PEDIATRIC PET/CT

SPR 2017

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PET/CT

CURRENT PRACTICES IN PEDIATRIC PET/CT

Current Practices in Pediatric PET/CT

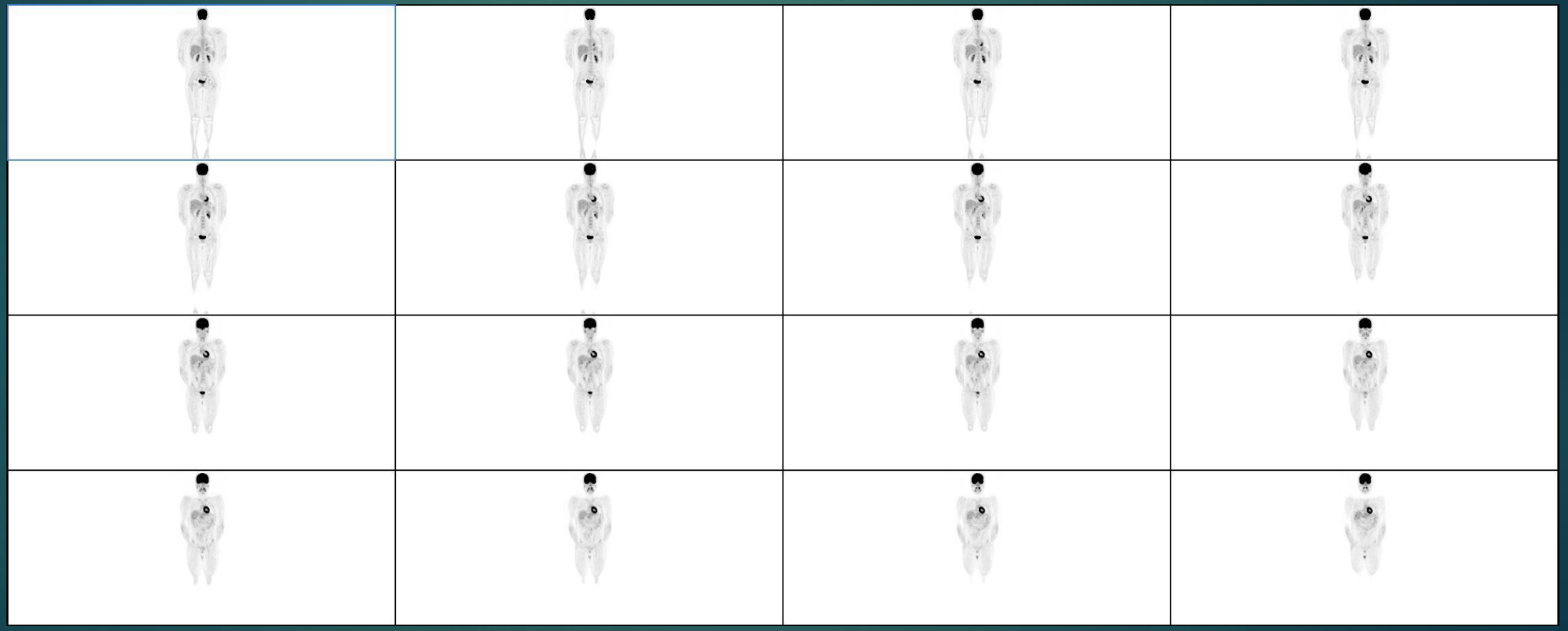
- What is PET?
- What is CT?
- What is PET/CT?

Current Practices in Pediatric PET/CT

- What is PET?
  - Positron Emission Tomography-is a nuclear medicine functional imaging technique that is used to observe metabolic processes in the body. The system detects pairs of gamma rays emitted indirectly by a *positron*-emitting radionuclide

Current Practices in Pediatric PET/CT

- What is PET?

