Guy's and St Thomas' NHS
NHS Foundation Trust

King's College London & Guy's and St Thomas' PET Centre

A Guide for Clinicians

KING'S College LONDON

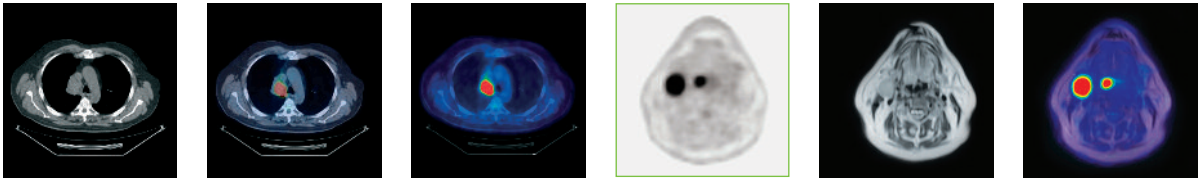
King's College London
& Guy's and St Thomas'
# PET Centre

PET (Positron Emission Tomography) is a highly sensitive imaging technique which, when combined with CT (Computed Tomography) or MRI (Magnetic Resonance Imaging), can provide functional and anatomical information important in managing many oncological conditions. PET-CT and PET-MR also have significant applications in neurological and cardiac disease.

Contents

The King's College London & Guy's and St Thomas' PET Centre was the first clinical PET Centre in the UK and has been scanning patients for over 20 years. Refurbished in 2013, we have two state-of-the-art PET-CT scanners and one of only two PET-MR scanners in the UK. We have an on-site cyclotron to manufacture radioactive tracers for clinical and research use and are currently developing novel tracers for imaging cancers, heart disease, and neuropsychiatric illnesses. The Centre's research includes cutting-edge applications for PET-CT and PET-MR technology, including integrating PET-CT with radiotherapy planning, 4D PET-CT and motion correction. Our new PET-CT scanners are able to scan patients faster, reducing scan times for the PET component and with a lower radiation dose for the CT component. They are fitted with flat beds and lasers for radiotherapy planning.

PET-CT Scanner



PET-CT scan shows uptake in a malignant right paratracheal node. Fused images can be manipulated to adjust the degree of blending.

PET, MRI and fused PET-MR scans showing lymphoma of the right tonsil and an enlarged cervical lymph node.

PET-MR Scanner

Effective patient management

Accurate and swift diagnosis is important for successful patient management. By defining the nature of a patient's disease and/or mapping its extent and location, PET-CT and PET-MR can assist clinicians to choose the most effective treatment to manage their patient's disease. Hybrid imaging is often superior to other imaging modalities in characterising disease, determining the site and extent of cancer, and in planning treatment. It can be used to make an early assessment of a patient's individual response to treatment as well as identifying failure of response or early relapse in a variety of cancers. The exciting development of PET-MR may also improve characterisation of neurological illnesses, and cancers where tissue characterisation is optimised by the use of MR, such as brain and pelvic cancers. PET-MR also offers the opportunity to reduce the radiation dose for some of our paediatric and young adult patients.

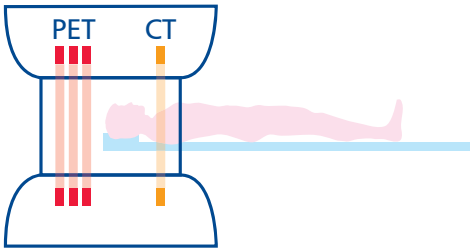
Both PET-CT and PET-MR bring function and anatomy together in one scan. PET-MR may enhance our ability to assess cancer and neurological illnesses where soft tissue characterisation is optimised by the use of MR.

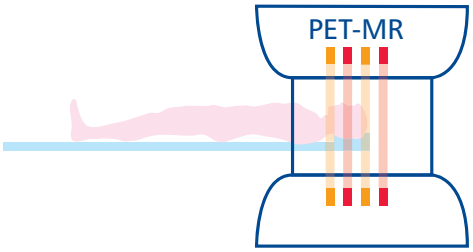
Oncology
Neurology
Paediatrics
Inflammation
Cardiology

The benefits of PET–CT and PET–MR technology

PET-CT and PET-MR are increasingly being used during the patient pathway in cancer management. Hybrid imaging makes a real difference because:

1. **More accurate staging reduces futile surgery.** More accurate staging of mediastinal involvement and detection of distant metastases reduces futile thoracotomy for lung cancer using PET-CT. PET-CT is the most sensitive technique for distant metastatic disease in oesophageal cancer, melanoma, and for extra hepatic disease in patients with colorectal cancer and liver metastases being considered for surgery. PET-CT enables better use of surgical resources in these and other cancers.
2. **Early response assessment allows monitoring of the effectiveness of costly treatment** and can exclude the possibility of progression in lymphoma and other cancers.





