Medical Imaging for Lymphoma:

X-ray, CT scans, Ultrasound, MRI and PET Scans

Lymphoma Support Group of Ottawa (LSGO)

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Overview

- Diagnostic imaging modalities
  - X-ray
  - CT
  - Ultrasound
  - MRI
  - PET
- How do we use imaging to help diagnose lymphoma?
- How is imaging used to assess response to treatment?
- A couple of cases
- Questions

Disclaimer

- I am not a radiologist or nuclear medicine physician
- I am not an expert in radiation exposure
- However, I will try to review basic concepts of various diagnostic imaging modalities, and to address specific questions provided by support group members!

Imaging Modalities

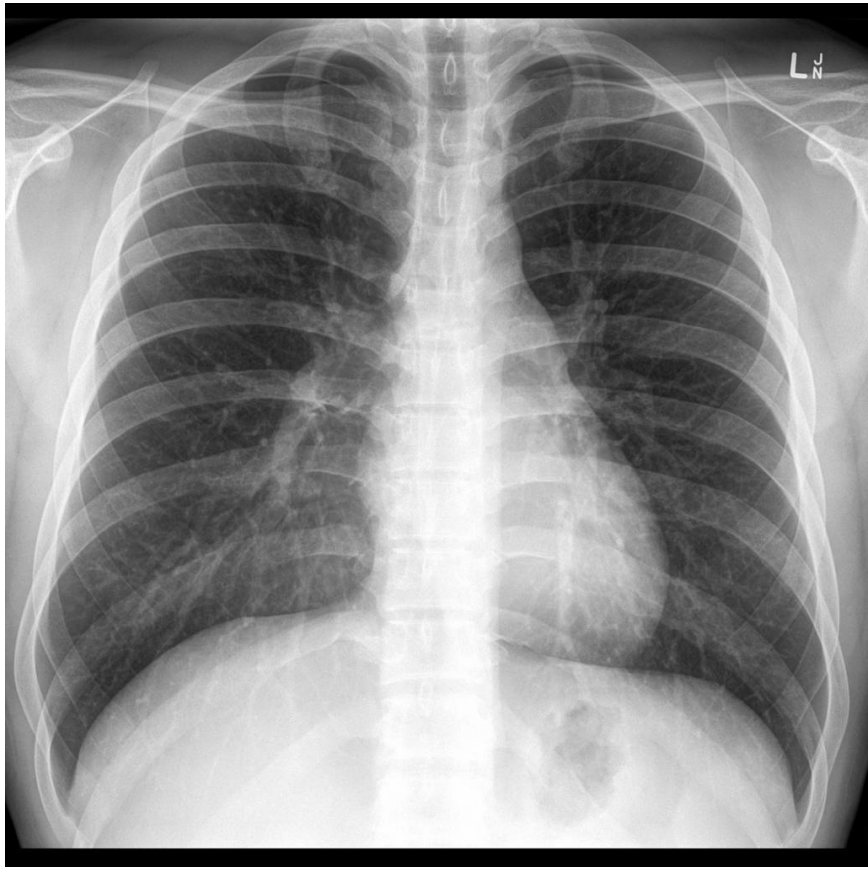
- Technologists use an imaging modality to gather images of a patient's body (often a specific part or region of the body)
- The images are evaluated by a physician specialized in diagnostic imaging (radiology or nuclear medicine)
- The most common imaging modalities are:
  - X-ray
  - CT
  - Ultrasound
  - MRI
  - PET

Imaging Modalities

- Each imaging “modality” is unique in terms of:
  - images obtained
  - equipment/technology used
  - parts of the body best imaged (and therefore, the conditions that can be diagnosed)
  - preparation
  - duration of test
  - exposure to ionizing radiation
  - cost and ease of access

X-ray

- aka “plain films”, “plain x-rays”
- Produces images of the structures inside the body
- X-ray beams pass through the body, absorbed in different amounts depending on the density of the material they pass through
- Dense material (such as bones or metal), show up white on an X-ray. Air (such as in the lungs) shows up black. Soft tissue (muscles and fat) appear as shades of grey
- Quick (10 minutes), easy to access
- Imaging method: ionizing radiation

