Evidence-based indications for the use of PET-CT in the United Kingdom 2022
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>03</td>
</tr>
<tr>
<td>Preface</td>
<td>04</td>
</tr>
<tr>
<td>1. Indications for 2-[^18F]fluoro-2-deoxy-D-glucose PET-CT</td>
<td>05</td>
</tr>
<tr>
<td><strong>Oncological applications</strong></td>
<td>05</td>
</tr>
<tr>
<td>Brain</td>
<td>05</td>
</tr>
<tr>
<td>Head and neck tumours</td>
<td>06</td>
</tr>
<tr>
<td>Thyroid carcinoma</td>
<td>08</td>
</tr>
<tr>
<td>Lung carcinoma</td>
<td>09</td>
</tr>
<tr>
<td>Pleural malignancy</td>
<td>11</td>
</tr>
<tr>
<td>Thymic tumours</td>
<td>12</td>
</tr>
<tr>
<td>Breast tumours</td>
<td>13</td>
</tr>
<tr>
<td>Oesophageal and oesophago-gastric junction cancers</td>
<td>16</td>
</tr>
<tr>
<td>Gastric cancer</td>
<td>17</td>
</tr>
<tr>
<td>Gastrointestinal stromal tumours</td>
<td>19</td>
</tr>
<tr>
<td>Hepatopancreatobiliary disease</td>
<td>20</td>
</tr>
<tr>
<td>Colorectal carcinoma</td>
<td>22</td>
</tr>
<tr>
<td>Anal carcinoma</td>
<td>24</td>
</tr>
<tr>
<td>Urological malignancy</td>
<td>25</td>
</tr>
<tr>
<td>Gynaecological malignancy</td>
<td>29</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>30</td>
</tr>
<tr>
<td>Myeloma</td>
<td>32</td>
</tr>
<tr>
<td>Skin tumours</td>
<td>33</td>
</tr>
<tr>
<td>Musculoskeletal tumours</td>
<td>35</td>
</tr>
<tr>
<td>Neuroendocrine tumours</td>
<td>36</td>
</tr>
<tr>
<td>Paraneoplastic syndromes</td>
<td>38</td>
</tr>
<tr>
<td>Carcinoma of unknown primary</td>
<td>39</td>
</tr>
<tr>
<td><strong>Non-oncological applications</strong></td>
<td>40</td>
</tr>
<tr>
<td>Neurological indications</td>
<td>40</td>
</tr>
<tr>
<td>Cardiological indications</td>
<td>43</td>
</tr>
<tr>
<td>Vasculitis</td>
<td>45</td>
</tr>
<tr>
<td>Infection and inflammatory disorders</td>
<td>46</td>
</tr>
<tr>
<td>Pyrexia of unknown origin</td>
<td>48</td>
</tr>
<tr>
<td>2. Non-FDG tracers for clinical practice</td>
<td>49</td>
</tr>
<tr>
<td><strong>Indications for non-FDG tracers</strong></td>
<td>49</td>
</tr>
<tr>
<td>Multitracer PET-CT imaging of prostate cancer</td>
<td>49</td>
</tr>
<tr>
<td>Choline PET in tumour imaging</td>
<td>54</td>
</tr>
<tr>
<td>^1H-metomidate</td>
<td>56</td>
</tr>
<tr>
<td>^82Rb</td>
<td>RbCl and ^13N-ammonia in myocardial perfusion imaging</td>
</tr>
<tr>
<td>^68Ga-labelled somatostatin receptor imaging</td>
<td>58</td>
</tr>
<tr>
<td>^18F</td>
<td>fluorodopa imaging</td>
</tr>
<tr>
<td>^18F</td>
<td>fluoride bone imaging</td>
</tr>
<tr>
<td>^18F-labelled amyloid tracer brain imaging</td>
<td>64</td>
</tr>
<tr>
<td>^18F</td>
<td>fluoroethyltyrosine, ^18F</td>
</tr>
<tr>
<td><strong>3. PET-CT in paediatrics</strong></td>
<td>68</td>
</tr>
<tr>
<td><strong>Oncological applications</strong></td>
<td>68</td>
</tr>
<tr>
<td><strong>Non-oncological applications</strong></td>
<td>72</td>
</tr>
<tr>
<td>Contributors</td>
<td>74</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>82</td>
</tr>
<tr>
<td>Appendix 1.– PET-CT illustrations</td>
<td>84</td>
</tr>
</tbody>
</table>
Foreword

These guidelines mark the 30th anniversary of clinical positron emission tomography (PET) in the UK.

Since its introduction into the UK clinical practice in 1992 by Professor Michael Maisey, PET, followed by positron emission tomography-computed tomography (PET-CT), has become a key multimodality molecular imaging technique in the assessment of a wide range of medical conditions.

The Inter-Collegiate Standing Committee on Nuclear Medicine (ICSCNM) supported the development of PET-CT in the UK through several initiatives including the 2003 document, ‘Positron emission tomography – A strategy for provision in the UK’ and the 2005 document ‘PET-CT in the UK: A strategy for development and integration of a leading edge technology within routine clinical practice’.

The publication of the first version of ‘Evidence-based indications for the use of PET-CT in the United Kingdom’ in 2012 and its third edition in 2016, authored by Sally Barrington and Andrew Scarsbrook, provided a guide for the use of PET-CT in clinical practice and the evidence base on which this was founded. The first version was used to inform the commissioning of PET-CT services in the UK and beyond. Now in its fourth edition, the 2022 document provides updated indications with key references underpinning the use of fluorodeoxyglucose (FDG) and non-FDG PET-CT tracers in malignant and non-malignant diseases in clinical practice.

The ICSCNM wishes to thank the multidisciplinary team of nuclear medicine (NM) physicians, radionuclide radiologists and oncologists for updating this invaluable reference guide.

Sabina Dizdarevic,
Chair of the Intercollegiate Standing Committee on Nuclear Medicine (ICSCNM)
Preface

A document prepared for the Intercollegiate Standing Committee on Nuclear Medicine, by members of The Royal College of Radiologists and the Royal College of Physicians.

Lead authors (for current edition):
Sabina Dizdarevic, Andrew Scarsbrook, Sally Barrington.

List of co-authors and contributors (for current edition) *


These guidelines comprise an up-to-date summary of relevant indications for the use of PET-CT, where there is good evidence that patients will benefit from improved disease assessment resulting in altered management and improved outcomes. This document supersedes the previous ‘Evidence-based indications for the use of PET-CT in the United Kingdom’ guidelines published by The Royal College of Radiologists in 2016.

The document will be updated at regular intervals.

The indications are divided into oncological and non-oncological applications then body area/system. This list is not exhaustive and there are cases where PET-CT may be helpful in patients who have equivocal or definite abnormalities on other imaging where PET-CT may alter the management strategy if found to be ‘positive’ or ‘negative’; for example, radical or high-risk surgery. PET-CT would be appropriate in such patients at the discretion of the local Administration of Radioactive Substances Advisory Committee (ARSAC) licence holder as a problem-solving tool when other imaging modalities have been inconclusive.

General references


* For a more detailed list of authors and contributors, please refer to appendix ‘Authors and contributors’ on page 74.
Evidence-based indications for the use of PET-CT in the United Kingdom 2022
The Royal College of Radiologists, Royal College of Physicians, British Nuclear Medicine Society, Administration of Radioactive Substances Advisory Committee

1 Indications for 2-[18F]fluoro-2-deoxy-D-glucose ([18F]FDG) PET-CT

Oncological applications

Brain

- Assist in decision-making and target selection for biopsy by identifying the grade of malignancy where there is uncertainty on anatomical imaging.1,2
- Suspected relapse where magnetic resonance imaging (MRI) is equivocal to inform decisions regarding surgery or radiotherapy planning.3
- Assessment of suspected high-grade transformation in low-grade glioma.1,4
- To differentiate recurrent glioma from post-treatment effects when MRI is unhelpful.1,4,5
- Differentiation between glioma and primary central nervous system lymphoma limited to the brain in combination with MRI in highly selected cases.4
- Differentiation of cerebral tumour from atypical infection in immuno-compromised patients with indeterminate lesions on MRI/CT.6

References


Head and neck tumours

- Staging of patients where staging is difficult clinically; for example, where there is uncertainty on other imaging or equivocal findings that would preclude radical treatment.1–8
- Staging or restaging of patients with a high-risk of disseminated disease such as advanced loco-regional disease and primary sites with a high propensity for disseminated disease such as nasopharyngeal and hypopharyngeal cancer.3–10
- To identify the primary site in patients presenting with metastatic squamous cell carcinoma in cervical lymph nodes, with no primary site identified on other imaging.7,11,12
- Response assessment three to six months’ post chemoradiotherapy in head and neck cancer with advanced locoregional or metastatic disease.7,8,13–17
- To differentiate relapse from treatment effects in patients suspected to have tumour recurrence where MRI is uncertain or equivocal.7,8,13,16–17

References


a Baseline PET-CT may be required in this group of patients as chemoradiotherapy is typically used for their treatment.


Thyroid carcinoma

- Assessment of patients with elevated thyroglobulin levels and negative iodine scintigraphy with suspected recurrent disease.1-3
- To evaluate disease in treated medullary thyroid carcinoma associated with elevated calcitonin levels with equivocal or normal cross-sectional imaging, bone and octreotide scintigraphy.1,4

See below for alternative PET imaging with Gallium-68 \[^{68}\text{Ga}\]Ga-DOTA-TATE (DOTA-TATE), \[^{68}\text{Ga}\]Ga-DOTA-1-Na\(^{+}\)-octreotide (DOTA-NOC) or \[^{68}\text{Ga}\]Ga-DOTA-octreotide (DOTA-TOC).