The cost-effective use of hybrid imaging can improve patient outcomes and direct resources to the area of greatest need. PET-CT enables timely diagnosis, aiding patient management and reducing waiting times for patients with cancer.


Patient Information
Protocol Selection
Anatomical Selector
Default Protocol
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3. **At the end of therapy, PET–CT allows more accurate assessment of treatment success or failure**, e.g. in head and neck cancer patients receiving chemoradiotherapy, and in lymphoma patients treated with chemotherapy and/or radiotherapy.
4. **Early relapse can be detected sooner** in the presence of rising tumour markers with PET-CT than CT alone in colorectal and other pelvic cancers, and effects of therapy can be distinguished from recurrent disease in symptomatic patients.
5. **For Radiotherapy Planning, PET–CT has become an essential tool** in many solid tumours and in lymphoma.
6. **Newer tracers** such as ^{11}C-Choline for prostate cancer and ^{68}Ga peptides for neuroendocrine tumours can better characterise cancers where ^{18}F-Fluorodeoxyglucose (FDG) has limited utility.

"Tracer production thanks to our in-house cyclotron, high-end PET-CTs, and now one of the UK's first simultaneous PET-MRs, all in the very heart of London, allow us to pursue diagnostic and research imaging at the highest level"

Professor Alexander Hammers
Head of the PET Centre
and Professor of Imaging
and Neuroscience

Non-oncology applications where PET-CT plays an important role in patient management include:

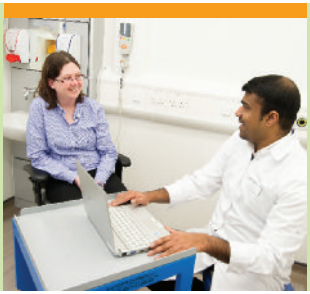
1. **Assistance with determining the seizure focus in drug resistant epilepsy** for surgical planning
2. **Determining the type of dementia** in patients presenting with dementia
3. **Assessment of cardiac viability** for selection and planning of revascularisation procedures and cardiac inflammation for determining immunosuppressant therapy
4. **Determining a cause of inflammation and infection** when other investigations have failed to identify a cause

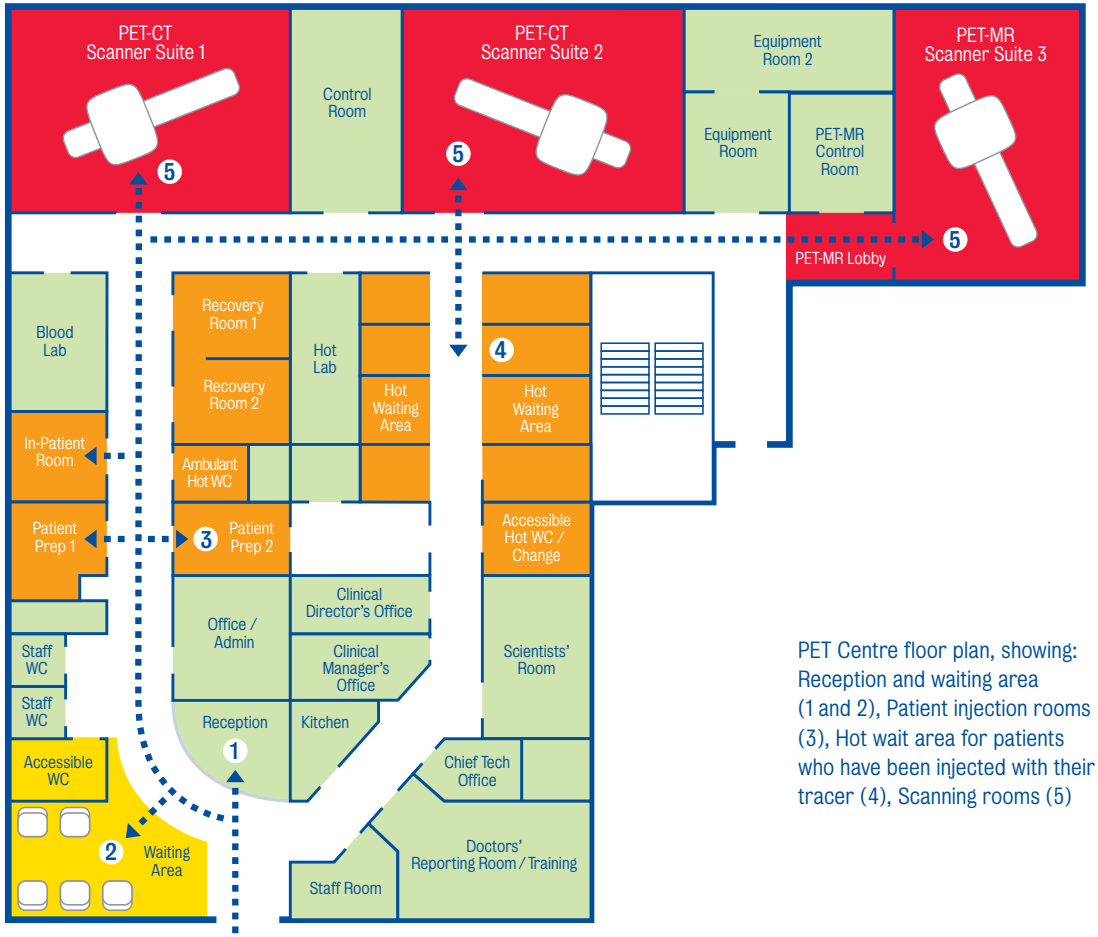
PET-MR is likely to further enhance the benefits of hybrid imaging, especially in neuropsychiatric diseases where better soft tissue contrast and the complementary functional information provided by MR is expected to further our understanding.

