PET-CT VIRTUAL GAME

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SWCSNMMI 2023

Protocol	Preparation	Misc	Cases	Challenges
$100	$100	$100	$100	$100
$200	$200	$200	$200	$200
$300	$300	$300	$300	$300
$400	$400	$400	$400	$400
$500	$500	$500	$500	$500

Last Slide

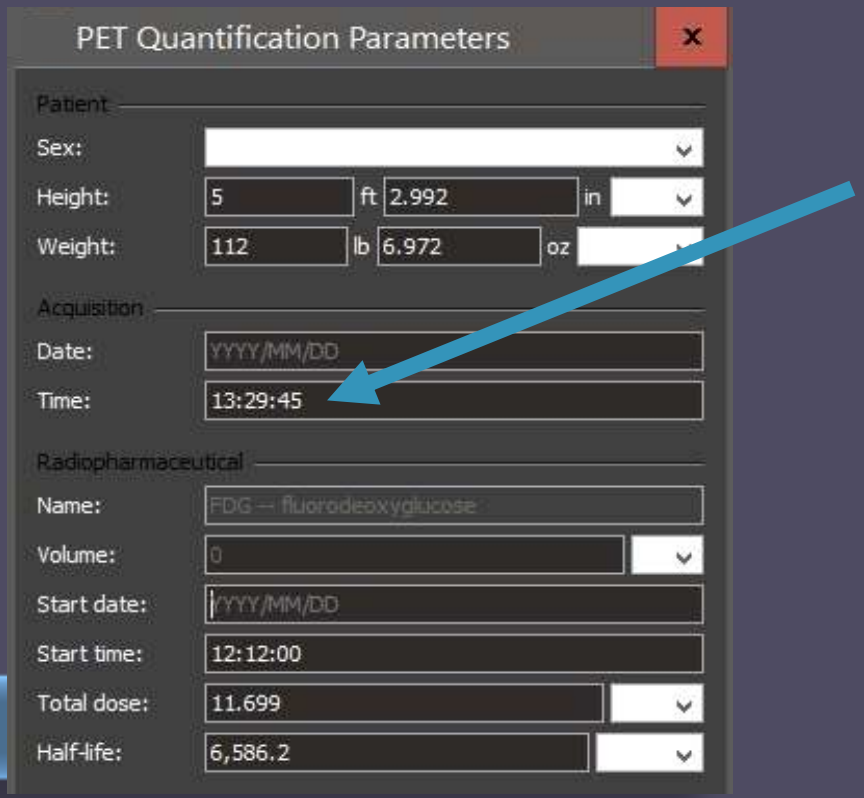
PROTOCOL - $100

How would a **later** acquisition start time most likely affect the SUV value (all else unchanged) for a malignant lesion?

A. Higher

B. Lower

C. No effect



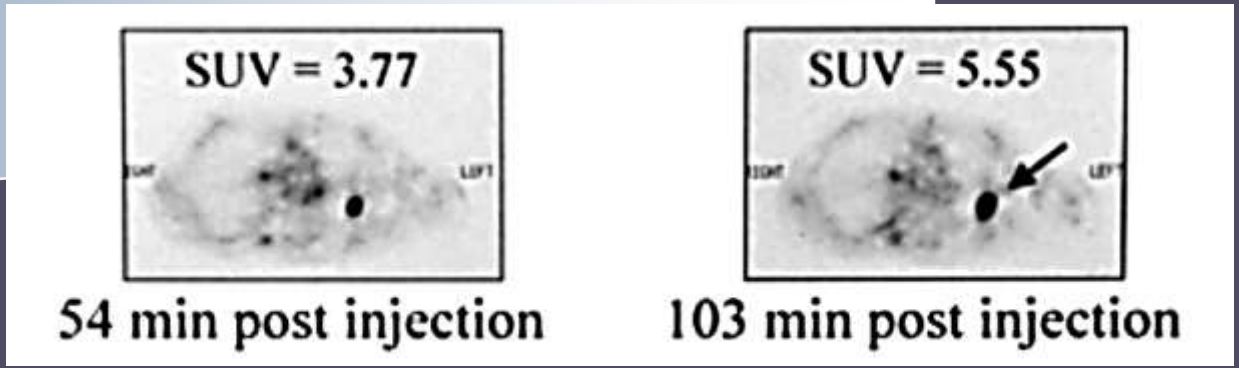
Answer: A - Higher

FDG Uptake Over Time

- Uptake in malignant lesions usually increases over time (+19.18% +/- 9.58%; P < 0.001).
- Uptake in inflammatory/infectious lesions usually remains stable over time. Examples are from radiation therapy (+1.16% +/- 7.23%; P > 0.05); lesions of painful lower limb prostheses (+4.03% +/- 11.32%; P > 0.05).
- Uptake in benign lung nodules usually slightly decreases over time (-6.3% +/- 8.1%; P < 0.05).
- An advantage of more delayed imaging -- increased sensitivity due to continued clearance of background activity & continued FDG accumulation in malignant lesions

Cheng G et al. When should we recommend use of dual timepoint and delayed timepoint imaging techniques in FDG PET? Springer. 2013.
Zhuang H et al. Dual timepoint 18F-FDG PET imaging for differentiating malignant from inflammatory processes. *J Nucl Med*. 2001; 42:1412-7.

Dual Timepoint (DTP) FDG PET



Elderly male with known malignant left lung nodule

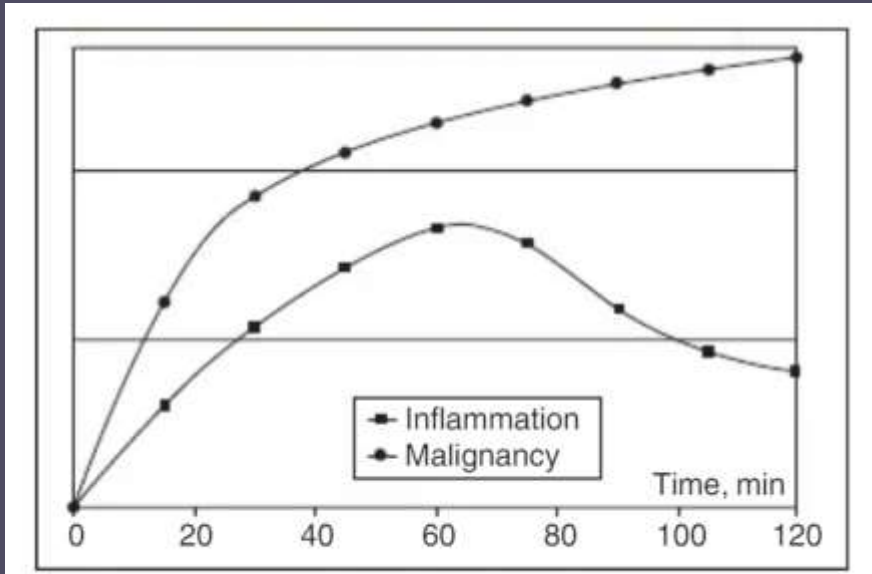


Figure 1. Difference between malignant and inflammatory cells in FDG uptake-imaging time.

Zhuang H et al. Dual timepoint 18F-FDG PET imaging for differentiating malignant from inflammatory processes. *J Nucl Med*. 2001; 42:1412-7.
Sanz-Viedma S et al. Potential clinical utility of dual time point FDG-PET for distinguishing benign from malignant lesions: implications for oncological imaging. *Rev Esp Med Nucl*. 2009; 28: 159-66.

PROTOCOL - $200

In general, the improved signal-to-noise ratio of time-of-flight (TOF) PET scanners allows for which of the following protocol or quality changes when compared to non-TOF scanners?

A. wider imaging field-of-view

B. no need for scatter correction

C. shorter scan acquisition time

D. lesser radiation dose for the same administered activity

Answer: C

Time-of-Flight

- The imaging **field of view depends on the diameter and number of rings within the PET scanner**. This will not necessarily be affected just because TOF acquisition was being performed.
- **Scatter events represent a high percentage of the detected events in 3D and TOF imaging** and, therefore, correction is necessary.
- Because the acquisition in TOF includes more useful information for each coincidence event collected, **the same image quality can be generated using fewer detected events,** allowing for shorter imaging times for the same administered activity.
- Absorbed dose in PET/CT is determined by the radiotracer, administered activity and the CT dose. For the same radiotracer and administered activity, therefore, **the absorbed dose would be the same for TOF and nonTOF PET/CT.**

Time-of-flight (TOF) refers to the estimation/approximation of the location of an annihilation event along a specific line of response by using the difference in the two emitted positrons' arrival times at the detector.

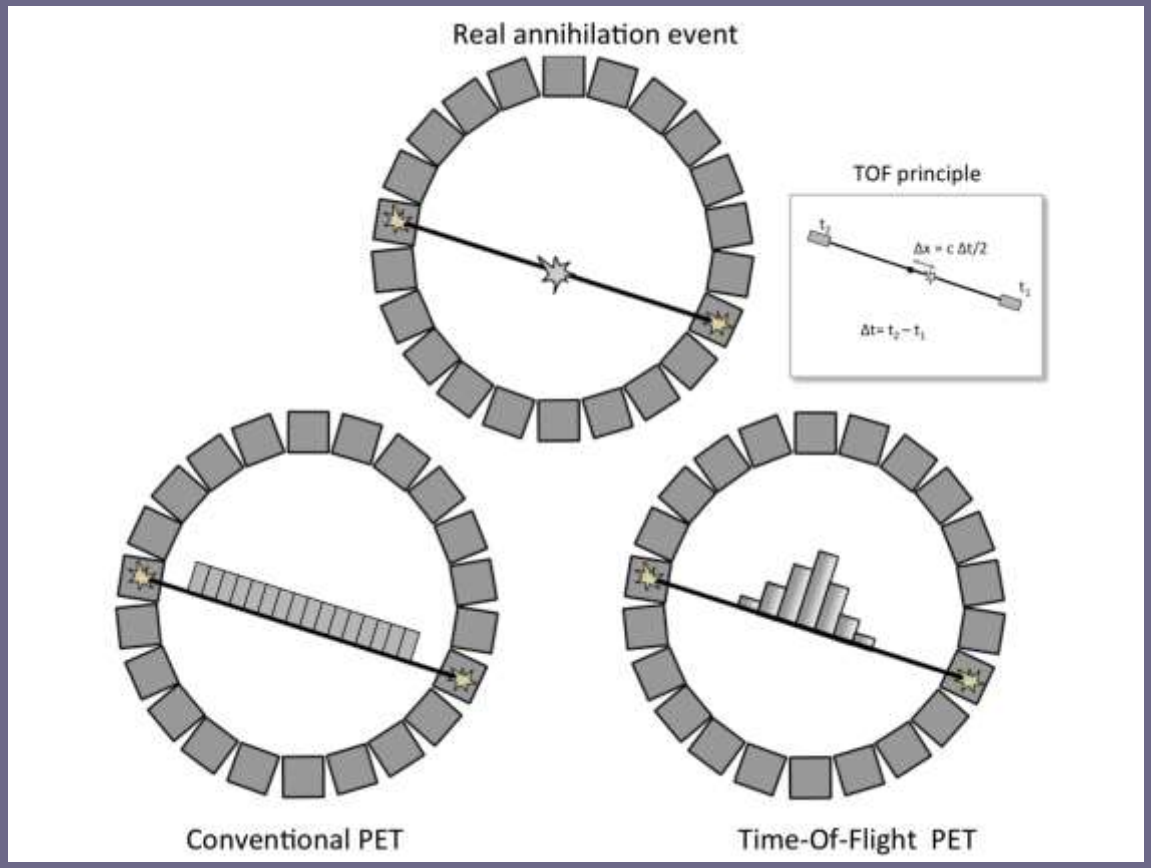


Image from:
Vandenberghe S, Mikhaylova E, D'Hoe E, Mollet P, Karp JS. Recent developments in time-of-flight PET. *EJNMMI Physics.* 2016; 3: 3.

PROTOCOL - $300

Which of the following is a primary difference between reconstruction of data from a 2D versus a 3D PET acquisition?

A. Reconstruction takes longer for 3D due to the higher number of randoms and coincidences
B. Use of oblique plane data in 3D mode decreases signal-to-noise ratio
C. Randoms in 3D are more likely to contain true annihilation location information
D. Dead time losses are not a concern in 3D resonstructions but they are in 2D

Answer: A

2D and 3D PET Reconstructions

- Due to the increased number of events in the absence of septa, 3D acquisitions require more computing power and time for reconstruction. This was one of the reasons why 3D imaging was limited for (whole) body PET in early clinical use.
- Because more events are captured (see above), more data is available and **signal-to-noise ratio is increased.**
- **Randoms in 3D are no more likely to contain true location data** (as a percentage of random events) than in 2D mode.
- With the increased number of events detected, **3D acquisitions require correction for these randoms to the same extent, if not more so,** than 2D acquisitions

3D acquisitions are now the norm.

Detected Coincidences in 2D and 3D PET

- In 3D mode, 30-40% of all events are scatter, about twice the percentage of events in 2D mode

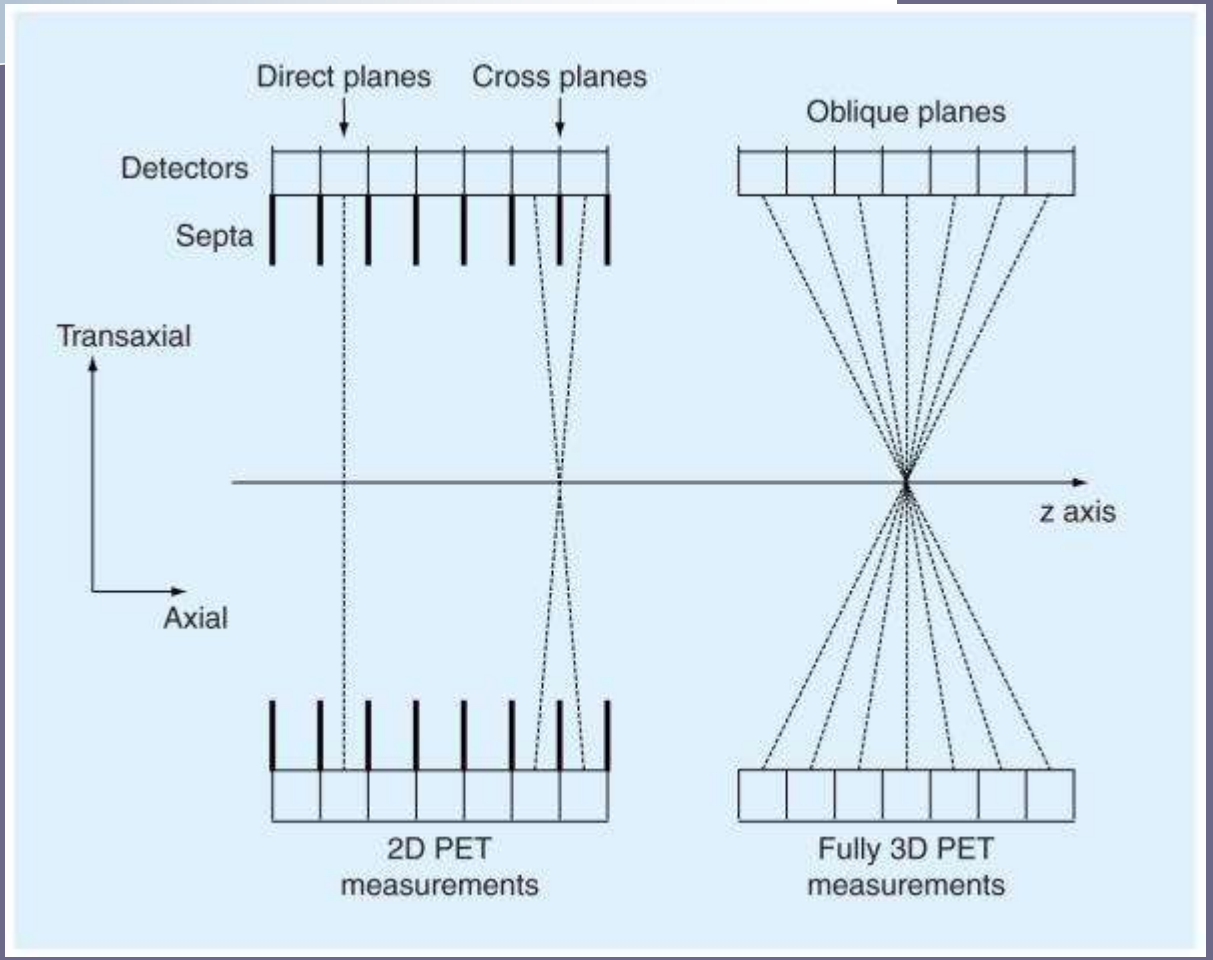


Figure: Tong S, Alessio AM, Kinahan PE. Image reconstruction for PET/CT scanners: Past achievements and future challenges. *Imaging Medicine.* 2010; 2(5): 529-545.
"What affects resolution in PET imaging? As accedd at https://www.people.vcu.edu/~mhcrosthwait/PETW/PETresolution.html on 15 Mach 2023.

PROTOCOL - $400

FDG-PET/CT: All of the following can increase brown fat uptake except:

A. Caffeine

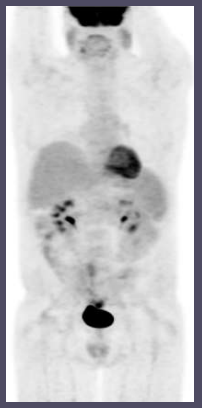
B. Nicotine

C. Ephedrine

D. Reserpine.

Answer: D - Reserpine

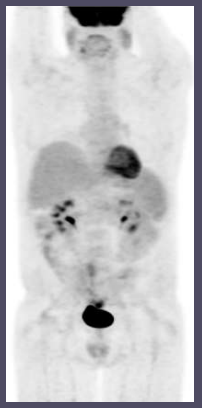
18F-FDG – Brown Fat Uptake

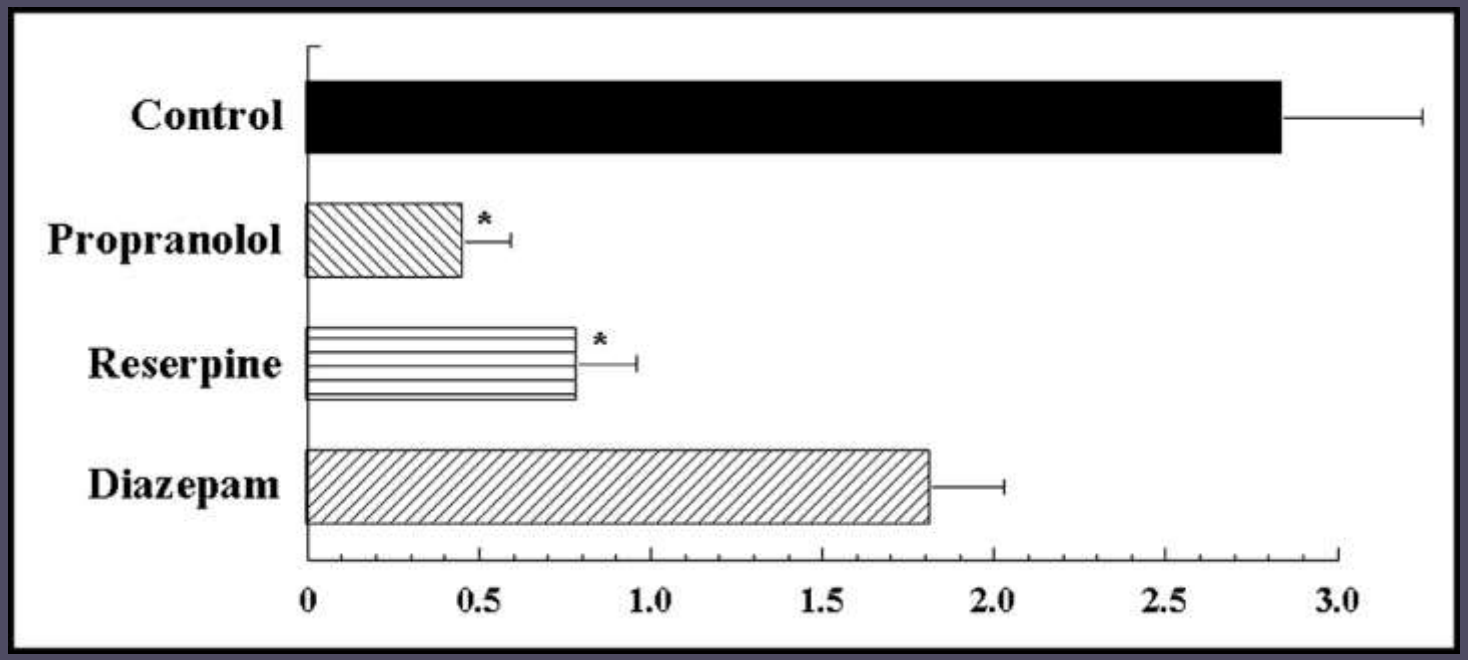


- Caffeine can mildly increase brown fat uptake.
- Nicotine can increase brown fat uptake significantly.
- Ephedrine can increase brown fat uptake.
- Reserpine has been shown to reduce brown fat uptake up to about 30%.

Shingo B et al. Effect of nicotine and ephedrine on accumulation of 18F-FDG in brown adipose tissue. J Nucl Med. 2007; 48:981-6.
Tatsumi M et al. Intense F-18 FDG uptake in brown fat can be reduced pharmacologically. J Nucl Med. 2004; 45:1189-93.

18F-FDG – Brown Fat Uptake





Tatsumi M et al. Intense F-18 FDG uptake in brown fat can be reduced pharmacologically. J Nucl Med. 2004; 45:1189-93.

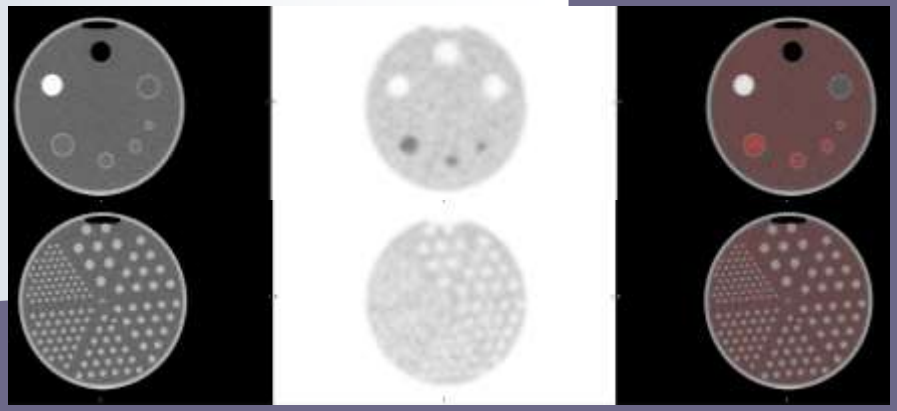
PROTOCOL - $500

The PET phantom is used to assess which aspect of PET quality control?

A. Uniformity
B. Linearity
C. Color contrast
D. Constancy

Answer: A - Uniformity

PET Phantom Use for Camera Quality Control



- Uniformity & noise are evaluated qualitatively by inspection of reconstructed tomographic sections from the phantom.
- Spatial resolution may be evaluated by identifying the smallest "cold" rods in the phantom, but it is instead most frequently assessed using a point source in air. It is not a component of the ACR tests required with this phantom.
- Lesion detectability is determined from the "hot" cylinders using a ROI specific ROI protocol (not explained here). The same protocol is used for the "cold" cylinders.
- Constancy reflects the stability of the system and measurements of system parameters over time. This is not accomplished using a phantom *per se*. "Constancy" is a term used mostly in SPECT, but for a PET scanner it is assessed by routinely (monthly-annually) cross-calibrating the scanner to the dose calibrator.

