The Royal Liverpool and Broadgreen University Hospitals NHS Trust

Common Artifacts in Conventional NM

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Artifacts

an object made by a human being, typically one of cultural or historical interest.
"gold and silver artefacts"

Artifacts

Head of Hygeia
Athens. 360 B.C.
Daughter of Asclepius
God of medicine

an object made by a human being, typically one of cultural or historical interest.
"gold and silver artefacts"

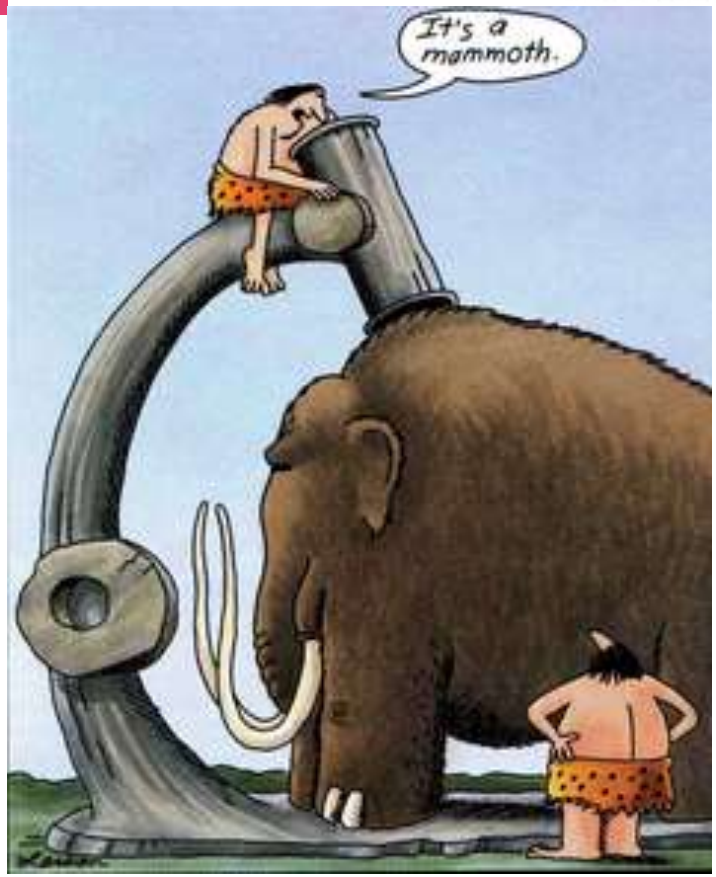


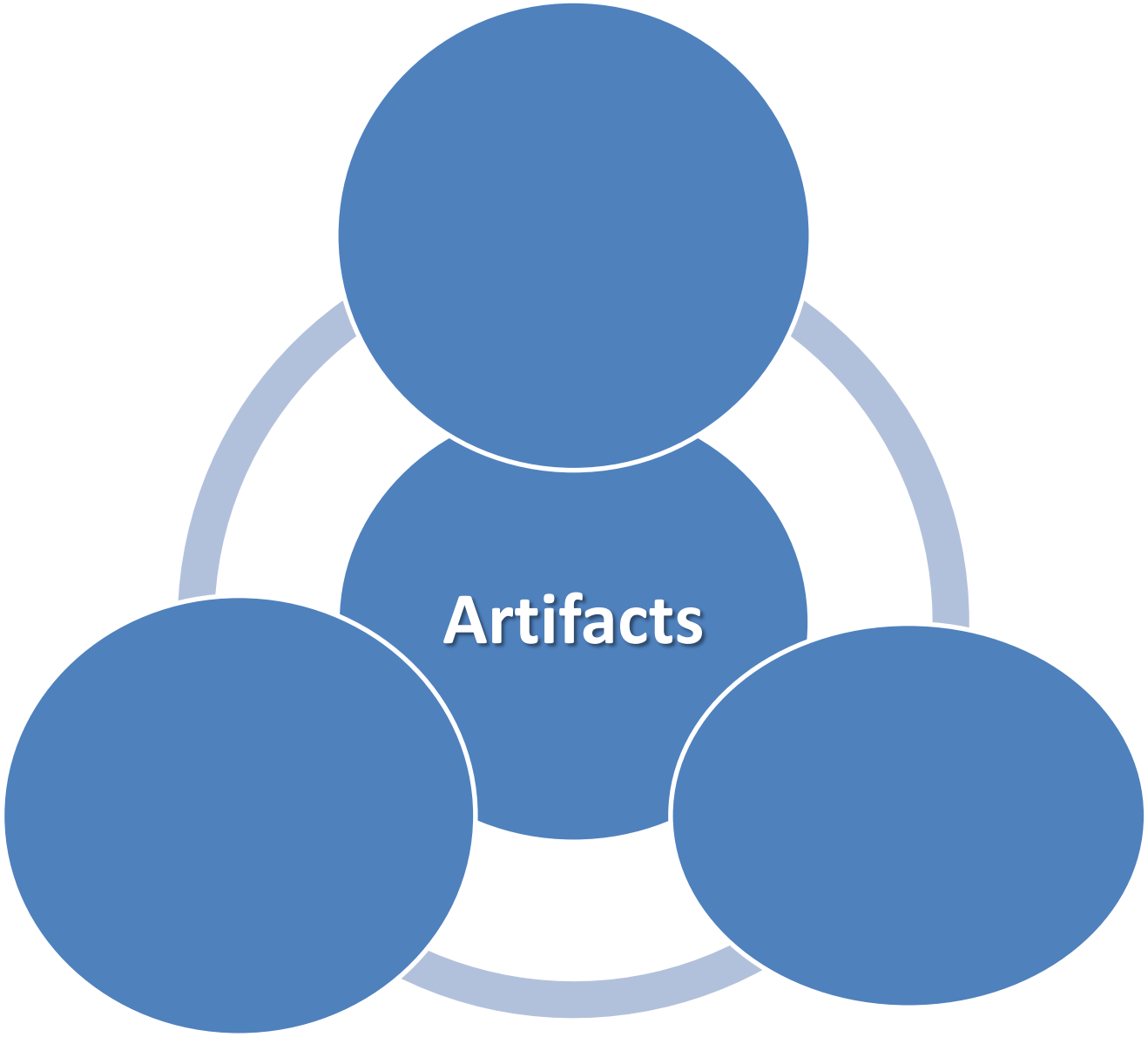
Image Artifact (brit. Artefact) is something observed in a scientific investigation that is not naturally present but occurs as a result of the investigative procedure. (oxford dictionary)

Manager

Liverpool

Team

Fans


Artifacts

Camera dependent

Artifacts

Camera dependent

Artifacts

Patient-related

Camera dependent

Artifacts

Patient-related

Radiopharmaceutical dependent

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NHS Trust

IONIZATION CHAMBER/DOSE CALIBRATOR ARTIFACTS

1. Altitude
2. Geometry
3. Materials

Sample holder

(geometry)

This dose calibrator dipper is specially designed to hold syringes and vials.

Geometric efficiency=

number of photons reaching the detector / the number of photons emitted from the sample

Increasing geometric efficiency

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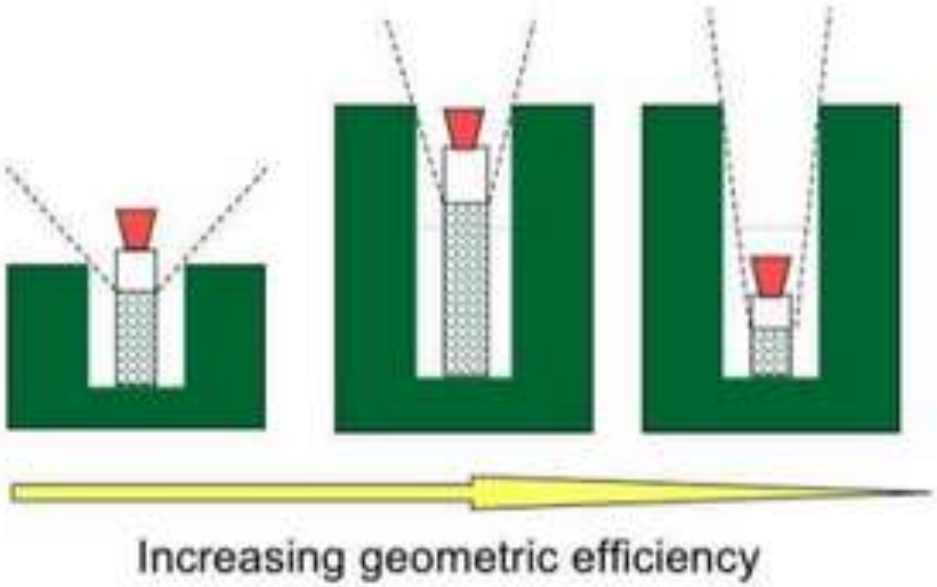
NHS Trust

IONIZATION CHAMBER/DOSE CALIBRATOR ARTIFACTS

1. Altitude
2. Geometry
3. Materials

Geometric efficiency

The quotient: number of photons reaching the detector over the number of photons emitted from the sample



Geometric efficiency=

number of photons reaching the detector / the number of photons emitted from the sample

Increasing geometric efficiency

IONIZATION CHAMBER/DOSE CALIBRATOR ARTIFACTS

1. Altitude
2. Geometry
3. Materials

How often is constancy checked on dose calibrator and what is used?

How often is linearity checked on dose calibrator?

How often is accuracy checked on dose calibrator?

How often is Geometry checked on dose calibrator?

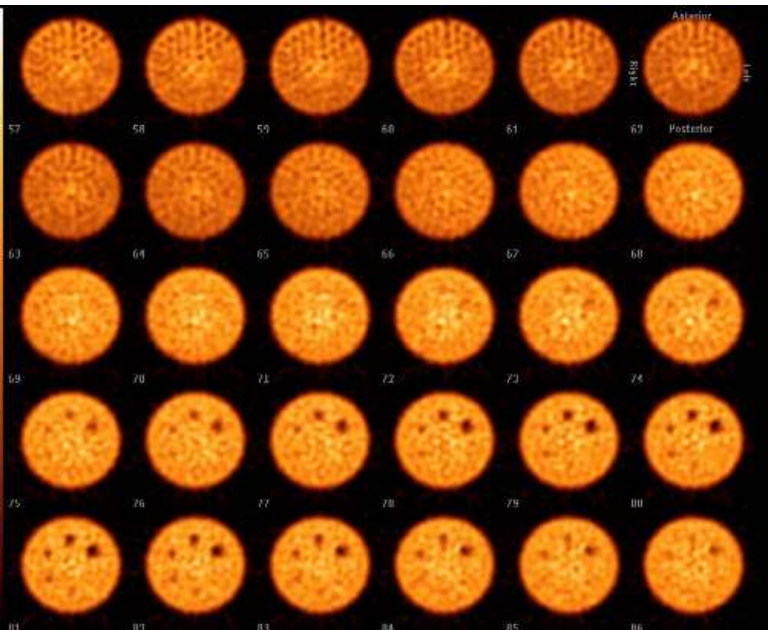
IONIZATION CHAMBER/DOSE CALIBRATOR ARTIFACTS

1. Altitude
2. Geometry
3. Materials

How often is constancy checked on dose calibrator and what is used?	Daily. Use Cs-137. Half life of 30 years.
How often is linearity checked on dose calibrator?	Quarterly
How often is accuracy checked on dose calibrator?	Annually
How often is Geometry checked on dose calibrator?	At installation, after repair, or moving instrument.

Camera dependent

SPECT phantom reconstructed slices

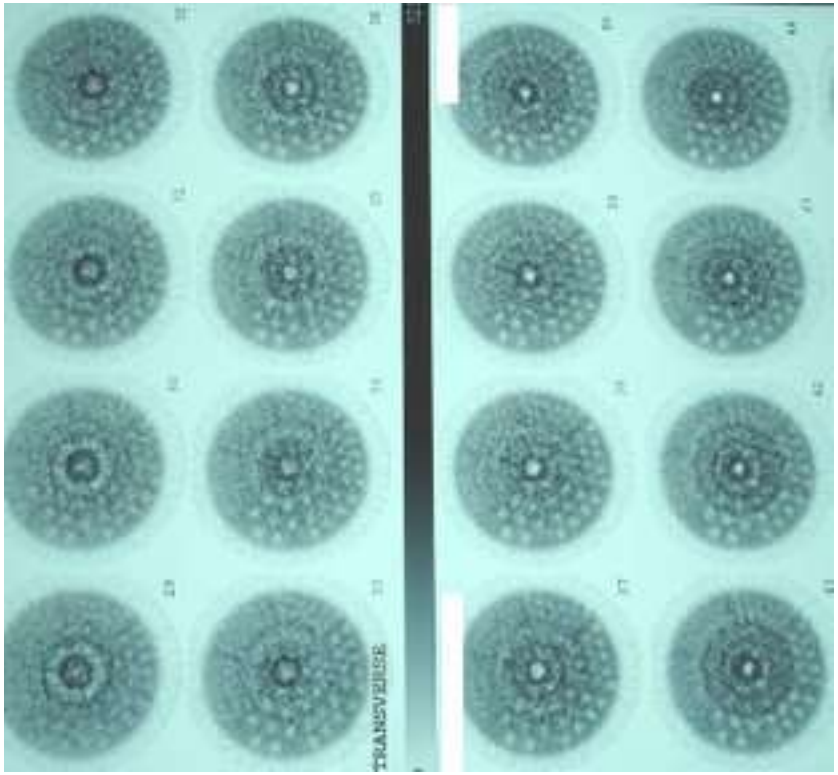


SPECT phantom imaging procedure

- ACR protocol is for 24 M total counts. Check count rate and adjust time per stop to achieve this
- Use 128 X 128 matrix, 120 or 128 views over 360 degrees
- Use a radius of rotation as close to 20 cm as possible
- For a large field of view camera, set the zoom between 1.33 and 1.46

Camera dependent

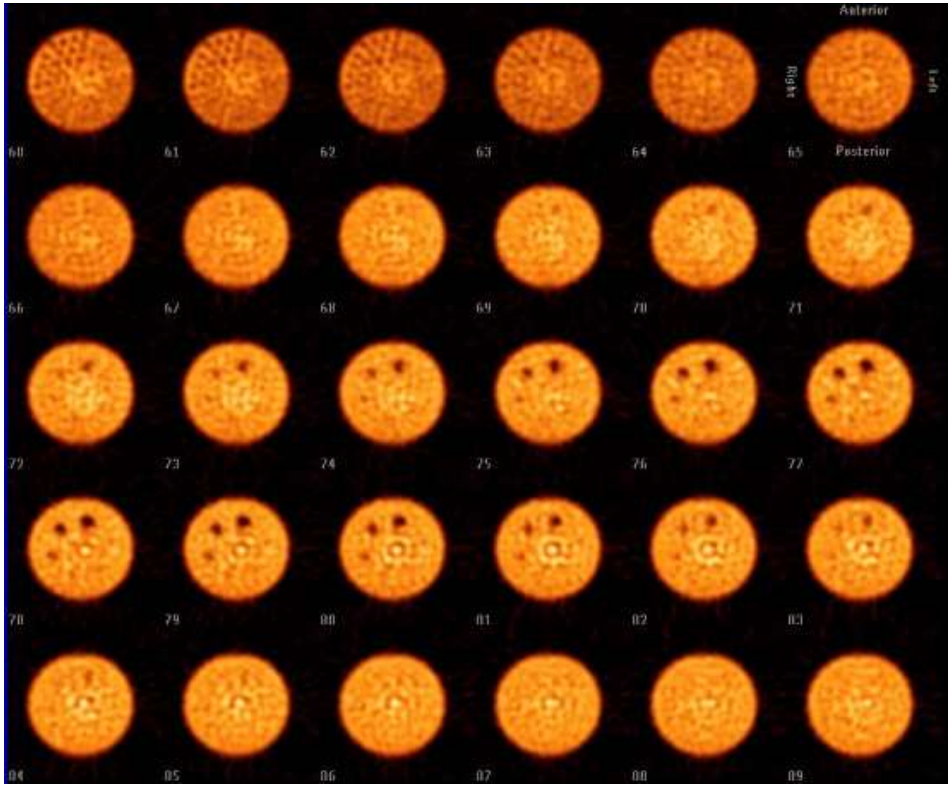
Name this artifact.
Cause?



1. Band Artifact
2. Ring Artifact
3. Rolling Stone Artifact
4. Bull's eye Artifact

Camera dependent

Name this artifact. Cause?



1. Band Artifact
2. Ring Artifact
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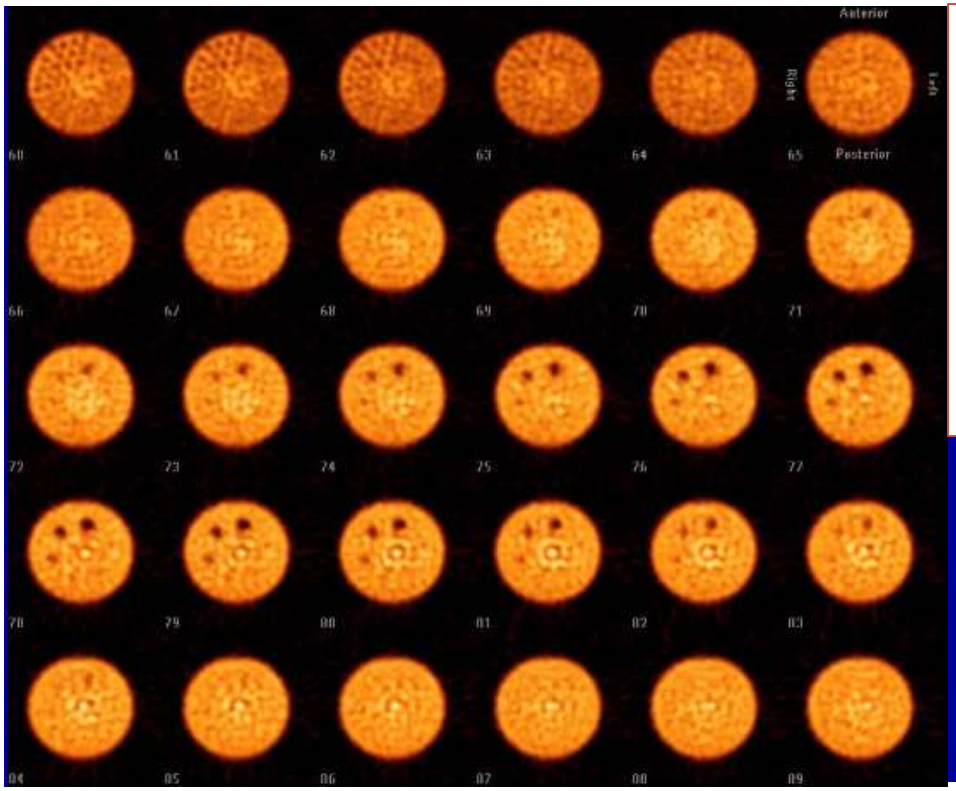
Camera dependent

Name this artifact.
Cause?