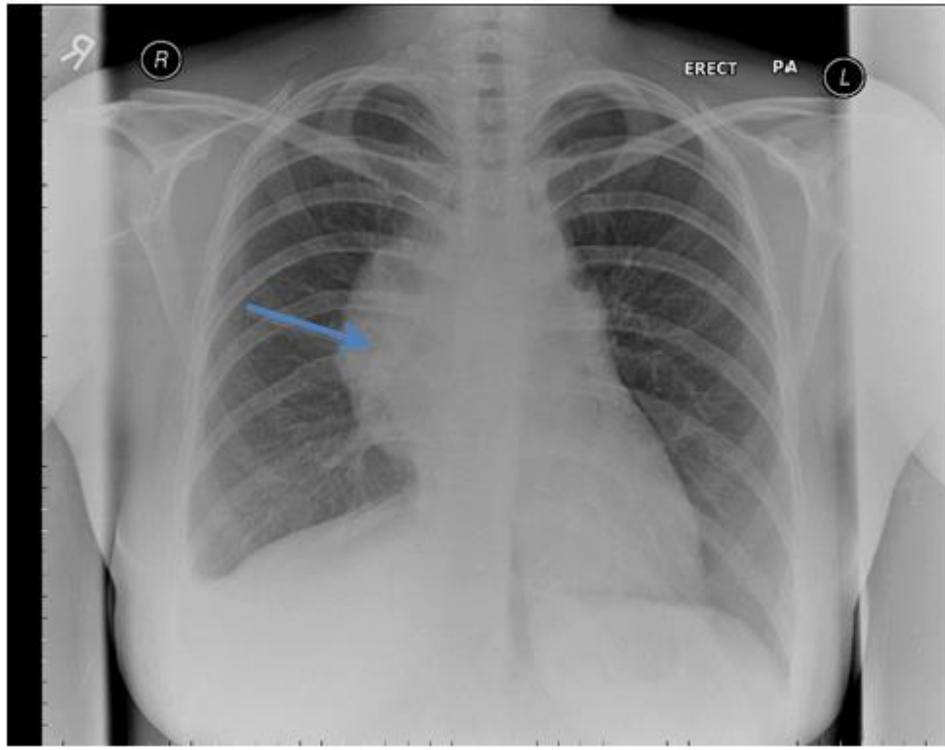


Adapted Radiopaedia.org

X-ray

- Limited use in diagnosing lymphoma
  - X-rays not ideal to assess soft tissue
  - Lymph nodes not easily imaged on X-ray, unless very large

- When would we use plain x-rays in a patient with lymphoma?
  - To assess lungs
  - To assess bones



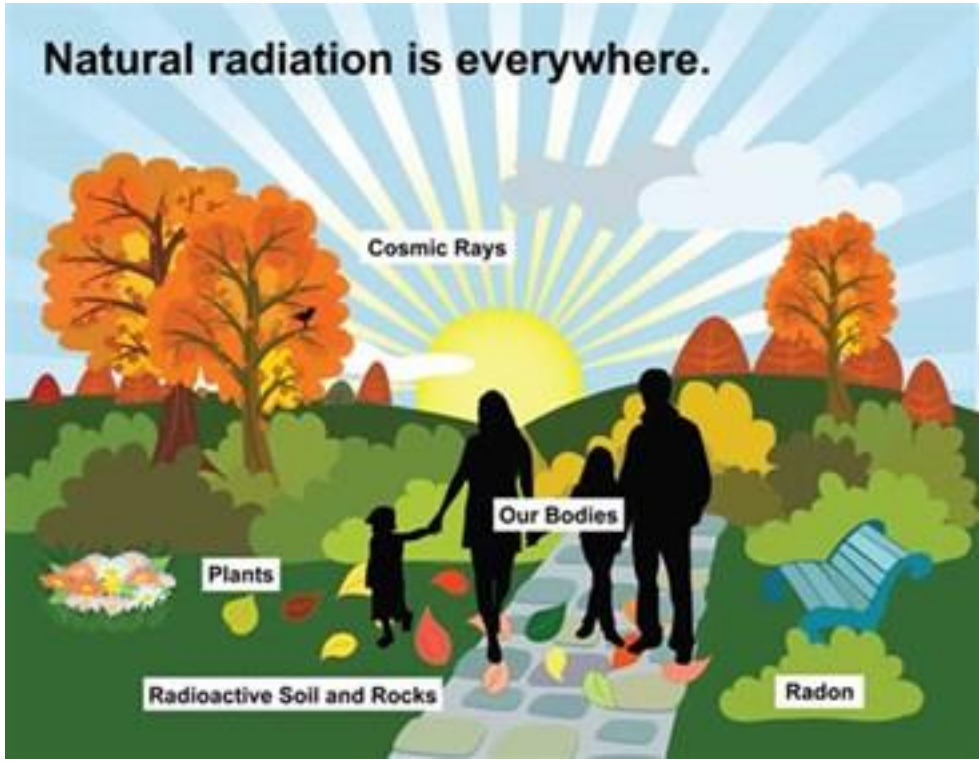
Adapted Ubaid et al., 2015 (International Journal of Case Reports and Images)

Ionizing radiation

- Radiation exposure can cause cell mutations that may increase the risk of cancer years later
- Sensitivity to the radiation depends on your age, with children being more sensitive than adults (ie. you need time to develop a problem)
- Radiation exposure from an x-ray is low, and the benefits from these tests usually far outweigh the risks
- The scientific unit of measurement for dose of whole body radiation is called the millisievert (mSv)