- Monitor response to tyrosine kinase inhibitor (TKI) therapy in patients with FDG-avid and non-iodine-avid disease.5-7
- Evaluation of anaplastic thyroid cancer in highly selected cases based on a multidisciplinary decision where impact on clinical management is expected.8-11

References

3. Haugen BR, Alexander EK, Bible KC et al. 2015 American Thyroid Association Management Guidelines for Adult Patients with Thyroid Nodules and Differentiated Thyroid Cancer: The American Thyroid Association Guidelines Task Force on Thyroid Nodules and Differentiated Thyroid Cancer. *Thyroid* 2016; **26**: 1–133.
5. Ahmaddy F, Burgard C, Beyer L et al. 18F-FDG-PET/CT in Patients with Advanced, Radioiodine Refractory Thyroid Cancer Treated with Lenvatinib. *Cancers (Basel)* 2021; **13**: 317.
11. Kim HJ, Chang H-S, Ryu YH. Prognostic Role of Pre-Treatment \[^{18}\text{F}\]FDG PET/CT in Patients with Anaplastic Thyroid Cancer. *Cancers (Basel)* 2021; **13**: 4228.
Lung carcinoma

- Staging of patients considered for radical treatment of non-small cell lung cancer.\textsuperscript{1,4,9,10}
  - Specifically, National Institute of Clinical Excellence (NICE) guidelines 2019 recommend PET-CT is used for intrathoracic lymph node staging in patients who could potentially have treatment with curative intent, such as those with a low probability of nodal malignancy (lymph nodes below 10 millimetre (mm) maximum short axis on CT) or in patients with enlarged intrathoracic lymph nodes (lymph nodes greater than or equal to 10 mm short axis on CT), and for confirming the presence of isolated distant metastases/synchronous tumours.\textsuperscript{3,13}

- Characterisation of a solid solitary pulmonary nodule with an initial risk of malignancy of >10\% (Brock model) where the nodule size is greater than local PET-CT detection threshold (8–10 mm) below which the influence of the partial volume effect is substantial and precludes adequate sensitivity.\textsuperscript{2,5,6,7,9,15}
  - Especially in the case of failed biopsy, a technically difficult biopsy or where there is a significant risk of a pneumothorax in patients with medical co-morbidities.
  - Smaller nodules in the upper lobes may be considered after multidisciplinary team (MDT) discussion or discussion with the local ARSAC licence holder if biopsy and/or CT follow-up are not appropriate.

- Assessment of response to chemotherapy and/or radiation treatment in selected patients who have had an apparently very good response on conventional imaging and surgery is being considered.\textsuperscript{9}

- Assessment of suspected disease recurrence:
  - To differentiate between treatment effects and recurrent cancer.\textsuperscript{5,11}

- Staging of patients with small-cell lung cancer with limited disease on CT being considered for radical therapy.\textsuperscript{12,14}

References


Pleural malignancy

- To guide biopsy in patients with suspected pleural malignancy with pleural thickening.
  - FDG is less likely to be useful in patients presenting with a pleural effusion only or with a history of previous pleurodesis.\(^1\)\(^-\)\(^4\)\(^a\)
- To exclude extra-thoracic disease in proven mesothelioma in patients considered for multimodality treatment including radical surgery/decortication.\(^2\)\(^,\)\(^5\)\(^,\)\(^6\)
- Response assessment to therapy where there is uncertainty on conventional imaging.\(^2\)\(^,\)\(^7\)\(^,\)\(^8\)

References


\(^a\) FDG PET-CT may demonstrate false positive appearances in patients with history of pleurodesis, however, in this clinical context FDG PET-CT may still be useful for assessment of potential mediastinal lymph node involvement, peritoneal extension of disease and in cases of progressive pleural disease suspected on CT.
Thymic tumours

- Staging of patients considered for surgical resection.¹
- Assessment of indeterminate thymic lesions if being considered for radical treatment.²⁻⁴
- Response assessment to therapy where there is uncertainty on conventional imaging.⁵

References

Breast tumours

Indeterminate or equivocal breast lesions

- In case of an FDG-avid intramammary incidental abnormality on a FDG PET-CT scan (performed for reasons other than breast cancer), it is recommended to evaluate on further investigations to exclude breast cancer, including correlation with dedicated breast imaging and, not infrequently, histological confirmation.1

Primary staging

- To be performed when standard staging imaging studies are equivocal or suspicious (problem-solving)2-4, and particularly when required to guide management decisions such as pre-operative systemic therapy.4,‡
- Staging of inflammatory or non-inflammatory locally advanced breast cancers (LABC) – instead of and not in addition to CT scan and bone scan.3, ‡
- Replacing or complementing standard staging imaging studies in high-risk patients, such as patients with:3,
  - High tumour burden:*”
    - Large tumours (e.g. > 5 cm, T3) and/or;
    - Clinically positive axillary nodes (cN+);
  - Aggressive tumour biology, e.g. triple-negative breast carcinoma;†
  - Clinical signs, symptoms or laboratory values suggesting the presence of metastases.
- To identify occult primary breast cancers in a highly selected group of patients with proven lymph nodal (particularly axillary) or distant metastatic disease but undetected lesions on dedicated breast imaging.5-10
- Replacing standard staging imaging studies in patients with proven or suspected allergy to CT or MRI contrast agents.

Notes:

* FDG PET-CT is less informative in cases of lobular cancers and low-grade tumour;2
**For the purpose of these recommendations, LABC means inoperable, non-metastatic locally advanced breast cancer;
***In the initial staging, FDG PET-CT imaging has been suggested in patients with clinical stage IIA (T1N1 or T2N0) and strongly recommended in patients with clinical stage >=IIB breast cancer, and is better when performed before surgery;
†Other aggressive breast cancer phenotypes which are known to be FDG-avid include grade 3 ductal cancer, high Ki67, ER/PR-negative, luminal B cancers.11-15
‡Bone scan or sodium fluoride PET-CT may not be needed if FDG PET-CT is performed.4
**Recurrence assessment**

- To be performed in patients in which standard imaging studies are equivocal or suspicious of recurrent disease *(problem-solving)*.2,4,5
- For restaging of patients with confirmed locoregional recurrence or clinical suspicion of relapsed disease (e.g. chest wall tenderness, elevated tumour markers*** and so on) equivocal on standard imaging.16,17
- Differentiation of treatment-induced brachial plexopathy from tumour infiltration in symptomatic patients with an equivocal or normal MRI.
- Replacing standard restaging imaging studies in patients with proven or suspected allergy to CT or MRI contrast agents.

**Notes:**

*When feasible/available, FDG PET-CT could be performed with a high-resolution diagnostic, contrast-enhanced CT, according to the imaging pathway algorithms of individual institutions;*4

**Bone scan or sodium fluoride PET-CT may not be needed if FDG PET-CT is performed and clearly indicates bone metastases;***

***Elevated CA-125, CEA or CA 15-3 markers;17

**Response to treatment**

- For early evaluation of response to neoadjuvant therapy, particularly in triple negative or Her2+ disease.4
- Assessing response to systemic treatment, as clinically indicated, particularly in patients whose disease is not well demonstrated using other diagnostic techniques (for example, bone metastases)*** or in complex patients with multisystemic disease (for identifying differential response and guide clinical management).*

**Note:**

* Baseline FDG PET-CT is recommended.

**References**


Evidence-based indications for the use of PET-CT in the United Kingdom 2022

The Royal College of Radiologists, Royal College of Physicians, British Nuclear Medicine Society, Administration of Radioactive Substances Advisory Committee


Oesophageal and oesophago-gastric junction cancers

- For staging/re-staging patients with oesophageal or oesophago-gastric carcinoma, particularly if considered at risk of metastases, suitable for radical treatment, including patients who have received neo-adjuvant treatment.1,4,7,*,**,***,†
- Evaluation of suspected recurrence of oesophago-gastric tumours when other imaging is negative or equivocal.1,3,4,†
- For radiotherapy planning/volume delineation of oesophageal and oesophago-gastric junction cancers.1,3
- To evaluate response assessment after primary treatment in patients with oesophageal or oesophago-gastric junction cancers.1,3,9-14

Notes:

*FDG PET-CT outperforms morphological imaging for the detection of distant metastases in oesophageal cancer; 4-8

**FDG PET-CT performs well and better than morphological imaging, in detecting regional or distant lymph node involvement;4,5,6,8,15-18

***FDG PET-CT evaluation could be reserved for patients with no evidence of M1 disease on CT;

†Review of CT and FDG PET-CT scans prior EUS is recommended to become familiar with the nodal distribution for FNA biopsy;

‡FDG PET-CT shows a good sensitivity for the diagnosis of recurrent disease, but lacks specificity, which means that histological proof of local FDG-avidity appears necessary.4-8

References


Gastric cancer

- To identify primary gastric tumours in case of equivocal findings on conventional imaging for patients which are eligible for radical treatment.1,2
- For staging and re-staging of confirmed gastric cancer if there is a curative treatment intent.1,4
- Assessment of suspected relapsed or disease progression in patients who are candidates for further chemotherapy or radiotherapy.1
- To identify recurrent disease in gastric bed, near anastomoses or stumps.2
- For treatment response assessment (particularly in cases of renal insufficiency or allergy to CT contrast).2,5

Notes:

* FDG PET-CT may be less informative in patients with mucinous or diffuse/non-intestinal types tumours1;

** Baseline clinical staging FDG PET-CT evaluation is recommended in >T1 suspected disease, particularly if nodal and/or metastatic disease is equivocal on initial CT chest+abdomen+pelvis imaging.1,3

*** Although CT chest+abdomen+pelvis with oral and IV contrast is the preferred imaging for follow-up/surveillance of patients with p stage II/III or yp stage I-II (treated with neoadjuvant ± adjuvant chemotherapy), FDG PET-CT can be considered in addition or replacing the CT, as above.2

References

Gastrointestinal stromal tumours

- Staging prior to treatment in patients who are likely to require systemic therapy.\(^1,2\)
- Response assessment to systemic therapy.\(^3,4\)
- Early treatment response (six to eight weeks) to imatinib.\(^4\)

References

Hepatopancreatobiliary disease

Pancreatic cancer
- Staging of patients with localised pancreatic cancer on CT before they have surgery, radiotherapy or systemic therapy to help in planning appropriate treatment.1,6
- Suspected recurrence of pancreatic cancer, where cross-sectional imaging is equivocal or negative, taking into consideration that up to 30% of pancreatic adenocarcinomas may not be FDG avid.2,4,6,8,9
- Diagnosis of primary pancreatic cancer when other imaging is non-diagnostic.6

Hepatocellular carcinoma
- Suspected recurrence of hepatocellular carcinoma (HCC), where cross-sectional imaging is equivocal or negative, taking into consideration that that up to 50% of HCC may not be FDG avid.10
- Identification of poor prognosis HCC.11-13
- Predicting probability of early recurrence after liver transplantation for HCC.13

Other tracers (e.g., 18F-choline/11C-choline, 11C-acetate) can be useful in imaging HCC. See section Choline PET for other tumours for more details.