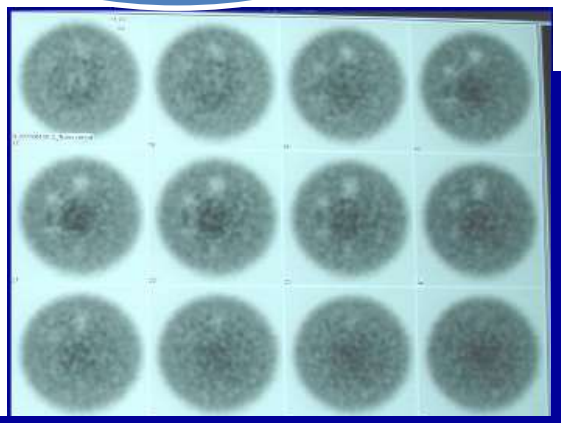


Ring Artifact

Ring artifacts visible

Camera dependent

Name this artifact. Cause?



Ring artifacts visible

- Caused by non-uniformities such as:
  - Visible non-uniformities in flood image due to camera being off peak, PMT gain imbalance, or need for new correction tables
  - Shift in photopeak as camera head rotates
  - Collimator defect or damage (not visible in intrinsic flood image)

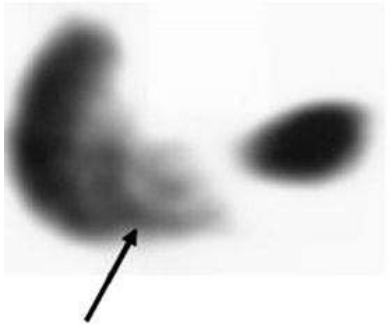
Camera dependent

- Phantom images are scored for:
  - Resolution – smallest size of rods visible
  - Contrast – number of spheres visible
  - Uniformity – look for ring type artifacts or other artifacts

- Even small non-uniformities can cause ring artifacts

Camera dependent

Name this artifact. Cause?



SPECT image, transverse image from ^{99m}Tc-sulfur colloid liver–spleen study

1. Band Artifact
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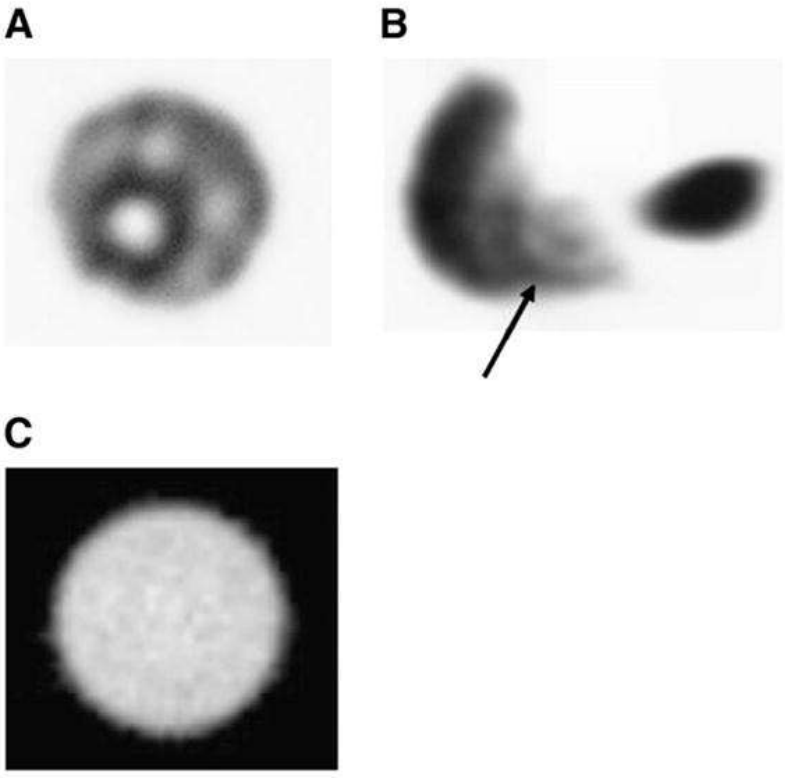
Camera dependent

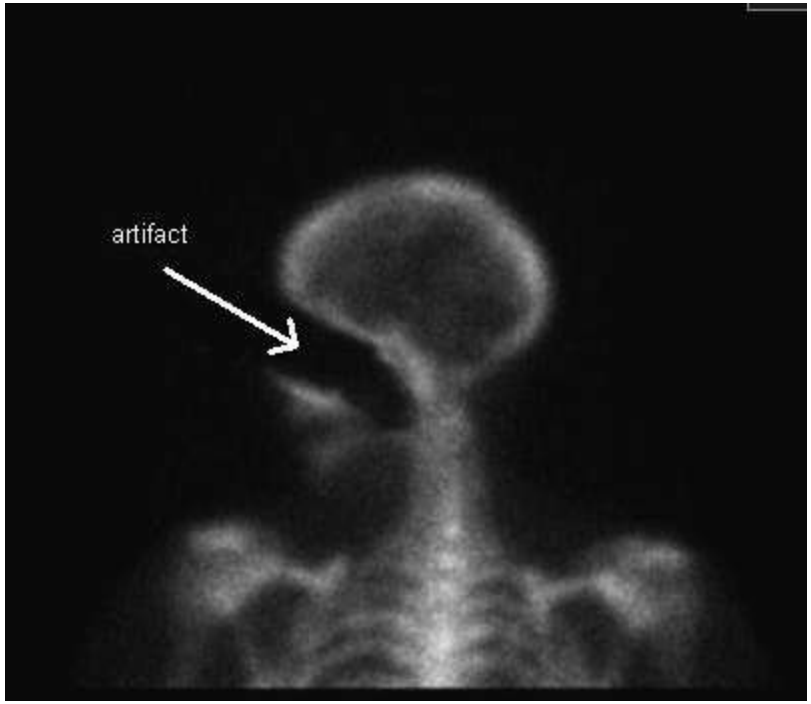
Name this artifact.
Cause?



Ring Artifact

Camera dependent

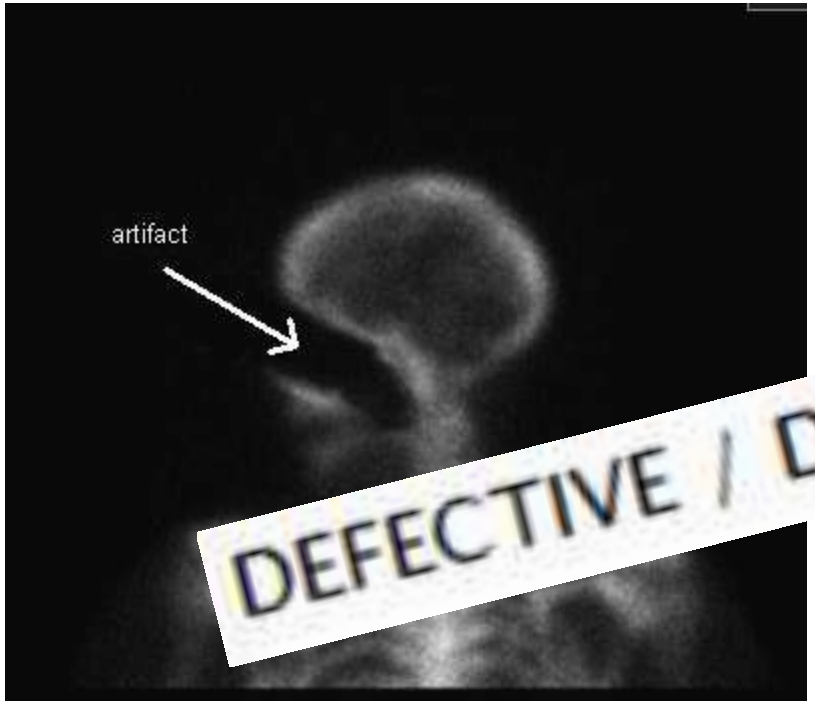
Name this artifact.
Cause?



DEFECTIVE PMT
IMPROPERLY ADJUSTED PHA
COLLIMATOR DEFECTS
METAL OBJECT ON PATIENT
DEFECTIVE / DAMAGED CRYSTAL
UNIFORMITY CORRECTION NOT PROPER
COMPUTER / ELECTRONICS ERROR
DISPLAY MONITOR PHOSPHOR PROBLEM

Camera dependent

Name this artifact.
Cause?



DEFECTIVE PMT
IMPROPERLY ADJUSTED PHA
COLLIMATOR DEFECT
METAL OB
DEFECTIVE / DAMAGED CRYSTAL
CRYSTAL
ENERGY CORRECTION NOT PROPER
COMPUTER / ELECTRONICS ERROR
DISPLAY MONITOR PHOSPHOR PROBLEM

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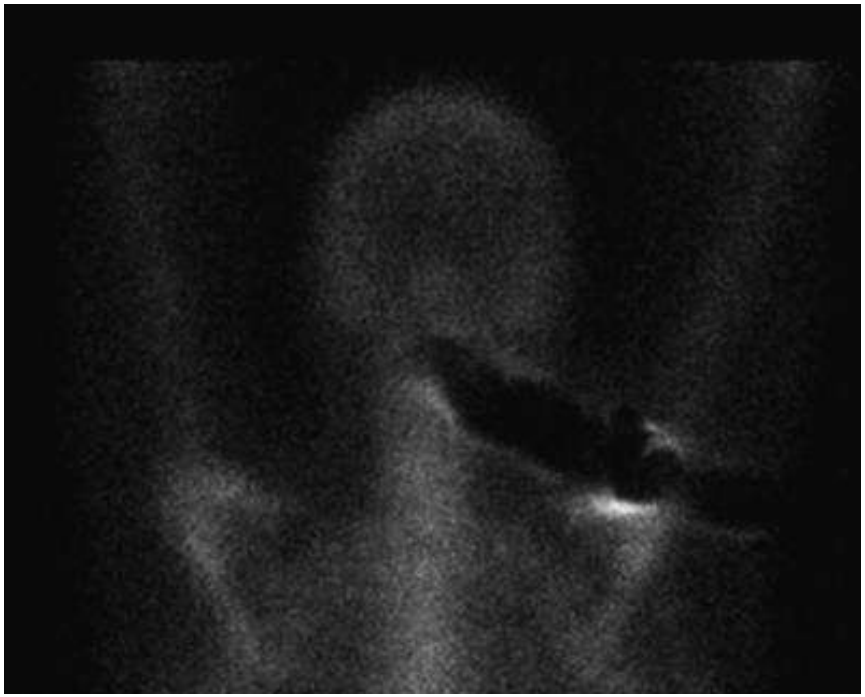
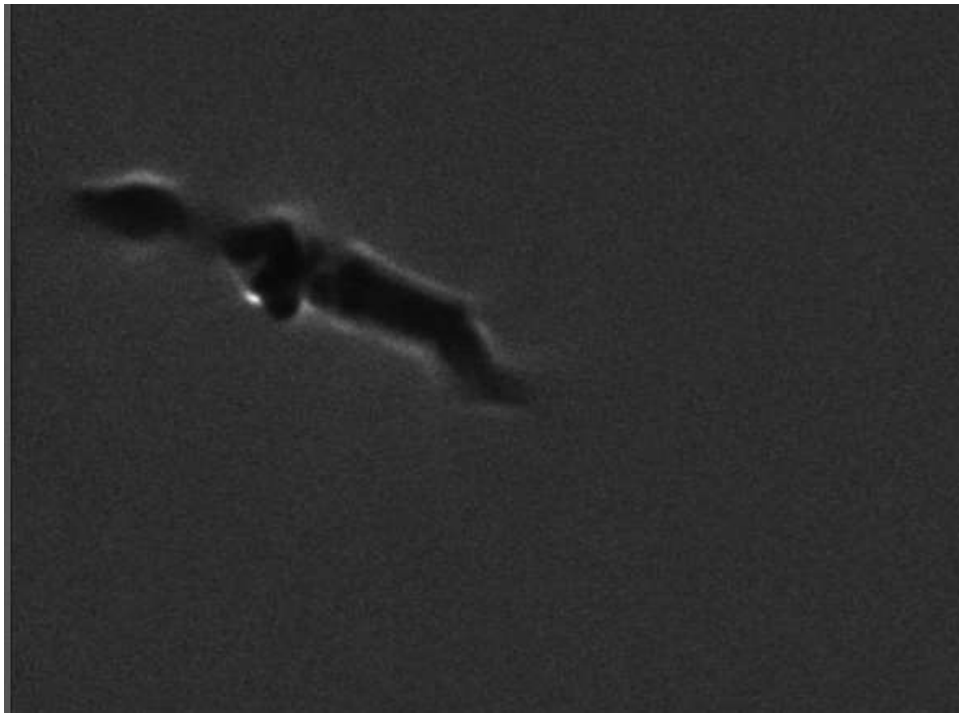
Camera dependent

Cracked crystal artifact



Flood image showing the cracked crystal artifact



Camera dependent

A cold spot artifact appears in a scintillation camera image. The artifact could be caused by all of the following ***except:***

A. The camera is incorrectly peaked for the radionuclide in the study.

B. The photomultiplier tube is defective.

C. The patient is wearing metallic jewellery.

D. An out-dated uniformity correction is used

E. The wrong collimator was used.

Camera dependent

A cold spot artifact appears in a scintillation camera image. The artifact could be caused by all of the following ***except:***

A. The camera is incorrectly peaked fo… …e in the study.

B. The p…

C. T… …llery.

D. An … …niformity correction is used

The wrong collimator would increase septal penetration and increase or decrease camera sensitivity, but could not produce a cold spot in the image.

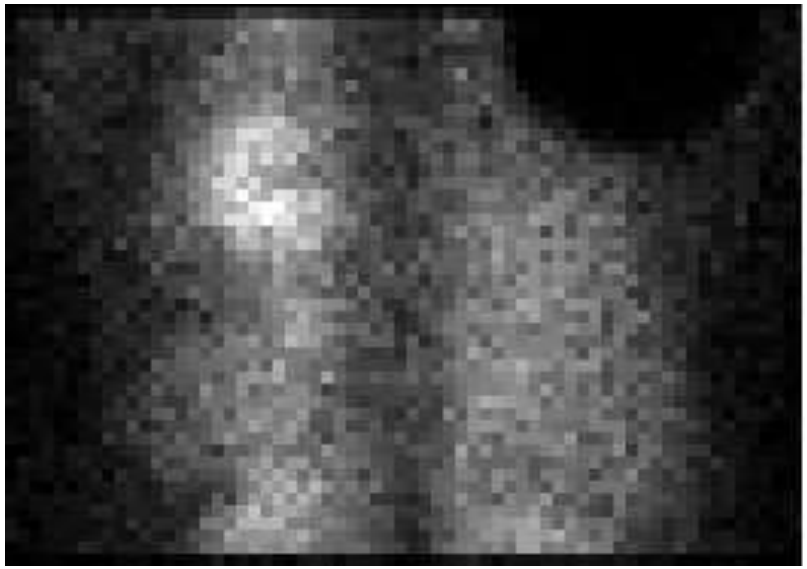
E. The wrong collimator was used.

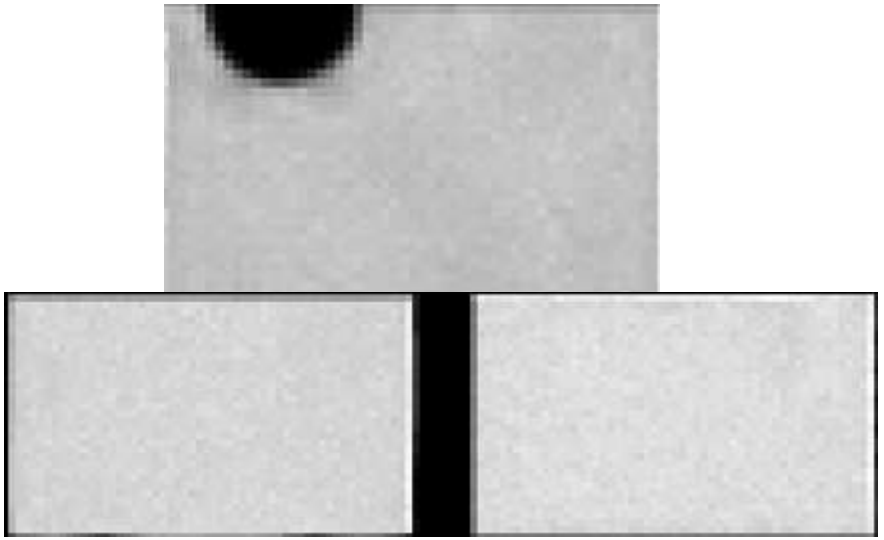
Camera dependent

Name this artifact.
Cause?

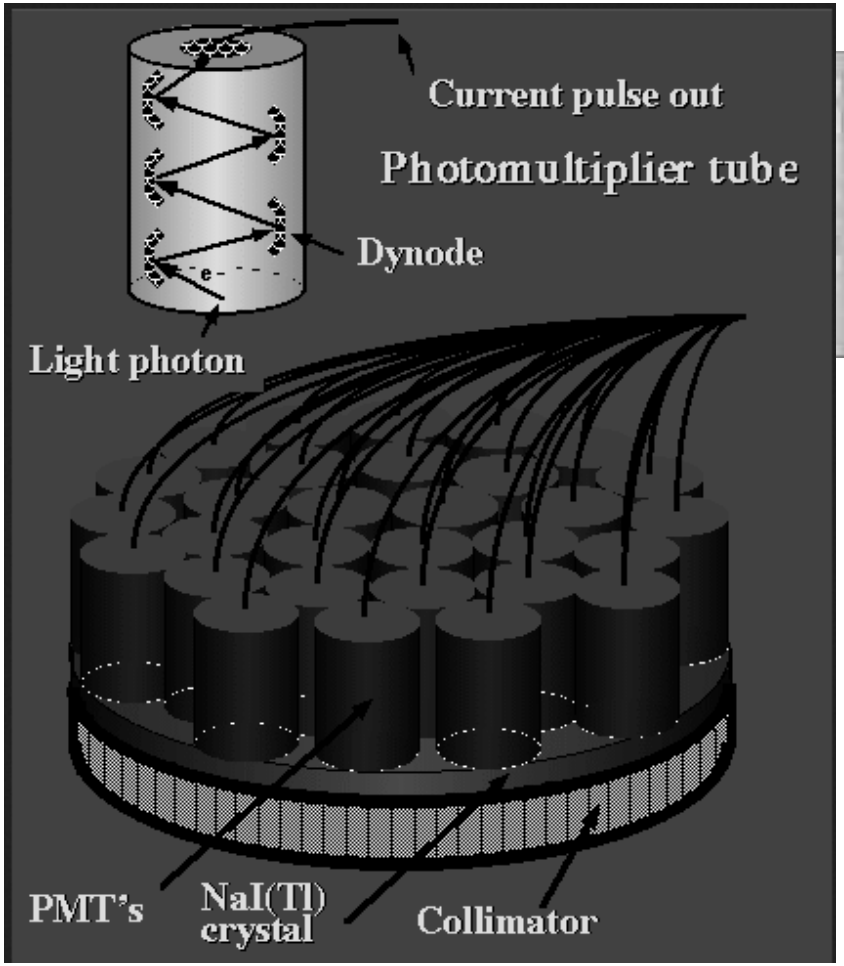
Daily flood field on the triple-head gamma camera

Single posterior projection image





Camera dependent



Name this artifact.
Cause?

