Optimisation of Clinical Protocols

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Clinical Protocols

• In molecular imaging, clinical protocols provide a comprehensive set of rigid criteria outlining the steps for
  – Imaging procedures
    • focus of this presentation
  – Non imaging laboratory procedures
  – Radionuclide Therapy
PET/CT in the Clinical Setting

Courtesy Dr. David Townsend
Optimise and Standardise the FDG PET/CT Imaging Protocol

• Unique advantage of PET/CT
  – Whole body imaging - to investigate primary and metastatic disease in one sweep
  – CT normally restricted to limited body imaging
  – With current advances in iterative reconstruction, dose optimisation is possible enabling WB CT’s to be performed
  – Metabolic information can then be incorporated with anatomic information
<table>
<thead>
<tr>
<th>Procedure</th>
<th>PET Component</th>
<th>CT Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient preparation</td>
<td>4-6 hour fast</td>
<td>700ml Oral Contrast 40mins Prior (Isoscan). 20g cannula</td>
</tr>
<tr>
<td>Pre-Scan</td>
<td>Check BSL&lt;br&gt;Inject FDG 60 minutes uptake&lt;brVoid at end of uptake period&lt;brAdminister sedation if reqd</td>
<td>Remove all clothes&lt;brRemove all external metal</td>
</tr>
<tr>
<td>Patient Positioning</td>
<td>Arms up or down&lt;brSupport for knees&lt;brSuitable head rest</td>
<td>Arms up&lt;brSupine</td>
</tr>
<tr>
<td>Scout Scan</td>
<td>Not applicable</td>
<td>Full Inspiration&lt;brChest apices to symphysis pubis&lt;brDefines Axial FOV for PET scan</td>
</tr>
<tr>
<td>IdCT/Diagnostic CT Scan</td>
<td>Not applicable</td>
<td>Full Inspiration&lt;br100ml Omnipaque 350 IV&lt;brChest Acquisition @ 30 sec&lt;brAbdominal acquisition @ 70secs&lt;brNo contrast WB scan at 120kVp 50-80mAs</td>
</tr>
<tr>
<td>Emission Scan</td>
<td>Multiple beds, single sweep - WB</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Data Processing</td>
<td>CT Attenuation correction using eg iterative, RAMLA or BLOB recon</td>
<td>5mm/5mm Planer reconstruction&lt;brChest/ Abdo&lt;br5mm/5mm Lung Axial Chest&lt;br10mm/8mm Lung MIP Hybrid Axial Chest</td>
</tr>
<tr>
<td>Image Analysis</td>
<td>3D fusion viewer&lt;brRegion of interest analysis&lt;brSUV</td>
<td>Soft Windows ww370/wl 40&lt;brLung Windows ww1600/wl-600&lt;brLung MIP ww2000/wl-200&lt;brAll have 50% ADIR (GE Iterative reconstruction)</td>
</tr>
</tbody>
</table>
Optimisation of PET/CT Whole Body Protocols

- Patient adequately fasted

- Determine CT dose levels adequate for
  - Attenuation correction purposes
    - 30-50mAs and 120-140kVp is sufficient
  - Diagnostic purposes
    - With iterative reconstructions now available, the mAs can be dropped significantly without impacting image quality

- Optimise injected radioactivity

- Position of arms
  - Arms down causes streak artefacts in the CT, which then propagates into the fused PET/CT images

- Support under knees to ensure even hips on both sides & patient comfort (so they will stay still)

- Ensure required axial range is in FOV
Dose reduction with iterative reconstruction
BMI based Guidelines for Acquisition Parameters for Optimal Image Quality

<table>
<thead>
<tr>
<th>BMI</th>
<th>mAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;18</td>
<td>30</td>
</tr>
<tr>
<td>19-35</td>
<td>50</td>
</tr>
<tr>
<td>&gt; 35</td>
<td>80</td>
</tr>
</tbody>
</table>

Note: tailored for IdCT

<table>
<thead>
<tr>
<th>BMI</th>
<th>Dose</th>
<th>Scan Time/bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 22</td>
<td>220 MBq</td>
<td>2 mins</td>
</tr>
<tr>
<td>22.1-25.9</td>
<td>250 MBq</td>
<td>2 mins</td>
</tr>
<tr>
<td>26-27.9</td>
<td>250 MBq</td>
<td>2.3 mins</td>
</tr>
<tr>
<td>&gt;280</td>
<td>300 MBq</td>
<td>3 mins</td>
</tr>
</tbody>
</table>
Choose the Correct Reconstruction Algorithm and be Consistent between Patients

FBP

iDose

iDose-corrected CTAC Image
Patient Positioning — Maintain Consistency in the Axial Range

State of the Art cameras have built in software that tolerates operator errors – Patient positioned out of FOV. But OFOV correction software automatically corrects this error.
Non Fasted State – Complicates Image Interpretation

Ensure patients are fasted at least 6 hours
4D PET/CT can be a Standard Addition to Study Lung and Liver Disease

Respiratory gated TOF imaging improves contrast resolution and accuracy
PET/CT in Clinical Trials
Standardise Performance of PET/CT Scanners

• Standards have been created by SNM and NEMA

• More recently the Clinical Trial Network, CTN, is collecting phantom data from multiple imaging sites

• These standards allow
  – direct comparison of PET/CT scanners
  – standardised tests to ensure scanners meet their specified performance
THE CTN Oncology Phantom Program:

Evaluating 6 Years of Scanner Performance Data

Since 2008, the Clinical Trials Network (CTN) under SNMMI has operated an active PET/CT phantom imaging program using their oncology clinical simulator chest phantom designed to validate scanners for participation in oncology clinical trials. Since its inception, the program has collected nearly 500 phantom data sets from nearly 200 imaging sites sampling the spectrum of modern PET and PET/CT technologies. These measurements are used either in clinical practice or, more importantly, in multicenter clinical trials.

