Nuclear Medicine

- Unsealed radioactive preparations

  the tracer mixes with the patients' body fluids on a molecular level (e.g. after intravenous injection)

- 3 main fields:
  - „In vitro": measuring concentrations of different molecules
  - „In vivo" imaging
  - Therapy
- Functional imaging
  while X-ray, US, MRI are structural

Nuclear Medicine: Manuals

- Required reading:
  Taylor A., Alazraki N., and Schuster D.M.:
  A Clinician's Guide to Nuclear Medicine (2nd Edition)
  The Society of Nuclear Medicine, Reston, 2006
  ISBN: 0972647872

- Link to English reference manual:
  http://www.auntminnie.com/index.asp?sec=ref&sub=ncm
- Lectures in English:
  http://www.nmc.dote.hu/nmt_eng/oktatas_e.htm
- In Hungarian:
  http://www.nmc.dote.hu/nmtk/index.html
- *Book:* Nukleáris Medicina
  (Szerk. Szilvási I.; Medicina Kiadó, 2010)

Nuclear imaging

Problems to solve:

- To produce radionuclides
- To link them to carrier molecules: radiopharmaceuticals
- To image the distribution of the tracer

Radiopharmaceuticals: Examples

Binding ^{99m}Tc or some other radionuclide to a carrier molecule → different functions

Radionuclide - radiopharmaceutical	*Mechanism*	*Study type*
$^{99m}TcO_4^-$ (pertechnetate)	(Iodine) trapping	thyroid scintigraphy
[^{99m}Tc] MDP	osteoblasts	bone scintigraphy
[^{99m}Tc] MIBI	mitochondria	myocardial perfusion parathyroid scintigraphy breast scintigraphy
[^{99m}Tc] DMSA	proximal tubules	kidney scintigraphy
[^{18}F] FDG	glucose metab.	metabolic imaging
etc.		

Gamma cameras
SPECT/SPET: „single photon emission computed tomography"

Emission imaging: study types

Static:
Imaging an equilibrium distribution

Whole body:
Static images connected

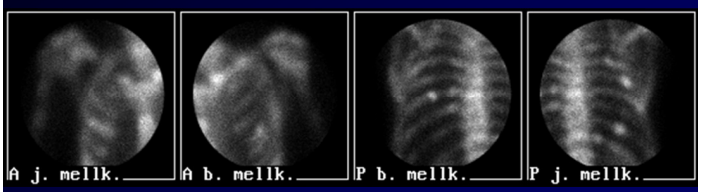
Dynamic:
Series of images following the accumulation / metabolic pathways / secretion of a radiopharmaceutical

Tomographic:
Single photon emission computed tomography (**SPECT**)
positron emission tomography (**PET**)

Bone scintigraphy - technique

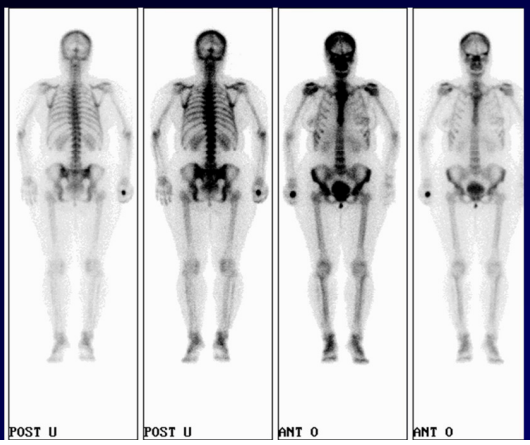
Pharmaceuticals:	[^{99m}Tc] diphosphonates (MDP, HEDP)
Used mechanism:	Osteoblastic activity + blood perfusion
Time of scanning:	2-3 hours post injection.
Usual pictures	1. Spot images 2. Whole body scan
Quantitative data:	Sacroiliac joint index
Abnormality detected:	High activity at tumor or metastatic sites, in osteomyelitis, etc.
Not useful:	in osteoporosis, at lytic bone sites

Bone scintigram (spot images)