DEFECTIVE PMT
IMPROPERLY ADJUSTED PHA
COLLIMATOR DEFECTS
METAL OBJECT ON PATIENT
DEFECTIVE / DAMAGED CRYSTAL
UNIFORMITY CORRECTION NOT PROPER
COMPUTER / ELECTRONICS ERROR
DISPLAY MONITOR PHOSPHOR PROBLEM

Camera dependent

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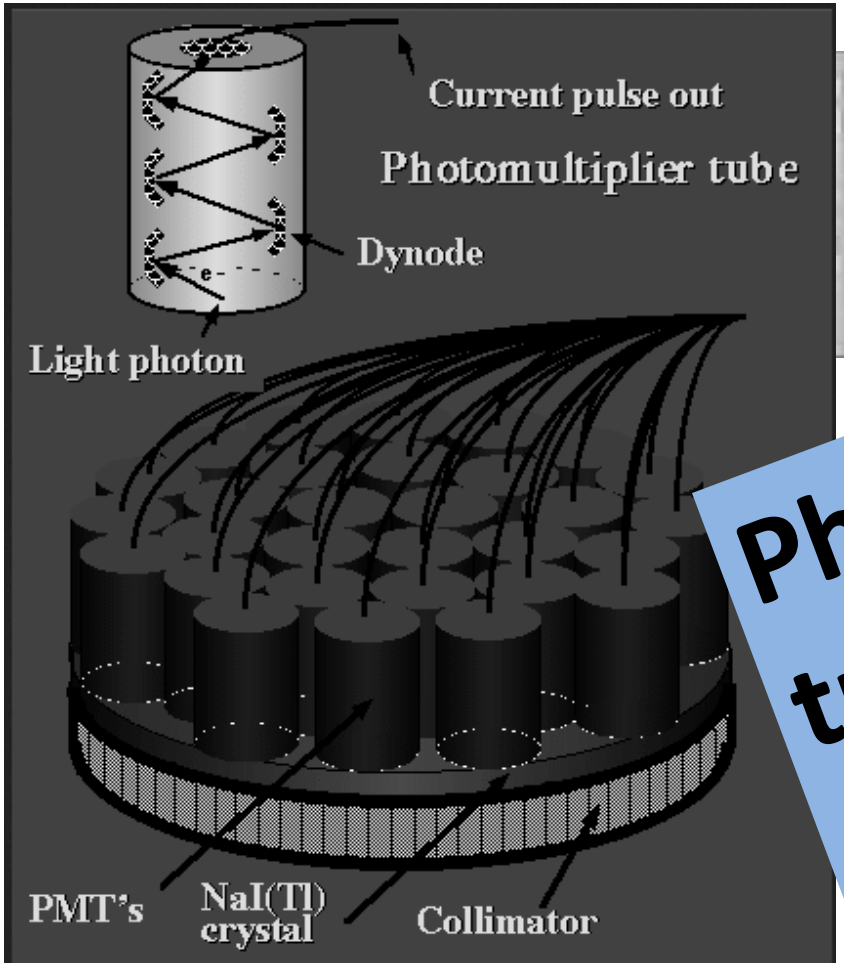
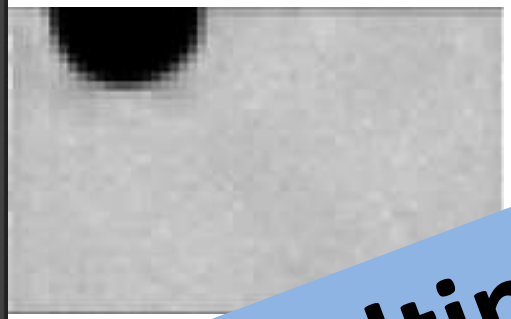
Cause?





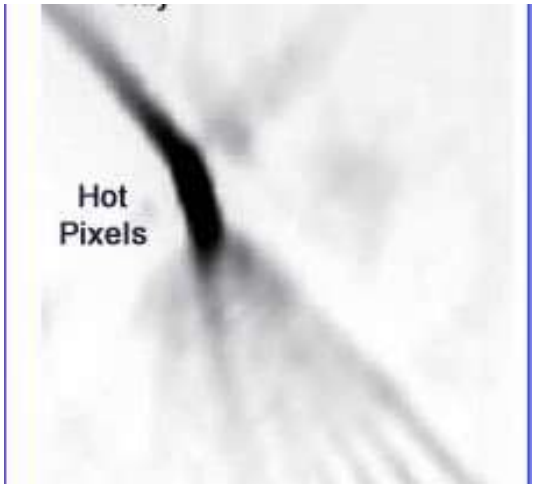
Photomultiplier tube malfunction

...ON NOT PROPER
...LECTRONICS ERROR
... MONITOR PHOSPHOR PROBLEM

Camera dependent

Name this artifact. Cause?

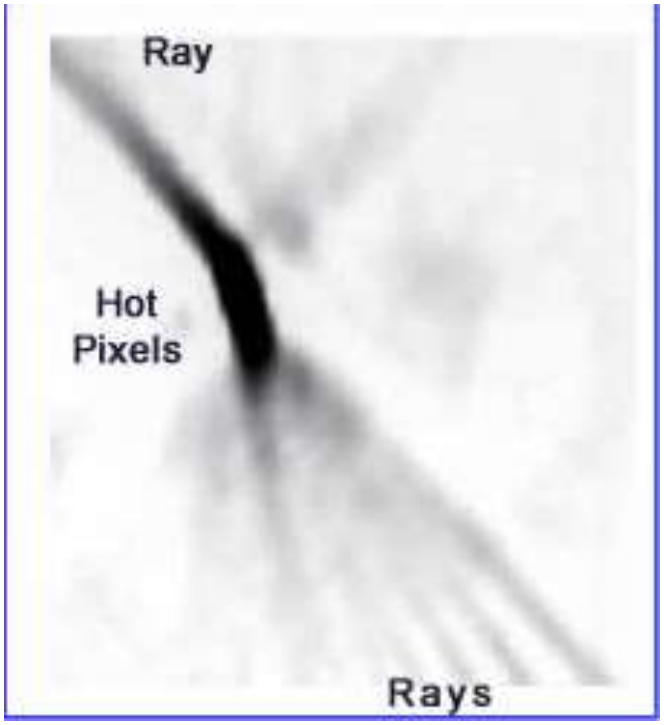
FBP image Cardiac



1. Ray Artifact
2. Ring Artifact
3. Motion Artifact
4. Truncation Artifact

Camera dependent

Name this artifact.
Cause?



1. Ray Artifact
2. [illegible]
3. Motion Artifact
4. Truncation Artifact

1. Ray Artifact

Camera dependent

Name this artifact.
Cause?

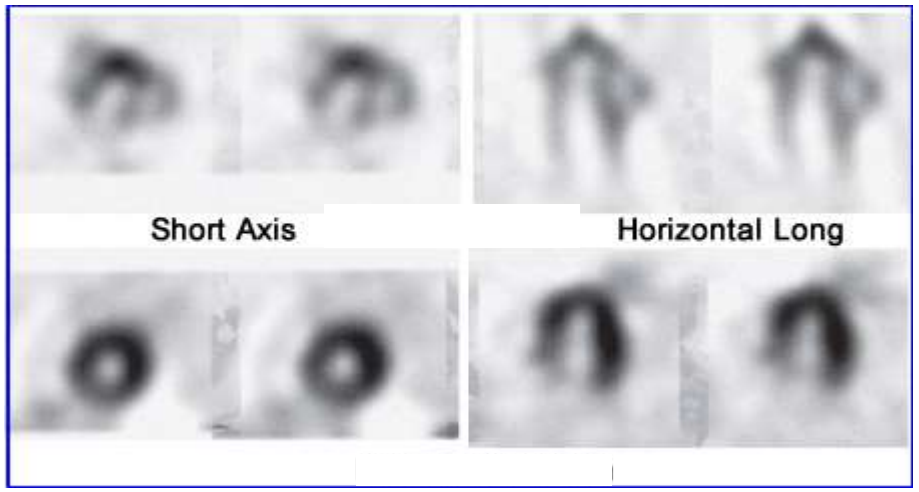
Two Slices of the Short Axis

Horizontal Views - Three Continuous Slices

1. Ray Artifact

Camera dependent

Name this artifact. Cause?



1. Ray Artifact
2. Ring Artifact
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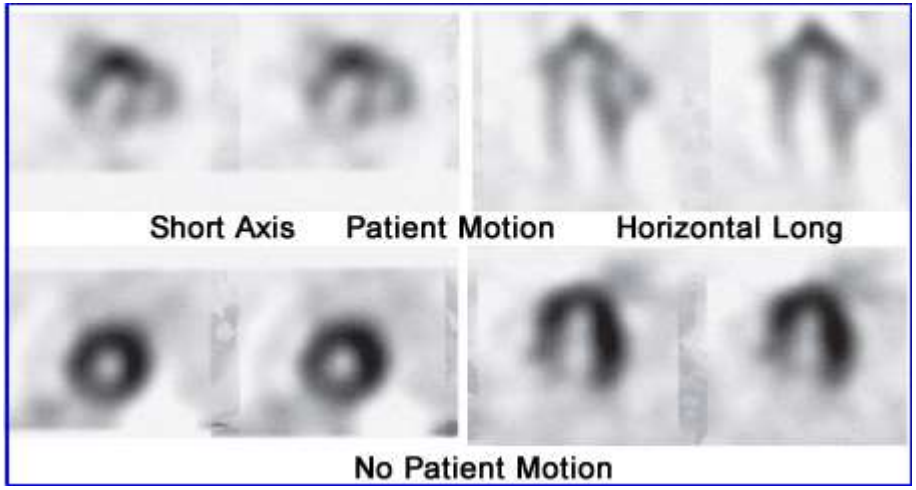
Camera dependent

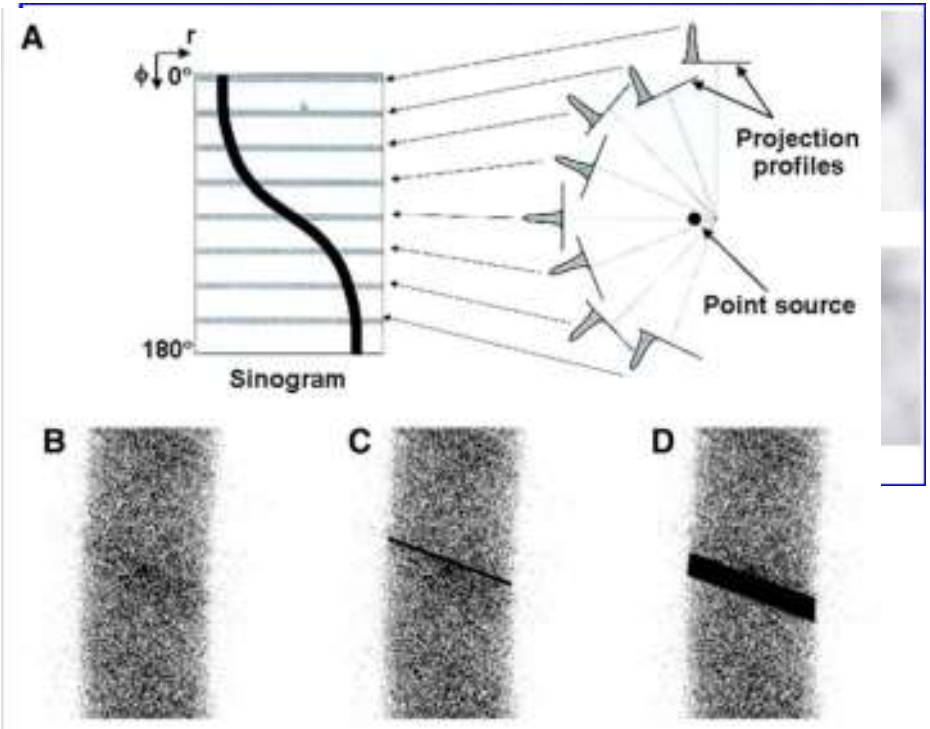
Name this artifact. Cause?



1. Ray Artifact
2. Ring Artifact
3. Motion Artifact
4. Truncation Artifact

Camera dependent

Name this artifact.
Cause?



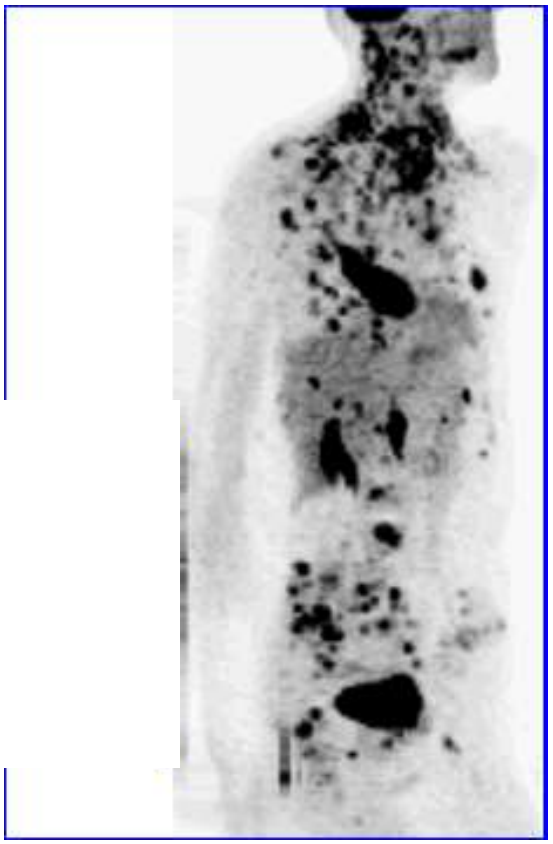
1. Motion Artifact

CHECK

SINO/LINOGRAM

Camera dependent

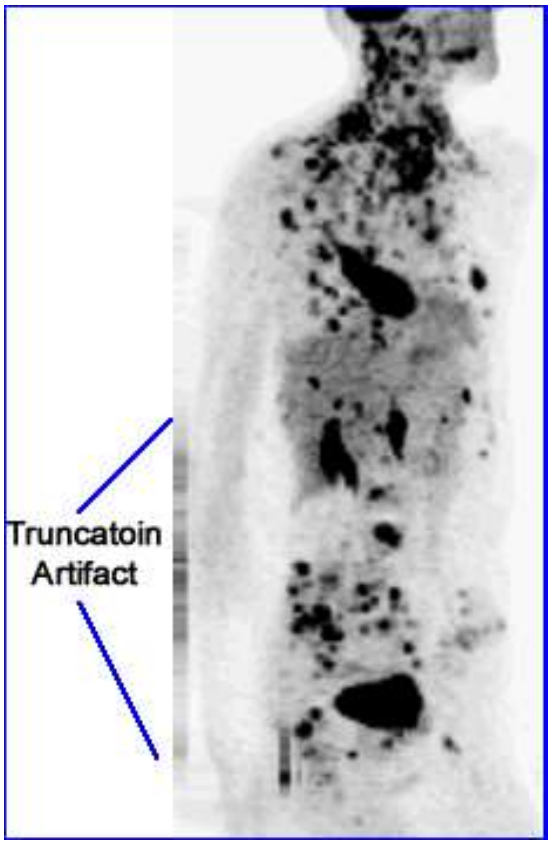
Name this artifact.
Cause?



1. Ray Artifact
2. Ring Artifact
3. Motion Artifact
4. Truncation Artifact

Camera dependent

Name this artifact.
Cause?

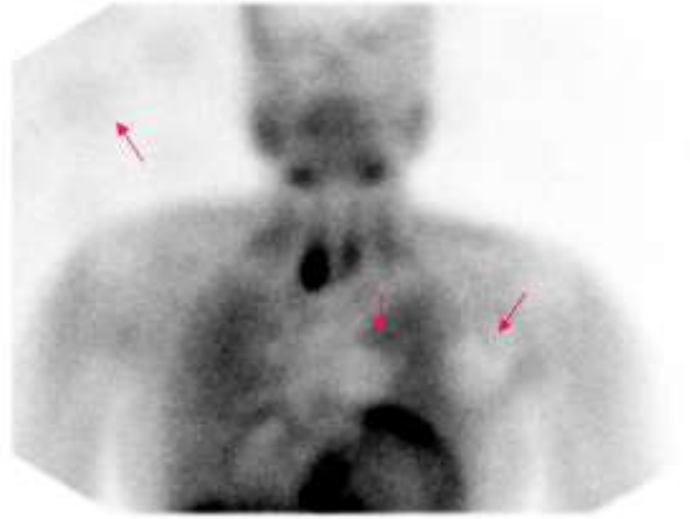


1. Ray Artifact
2. [illegible]
3. [illegible] Artifact
4. Truncation Artifact

1. Truncation Artifact

Camera dependent

Name this artifact. Cause?

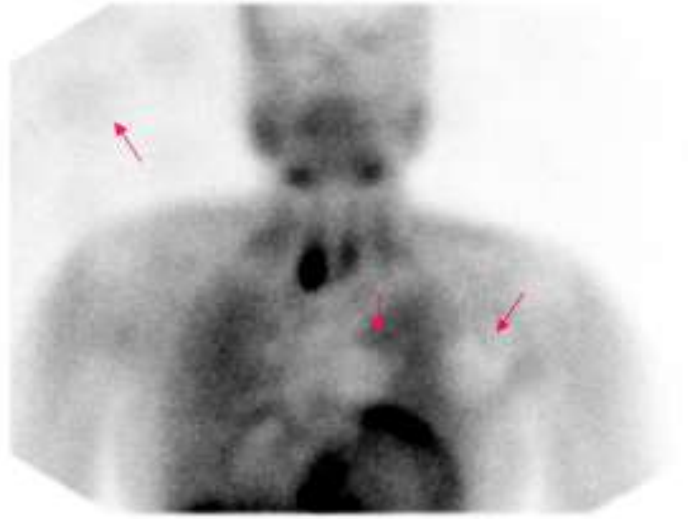


Parathyroid planar images

1. Ray Artifact
2. Ring Artifact
3. Motion Artifact
4. Truncation Artifact

Camera dependent

Name this artifact. Cause?