Ionizing radiation

- We are exposed to natural sources of ionizing radiation every day
- Average effective dose of ionizing radiation from natural sources is roughly 3 mSv a year in Canada
- This can vary greatly depending on where you live
- Approximate effective radiation dose of:
  - one chest X-ray is 0.1 mSv (comparable to 10 days of background radiation)
  - dental x-rays 0.01 mSv



Adapted Canadian Nuclear Safety Commission Fact Sheet Nov 2020

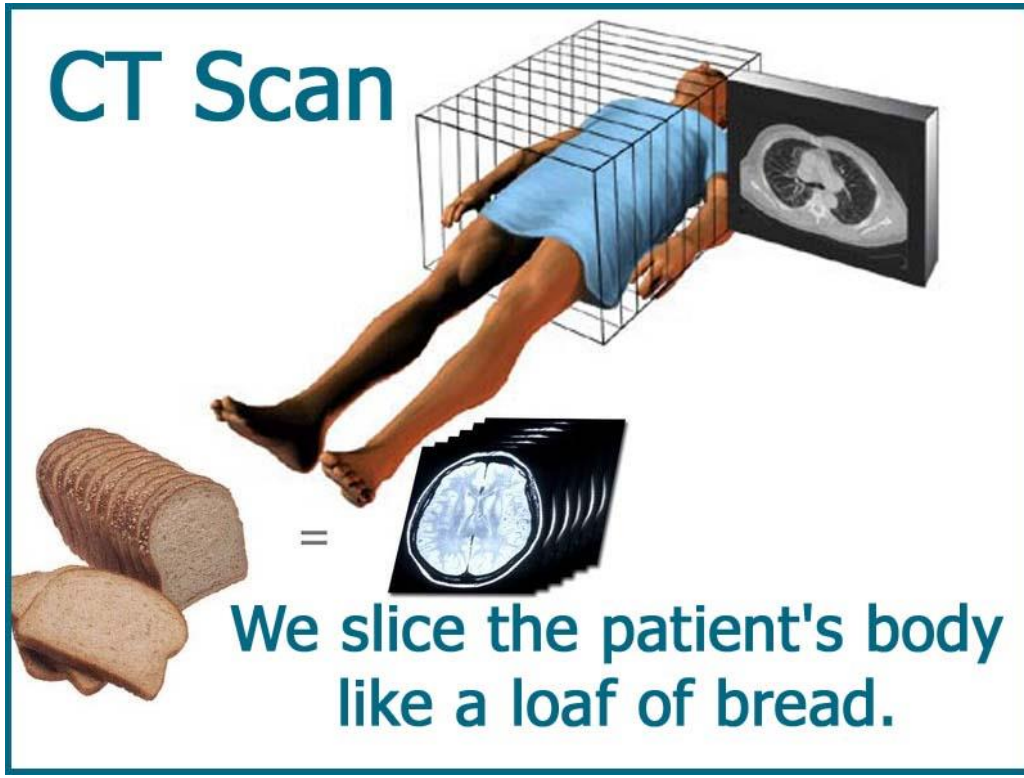
Computed Tomography (CT)

- Series of many x-rays taken from different angles around patient's body
- Patient lies down on a table that slides into the scanner
- The scanner looks like a large donut
- Computerized processing used to create "slices" of the body part or region imaged
- Quick (15 minutes)
- Imaging method: ionizing radiation