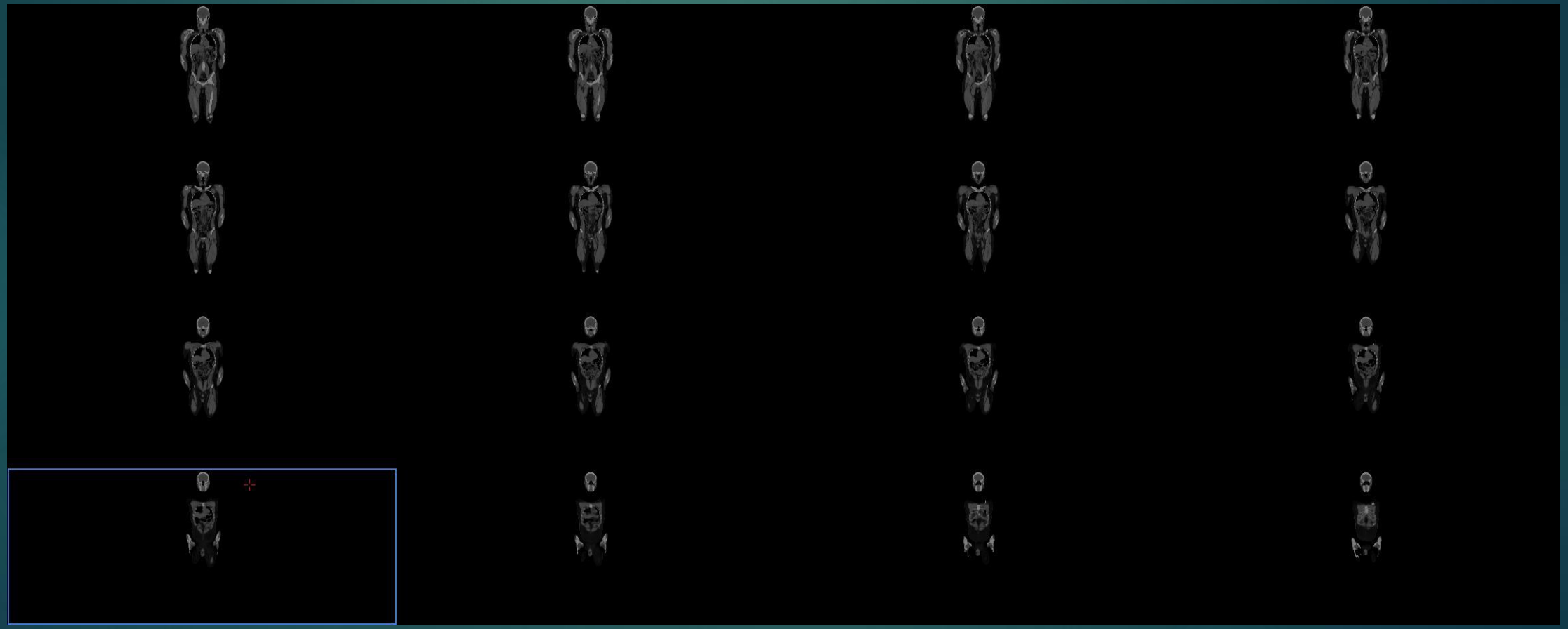


Current Practices in Pediatric PET/CT

- What is CT?
  - Computed Tomography or Computed Axial Tomography-A **CT scan** (often referred to as a CAT **scan**) makes use of computer-processed combinations of many X-ray images taken from different angles to produce cross-sectional (tomographic) images (virtual "slices") of specific areas of a scanned object, allowing the user to see inside the object without cutting

Current Practices in Pediatric PET/CT

What is CT?