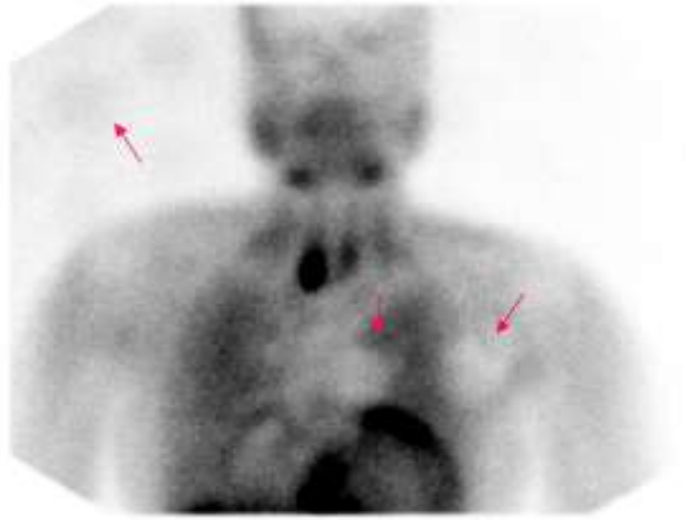


Parathyroid planar images

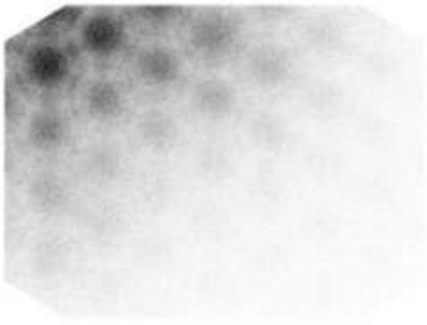
1. Ray
2. Ring
3. Motic
4. Truncat

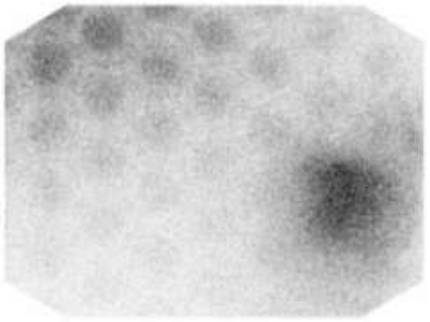
Camera dependent

Image made with no other source other than aerosol pulled into camera head



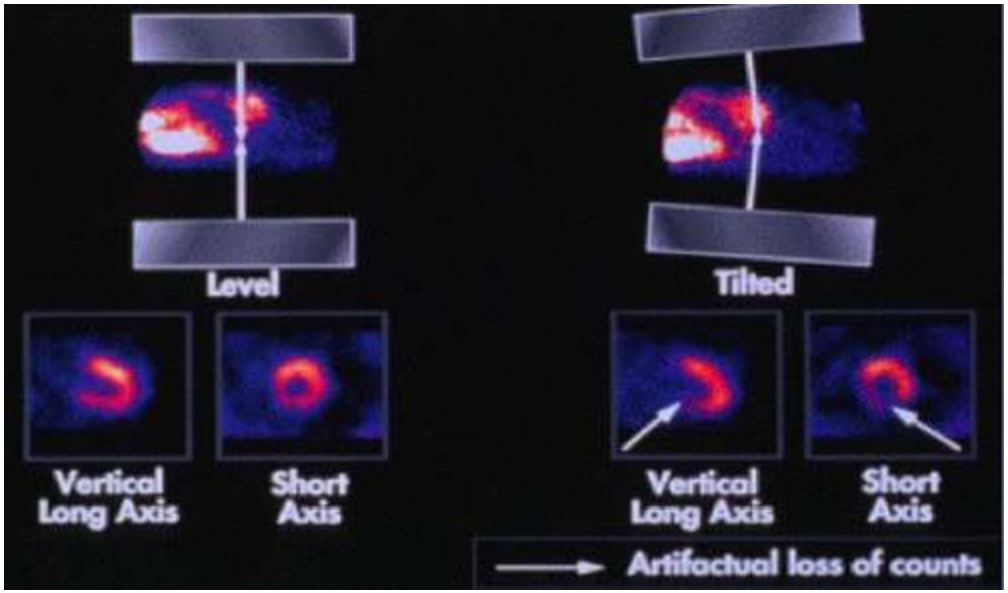
Parathyroid planar images





Cause:
99m Tc Aerosol from previous patient pulled into camera head by fans

Camera dependent



Tilted Detector

Camera dependent

Name this artifact. Cause?

In an anterior spot image of the thyroid, a starburst artifact may be seen. The cause of this artifact is:

A. Contamination of the collimator.
B. Imperfections in the evenness of the collimator holes.
C. An image reconstruction artifact caused by filtered back projection.
D. Local photomultiplier tube dead time.
E. Septal penetration.

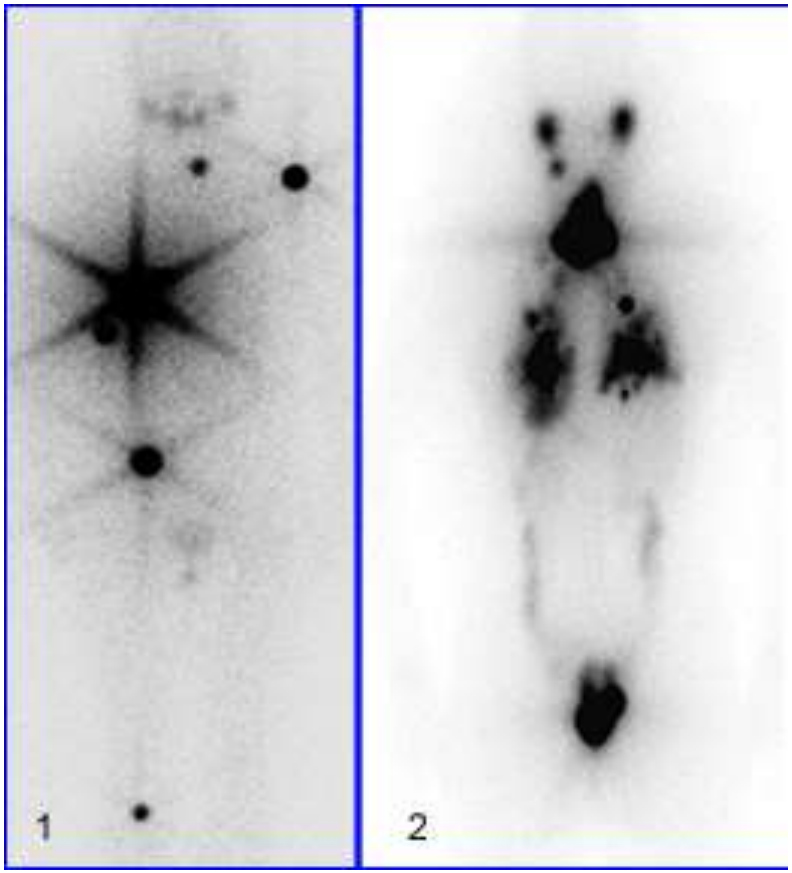
Camera dependent

Name this artifact. Cause?

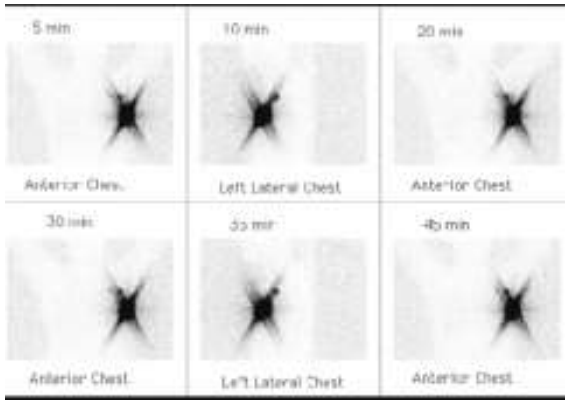
1. STAR Artifact
2. STAR Artifact
3. STAR Artifact
4. STAR Artifact

Camera dependent

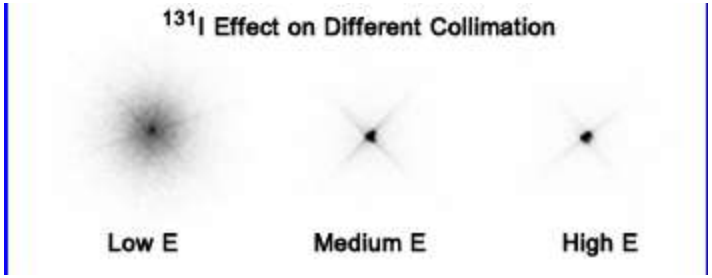
Name this artifact.
Cause?



Penetration fraction (PF) These photons have penetrated one or more lead septa, but are not attenuated enough, therefore cause scintillation and are accepted by the PHA.



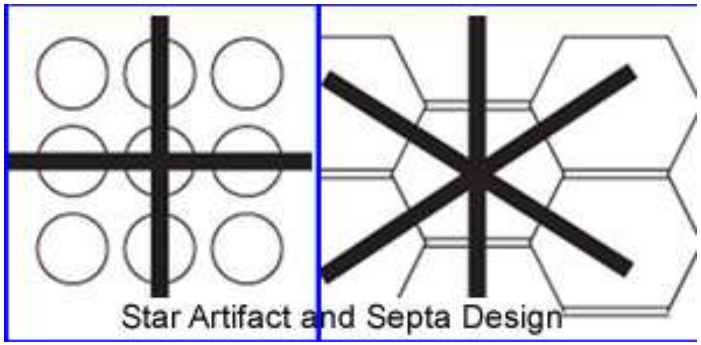
Camera dependent



Septa Thickness

Thickness must increase with acquisition for higher energy gammas. This reduces the

Penetration fraction.



Camera dependent

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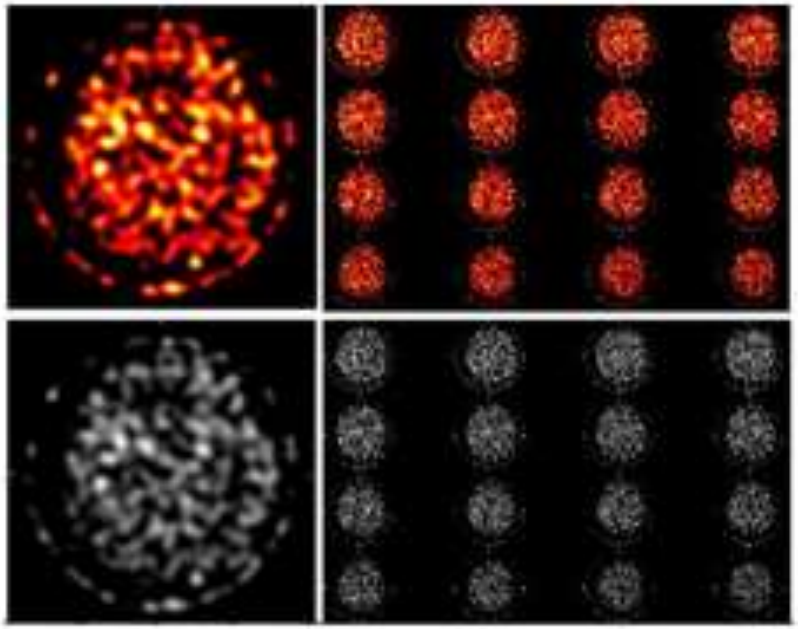
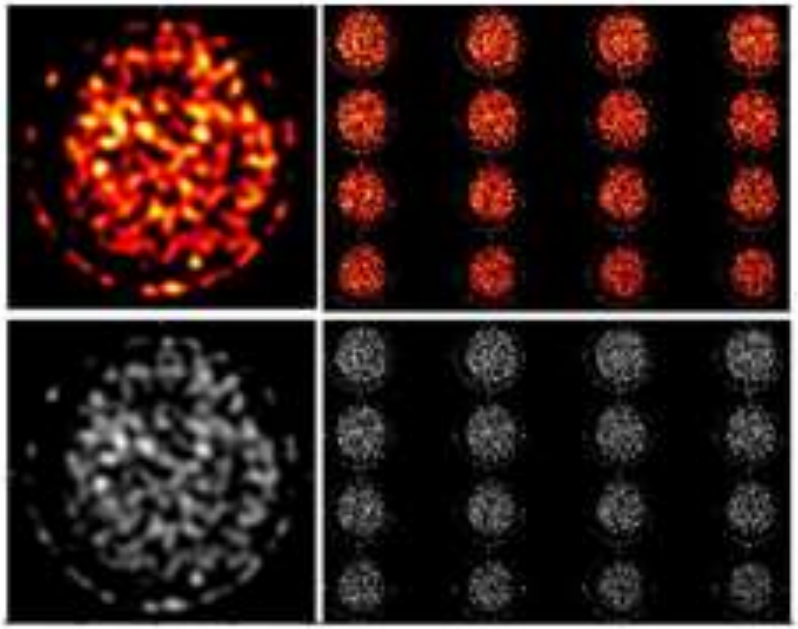
Cause?

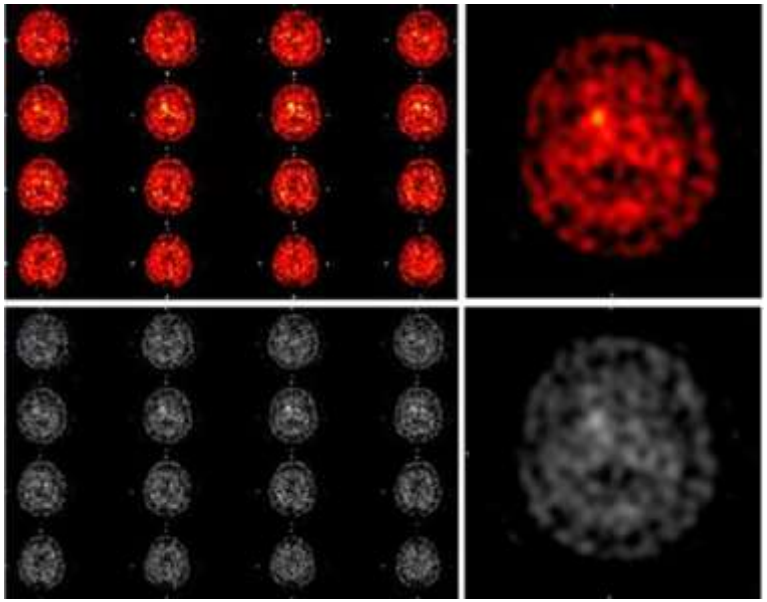


1. Ray Artifact
2. Ring Artifact
3. Motion Artifact
4. Truncation Artifact
5. Wrong Energy Window

Camera dependent



Incorrect Energy window outside 10%



CORRECT ENERGY WINDOW

Movement!

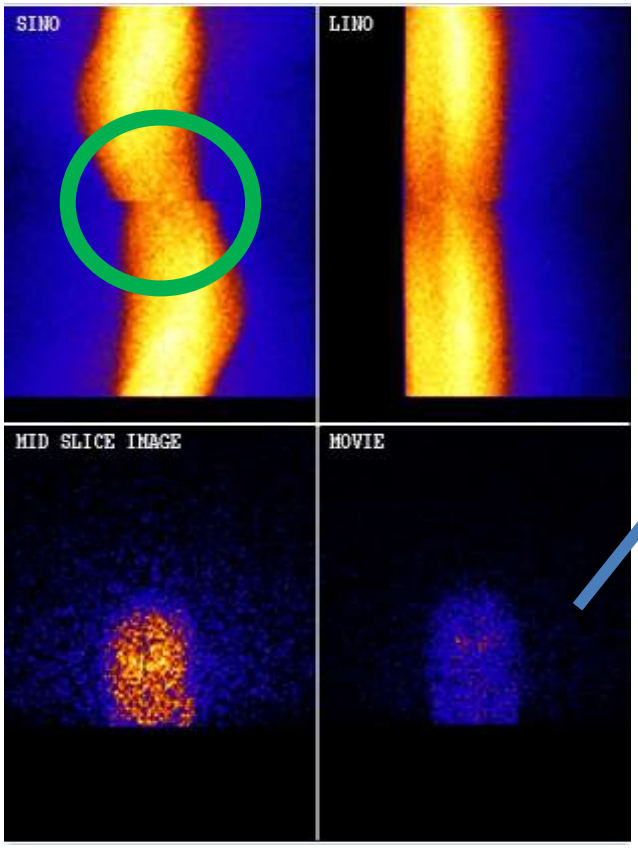
Long scan times (20-50 minutes) can lead to movement
Most common artefact – patient population.
Can minimise by reducing scan time, but leads to noisy data!

