the possibility that a microdosimetric approach is needed to understand and predict the clinical response of bone metastasis cannot be excluded.