In cancer imaging, the combination of whole-body molecular information from PET and anatomical and functional information from MRI has the potential to improve cancer detection, characterisation and staging, as well as treatment response prediction and monitoring.

Patients relax in the care of Centre staff as a radioactive tracer is produced and injected prior to their scan.

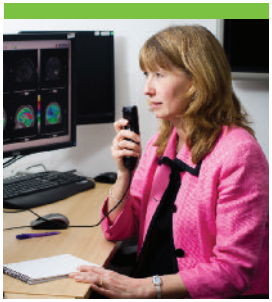




PET Centre floor plan, showing: Reception and waiting area (1 and 2), Patient injection rooms (3), Hot wait area for patients who have been injected with their tracer (4), Scanning rooms (5)

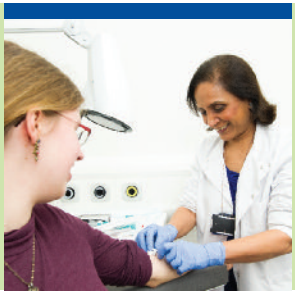
How PET–CT and PET–MR imaging work



PET is used to monitor the distribution of a radioactive tracer within the body. Tracer is taken up into abnormal tissues according to the metabolic changes induced by disease. Most often FDG is used to image the enhanced transport and metabolism of glucose that occurs in many cancers. Other aspects of tissue function however can also be measured such as amyloid deposition in Alzheimer's disease, the occupancy of a receptor by an endogenous ligand, incorporation of choline into cell membranes, amino acid metabolism, etc. The tracer remains in the body for up to a few hours, is harmless to the patient and causes no side effects.

The combination of a CT or MRI scanner with the PET scanner enables functional abnormalities seen in cancer, infection, inflammation and other conditions to be accurately localised. Abnormalities can be identified anywhere in the area imaged including the skin, soft tissue, solid organs, and bone. We have the facility to perform contrast-enhanced CT scans where necessary but will use a lower dose CT scan to minimise the radiation dose for the patient where this will give the required information.

PET-CT and PET-MR enable metabolic changes induced by disease to be imaged and accurately localised



The services we offer

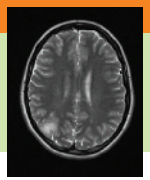
Training

We are the UK's leading centre for the development and clinical implementation of hybrid imaging techniques. We run training courses for physicians, radiologists and scientists. Our experts have authored national and international clinical guidelines in adult, paediatric practice and nuclear medicine as well as PET textbooks.

Research

We have an extensive research programme, which includes the co-ordination of national and international cancer trials using PET-CT imaging. The National Cancer Research Institute (NCRI) Core Lab is based at St Thomas' and co-ordinates national clinical trials of PET in cancer management (**www.ncri-pet.org.uk**). The Core Lab is involved in international collaborations to set standards for PET imaging and research with the European Association of Nuclear Medicine and the Radiological Society of North America. The research work of our Centre is published in international peer reviewed journals.