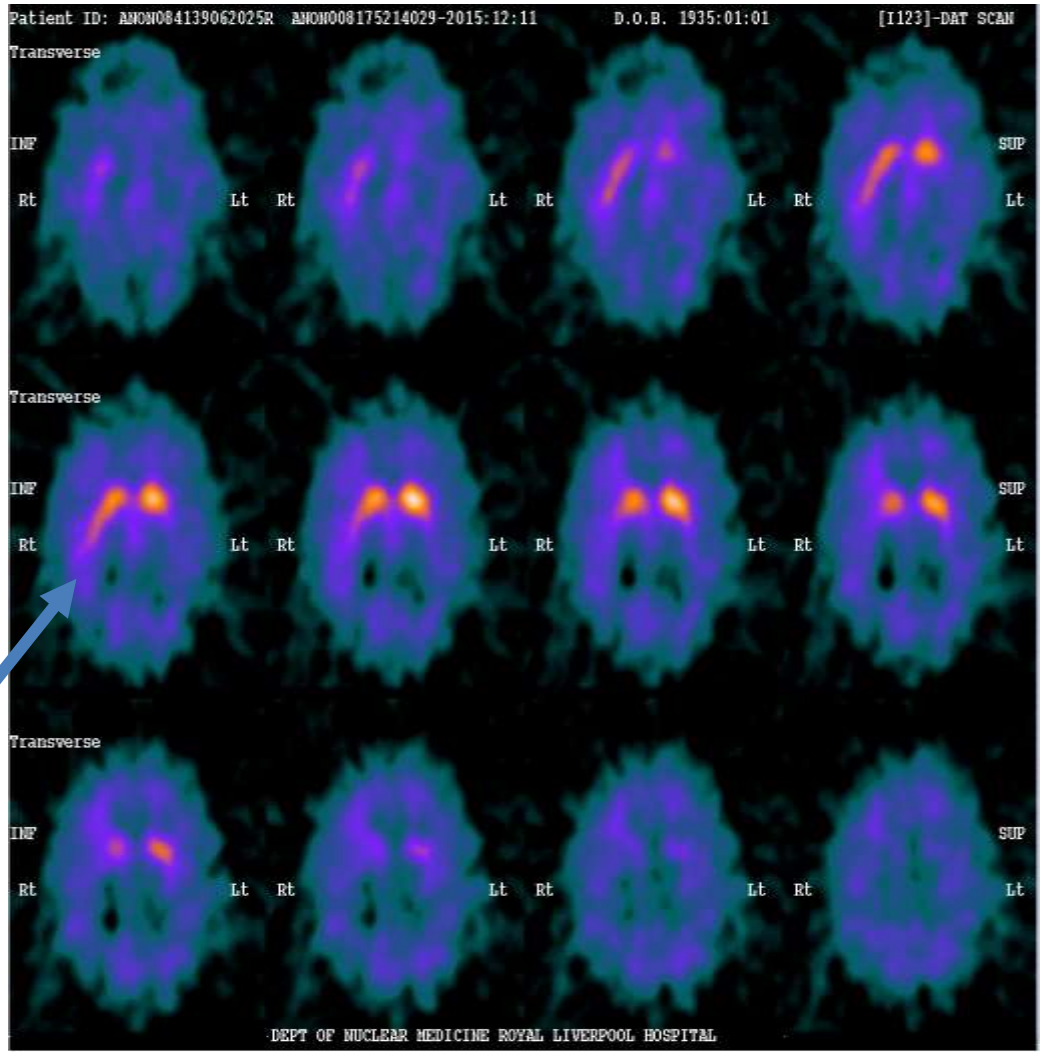
Attenuation artefacts

Additional material obscuring the radiopharmaceutical distribution
Rare

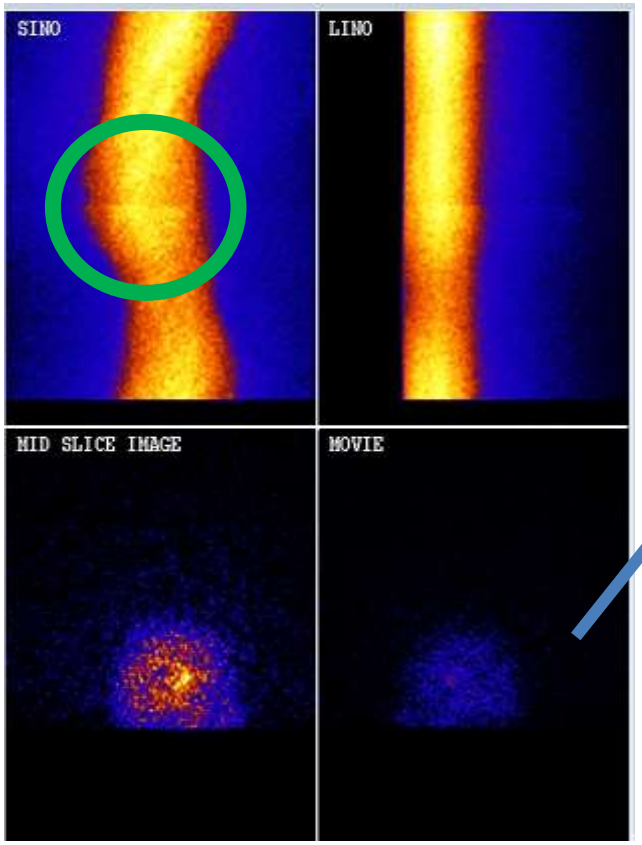
Patient-related

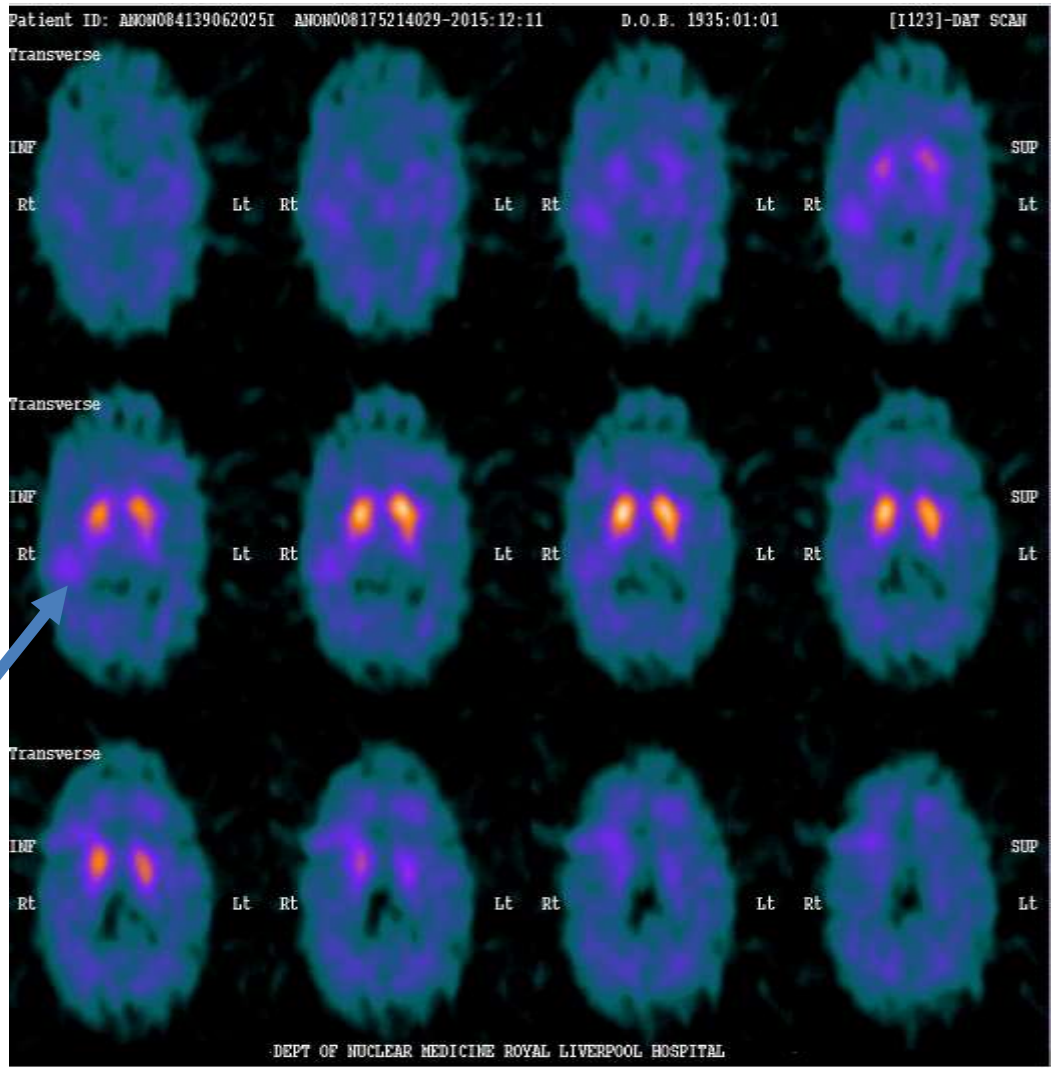
- Patient movement during scan





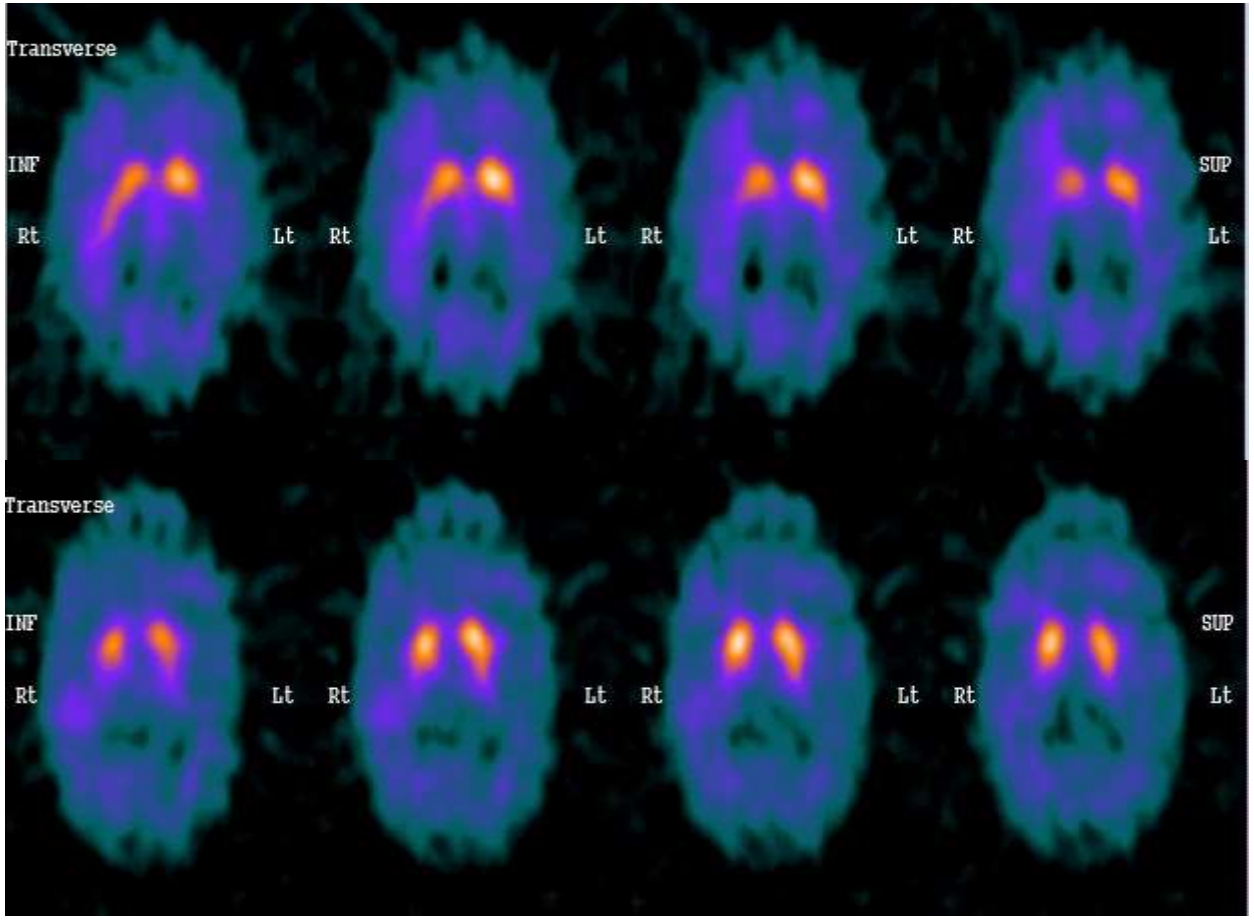
- Patient movement during scan





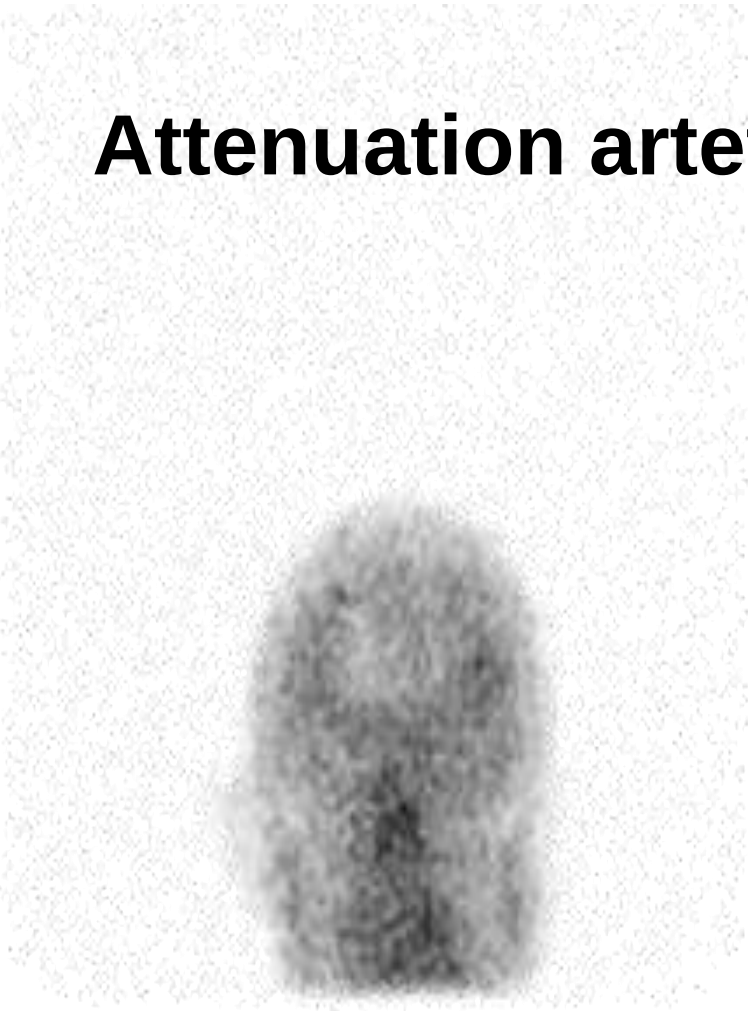
Movement

Post correction



Have you noticed anything peculiar?

Attenuation artefact



Photopaenic rim
Due to technologist arm helping patient

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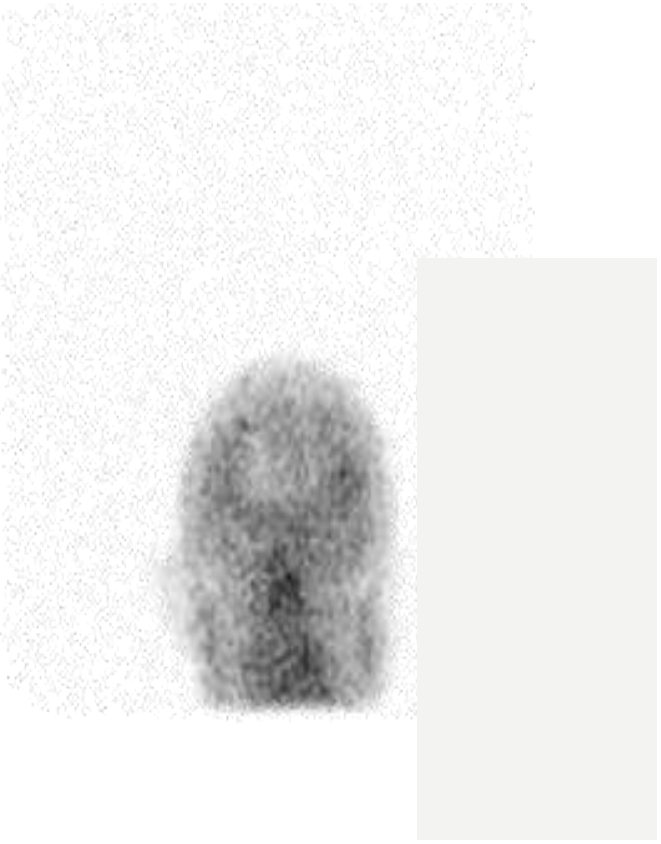
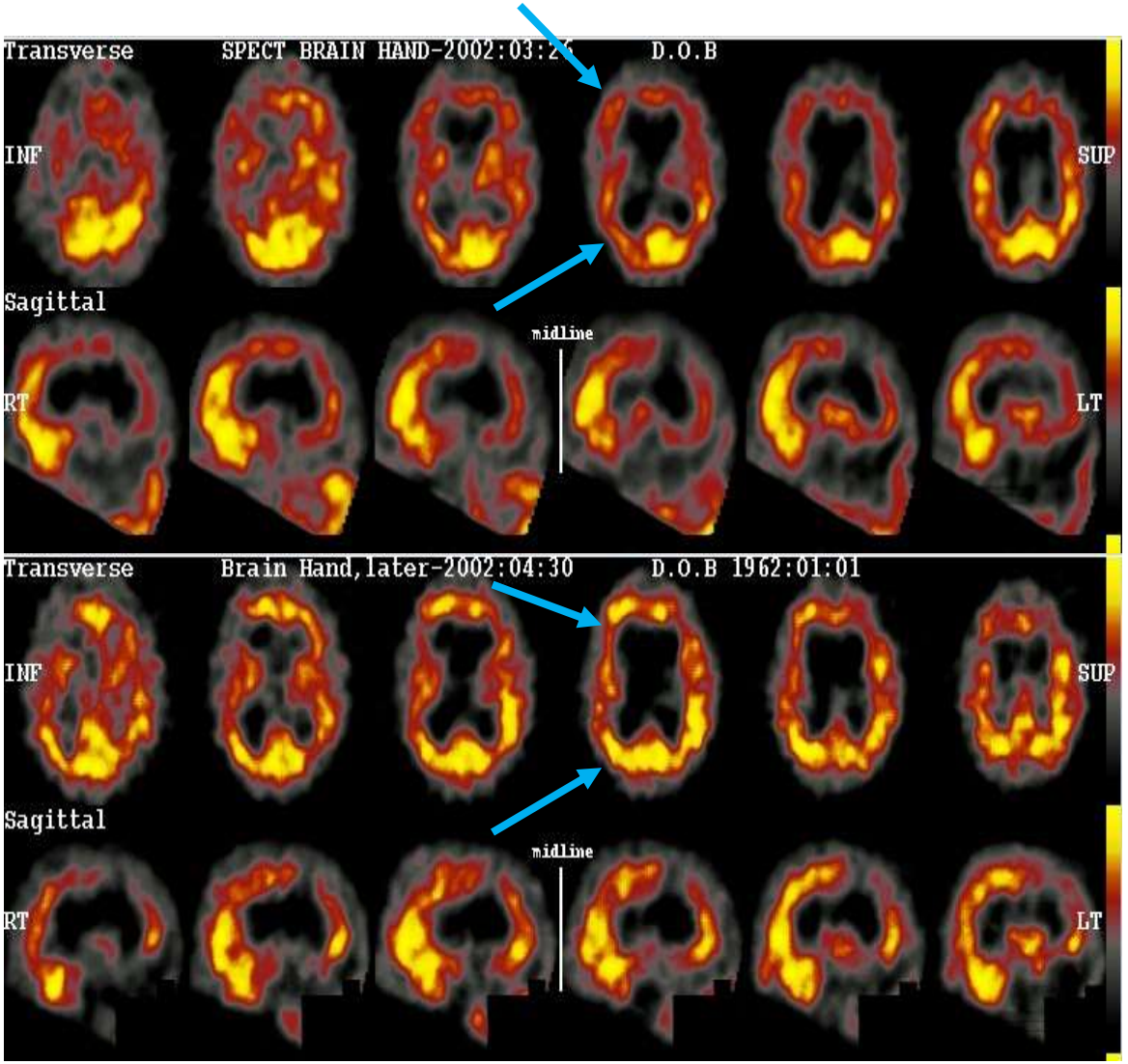
Attenuation artifact



Repeat

Attenuation Artifact



Repeat

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Bone Scan Artifacts

Most Common Study in General Nuclear Medicine

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Bone Scan

Common Artifacts in Bone Scintigraphy

Radiopharmaceutical	Free pertechnetate (stomach, thyroid, salivary glands)
Technical	Injection site, lymph node (radiotracer extravasations), injection into central venous catheter, arterial injection
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Metallic	Belt buckle, medallion, jewellery, pace maker
Instrumentation	Photomultiplier tube, cobalt peak, image contrast
Treatment	Postradiotherapy

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Bone Scan

Effects of Faulty Radiopharmaceutical Preparation on Bone Scan

Fault	Effect on bone scan
Free pertechnetate due to presence of air in container, a long-standing preparation, an inappropriate amount of stannous ion, or altered preparation	Thyroid uptake on early images (blood pool) and stomach, gastrointestinal tract, and salivary gland uptake
Colloid formation due to aluminum	Diffuse liver uptake and reduced bone uptake
High pH in the preparation	Liver, gallbladder, and gastrointestinal tract uptake
Drug interaction:	
Diphosphonates, etidronate	Decreased bone uptake
Iron	Increased soft-tissue uptake; renal cortex uptake
Chemotherapy	Renal cortex uptake and diffuse skull uptake