PREP - $100

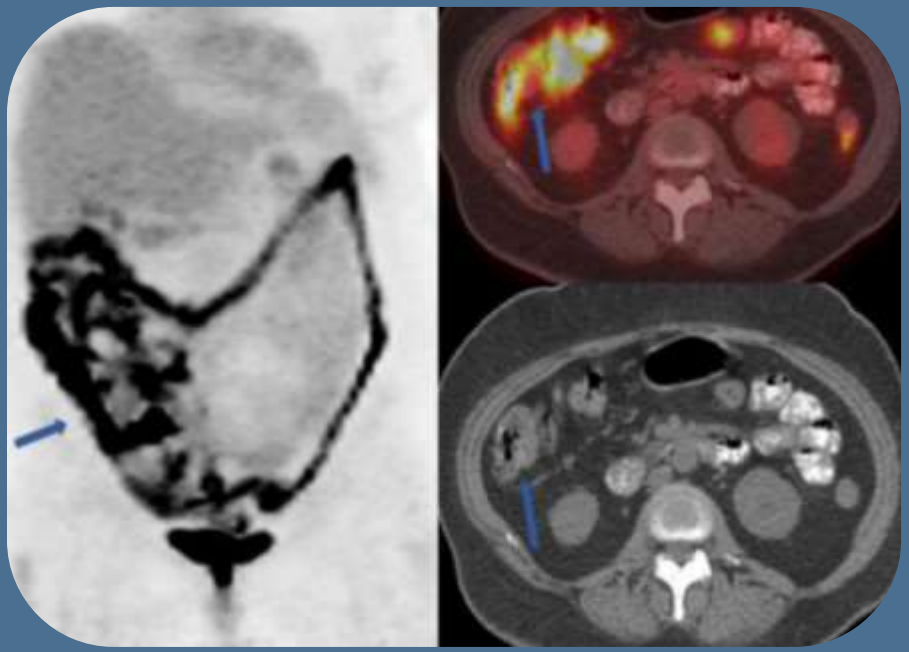
Which of the following is correct regarding metformin & FDG uptake?

A. Increases FDG uptake in bowel
B. Downregulates GLUT transporters
C. Only accumulates in bowel wall & not in lumen
D. Has no effect on FDG bowel uptake

Answer: Increases FDG uptake in bowel

Metform & FDG PET

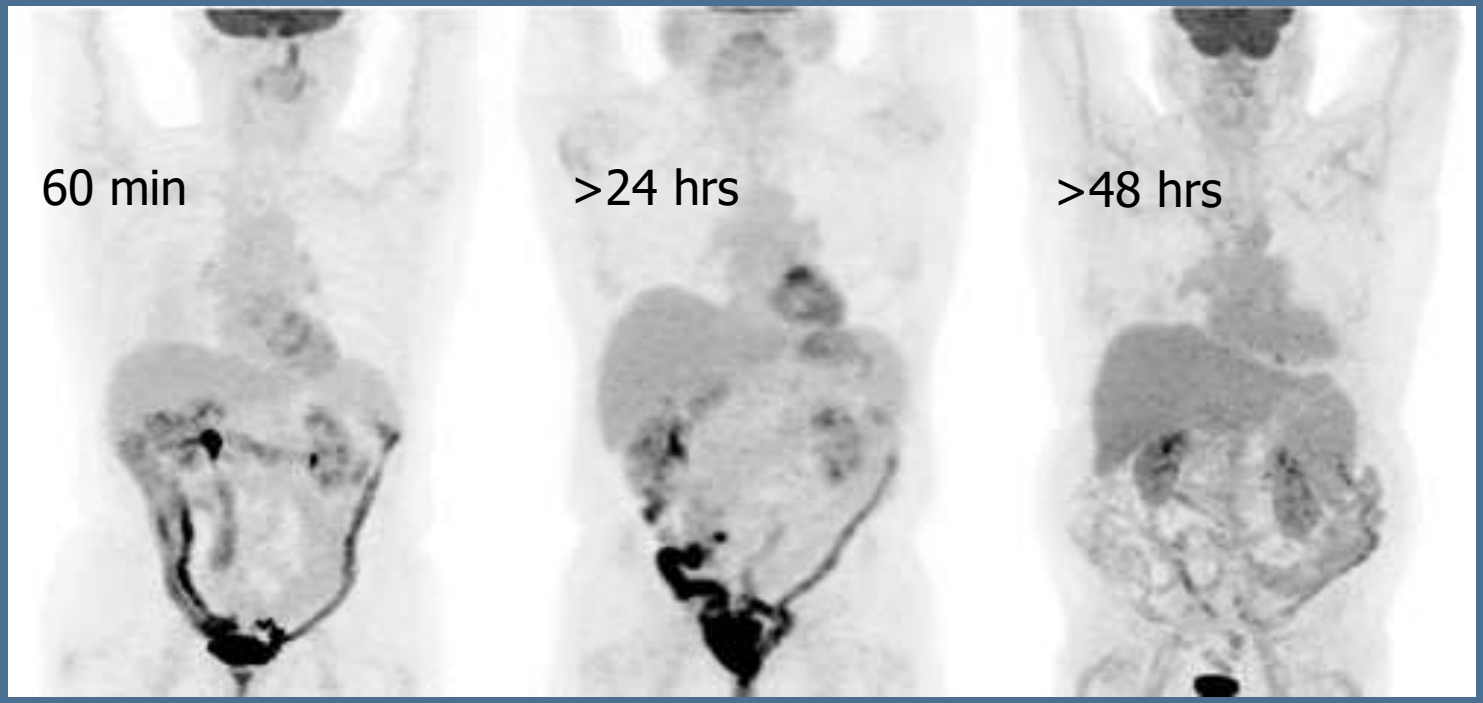
- An oral antidiabetic drug
- Can cause diffuse increased large & small bowel uptake complicating interpretation & may cause FPs
- Upregulates GLUT transporters increasing FDG uptake
- Has greater accumulation in the bowel lumen (and therefore, stool) compared to bowel wall



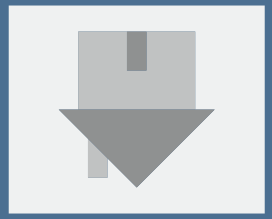
Japaprakasam VS, Paroder V, Schoder H. Variants and pitfalls in PET/CT imaging of Gastrointestinal Cancers. *Semin Nucl Med.* 2021; 51:485-501.
Morita Y, Nogami M, Sakaguchi K, et al. Enhanced release of glucose into the intraluminal space of the intestine associated with metformin treatment as revealed by 18F-fluorodeoxyglucose Pet/MRI. *Diabetes Care.* 2020; 43: 1796-1802.

Metform & FDG PET

- Less bowel uptake if withheld for at least 48 hrs before FDG injection



Hamidizadeh R, Eftekhari A, Wiley A, et al. Metformin discontinuation prior to FDG PET/CT: A randomized controlled study to compare 24- and 48-hour bowel activity. *Radiology*. 2018;



PREP - $200

Which of the following is *correct* regarding patient preparation for 18F-FES-PET?

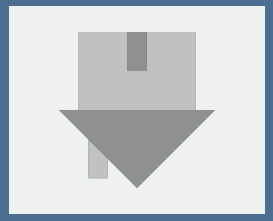
A. There is no need to assess pregnancy status.
B. A low carbohydrate diet is recommended for 24 hr prior to the FES injection.
C. No prior breast lesion biopsy is required.
D. It is preferrable to image with FES prior to starting systemic endocrine therapies that target ERs.

Answer: D – Preferred to image before ER-targeting TXs

18F-FES PET/CT Prep

- Assessment of pregnancy status in reproductive age females is recommended.
- There are no dietary restrictions. Adequate oral hydration is recommended.
- Image patients with FES prior to starting systemic endocrine therapies that target ERs (ex: tamoxifen, fulvestrant).
- Do not use FES in lieu of BX when biopsy is indicated in pts with recurrent or metastatic breast cancer.

Package insert: https://www.accessdata.fda.gov/drugsatfda_docs/label/2020/212155s000lbl.pdf



PREP - $300

In pts undergoing F-18 NaF bone scanning for detection of metastatic disease, which of the following elements of pt preparation is most recommended?

A. Discontinuation of oral bisphosphonates for at least 5 half-lives prior to imaging
B. 2-4 hour pre-study fast
C. Hydration (at least 400 mL) prior to and during tracer uptake
D. Use of methods of contraception with ≥99% efficacy

Answer: C – Hydration (at least 400 mL) prior to & during tracer uptake

18F-NaF PET/CT

- Discontinuation of bisphosphonates is not routinely recommended.
- Fasting is not required for single photon or PET-based bone scanning.
- Hydration, as well as frequent voiding before and after the scan, is recommended for single photon and PET-based bone scanning to limit the radiation dose to the bladder.
- Examinations producing radiation should be limited in pregnant & nursing women. However, no recommendations regarding contraception are currently in place for bone scanning (note that breastmilk concentrations likely parallel maternal blood concentrations of tracer).

Radiation Dose in NaF Bone Scanning

TABLE 1
Radiation Dosimetry in Adults

Radiopharmaceutical	Administered activity (MBq)	Critical organ (bladder)	Effective dose
^{99m}Tc-phosphates (intravenous)	500–1,110	0.047 (mGy/MBq)	0.0049 (mSv/MBq)
		34.8 (mGy/740 MBq)	3.6 (mSv/740 MBq)
		52.2 (mGy/1,110 MBq)	5.4 (mSv/1,110 MBq)

Values for normal bone uptake and normal renal function are from *Radiation Dose to Patients from Radiopharmaceuticals*. London, U.K.: ICRP; 1988:215. ICRP report 53. See also Weber DA, Makler PT Jr, Watson EE, Coffey JL, Thomas SR, London J. MIRD dose estimate report no. 13: radiation absorbed dose from technetium-99m-labeled bone imaging agents. *J Nucl Med*. 1989;30:1117–1122.

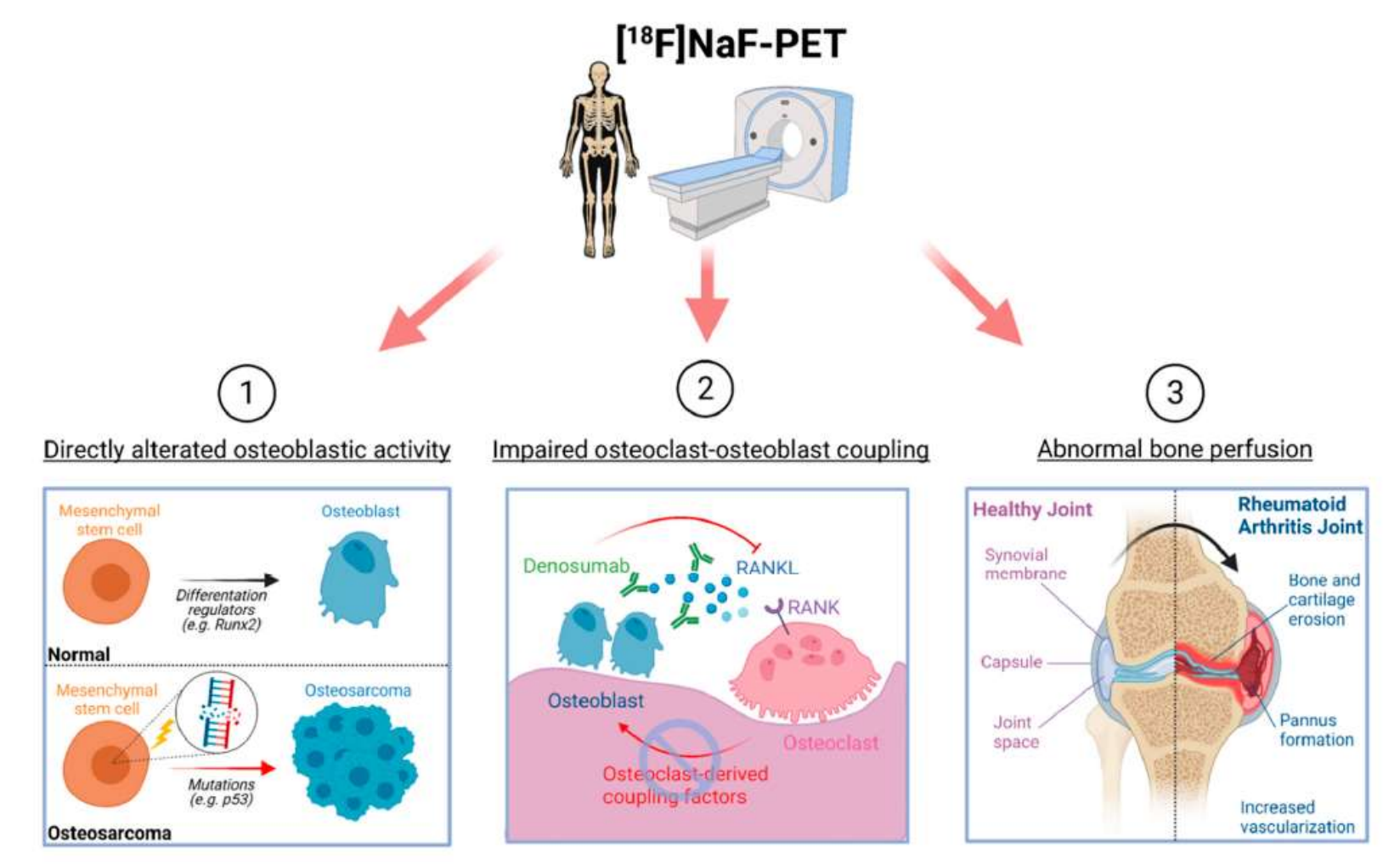
TABLE 2
Radiation Dosimetry in Children (5 y old)

Radiopharmaceutical	Administered activity (MBq)	Critical organ (bladder)	Effective dose
^{99m}Tc-phosphates (intravenous)	170–210	0.11 (mGy/MBq)	0.012 (mSv/MBq)
		18.7 (mGy/740 MBq)	2.0 (mSv/740 MBq)
		23.1 (mGy/1,110 MBq)	2.5 (mSv/1,110 MBq)

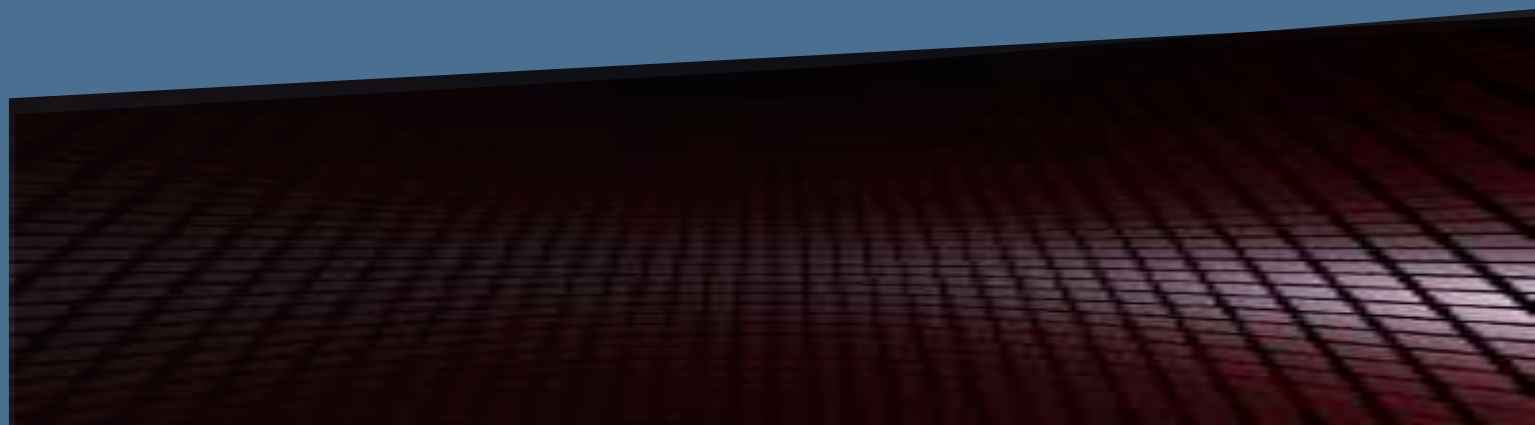
Values for normal bone uptake and normal renal function are from *Radiation Dose to Patients from Radiopharmaceuticals*. London, U.K.: ICRP; 1988:215. ICRP report 53. See also Weber DA, Makler PT Jr, Watson EE, Coffey JL, Thomas SR, London J. MIRD dose estimate report no. 13: radiation absorbed dose from technetium-99m-labeled bone imaging agents. *J Nucl Med*. 1989;30:1117–1122.

Bartel TB et al. J Nucl Med Technol.. 2018; 46(4): 398-404.

Factors Influencing Bone Uptake of NaF



Park PSU et al. Int J Mol Sci. 2021; 22:6504.



PREP - $400

Which of the following is *correct* in preparing a pt for an 18F-FDG PET/CT for seizures?

A. There is no need to avoid caffeine or alcohol before FDG injection.

B. Sedatives do not need to be avoided beforehand.

C. There is no glucose level cutoff requirement when imaging the brain with FDG.

D. Insulin can be administered to lower a hyperglycemic state.

Answer: Insulin can be utilized.

18F-FDG PET/CT for Seizures

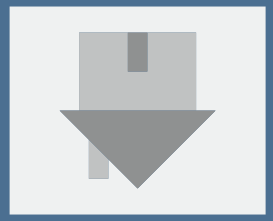
- Caffeine & alcohol should be avoided prior to FDG injection as they can affect cerebral glucose metabolism, the major energy source for the brain.

- Sedatives, amphetamines, cocaine, narcotics, antipsychotic medications, & corticosteroids can alter cerebral metabolism.

- If blood glucose is >150-200 mg/dL prior to FDG injection, the pt should be rescheduled. Hyperglycemia can cause high circulating insulin levels to drive FDG into muscle & reduce uptake in the brain.

- In hyperglycemic pts, insulin can be administered. However, the administration of FDG should be delayed following insulin (duration of delay dependent on type & route of insulin administration. Correction of increased intracellular glucose levels lags behind correction of plasma glucose level.

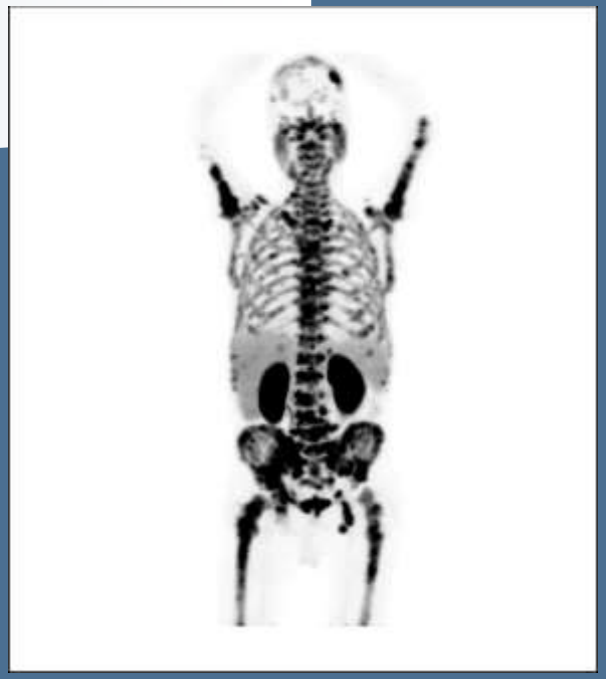
Sarikaya I. PET studies in epilepsy. *Am J Nucl Med Mol Imaging*. 2015; 5:416-30.
SNMMI guideline. 2009.



PREP - $500

72 year-old with Gleason 10 prostate adenocarcinoma presents for a third treatment with Lu-177-PSMA (Pluvicto™). No prior serious adverse reactions. Which of the following pre-treatment evaluations would prompt a reduction in the administered activity?

A. >75% decrease in Cr (Gr 3+)
B. Mild/mod GI toxicity (Gr 1 or 2)
C. Severe decrease in Hgb (Gr 3+)
D. Severe dry mouth (Gr 3)



Occurring in >20%: fatigue, nausea, dry mouth, diarrhea, anemia, decreased appetite, constipation.
Occurring in >30%: low lymphocytes, hemoglobin, leukocytes, platelets, Ca and Na.

Answer: D

Selected Adverse Reactions from Radio-Therapies

Reaction	Therapies Associated with the Reaction
Myelosuppression	Pluvicto™, Lutathera™, Xofigo™
Risk of Infertility	Pluvicto, Lutathera
Nephrooxicity	Pluvicto, Lutathera
Elevated Liver Enzymes/Toxicity	Luvicto, Lutathera
Electrolyte Abnormalities	Pluvicto
Dry Mouth	Pluvicto, radioiodine
Dysgeusia/Ageusia	Radioiodine
Salivary Gland Pain/Swelling	Radioiodine
Fatigue	Pluvicto
Secondary MDS/Leukemia	Lutathera
Hypersensitivity Reaction	Lutathera
Neuroendocrine/Hormonal Crisis	Lutathera
Fractures	Xofigo
Embryo-fetal Toxicity*	Pluvicto, Lutathera, Xofigo, radioiodine
Nausea/Vomiting	Pluvicto, radioiodine

See full prescribing information for Pluvicto, Xofigo, Lutathera.

Pluvicto™ Dose Modifications for Adverse Reactions

Reduce Pluvicto dose by 20% if:

- **Mild renal toxicity: Cr ↑ ≥40%, ClCr ↑ >40%**
- **Grade 3 dry mouth; consider for Grade 2**
- **Grade 3+ myelosuppression**
- **Grade 3+ GI toxicity not manageable with meds**

Grading derived from Common Terminology Criteria for Adverse Events (CTCAE) at ctep.cancer.gov.

Recommended dosage modifications of PLUVICTO for adverse reactions

Adverse reaction	Severity	Dosage modification
Myelosuppression (anemia, thrombocytopenia, leukopenia, or neutropenia)	Grade 2	Withhold PLUVICTO until improvement to grade 1 or baseline.
	Grade ≥3	Withhold PLUVICTO until improvement to grade 1 or baseline. Reduce PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Recurrent grade ≥3 myelosuppression after 1 dose reduction	Permanently discontinue PLUVICTO.
Renal toxicity	Defined as: • Confirmed serum creatinine increase (grade ≥2) • Confirmed CLcr <30 mL/min; calculate using Cockcroft-Gault with actual body weight	Withhold PLUVICTO until improvement.
	Defined as: • Confirmed ≥40% increase from baseline serum creatinine, and • Confirmed >40% decrease from baseline CLcr; calculate using Cockcroft-Gault with actual body weight	Withhold PLUVICTO until improvement or return to baseline. Reduce PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Grade ≥3 renal toxicity	Permanently discontinue PLUVICTO.
	Recurrent renal toxicity after 1 dose reduction	Permanently discontinue PLUVICTO.
Dry mouth	Grade 2	Withhold PLUVICTO until improvement or return to baseline. Consider reducing PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Grade 3	Withhold PLUVICTO until improvement or return to baseline. Reduce PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Recurrent grade 3 dry mouth after 1 dose reduction	Permanently discontinue PLUVICTO.
Gastrointestinal toxicity	Grade ≥3 (not amenable to medical intervention)	Withhold PLUVICTO until improvement to grade 2 or baseline. Reduce PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Recurrent grade ≥3 gastrointestinal toxicity after 1 dose reduction	Permanently discontinue PLUVICTO.
Fatigue	Grade ≥3	Withhold PLUVICTO until improvement to grade 2 or baseline.
Electrolyte or metabolic abnormalities	Grade ≥2	Withhold PLUVICTO until improvement to grade 1 or baseline.
AST or ALT elevation	AST or ALT >5 times ULN in the absence of liver metastases	Permanently discontinue PLUVICTO.
Other nonhematologic toxicity	Any unacceptable toxicity	Permanently discontinue PLUVICTO.
	Any serious adverse reaction that requires treatment delay of >4 weeks	Permanently discontinue PLUVICTO.
	Any recurrent grade 3 or 4 or persistent and intolerable grade 2 adverse reaction after 1 dose reduction	Permanently discontinue PLUVICTO.