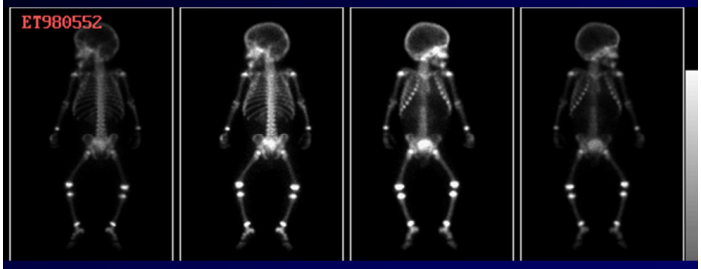


Normal whole body bone scintigram

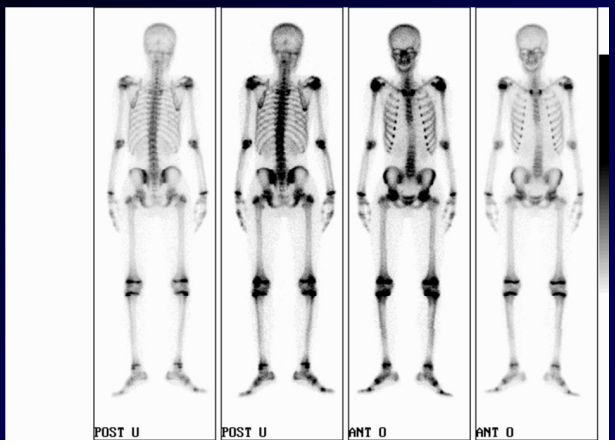
Normal whole body



High osteoblast activity in the joints of an infant



Normal whole body (young patient)



Bone scintigraphy - indications

1. To detect and follow up bone metastases (mainly of breast, prostate or lung cancer)
2. Benign illnesses:
   - osteomyelitis
   - fractures
   - cause of joint prosthesis pain
   - aseptic necrosis of bones
   - osteodystrophy (of renal origin)

1. Oncological indications:

- Secondary tumours (metastases)
  - Staging and follow-up of neoplastic diseases.
  - Distribution of osteoblastic activity prior to radiometabolic therapy (^{89}Sr, ^{153}Sm-EDTMP, ^{186}Re-HEDP).
- Primary tumours (e.g. Ewing's sarcoma, osteosarcoma).
  - Staging,
  - Evaluation of response to therapy and
  - Follow-up of primary bone tumors

2. Non-neoplastic diseases:

- Osteomyelitis
- Perthes Disease, Avascular necrosis
- Metabolic disorders (Paget, osteoporosis)
- Arthropathies
- Fibrous dysplasia and other rare congenital conditions
- Stress fractures, shin splints
- Loose or infected joint prosthesis
- Low back pain, sacroiliitis
- Reflex sympathetic syndrome
- Any other bone injuries

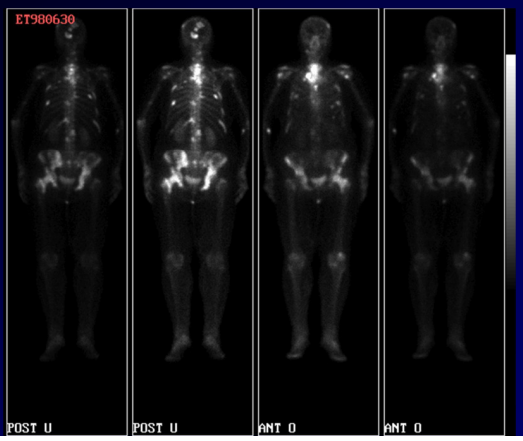
Factors influencing the uptake and distribution of radiopharmaceutical:

- Osteoblast activity
- Blood supply

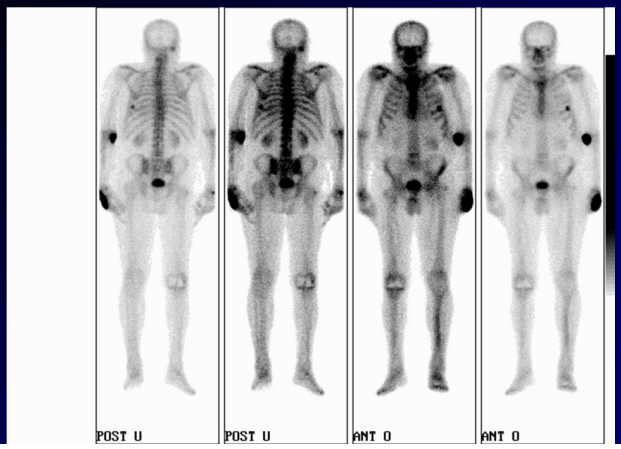
False negative bone scintigram occurs:

- Lower local blood perfusion
- Dominant osteoclast activity
- A process primarily involving the bone marrow
- Therapy with phosphonates