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Bone Scan

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0.5sec per frame

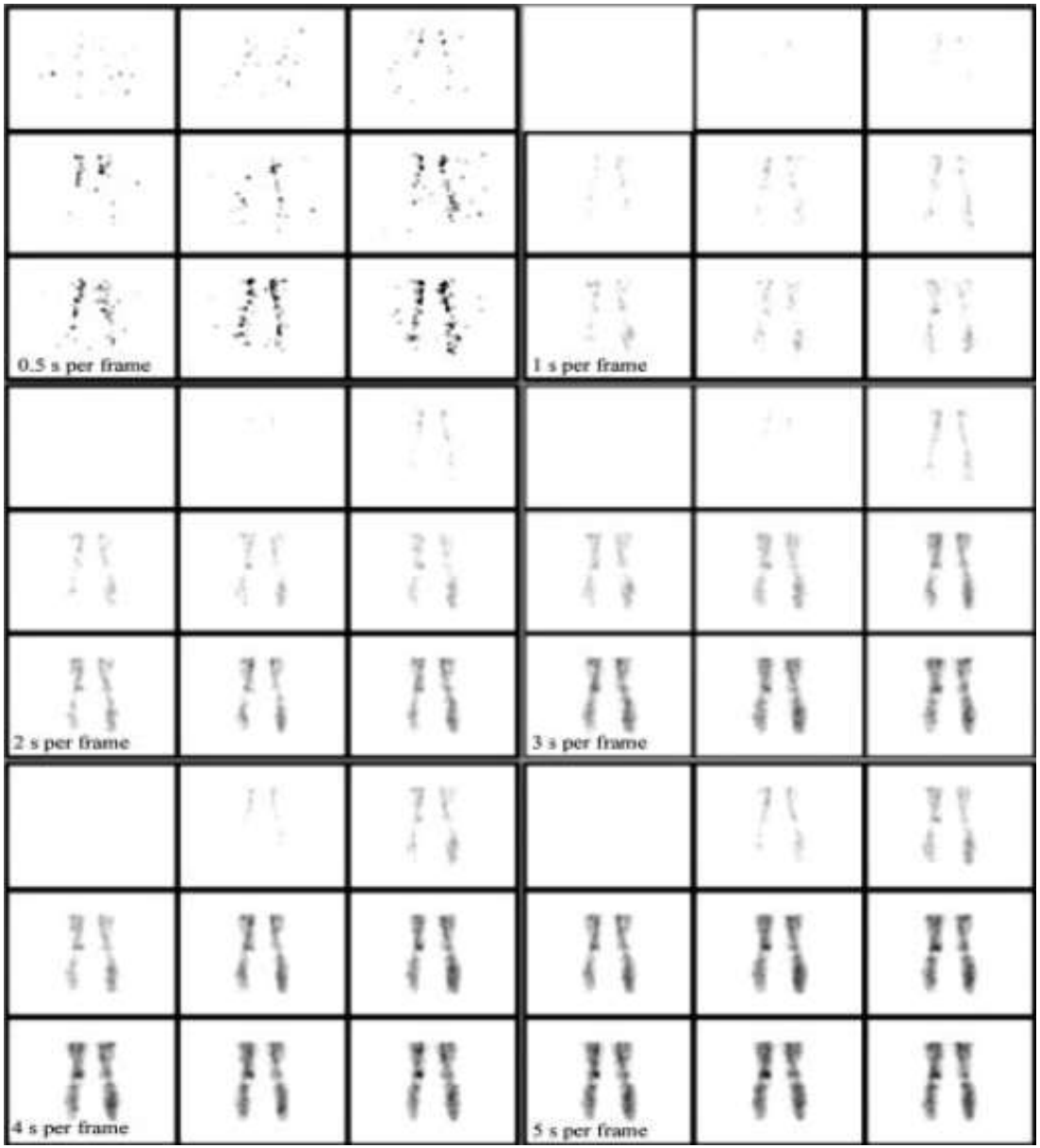
1sec per frame

2sec per frame

3sec per frame

4sec per frame

5sec per frame



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Bone Scan

Can you match the image with the correct collimator???

1.LEHR **2.ME** **3. LEGP**

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Bone Scan

LEHR **LEGP** **ME**

Can you match the image with correct collimator???

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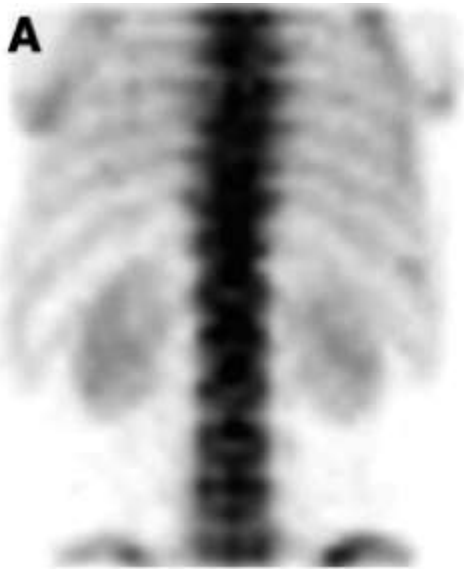
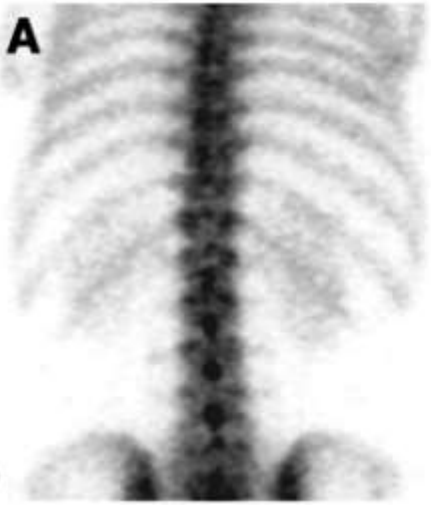
Bone Scan

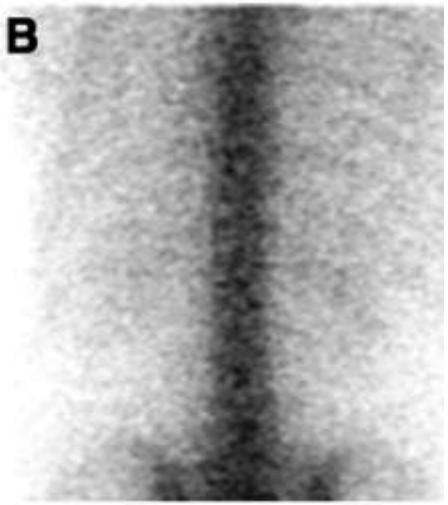


20% 140-keV photo-peak

20% 122-keV photo-peak



Matrix 64x64



Matrix 256x256

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Bone Scan

Common Artifacts in Bone Scintigraphy

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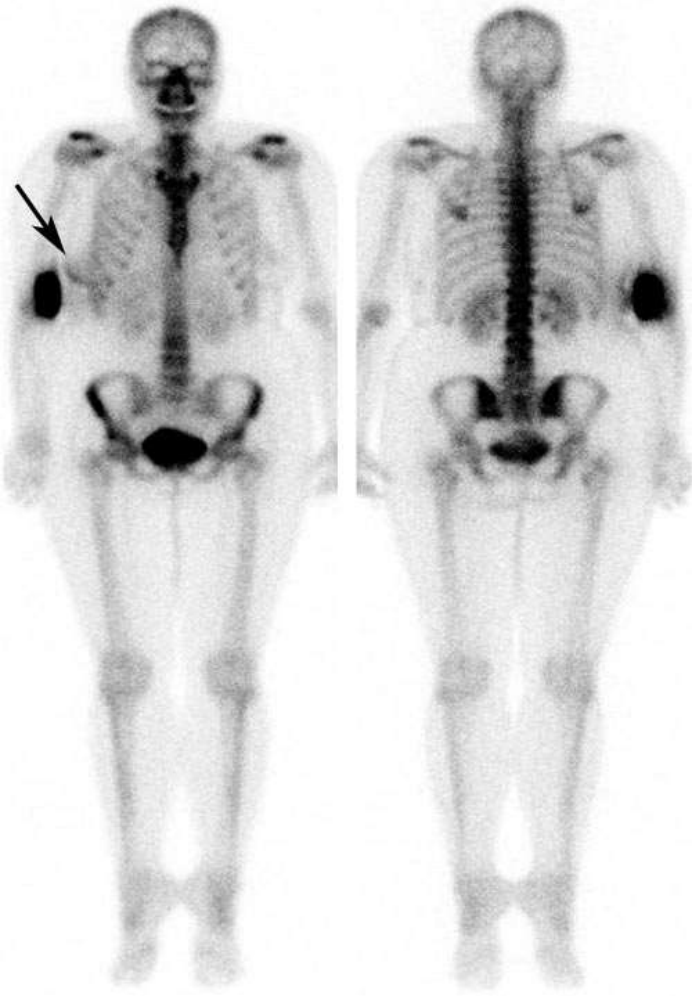
Bone Scan

Common Artifacts in Bone Scintigraphy

Tracer extravasation

?Breast uptake

?Inflammation/Infection



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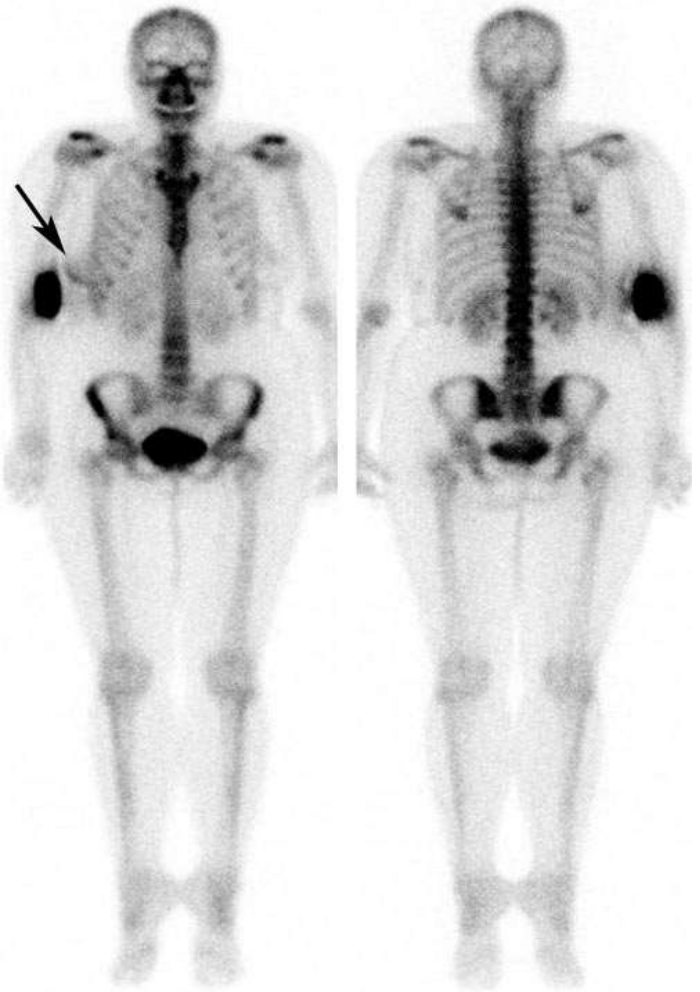
Bone Scan

Common Artifacts in Bone Scintigraphy



Tracer extravasation

Compton scatter from a partially infiltrated dose

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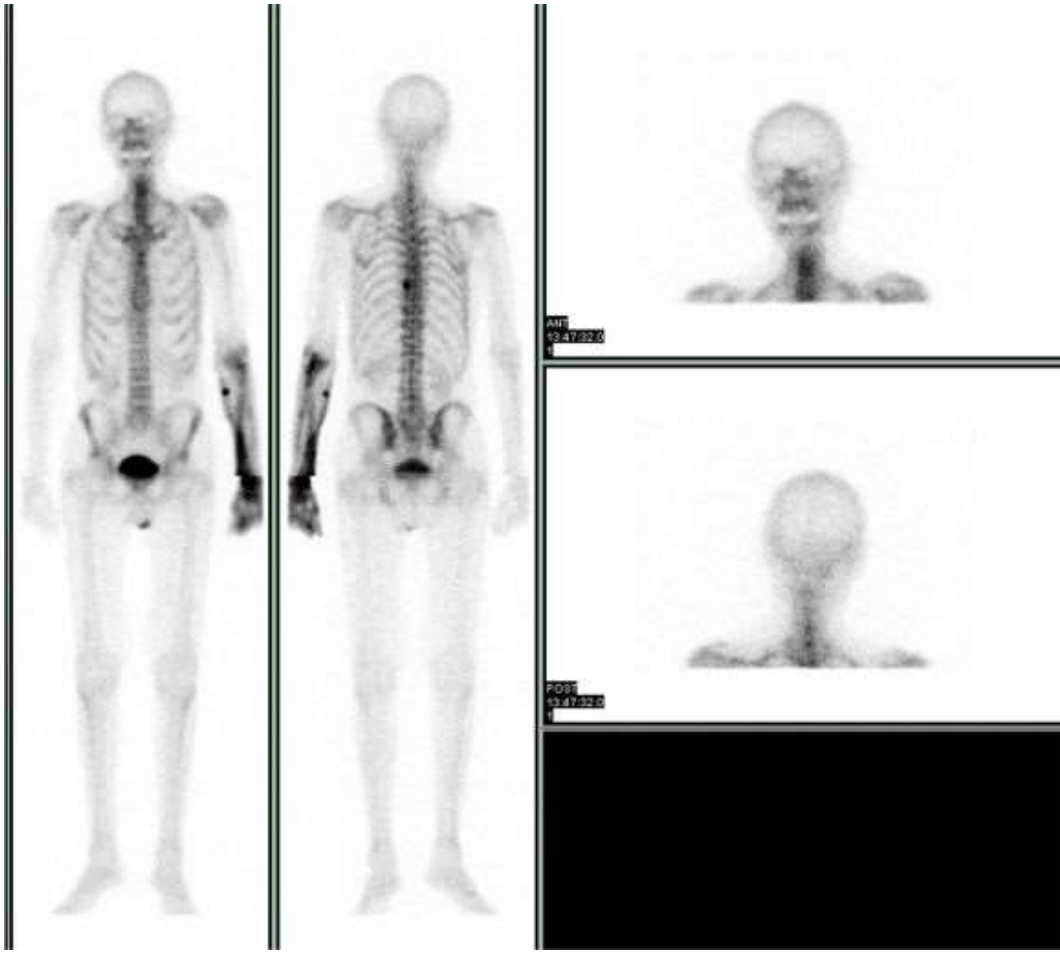
Bone Scan



?Inflammation/Infection
Of the left forearm
?Contamination

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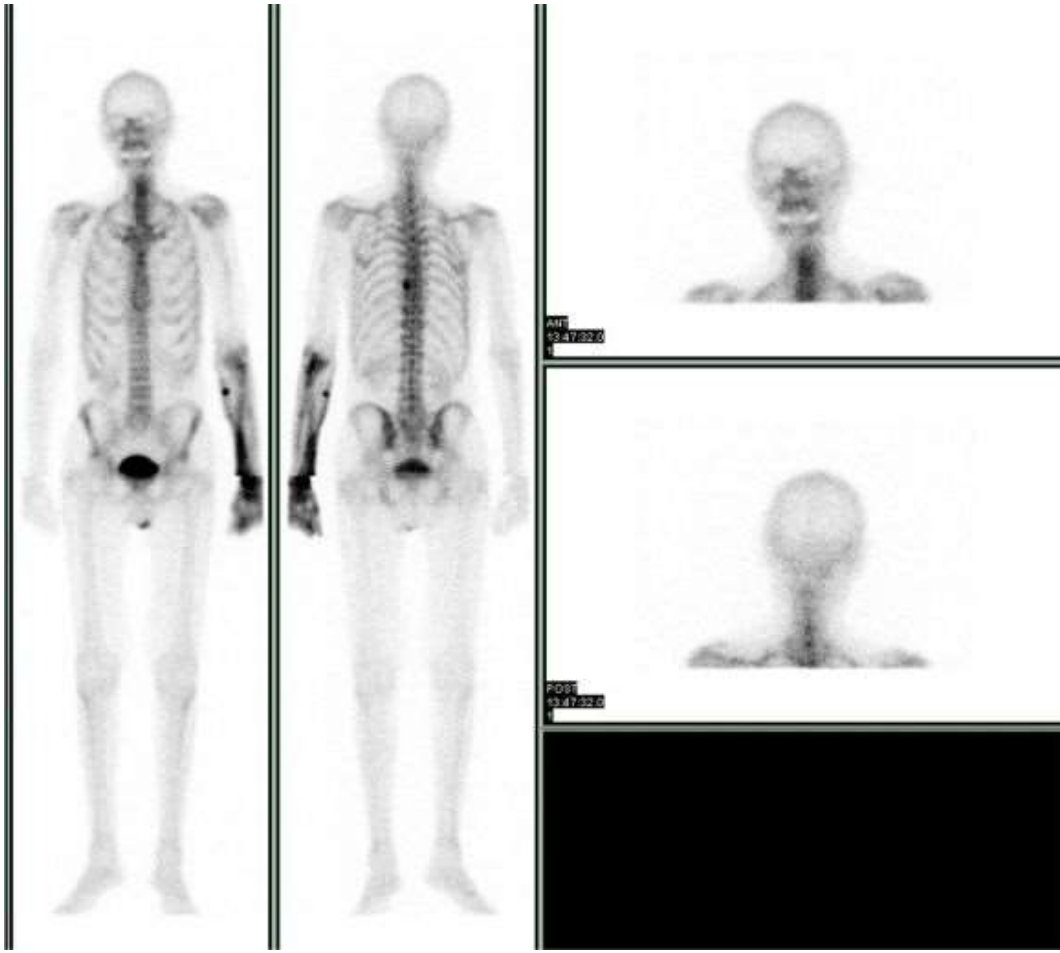
Bone Scan