ALT, alanine aminotransferase; AST, aspartate aminotransferase; CLcr, creatinine clearance; ULN, upper limit of normal.
Grading according to most current Common Terminology Criteria for Adverse Events (CTCAE).

PLUVICTO™
lutetium Lu 177 vipivotide tetraxetan
INJECTION FOR INTRAVENOUS USE

Pluvicto HCP Dosing Guide, as accessed on 03/15/2023 at chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.hcp.novartis.com/siteassets/vilupsa/dosing/226784-pluvicto-hcp-dosing-guide-digital.pdf

Pluvicto™ Dose Modifications for Adverse Reactions

Permanently discontinue Pluvicto if:

- **Grade ≥3 renal toxicity**
- **AST or ALT >5x ULN with no liver metastases**
- **Any "unacceptable" toxicity**
- **Serious AE that delays Rx for >4wks**
- **After 1 dose reduction:**
  - Recurrent grade 3 or 4 ARs or persistent/intolerable grade 2 ARs

Recommended dosage modifications of PLUVICTO for adverse reactions

Adverse reaction	Severity	Dosage modification
Myelosuppression (anemia, thrombocytopenia, leukopenia, or neutropenia)	Grade 2	Withhold PLUVICTO until improvement to grade 1 or baseline.
	Grade ≥3	Withhold PLUVICTO until improvement to grade 1 or baseline. Reduce PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Recurrent grade ≥3 myelosuppression after 1 dose reduction	Permanently discontinue PLUVICTO.
Renal toxicity	Defined as: • Confirmed serum creatinine increase (grade ≥2) • Confirmed CLcr <30 mL/min; calculate using Cockcroft-Gault with actual body weight	Withhold PLUVICTO until improvement.
	Defined as: • Confirmed ≥40% increase from baseline serum creatinine, and • Confirmed >40% decrease from baseline CLcr; calculate using Cockcroft-Gault with actual body weight	Withhold PLUVICTO until improvement or return to baseline. Reduce PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Grade ≥3 renal toxicity	Permanently discontinue PLUVICTO.
	Recurrent renal toxicity after 1 dose reduction	Permanently discontinue PLUVICTO.
Dry mouth	Grade 2	Withhold PLUVICTO until improvement or return to baseline. Consider reducing PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Grade 3	Withhold PLUVICTO until improvement or return to baseline. Reduce PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Recurrent grade 3 dry mouth after 1 dose reduction	Permanently discontinue PLUVICTO.
Gastrointestinal toxicity	Grade ≥3 (not amenable to medical intervention)	Withhold PLUVICTO until improvement to grade 2 or baseline. Reduce PLUVICTO dose by 20% to 5.9 GBq (160 mCi).
	Recurrent grade ≥3 gastrointestinal toxicity after 1 dose reduction	Permanently discontinue PLUVICTO.
Fatigue	Grade ≥3	Withhold PLUVICTO until improvement to grade 2 or baseline.
Electrolyte or metabolic abnormalities	Grade ≥2	Withhold PLUVICTO until improvement to grade 1 or baseline.
AST or ALT elevation	AST or ALT >5 times ULN in the absence of liver metastases	Permanently discontinue PLUVICTO.
Other nonhematologic toxicity	Any unacceptable toxicity	Permanently discontinue PLUVICTO.
	Any serious adverse reaction that requires treatment delay of >4 weeks	Permanently discontinue PLUVICTO.
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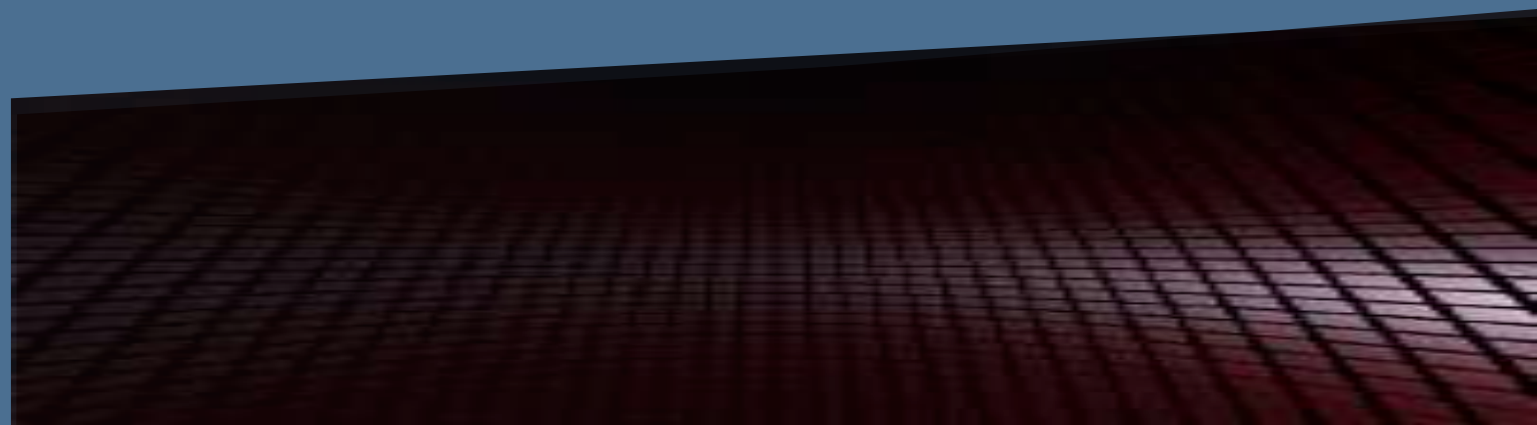
ALT, alanine aminotransferase; AST, aspartate aminotransferase; CLcr, creatinine clearance; ULN, upper limit of normal.
Grading according to most current Common Terminology Criteria for Adverse Events (CTCAE).

PLUVICTO™
lutetium Lu 177 vipivotide tetraxetan
INJECTION FOR INTRAVENOUS USE

Pluvicto HCP Dosing Guide, as accessed on 03/15/2023 at chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.hcp.novartis.com/siteassets/vilupsa/dosing/226784-pluvicto-hcp-dosing-guide-digital.pdf



MISC - $100

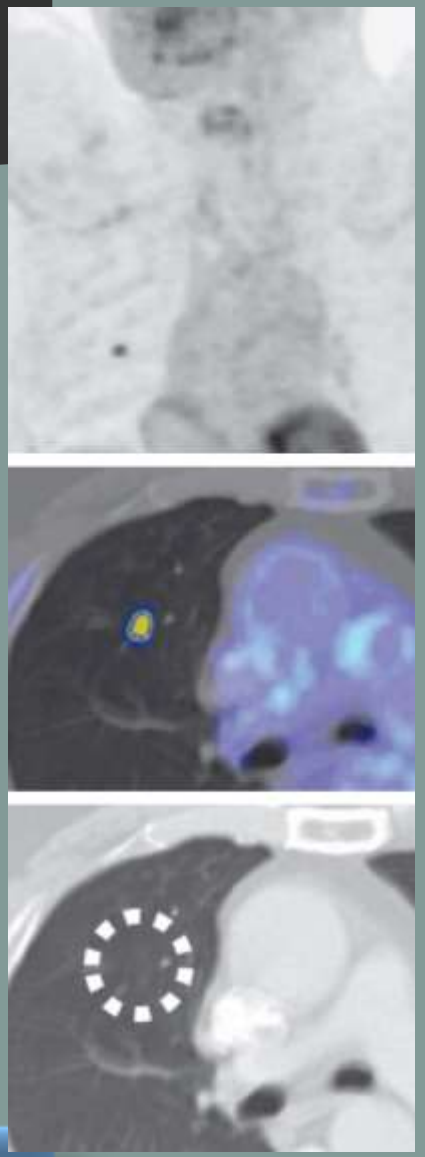
A hot spot is seen in the right chest without a CT anatomic correlate. This FDG-PET/CT was otherwise negative. How could this have been prevented?

A. Clean the area, then reimage.

B. Avoid aspiration of blood into the syringe.

C. Apply an abdominal compression device, have the pt perform shallow breaths, & reimage.

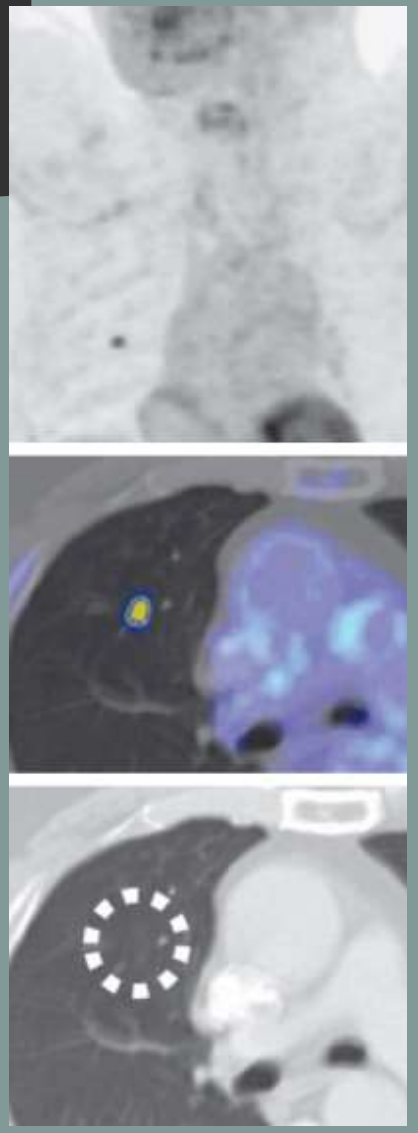
D. Center the pt in the FOV with arms above the head.



Answer: Avoid blood aspiration into syringe.

PET/CT Artifact

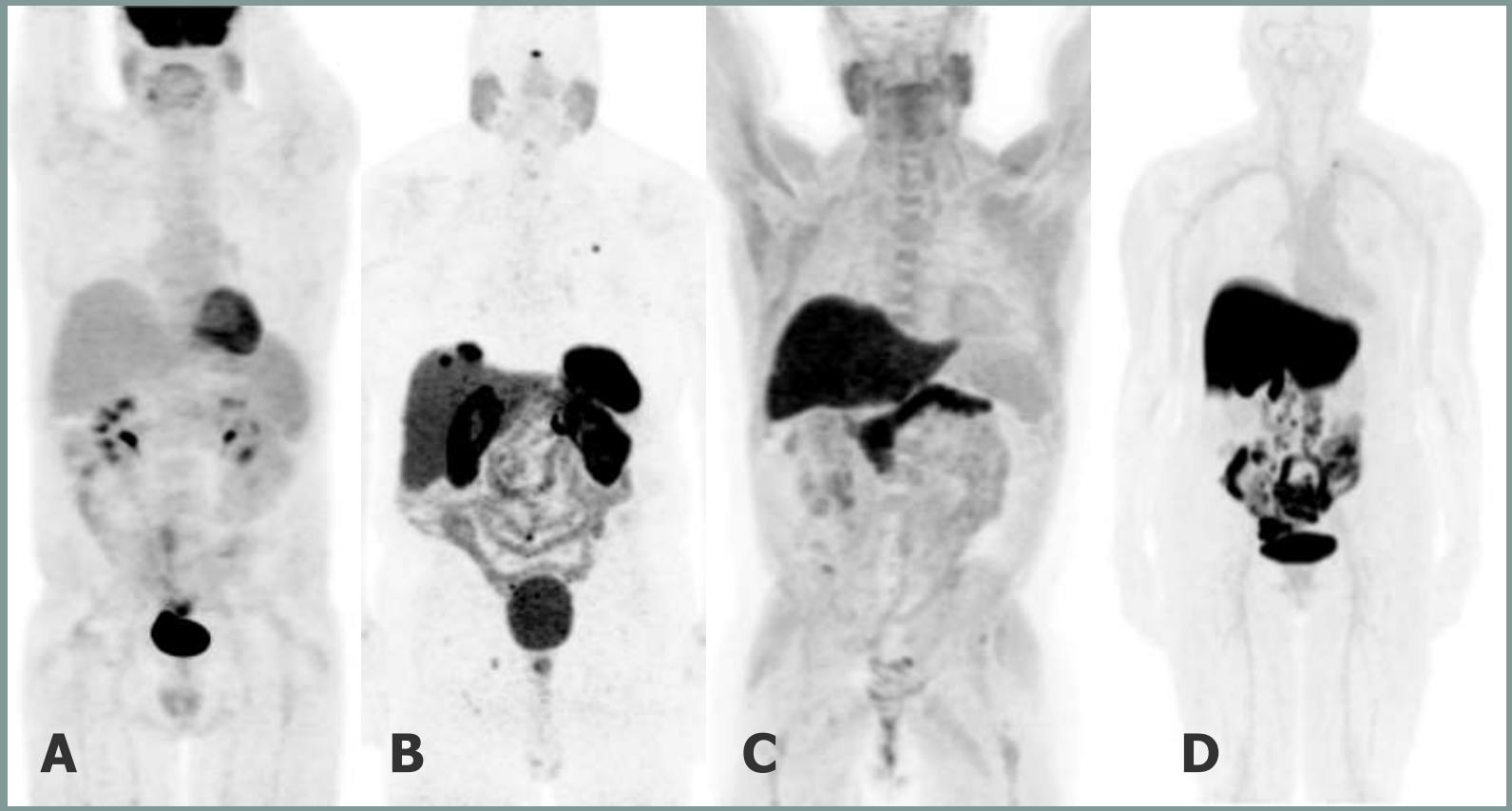
- This is an example of a “hot clot” or microembolus in the lung from the blood in the syringe having been aspirated. Venous access should be secured.
- This is clearly not contamination.
- This is not due to misregistration between PET & CT from breathing. Therefore, compression and shallow breathing with reimaging is not correct.
- This is not due to truncation artifact which would be at the periphery.



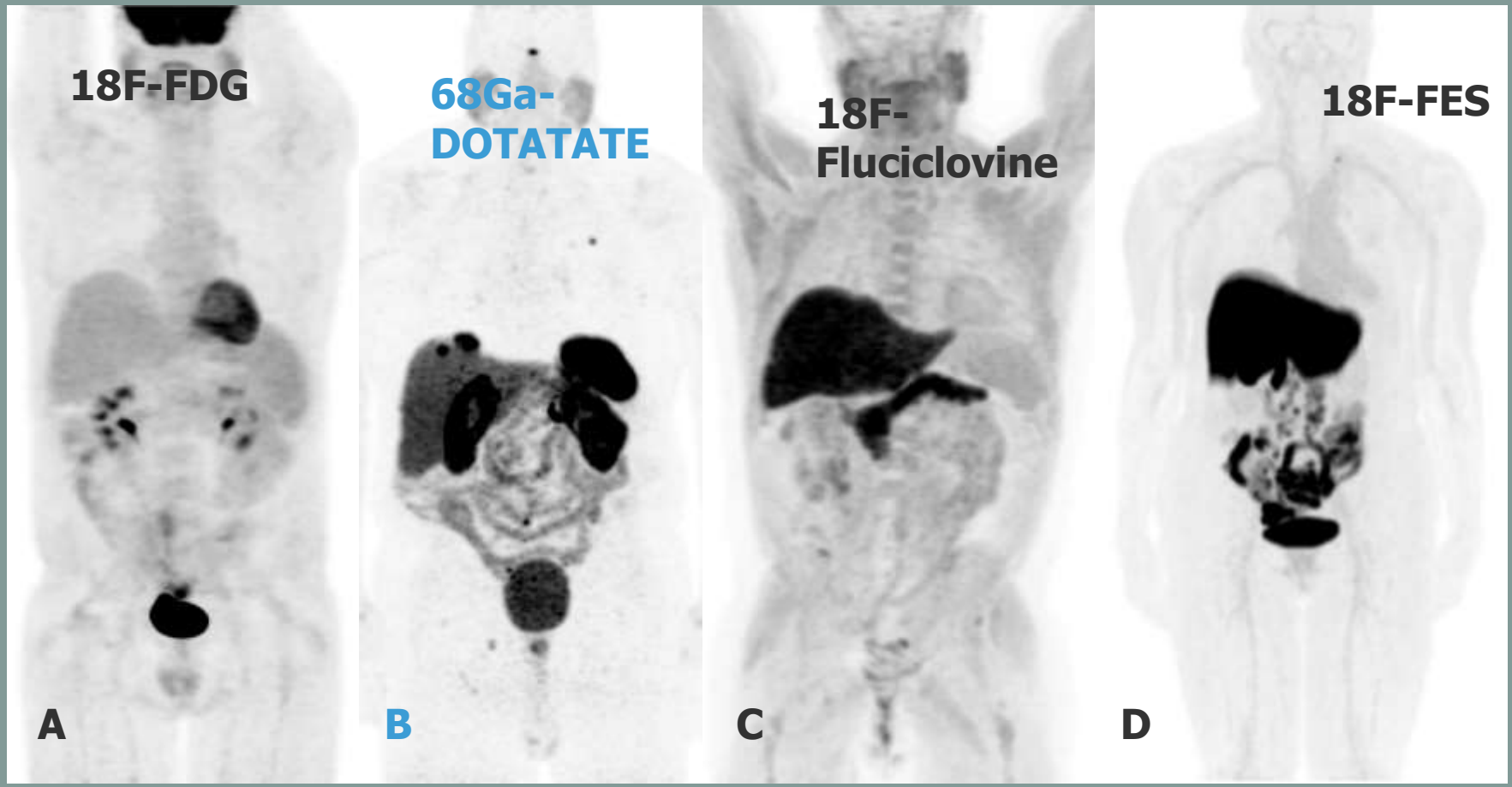
Simpson DL, et al. FDG PET/CT: Artifacts and pitfalls. *Contemp Diag Radiol.* 2017; 40:1-8.

MISC - $200

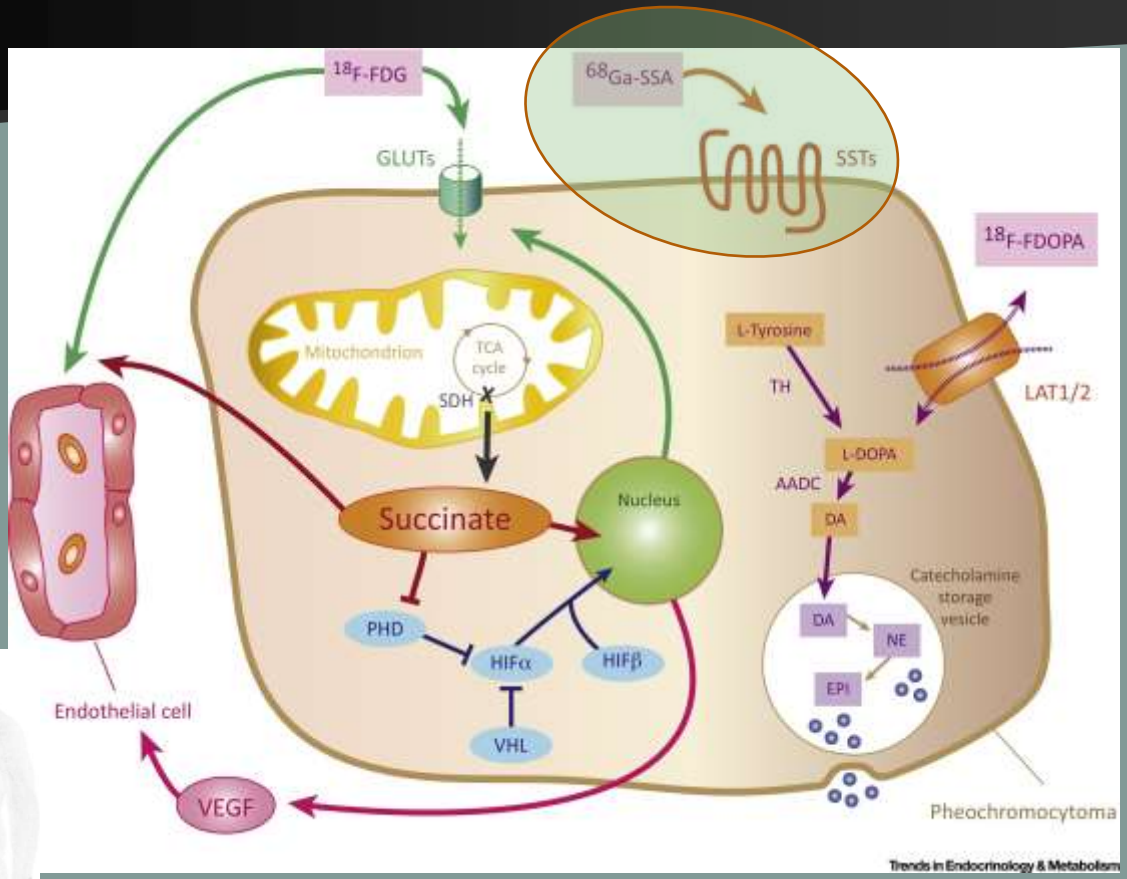
Which of the following portrays an uptake mechanism based upon a small neuropeptide associated with neural signaling?

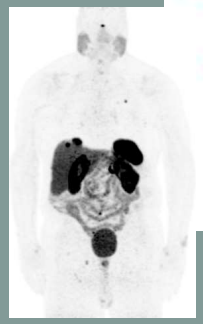


Which of the following portrays an uptake mechanism based upon a small neuropeptide associated with neural signaling?