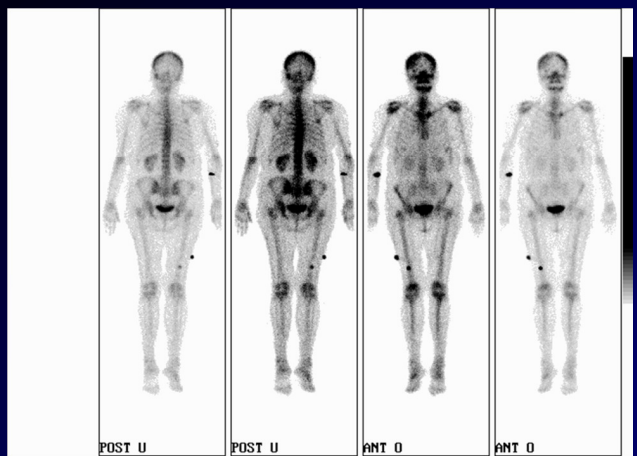
Multiple metastases



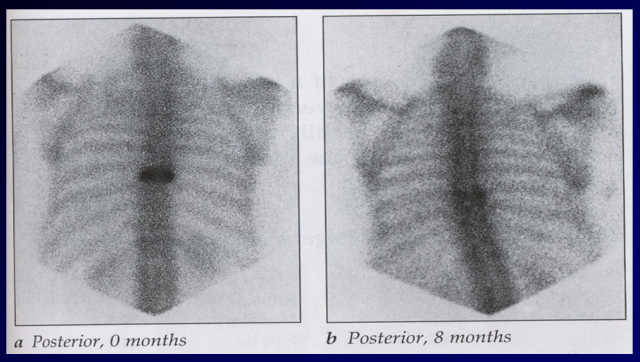
Rib and vertebra



Urinary contamination

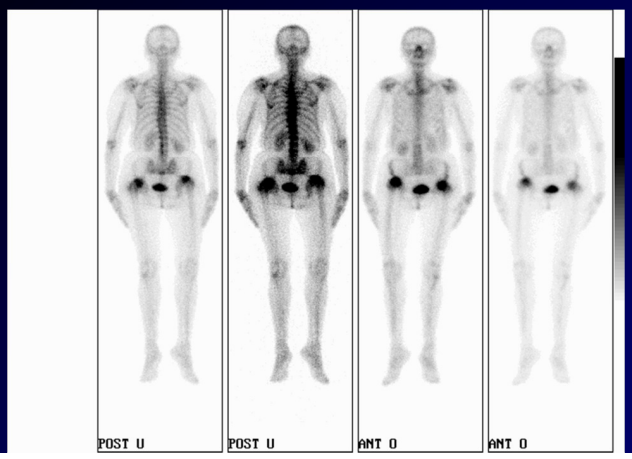


Osteoporotic collapse

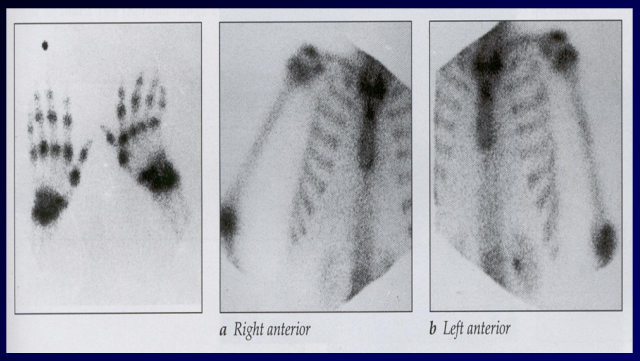


a Posterior, 0 months *b* Posterior, 8 months

Degenerative disease affecting hips

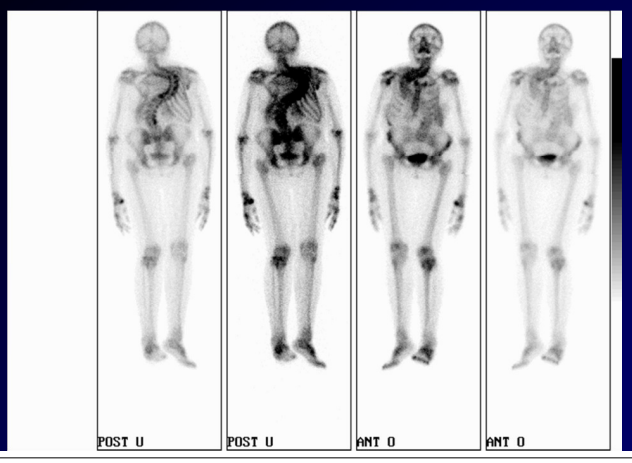


Rheumatoid arthritis

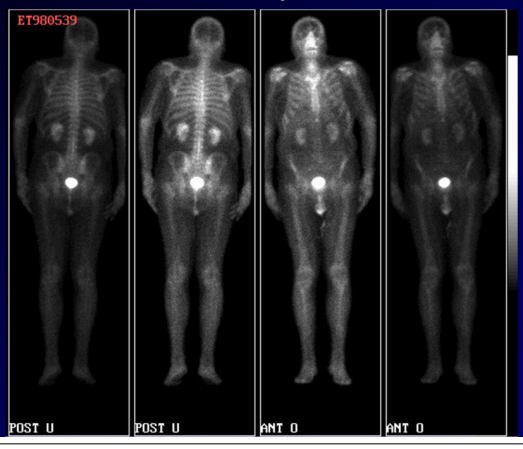


a Right anterior *b* Left anterior

Spinal torsion



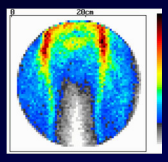
Scattered radiation in a fat patient

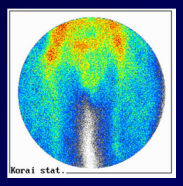


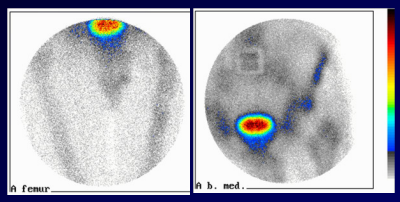
3-phase bone scintigraphy

3 phases:

- radioangiography
- early (blood pool)
- osteoblast activity





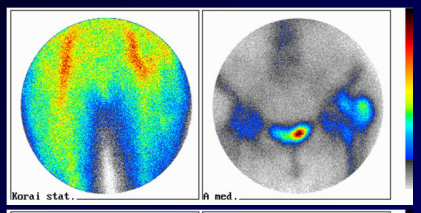


3-phase bone scintigraphy

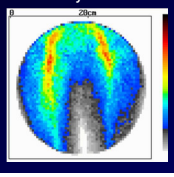
painful prosthesis:

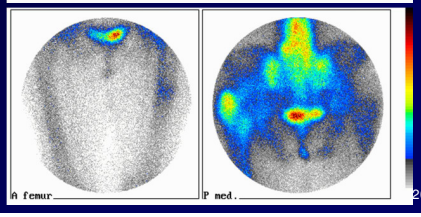
loosening

Early phase Delayed



Sum of dynamic series

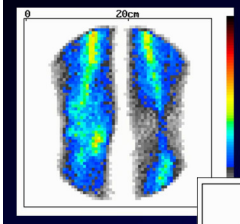




Differential diagnosis: painful prosthesis

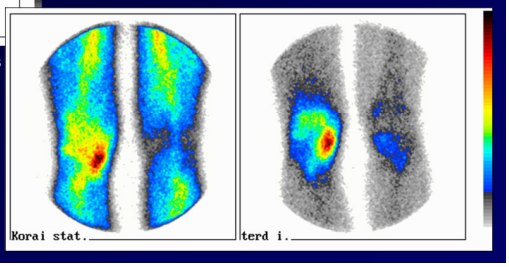
Prosthesis …	*Blood pool (early phase)*	*Late uptake*
loosening	normal	increased
infection	increased vascularity	increased

3-phase bone scintigraphy: Osteomyelitis



Sum of dynamic series

Early phase Delayed



Differential diagnosis: osteomyelitis

	Blood pool	*Late uptake*
Septic arthritis, cellulitis	increased	normal or low
Acute osteomyelitis	increased vascularity	increased

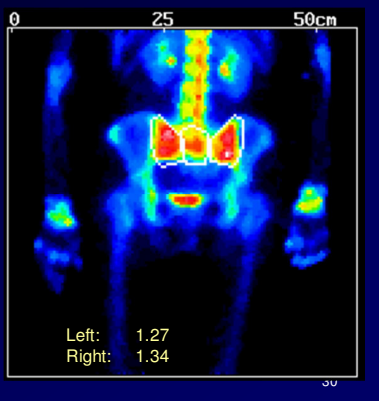
Quantitative parameters

SACROILIAC INDEX:

ROIs to sacral and sacroiliac region

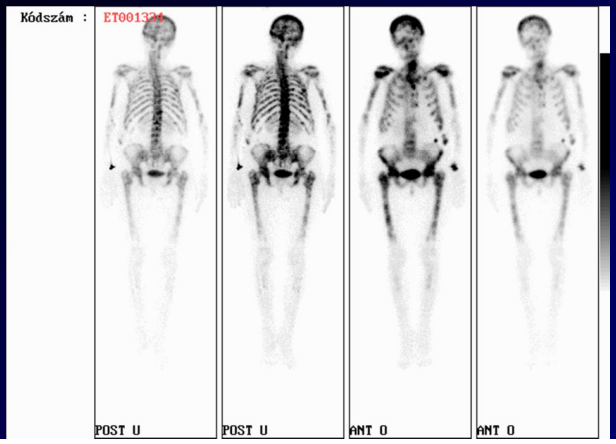
$$\text{SI}-\text{index} = \frac{\text{maximum SI pixel (count)}}{\text{maximum S pixel (count)}}$$