Glove's sign due to arterial injection

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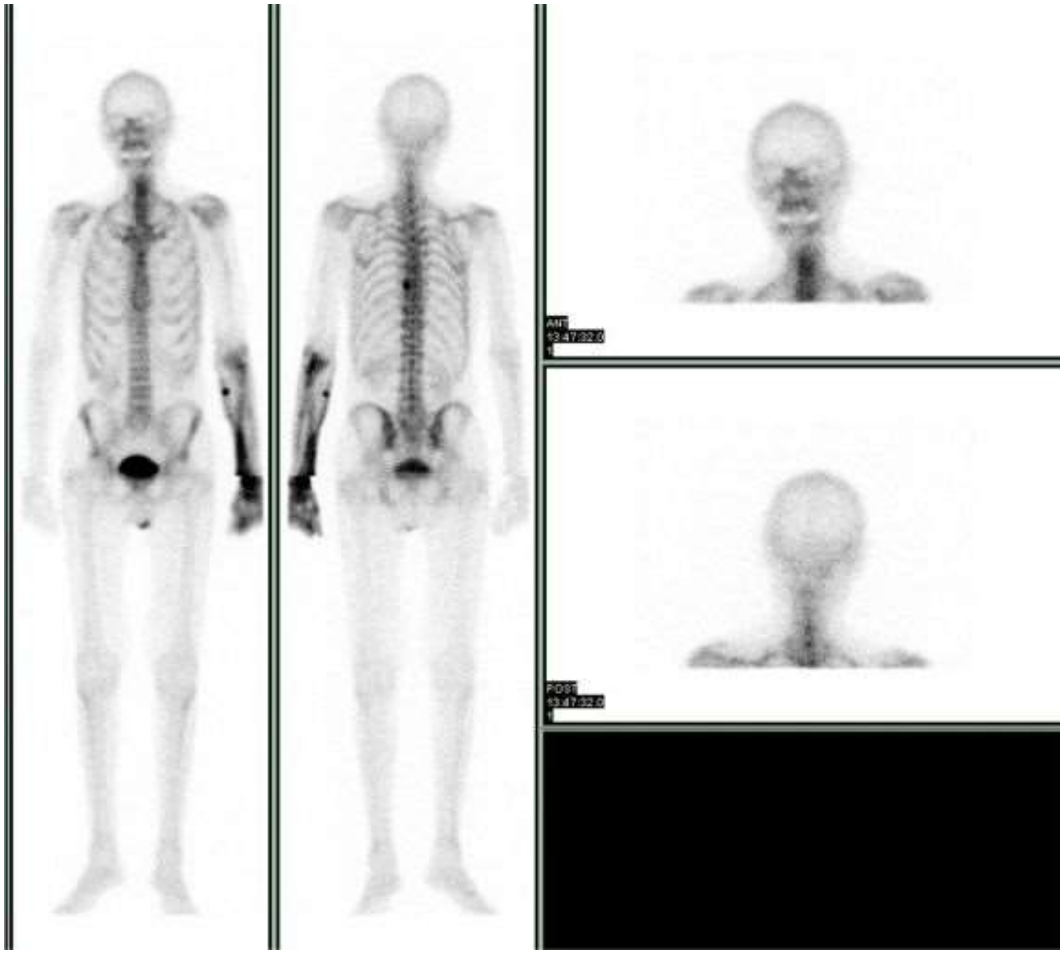
Bone Scan



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Bone Scan

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Bone Scan

?Plaster problem

?Inflammation/Infection

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Bone Scan

Urinary Contamination at the site of sock

Bone Scan

Common Extraosseous Activity in bone scan

Organs	Conditions
Breast uptake	Diffuse: gynecomastia induced by hormonal therapy (prostate cancer), normal breast (females) Focal: benign and malignant conditions
Cardiac uptake	Focal uptake: myocardial necrosis, unstable angina, myocardial contusion, ventricular aneurysm Diffuse uptake: amyloidosis, hypercalemia, adriamycin induced cardiotoxicity, alcoholic cardiomyopathy, pericardial tumors, pericarditis
Muscle uptake	Rhabdomyolysis: injury/trauma, excessive exertion, electric burns, renal failure, non-traumatic causes include cocaine/alcoholic intoxication, scleroderma, polymyositis, carcinomatosis myopathy, muscular dystrophy, dermatomyositis Heterotopic bone formation/myositis ossificans: Following direct trauma/paralysis, complicated hip arthroplasty, patients with burns
Renal uptake	Diffuse increased uptake: Following chemotherapy (vincristine, doxorubicin cyclophosphamide) nephrocalcinosis/hypercalcemia, iron overload, sickle cell disease, early stages of acute tubular necrosis, glomerulonephritis Focal increased uptake: normal or obstructed collecting systems (rarely in renal neoplasms) Decreased uptake/non-visualization: superscan (malignant and metabolic), nephrectomy Focal reduced uptake: cyst, partial nephrectomy, abscess, tumor, scarring
Pulmonary uptake	Radiation pneumonitis, postradiotherapy, malignant pleural effusion, hyperparathyroidism/hypocalcemia, rarely bronchogenic carcinoma and sarcoidosis, etc
Splenic uptake	Sickle cell disease, glucose-6-phosphtase deficiency, lymphoma, leukemia, thalassemia
Gastric uptake	Free pertechnetate, hypercalcemia (with metastatic calcification)
Bowel uptake	Surgical diversion, necrotising enterocolitis, ischemic bowel infarction, patient practicing urine therapy
Liver uptake	Liver metastases, elevated aluminum ion breakthrough in ^{99m}Tc eluate, amyloidosis, hepatic necrosis
Tumor uptake	Neuroblastoma, lung tumors/metastases, breast tumors, sarcomas, etc
Ascites	Malignancy
Superficial skin surface	Body folds in obese patients/hyperhydrosis
Arteries	Calcification of major arteries (eg, femoral)
Brain	Cerebral infarct

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ne Scan

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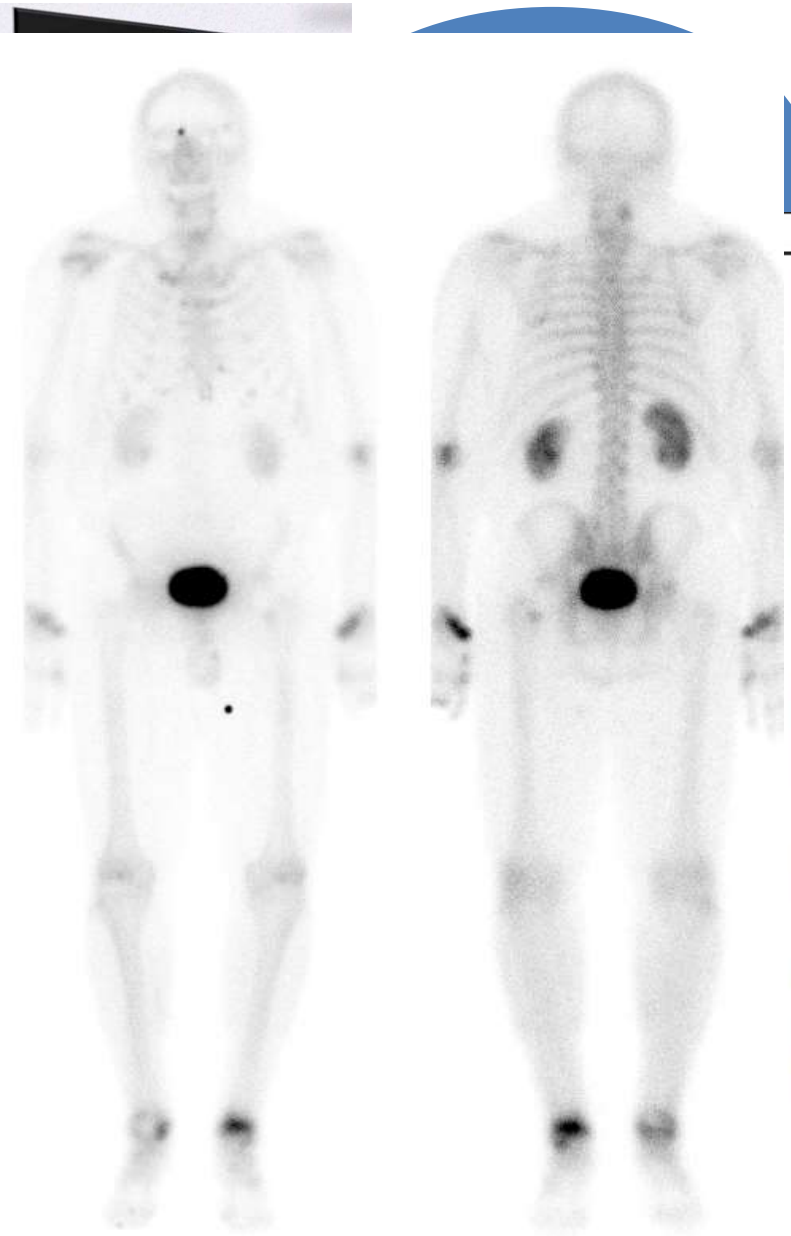

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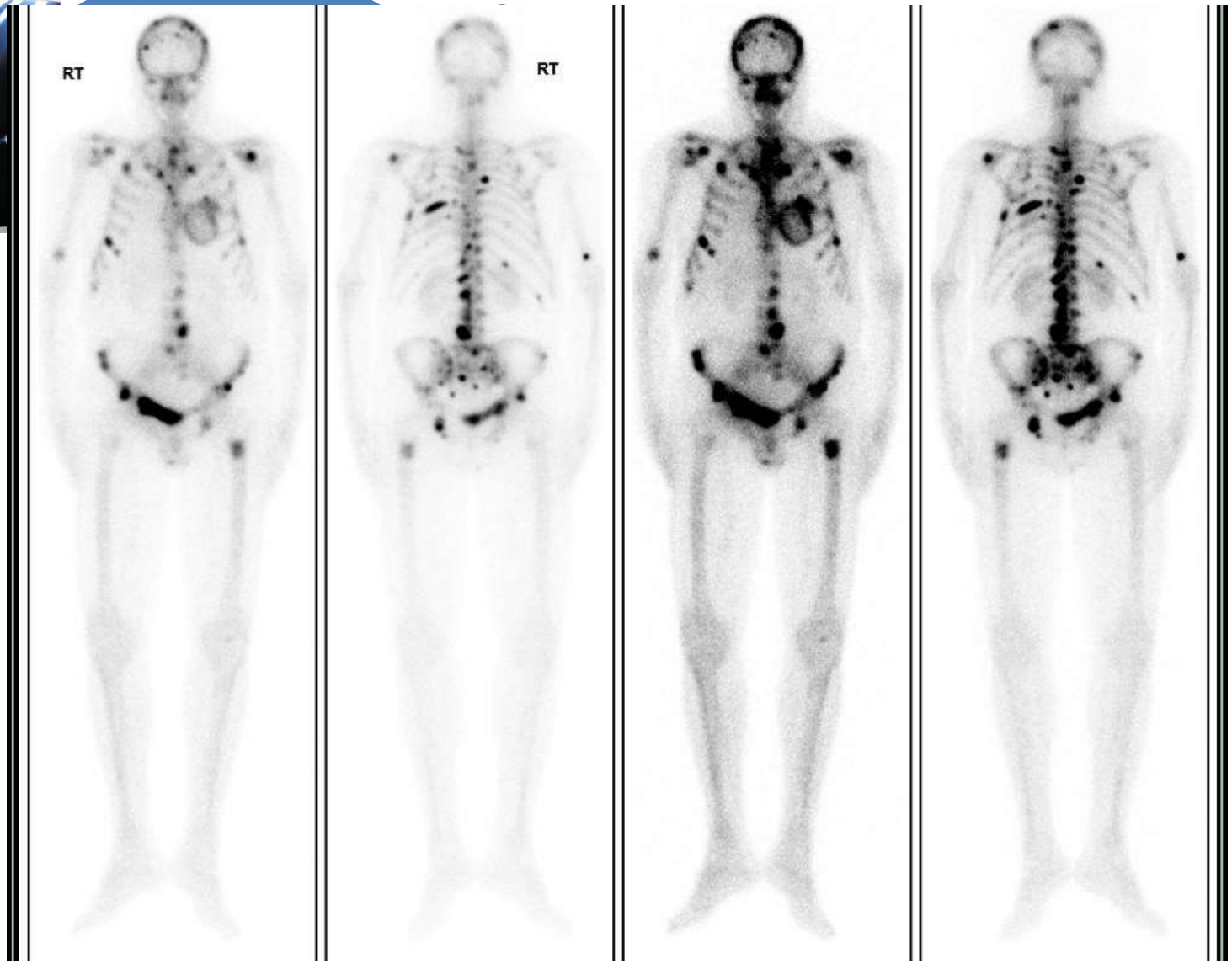

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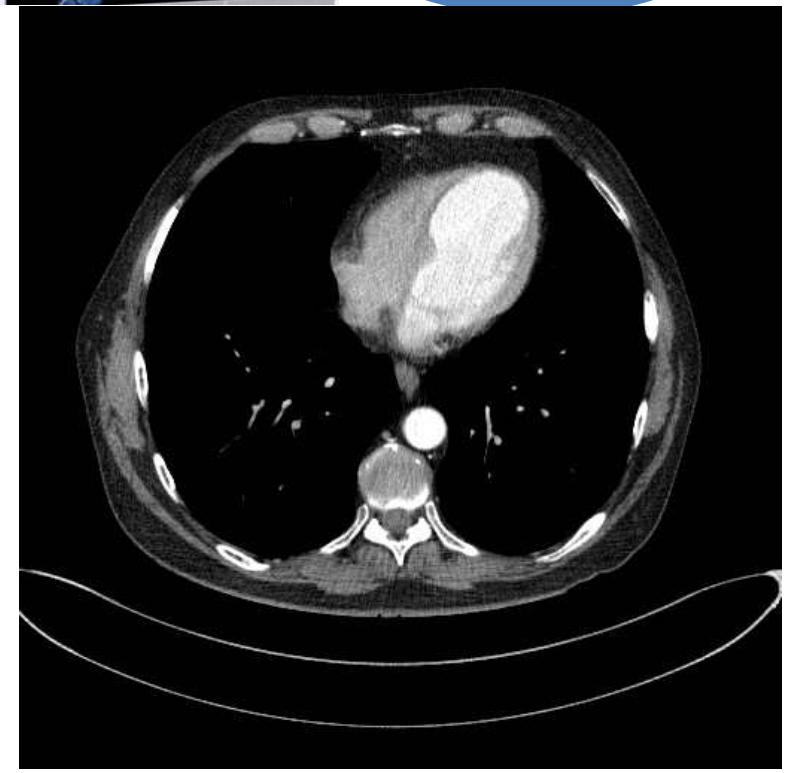
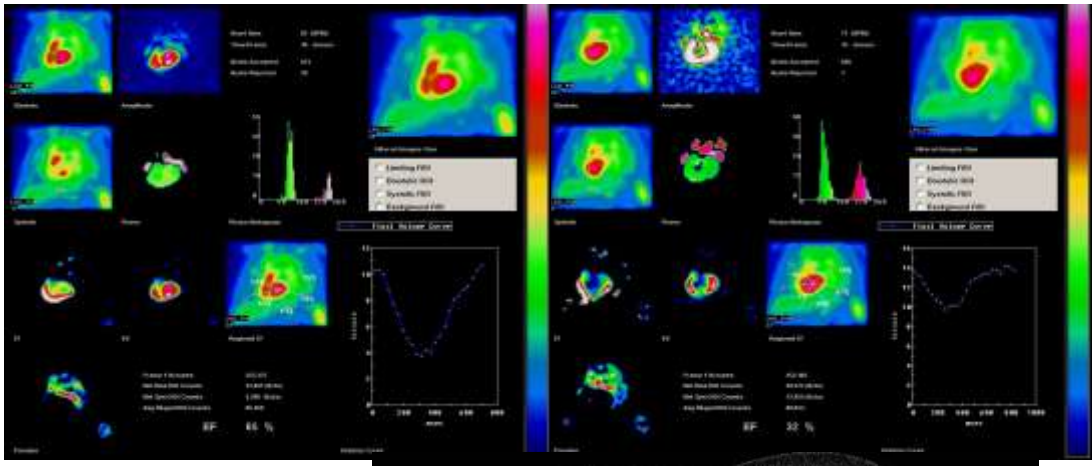
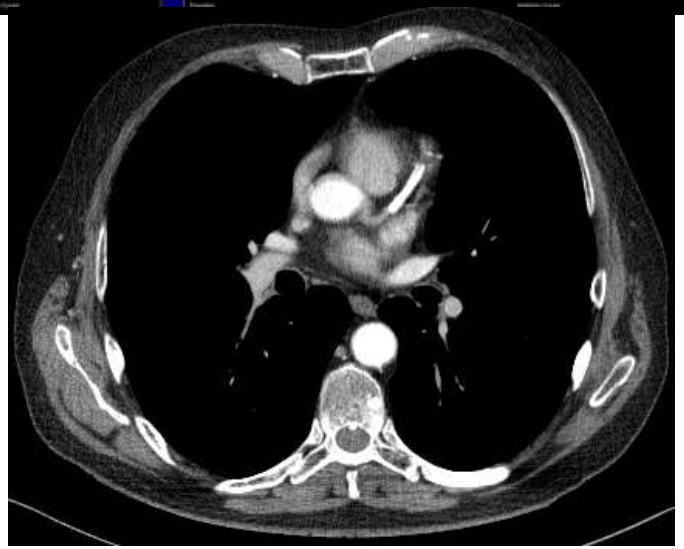
Bone Scan

Cardiac diffuse tracer activity due to MI- PCI in LAD







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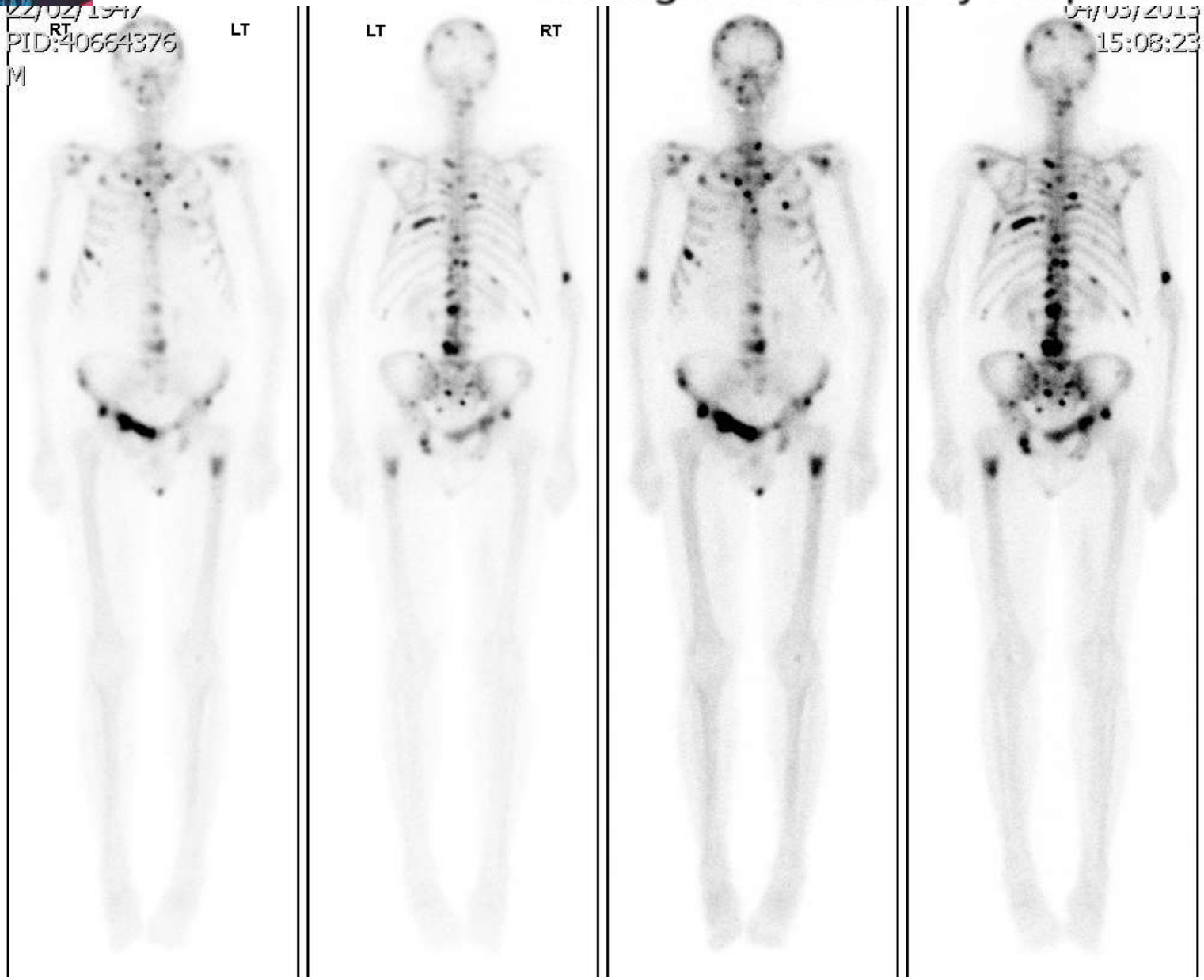