68Ga-DOTATATE

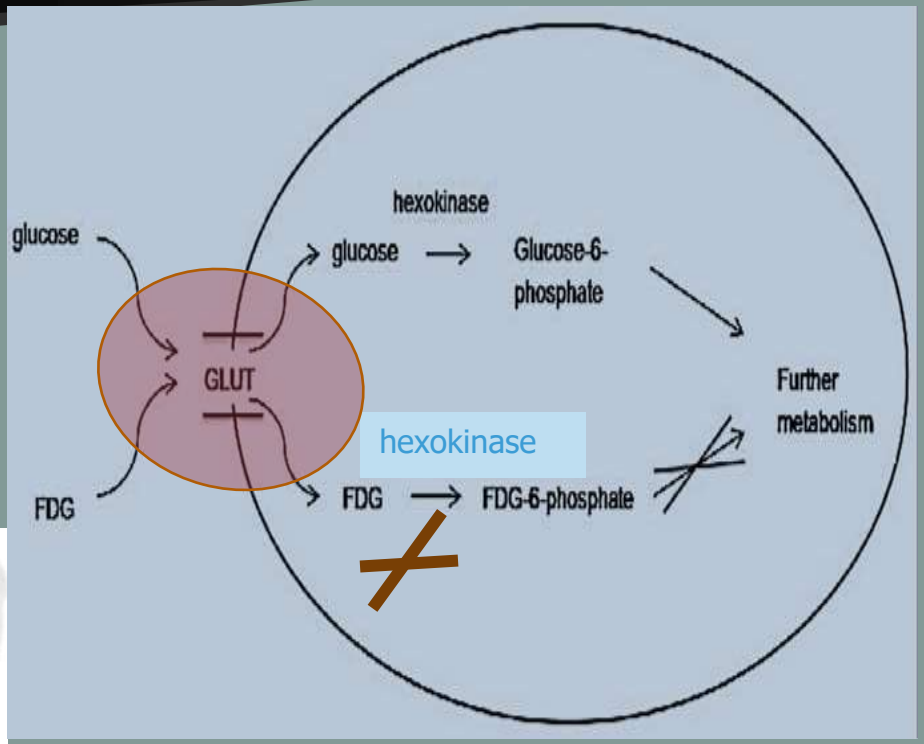


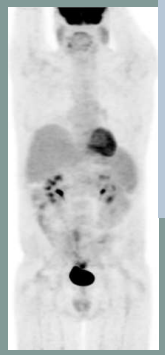


- Indication: NETs
- Mechanism of Action:
- - Somatostatin receptor - small neuropeptide associated with neural signaling
- - High affinity for SSRT2

https://www.cell.com/trends/endocrinology-metabolism/fulltext/S1043-2760(17)30103-0

18F-FDG (fluorodeoxyglucose)

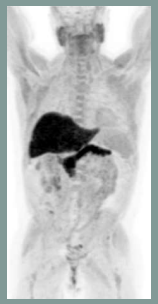


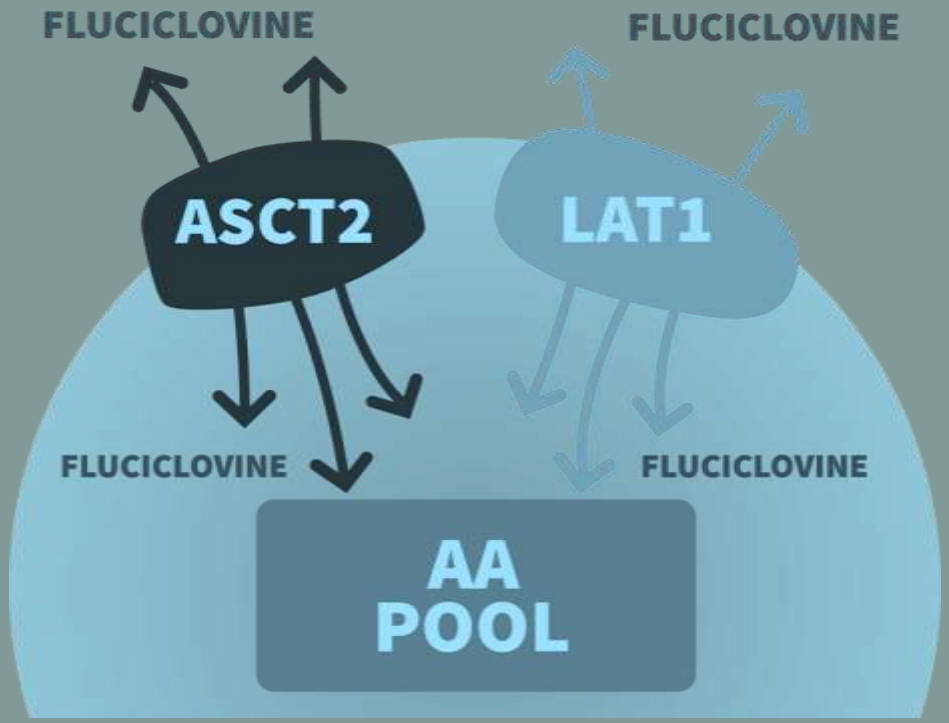


- Indication: Various cancers
- Mechanism of Action:
- - Uptake in cells by GLUT transporters
- - Phosphorylated by hexokinase & trapped in cells (doesn't enter Krebs Cycle)

https://www.researchgate.net/figure/Fig-4-Uptake-and-trapping-mechanism-of-FDG-in-cells_fig3_233488356…..

18F-Fluciclovine

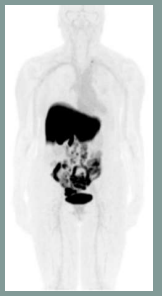


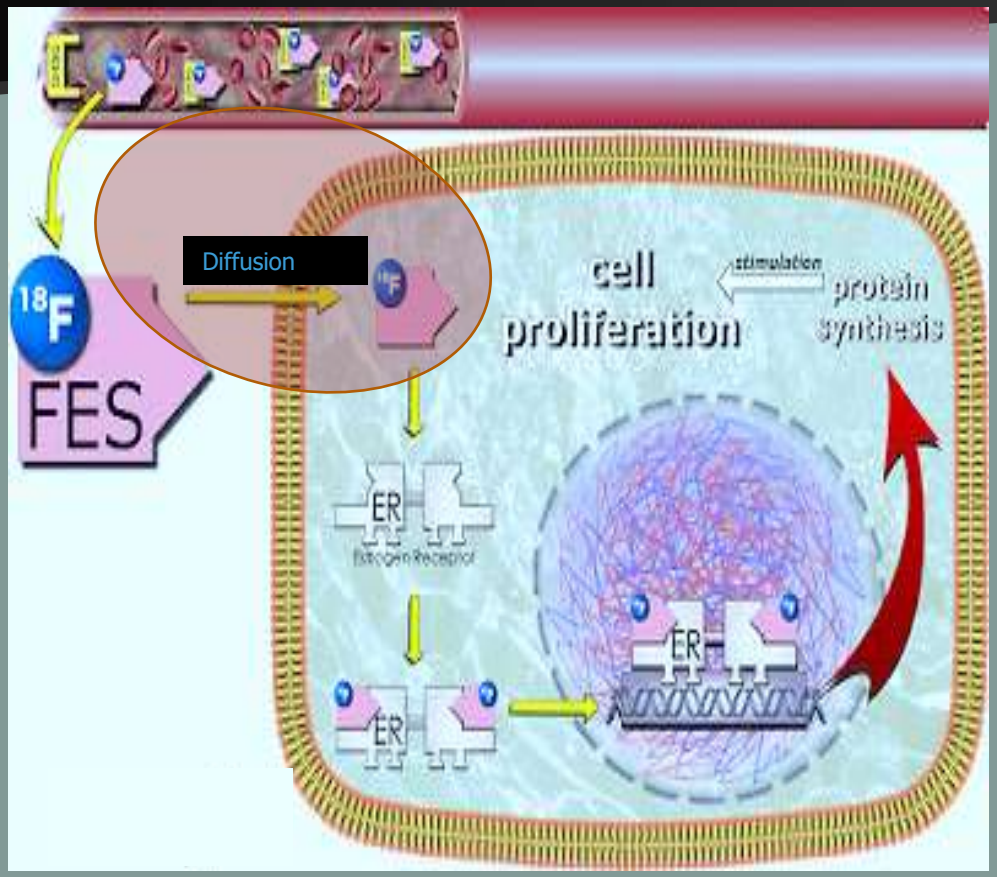


- Indication: Suspected prostate CA recurrence based on elevated blood PSA levels following prior treatment
- Mechanism of Action: Increased uptake into prostate cancer cells via upregulation of amino acid transporters

Package insert - https://www.axumin.com/about/moa

18F-FES (fluoroestradiol)





- Indication: Detection of ER+ lesions as adjunct to BX in pts with recurrent or metastatic breast CA

- Mechanism of Action:
  - Diffusion into cell, then binds to estrogen receptors

https://pet-ctbeyond18fdg.blogspot.com/2016/11/18f-fes.html

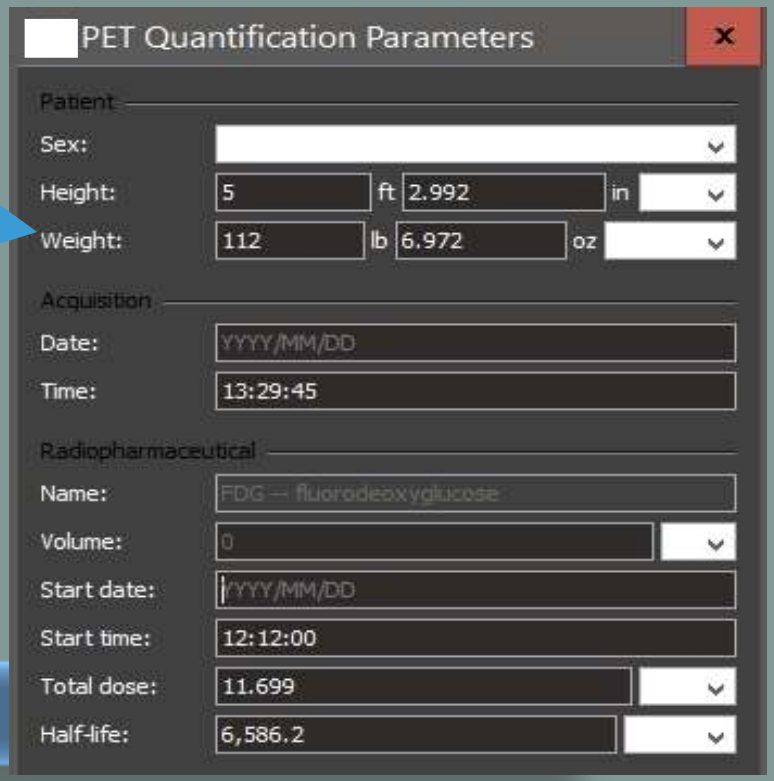
MISC - $300

How would significant weight loss affect the FDG SUV value if all other factors like dosage, uptake period, imaging, etc, are constant?

A. Higher

B. Lower

C. No change



Answer: B - Lower

SUV

- Semiquantitative measurement of tissue metabolic activity

SUV =[activity concentration in tissue]/[(injected activity)/(body size)]

- “Body size” --- most commonly based upon body weight

Sarikaya I, Albatineh AN, Sarikaya A. Revisiting weight-normalized SUV and lean-body-mass-normalized SUV in PET studies. J Nucl Med Technol. 2020; 48:163-7

SUV in Weight Change

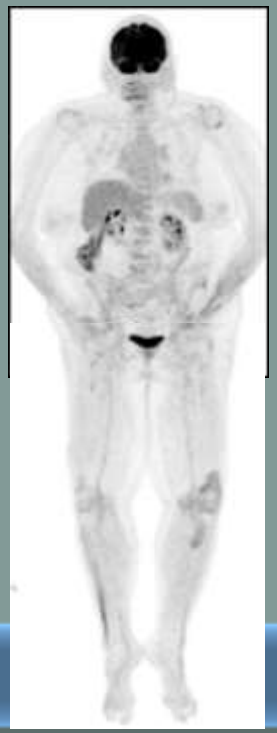
- Max or mean SUV → decrease in body weight = SUV decrease
- Lighter patients = lower body fat = less uptake in the lesion of interest
- Stated in a different way → thinner patients with more muscle will have a lower SUV in a given lesion due to muscle competing for the same FDG as the lesion.

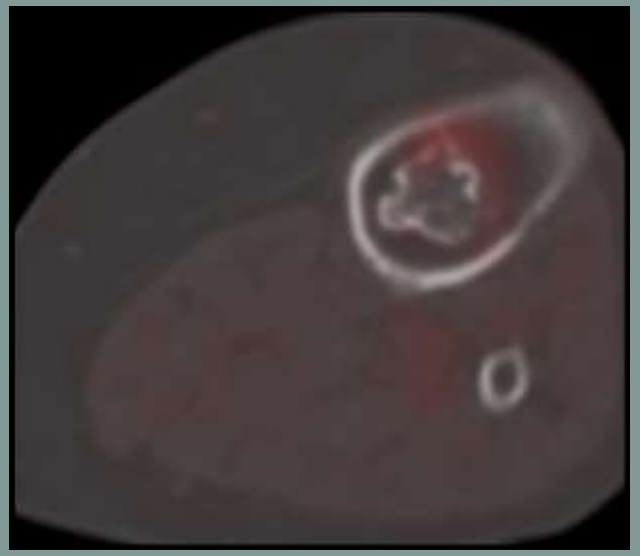
Adams MC, Turkington TG, Wilson, JM, et al. A systematic review of the factors affecting accuracy of SUV measurements. AJR. 2010; 195:310-20.

MISC - $400

An asymptomatic pt undergoes FDG PET/CT for bladder cancer follow-up. Incidental findings in the left lower extremity, one being an effusion. Which of the following is the most likely etiology for the finding in the left tibia?

A. Giant cell tumor
B. Low-grade chondrosarcoma
C. Enchondroma
D. Osteosarcoma





Answer: C - Enchondroma

Benign Bone Tumors on FDG PET/CT

- There is overlap in the degree of uptake between benign & malignant lesions, & an SUVmax cutoff may be difficult to define.

- CT characteristics associated with benignity include distinct margins, continuous cortical expansion (if present) and thick spiculations (if present). Location is also helpful for identifying the most likely tumor type.

- Patient age remains a primary predictor of lesion type & likely aggressiveness.

Enchondroma

- On CT - rings & arcs pattern with sclerotic rim.

- FDG uptake does not differentiate well between enchondroma & chondrosarcoma. MRI is required for this purpose. Differences in uptake or SUV may allow for grading of tumor within a given type (ex: high-grade vs low-grade sarcoma).

- Other findings that would favor chondrosarcoma more would be an
- associated soft tissue mass, cortical breakthrough, > 5 cm in size,
- endosteal scalloping. There is typically pain, also, with
- chondrosarcoma.

- Giant cell tumors & osteosarcomas are usually more intensely FDG avid

Enchondroma

- MC in tubular bones (hand, foot), femur, tibia, humerus
- Lytic
- Expansile
- Narrow zone of transition
- Scalloped endosteum
- Chondroid calcifications (“arcs & rings”)
- No periosteal reaction or associated mass

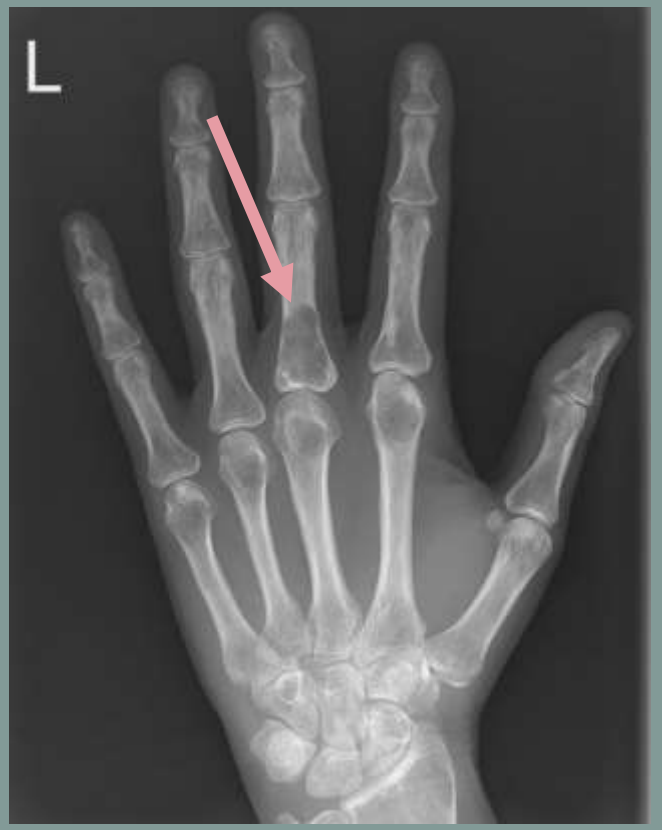
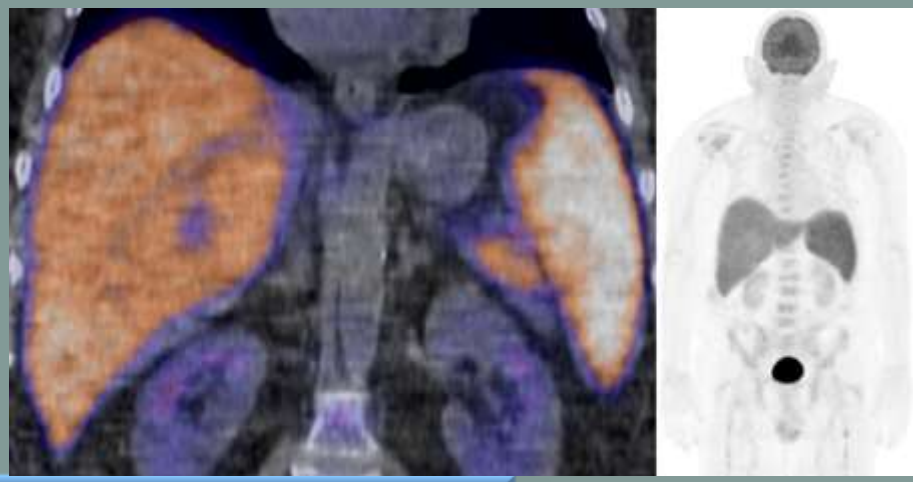


Image from Radiopaedia

MISC - $500

COVID vaccination 4 days before this FDG study & looked a little jaundiced during imaging. Pt clinically & this study negative for recurrent lung CA for years. Which is the BEST cause of uptake in the liver & spleen?

A. Reactive inflammation
B. CA treatment-related
C. Drug-induced injury
D. Osteosarcoma



Answer: C – Drug-induced injury

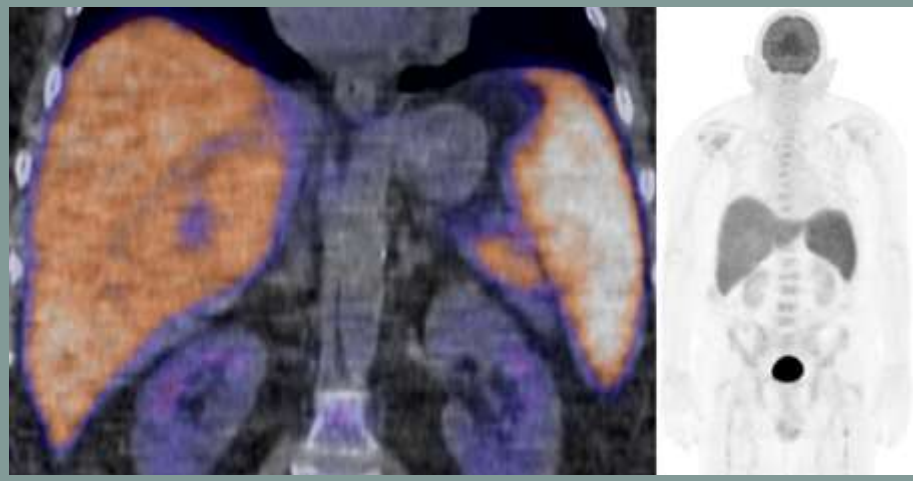
ARRAY OF PET/CT FINDINGS RELATED TO COVID-19 VACCINATION OR INFECTION

Bartel, Twyla B; Yarbrough, Tracy L
Global Advanced Imaging, PLLC

SNMMI Vancouver 2022

HEPATIC & SPLENIC INVOLVEMENT

- Increased uptake in new hepatosplenomegaly
- Pt diagnosed with autoimmune hepatitis (AIH) after this study
- COVID vaccination can trigger
- drug-induced liver injury with eosinophilic infiltration, autoantibodies, & features of AIH.
- This can also occur with natural COVID infection with general liver inflammation.



Hong JK, et al. Autoimmune hepatitis triggered by COVID-19. 2021; 51:1182-3.
McShane C, et al. The mRNA COVID vaccine – A rare trigger of autoimmune hepatitis? J Hepatol. 2021; 75:1252-4.

ARRAY OF PET/CT FINDINGS RELATED TO COVID-19 VACCINATION OR INFECTION

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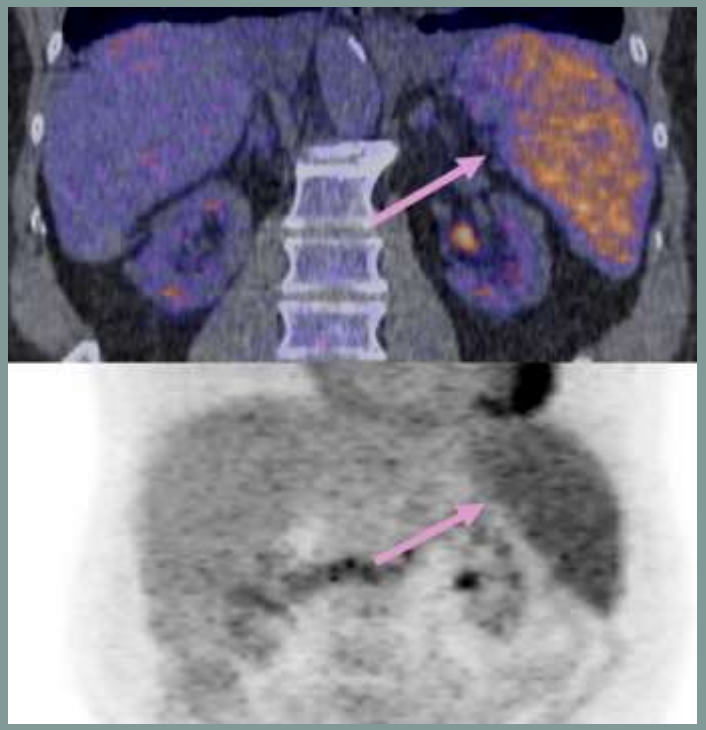
SNMMI Vancouver 2022

HEPATIC & SPLENIC INVOLVEMENT

- Hx: Incidental FDG-PET/CT finding & otherwise negative study. Very recent asymptomatic COVID infection. No prior vaccinations.
- FDG-PET/CT: Diffuse hypermetabolic mildly enlarged spleen (pink arrows).
- Inflammation & sequelae from the recent COVID infection. While pulmonary &/or chest nodal involvement are more frequently seen, isolated splenic uptake has also been reported. This pattern of uptake in the spleen can also be seen after COVID vaccination.



Minamimoto R, et al. Effects of COVID-19 vaccination on FDG-PET/CT imaging: A literature review. Glob Health Med. 2021; 3:129.33.
Subesinghe M, et al. A case control evaluation of pulmonary & extrapulmonary findings of incidental asymptomatic COVD-19 infection on FDG-PET/CT. 2022; 95:1130.
.

CASES - $100

Which is correct regarding utilization of FDG-PET/CT for fever of unknown origin (FUO)?