normal value: <1.65
if elevated → sacroiliitis

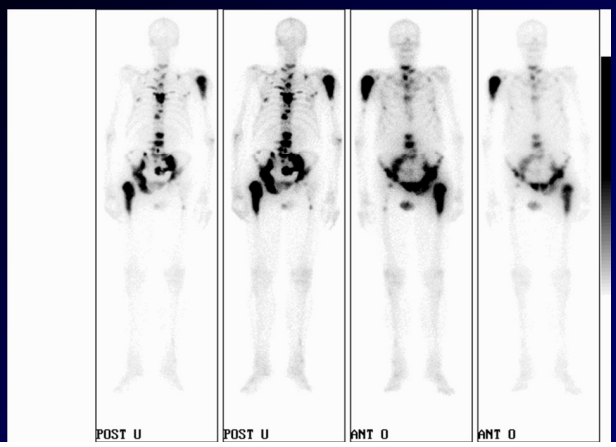


Examples

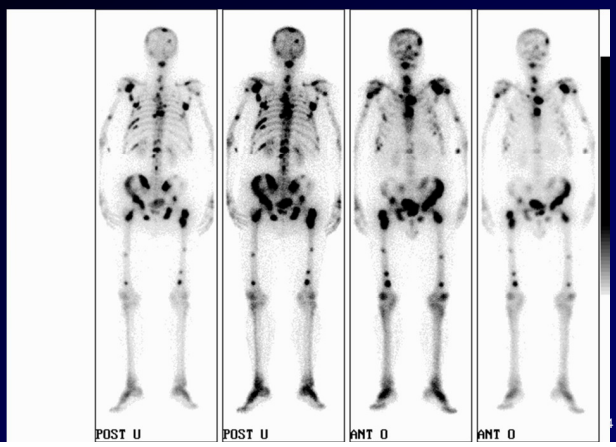
Multiple metastases

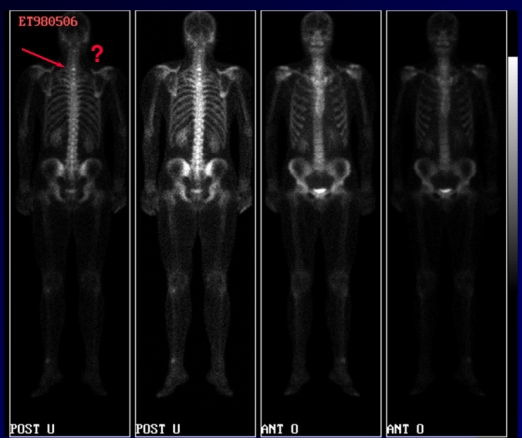


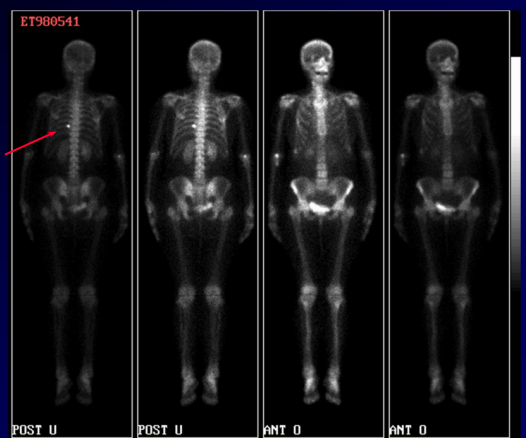
Multiple metastases



