The Biology of Cancer – Week 5 Notes

* Imaging Overview
* Introduction to Imaging

Imaging is used in the management of patients with cancer.

Medical Imaging – the technique and process of creating visual representations of the inside of a body for clinical analysis and medical intervention.

2D images show us the length and width of structures.

3D images will show us the depth, as well as the length and width; this allows us to see the relationship between structures.

2D image projections are taken in 1 or 2 projections. Back to front: Posterior to anterior. Side view (lateral). When it comes through from behind, it is termed a PA view. A PA view will be in reverse. It will be as if you are facing the patient.

Image Orientation - Based on the anatomical planes of the human: transverse (axial) separates head from feet. Frontal (coronal) separates front from back. Lateral (sagittal) separates right from left.

Density and Contrast Media – The reason we see different structures is because they have different densities. Bone is thickest tissue. Thin tissues, filled with air, are dark. Moderately dense are the organs, they show up grey. Tumor masses are dense, show up as white. Now, organ tissue is normally grey, but it will show up white like bone when enhanced with contrast agents.

When we want to differentiate structures of similar densities, we use contrast agents. Contrast agents or contrast media or X-ray dye are usually given orally, or through a vein (IV) or artery (IA). Common contrasts are iodine or barium.

* Types of Imaging

Different types of imaging use different amounts of energy. Four basic types of energy: x-ray, magnetic field, sound waves, radioisotopes.

X-Rays are short wavelength EM radiation. Results when an electric field and magnetic field produce synchronized waves. (EM waves)

X-rays are at the far right of the EM spectrum and can penetrate the body.

X-ray images: the x-ray tube emits the x-rays, they come out in a beam and strike an object (patient) and the object absorbs the x-rays differentially depending on the tissue thickness. The remnant x-rays that exit out of the body are what expose the image and show us the different densities.

Ultrasound images: Sounds waves are emitted. They reflect back to the transducer at varying transmissions. The returned transmissions are converted into an image. Some waves are absorbed but many of them are bounced back. That is the information that is converted by the transducer to produce an image.

MRI: All of the tissues in the body have hydrogen atoms. MRI creates a magnetic field that polarizes the hydrogen atoms, they all become aligned. The hydrogen atoms depolarize differentially in different tissues, creating signals that are converted into an image.

Radionuclide – Radionuclide is a radioactive drug. It will be taken up differentially in various tissues. (The entire storage container is lead). A detector is measuring the radioactivity in the body. Once the radionuclide is taken up, it begins to decay. The decay emits energy and that’s converted into an image which shows hot spots in areas where the tissue took up the radionuclide.

* Imaging in Clinical Oncology

Of six cancer management techniques, five involve imaging.

1. Keep it away (prevention)
2. Watch out for it. (cancer screening)
3. If we think it’s there, we determine if it is (cancer diagnosis)
4. If we know it’s there, we determine how advanced it is (cancer staging)
5. Once we have treated it, we check to see if the treatment worked (assess treatment response)
6. After treatment, we keep watching (monitoring)

Cancer Screening – Screening tests are done to find cancer at an early stage (before symptoms appear) when it may be easier to treat and possibly cure.

Screening tests should be inexpensive and safe, with low risk and high benefit.

In common cancers, imaging used in screening:

1. Lung: CT scans
2. Colon: plain films (barium enema)
3. Breast: mammography
4. -Prostate: none
5. Liver: ultrasound
6. –Gastric none

Lung Cancer Screening: With a high pack-year exposure, yearly low dose CT scan or 3 years (National Lung screening trial)

Colon Cancer Screening: double contrast barium enema. Left lateral decubitus (laying on left side)

Breast Cancer Screening: self exam, mammograms, MRI, ultrasound. (Caudal. From top to bottom). No contrast is needed in the mammogram. MRIs of the breast can be color enhanced to help locate the lesions.

Liver Cancer Screening: There is no proven strategy for liver cancer screening. If high risk, do alpha-fetoproteins tests and ultrasound exams every 6-12 months. Ultrasound is much less expensive than other imaging.

Cancer Diagnosis: Pathology is the gold standard in cancer diagnosis.   
Imaging is generally part of a cancer diagnostic work-up and is used to support the diagnosis.  
Biopsies of the lung, breast, and liver may be image guided.

Cancer Staging: Determine how advanced cancer is to predict disease course (prognosis) and to determine treatment options. How do we do this? We evaluate the invasiveness of the cancer. What is the organ of origin – primary tumor? Are the nearby lymph nodes affected? Are any distant tissues affected? TNM System: Tumor, Lymph Nodes, Metastases.

When cancer cells extravasate, they “home” to different organ sites. “Tropism” cancer cells go to certain sites where they will thrive. (Part of the seed and soil hypothesis.)

Imaging to Assess Treatment Response – Imagine is used to assess change in tumor burden (tumor shrinkage) in response to treatment.

Purpose: to guide cancer treatment. RECIST (response evaluation criteria in solid tumors) guideline.  
-CR (complete response) Disappearance of all target (treated) lesions.  
-PR (partial response) 30% decerase in size of sum of target lesions  
-PD (progressive disease) 20% increase in sum of target lesions  
-SD (stable disease) smaller changes that do not meet above criteria

Monitoring After Therapy with Imaging – At the completion of treatment, use the imaging modality that best characterized the cancer at baseline to monitor for recurrent cancer.   
-Exploit cancer hallmarks to monitor patients after therapy.  
-Cancer cells preferentially take up more glucose. Radio tagged glucose will light up the tumor. “hot stop” after treatment would “show up cold.”

-Cancer cells prompt growth of new blood vessels. IV contrast enhanced studies will preferentially go to tumors because they are hypervascular. Iodinated contrast is injected into a blood vessel and helps light this up on CT scan.

* Theory of Oligometastasis and How Treatment is Supported by Imaging

Historically there have been limited reports of patients with metastatic cancer who were treated and cured.

1994 – The state of limited metastatic potential termed oligometastasis

Since 1994, due to improved imaging and novel treatment options, more patients have been designated oligometastatic.

Proposed Mechanisms – There is a spectrum in which metastasis occurs. In that spectrum there is a place where metastasis is more “laid back” – oligometastasis.

1. Conditions in primary tumor are not very harsh, the cells that break off are less aggressive CTCs
2. There are fewer sloughed-off CTCs that survive travel through circulation.
3. Organs where the CTCs land are inhospitable. Less become DTCs (disseminated tumor cell).

An oligometastatic diagnosis means treatment intent may be to cure.   
More work has to be done to characterize oligometastasis on a molecular level, on the pre-clinical level, and in the clinic. However, imaging is playing a strong role in moving this theory into the clinic.