A. Sensitivity is ~80%
B. Specificity is > 90%
C. Better performance in pts with autoimmune DZ compared to those with infections or neoplasms
D. Superior to other nuclear imaging methods

Answer: D – Superior to other NM methods

FDG - FUO

- Meta-analyses have shown FDG-PET/CT for FUO with sensitivities ranging from 86 to 98%
- Specificities ranging from 52 to 85%
- Better performance in pts with infections/neoplasms compared to those with autoimmune DZ
- Superior to other nuclear imaging methods (i.e. PET without CT and gallium or leukocyte scintigraphy) in both adults and children

Hadair G, Singh N. Fever of unknown origin. New Engl J Med. 2022; 386:463-77

FDG - FUO

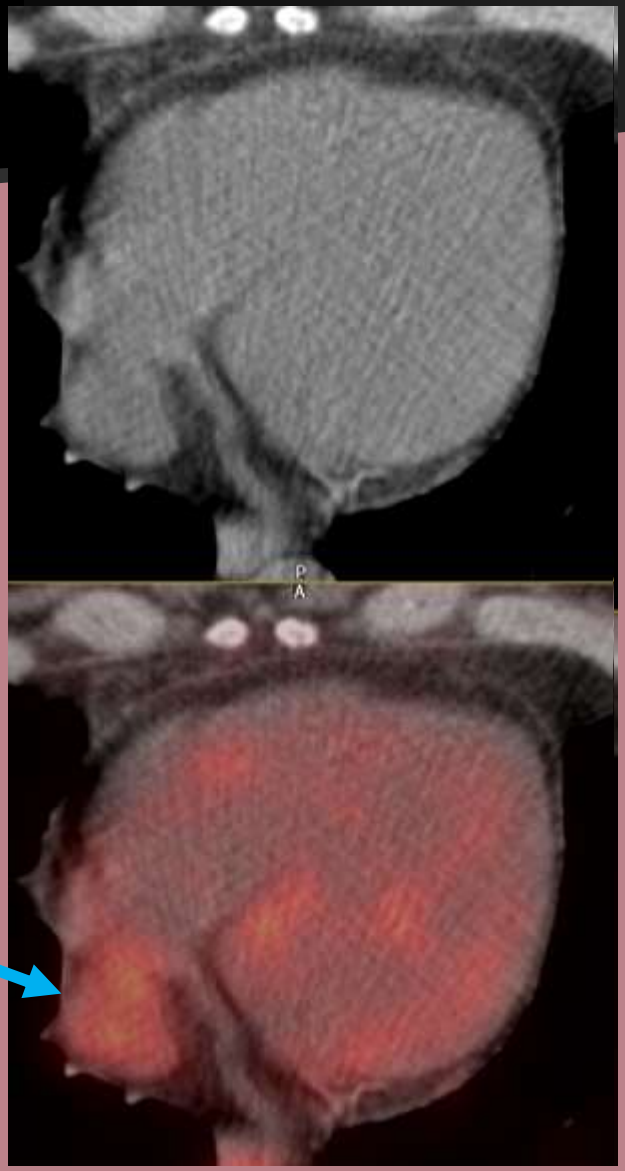
Table 1. Broad Categories of Fever of Unknown Origin (FUO).*

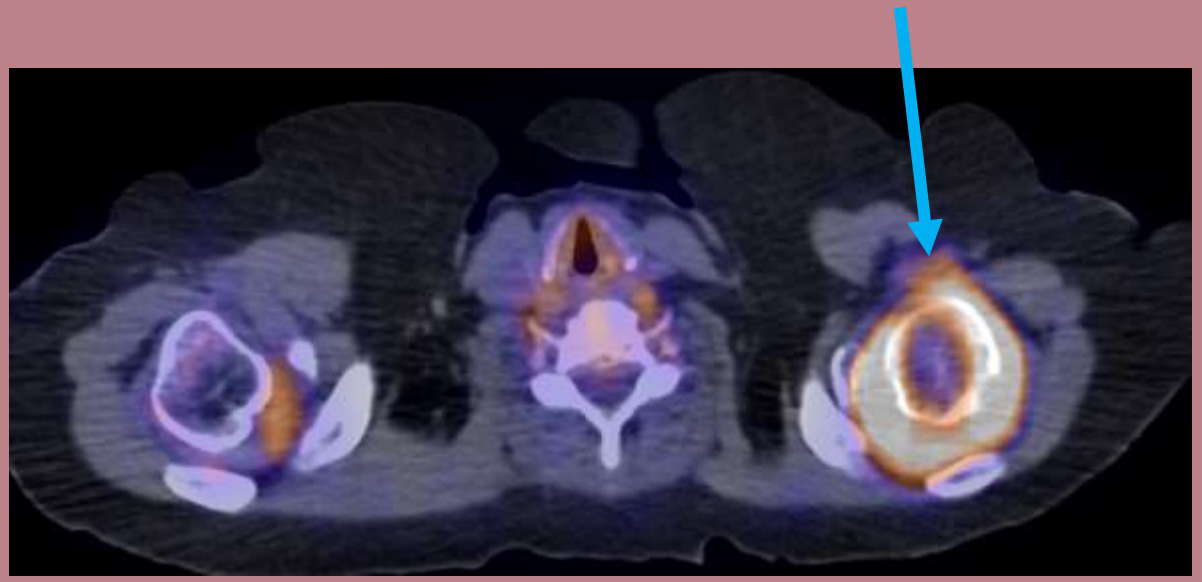
Category	Definition and Causes
Classic FUO	FUO despite reasonable initial investigations in the inpatient or outpatient setting; includes FUO in persons with HIV infection who are virally suppressed, with CD4 counts >200 cells/mm^3; causes fall into four categories: infections (e.g., tuberculosis, endocarditis, occult abscesses, Whipple's disease, enteric fever, syphilis [mainly secondary], various zoonoses, and histoplasmosis), cancer, autoimmune and autoinflammatory disorders, and miscellaneous causes
Nosocomial FUO	FUO that develops in hospitalized persons
ICU patients	Causes include infections (bacteremia, pneumonia, *Clostridioides difficile* infection, fungemia, catheter-associated infections, decubitus ulcers), thromboembolic events, acalculous cholecystitis, drug-associated fever, strokes, cerebral hemorrhages, and bleeding
Non-ICU patients	Similar causes to those listed for FUO in ICU setting, although patients are not critically ill
Immunodeficiency-associated FUO	Causes are highly variable, depending on the type of underlying immunodeficiency
Organ-transplant recipients	Causes include viruses, donor-derived infections, *Strongyloides stercoralis* hyperinfection, opportunistic fungal infections, rejection, and in rare cases, GVHD, graft intolerance syndrome (from retained kidney grafts in situ after graft failure), old nonfunctioning arteriovenous grafts after kidney transplantation (may cause occult infection or fever), hemophagocytic lymphohistiocytosis, and ureaplasma-related hyperammonemia syndrome
Patients with neutropenia	High-risk patients with neutropenia are considered to have FUO if they have been febrile for >5 days despite appropriate empirical antibiotic therapy; etiologic diagnosis affected by duration of neutropenia, immunosuppression for GVHD treatment or prophylaxis, and prophylactic antimicrobial therapy
Hematopoietic-cell transplant recipients	Causes before engraftment: similar to causes of neutropenic FUO Causes in early period after engraftment: engraftment itself, opportunistic herpesvirus infections, adenovirus infection, hyperacute GVHD, infectious pneumonia, idiopathic pneumonia syndrome Causes in late period after engraftment: multiple causes, including relapsed cancer; immune reconstitution is not fully restored for approximately 24 mo, and patients remain at risk for infection (e.g., from encapsulated organisms) during that period
Patients with HIV infection not receiving ART, patients with AIDS	Causes include acute retroviral syndrome, mycobacterial infection, endemic mycoses, toxoplasmosis, cryptococcosis, HHV-8 infection (e.g., Kaposi's sarcoma, primary effusion lymphoma, Kaposi's sarcoma herpesvirus inflammatory cytokine syndrome), and lymphoma
Travel-associated FUO	Causes include malaria, enteric fever, leptospirosis, viral hemorrhagic fevers, typhus, and acute undifferentiated febrile illness of tropical countries[24]

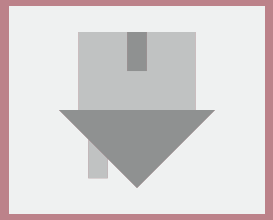
* The table includes a selected list of entities that may be associated with FUO. Data are from Durack and Street[3] and Wright and Auwaerter.[23] AIDS denotes acquired immunodeficiency syndrome, ART antiretroviral therapy, GVHD graft-versus-host disease, HHV human herpesvirus, HIV human immunodeficiency virus, and ICU intensive care unit.

Hadair G, Singh N. Fever of unknown origin. New Engl J Med. 2022; 386:463-77

FDG - FUO

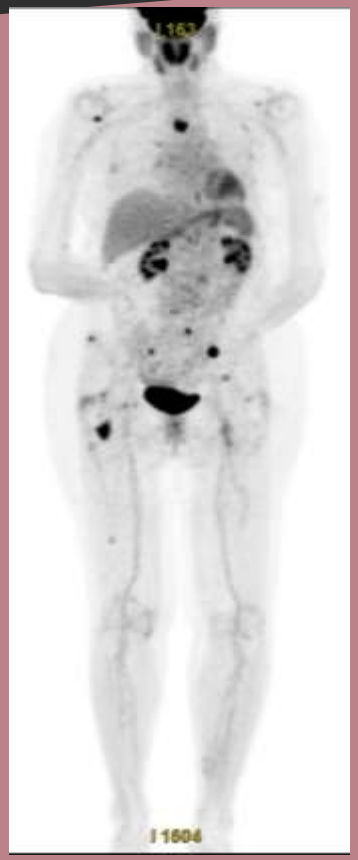


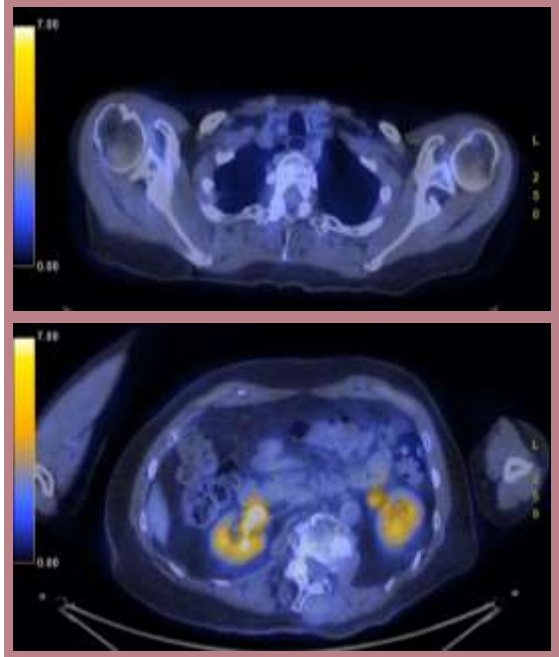




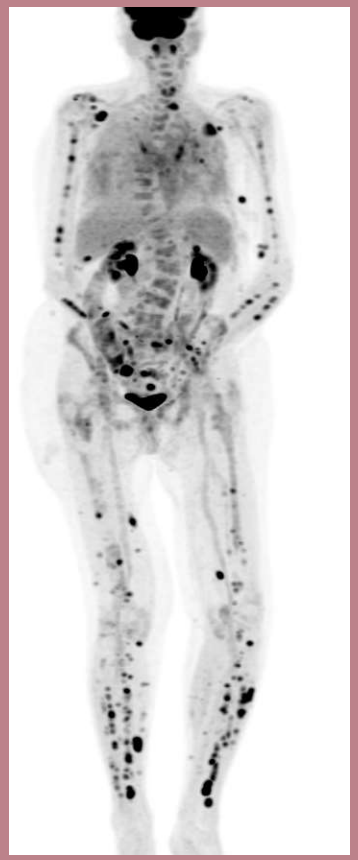
CASES - $200

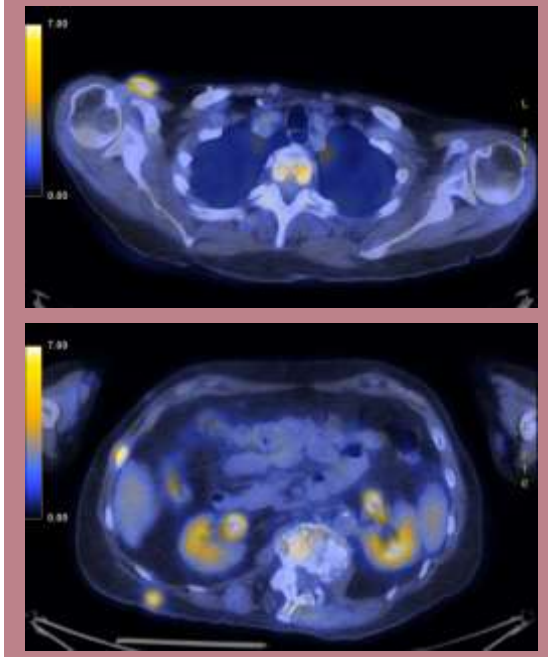
76 year-old woman with relapsed IgG kappa multiple myeloma.
Presents for restaging in the setting of slightly increasing serum kappa light chains.





Prior (-966 days)

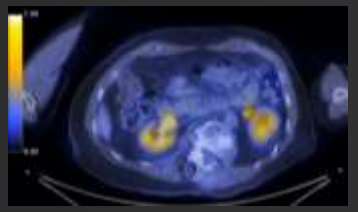




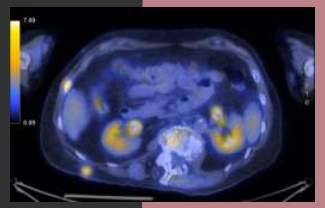
Current

Answer:

CASES - $200



Prior



Current

Which of the following has(have) been shown to be a prognostically significant indicator(s) in patients with multiple myeloma?

A. Number of FDG+ focal lesions (FLs) on staging (pre-treatment) FDG PET
B. Presence of extramedullary disease on FDG PET in relapse
C. Normalization of FDG PET post-transplant
D. All of the above.

Answer: D

TABLE 1 | Main characteristics of ^{18}F-FDG PET/CT and MRI for multiple myeloma imaging at baseline.

	^{18}F-FDG PET/CT	MRI
Scanning time	15–20 min Starts 60 min after FDG injection	Between 30 and 50 min
Radiation exposure	10–25 mSv (PET+CT component)	None
Bone involvement	High sensitivity ~10% of PET false-negative MM	High sensitivity of AS-MRI Highest sensitivity of WB DW-MRI
Diffuse bone marrow disease	Moderate sensitivity	Gold standard
Extramedullary disease	Preferred technique	Diagnostic value less explored
Impact on clinical decision	More than WB DW-MRI	Less than ^{18}F-FDG PET/CT
Prognostic value	>3FL EMD SUV_{max} Other quantitative PET parameters (MTV and TLG)	Diffuse disease >3 large FLs on WB DW-MRI (>5 cm^2)
Standardization for acquisition, interpretation, and reporting	IMPETUS criteria	WB DW-MRI: MY-RADS criteria

^{18}F-FDG PET/CT, fluorodeoxyglucose positron emission tomography–computed tomography; MM, multiple myeloma; AS-MRI, axial skeleton MRI; WB DW-MRI, whole-body diffusion-weighted MRI, FL, focal lesion; MTV, metabolic tumor volume; TLG, total lesion glycolysis; SUV_{max}, maximum standardized uptake value; IMPETUS, Italian Myeloma Criteria for PET Use; MY-RADS, Myeloma Response Assessment and Diagnosis System.

FDG PET Prognostic-ation in Multiple Myeloma

Han S, Woo S, Kim Y-I, Yoon DH, Ryu J-S. Prognositic value of 18F-fluorodeoxyglucose positron emission tomography/computed tomography in newly diagnosed multiple myeloma: a systematic review and meta-analysis.

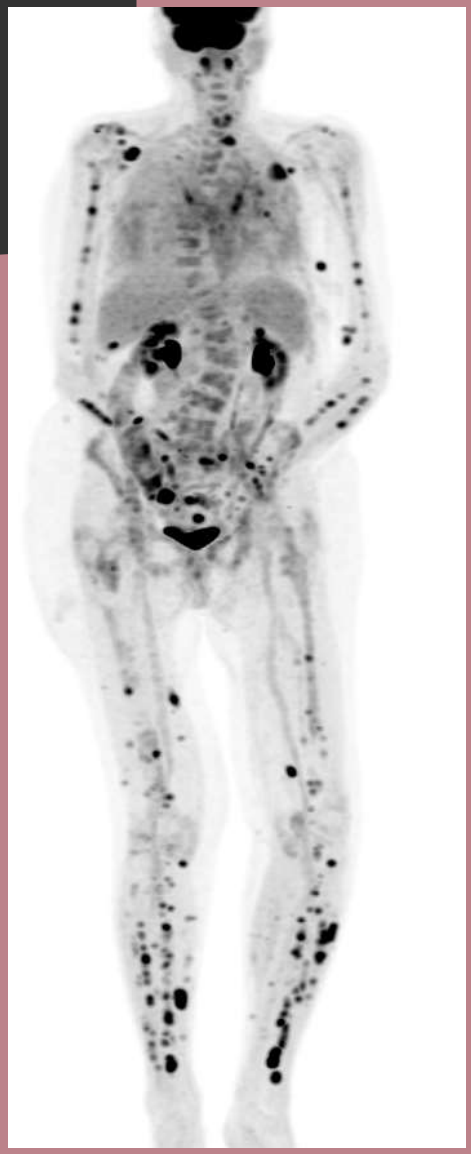
Mesguich C et al. 18F-FDG PET/CT and MRI in the Management of Multiple Myeloma: A Comparative Review. *Frontiers in Nuclear Medicine*. 2022; 1: 808627.

Zukovs R, et al. 18F-FDG PET/CT in relapsed multiple myeloma: Are prognostic thresholds different from first-line therapy? *BMC Medical Imaging.* 2022; 22: 64.

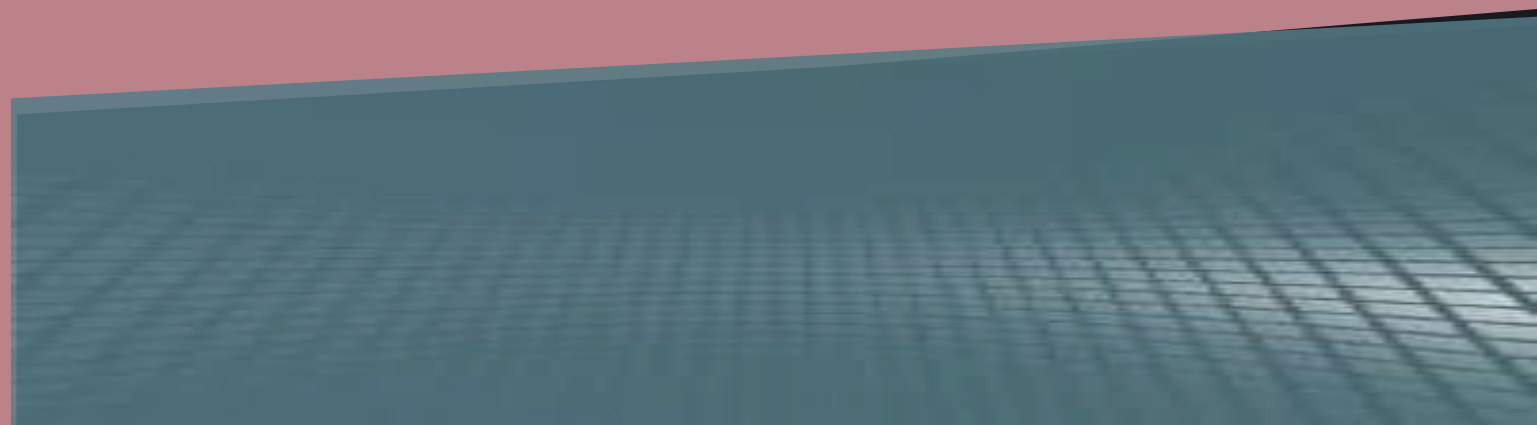
The IMPeTUS Criteria in Multiple Myeloma

IMPeTUs = Italian myeloma criteria for PET use

- Diffuse bone marrow FDG uptake (score 1-5 using Deauville criteria) **-- 4**
- Focal (FDG+) bone lesion number: 0; 1-3; 4-10; >10 **-- 4**
- Focal (FDG+) bone lesion SUV (Deauville score at hottest site) **-- 5**
- Lytic bone lesion number: 0; 1-3; 4-10; >10) **-- 4**
- Extramedullary disease SUV (Deauville at hottest site) **-- 5**



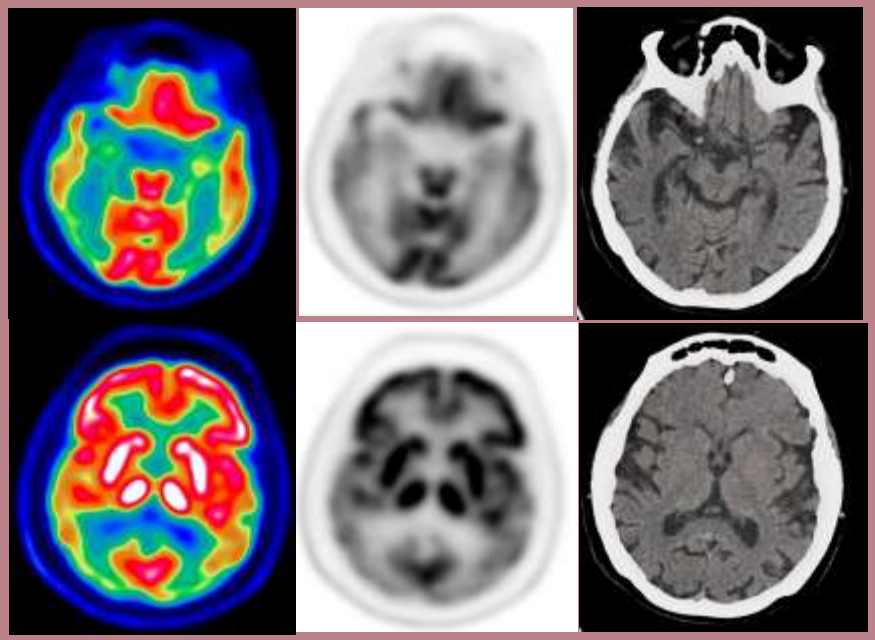
Nanni C. PET-FDG: Impetus. *Cancers (Basel)*. 2020; 12(4): 1030.



CASES - $300

67 year-old male with changes in cognition, attentional disturbances, visual hallucinations, and other vague symptoms. What is the most likely diagnosis?

A. Alzheimer Disease (AD)
B. Dementia with Lewy Bodies (DLB)
C. Multi-infarct (vascular) Dementia
D. Multi-focal Epilepsy



Answer: B

Patterns of FDG PET Distribution in Selected Dementia Etiologies

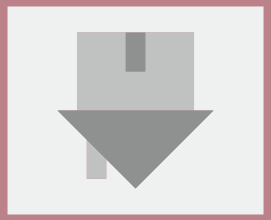
- Findings characteristic for AD include posterior parieto-temporal hypometabolism, typically sparing the precentral gyrus and occipital lobes
- In patients with DLB, FDG PET classically demonstrates hypometabolism involving the parietal and occipital lobes with preserved uptake in the posterior cingulate gyrus (“cingulate island sign”)
- Patients with multi-infarct dementia tend to exhibit scattered areas of focal or regional cerebral and cerebellar hypometabolism
- Ideally, FDG PET will demonstrate focal hypometabolism at the seizure focus, which often can be correlated with areas of enhancement on MRI and hyperemia on brain SPECT

Jreige M, et al. The diagnostic performance of functional dopaminergic scintigraphic imaging in the diagnosis of dementia with Lewy bodies: An updated systematic review. *Eur J Nucl Med Mol Imaging.* 2023; epub ahead of prient. Doi: 10.1007/s00259-023-06154-y.
Ponosio MR, et al. The Role of SPECT and PET in Epilepsy. *Am J Roentgeneology.* 2021; 216: 759-768.
Shivamurthy VKN, et al. Brain FDG PET and the Diagnosis of Dementia. *Am J Roentgenology.* 2015; 204(1): W76-W85.

Clinical Imaging of Lewy Body Dementia (DLB)

Modality	Application As Related to DLB	Characteristic Findings
FP-CIT SPECT (DaTscan™)	Differentiation from Alzheimer Disease (AD) and (HC)	Decreased dopamine tracer uptake in the basal ganglia
FDG PET	Supporting of DLB diagnosis	Occipital lobe hypometabolism, cingulate island sign, with involvement of parieto-temporal and visual association cortices/lobes in DLB
CT	Exclusion of secondary causes of dementia such as space-occupying lesions (tumors, hematomas)	DLB will have intact brain structures and white matter integrity
MRI	Differentiation from AD	Preservation of mesial temporal lobe structures in DLB as compared to AD, with other characteristic patterns
MIBG Cardiac SPECT	Differentiation from AD	Low uptake indicating the presence of cardiac post-ganglionic sympathetic denervation, characteristic of neurodegenerative diseases with Lewy body pathology

Chart adapted from: Yousef T, et al. Neuroimaging in Lewy body dementia. *Journal of Neurology.* 2019; 266: 1-26.
Kang SW, et al. Implication of metabolic and dopamine transporter PET in dementia with Lewy bodies. *Scientific Reports.* 2021; 11: 14394.



CASES - $400

Which of the following is(are) FDA-approved appropriate uses for prostate-specific membrane antigen (PSMA) PET?