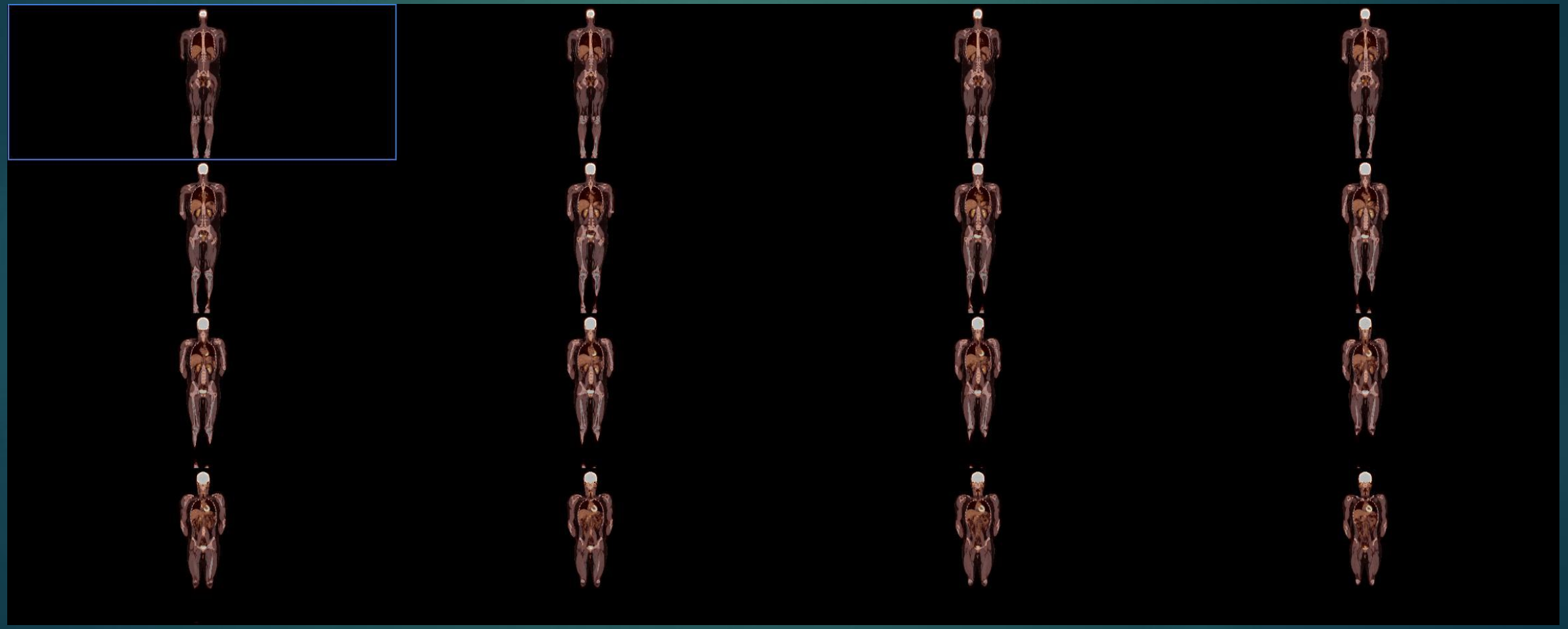


Current Practices in Pediatric PET/CT

- What is PET/CT?
  - PET/CT combines positron emission tomography (PET) and computed tomography (CT) into one machine. PET/CT scans reveal information about the structure and the function of cells and tissues in the body during a single imaging period. Combining information about the body's anatomy and metabolic function, a PET/CT scan can give more information and better images of disease than either test by itself.

Current Practices in Pediatric PET/CT

- What is PET/CT?