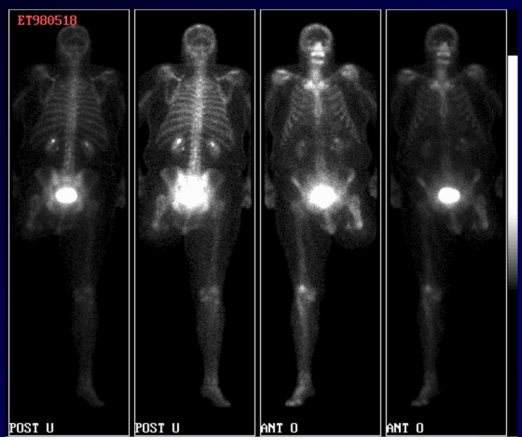
Multiple metastases

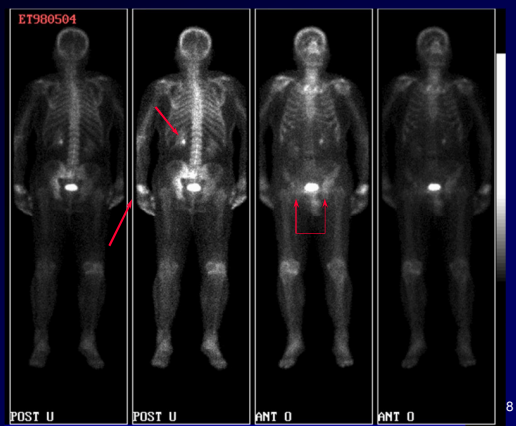


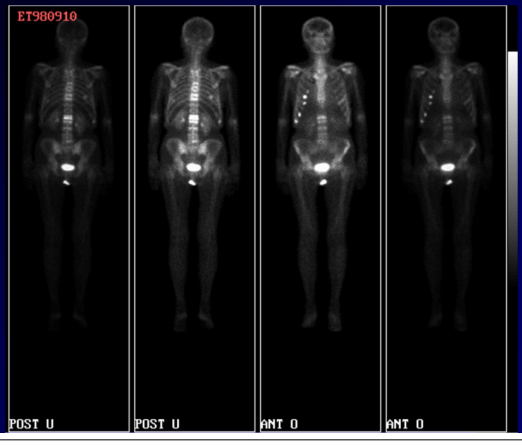


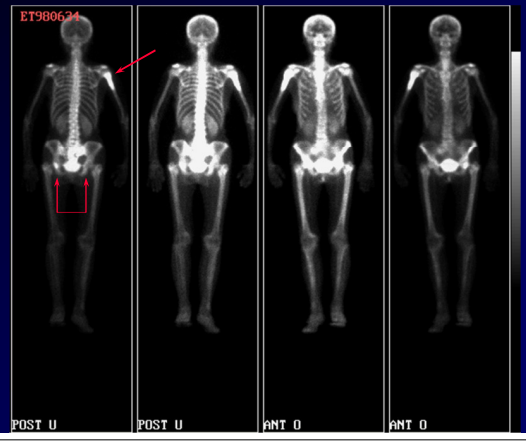


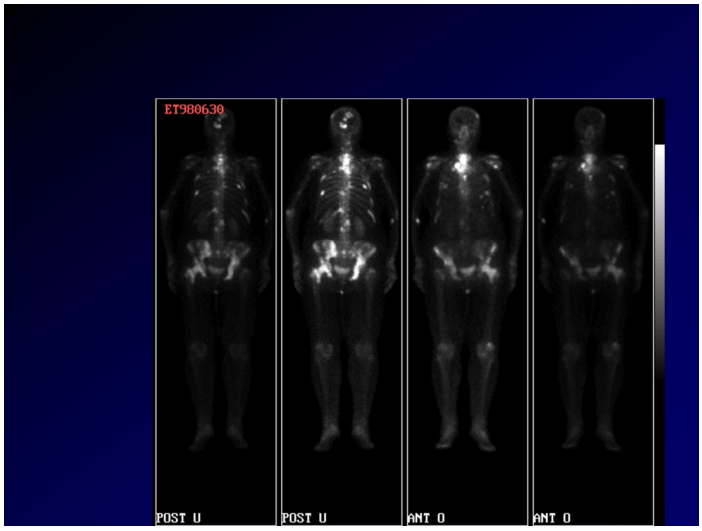
Huge bladder (patient could not void)