We equip scientists and technical staff with skills necessary to run a high quality service



MR scan

CT scan

^{11}C methionine brain scan

PET
whole body scan

FDG brain scan

Clinical

Clinicians at the Centre are always happy to discuss individual patient cases with you. We aim to scan patients within a week of a referral although urgent scans will be performed within 24-48 hours and we endeavour to have reports available within 24 hours. If there is greater urgency the result can be discussed on the same day.

One of the features of our high-quality service is that all our scans are dual reported by our experienced clinicians. Images are transferred to PACS (Picture Archiving and Communications System) or put onto a CD so they can be viewed by referring clinicians and are available for multidisciplinary team meetings.

In addition to ^{18}F-FDG (FDG), other tracers are available, some for research indications only, including: ^{18}F-Fluoride, ^{64}Cu-ATSM, ^{18}F-Fallypride and ^{18}F-L-Thymidine (FLT)

Positron
Emission

X-rays

Patient focused service delivery

Our priority is to provide a patient centred service of the highest quality. Our patients have been involved in the design of the new centre and we regularly audit the patient experience.

We aim to engage clinicians working in areas which will benefit from PET-CT imaging, and to help improve access to PET-CT facilities. We are happy to share information with local imaging services in referring hospitals to help with individual patient management. This same ethos will be applied to PET-MR imaging as its role expands.

All clinicians who refer patients to the Centre can always talk directly to our staff, who are at hand to provide advice and information about the patient at every stage of the imaging process.

"We continue to provide leadership and set standards of excellence"

Professor Gary Cook,
Professor of Clinical PET Imaging
and Head of Cancer Imaging

Magnetic
Resonance

Paediatric scanning

The PET Centre, in conjunction with Evelina London Children's Hospital at St Thomas', provides a comprehensive PET-CT scanning service for children including for those who may need sedation or general anaesthetic.

We are the leading centre in the UK with expertise in scanning paediatric patients with PET-CT

Professor Alexander Hammers
Head of the PET Centre
and Professor of Imaging
and Neuroscience

Professor Gary Cook
Professor of Clinical
PET Imaging and
Head of Cancer Imaging

Dr Sally Barrington
Reader and Consultant
in Nuclear Medicine

Dr Teresa Szyszko
Consultant in Nuclear
Medicine and Radiology

Dr Victoria Warbey
Consultant in Nuclear
Medicine and Radiology

Meet the team at St Thomas'...

Our experts have a wide range of skills and knowledge in PET-CT imaging and run or participate in international courses, conferences and seminars. We have a proven track record with more than 20 years' experience, having scanned in excess of 50,000 patients. The new Centre will have a new (second) cyclotron and much improved radiochemistry facilities.

The group continues to contribute to international research. The ultimate goal of all our research, whether it be clinical, methodological or basic science is focused on directly improving patient care.

The new Centre will enable increased numbers of patients to be scanned faster than before and with a lower radiation dose. It is the first UK Centre with its own cyclotron to offer radiotracer production, PET-CT and PET-MR all in one place for clinical and research applications.

We provide leadership and set standards of excellence nationally and internationally

Professor
Paul Marsden
Professor of PET Physics

Mrs Pallavi Patel
Head of Clinical and
Research PET Services

Professor
Tony Gee
Professor of PET
Radiochemistry

Mr Joemon John
Superintendent
Radiographer

Professor Vicky Goh
Professor of Clinical
Cancer Imaging

Expertise is also provided by Clinical Colleagues from Nuclear Medicine and Radiology

Dr D Dasgupta	Professor I Fogelman
Dr G Gnanasegaran	Professor V Lewington
Dr H K Mohan	Dr F Ul-Hassan
Dr S Vijayanathan	Dr Z Viney

For a comprehensive list of team members and further details, please visit our website **www.sthpetcentre.org.uk/index.php**

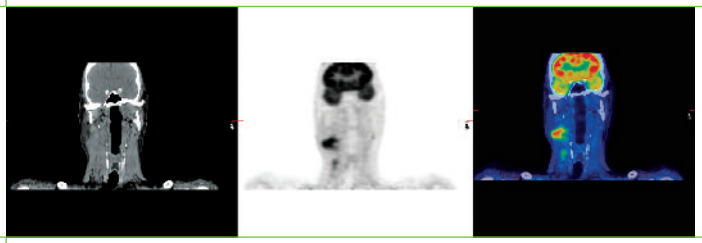
The PET Centre is at the forefront of setting standards for PET imaging in the UK and worldwide. The Centre is part of the King's College London Division of Imaging Sciences and Biomedical Engineering with 380 researchers. With its strong international reputation and placed within the Division's active research programme, the PET Centre at St Thomas' Hospital is uniquely placed to translate research developments into routine clinical usage leading to more accurate diagnosis and faster access for a greater number of patients.