References


**Gallbladder cancer**

- Pre-operative staging.1,2

**References**


Colorectal carcinoma

- Staging of patients with synchronous metastases at presentation suitable for resection or patients with equivocal findings on other imaging; for example, pulmonary or liver lesions.1,4,6
- Restaging of patients with recurrence being considered for radical treatment and/or invasive targeted techniques (for example, metastatectomy/selective internal radiation therapy [SIRT]).1,5,6
- Assessment of treatment response in patients with rectal carcinoma post (chemo) radiotherapy with indeterminate findings on other imaging.7,9
- Evaluation of indeterminate pre-sacral masses post-treatment.7,9
- Assessment of treatment response following targeted therapy (ablative techniques for liver or lung metastases, selective internal radiotherapy for liver metastases) in metastatic colorectal carcinoma when findings on other imaging are inconclusive.10,11
- PET-CT follow up after liver metastasis ablation.12-14
- Detection of recurrence in patients with rising tumour markers and/or clinical suspicion of recurrence with normal or equivocal findings on other imaging.15
- Monitoring metabolic response in patients with metastatic colorectal cancer being treated with oral multikinase and immune checkpoint inhibitors.16

References


Anal carcinoma

- For staging in patients with T2-T4 anal tumours suitable for radical treatment.\(^1,2,4,6-9\)
- For re-staging/re-assessment in patients treated with radical chemoradiotherapy.\(^1,5,7,8\)

References

Urological malignancy

Renal cancer

- Assessment of metastatic renal or ureteric carcinoma in staging and restaging of extra-renal or extra-ureteric disease in selected cases with equivocal imaging (recognising that ~50% of renal cell carcinomas may not be FDG-avid and that the radiotracer is excreted into the urinary tract, however, it’s useful in cases when disease is FDG-avid and for potential problem solving).¹²⁻⁴⁻⁶⁻⁸
- Assessment of disease recurrence within the nephrectomy bed.²⁻³⁻⁵⁻⁷
- Monitoring response to treatment if previously FDG-avid metastatic disease.²⁻⁴⁻⁵

References

Bladder cancer

- Staging – In the setting of proven muscle invasive bladder cancer or high-risk non-muscle-invasive bladder cancer before radical treatment if there are indeterminate findings on CT or MRI, or a high-risk of metastatic disease (e.g., T3b disease).\(^3\)\(^5\)\(^7\)\(^9\)\(^12\)
- Re-staging following treatment or in suspected extra-vesical recurrence (nodal or visceral).\(^1\)\(^3\)\(^6\)\(^8\)\(^12\)

References

**Prostate malignancy**

- Positive FDG PET is a poor prognostic marker in prostate malignancy and can be used in combination with multitracer imaging (e.g., prostate-specific membrane antigen (PSMA) tracer imaging, DOTATATE, Na\(^{18}\)F) in highly selected patients based on MDT approach.\(^1\)-\(^3\)

  *See below for alternative PET imaging with non-FDG tracers in prostate malignancy.*

**References**


**Testicular malignancy**

- In selected cases of primary staging of testicular germ cell tumours with equivocal findings on conventional work-up.\(^1\),\(^2\)
- Assessment of recurrent disease in seminoma patients with elevated or rising tumour markers and equivocal or normal anatomical imaging.\(^3\)-\(^8\)
- Post chemotherapy assessment of residual masses in patients with metastatic seminoma (note high NPV especially for masses > 3 cm but false positives can occur secondary to inflammation and desmoplastic reaction so ideally perform at least eight weeks post chemotherapy).\(^3\)-\(^8\)

  *Note for non-seminomatous germ cell tumours, teratomas have variable, low or no FDG uptake, so FDG PET is not reliable to distinguish disease versus fibrosis or necrosis.*

**References**


**Penile carcinoma**

- Staging of high-risk penile carcinoma.¹⁴

**References**


Gynaecological malignancy

- Staging of patients with locally advanced cervical cancer being considered for radical chemoradiotherapy.\(^1^4\)
- Response assessment of locally advanced cervical cancer after chemoradiotherapy if felt clinically warranted.\(^1^4\)
- Suspected recurrence of vulval, endometrial or cervical carcinoma when other imaging is equivocal.\(^5\)
- Staging or restaging of patients with vulval or uterine (cervix/endometrium) carcinoma considered for exenterative surgery.\(^6\)
- Detection of tumour in selected patients with ovarian carcinoma who have rising CA125 levels and equivocal or negative imaging.\(^7\)
- Staging of high-risk endometrial cancer with equivocal findings on conventional work-up.\(^8^,^9\)

References

Lymphoma

- Staging and restaging of FDG-avid lymphoma (including indolent lymphoma and post-transplant lymphoproliferative disorder (PTLD) in patients being for considered for active treatment.\(^1\)\(^{11}\)
- Response assessment using Deauville criteria and Lugano classification.\(^1\)\(^{4}\)\(^{8}\)\(^{12}\)\(^{24}\) Semi-quantitative evaluation should be performed using iterative reconstruction rather than advanced reconstructions employing point spread function compensation or penalised likelihood reconstruction.\(^25\)
- In cases where there is a high index of clinical suspicion for high grade transformation to identify a suitable biopsy site in low grade lymphoma. Re-biopsy is not required prior to immunochemotherapy based on standardised uptake value (SUV) alone.\(^1\)\(^{26}\)
- Evaluation of suspected relapse for FDG-avid lymphomas in symptomatic patients. Surveillance imaging is not recommended.\(^1\)\(^{7}\)\(^{27}\)\(^{29}\)
- Prior to bone marrow transplant to assess remission status and residual volume of disease and suitability for transplant.\(^1\)\(^{5}\)\(^{30}\)\(^{31}\)

References


Myeloma

- Work-up of patients with newly diagnosed, relapsed or refractory multiple myeloma.\(^a\)\(^b\)\(^c\)\(^1\)-\(^5\)
- Work-up of patients with a solitary extramedullary plasmacytoma, as well as in cases of solitary bone plasmacytoma if whole-body MRI is not available or contraindicated.\(^5\)
- Distinguish between smouldering and active myeloma.\(^1\),\(^5\)
- Monitor the effects of treatment.\(^1\),\(^5\),\(^8\)

References


\(^a\) According to the International Myeloma Working Group recommendations.

\(^b\) In accordance with NICE guidance on ‘Myeloma: diagnosis and management’ (NG35) for cases of suspected myeloma whole-body MRI is the preferred first-line imaging method, but for cases of already diagnosed myeloma, whole-body imaging with either CT, MRI or [18F]FDG PET-CT (depending on local availability) should be considered.

\(^c\) Whole-body MRI is more sensitive than [18F]FDG PET-CT in the diagnosis of multiple myeloma before treatment, however, [18F]FDG PET-CT is more specific than whole-body MRI in detecting residual disease in treated patients.\(^5\),\(^10\)
Skin tumours

- Staging of patients with known disseminated melanoma to assess extent of disease prior to treatment.¹⁻¹³
- To assess for distant disease in patients with melanoma when radical dissection is contemplated (nodal or metastatic disease).²
- To assess response to isolated limb infusion for malignant melanoma.¹³
- [¹⁸F]FDG PET-CT is a useful non-invasive tool in the work-up of locally advanced (unresectable) and metastatic Merkel cell carcinoma, providing information for initial staging, therapy response evaluation, and monitoring of recurrent disease.¹⁴⁻²⁰
- To exclude systemic involvement in skin lymphomas and exclude large cell transformation in mycosis fungoides.²¹⁻²³
- To exclude primary malignancy where dermatomyositis suspected to represent a paraneoplastic manifestation.²⁴
- Response assessment to immunomodulatory therapy for melanoma.²⁵,²⁶
  
  Not indicated for early-stage patients who should undergo sentinel node biopsy.²⁷

References


Musculoskeletal tumours

- Staging of high-grade sarcomas (e.g., Ewing’s sarcoma, rhabdomyosarcoma, osteosarcoma), unless already proven to have metastatic disease.1-4
- In the pre-amputation setting of a high-grade sarcoma where detection of distant disease will alter the surgical management.5
- Staging of patients with metastatic sarcoma considered for liver or lung metastatectomy where anatomical imaging has not identified any extra-thoracic or extra-hepatic disease which would preclude surgery.1,6
- Treatment response assessment in high-grade sarcomas.1,2,7,8
- Follow-up assessment post surgical treatment (i.e., operative bed surveillance for local recurrence), particularly in cases where metallic orthopaedic implants preclude or complicate conventional imaging.9
- Aid in differentiation of equivocal findings from conventional imaging in selected cases.1,6
- Assessment of suspected malignant transformation within plexiform neurofibromas in patients with neurofibromatosis type 1, particularly with dual-time-point imaging.10,11

References


While [18F]FDG PET-CT may be helpful for differentiating between benign and malignant findings, there can be considerable overlap.

Additional delayed imaging recommended at four hours when there is initial [18F]FDG uptake at 60–90 minutes.
Neuroendocrine tumours

- Staging or restaging (including pre-operative assessments) of selected patients with poorly differentiated neuroendocrine tumours (NETs) including phaeochromocytoma and paraganglioma (in particular those with succinate dehydrogenase mutations) prior to treatment with negative somatostatin receptor imaging with single photon techniques or $^{68}$Ga-DOTA-TOC or $^{68}$Ga-DOTA-TATE PET-CT. 1-8
- Staging of well-differentiated neuroendocrine tumour with lesion(s) showing rapid progression. 1-8
- Staging of well-differentiated neuroendocrine tumour with lesion(s) on cross-sectional imaging that is negative on SSR imaging to evaluate for secondary pathology or dedifferentiation. 1-8
- Identify patients who are unlikely to respond to $^{177}$Lu-DOTATATE therapy (ie, discordant lesions that are SSR negative and FDG positive). 9-11
- Risk stratification of well-differentiated NETs for treatment planning. 5,7,9,10-14
- Assessment of possible multifocal disease in patients with paraganglioma considered for surgery in combination with $^{68}$Ga-DOTA-TOC or $^{68}$Ga-DOTA-TATE PET-CT. 4,5,15
- Assessment of selected patients with adrenocortical carcinoma being considered for invasive treatment where cross-sectional imaging is inconclusive. 16

References


Paraneoplastic syndromes

- To detect an occult primary tumour in selected patients with non-metastatic manifestations of neoplastic disease when other imaging is negative or equivocal.¹–⁸

References


Carcinoma of unknown primary

- Detection of the primary site when imaging and histopathology has failed to show a primary site, where the site of tumour will influence choice of chemotherapy.¹⁻⁵

References

Non-oncological applications

Neurological indications

**Dementia and other neurodegenerative disorders**\(^a\)

- To assess progressive cognitive decline where Alzheimer’s dementia (AD) or frontotemporal dementia (FTD) are possible diagnoses if structural imaging (e.g., MRI, CT) has been inconclusive and clinical suspicion for dementia remains high, particularly in cases of early symptom onset or atypical presentation.\(^1,8\)

- Aid differential diagnosis of dementia types (e.g., AD versus FTD) and subtypes based on disease-specific patterns of glucose hypometabolism with the understanding that diagnostic overlap may still persist.\(^1,3,4,6-11\)

- Monitor progression of neurodegenerative diseases in highly selected cases (e.g., borderline abnormal scans), as an adjunct to clinical evaluation and cognitive assessment tools\(^b,1,10\).