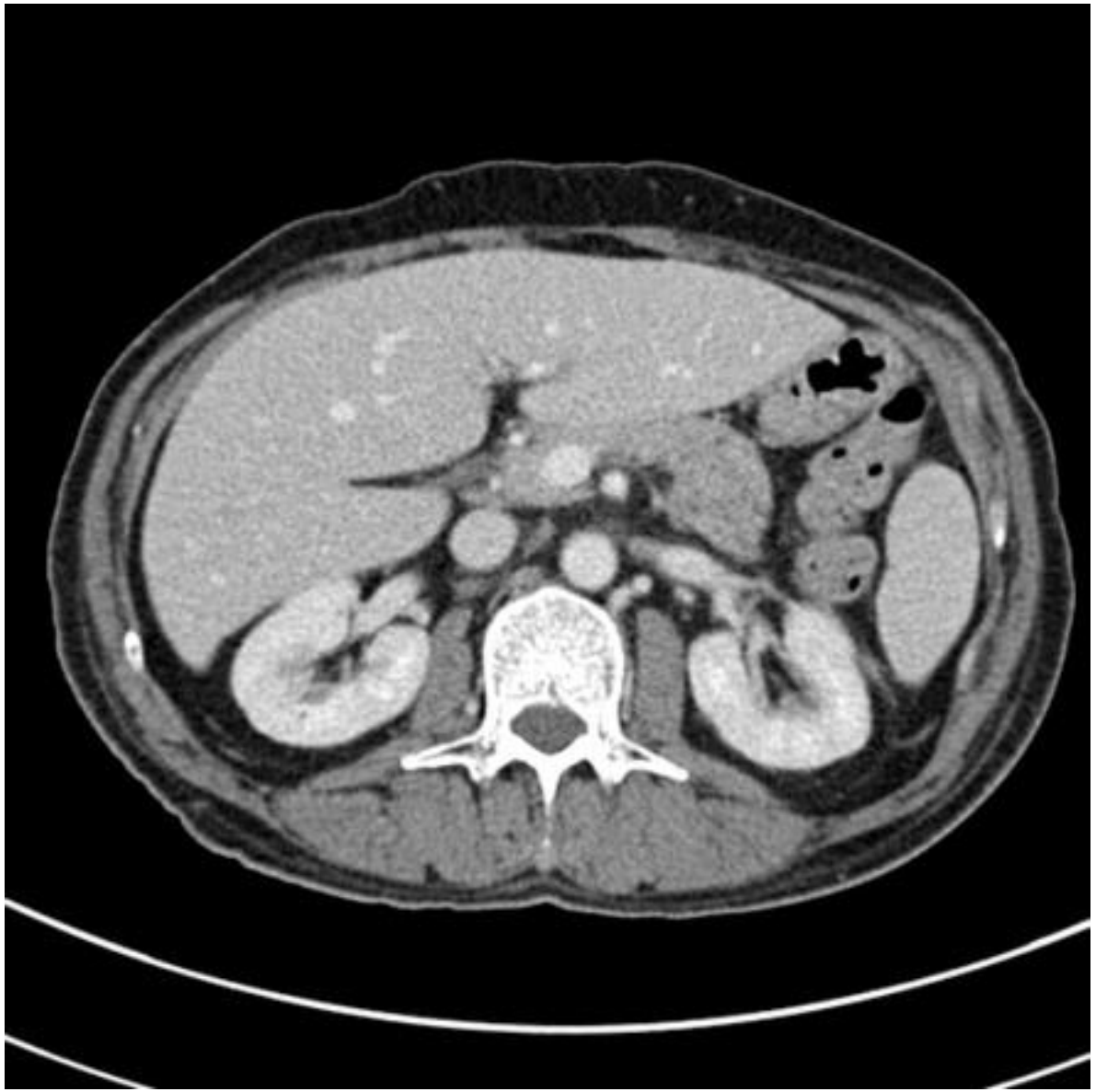
Adapted Mayo Clinic

Computed Tomography (CT)

- This creates a 3D image with much more detail than a plain x-ray
- Sometimes a special dye (ie. contrast) is used before the images are collected. May be administered intravenously and/or orally
- Contrast blocks x-rays from passing, and so appears white on images. This can help emphasize different parts of the body
- Although rare, contrast can at times cause allergic reactions or other medical problems



Adapted Google Image



Adapted Radiopaedia.org

Computed Tomography (CT)

- CT scans are very useful management of patients with lymphoma
- Sometimes they are used to help with diagnosis:
  - For example, a patient may present to medical attention due to symptoms such as discomfort or swelling. A CT scan might show abnormal LN swelling inside the body (that can't be seen or felt on the outside of the body), and this could help guide biopsy location
- CT scans are often used to stage a patient with a confirmed diagnosis of lymphoma.
  - CT scans of the chest, abdomen and pelvis may be performed to look for enlarged lymph nodes or enlarged organs (ie. spleen and/or liver)
  - Radiologist provides measurements of the enlarged lymphatic tissue
  - This can help with treatment decision making, and also serves as a baseline

Computed Tomography (CT)

- CT scans are commonly used to assess response to treatment
  - For example, a patient might embark on a 6 month course of chemotherapy. CT scans of the chest, abdomen and pelvis may be performed after completing chemotherapy to assess the improvement in abnormal lymph nodes that are on in the inside of the body

- More ionizing radiation than a plain X-ray
  - CT chest: roughly 7 mSv
  - CT abdo: roughly 8 mSv
  - Difficult to know just how much radiation exposure required to increase risk of cancer