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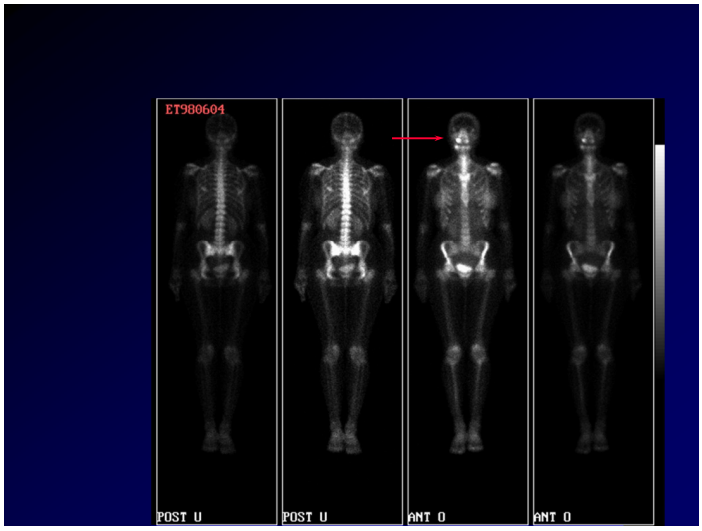
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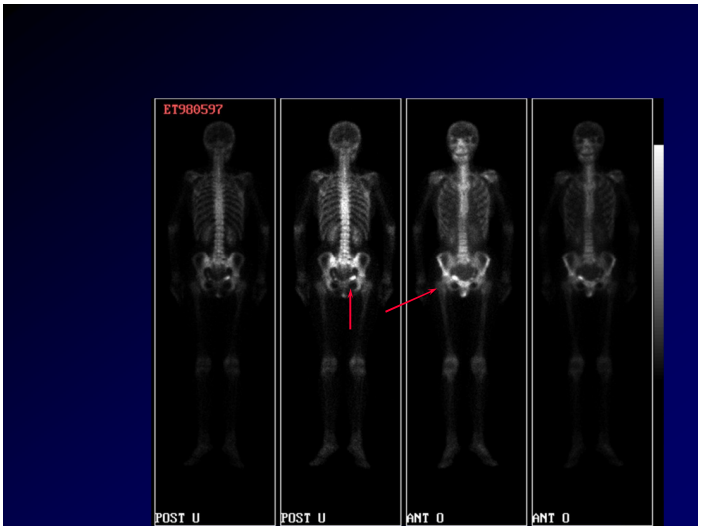
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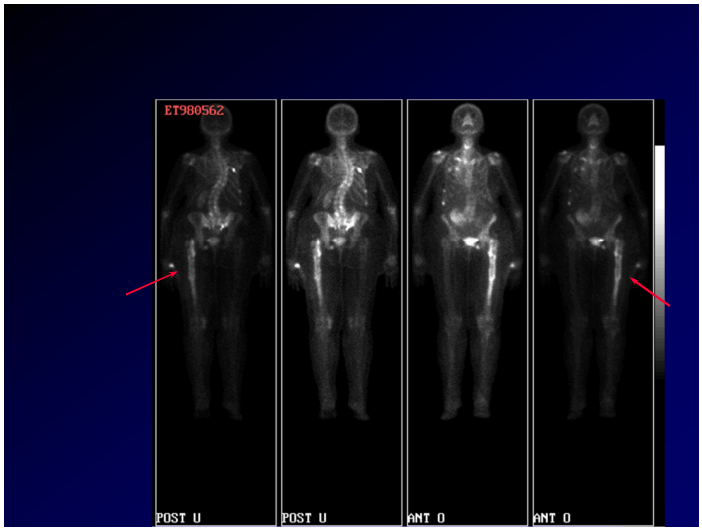
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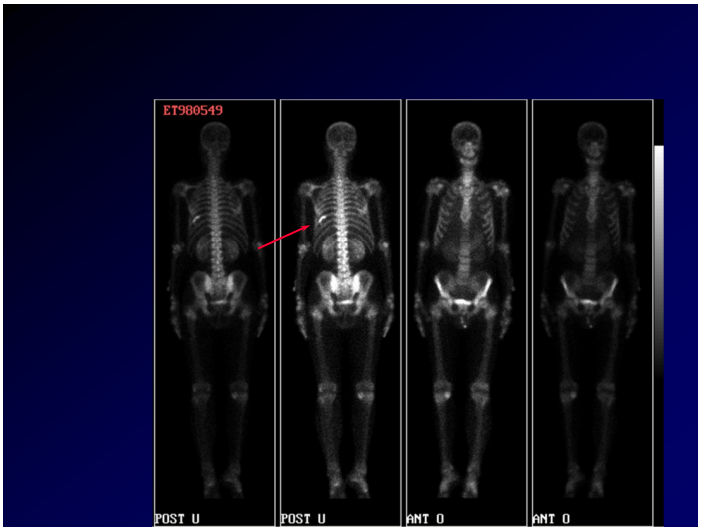
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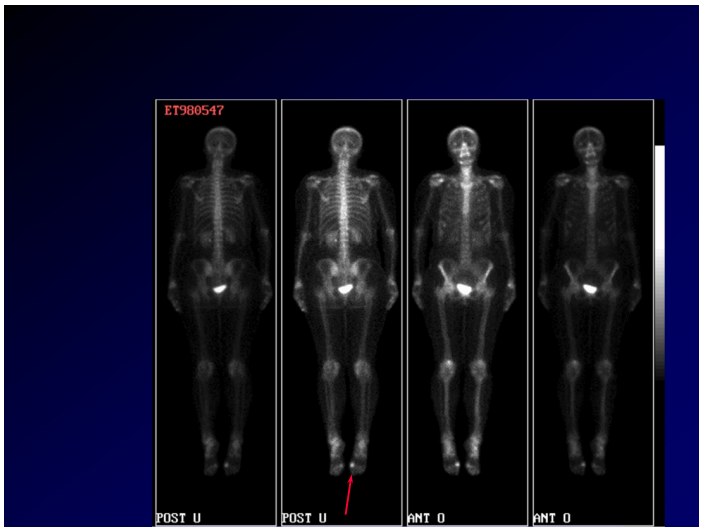
