Precision imaging of cancer using positron emission tomography

Robert Flavell, MD, PhD, Assistant Professor in Residence
Section of Nuclear Medicine
Department of Radiology and Biomedical Imaging
Robert.flavell@ucsf.edu
Imaging in cancer

• Radiology is an integral part of modern medicine
• In no area is this more important than oncology
• Imaging allows us to see inside the body, detecting abnormalities underlying symptoms and diseases, and lets us monitor response to therapy
Tonight’s lecture outline

• Review the development of oncologic imaging leading to the development of positron emission tomography
• Illustrate fluorodeoxyglucose (FDG) PET technique, and what happens behind the scenes
• Discuss how PET scans matter to patients and what the results can show
Imaging in cancer

1920’s
Chest X ray:
lung masses

1970-80’s
CT:
lung cancer
Imaging in cancer

1980 – 90’s: MRI – breast mass
Structural vs. functional imaging

- All these images have features in common: they see alterations in tissue **structure**
- However, changes in **metabolism or tissue function** often come before gross alterations in tissue structure
- For this reason, **metabolic or functional imaging** can be more sensitive for detecting or following response to treatment in cancer
Altered metabolism in cancer

- Cancer cells have profound alterations in metabolism that let them survive in an organism that would like to destroy them.
- One of the most well known changes is called the “Warburg Effect” after Otto Warburg.
- “Cancer, above all other diseases, has countless secondary causes. But, even for cancer, there is only one prime cause. Summarized in a few words, the prime cause of cancer is the replacement of the respiration of oxygen in normal body cells by a fermentation of sugar.”
FDG-PET – imaging the Warburg Effect

Glucose

How to image?

Image label on F atom \(^{18}\text{F}\)

1980-90s
Positron emission tomography or “PET” lets us visualize the biodistribution of an administered radiopharmaceutical.
PET/CT and PET/MRI – the final part of the puzzle

PET/CT – 00’s    PET/MRI – last 5-10 years
FDG PET

Brain
Heart
Kidneys
Bladder
Liver
Example: Added value of PET

70 yo M with melanoma in remission

Finding?

Diagnosis:

New skeletal muscle metastasis
Example: Added value of CT

Where is this mass located?
- Lung
- Rib
- Pleura
- Chest wall
Clinical utility of FDG PET

- Initial staging
- Restaging and monitoring response to therapy
- Surveillance in patients with a history of cancer
Patient scenario: Initial staging

A 67 year old man with a history of smoking was referred to head and neck surgery for enlarging masses in his neck. On exam, the patient had firm palpable masses in his neck consistent with enlarged lymph nodes. Biopsy of a lymph node demonstrated squamous cell cancer.
Patient scenario: monitoring response to treatment

An 86 year old man presented to his primary care doctor with complaints of weakness, fatigue, fevers, night sweats and abdominal bloating. An abdominal CT demonstrated abdominal masses concerning for malignancy. CT guided biopsy then demonstrated high grade diffuse large B-cell lymphoma.
Patient scenario: monitoring response to treatment

Based on aggressive histology and molecular markers as well as widespread disease on PET/CT, the patient was treated with an aggressive chemotherapy regimen. He felt better after six cycles of chemotherapy.
Patient scenario: monitoring response to treatment

A 64 year old woman with a longstanding history of metastatic breast cancer was placed on a clinical trial for management of metastatic disease to bones, lungs, and brain.

As part of the clinical trial, she underwent an initial and follow up PET/CT.
Patient scenario: Surveillance

A 55 year old woman with history of colon cancer presents to her oncologist’s office for routine surveillance, six months after hemicolectomy. She is asymptomatic. A CT scan performed two weeks ago demonstrated postsurgical changes but was otherwise unremarkable.
55-year-old woman with colon cancer status post resection

Recurrent colon cancer
Cancers in which FDG PET works well

- Lung
- Breast
- Melanoma
- Colorectal
- Esophageal
- (high grade) lymphoma
- Head and neck squamous cell cancer
- High risk, undifferentiated subtypes of other malignancies
Key take home points

• Metabolic and functional imaging can improve sensitivity for detecting cancer and response to treatment

• PET/CT was developed over 80’s – 00’s and was a result of key technological developments in engineering, physics, and chemistry

• PET/CT is now the gold standard method for imaging and studying response to therapy in many of the common cancers
Thank you for your attention!