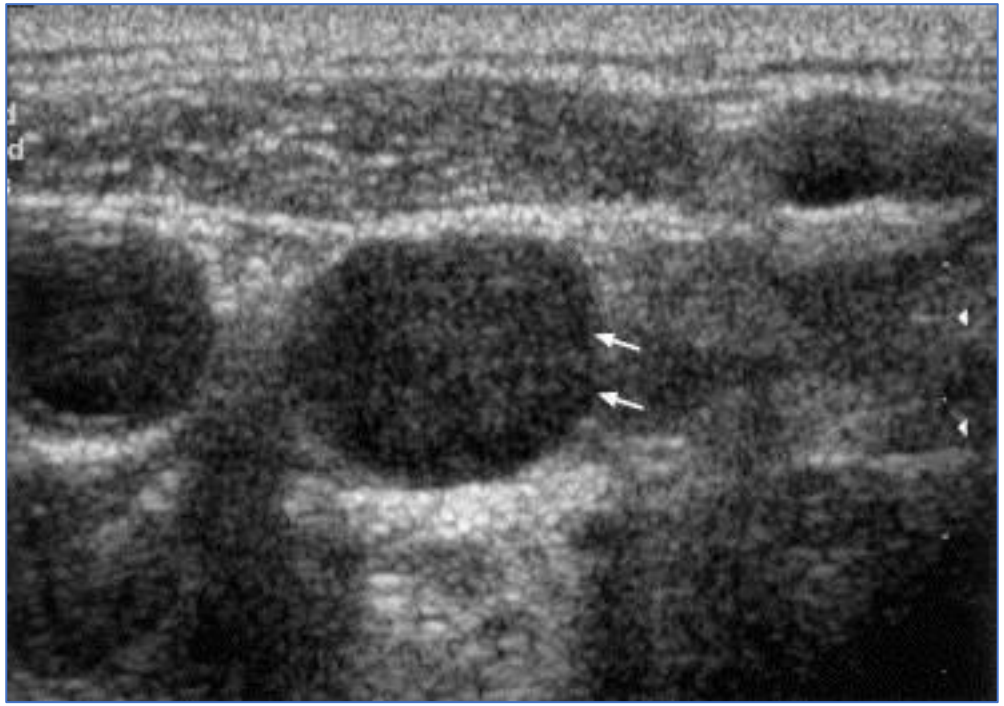
Ultrasound

- aka “sonography”, “sonogram”, “echo”
- Uses high frequency sound waves to produce images
- Technologist usually applies gel on the outside of body part, and ultrasound probe applied
- Imaging method: sound waves (no ionizing radiation)

Ultrasound

- When is U/S useful in managing patients with lymphoma?
  - Can be used to guide biopsies to confirm diagnosis (ie. groin, under arm, sometimes neck or abdomen)
  - Can be helpful to assess size of the spleen
  - Very good at imaging the liver, gallbladder and biliary tree
  - Can be useful to diagnose blood flow problems

- Limited use in assessing lymph node sizes in the chest and abdomen, unless very large