- Adjunct in differentiation of degenerative parkinsonism, particularly if associated with cognitive impairment in combination with dopamine transporter radionuclide imaging methods and/or \(^123\)I-metaiodobenzylguanidine (mIBG).\(^12-17\)

- Consider when conventional neuroimaging (i.e., MRI, CT) is inconclusive, but the clinical impression of an underlying neurodegenerative disorder warrants further assessment, namely in progressive speech disorders (e.g., primary progressive aphasia)\(^6\), differential diagnosis between depressive pseudo-dementia and neurodegeneration disorders\(^6\), HIV-associated neurocognitive disorder (HAND)\(^18,19\) and so on.

See below for amyloid imaging which may be helpful in highly selected patients with suspected dementia.

### References


---

\(a\) FDG PET-CT is indicated if structural brain imaging with MRI (or CT if MRI is contraindicated) is normal or inconclusive and clinical suspicion for a neurodegenerative disorder remains high.

\(b\) Based on established clinical practice functional neuroimaging at intervals of 12–24 months is suggested for monitoring progression of neurodegeneration.


Evidence-based indications for the use of PET-CT in the United Kingdom 2022

The Royal College of Radiologists, Royal College of Physicians, British Nuclear Medicine Society, Administration of Radioactive Substances Advisory Committee

**Epilepsy**

- Localisation of epileptogenic focus (especially when co-registered with MRI), both in the paediatric and adult population.¹⁻⁴
- Pre-surgical assessment of drug resistant focal epilepsy and complex partial seizures.³⁻⁸

**References**


**Encephalitis**

- Diagnosis of autoimmune encephalitis and differentiation of its subtypes.¹⁻²

**References**


---

PET-MRI if available is preferable to PET-CT.
Cardiological indications

- **Assessment of myocardial hibernation and viability** in patients with ischaemic heart failure and poor left ventricular function being considered for revascularisation, usually in combination with perfusion imaging with sestamibi/tetrofosmin or ammonia/rubidium. Preparation with glucose loading and short-acting insulin titrated according to blood glucose level enhances FDG delivery to the chronically ischaemic myocardium.1,2

- **Cardiac Inflammation** - The cardiological applications are increasing due to wider awareness and complex clinical scenarios in inflammation and infection imaging requirements. FDG PET-CT can provide important information that may not be evident on other non-invasive imaging techniques but requires specific pre-procedural preparation and careful interpretation9 with knowledge of possible artifacts in a multi-disciplinary team environment.

To suppress normal physiological FDG uptake in normal myocardium specific dietary manipulation (high fat, no carbohydrate diet) for 12-24 hours and prolonged fast (12-18 hours) with or without Heparin before FDG scan is recommended whenever inflammation/infection in the myocardium is suspected.

- **Sarcoidosis diagnosis** - FDG PET-CT aids in the diagnostic process of sarcoidosis, especially when conventional tests are inconclusive. In addition, FDG PET-CT reveals treatable active disease, particularly in heart, lungs and other extra-cardiac sites such as lymph nodes which help to get tissue diagnosis.3-5 This may be performed in combination with resting perfusion imaging to assess perfusion metabolism mismatch which is of prognostic importance in cardiac sarcoidosis. Important pre-requisites are exclusion of coronary artery disease.

- **Treatment Response** – FDG PET with SUV quantitation and in conjunction with myocardial perfusion imaging is useful to detect myocardial inflammation and monitor progression of scar and inflammation and assess response to active immunosuppressive therapies in cardiac sarcoidosis.4

- **Myocarditis** - Assessment of suspected myocarditis in difficult cases where other modalities such as cardiac MRI are uncertain and where diagnosis is likely to impact patient management, e.g. viral, drug induced myocarditis.6

- **Cardiac Infection**

  - **Infective Endocarditis (IE)** – PET-CT is a useful adjunctive diagnostic tool in the evaluation of diagnostically challenging cases of IE, particularly in prosthetic valve endocarditis.7,8 It also has the potential to detect clinically relevant extra-cardiac foci of infection, malignancy and other sources of inflammation leading to more appropriate treatment regimens and surgical intervention.8

Caution must be exercised when interpreting [18F]FDG PET-CT results in patients who have recently undergone cardiac surgery, as a postoperative inflammatory response may result in non-specific FDG uptake in the immediate postoperative period. Furthermore, several pathological conditions can mimic the pattern of focally increased uptake that is typically observed in IE, such as active thrombi, soft atherosclerotic plaques, vasculitis, primary cardiac tumours and metastasis, post-surgical inflammation and foreign body reactions.

---

aPET-CT may also be helpful as a complementary imaging tool for assessment of cardiac masses and extra-cardiac involvement in cases of suspected rheumatological cardiac conditions, but evidence in this area is still evolving.
Septic emboli appear as focal areas of FDG uptake and are typically located in the spleen, liver, lungs and kidneys. Uptake at the inter-vertebral disks and/or the vertebral bone (spondylodiscitis) suggests metastatic infection, which can also be observed in muscles and joints.

- **Cardiac Implantable device Infection** - FDG PET-CT is useful to identify infection in generator pocket of pacemaker, defibrillator and left ventricular assist devices and its components.9,10,11 Diet and fasting are necessary when normal myocardial uptake is likely to interfere with interpretation or infection is suspected within the heart. Caution should be exercised in interpretation for about two months post implantation due to inflammatory response. Attenuation corrected and non-corrected images should be viewed concurrently.

### References

Vasculitis

- **Suspicion of vasculitis**
  - To determine the presence, extent and distribution of active extracranial disease in patients with suspected medium or large vessel vasculitis.¹⁴*
  - To exclude other pathological processes which could result in atypical clinical presentation mimicking vasculitis, such as infection, multisystemic inflammatory disease, malignancies and potential paraneoplastic phenomenon.⁵,⁶
  - To confirm active extracranial vascular disease in patient with clinical suspicion of vasculitis in which conventional imaging (ultrasonography, CT angiography or magnetic resonance angiography) is negative or equivocal.¹,²,⁴,*,**,³

Notes:

* Withdraw or delay of glucocorticoid (GC) therapy until after FDG PET-CT is suggested, unless there is risk of ischaemic complications, as in the case of GCA with temporal artery involvement. FDG PET-CT within 3 days after start of GC is suggested.

** Normal blood glucose levels during FDG PET-CT are desirable, but glucose levels below 7 mmol/L (126 mg/dL) are preferable.

- **Suspicion of vasculitis relapse (during glucocorticoid taper and/or immunosuppressive therapy)**
  - In case of suspicion of vasculitis relapse (vasculitis-related inflammation of the aorta and/or its proximal branches), investigation with FDG PET-CT imaging should be considered.²

References

1. Slart RHJA, Writing group, Reviewer group et al. FDG-PET/CT(A) imaging in large vessel vasculitis and polymyalgia rheumatica: joint procedural recommendation of the EANM, SNMMI, and the PET Interest Group (PIG), and endorsed by the ASNC. *Eur J Nucl Med Mol Imaging* 2018; 45: 1250–1269.
Infection and inflammatory disorders (excluding sarcoidosis and vasculitis)

- Specific indications where FDG PET-CT may offer advantages over other forms of imaging include the following:
  - suspected implantable cardiac device related infection in selected cases provided sufficient time has elapsed since surgery;¹⁻³
  - suspected central or peripheral vascular graft infection;⁴⁻⁶, a
  - bone and soft tissue infections in the feet of patients with diabetes mellitus;⁵,⁷
  - detection of focal site(s) of infection in immunocompromised patients;⁵,⁸
  - spinal infections;⁹
  - possible multi-resistant tuberculosis especially in HIV positive or otherwise immunocompromised patients;¹⁰⁻¹²
  - post-fracture osteomyelitis.⁵,¹³
- For diagnosis and prognostication of idiopathic retroperitoneal fibrosis.¹⁴,¹⁵
- May be considered as a problem-solving tool in complex cases of autoimmune disease.¹⁶

References


a If radiolabelled leukocyte studies are not available.


Pyrexia of unknown origin

- To identify the cause of pyrexia of unknown origin where conventional investigations have not revealed a source.\(^{1-10}\)

References


The role of FDG in a range of malignancies is established, but there are limitations to using FDG for imaging some tumours. Non-FDG tracers can be used to image a limited number of tumours, which are important for patient care. The exceptions are the potential use of choline derivatives for imaging prostate cancer and the use of amyloid tracers for assessment of patients with cognitive impairment/dementia.

Fluorinated tracers can be produced in a regional cyclotron and transported, such as FDG and fluoro-choline. Generators that are used to produce radionuclides such as $^{68}$Ga can be purchased and the tracers produced in nuclear medicine department radiopharmacies. Other short-lived tracers such as $^{13}$N-ammonia and $^{11}$C-labelled compounds are produced in a cyclotron which needs to be on the same site as the scanner.

It is recognised that cyclotron and generator-produced tracers are available in a few specialist centres and that fluorinated tracers and generator-produced tracers may become more widely available. The rationale for using alternative tracers to FDG for these indications is highlighted in italics.