The CTN oncology clinical simulator phantom is an anthropomorphic chest phantom, with lung fields and six spherical objects with inner-diameters ranging from 7-20 mm, reproducibly secured at specific locations.
Lesion Size and Locations in the CTN Chest Phantom

Targeted outcomes – use of CTN Phantoms for Clinical Trials

- Standardise imaging methodologies
- Raises awareness of non conformance of scanner calibrations
- Standardise iterative reconstruction parameters across imaging sites
  - Reduce variability of SUV assessments of tumour behavior which is used as end points in clinical trials.
Optimise Protocols for Clinical Trials

• A clinical trial protocol is designed to standardise procedures for
  – Patient preparation
    • Eg most trials specify limits for BSL
  – Acquisition
  – Reconstruction
  – Image Analysis
  – Data handling and archiving

• Adherence to a standardised clinical protocol ensures scans can be reported in standardised fashion.

• Standardised acquisition and reconstruction protocols and image analyses methods is helpful in ensuring quantitative end points are not affected by variability of above procedures.
Consistency of Procedures between Patient Visits

• Consistent
  – uptake time for each visit
  – acquisition parameters
  – injected dose
    • unless BMI has altered significantly

• Image analysis - use same software for each patient visit
  – ROI analysis and SUV calculations
  – Total lesion glycolysis
  – Ensure consistent SUV thresholds
Consistency across Multiple Sites

• Use of phantoms to calibrate the scanners and dose calibrators, ensure images are comparable between multiple images sites even when using different scanners

• Use same scan parameters across sites

• Image analysis software may vary – SUV thresholds should be agreed to
Clinical Trials using Novel Tracers

• Optimal
  – Acquisition protocol
  – Reconstruction algorithm
  – Image display

• Calibration of scanners and dose calibrators
  – Using eg CTN phantoms is recommended especially for multi centre trials where images are uploaded to CRS
  – Enables standardised, accurate and reliable SUV calculations across imaging sites participating in multi centre trials.

• Accurate and consistent quantitative information is essential to promote use of novel tracers in clinical trials to help development of new drugs
FCH & PSMA - Pelvic Nodes

$^{18}$F-FCH

$^{68}$Ga-PSMA
63 year old man with metastatic neuroendocrine tumour to the liver for staging. Somatostatin receptor +ve lesions in the mesentery & throughout the liver with primary in distal ileum. Note FDG –ve, indicative of well-differentiated tumour type.
Optimising PET/CT for Radiation Therapy Planning (RTP)
PET/CT

• Imaging modality with the most significant effect on RTP recently

• Estimated that 55%-60% of patients submitted for functional imaging have potential changes in target volumes and/or dose distribution parameters

• Most commonly refers to FDG PET/CT, but other radiopharmaceuticals are also used to assess underlying tumour biology
PET/CT In RTP – Reproducibility between PET/CT, Simulation CT and Treatment Sessions

• RTP Flat Palette
  - as for radiotherapy.
  - marked with numerical position indicators
  - can accommodate fixation of immobilization devices.
    - Thermoplastic shell

• Positioning lasers
  – on the ceiling and both opposing walls of the PET/CT scanning room
  – sited according to the PET/CT gantry iso center.
  – Positioning: by alignment of laser cross-beams with marks and tattoos on the patient; duplicates the treatment position.

• Important to maintain reproducibility between PET/CT and simulation CT to facilitate accurate definition of planning volumes
Placing fiducial marker over patient's tattoo

Laser positioning

Planning scan

Injecting radiotracer

Patient in head rest and footrest
Quality Control and Quality Assurance
Quality Control

• Daily, Weekly, Quarterly, Annual
• Detector check
• Uniformity correction
• Normalisation
• SUV calibration/ validation
• Laser alignment
Quality Assurance QA

• Purpose of QA programs
  – Continually evaluate the quality of all activities in the department, so that
  – Protocols can be standardised and optimised

• Process approach to managing QA
  – desired result is achieved more efficiently when activities and related resources are managed as a process.

• SOP – Standard Operating Procedures
  – well written, complies with local regulations
  – succinct, easy to read and easy to follow

• Ensures inter operator consistencies in all procedures

• A Process map is vital
  – All aspects of the process map must have detailed documentation
Process Map - Primary, Management and Support Processes

Conclusion

• Standardising and Optimising Clinical Protocols leads to
  – Best practice standards
  – Consistency in methodology
  – Best patient care
  – Compliance with regulations
    ▪ Regulatory bodies
    ▪ Clinical trial bodies