For information on key publications written by members of the PET Centre team, please visit our website: **www.sthpetcentre.org.uk**

01

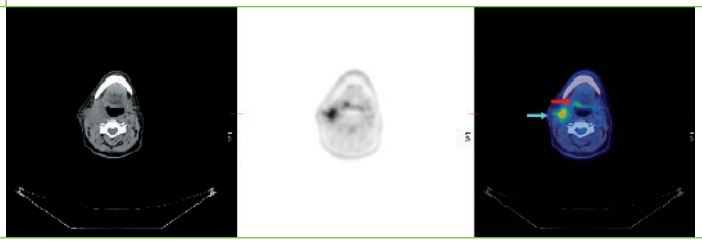
Case study: Head and Neck Cancer

1 Coronal



2 Coronal

3 Axial



Clinical history

This patient was referred with swelling of right cervical lymph nodes. Biopsy revealed squamous cell carcinoma. Clinical examination had not revealed a primary site.

Findings

There was focal high grade increased FDG uptake at the base of the tongue on the right side in addition to high grade uptake in a bulky nodal mass at level II on the right and in enlarged level III right cervical nodes.

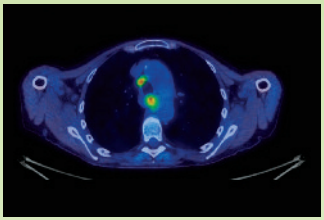
The scan appearances were consistent with a primary malignancy involving the base of the tongue on the right (red arrow on axial image) with involvement of ipsilateral cervical nodes (blue arrow on axial image).

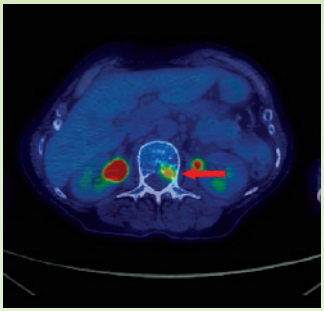
Teaching point

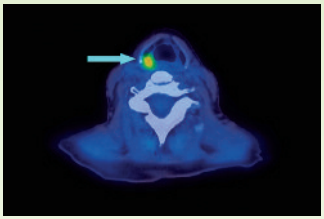
PET-CT can be useful in finding an occult primary head and neck malignancy when the patient presents with nodal disease.

02

Case study: Oesophageal Cancer







Clinical history

This patient was referred for staging of newly diagnosed squamous cell carcinoma of the oesophagus. Treatment options being considered were radical surgery and radiotherapy.

Findings

There was high grade uptake in the oesophageal primary malignancy with local nodal involvement but in addition PET-CT showed a vertebral metastasis (red arrow) and a second primary tumour within the right pyriform fossa (blue arrow).

Teaching point

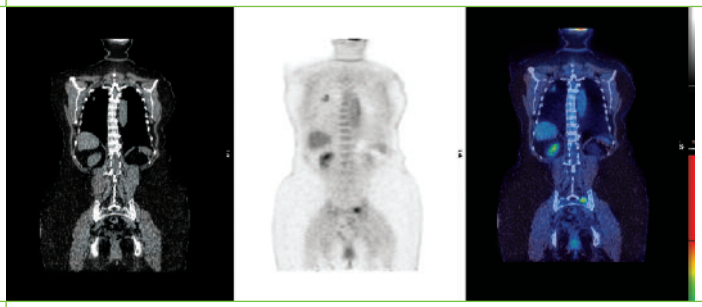
FDG PET-CT has better sensitivity for metastatic disease than CT in oesophageal malignancy. The discovery of occult metastases alters management.

Cancers of the upper aero-digestive tract share common risk factors. A potential second primary is found in up to 10% in some patient series.

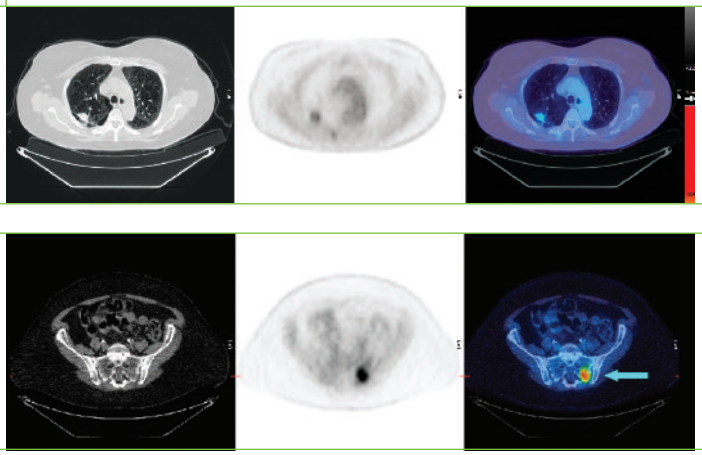
03

Case study: Lung cancer

1 Coronal



2 Axial



Clinical history

This patient presented with a small lesion at the right lung apex, increasing in size over time. PET-CT was requested to further characterise the lesion and for staging.