Indications for non-FDG tracers

**Multitracer (PSMA and other relevant tracer) PET-CT imaging of prostate cancer**

1. **PET tracers**
   a. Prostate-specific membrane antigen (PSMA) tracers are considered the first-line PET tracer for prostate cancer. However, this may not be accessible at all sites in the UK. Radiolabelled fluciclovine and Choline may be used as an alternative as documented below:
   b. There are several different types of PSMA being used for diagnostic evaluation of Prostate Cancer. Currently in the UK, this includes $[^{68}\text{Ga}]$Ga-PSMA-11 (also known as $[^{68}\text{Ga}]$Ga-HBED PSMA), $[^{68}\text{Ga}]$Ga-THP-PSMA and $[^{18}\text{F}]$PSMA-1007. Although the target is the same, each of these have slightly different imaging characteristics. For the purposes of this document, PSMA PET may refer to any of these types of PSMA agents.
   c. There is only one type of fluciclovine PET tracer available for clinical use, $[^{18}\text{F}]$fluciclovine. This has a different mechanism, protocol and imaging characteristics to the PSMA tracers. The uptake of $[^{18}\text{F}]$fluciclovine is mediated by sodium-dependent (Na$^+$) and independent (Na$^-$) amino acid transport systems.
   d. Radiolabelled choline $[^{14}\text{F}$ (methyl or ethyl) or $[^{11}\text{C}$] PET have similar physiological distribution pattern and cellular retention reflects activity of choline kinase (a rate limiting enzyme in the Kennedy pathway to generate cell membrane lipids).

2. **Biochemical relapse post radical prostatectomy**
   Offer PET in patients with biochemical recurrence after radical prostatectomy and if the results will influence subsequent treatment decisions.
   2.1 **PSMA**
      - Recommended if the PSA ≥ 0.2 ng/ml.

---

1. $^{11}$C-choline is not excreted in urine and, therefore, is more suitable for imaging prostate cancer than $^{18}$F choline but has extremely limited availability.
2.2 Fluciclovine
   - Fluciclovine is considered a suitable alternative PET tracer where PSMA is unavailable.

2.3 Radiolabelled Choline
   - Radiolabelled Choline is considered a suitable alternative PET tracer where PSMA is unavailable, if PSA levels are ≥ 1.0 ng/ml and the patient is not being considered for prostate bed RT. Sensitivity of Choline is very low with PSA levels < 1.0 ng/ml, where prostate bed RT is more efficacious.

It should be noted that there is evidence to suggest superior diagnostic performance of PSMA over fluciclovine for the detection of biochemically recurrent prostate cancer, although in some cases there may be potential benefit for evaluation of the prostatectomy bed (due to lack of urinary excretion/bowel accumulation). There is no recommended threshold PSA value above which fluciclovine is favoured. A recent metanalysis of the performance of all PSMA radiotracers and [18F]fluciclovine in the setting of biochemical recurrence showed superior performance of PSMA radiotracers for patients with PSA values of 1.0-1.9 ng/ml. At lower levels of PSA the pooled detection rates were equivalent between PSMA and fluciclovine. It should be noted that there has been variation in imaging protocols which may have influenced image quality in some studies using fluciclovine.

PSMA is superior to choline in detection of recurrence. It has been reported that sequential imaging approach designed to limit 68Ga PSMA imaging to patients with negative choline scans resulted in high detection rates. 68Ga PSMA PET-CT identified sites of recurrent disease in 43.8% of the patients with negative 18F-choline PET-CT scans.

3. Detectable PSA post-prostatectomy
   - PSMA PET
     - May be performed in the setting of persistent elevation of PSA (≥ 0.2 ng/ml) post prostatectomy, to assess for residual or otherwise occult disease, not identified in the pre-operative setting.
   - Fluciclovine
     - Fluciclovine is considered a suitable alternative PET tracer where PSMA is unavailable.
   - Radiolabelled choline
     - Radiolabelled choline is considered a suitable alternative PET tracer where PSMA is unavailable, when PSA levels ≥ 1.0 ng/ml.

4. Biochemical Relapse post radical prostatectomy and prostate bed radiotherapy
   - PSMA PET
     - Recommended if the PSA ≥ 0.2 ng/ml.
   - Fluciclovine
     - Fluciclovine is considered a suitable alternative PET tracer where PSMA is unavailable.
   - Radiolabelled choline
     - Radiolabelled choline is considered a suitable alternative PET tracer where PSMA is unavailable, when PSA levels ≥ 1.0 ng/ml.
5. Biochemical relapse post radical radiotherapy 5-7,11

5.1 PSMA PET
Offer PSMA PET in patients with biochemical recurrence after radical radiotherapy/brachytherapy (PSA nadir + 2 ng/ml) in patients fit for salvage local therapy (salvage prostatectomy. Note multi-parametric prostate MRI should be performed for local staging if PSMA PET shows no metastatic disease.

5.2 Fluciclovine
Fluciclovine is considered a suitable alternative PET tracer where PSMA is unavailable.

5.3 Radiolabelled choline
Radiolabelled choline is considered a suitable alternative PET tracer where PSMA is unavailable.

6. Non-metastatic castrate-resistant prostate cancer (nmCRPC)

6.1 PET is not recommended routinely in patients with nmCRPC as the clinical benefit and impact on management in detecting metastases in disease thought to be non-metastatic by conventional imaging remains unclear.19

7. Metastatic prostate cancer

7.1 Patients being considered for 177Lu-labelled PSMA-ligand therapy, a PSMA PET should be performed. Consider paired [18F]FDG PET to optimise patient selection.20

7.2 Increased [18F]FDG uptake seems to be more frequent in aggressive forms, aberrant histology (e.g., neuroendocrine), and advanced cases of metastatic castration-resistant PCa (mCRPC).

8. Staging in high-risk prostate cancer

8.1 Equivocal lesions: Consider PSMA PET in selected patients with equivocal lesions on baseline conventional staging investigations where management will be directly influenced by the PSMA result, after discussion in the MDT.5,21,22 It should be noted that no currently available PET tracer can replace lymph node dissection and histopathologic confirmation.23,24 [18F]Fluciclovine or [18F]/[11C]-radiolabelled choline may identify disease sites which were occult or equivocal on standard of care imaging. However, there is insufficient data to recommend the routine use in this setting.25

8.2 Discordant biopsy or contraindications to biopsy:26-28
Consider PSMA PET in high-risk patients who have discordant biopsy results (ie, negative repeated biopsy, patient refusal, or contraindication to biopsy due to comorbidities) where exclusion of nodal or visceral metastatic disease is required. This includes patients with high clinical suspicion of occult metastatic disease provided decision has been made at MDT level.26-28

References


Choline (¹⁸F/¹¹C-radiolabelled) PET in tumour imaging

**Choline PET in parathyroid adenoma**

- For parathyroid gland localisation indications prior to surgery when, despite first line imaging (ultrasonography, sestamibi SPECT-CT, 4D-CT), the location of the parathyroid adenoma(s) cannot be confidently determined.¹⁻⁵
- In persistent (post surgery) / recurrent primary hyperparathyroidism (PHPT) when conventional imaging fails to localise parathyroid adenoma.⁵

*Note that ¹¹C-methionine has been reported to have better sensitivity for localising parathyroid tumour than FDG in difficult cases.*⁶

References


---

a Selective venous sampling of parathyroid hormone levels can be considered before choline PET when available and if clinically appropriate.
b Functional parathyroid imaging cannot distinguish between parathyroid adenoma and the rare occurrence of carcinoma.
**Choline PET for other tumours**

- Assessment of patients with HCC being considered for transplant or other radical treatment where the results would directly influence patient management.¹-⁴
- Delineation of brain tumours where $^{11}$C-methionine and $[^{18}F]$fluoroethyltyrosine are not available and to guide biopsy.⁵

---

**References**

**References**


---

**11C-metomidate**

- The diagnosis of adrenal Conn's tumours pre-surgery.¹

---

- Cyclotron-produced, short-lived tracer.
**[82Rb]RbCl and 13N-ammonia in myocardial perfusion imaging**

- While single-photon emission computed tomography (SPECT) imaging continues to be the most widely available functional imaging modality in patients with suspected or known coronary artery disease (CAD), there is increasing use of perfusion PET as endorsed by the guidelines published by the American Society of Nuclear Cardiology and European Association of Nuclear Medicine and Molecular Imaging. Cardiac PET has significant advantages over SPECT – lower radiation burden to patients and staff, accurate attenuation correction, better diagnostic accuracy and the only modality that allows routine measurement of myocardial blood flow during stress and rest. Where there is access to perfusion PET, it is preferred to SPECT under the following clinical conditions:
  - Previous poor quality SPECT images; equivocal other functional imaging or CT coronary angiography (CTCA); functional imaging results discordant with clinical assessment or coronary angiogram findings.
  - Body characteristics where artefacts are likely to affect image quality, e.g., in high-body mass patients where significant attenuation of the inferior and anterior walls limits assessment.
  - High-risk patients (e.g., significant CAD on coronary angiogram including left main or proximal epicardial disease, cardiac transplant vasculopathy, severe left ventricular dysfunction).
  - In view of the lower radiation burden, young patients with established CAD or those with suspected CAD who cannot undergo non radiation functional imaging to exclude ischaemia.
  - Patients in who myocardial blood flow would be helpful to exclude multivessel disease causing ischaemia or patients with suspected microvascular dysfunction.
  - Assessment of perfusion in selected patients with coronary anomalies with congenital disease, after surgery and with Kawasaki’s disease.

13N-ammonia allows quantitative assessment of myocardial perfusion to be performed and is better used to assess disease in patients with balanced three vessel disease. Rubidium has improved image quality compared to technetium 99mTc and may be cost-effective compared to 99mTc when there is a large throughput of patients (around five cases per day Monday to Friday).