Current Practices in Pediatric PET/CT

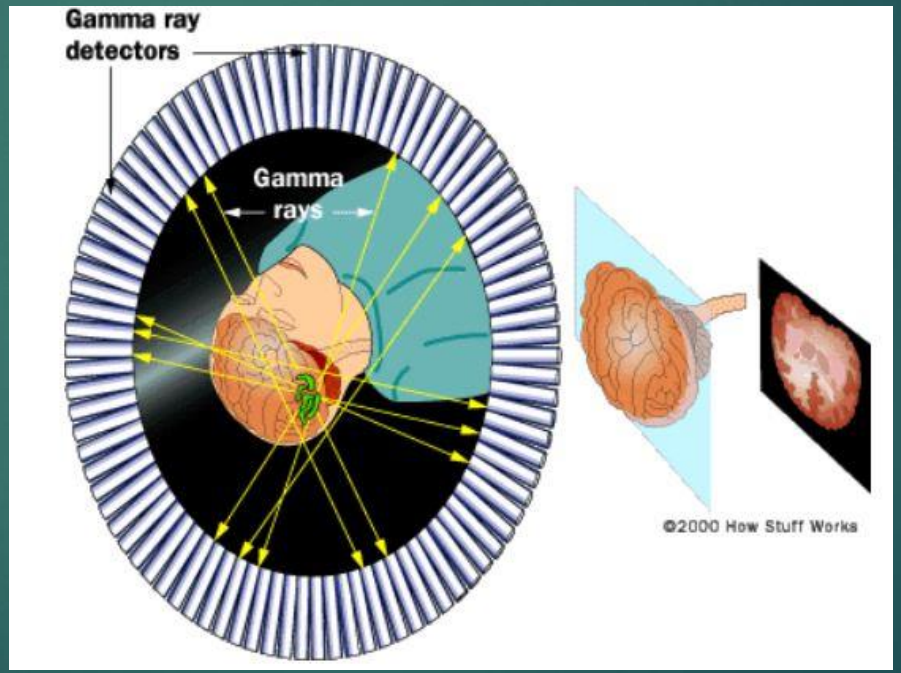
- History (quick) of PET Imaging-Technology and Pharmaceutical
  - Began in 1950 when Benedict Cassen, a physicist at the University of California in 1950, developed the first true radioisotope imaging system, the scintiscanner. Cassen combined the Geiger counter, the only detector of radioactivity at the time, with crystal components of the newly developed photomultiplier tube, which facilitated amplification and detection of gamma ray emissions
  - in 1956, Dr. David Kuhl, then a resident at the University of Pennsylvania, modified Cassen's device and developed the photoscanner. In his design, a radioisotope emission-activated glow lamp provided grayscale images with a greater sensitivity and resolution than ever before.[16] Kuhl developed several SPECT devices known as Mark II, Mark III, and Mark IV in 1964, 1970, and 1976, respectively.

Current Practices in Pediatric PET/CT

- History (quick) of PET Imaging-Technology
  - Kuhl improved the machines to measure in 3D physiologic function and to develop cross-sectional reconstructions. The machines are considered the forerunners of SPECT, PET, and CT technology. Kuhl has been referred to as “the father of emission tomography.”.
  - These early devices predated x-ray CT, developed in 1971 by Godfrey Hounsfield.

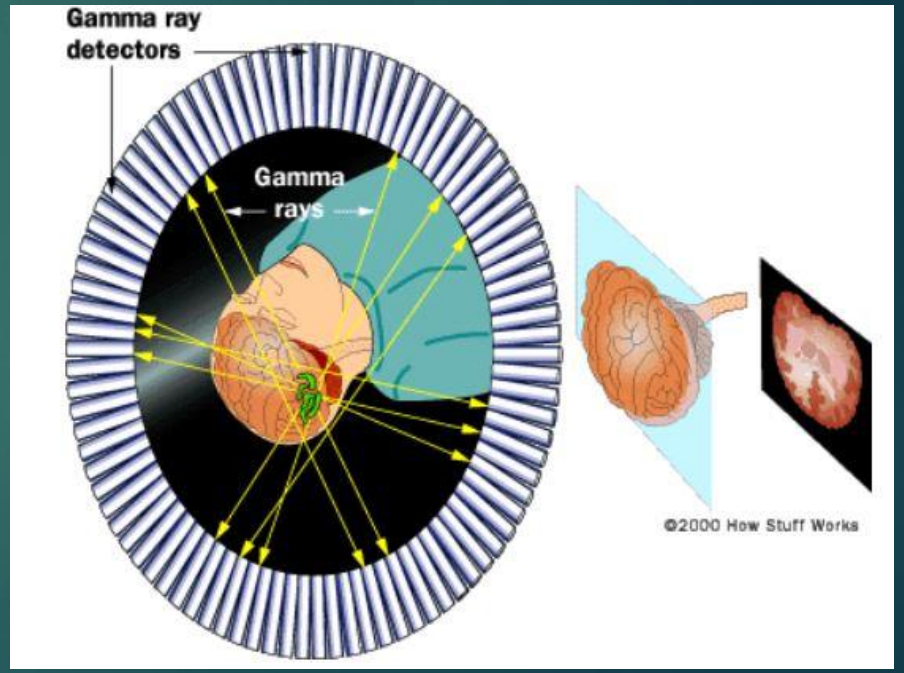
Current Practices in Pediatric PET/CT

- History (quick) of PET Imaging-Technology
  - How images are formed



Current Practices in Pediatric PET/CT

- History (quick) of PET Imaging-Technology
  - Time of Flight Imaging
    - Allows faster imaging
    - Includes larger number of true coincidence events because data reconstruction info is more accurately tracked to its annihilation event origin location.