A. Suspected prostate cancer recurrence in patient with minimally/un-detectable PSA (prostate-specific antigen)
B. Suspected metastases in patient with potentially surgically curable renal cell CA
C. Suspected metastases in patient with potentially surgically curable prostate CA
D. Guidance of biopsy for patients with elevated PSA and abnormal digital rectal examination

Answer: C

Harmonizing FDA Approval and Appropriate Use Criteria in PET

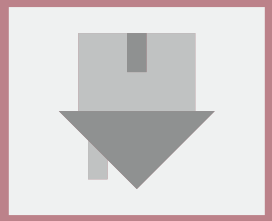
- PSMA is not currently FDA-approved for evaluation of patients with malignancies OTHER THAN prostate adenocarcinoma
- The only currently FDA-approved indications for PSMA and fluciclovine PET include: 1) detection of metastasis in patients with prostate cancer **potentially curable by definite therapy** (surgery or radiotherapy) AND 2) detection of sites of active disease in patients with **suspicion of recurrence based on rising prostate specific antigen** (PSA) levels
- PSMA PET is not appropriate in patients who have yet to be diagnosed with prostate adenocarcinoma by histopathology

Jadvar H, et al. Appropriate use criteria for Prstate-Specific Membrane Antigen PET Imaging. *J Nucl Med.* 2022; 63(1): 59-68.
As accessed on 3/21/2023 at https://www.fda.gov/drugs/news-events-human-drugs/fda-approves-second-psma-targeted-pet-imaging-drug-men-prostate-cancer

Guidelines for Use of PSMA and Fluciclovine PET

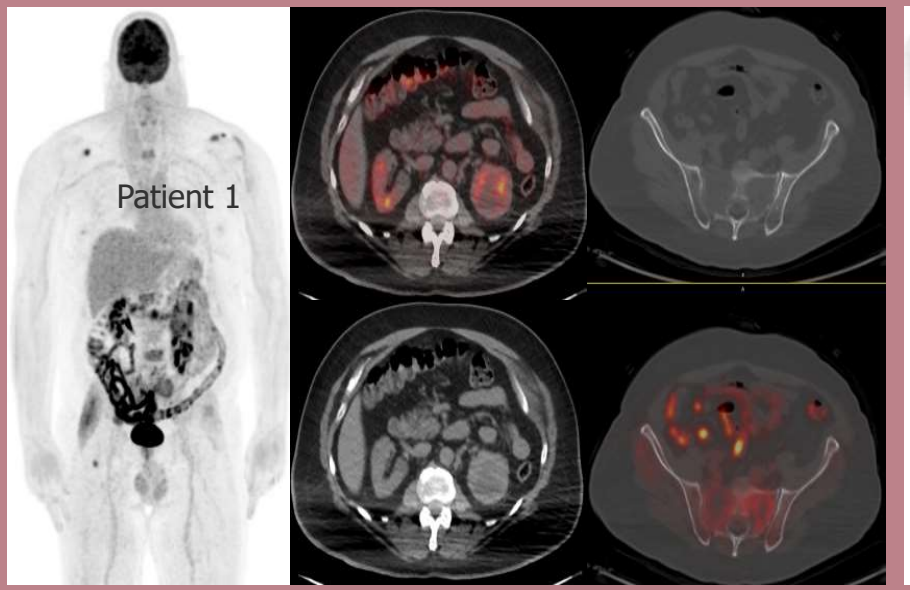
Patients with the following scenario…	**PSMA PET** Appropriateness Ratings per SNMMI AUC	**Fluciclovine PET** "Appropriateness Use" per NCCN Guideline
- PSA persistence or rise from undetectable after prostatectomy or definitive Rx; - staging unfavorable intermediate or high-risk Pr CA (& with neg or equivocal findings on conventional imaging); - nmCRPC on conventional imaging; post-treatment PSA rise in mCRPC if being considered for PSMA-targeted Rx*	7, 8 or 9 (Appropriate)	
- newly diagnosed Pr CA with mets on conventional imaging; - PSA rise after focal Rx to primary; - post-treatment PSA rise in mCRPC if NOT being considered for PSMA-targeted Rx*; - evaluation of therapy response	4, 5 or 6 (May be appropriate)	May be used for detection of disease at biochemical recurrence and progression of disease in bone and soft tissues (See NCCN Guidelines algorithm for more details)
-v. low, low and favorable intermediate-risk Pr CA; -suspected prostate CA for targeted biopsy	1, 2 or 3 (Rarely appropriate)	

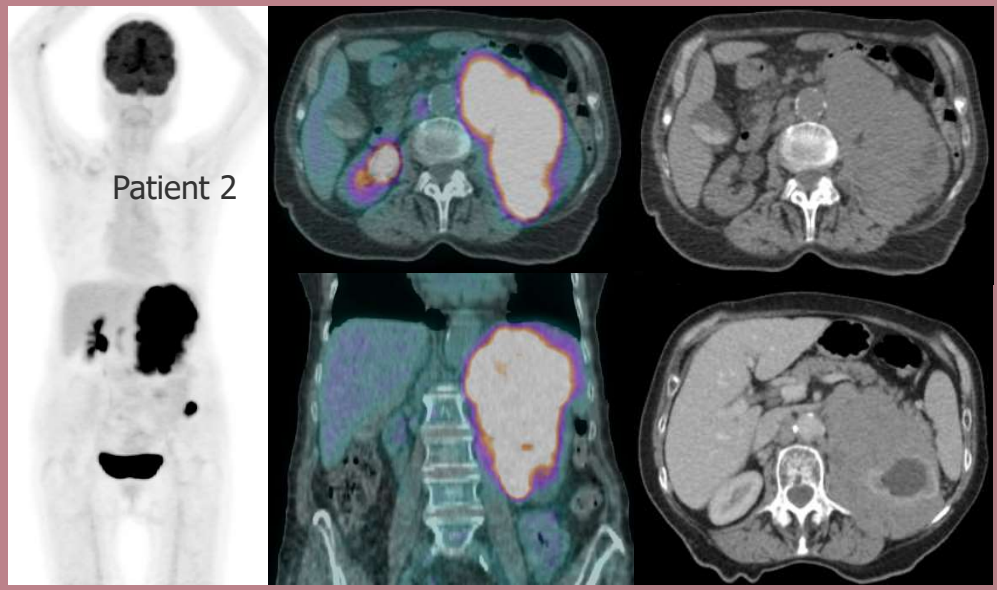
Jadvar H, et al. Appropriate use criteria for Prstate-Specific Membrane Antigen PET Imaging. *J Nucl Med.* 2022; 63(1): 59-68
Hope TA and Jadvar H. Updates to appropriate use criteria for PSMA PET. *J Nucl Med*. 2022; 63(5): 14N.
NCCN Guidelines for Prostate Cancer, as accessed on 3/21/2023 at https://www.nccn.org/professionals/physician_gls/pdf/prostate.pdf

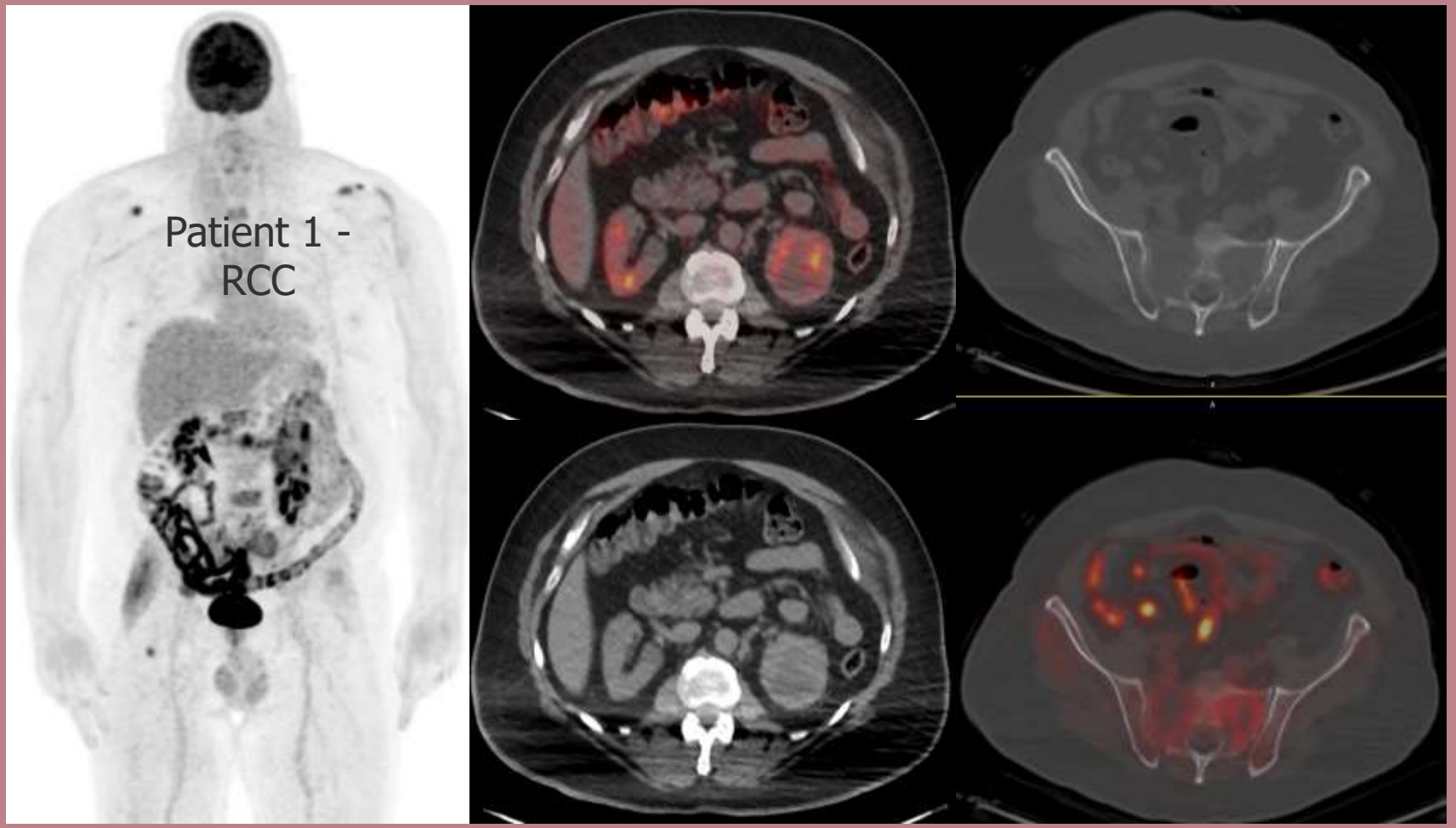


CASES - $500

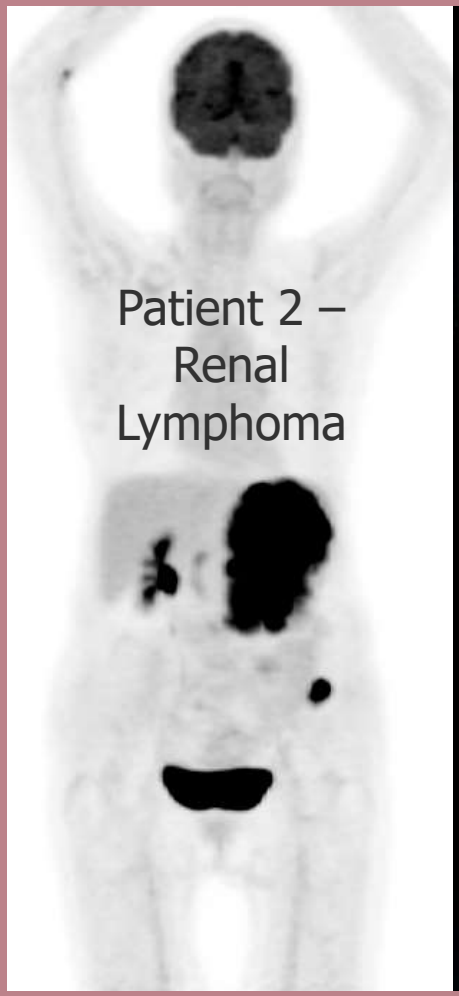
FDG PET/CTs. Renal abnormalities in 2 pts.

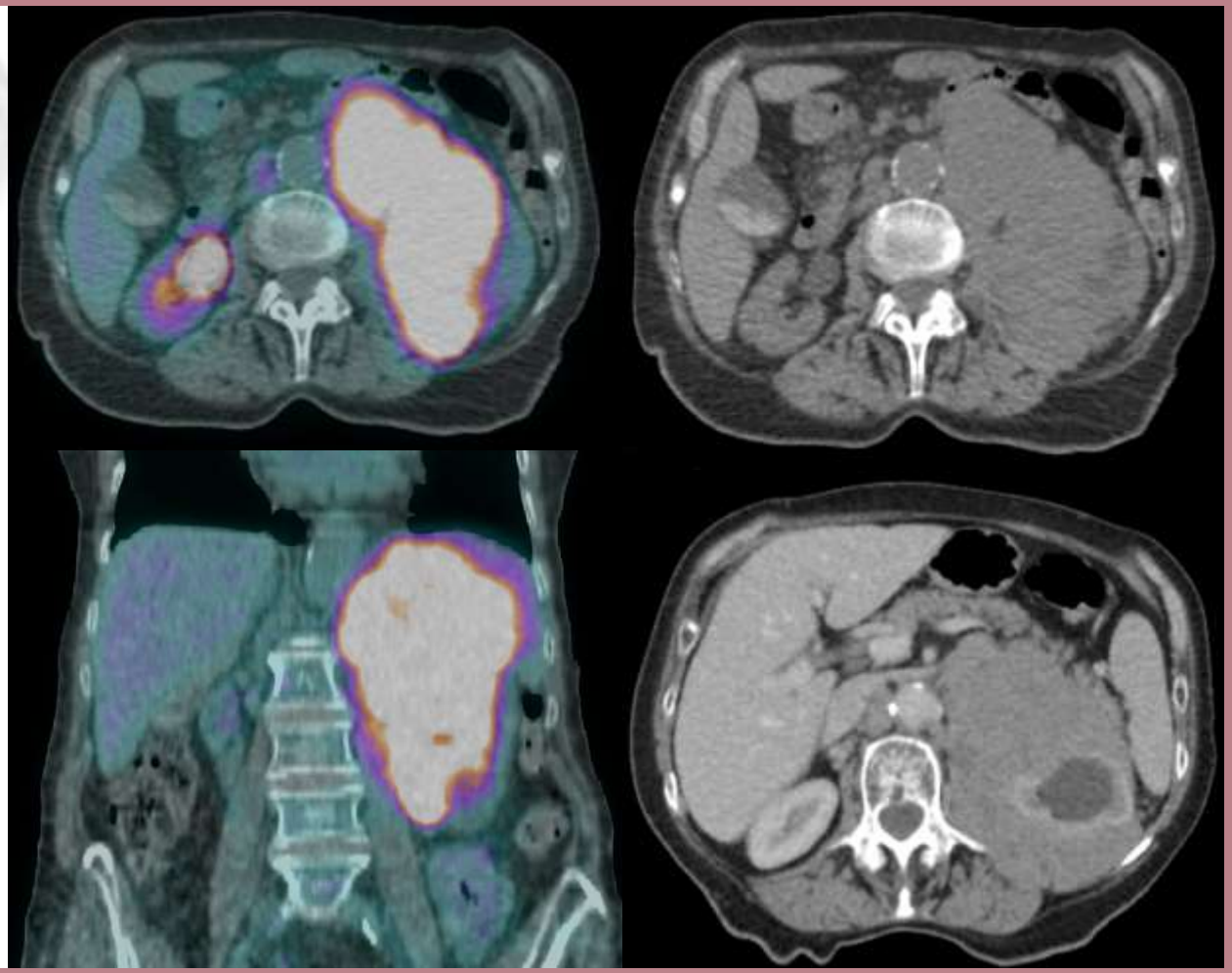





Patient 1 -
RCC

Patient 2 – Renal Lymphoma

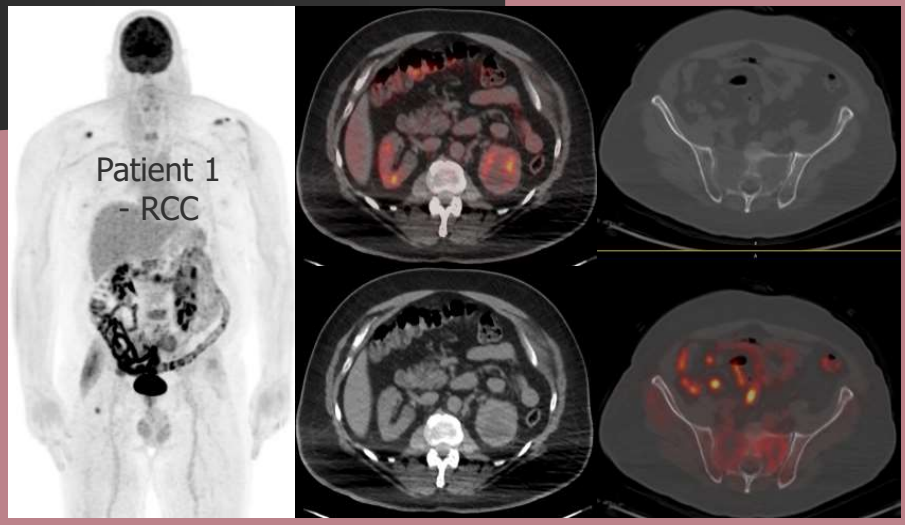


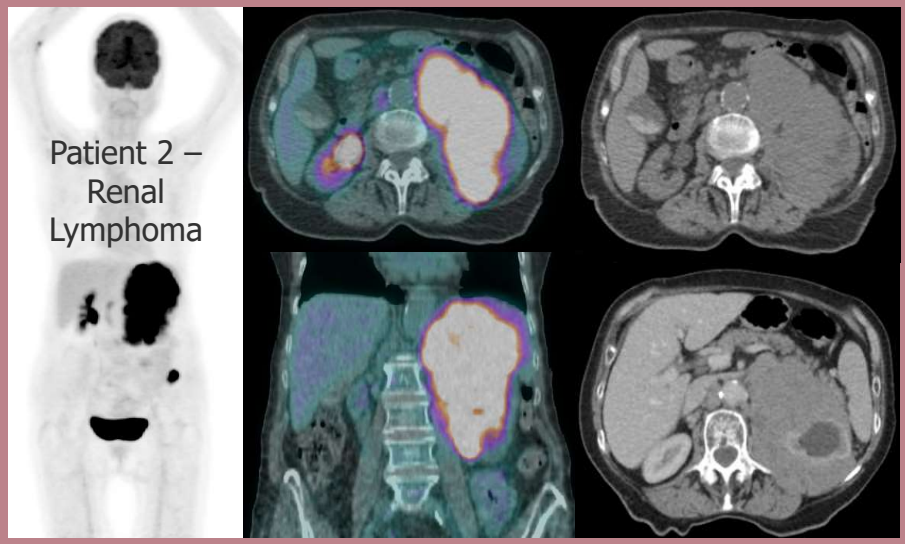


CASES - $500

Which is MOST CORRECT regarding FDG PET/CT for these two entities?

A. RCC always has increased uptake for the primary lesion.
B. SUVs/uptake is higher for lymphoma.
C. The MC CT appearance of renal lymphoma is cystic masses.
D. Higher FDG PET RCC uptake indicates lower GLUT-1 expression.





Answer: B – SUVs higher for lymphoma

FDG PET/CT RCC vs Renal Lymphoma

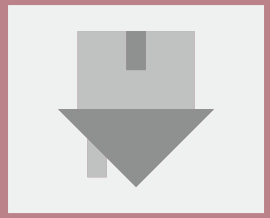
- Renal lymphoma typically has higher SUVs than RCC. Nicolau et al - All renal lymphomas have a SUVmax > 5.98 g/mL (median, 10.99 g/mL), whereas all RCCs have a SUVmax < 5.26 g/mL (median, 2.91 g/mL).

- The primary lesion for RCC detection with FDG PET/CT has *pooled sensitivity of 50-60%*. Detection is higher for RCC mets.

- The MC CT appearance of renal lymphoma is multiple *solid* renal masses.

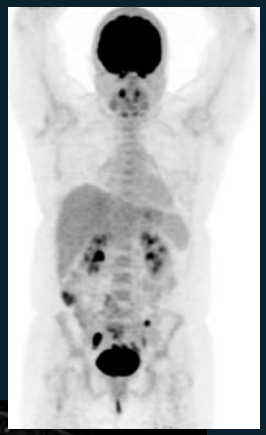
- There is *higher GLUT-1* expression with higher grade RCCs along with greater FDG uptake.

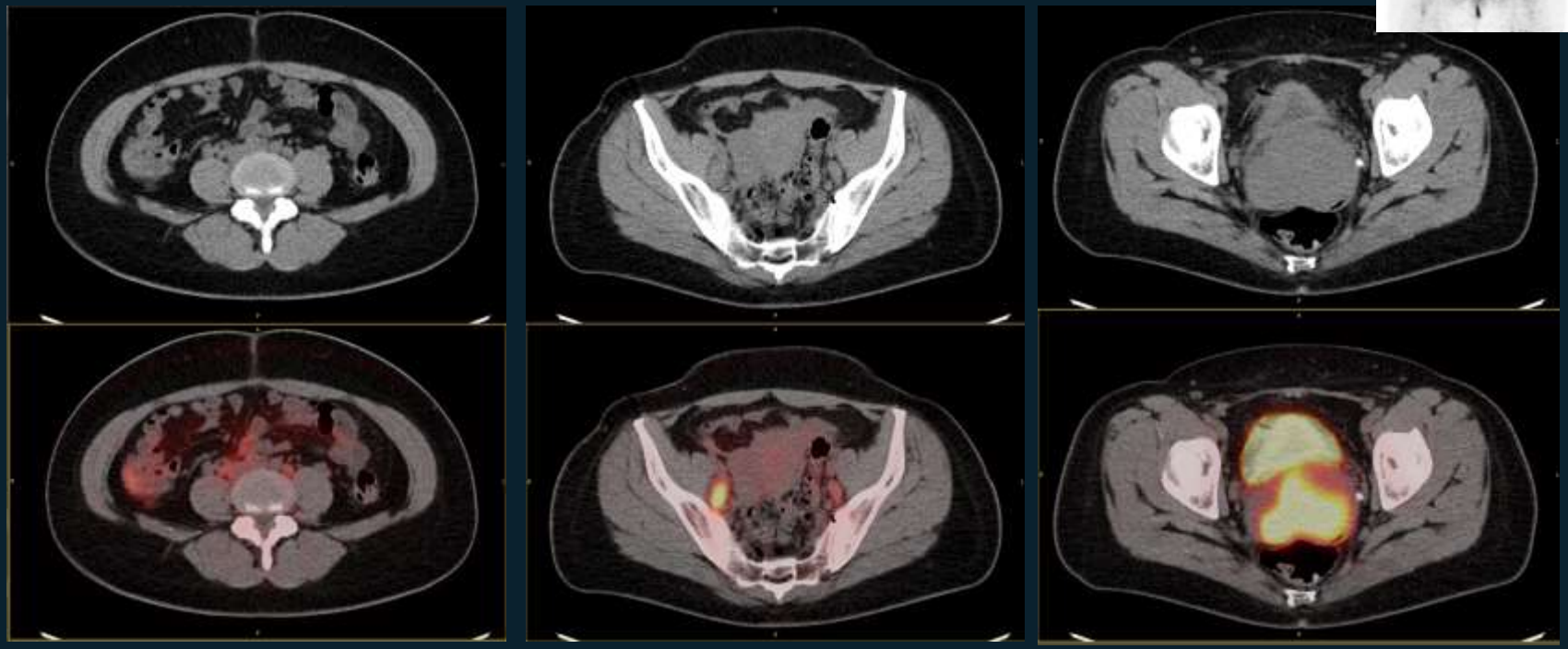
Liu Y. The place of FDG PET/CT in renal cell carcinoma: Value and limitations. *Front Oncol*. 2016.
Kochhar R et al. Pictorial essay: Role of FDG PET/CT in imaging or renal lesions. *J Med Imaging Radiation Oncol.* 2010; 54:347-57.
Nguyen T et al. Multimodality imaging of renal lymphoma and its mimics. *Insights into Imaging.* 2022; 13
Nicolau C et al. Renal masses detected on FDG PET/CT in patients with lymphoma: imaging features differentiating primary renal cell carcinomas from renal lymphomatous involvement. *AJR.* 2017; 208:849-53.