**References**


**Assessment of neuroendocrine tumours**

- Localisation of primary tumour in patients with known metastatic disease but unknown primary.\(^1,2\)
  - Selection of patients for somatostatin receptor-targeted peptide receptor radionuclide therapy PRRT of G1 and G2 neuroendocrine tumour, especially if negative on 111In or 99mTc somatostatin receptor imaging.\(^3-22\)
- Staging of NETs before planned ‘curative’ surgery.\(^1-22\)
- Evaluation of mass suggestive of NET not amenable to endoscopic or percutaneous biopsy (e.g., ileal lesion, hypervascular pancreatic mass, mesenteric mass).\(^1-16,21,22\)
- Monitoring of NETs seen predominantly on SSTR PET though interval of scanning needs careful thought. For most patients a gap of 12 months between studies should be sufficient unless rapidly progressive or in active treatment phase or determining progression pre-PRRT.\(^12\)
- Evaluation of patients with biochemical evidence and symptoms of NET without evidence on cross-sectional imaging and without prior histologic diagnosis of NET.\(^1,2,12\)
- Imaging phaeochromocytomas and paragangliomas with succinate dehydrogenase (SADHD) mutation.\(^23,24\)

Imaging with [68Ga]Ga-DOTA-TATE should be undertaken after discussion with local or network specialist NET MDT and all subsequent scans should be discussed within that MDT to ensure optimal therapy options.

Most NETs have low uptake of FDG; however, tracers that bind to somatostatin receptors, which are expressed by these tumours have high uptake. Somatostatin receptor (SSR) scintigraphy using SPECT tracers, for example 111In-octreotide, have been in clinical use for a number of years. Newer peptides labelled with 68Ga such as DOTATOC and DOTATATE show much higher affinity for NETs. Recently radionuclide treatments using SSR agents have resulted in improved quality of life and an 82% increase in progression free survival for patients with NETs and SSR imaging helps to select and manage patients for radionuclide therapy.

**References**


\(^a\) Generator-produced, short-lived, but transportable for up to one hour.

7. Kayani I, Bomanji JB, Groves A et al. Functional imaging of neuroendocrine tumors with combined PET/CT using 68Ga-DOTATATE (DOTA-DPhe1,Tyr3-octreotate) and 18F-FDG. *Cancer* 2008; **112**: 2447–2455.


In meningioma imaging

- Meningioma delineation prior to resection and defining optimal radiotherapy target volume.¹⁻³

References

Evidence-based indications for the use of PET-CT in the United Kingdom 2022

The Royal College of Radiologists, Royal College of Physicians, British Nuclear Medicine Society, Administration of Radioactive Substances Advisory Committee

www.rcr.ac.uk

[18F]fluorodopa imaging

In tumour assessment

- To identify locoregional and/or distant metastases in medullary thyroid cancer.1-4
- For imaging of primary brain tumours of all grades of differentiation (for primary assessment, radiotherapy planning, diagnosis of tumour recurrence, therapy monitoring and assessment of prognosis).5-8
- For assessing suspected congenital hyperinsulinism and other hypoglycaemic syndromes.9-11
- In the assessment of pheochromocytoma/paragangliomas.12,13
- In the assessment of selected cases of NETs.14,15

References

In movement disorders

- Assessment of movement disorders.¹

References

[**[^18F]**fluoride**]bone imaging**

- Assessment of benign and malignant bone diseases in selected patients.1-7

Sodium [**[^18F]**fluoride produces very high-quality images of the skeleton with high uptake in bone and rapid clearance from blood. [**[^18F]**fluoride has been evaluated against [**[^99mTc]**Tc-MDP planar and SPECT imaging in patients with suspected or known metastatic bone disease. These studies show it to be more sensitive and specific than [**[^99mTc]**Tc-MDP scintigraphy, and the addition of CT increases further the specificity of the test.

Uptake times are shorter than conventional bone scintigraphy, 15-30 minutes versus three-four hours, and imaging times are shorter 15-30 minutes versus 30-60 minutes suggesting that [**[^18F]**fluoride imaging for some patients with bone disease may be an appropriate use of PET-CT.

---

**References**


---

*a* cyclotron-produced, but transportable.
18F-labelled amyloid tracer (florbetapir, florbetaben, flutemetamol) brain imaging

Amyloid PET imaging detects the presence of human amyloid deposition in the brain. A negative PET amyloid scan can reliably exclude amyloid pathology, as confirmed by histopathology.1-7 While presence of amyloid plaques is one of the defining pathological features of Alzheimer’s dementia (AD), it is not specific and can be present as part of the normal ageing process and in other clinical syndromes.8-10 Therefore, it is essential that this test is only used in patients who have been fully assessed by an expert clinician. It is considered that amyloid imaging cannot diagnose AD but can contribute to diagnosis in combination with clinical assessment and other factors and more importantly, can exclude AD type pathology.

Amyloid brain PET is used according to the Appropriate Use Criteria (AUC), which were developed by the Society of Nuclear Medicine and Molecular Imaging and the Alzheimer’s Association.11,12 It is indicated in highly selected patients with cognitive impairment where

- AD is a possible diagnosis, but this remains uncertain after comprehensive evaluation by a dementia expert and conventional imaging work-up\(^a\) and;
- where knowledge of the presence or absence of amyloid is expected to increase diagnostic certainty and influence patient management.

Inappropriate scenarios for use would include:

- patients 65 years or older who meet standard definitions and tests for AD;
- where there is no clinical evidence of memory impairment (that is, as a screening tool);
- to assess the severity of dementia;
- in asymptomatic patients with a family history of dementia;
- for non-medical reasons such as pre-employment screening.

There is now sufficient evidence to support the use of this technique in the scenarios defined above by the AUC, where the patient has persistent or progressive unexplained memory impairment not confirmed by standard medical tests, an unusual clinical presentation and/or an atypically early age of onset (usually defined as 65 years or less in age)\(^\text{11,13}\)

It has been demonstrated that the introduction of amyloid brain PET in the investigative pathway has led to significant change in management and diagnosis therefore reducing the need for additional diagnostic testing.14-17 These findings are even more pertinent with the recent regulatory approval of the disease modifying drug aducanumab\(^c\).18

References


\(^a\) Cyclotron-produced, but transportable.

\(^b\) In patients older than 70 years with clinical suspicion for a possible AD, [18F]FDG PET-CT should be considered after inconclusive structural conventional imaging (CT, MRI) and before amyloid imaging. However, in younger patients with an early onset of dementia (65 years and younger, as well as in selected cases of 65-70 year old patients) and progressive decline that has features of AD dementia as well as of a non-AD dementia, where the presence of absence of amyloid plaque depositions and AD type pathology is a critical component of the initial differential diagnosis, 18F-labelled amyloid tracer imaging, if available, may be considered in a dementia multidisciplinary meeting after inconclusive structural brain imaging (CT, MRI) and prior to [18F]FDG PET-CT.

\(^c\) Aducanumab is not yet approved for use by MHRA or EMA but has been approved by FDA.


[18F]fluoroethyltyrosine, [18F]fluciclovine and 11C-methionine\textsuperscript{a} in brain tumours\textsuperscript{b}

11C-methionine, [18F]fluoroethyltyrosine (FET) and [18F]fluciclovine are superior in defining the extent of tumour in low and intermediate grade gliomas compared to FDG which has limited use because of high uptake in normal brain. Uptake tends to occur in lower grade tumours with a better prognosis. Also, the low uptake in normal brain makes these agents ideal in finding small post-treatment recurrence and separating progression form pseudo-progression.

- Assessment of tumour grade and extent in some patients with glioma for staging target biopsy or plan treatment.\textsuperscript{1-9}
- To differentiate between post-treatment progression and pseudo progression.\textsuperscript{10-12}
- Identify the site of a pituitary adenoma pre-surgery or find post-surgical residual tumour (11C- methionine only).\textsuperscript{13-14}
- Assessment of tumour grade.\textsuperscript{15-21}

References


\textsuperscript{a} Cyclotron-produced, short-lived tracer.

\textsuperscript{b} Please, also note that choline (18F/11C) is used for brain tumour imaging. See section Choline ([18F/11C]-radiolabelled) PET in tumour imaging on page 54.


### 3 PET-CT in paediatrics

#### Oncological applications

**Hodgkin’s lymphoma**
- Baseline staging (routine).\(^1,2,4,8\)
- Interim response assessment after two cycles of OEPA (routine)\(^1,2,17\)
- End of treatment assessment (consider).\(^17\)
- Clinical suspicion of relapse (consider).\(^17\)

**Non-Hodgkin’s lymphoma**
- Staging.\(^1,17\)
- Response assessment in selected cases.\(^17\)
- Suspicion of relapse.\(^17\)

**Leukaemia**
- Cross-sectional imaging performed in case of suspected extra-medullary disease (EMD); 20%-40% of patients with acute myeloid leukaemia have EMD at diagnosis; this is associated with high relapse rates.
- FDG PET-CT aids in detecting EMD, especially in the case of subclinical multifocal disease; however, the lack of definitive treatment options limits the clinical use of PET.\(^17\)

**Osteosarcoma**
- FDG PET/CT is the most accurate imaging technique for staging apart from the lungs (superior accuracy for bone metastases).
- Thin slice chest CT in full inspiration required for lung metastases.
- End-of-treatment FDG PET-CT usually not done, assessment based on histology. However, initial reports suggest decreased FDG avidity in primary osteosarcoma correlates with histological response.\(^17,18\)
- Value of interim FDG PET-CT not proven (no alternative chemotherapy alters outcome in poorly responding osteosarcomas).
- Possible role of FDG PET-CT in relapse to define extent of disease (probably more accurate than CT, especially in peri-prosthetic recurrence).

**Ewing’s sarcoma**
- At staging, FDG PET-CT more sensitive to detect metastatic disease, apart from the lungs (chest CT required).\(^1,17\)
- Conflicting results on the use of PET-CT in predicting response to chemotherapy; further research is needed.

**Soft tissue sarcoma**
- Rhabdomyosarcoma (RMS, four histological subtypes) includes over 50% of soft tissue sarcomas.
- Sites of metastatic disease: lungs, loco-regional lymph nodes, bone marrow and cortical bone.