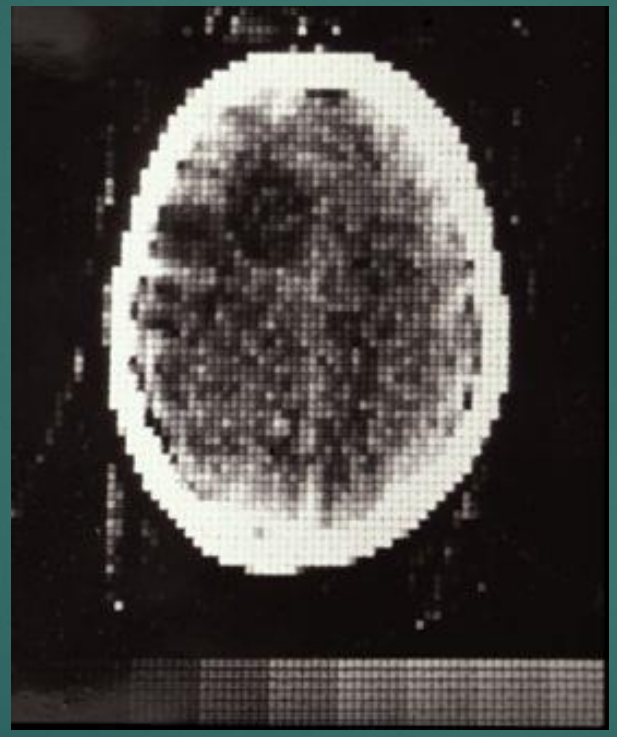
Current Practices in Pediatric PET/CT

- History (quick) of PET Imaging-Technology
  - The first large-scale use of a human positron imaging device was developed by physicist Gordon Brownell and neurosurgeon William Sweet at the Massachusetts General Hospital in the 1950s. Their machine was used to detect brain tumors with sodium iodide. Refinements led to increased sensitivity and to multiple detectors. PC-I, one of the first PET imaging devices, was unveiled in 1972 at the Meeting on Tomographic Imaging in Nuclear Medicine. While lecturing on PC-I and the resulting PET images at Washington University in St. Louis in 1974, Brownell discussed the possibility of a hexagonal arrangement of detectors with nuclear physicist Michael Ter-Pogossian. Michael Phelps and Edward Hoffman, then assistant professors in the Ter-Pogossian laboratory, constructed and in 1975 introduced an improved PET scanner with hexagonal detectors.[2] A ring-shaped PCR-I (1985) and a cylindrical shaped PCR-II (1988) detector provided even better resolution and sensitivity.

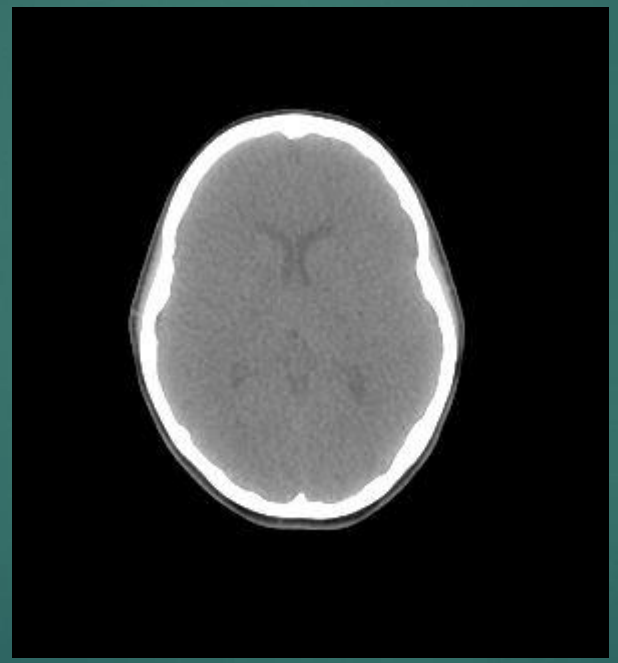
Current Practices in Pediatric PET/CT

- History (quick) of CT Imaging-Technology
  - October 1971 first clinical scan taken by Gregory Hounsfield and his team
  - Mid 1970's saw marketing and sale of clinical CT scanners
  - Improvements in Matrix Size and speed of scans
  - Helical or Spiral CT was introduced in the 1980's