Findings

There was moderate uptake in a spiculated mass in the right upper lobe of the lung with extensive bilateral emphysematous changes. There was no increased uptake in mediastinal lymph nodes, however there was a small focus of uptake in the left side of the sacrum extending to the sacroiliac joint, indicative of bone metastasis (arrow).

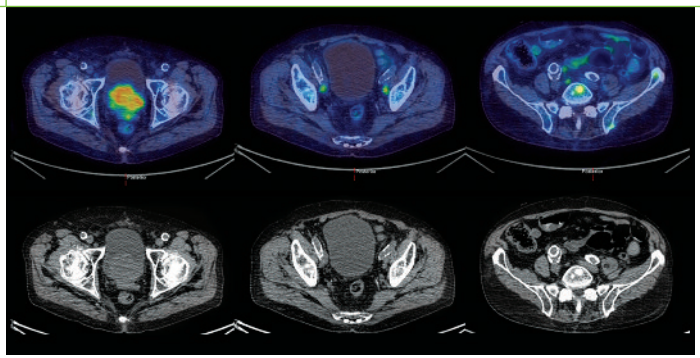
Teaching point

PET-CT is the most accurate investigation for staging of lung cancer and should be considered in all patients suitable for radical treatment with either surgery or chemo-radiotherapy.

04

Case study: Prostate Cancer

1 Axial



Clinical history

This patient complained of urinary symptoms and was found to have an enlarged malignant feeling prostate gland and a high level of the serum tumour marker PSA. An ^{11}C-choline PET-CT scan was requested to determine if the probable prostate cancer had spread.

Findings

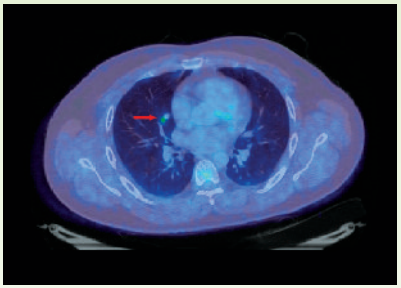
The scan shows abnormal uptake in an enlarged prostate gland, in pelvic lymph nodes and in multiple scattered bone metastases. Normal uptake can be seen in the salivary glands, liver, spleen, pancreas, kidneys and bowel.

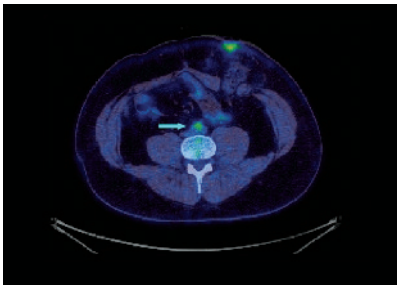
Teaching point

Whilst FDG PET-CT is not usually a sensitive imaging test in prostate cancer, ^{11}C or ^{18}F-choline PET-CT is able to detect primary, nodal and distant metastases with high sensitivity and frequently detects metastases not seen on other imaging.

05

Case study: Recurrent Colorectal Cancer





Clinical history

This patient was referred with a probable lung metastasis from colorectal cancer identified on CT and was being considered for surgical metastasectomy.

Findings

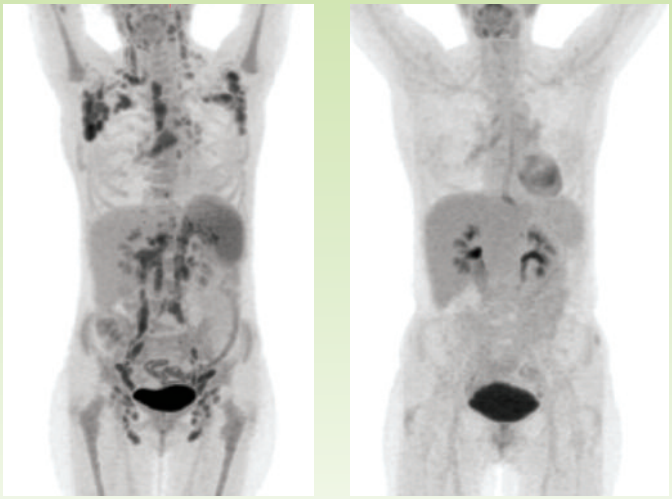
There was intense uptake of FDG within the small middle lobe pulmonary nodule consistent with a metastasis and in addition uptake within small volume lymph nodes anterior to the aortic bifurcation. Moderate FDG uptake at the stoma site was due to local inflammation.