---

Evidence-based indications for the use of PET-CT in the United Kingdom 2022

The Royal College of Radiologists, Royal College of Physicians, British Nuclear Medicine Society, Administration of Radioactive Substances Advisory Committee

- Outcome linked to site and number of metastases - routine FDG PET-CT at staging (lymph nodes, bone marrow and cortical bone) recommended, more sensitive than CT.\textsuperscript{3,5,6} Dedicated thin slice chest CT for assessment of possible lung disease required.
- Parametric PET factors (SUVmax, MTV, TLG) not predictive of poor prognosis.\textsuperscript{11}

**Malignant peripheral nerve sheath tumours (MPNST)**
- Malignant transformation in previously benign plexiform neurofibromata in neurofibromatosis type 1 patients.
- High NPV of FDG PET-CT (a positive PET-CT scan has low specificity).\textsuperscript{17}
- Strong reliance on histological sampling when malignant transformation based on clinical symptoms is suspected.
- Possible role of FDG PET-CT in predicting malignant change in asymptomatic patients or in children with difficulty in verbally expressing symptomatology, for earlier diagnosis and improved overall survival.\textsuperscript{17}

**Brain tumours**
- FDG PET-CT currently used as a problem-solving tool.\textsuperscript{1,17}
  - To improve diagnostic yield from biopsy to assess the histological grade
  - Glioblastomas and medulloblastomas show high grade FDG uptake
  - Brain stem gliomas have low-grade uptake
  - Ependymomas have low-grade uptake
  - FDG PET can improve tumour delineation when co-registered with MRI
  - To distinguish between residual disease or recurrence
  - Superior accuracy of amino-acid analogue PET-CT (e.g. choline, L-dihydroxyphenylalanine ([\textsuperscript{18}F]fluorodopa), [\textsuperscript{18}F]fluoroethyl-L-tyrosine, \textsuperscript{11}C-methionine), with a higher tumour-to-background ratio than FDG.\textsuperscript{7,12,16}

**Neuroblastoma**
- Valuable role of FDG PET-CT in mIBG negative neuroblastoma.\textsuperscript{1}
- FDG PET-CT: higher sensitivity but lower specificity than mIBG: biopsy may be needed for soft tissue lesions.
- Small volume bone marrow involvement may be missed with both FDG PET-CT and mIBG SPECT-CT: bone marrow biopsy needed.
- FDG PET-CT may be a better predictor of PFS than mIBG.\textsuperscript{13}
- \textsuperscript{123}I-mIBG still gold standard after chemotherapy (FDG PET-CT less sensitive and specific for bone/bone marrow disease).
- mIBG positive neuroblastomas can become mIBG negative; problem-solving role of FDG PET-CT in these cases.\textsuperscript{17}
- [\textsuperscript{18}F]fluorophenylalanine (F-DOPA) and [\textsuperscript{68}Ga]Ga-somatostatin receptor (SSR) analogues are alternative PET tracers, not widely available yet, with higher sensitivity compared to FDG PET-CT and \textsuperscript{123}I-mIBG SPECT-CT.\textsuperscript{14,15}
- [\textsuperscript{18}F]meta-fluorobenzylguanidine (MFBG) new promising tracer.
Wilms’ tumour

- Limited data on FDG PET-CT
  - May predict tumour viability after neoadjuvant chemotherapy
  - May detect more sites of disease at relapse versus MRI
- Current, problem-solving role for restaging relapsed patients.17

Langerhans cell histiocytosis (LCH)

- Single or several lesions (involving a single or multiple body systems).9
- Prognosis determined by organ involvement and treatment response.
- FDG PET-CT appears to be highly sensitive for staging and response assessment with a low false-positive rate.10

Germ cell tumour

- As a problem-solving tool at staging, biopsy guidance, assessment of residual metabolic activity and recurrence detection.17

Hepatoblastoma

- Currently limited role for FDG PET-CT in the detection of suspected tumour relapse with negative conventional imaging and rising blood serum alpha-fetoprotein.1,17

References


Non-oncological applications

Epilepsy

*Please, refer to the general epilepsy section (on page 42).*

Paediatric dystonia

- Evaluation of dystonia in children and young adults, particularly secondary dystonias and prior to deep brain stimulation therapy.¹⁶

References


**Childhood hyperinsulinaemia/insulinoma**

- Insulinoma localisation and staging prior to surgery
  
  - [18F]fluorodopa and [68Ga]Ga-DOTA-TOC or [68Ga]Ga-DOTA-TATE PET-CT may be used as a complementary diagnostic study for insulinoma localisation and staging prior surgery when standard imaging studies are equivocal or suspicious (problem-solving).\(^1\)\(^{a,b,c,d}\)

- Assessment of the extent of metastatic disease in malignant insulinomas
  
  - Somatostatin receptor imaging can be used as a complementary diagnostic study for assessing the extent of metastatic disease in malignant insulinomas, particularly in cases when PRRT (suitability assessment).\(^2\)\(^d\)

**References**


---

\(^{a}\) The most used imaging modalities are gadolinium-enhanced dynamic magnetic resonance imaging (MRI), 3-phase computed tomography (CT) and endoscopic ultrasound.

\(^{b}\) Promising results have been obtained with [18F]fluorodeoxy PET-CT and [68Ga]Ga-exendin-4 PET-CT; other imaging includes [11]C-5-hydroxytryptophan PET-CT, somatostatin receptor imaging, including [68Ga]Ga-DOTA-TOC or [68Ga]Ga-DOTA-TATE PET-CT.\(^{11}\)

\(^{c}\) There is a wide variability with regard to the results for localisation between different centres for each of these imaging studies presumably reflecting the specialist expertise and the availability of tracer and equipment. It is, therefore, recommended that any proposed imaging algorithm would take into account cost, sensitivity, availability and local expertise.\(^{12}\)

\(^{d}\) [18F]FDG PET-CT is not recommended for insulinoma imaging, with the exception of patients with metastatic insulinoma.\(^{1, 13}\)
### Contributors

<table>
<thead>
<tr>
<th>Co-author/contributor</th>
<th>Medical role(s) and affiliation(s)</th>
<th>Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Asim Afaq</td>
<td>Clinical Associate Professor of Radiology, Division of Body Imaging, Department of Radiology, Carver College of Medicine, University of Iowa Hospitals and Clinics; Honorary Consultant Radiologist, Institute of Nuclear Medicine, University College London Hospitals</td>
<td>- Prostate malignancy;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Multitracer (PSMA and other relevant tracer) PET-CT imaging of prostate cancer</td>
</tr>
<tr>
<td>Dr Parthiban Arumugam</td>
<td>Clinical Director, Nuclear Medicine Department, Manchester University NHS Foundation Trust</td>
<td>- Cardiological Indications (within Indications for 18F-fluorodeoxyglucose (FDG) PET-CT);</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 82-Rubidium chloride and 13N-ammonia in myocardial perfusion imaging (within Non-FDG tracers for clinical practice)</td>
</tr>
<tr>
<td>Prof. Sally Barrington¹</td>
<td>Professor of PET Imaging and NIHR Research Professor, School of Biomedical Engineering and Imaging Sciences, King’s College London and Guy’s and St Thomas’ PET Centre</td>
<td>- Lymphoma;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- PET-CT in paediatrics</td>
</tr>
<tr>
<td>Prof. Tara Barwick</td>
<td>Consultant Radiologist and Nuclear Medicine Physician, Imperial College Healthcare NHS Trust; Professor of Practice (Cancer Imaging), Imperial College London</td>
<td>- Urological malignancy;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Renal cancer;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Bladder cancer;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Prostate malignancy;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Testicular malignancy;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Gynaecological malignancy;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Multitracer (PSMA and other relevant tracer) PET-CT imaging of prostate cancer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Choline PET in parathyroid adenoma</td>
</tr>
</tbody>
</table>