Current Practices in Pediatric PET/CT



Current Practices in Pediatric PET/CT



Current Practices in Pediatric PET/CT

Current Practices in Pediatric PET/CT

- History (quick) of CT Imaging-Technology
  - CT or Computed Axial Tomography-CT scans produce 2-dimensional images of a "slice" or section of the body, but the data can also be used to construct 3-dimensional images
  - Spiral CT-For spiral CT, the x-ray tube spins in a continuous spiraling motion to take detailed pictures of the body and organs. Then we generate a 3D image of the pictures taken.

Current Practices in Pediatric PET/CT

- History (quick) of PET Imaging-Pharmaceutical
  - Began in 1960's using compound 2-deoxyglucose (DG), for Brain Imaging
  - In 1969 began using [^{14}C]DG to measure cerebral glucose metabolization in research
  - 1976 synthesized 2-[^{18}F]fluoro-2-deoxy-d-glucose (FDG).
  - 1977 published paper detailing the method of using [^{14}C]DG for brain mapping

Current Practices in Pediatric PET/CT

- US FDA Approved-Radiopharmaceuticals in PET imaging
  - sodium fluoride ($Na^{18}F$) for bone imaging,
  - rubidium chloride ($^{82}RbCl$) for assessment of regional myocardial perfusion in the diagnosis and localization of myocardial infarction,
  - fluorodeoxyglucose (^{18}FDG) for identifying the regions of abnormal glucose metabolism and primary and metastatic malignant diseases and
  - ammonia ($^{13}NH_3$) for assessment of myocardial blood flow.
  - ^{18}FDG is currently the most widely used PET radiopharmaceutical in clinical oncology in addition to its clinical applications in cardiology and neurology.
  - Dotatate Ga^{68} Neuroendocrine applications recently approved by US FDA

Current Practices in Pediatric PET/CT

- Additional Radiopharmaceuticals in PET imaging
  - C-11 20.4 minutes
  - N-13 9.97 minutes
  - O-15 122 second
  - F-18 110 minutes
  - K-38 7.64 minutes
  - Cu-62 9.74 minutes
  - Cu-64 12.7 hour
  - Ga-68 68.1 hour
  - Rb-82 75 second
  - I-124 4.18 day

Current Practices in Pediatric PET/CT

- Indications
  - Cancer
    - Lymphoma
    - Rhabdomyosarcoma
    - Osteosarcoma
    - Neuroblastoma
    - Thyroid
    - A host of others
  - Infections
  - Inflammation
  - Fever of Unknown Origin
  - Bone Injuries/Disease
  - Neuro Imaging
  - Cardiology

Current Practices in Pediatric PET/CT

- Preparing for the Scan
  - NPO
  - Physical Activity
  - Diabetic
  - Glucose Loading

Current Practices in Pediatric PET/CT

- Sedation/Anesthesia
  - Prep
  - Instructions

Current Practices in Pediatric PET/CT

- Having the scan
  - IV
  - Glucose Check
  - Uptake Period
  - Void
  - Scan

Current Practices in Pediatric PET/CT

- After the scan
  - IV removal
  - QC check
  - Release Instructions
  - Physician Reading