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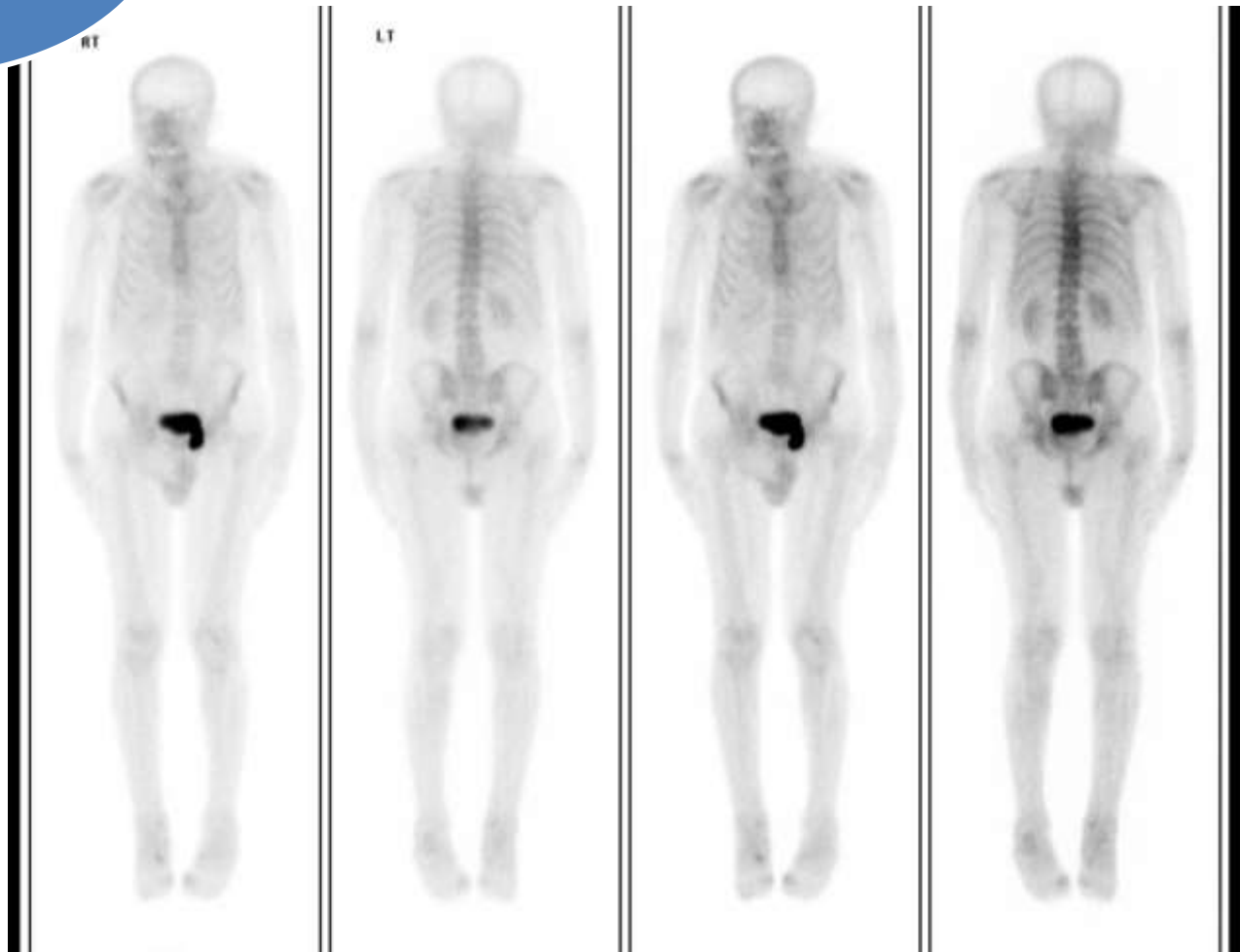
Bone Scan

?Bladder
?Contamination
?Bone Metastases
What should have been done to help

- ?additional views



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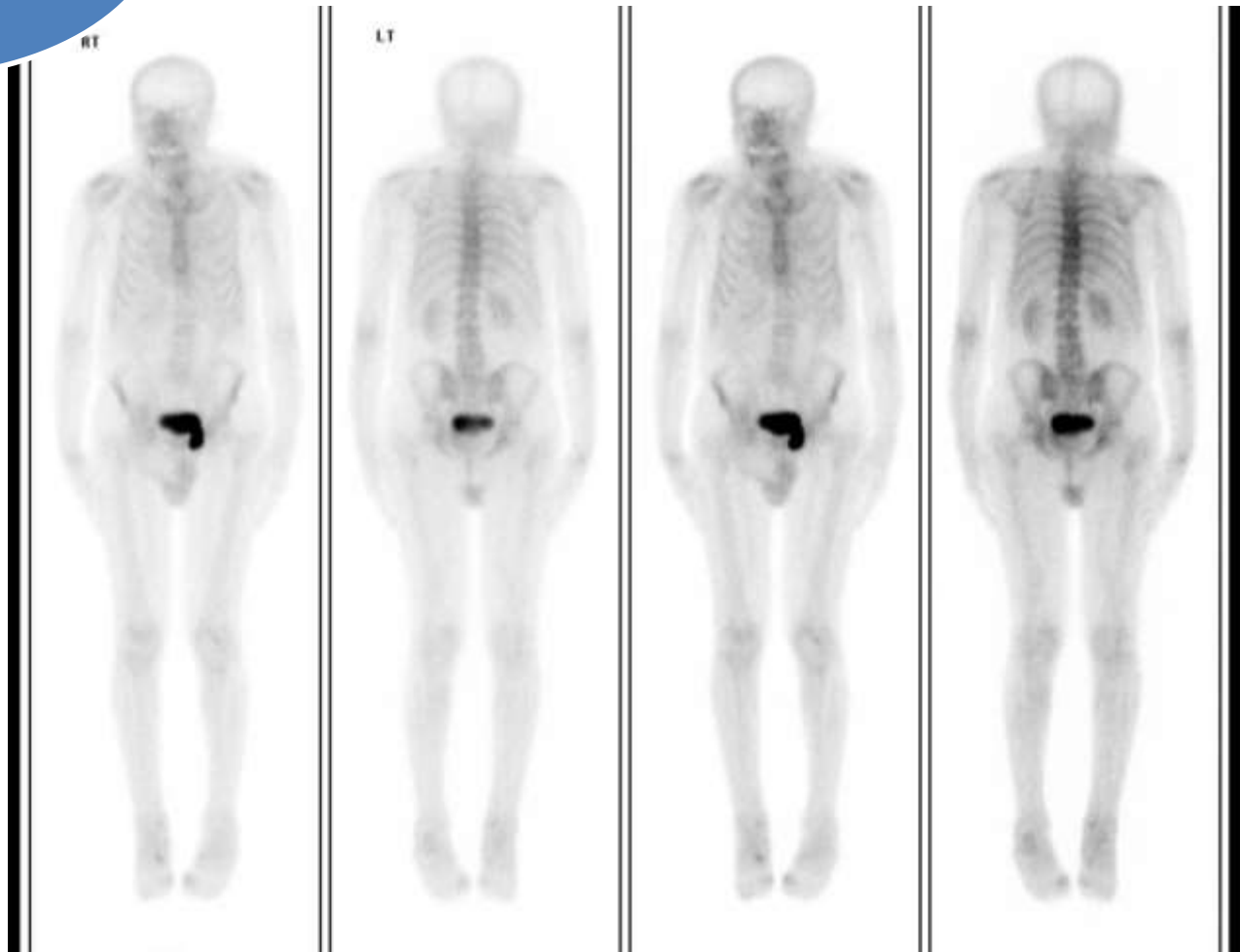
Bone Scan

Or check
Previous images



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Bone Scan

Left inguinal hernia containing urinary bladder

Bone Scan

Artifacts on SPECT/CT

Misregistration	• Poor calibration of the relative position of the modalities' isocenters, • Change in the isocenter due to couch movement or sagging • Change in the SPECT center of rotation for example with heavy high energy collimators • Patient movement (voluntary or involuntary)	• Misregistration artifacts will be most apparent at the boundaries of organs/structures • Localisation becomes confused • Misapplication of attenuation correction data may over or under correct the SPECT data and so mimic the appearance of uptake defects or an underlying pathology
Respiration	• Patient continues with normal shallow respiration during the CT and SPECT • Patient holds breath for CT but breaths for SPECT	• CT movement artifacts around the diaphragm, but the overall position and shape of the internal organs will better match that of the averaged respiration position of the SPECT scan • Positional differences between SPECT and CT in the lungs, heart and around the diaphragm
Truncation	• The FOV is too small or the patient too large • Patient arms extend outside selected FOV. (Likely if patient can not raise arms out of FOV for the duration of a SPECT/CT scan)	• Hyperdense areas on CT seen adjacent to the section outside the FOV • Streaking artifacts
Highly attenuating foreign bodies	• Metal pins, joints and/or fillings • Contrast agents	• Low photon count areas of the projections, and their associated higher noise, cause major streaking and an inaccurate attenuation coefficient measurement
CT noise	• Large patient • Low dose CT settings	• Low photon count leading to noise which is amplified during reconstruction • Errors in the defining CT number • Potential loss of visibility of smaller details
Thick CT slices	• Limitations of the equipment • Incorrect reconstruction parameters	• Stair step slices in the craniocaudal direction

Bone Scan

Artifacts on SPECT/CT

Misregistration	• Poor calibration of the relative position of the modalities' isocenters	• Misregistration artifacts will be most apparent at the boundaries of organs/structures
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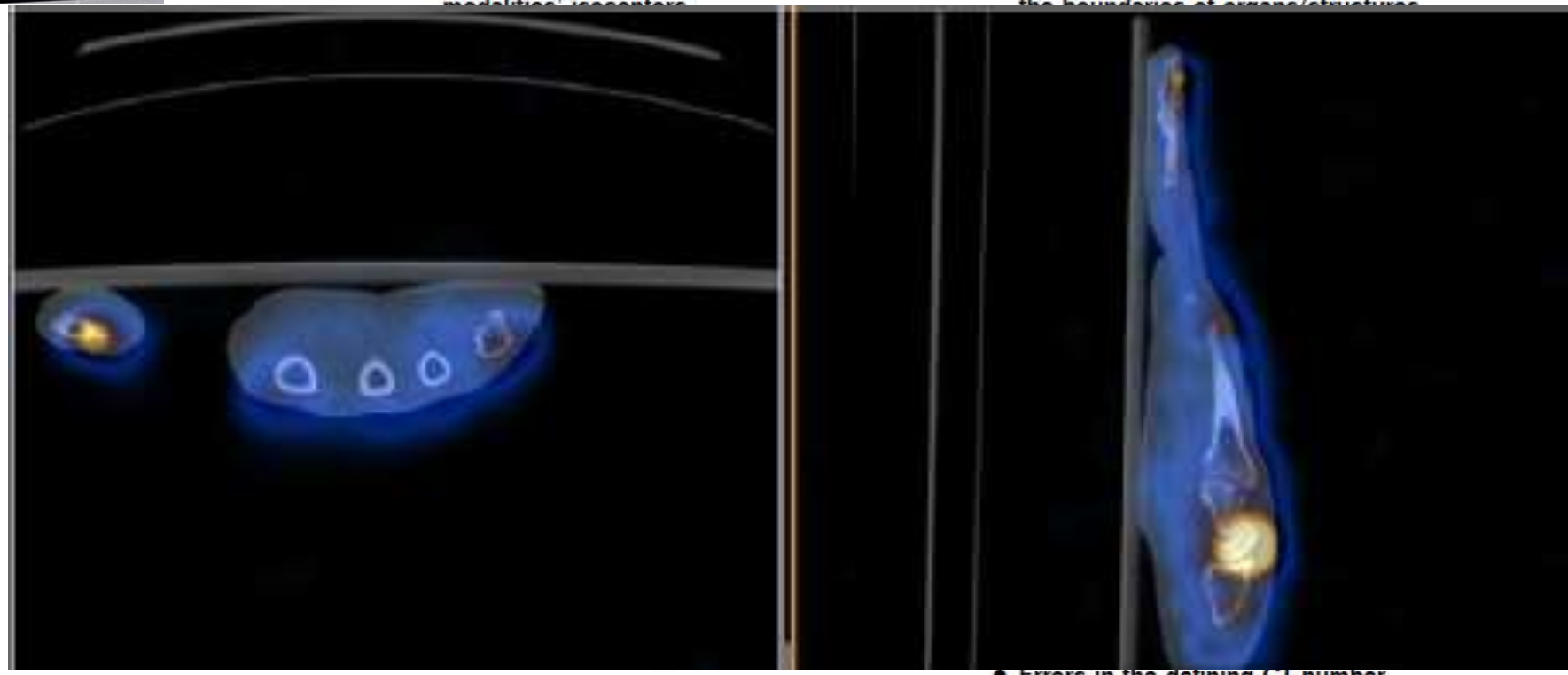

Bone Scan

Artifacts on SPECT/CT

Misregistration

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- Change in the isocenter due to couch movement or sagging

- Misregistration artifacts will be most apparent at the boundaries of organs/structures
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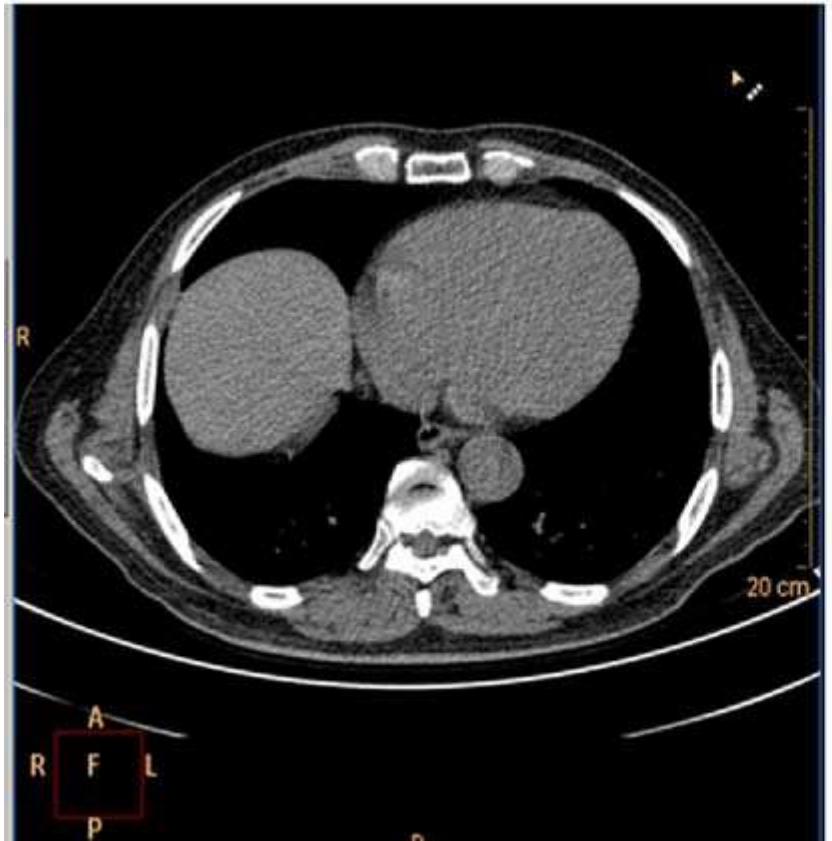
- Misapplication of attenuation correction data



Bone Scan

Artifacts on SPECT/CT

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Thick CT slices

- Limitations of the equipment
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Bone Scan

A patient with a history of thyroid cancer has suspected bone marrow metastases in the cervical spine. It is recommended to perform both an I-131 radioiodine scan as well as a bone scan using the Tc-99m-MDP. Which would be the optimum sequence to perform unambiguous scans in the shortest time?

A. Administer the I-131 and Tc-99m simultaneously. Perform the bone scan first and recall the patient after 24 hours for the radioiodine scan.

B. Administer the I-131 first. Perform the I-131 thyroid scan at 24 hours, then inject Tc-99m MDP and perform the bone scan shortly afterwards.

C. Administer the I-131 first. Perform the I-131 thyroid scan at 24 hours, then ask the patient to wait 3 to 6 weeks until the I-131 has fully decayed before performing the bone scan.

D. Administer the Tc-99m MDP first. Perform the bone scan. Then administer the I-131, and perform the thyroid scan after 24 hours.

E. Administer the Tc-99m MDP first, followed shortly thereafter by the I-131. Then perform the bone scan followed by the thyroid scan after 24 hours.

Bone Scan

The presence of I-131 will interfere with a Tc-99m bone scan but not vice versa.

This is because the higher energy 364 keV I-131 photons down-scatter into the Tc-99m window, while the reverse is not physically possible. Therefore, the Tc-99m must be administered and scanned first.

Answer C would work, but would not optimize the time.

Scintillating Icons, Images of the past and visions for the future
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Bone Scan

What would be the appearance of a gamma camera image if a Tc-99m isotope scan were performed for the same duration but with the wrong collimator: a medium Energy general-purpose instead of a low-energy general-purpose collimator ?

A. There would be absolutely no effect.
B. The image will be more noisy, but probably clinically acceptable.
C. The image quality would be poor due to septal penetration. The study would need to be repeated.
D. There would be so few counts that the study would need to be repeated.
E. This mistake could never happen, because instrument interlocks would prevent a Tc-99m study being performed with the wrong collimator.

Bone Scan

The thicker septa (and smaller hole diameters) of a medium-energy collimator would diminish the count rate by approximately 30% and render the image more statistically noisy.

This is less serious than if a low-energy collimator were used for a medium-energy isotope. In this case, significant septal penetration would substantially degrade the image contrast and render the image unreadable.

Whereas the selection of the wrong collimator for a specified isotope would give the technologist a warning message, it would not prevent the gamma camera from acquiring an image in this configuration.

Liverpool vs Dortmund

UEFA Europa League Quarter-final, Game 2
Thursday, 14 April, 20:05
Anfield, Liverpool

Liverpool **4 - 3** Dortmund

FT

Thank you!