Teaching point

FDG PET-CT can detect occult sites of malignancy in the restaging of colorectal cancer. In this case a futile surgical resection of the lung nodule was avoided.

06

Case study: Lymphoma



Clinical history

Following a diagnosis of non-Hodgkin lymphoma, this patient was referred for staging. The scan was repeated during treatment to assess the response to chemotherapy.

Findings

There is intense uptake in multiple nodal groups above and below the diaphragm with focal uptake in the spleen and increased uptake throughout the bone marrow consistent with stage IV non-Hodgkin lymphoma before treatment. The mid treatment scan showed resolution of abnormal uptake indicating that the disease was responding to chemotherapy.

Teaching point

PET-CT is the most accurate imaging modality for staging lymphoma.

PET-CT is unrivalled in assessing treatment response in lymphoma.

07

Case study: Paediatric Lymphoma

1 Coronal

2 Axial

Clinical history

This child presented with a right neck mass, biopsy showed Burkitt's lymphoma. PET-CT was requested for staging.

Findings

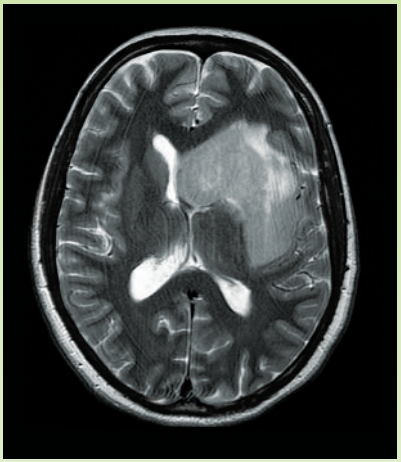
High grade uptake was seen within two lymph nodes in the right neck. Note also the presence of a right renal transplant. This young child was intubated as the scan was performed under a general anaesthetic. The PET scan suggested that lymphoma was limited to the right side of the neck (stage 1).

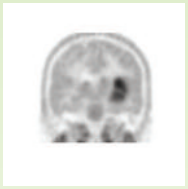
Teaching point

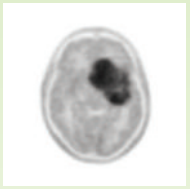
PET-CT accurately stages lymphoma. Paediatric patients often require a general anaesthetic for their PET-CT scan.

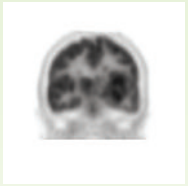
08

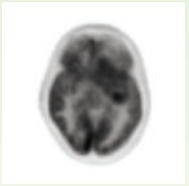
Case study: Brain Tumour











Clinical history

This patient presented with numbness and altered sensation in the right hand and foot. MRI demonstrated a lesion in the left frontal and temporal lobes suggestive of tumour (top image). PET was requested to assess the likely grade of the tumour and to direct biopsy.

Findings

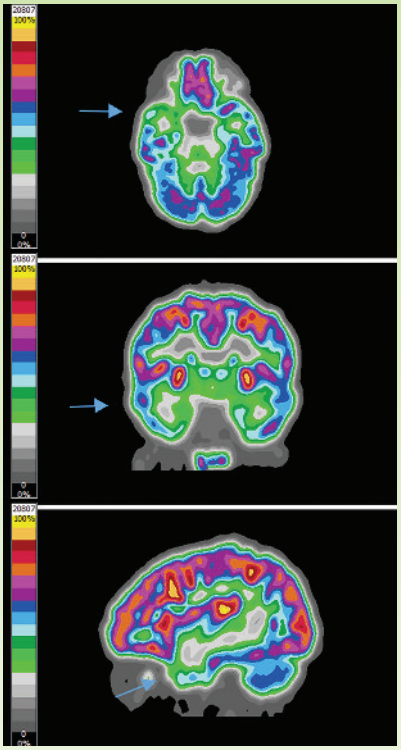
There was diffuse uptake of ^{11}C-methionine (middle images) throughout the tumour, delineating the extent of the tumour. There was a more limited area of high grade uptake of FDG (bottom images) inferiorly within the temporal lobe suggestive of high grade glioma.