Current Practices in Pediatric PET/CT

- Common Variants seen in Pediatric PET/CT
  - Brown Fat

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- Common Variants seen in Pediatric PET/CT
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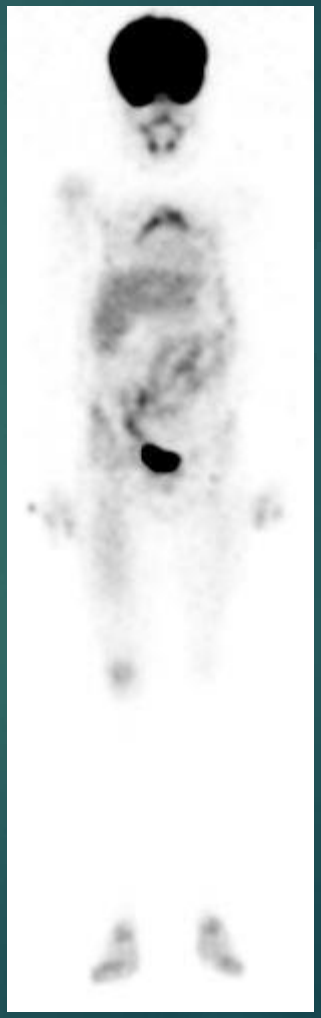

Current Practices in Pediatric PET/CT

- Common Variants seen in Pediatric PET/CT
  - Uptake in hand (bilateral or unilateral)

Current Practices in Pediatric PET/CT

- Common Variants seen in Pediatric PET/CT
  - Uptake in hand/arm (bilateral or unilateral)

Current Practices in Pediatric PET/CT

- Reading Physician (Tidbits to keep in mind)
  - The overall SUV is lower on average for small kids than for adults
  - Adult liver SUV typically 2-2.5 is considered normal
  - Pediatric liver SUV typically about 1 (up to about 5 years old)
  - Lymphoma standard is to compare liver SUV to uptake site SUV to determine if elevated
  - In Pediatrics must compare liver SUV to uptake site SUV to determine if elevated for other indications as well

Current Practices in Pediatric PET/CT

- Pediatric Hospital Survey Response
  - Top Indications
    - Lymphoma
    - Rhabdomyosarcoma
    - Seizures
    - PTLD (Post transplant lymphoproliferative disease)
    - Neuroblastoma
    - Other Oncology Diseases

Current Practices in Pediatric PET/CT

- Best practices
  - Dose reduction
    - PET
    - CT
  - Half-time Imaging
  - Image Intensification
  - Child Life/Distraction

Current Practices in Pediatric PET/CT

- Physician Interpretation
  - Nuclear Medicine Physician-dedicated NM physician at approximately 50% of sites (slightly less)
  - Radiologist with Nuclear Medicine Experience-at approximately 50% of sites (slightly more)

Current Practices in Pediatric PET/CT

- Physician Interpretation-Contrast
  - IV and Oral contrast used as part of PET study and used for attenuation correction on slightly less than 50% of respondents (most were outside of the US)
  - At sites where IV and oral contrast was used regularly there was reading by either a radiologist or radiologist and nuclear medicine physician would over-read together

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Current Practices in Pediatric PET/CT

- PET Technologist
  - All nuclear medicine technologists can perform PET and PET/CT imaging

  However the following statistics breakdown the certifications of the technologists performing these studies from the survey respondents.

  - 45% of Nuclear Medicine Technologists performing PET and PET/CT imaging were certified in both radiography and nuclear medicine
  - 10% of Nuclear Medicine Technologists performing PET and PET/CT imaging were certified in both CT and nuclear medicine
  - 10% of Nuclear medicine technologists performing PET and PET/CT imaging were certified in both PET and nuclear medicine

Current Practices in Pediatric PET/CT

- Sedation and Anesthesia
  - Sedation and Anesthesia use varies greatly among the respondents with some sites doing as little as 10% of their PET studies with Sedation or Anesthesia others as high as 85%
  - The larger hospital based practices seemed to do more sedation/anesthesia
  - On average 48% of pediatric PET or PET/CT studies were sedated across all respondents

Current Practices in Pediatric PET/CT

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- Thank you to all of the respondents to the survey and the Nuclear Medicine team at CHOP.
- Dr. Hongming Zhuang
- Dr. Lisa States
- Dr. Sabah Servaes
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- Kelly Sciole from DuPont Nemours
- Jennifer Foley Children's Mercy Kansas City, MO
- And a bunch of others who wished to remain anonymous