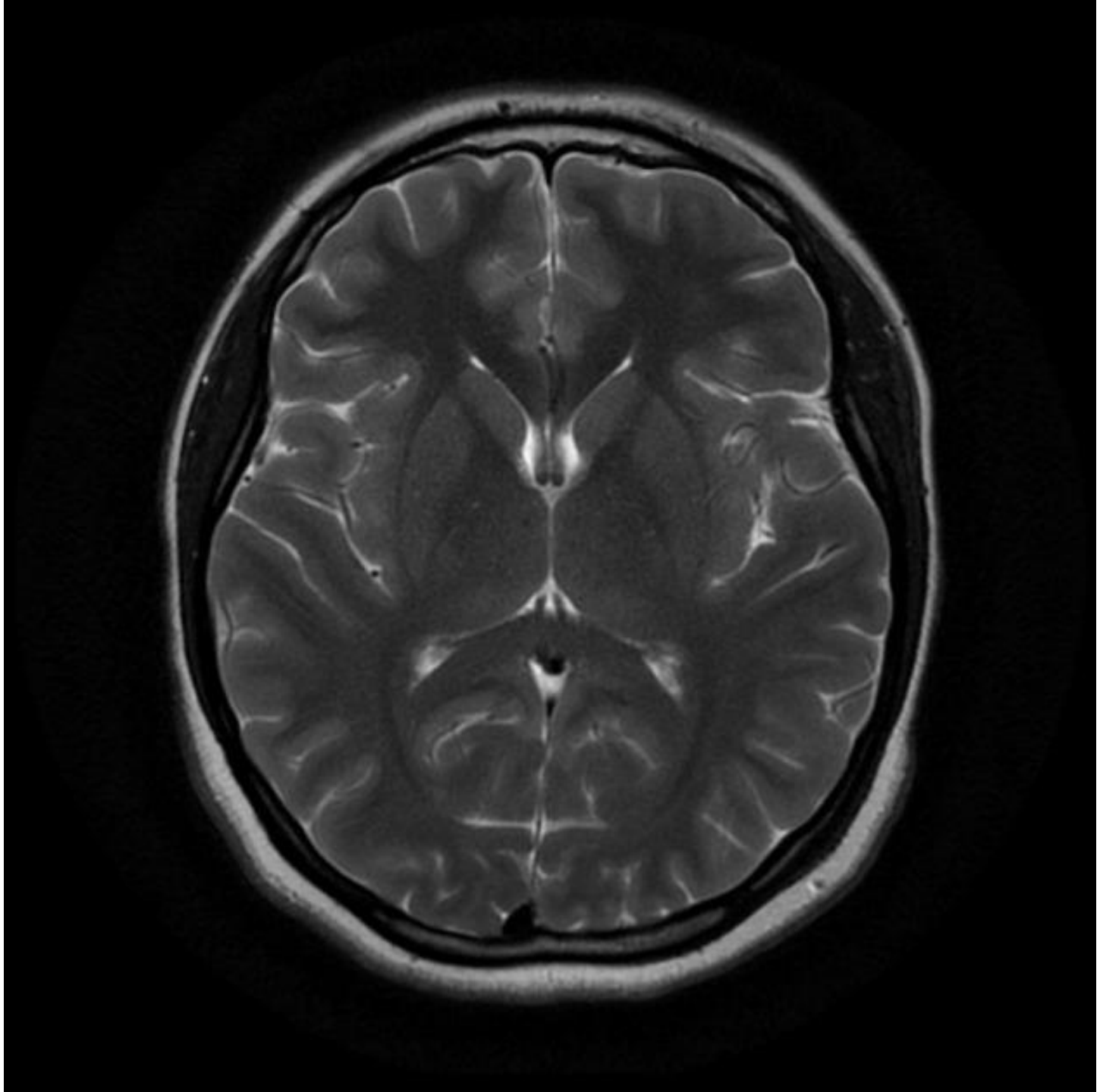
Adapted Radiopaedia.org

Magnetic resonance imaging (MRI)

- Uses strong magnetic fields and radio waves to create detailed images of organs and tissues in the body
- MRI machine is a large, tube shaped magnet
- Magnetic field temporarily aligns water molecules in the patient's body. Then radio waves cause the aligned atoms to produce a signal that is detected by the MRI machine
- Long test (45 minutes – 60 minutes), tight enclosed space, noisy, more difficult to access
- Can be affected by metallic objects
- Imaging method: magnetic waves (no ionizing radiation)

Magnetic resonance imaging (MRI)

- When is MRI useful in managing patients with lymphoma?
  - Particularly good at assessing the spinal cord and brain
  - Liver and biliary tree
  - Bones and joints
  - Staging scans for pregnant patients, especially in first trimester



Adapted Radiopaedia.org

Positron emission tomography (PET)

- Nuclear medicine test using a radioactive drug (tracer) to show both normal and abnormal metabolic activity. Images from PET are combined with CT scan
- In most cancer care, the tracer used is fluorodeoxyglucose (FDG). This is a radioactive medication with glucose, administered intravenously before the scan.
- Glucose is usually taken up by quickly growing cells faster than normal tissue
- The tracer will then collect into areas of the body that have higher levels of metabolic activity, gives off radiation, detected by PET machine. This can help pinpoint the location(s) of disease
- Low dose CT performed at the same time
- 1.5 – 2 hours
- Imaging method: radiotracers and ionizing radiation

Positron emission tomography (PET)

- Why is this useful in management of many lymphoma patients?
  - PET usually more sensitive than CT scans, especially for quickly growing lymphomas
  - PET scans can often detect disease in areas where we don't usually see lymphatic tissue (ie. bone, muscle, bowels, etc.)
  - Has decreased use of staging bone marrow biopsies (invasive procedure)
  - Commonly used to assess treatment response
  - Can be very helpful in assessing residual lymph node tissue after treatment (ie. a large lymph node conglomerate may not entirely resolve after treatment, but if it is not "metabolically active", it may represent scar tissue)

Positron emission tomography (PET)

- SUV values – Standardized Uptake Values
  - How “bright” something lights up on a PET scan
  - Aggressive or quickly growing lymphoma tend to light up brighter than indolent/low grade lymphomas