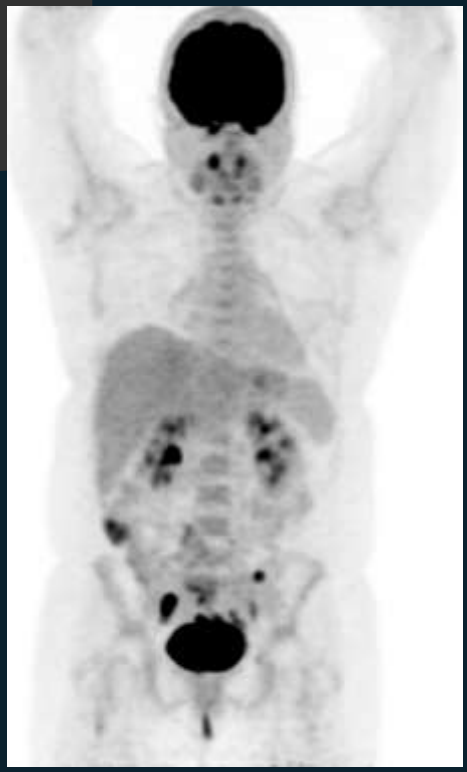
CHALLENGE - $100

Woman with newly diagnosed (untreated) cervical cancer, status-post laparoscopic exploratory exam under anesthesia (EUA).





Which of the following reflects the most common nodal (lymphatic) drainage patterns from cervical cancer?



A. Para-aortic and external iliac (1°) → common iliac (2°)
B. Lateral pelvic (obturator) and junctional/ interiliac (1°) → common iliac and para-aortic (2°)
C. Superficial inguinal (1°) → external iliac (2°)
D. Lateral pelvic (obturator) and hypogastric junctional/interiliac (1°) → external iliac (2°)

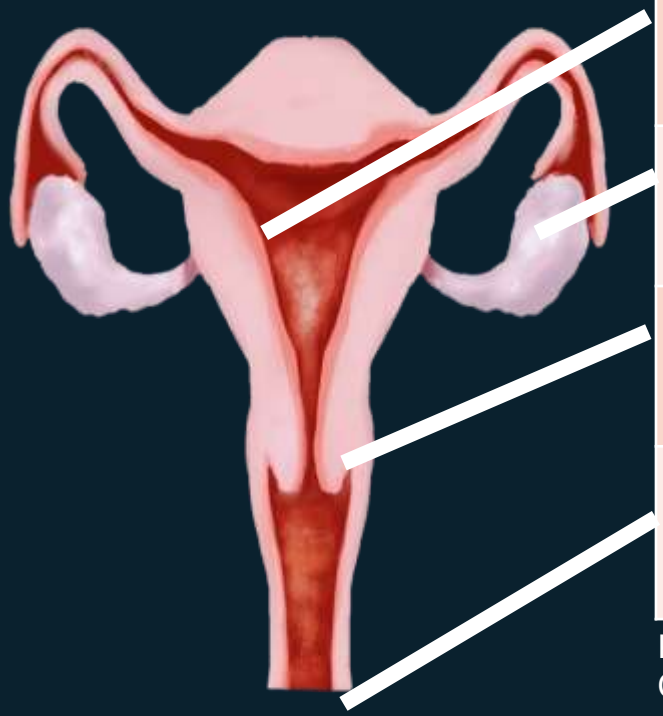
Answer: D

Common Lymphatic Drainage Patterns in Gynecologic Malignancies

A. Para-aortic and external iliac (1°) → common iliac (2°) = ovarian
B. Lateral pelvic (obturator) and hypogastric (junctional/interiliac) (1°) → common iliac and para-aortic (2°) = endometrial
C. Superficial inguinal (1°) → external iliac (2°) = vulvar
D. Lateral pelvic (obturator) and hypogastric junctional/interiliac (1°) → external iliac (2°) = cervical

Paño B, et al. Pathways of lymphatic spread in gynecologic malignancies. *Radiographics*. 35(3):

"Regional" Nodes in Gynecologic Malignancies



Primary Tumor Site	Nodal Stations	
	Regional	Non-Regional
Endometrium	PV, PA, CI, EI, II	I = TNM M1 & FIGO IVB
Ovaries	PV, PA, CI, EI, II	I = TNM M1 & FIGO IVB
Cervix	PV, CI, EI, II	PA, I = TNM M1 & FIGO IIIC2
Vulva	PV, I	PA, CI, EI and II = TNM M1 & FIGO IVB

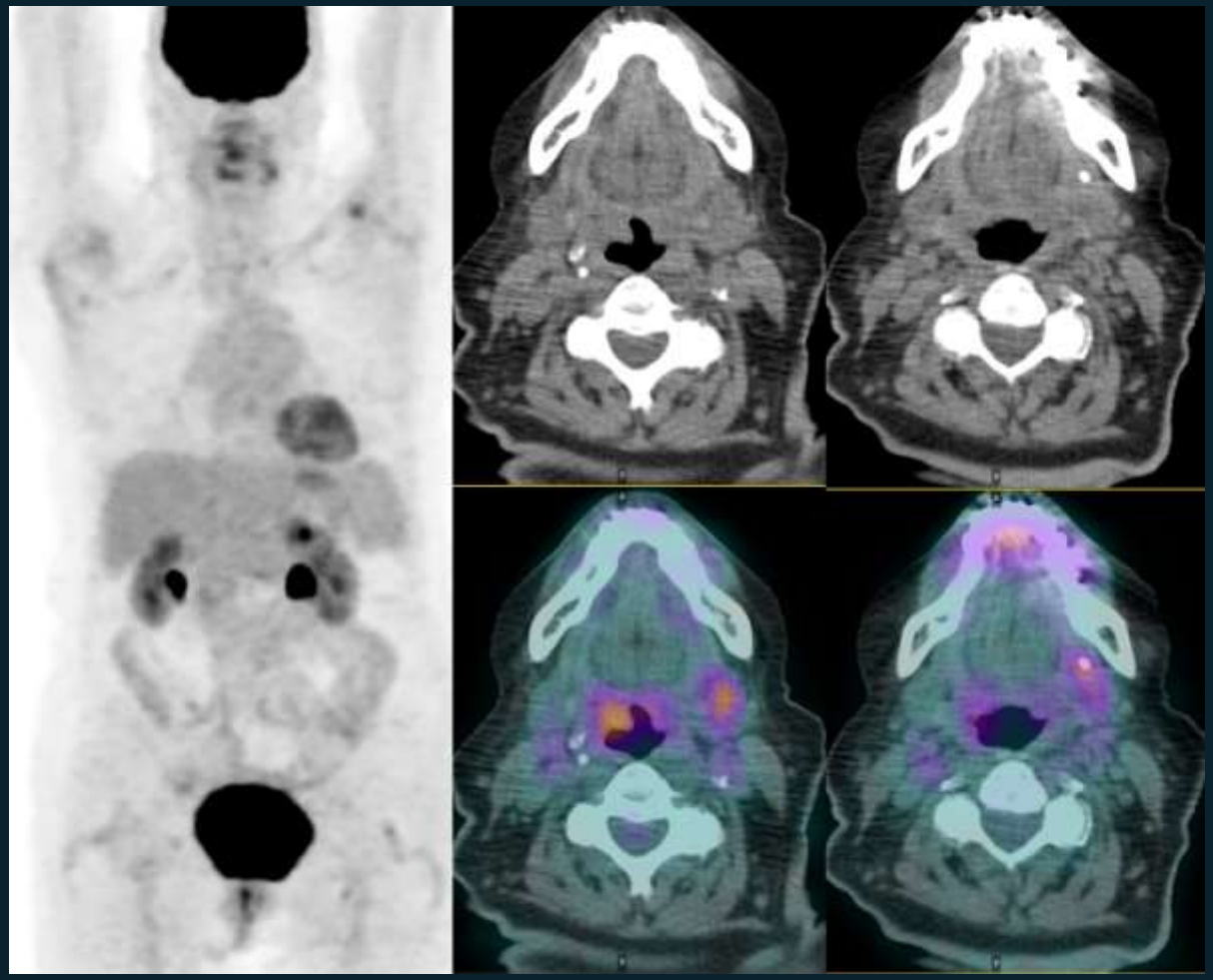
PA=para-aortic, PV=perivesicular, II=internal iliac, I=inguinal, EI=external iliac, CI=common iliac; TNM and FIGO staging.

Image as accessed on 3/21/2023 at https://jschoi.org/20/body-emoji/

Chart adapted from Ramanathan S, et al. Nodal metastasis in gynecologic malignancies: Update on imaging and management. *Clinical Imaing.* 2020; 59(2): 157-166.

CHALLENGE - $200

Pt with a history of lymphoma & no evidence of recurrence clinically or by imaging.



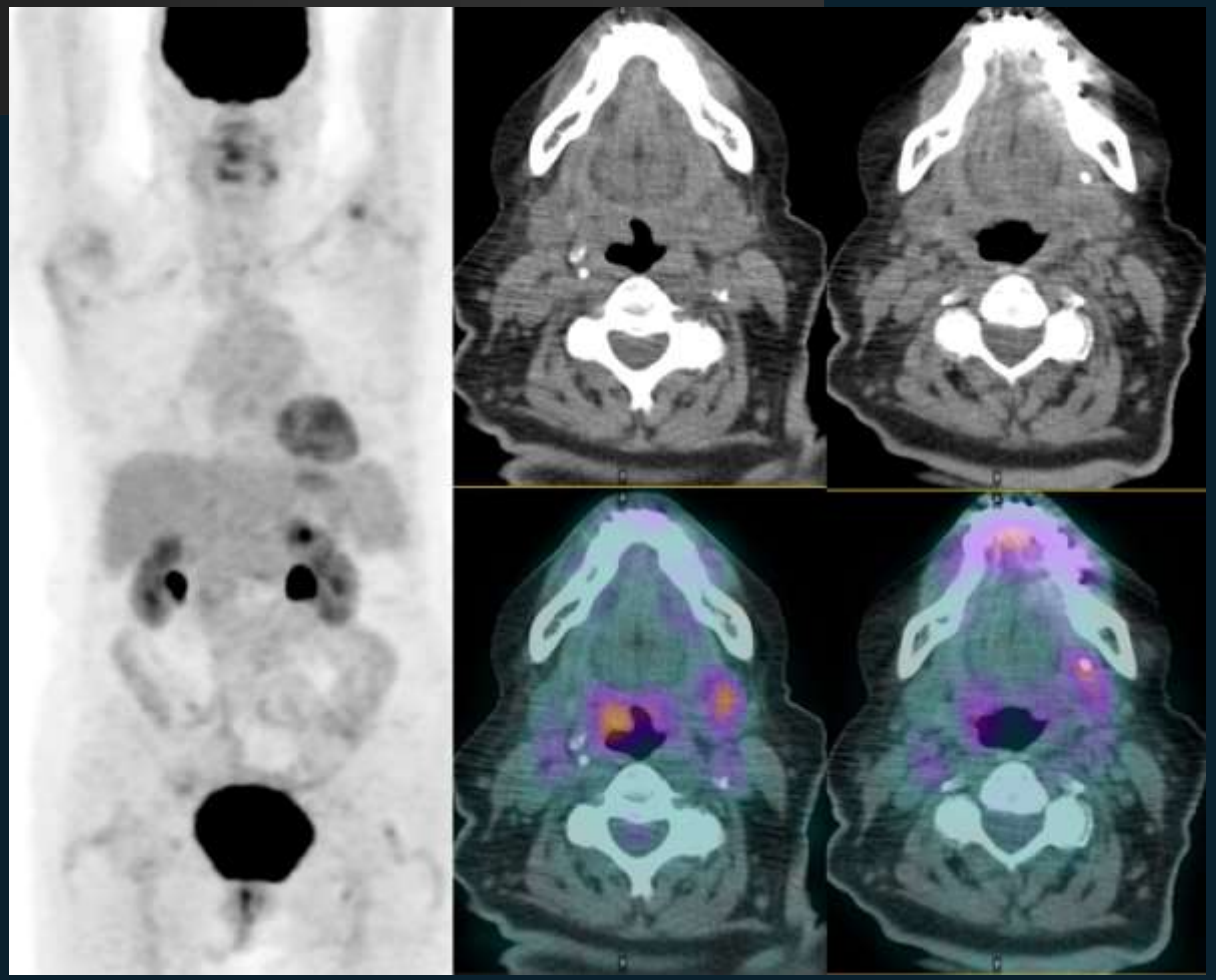
What is the next best step in management for the left neck abnormality?

A. Biopsy

B. Chemotherapy

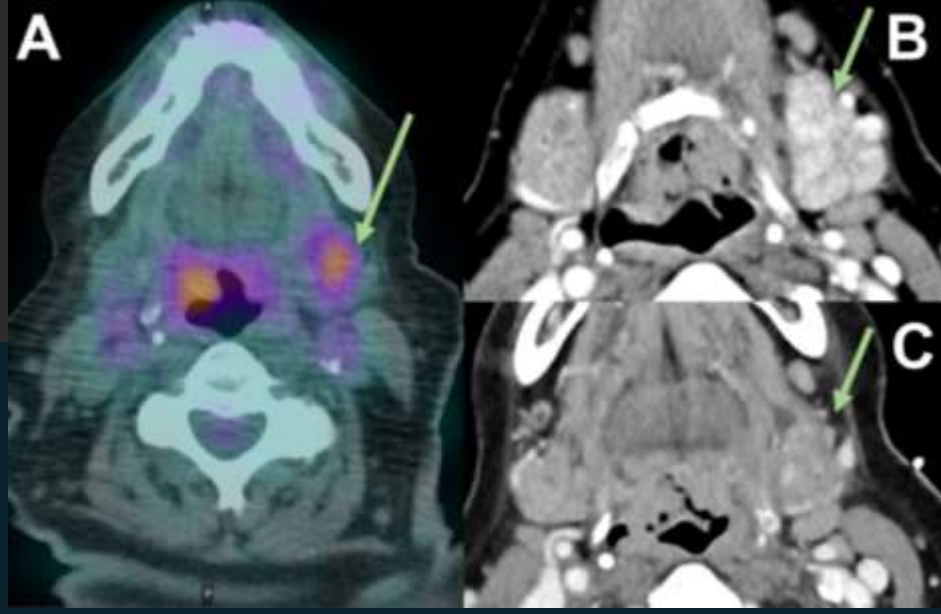
C. Antibiotics

D. Surgery



Answer: C - Antibiotics

FDG Inflammation



- Left-sided sialolith with inflammatory uptake/sialadenitis

- The initial treatment of acute sialadenitis consists of antibiotic therapy, hydration, and anti-inflammatory medications with the hope that the sialolith will dislodge without needed removal. This patient was lymphoma recurrence free clinically & by imaging otherwise.

- Image A - green arrow pointing to inflamed left submandibular gland. B - CT prior to the FDG-PET/CT demonstrating enlargement and enhancement of the affected left submandibular gland. C - folllowing TX & removal of stone showing improvement of the gland.

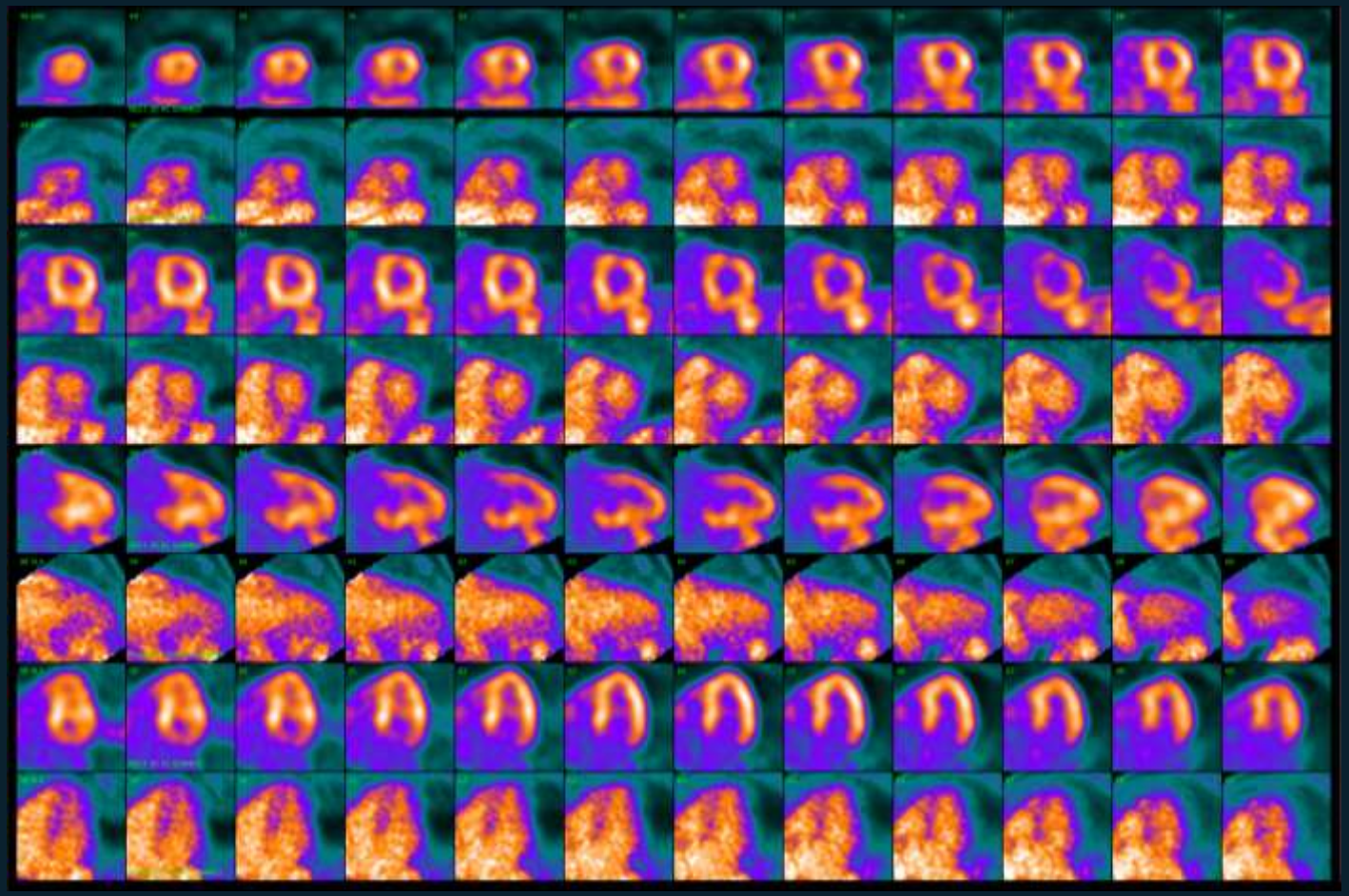
RCarlson ER, Ord RA. Salivary Gland Pathology: Diagnosis and Management. Wiley Blackwell. 2015.
Liu Y. Chronic sialadenitis with marked lymphadenopathy mimicking lymphoma on FDG PET/CT. Clin Nucl Med. 2014; 39:738-9.

CHALLENGE - $300

73 year-old man with ventricular arrhythmia and history of systemic sarcoidosis, presents for evaluation of possible cardiac sarcoid.

Rb

FDG



CHALLENGE - $300

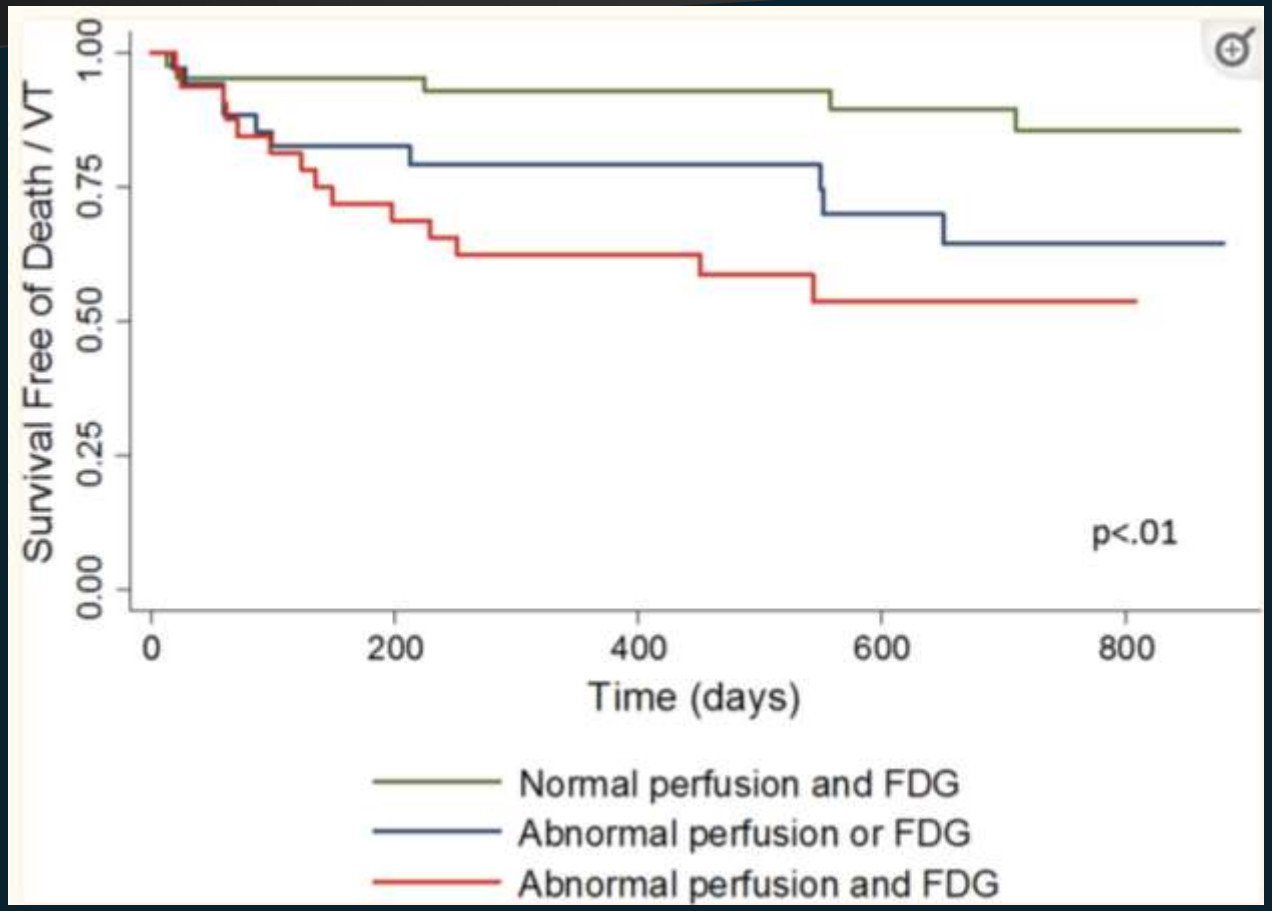
In patients with Rb+FDG imaging study findings like this patient, what is the annualized rate of adverse cardiac events (death or ventricular tachycardia)?

A. <10%
B. 15-20%
C. 25-40%
D. >50%

Answer: A

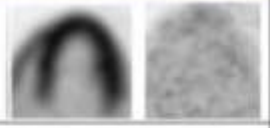
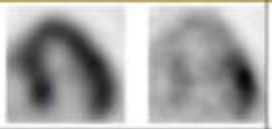
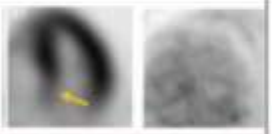
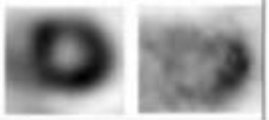
Myocardial PET in Cardiac Sarcoid Prognostication

- Patients with normal perfusion + metabolism had an event rate of 7.3%.
- Presence of perfusion + metabolism defects was associated with a hazard ratio of 3.9.

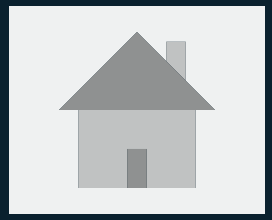


Blankstein R, et al. Cardiac positron emission tomography enhances prognostic assessments of patients with suspected cardiac sarcoidosis. *J Am Coll Cardiol.* 2014; 63(4): 329-36.
Hotta M, et al. Radionuclide imaging of cardiac amyloidosis and sarcoidosis: Roles and characteristics of various tracers. *Radiographics.* 2020; 40: 2029-2041.