Teaching point

The combination of the two tracers helped to characterise the tumour as high grade, define the functional extent of the tumour and direct the surgeon to the area with highest grade uptake for biopsy.

09

Case study: Epilepsy



Clinical history

This patient had seizures suggestive of focal epilepsy. Video telemetry and EEG were suggestive of a right temporal onset. MRI was normal. PET was requested to determine if the site of seizure onset could be identified.

Findings

Hypometabolism (reduced uptake of FDG) was seen in the right temporal lobe.

Teaching point

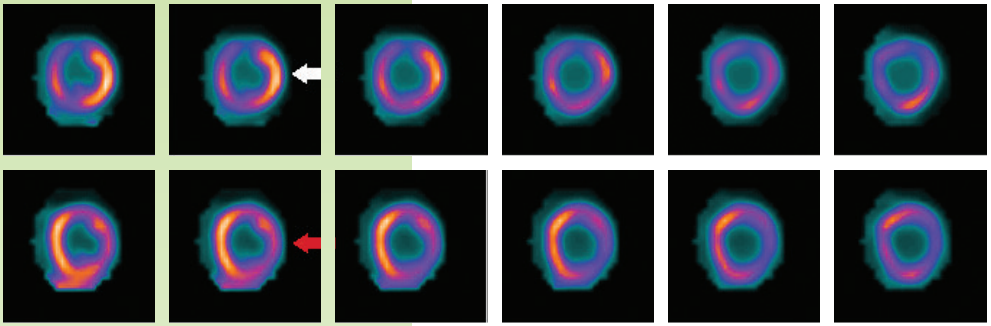
The PET hypometabolism strongly suggests a right temporal focus at the origin of the seizures and was supportive of surgery as an option for improved control of seizures.

Epilepsy is a common condition that usually responds well to treatment with medication. If medication is not working then PET scanning may help to identify the focus for epilepsy non-invasively and enable surgical intervention if a single focus is identified. In children these PET studies may require a general anaesthetic which our unit is set up to do safely.

PET-MR is expected to provide a one-stop shop for a comprehensive evaluation of medically refractory focal epilepsy, allowing a simultaneous assessment of brain structure and function.

10

Case study: Sarcoidosis



Clinical history

This patient presented with unexplained ventricular tachycardia. MRI showed delayed enhancement in both ventricles suggestive of scar tissue. PET-CT perfusion and glucose metabolism cardiac scans were requested to exclude cardiac inflammation and possible sarcoidosis.

Findings

The scan showed increased FDG metabolism in the lateral wall (white arrow, top image) accompanied by reduced perfusion using ^{13}N ammonia in the same area (red arrow, bottom image) suggestive of active inflammation.

Teaching point

The combination of reduced perfusion and increased FDG uptake was suggestive of active cardiac inflammation.

Referring patients for a PET–CT or PET–MR scan at St Thomas'

The King's College London & Guy's and St Thomas' PET Centre is a world leader in Positron Emission Tomography. Our expertise is formidable and our reputation of the highest standing.

If you think your patient could benefit from the use of PET-CT or PET-MR, please contact us to see how we can help.

Patient information, referral forms, clinical applications and evidence-based indications are available on our websites:

www.sthpetcentre.org.uk www.gstt.nhs.uk www.kcl.ac.uk

To book a scan, email: **petimaging@gstt.nhs.uk**

King's College London
& Guy's and St Thomas'
PET Centre

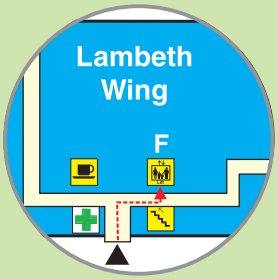
First Floor, Lambeth Wing, St Thomas' Hospital
Westminster Bridge Road, London SE1 7EH
Tel: 020 7188 4988 Fax: 020 7620 0790

St Thomas' Hospital

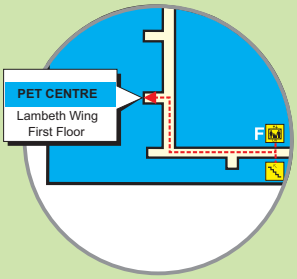
Directions

1. Enter Lambeth Wing and turn right into the corridor and take F lift or stairs to the first floor.
2. Turn right out of the lift (or left from the stairs) and follow the corridor, turning right after a short distance. The entrance to the PET Centre is through the first door on the left.

Please remember that the congestion charge applies.



1. Ground Floor



2. First Floor

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