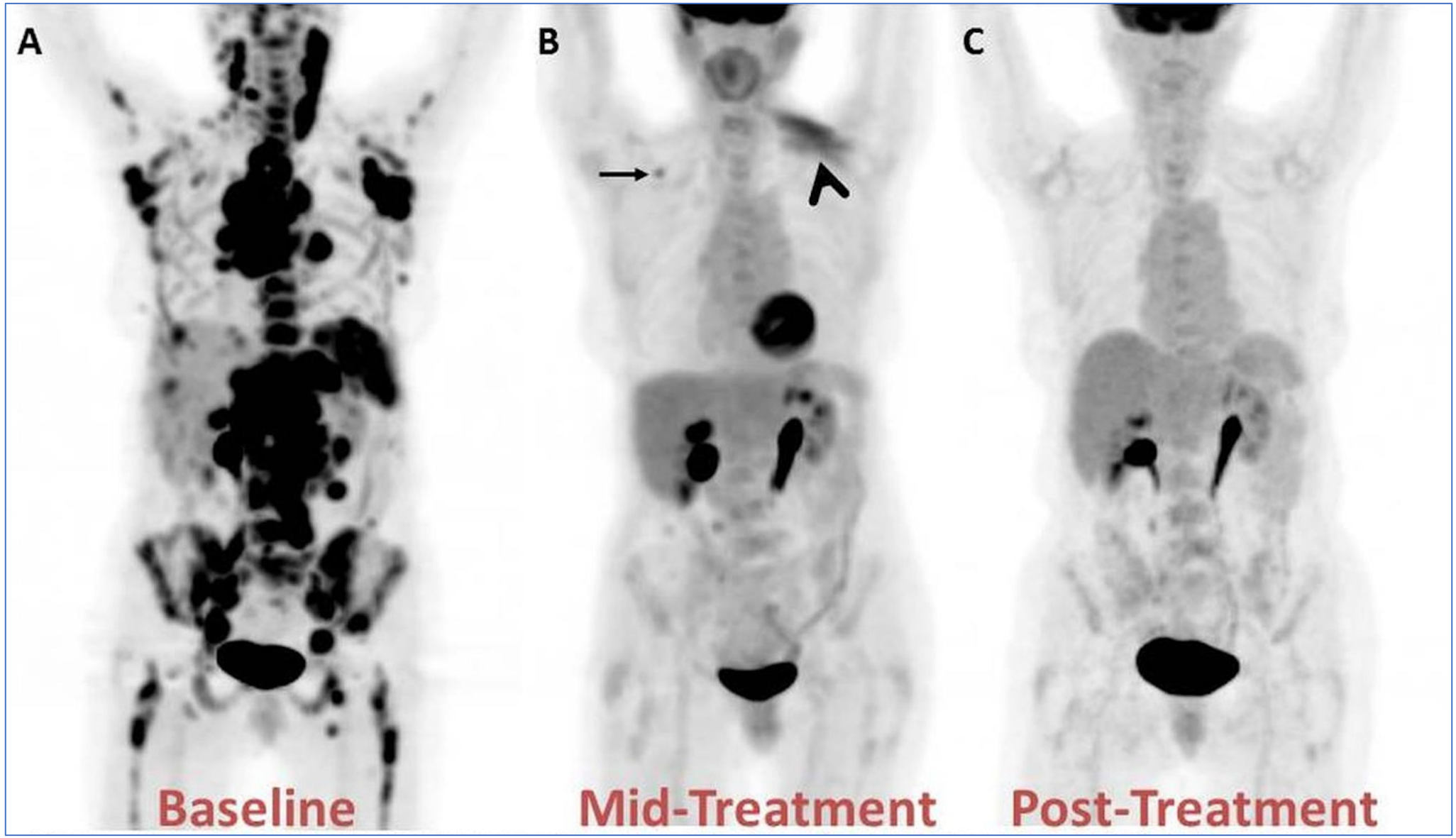
- Deauville Score – 5 point scale
  - Standard scoring system used to describe post treatment PET scans
  - Patient acts as their own control
  - SUV values are compared against FDG uptake in the liver and mediastinal pool

- Score 1: No uptake above the background
- Score 2: Uptake ≤ mediastinum
- Score 3: Uptake > mediastinum but ≤ liver
- Score 4: Uptake moderately increased compared to the liver at any site
- Score 5: Uptake markedly increased compared to the liver at any site
- Score X: New areas of uptake unlikely to be related to lymphoma

Positron emission tomography (PET)

- Challenges
  - False positives (timing, infection/injury, COVID19 vaccination, etc.)
  - Affected by food/drink, glucose control
  - Access limited to those with confirmed diagnosis of lymphoma, and CCO reimbursement for specific scenarios
  - Not all lymphomas are FDG-avid (ie. low grade or indolent lymphomas)

- Approximate effective radiation dose: 20 mSv (comparable to 7 years of background radiation)



Adapted Han et al., JNM 2017

Practicalities

- How do we use imaging to help diagnose lymphoma?
  - Ultrasound-guided LN biopsy and CT-guided LN biopsy
  - These biopsies are “core needle” biopsies and can often confirm a diagnosis without surgical biopsy
  - Sometimes incidental findings on scans done for other reasons

- How is imaging used to assess response to treatment?
  - CT scans can help determine how well abnormally enlarged lymphatic tissue has decreased in size
  - PET scans can help us in the same way, but can also inform us on presence of leftover metabolic “activity” post treatment

Practicalities

- What is “PET-adaptive treatment”?
  - For certain types of lymphoma, we may use PET scans part way through planned treatment, and at the end of planned treatment to assess response
  - At our institution, we commonly use this for management of patients with Hodgkin lymphoma
  - This strategy can help us select patients who may be able to avoid radiation therapy, and also those patients who may benefit from more intensive chemotherapy treatments

Case 1

- Nancy is a 72 year old retired woman who noticed a lump in her left groin a few months ago. She is previously in good health and takes only one medication for high blood pressure. Nancy otherwise feels entirely well. She has not had night sweats, unwanted weight loss or unexplained fever.
- The lump does not go away so she sees her family physician. Physical examination confirms a palpable enlarged lymph node in the left groin, but no other palpable nodes in other regions. Her family physician does not detect enlargement of her spleen based on physical examination.
- Routine blood work is arranged and is unremarkable. Nancy's GP arranges an U/S of the left groin.