Patterns of FDG Uptake in Cardiac Sarcoid

Rest Perfusion	FDG	Frequency	Example		Interpretation / Comment
			Perfusion	FDG	
Normal perfusion and metabolism					
Normal	Normal (negative)	32 (27%)			Normal
Normal	Diffuse (non-specific)	15 (12%)			Diffuse FDG most likely due to failure to suppress FDG from normal myocardium,.
Abnormal perfusion or metabolism					
Normal	Focal	20 (17%)			Nonspecific pattern ; focal increase in FDG may represent early disease vs. normal variant
Positive	Negative	17 (14%)			Rest perfusion defect may represent scar from cardiac sarcoidosis or other etiologies
Abnormal perfusion and metabolism					
Positive	Focal increase ("mismatch pattern")	23 (19%)			Presence of active inflammation ± scar in the same location
Positive	Focal on diffuse	6 (5%)			Similar to above but also areas of inability to suppress FDG from normal myocardium vs. diffuse inflammation
Positive	Focal increase (different area)	5 (4%)			Presence of both scar and inflammation but in different segments

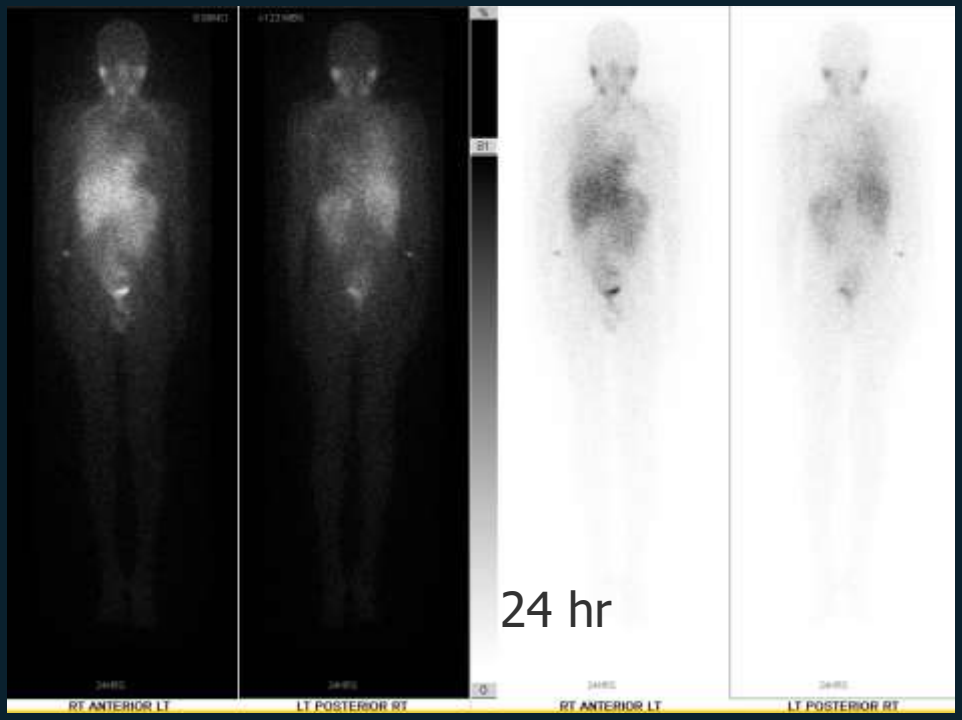
Blankstein R, et al. Cardiac positron emission tomography enhances prognostic assessments of patients with suspected cardiac sarcoidosis. *J Am Coll Cardiol.* 2014; 63(4): 329-36.

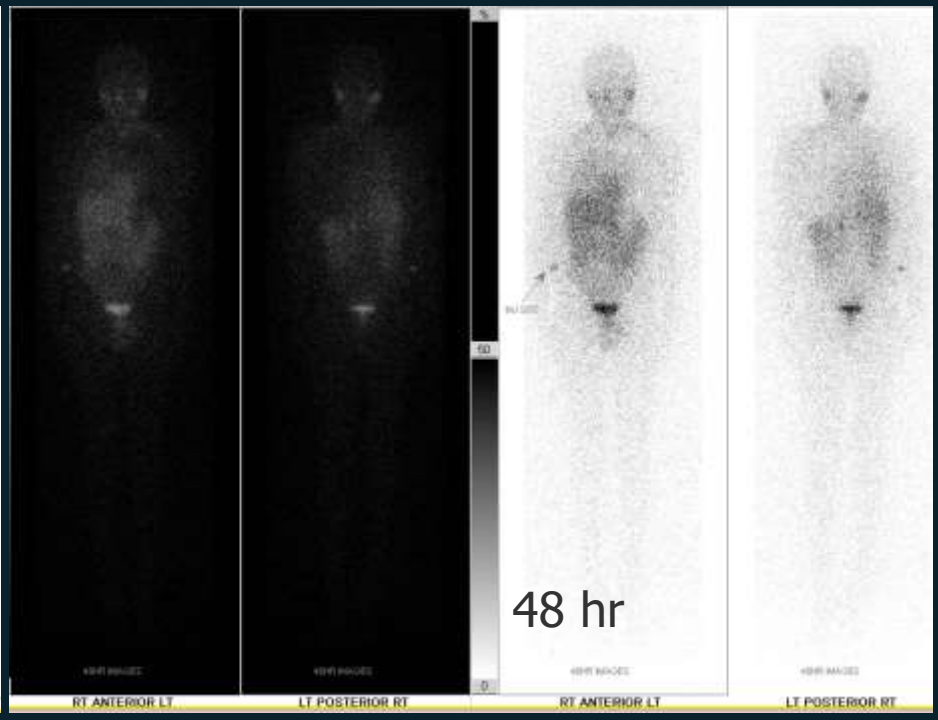


Ref…..

CHALLENGE - $400

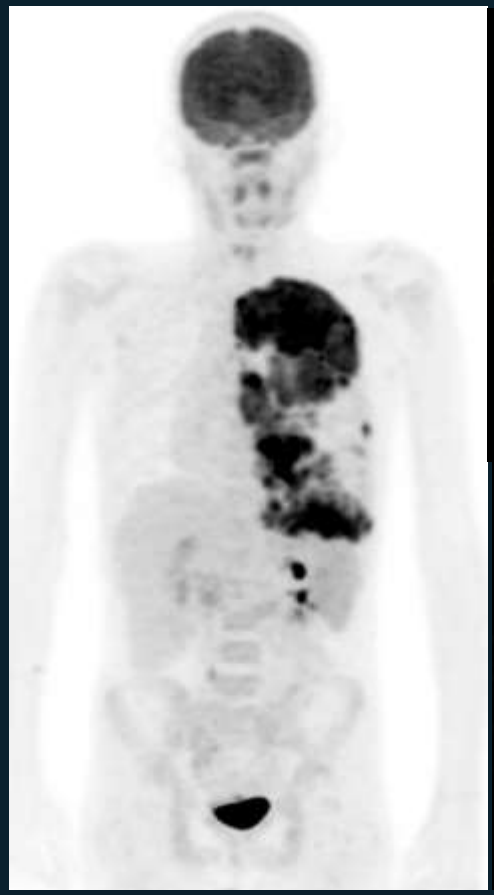
15 yo BX left chest mass (+) small round blue round cell tumor.
Negative 123I-MIBG & positive 18F-FDG scans.

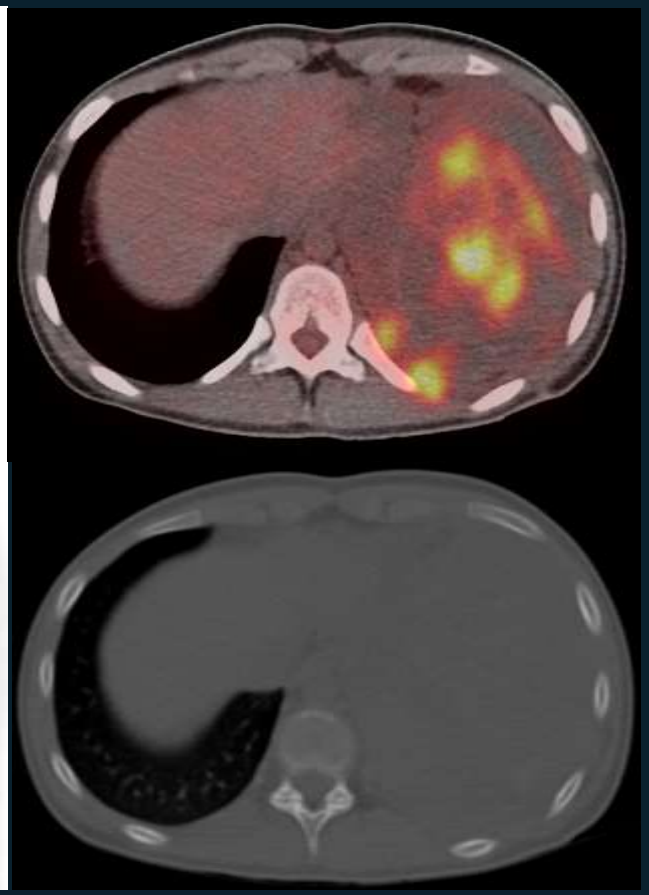


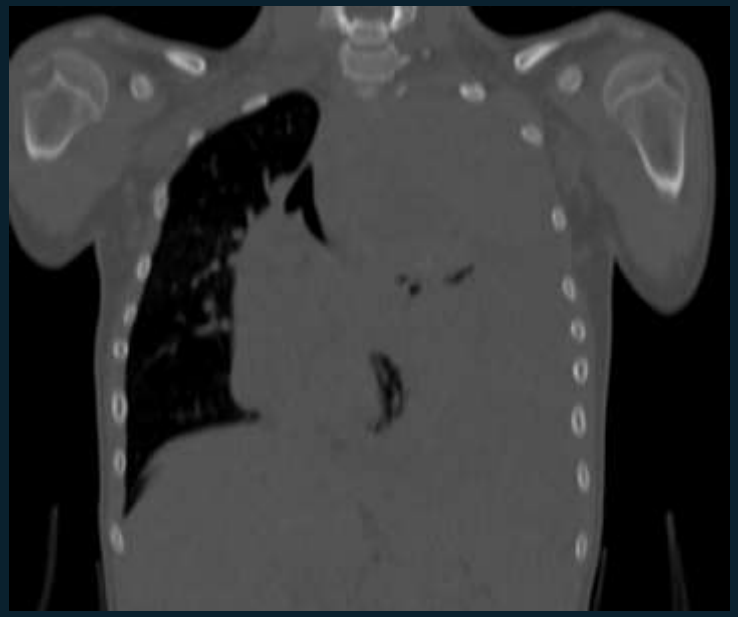


CHALLENGE - $400

15 yo BX left chest mass (+) small round blue round cell tumor. Negative 123I-MIBG & positive 18F-FDG scans.







CHALLENGE - $400

15 yo BX left chest mass (+) small round blue round cell tumor; CD99+. Neg catecholamines. *Negative* 123I-MIBG & *positive* 18F-FDG scans. Which is the most likely diagnosis?

A. Neuroblastoma
B. Wilm's Tumor
C. Askin Tumor
D. Chondrosarcoma

Answer: C – Askin Tumor

Askin Tumor

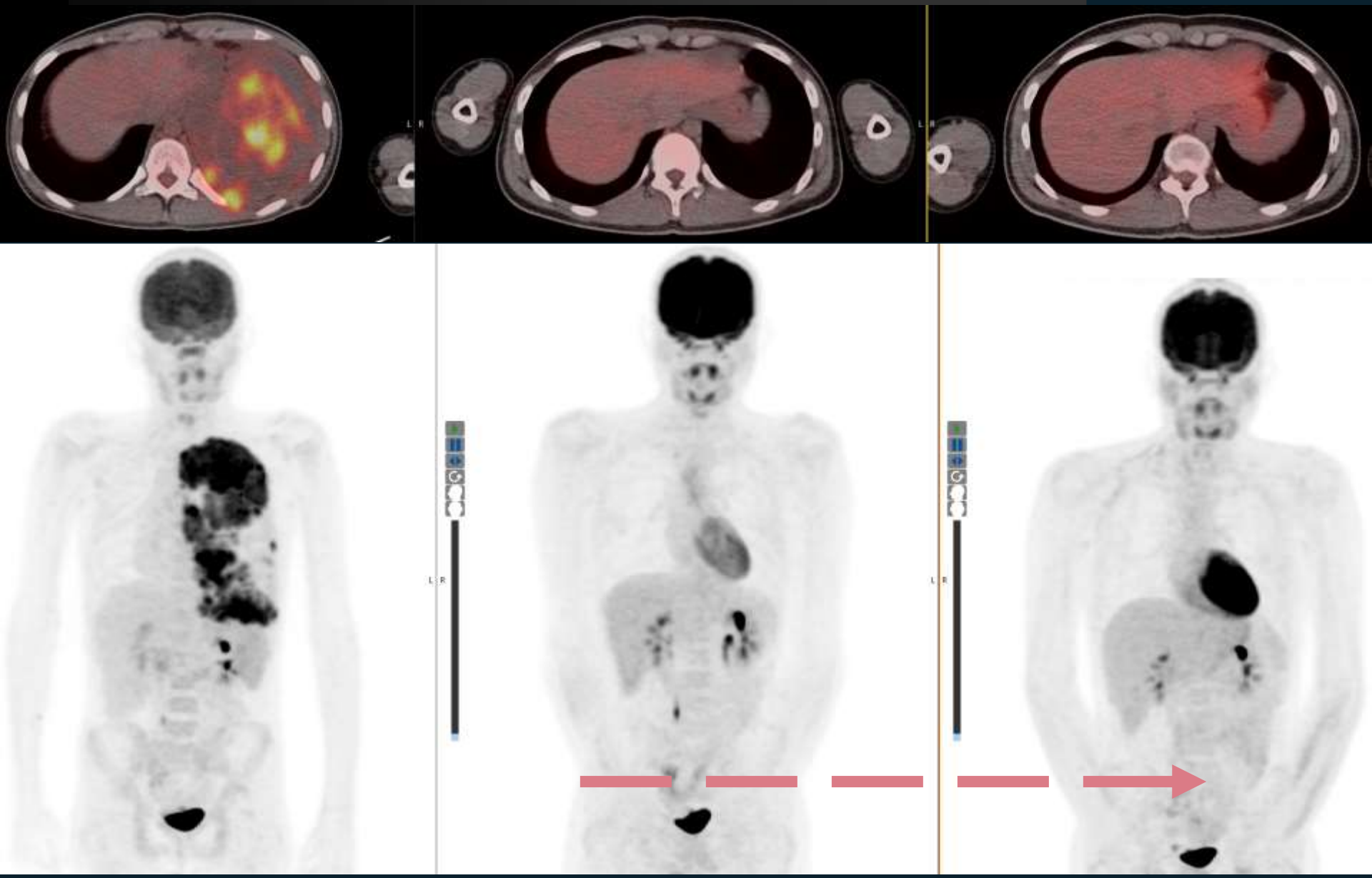
- Rare chest neoplasm in children and adolescents
- Highly malignant & poor prognosis
- Blue cell tumor with CD99 (+) – diagnostic for Ewing's sarcoma family (neuroectodermal tumor)
- No well-defined TX guidelines

Singh A et al. Askin tumor: A rare neoplasm of thoracopulmonary region. *Lung India*. 2016; 33:196-8.

Other Chest Tumors

- Neuroblastoma – usually MIBG positive, elevated catecholamines
- Wilm's tumor – arises from kidney; may or may not accumulate MIBG
- Chondrosarcoma – involves bones (cartilaginous tumor); Rare but can be primary chest mass and with (+) blue round cells

Capps E et al. Chest wall chondrosarcoma. *Proc*. 2009; 22:362-5.



Ref.....

After surgical resection & chemotherapy

Ref…..

CHALLENGE - $500

Which of the following processes within the prostate gland is best matched with its typical uptake patterns within the gland on PET?

Primary process	FDG PET	DOTATATE PET	PSMA PET
A. Benign chronic prostatitis	+++, focal	+++, focal	+/++, nonfocal (diffuse)
B. Benign prostate hyperplasia	+/++, diffuse	++, focal	+++, focal
C. Hormone-sensitive adenocarcinoma	+, focal	-/+, focal	+++, focal
D. Castration-resistant neuroendocrine carcinoma	-/+, diffuse	+++, focal	+++, diffuse

Uptake: -- = none or minimal; + = mild; ++ = moderate; +++ = intense

Answer: C

Patterns of Uptake in Prostate Pathology – Use of Molecular Imaging Agents (1)

- Prostatitis may be positive, often diffusely mildly-to-moderately positive (i.e. not focal), on each of the three study types due to the expression of the relevant transporters (GLUT, somatostatin) within inflammatory cells; the exact mechanism of PSMA accumulation in sites of inflammation and infection are not well-understood but may be related to neovascularization.
- Prostate hyperplasia represents a nodular growth of glandular-epithelial and stromal tissues within the prostate gland. Though isolated reports of intense uptake have been made in the literature, hyperplasia is typically mild-to-moderate on both PSMA PET and somatostatin receptor imaging. In addition, hyperplasia is typically mild-to-moderate and diffuse on FDG PET.

Conteduca V, et al. Clinical features of neuroendocrine prostate cancer. Eur J Cancer. 2019; 121: 7-18.
Gofrit ON, et al. PET/CT with 68Ga-DOTA-TATE for diagnosis of neuroendocrine differentiation in patients with castrate-resistant prostate cancer. Clin Nucl Med. 2017; 42(1):1-6.
Malan N, Vangu M-d-T. Normal variants, pitfalls, and artifacts in Ga-68 prostate specific membrane antigen (PSMA) PET/CT imaging. Front Nucl Med. 2022; 2: 825512.

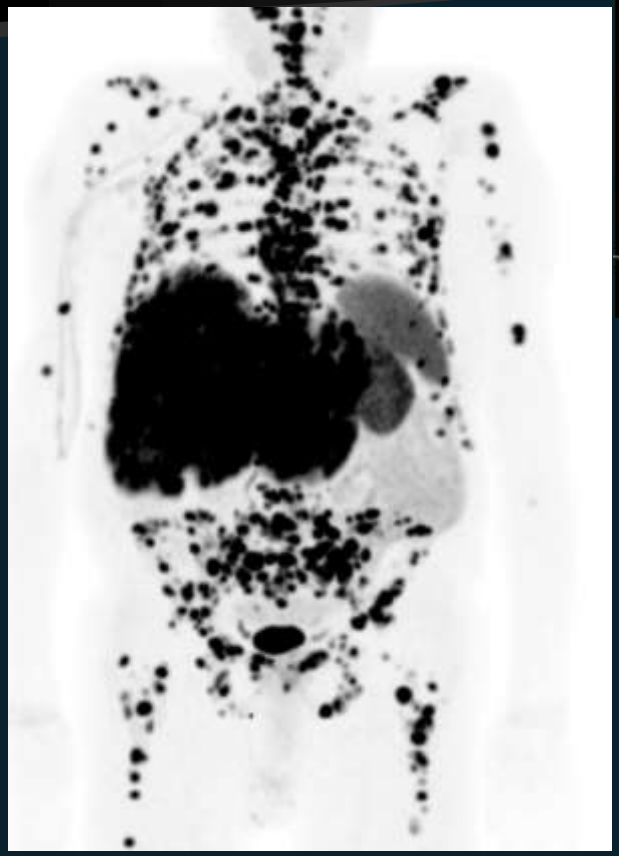
Patterns of Uptake in Prostate Pathology – Use of Molecular Imaging Agents (2)

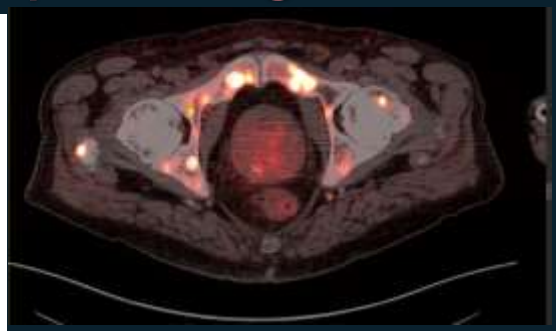
- Prostate adenocarcinomas express prostate-specific membrane antigen (PSMA), and are therefore expected to be at least moderately positive on PSMA PET, typically in a focal or multifocal (i.e., not diffuse) pattern. Adenocarcinomas may also demonstrate low-grade DOTATATE and FDG uptake as well.
- Neuroendocrine carcinoma, like adenocarcinoma, will typically present a focal or multifocal (i.e. not diffuse) pattern at the site of tumors within the prostate gland. In addition, the prostate gland will often demonstrate moderate-to-intense FDG uptake, as well as being intensely tracer-avid on somatostatin receptor imaging. PSMA would not be expected to be positive, as neuroendocrine tumors of the prostate tend to be castrate-resistant and express less PSMA.

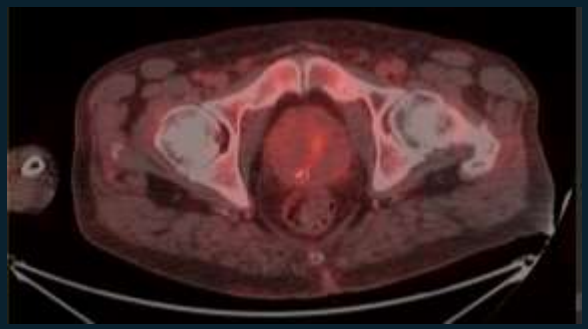
Conteduca V, et al. Clinical features of neuroendocrine prostate cancer. Eur J Cancer. 2019; 121: 7-18.
Gofrit ON, et al. PET/CT with 68Ga-DOTA-TATE for diagnosis of neuroendocrine differentiation in patients with castrate-resistant prostate cancer. Clin Nucl Med. 2017; 42(1):1-6.
Malan N, Vangu M-d-T. Normal variants, pitfalls, and artifacts in Ga-68 prostate specific membrane antigen (PSMA) PET/CT imaging. Front Nucl Med. 2022; 2: 825512.

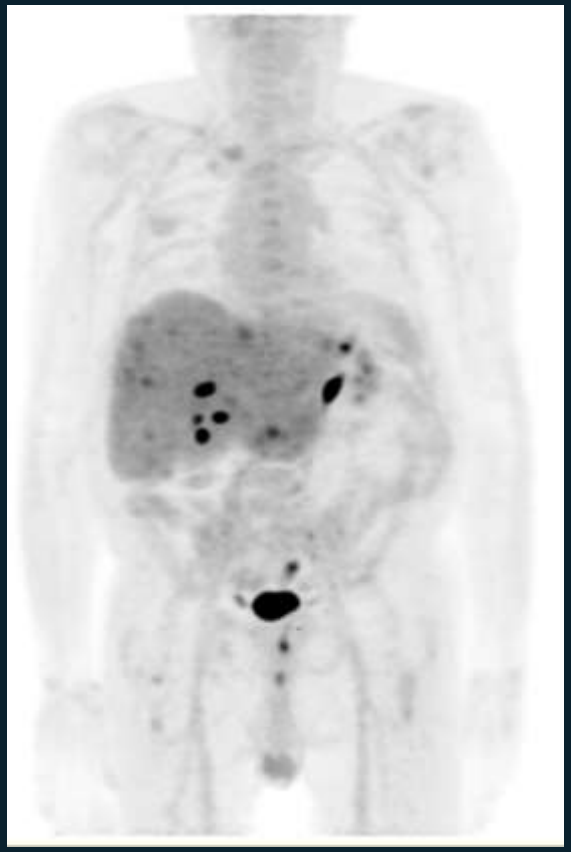
FINAL JEOPARDY:

67 year-old man with metastatic carcinoma, possibly of primary prostate origin. What is the most likely histopathologic tumor type?









THANK YOU!!