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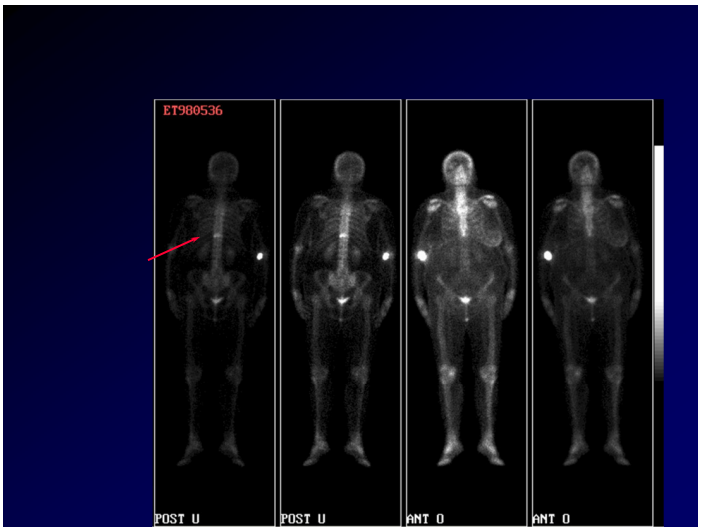
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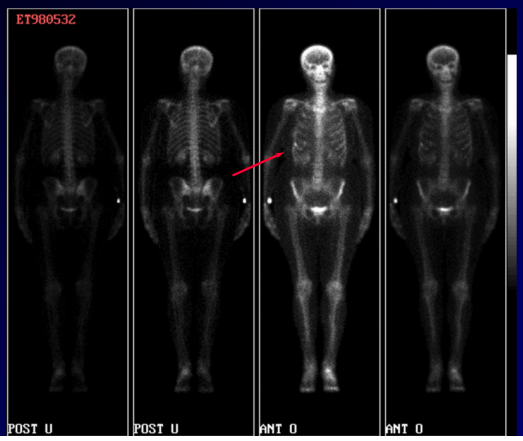
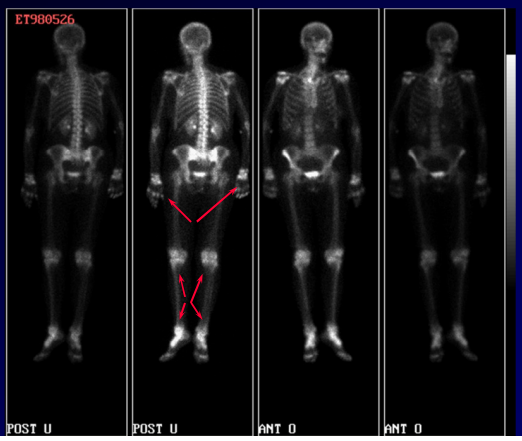
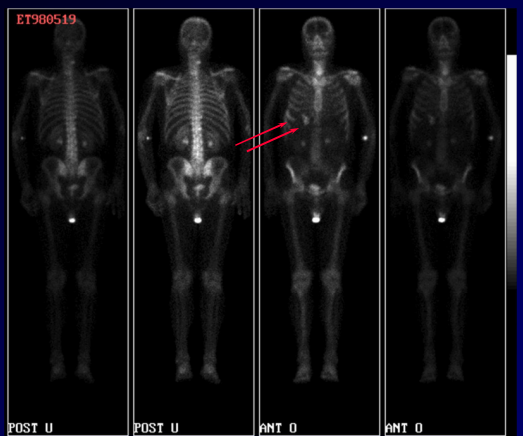
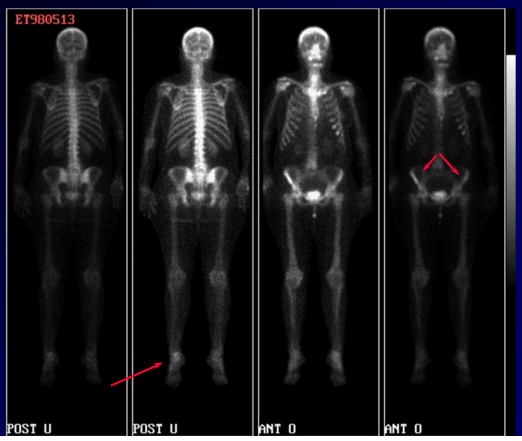
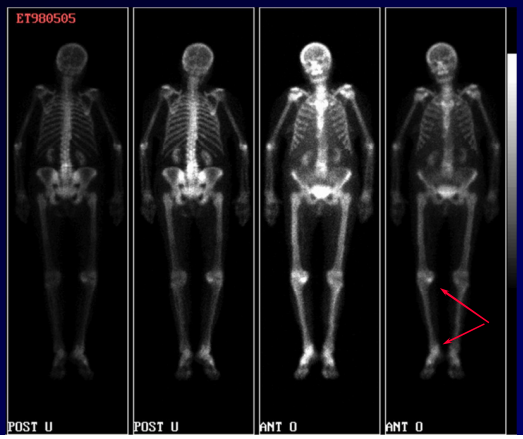
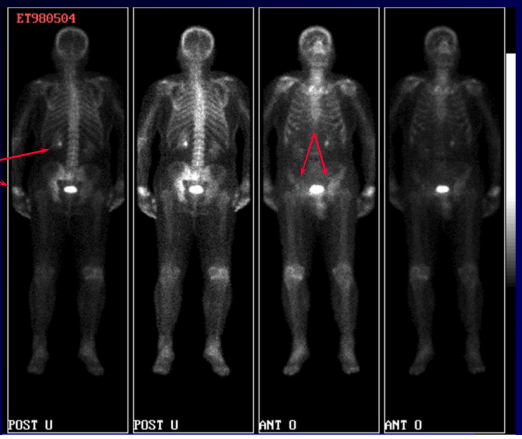
Metast.: rib



Increased uptake in inflammatic joints



Metastases in ribs