Case 1

- U/S demonstrates an abnormally enlarged lymph node in the left groin, measuring 3 x 3 cm (normal is up to 1 cm).
- Nancy's GP knows that a surgical biopsy would be best to evaluate this LN. A surgical biopsy is one where a large amount of lymph node tissue is surgically resected/removed. However, her GP worries about the wait time to see a general surgeon because of the pandemic. So she orders an U/S guided LN biopsy at TOH, and counsels Nancy that if this needle biopsy is not diagnostic that she may need to be seen by a surgeon.
- While waiting for the U/S guided LN biopsy, Nancy's GP also orders CT scans of her abdomen and pelvis with IV contrast. Nancy has no documented allergy to contrast dye.

Case 1

- Nancy undergoes the U/S guided needle biopsy. The U/S is used to guide the biopsy needle into the lymph node tissue, the radiologist is able to safely avoid nearby blood vessels. Several cores of tissue are obtained and sent to the pathology lab for evaluation.
- The biopsy reveals follicular non-Hodgkin lymphoma (FL), grade 1-2
- CT scan of abdo/pelvis does not show evidence of any abnormal lymph node enlargement, apart from the known groin node. Nancy's spleen is normal
- Nancy's GP refers her to the Cancer Program for management and follow-up.

Case 1

- Does Nancy need any further staging investigations?
- Will Nancy be recommended treatment?

Case 1

- Does Nancy need any further staging investigations?
  - Could consider CT scan of chest + BM biopsy or PET
  - Before improved access to PET scans, we routinely performed bone marrow biopsies on patients to complete staging
  - PET can be used to confirm disease localized to one region
  - PET more sensitive than CT scan, so often “up-stages” patient
- Will Nancy be recommended treatment?
  - Follicular lymphoma is an indolent B-cell lymphoma
  - If disease limited to one area, patients are candidates for radiation therapy with very good long term disease control (and possibly cure)
  - Let’s say her PET scan shows non-bulky left groin node with SUV of 7, and no other areas of body lighting up → Stage 1A → RT with curative intent

Case 1

- What if Nancy had small volume enlarged lymph nodes in the neck, chest, and groin? Would she require treatment then?

- This case illustrated use of U/S to help confirm lymphoma diagnosis, the use of CT scans to stage patient, and use of PET scan to confirm stage and guide treatment decisions.

Case 2

- Matthias is a 65 year old man with no past medical history who develops progressive abdominal pain over the past 6 weeks. He has also lost more than 10% of his baseline body weight and has developed night sweats. He has abdominal imaging done revealing large mesenteric abdominal lymph node mass, measuring close to 7 cm.
- He undergoes CT-guided core needle biopsy of the mesenteric lymph node. Biopsy reveals a diagnosis of diffuse large B-cell lymphoma (aggressive non-Hodgkin lymphoma)
- He has a staging PET scan which shows metabolically active lymph nodes above and below the diaphragm. His spleen and liver are normal. His blood work is unremarkable, and he has a mildly elevated LDH at 300.

Case 2

- He is diagnosed with Stage 3B diffuse large B-cell lymphoma (aggressive non-Hodgkin lymphoma).
- He is treated with 6 cycles of R-CHOP chemotherapy

- How do we assess Matthias' response to chemotherapy?
- What is the optimal timing for post-treatment imaging?

Case 2

- How do we assess Matthias' response to chemotherapy?
  - Clinically
  - Sometimes consider mid-treatment imaging
  - Post-treatment PET would be ideal, particularly because we have a pre-treatment PET to compare against
- What is the optimal timing for post-treatment PET?
  - 6-8 weeks post treatment to avoid false positive results

Case 2

- Matthias undergoes end of treatment PET 7 weeks after chemo
  - Reference SUV in mediastinum 3, in liver 4
  - PET shows complete resolution of all adenopathy, except for small residual lymph node tissue in mesentery now measuring 1.7 cm. There is no FDG uptake in this residual LN.
  - PET scan reported as Deauville 1. Matthias is in a complete metabolic remission.
  - He is followed clinically every 3 months with history, physical examination, and lab work for the first two years, then every 6 months for a total of 5 years.
- Should Matthias have surveillance imaging? Repeat PET?

Member Questions

“What is the difference between a CT Scan, MRI or Ultrasound?”

“When does a hematologist choose a CT Scan, MRI or Ultrasound to diagnose lymphoma?”

“Do certain lymphomas require different medical imaging devices?”

“When would a hematologist require more than one of these imaging devices to be used?”