¹ Please, see Acknowledgements on page 82 for additional details.
<table>
<thead>
<tr>
<th>Co-author/contributor</th>
<th>Medical role(s) and affiliation(s)</th>
<th>Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Clare Beadsmoore</td>
<td>Consultant Radiologist and Radionuclide Radiologist, Norfolk and Norwich University Hospital</td>
<td>▪ Colorectal carcinoma; ▪ Lymphoma; ▪ Myeloma; ▪ Carcinoma of unknown primary</td>
</tr>
<tr>
<td>Dr Lorenzo Biassoni</td>
<td>Consultant in Nuclear Medicine, Great Ormond Street Hospital for Children NHS Foundation Trust</td>
<td>▪ Paediatric Oncological applications</td>
</tr>
<tr>
<td>Prof. Jamshed Bomanji</td>
<td>Consultant in Nuclear Medicine and Clinical Lead and Head of Clinical Department, Institute of Nuclear Medicine, University College London Hospitals NHS Foundation Trust</td>
<td>▪ 18F-DOPA imaging ▪ Childhood hyperinsulinaemia (insulinoma)</td>
</tr>
<tr>
<td>Dr John Buscombe</td>
<td>Locum Consultant in Nuclear Medicine, Barts Health NHS Trust</td>
<td>▪ Brain; ▪ Oesophageal and oesophago-gastric junction cancers; ▪ Gastric cancer ▪ Gastrointestinal stromal tumours; ▪ Hepatopancreatobiliary disease; ▪ Neuroendocrine tumours; ▪ Paraneoplastic syndromes; ▪ Carcinoma of unknown primary; ▪ Infection and inflammatory disorders (excluding sarcoidosis and vasculitis); ▪ Pyrexia of unknown origin; ▪ 18F-fluoroethyltyrosine (FET), 18F-fluciclovine and 11C-methionine in brain tumours</td>
</tr>
<tr>
<td>Dr Amarnath Challapalli</td>
<td>Consultant Clinical Oncologist, Bristol Haematology and Oncology Centre, University Hospitals Bristol and Weston NHS Foundation Trust</td>
<td>▪ Prostate malignancy; ▪ Skin tumours; ▪ Multitracer (PSMA and other relevant tracer) PET-CT imaging of prostate cancer</td>
</tr>
<tr>
<td>Co-author/contributor</td>
<td>Medical role(s) and affiliation(s)</td>
<td>Sections</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Dr Greg Chambers</strong></td>
<td>Consultant Radiologist in Paediatric Radiology and Nuclear Medicine, Leeds Teaching Hospitals NHS Trust</td>
<td>▪ PET-CT in paediatrics</td>
</tr>
<tr>
<td><strong>Prof. Gary Cook</strong></td>
<td>Professor of Molecular Imaging, Department of Cancer Imaging and King’s College London and Guy’s and St Thomas’ PET Centre, School of Biomedical Engineering and Imaging Sciences</td>
<td>▪ Breast tumours;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Gastric cancer</td>
</tr>
<tr>
<td><strong>Dr Stephen Daw</strong></td>
<td>Consultant Paediatric and Adolescent Haemato-Oncologist, University College London Hospitals</td>
<td>▪ PET-CT in paediatrics</td>
</tr>
<tr>
<td><strong>Prof. Sabina Dizdarevic</strong></td>
<td>Principal Lead Consultant in Imaging and Nuclear Medicine, University Hospitals Sussex NHS Foundation Trust; Honorary Clinical Professor / Clinical PET-CT Lead, Clinical Imaging Sciences Centre, Brighton and Sussex Medical School</td>
<td>▪ Thyroid carcinoma;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Gastric cancer;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Anal carcinoma;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Urological malignancy;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Bladder cancer;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Prostate malignancy;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Testicular malignancy;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Penile carcinoma;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Musculoskeletal tumours;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Dementia and other neurodegenerative disorders;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Multitracer (PSMA and other relevant tracer) PET-CT imaging of prostate cancer;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ 68Ga-DOTATE in meningioma;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ 18F-labelled amyloid tracer brain imaging;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ 18F-fluoroethyltyrosine (FET), 18F-fluciclovine and 11C-methionine in brain tumours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ PET-CT in paediatrics</td>
</tr>
<tr>
<td>Co-author/contributor</td>
<td>Medical role(s) and affiliation(s)</td>
<td>Sections</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Dr Amy Eccles</td>
<td>Consultant Radionuclide Radiologist, Imperial College Healthcare NHS Trust</td>
<td>- Prostate malignancy;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Skin tumours;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Neuroendocrine tumours;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Multitracer (PSMA and other relevant tracer) PET-CT imaging of prostate cancer;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 68Ga-labelled somatostatin receptor (SSR) imaging for neuroendocrine tumours</td>
</tr>
<tr>
<td>Dr Sameer Gangoli</td>
<td>Consultant Radiologist, University Hospitals Sussex NHS Foundation Trust</td>
<td>- Head and neck tumours</td>
</tr>
<tr>
<td>Dr Gopinath Gnanasegaran</td>
<td>Consultant In Nuclear Medicine, Royal Free London NHS Foundation Trust</td>
<td>- Hepatopancreatobiliary disease</td>
</tr>
<tr>
<td>Dr Deepa Gopalan</td>
<td>Consultant Cardiac Radiologist, Imperial College Healthcare NHS Trust and Cambridge University Hospitals NHS Foundation Trust</td>
<td>- Cardiological Indications;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 82-Rubidium chloride and 13N-ammonia in myocardial perfusion imaging</td>
</tr>
<tr>
<td>Prof. Richard Graham</td>
<td>Deputy Medical Director and Consultant Radiologist, Royal United Hospitals Bath NHS Foundation Trust; Head of School of Radiology, Health Education England South West-Severn Deanery; President of British Nuclear Medical Society</td>
<td>- Myeloma;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Musculoskeletal tumours;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Dementia and other neurodegenerative disorders;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Vasculitis;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Choline PET in parathyroid adenoma</td>
</tr>
<tr>
<td>Co-author/contributor</td>
<td>Medical role(s) and affiliation(s)</td>
<td>Sections</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Dr Prasad Guntur</strong></td>
<td>Consultant Radiologist, Ninewells Hospital and Medical School, NHS Tayside; Honorary Senior Clinical Lecturer and Co-Director of Clinical Research Imaging Facility, University of Dundee</td>
<td>▪ Lung carcinoma; ▪ Pleural malignancy; ▪ Thymic tumours; ▪ Prostate malignancy; ▪ Paraneoplastic syndromes; ▪ Carcinoma of unknown primary; ▪ Pyrexia of unknown origin; ▪ Multitracer (PSMA and other relevant tracer) PET-CT imaging of prostate cancer</td>
</tr>
<tr>
<td><strong>Dr Sai Han</strong></td>
<td>Consultant in Nuclear Medicine and PET-CT, NHS Greater Glasgow and Clyde</td>
<td>▪ Lung carcinoma; ▪ Pleural malignancy; ▪ Thymic tumours</td>
</tr>
<tr>
<td><strong>Dr Athar Haroon</strong></td>
<td>Consultant Radionuclide Radiologist, St Bartholomew's Hospital, London</td>
<td>▪ Multitracer (PSMA and other relevant tracer) PET-CT imaging of prostate cancer</td>
</tr>
<tr>
<td><strong>Dr Iain Lyburn</strong></td>
<td>Consultant Radiologist, Gloucestershire Hospitals NHS Foundation Trust; Visiting Professor, Cranfield University; Medical Director, Cobalt Medical Charity</td>
<td>▪ Breast tumours</td>
</tr>
<tr>
<td><strong>Dr Sergejs Magers</strong></td>
<td>Clinical Fellow in Nuclear Medicine, University Hospitals Sussex NHS Foundation Trust</td>
<td>▪ Thyroid carcinoma; ▪ Musculoskeletal tumours; ▪ Dementia and other neurodegenerative disorders</td>
</tr>
<tr>
<td><strong>Dr Vanessa Morris</strong></td>
<td>Consultant Rheumatologist, University College London Hospitals NHS Foundation Trust</td>
<td>▪ Vasculitis</td>
</tr>
<tr>
<td>Co-author/contributor</td>
<td>Medical role(s) and affiliation(s)</td>
<td>Sections</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Dr Shaunak Navalkissoor</td>
<td>Consultant In Nuclear Medicine, Royal Free London NHS Foundation Trust</td>
<td>▪ Neuroendocrine tumours;</td>
</tr>
<tr>
<td></td>
<td>▪ 68Ga-labelled somatostatin receptor (SSR) imaging for neuroendocrine tumours</td>
<td></td>
</tr>
<tr>
<td>Dr Bob Phillips</td>
<td>Consultant in Paediatric (Teenage and Young-Adult) Oncology, Leeds Teaching Hospitals NHS Trust</td>
<td>▪ Paediatric;</td>
</tr>
<tr>
<td></td>
<td>▪ Oncological applications</td>
<td></td>
</tr>
<tr>
<td>Dr Eliana Reyes</td>
<td>Consultant Nuclear Cardiologist, Barts Health NHS Trust; Clinical Lecturer in Cardiac PET Imaging, King’s College London</td>
<td>▪ Cardiological Indications</td>
</tr>
<tr>
<td>Dr Rebecca Roylance</td>
<td>Consultant Medical Oncologist, University College London Hospitals NHS Foundation Trust; Honorary Associate Professor, University College London</td>
<td>▪ Breast tumours</td>
</tr>
<tr>
<td>Prof. Andrew Scarsbrook</td>
<td>Consultant Radiologist and Nuclear Medicine Physician, Leeds Teaching Hospitals NHS Trust; Professor of Radiology, University of Leeds</td>
<td>▪ Anal carcinoma;</td>
</tr>
<tr>
<td></td>
<td>▪ Penile carcinoma;</td>
<td>▪ PET-CT in paediatrics</td>
</tr>
<tr>
<td>Dr Ananth Shankar</td>
<td>Consultant Paediatric and Adolescent Oncologist, University College London Hospitals NHS Foundation Trust</td>
<td>▪ PET-CT in paediatrics</td>
</tr>
<tr>
<td>Co-author/contributor</td>
<td>Medical role(s) and affiliation(s)</td>
<td>Sections</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Dr Nitasha Singh</td>
<td>Lead Consultant in Nuclear Medicine, University Hospitals Sussex NHS Foundation Trust</td>
<td>Thyroid carcinoma; Anal carcinoma; Urological malignancy; Renal cancer; Bladder cancer; Testicular malignancy; Dementia and other neurodegenerative disorders</td>
</tr>
<tr>
<td>Dr Teresa Szyszko</td>
<td>Consultant in Nuclear Medicine, Royal Free London NHS Foundation Trust; Honorary Associate Professor, University College London</td>
<td>Brain; Pleural malignancy; Oesophageal and oesophago-gastric junction cancers; Gastric cancer; Epilepsy; Choline PET for other tumours; 68Ga-labelled somatostatin receptor (SSR) imaging for neuroendocrine tumours; 18F-DOPA imaging; 18F-fluoroethyltyrosine (FET), 18F-fluciclovine and 11C-methionine in brain tumours; Paediatric; Non-oncological applications</td>
</tr>
<tr>
<td>Miss Sharlini Varatharajah</td>
<td>Medical Student, Brighton and Sussex Medical School</td>
<td>Bladder cancer</td>
</tr>
<tr>
<td>Prof. Sobhan Vinjamuri</td>
<td>Lead Consultant in Nuclear Medicine, Royal Liverpool and Broadgreen University Hospitals NHS Trust</td>
<td>Colorectal carcinoma</td>
</tr>
<tr>
<td>Co-author/contributor</td>
<td>Medical role(s) and affiliation(s)</td>
<td>Sections</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Dr Stefan Vöö</strong></td>
<td>Consultant in Nuclear Medicine, University College London Hospitals NHS Foundation Trust; Clinical Lead in Nuclear Medicine, Whittington Hospital; Research Associate, NIHR Biomedical Research Centre at University College London Hospitals NHS Foundation Trust and University College London</td>
<td>▪ Breast tumours; ▪ Oesophageal and oesophagogastric junction cancers; ▪ Gastric cancer; Vasculitis; ▪ 18F-DOPA imaging; Childhood hyperinsulinaemia (insulinoma)</td>
</tr>
<tr>
<td><strong>Dr Kshama Wechalekar</strong></td>
<td>Cross-site Lead for Nuclear Medicine and PET, Royal Brompton and Harefield Hospitals; Honorary Senior Lecturer, National Heart and Lung Institute, Imperial College London</td>
<td>▪ Cardiological Indications</td>
</tr>
<tr>
<td><strong>Dr Zarni Win</strong></td>
<td>Consultant Radiologist and Nuclear Medicine Physician, Head of Service Nuclear Medicine, Imperial College Healthcare NHS Trust</td>
<td>▪ 18F-labelled amyloid tracer brain imaging</td>
</tr>
<tr>
<td><strong>Dr Wai Lup Wong</strong></td>
<td>Consultant Radiologist (Nuclear Medicine), East and North Hertfordshire NHS Trust; Honorary Senior Lecturer and Clinical Guardian, University College London; National Specialty Advisor [PET-CT], NHS England</td>
<td>▪ Head and neck tumours; ▪ Prostate malignancy; ▪ Multitracer (PSMA and other relevant tracer) PET-CT imaging of prostate cancer</td>
</tr>
</tbody>
</table>
These guidelines have been updated on behalf of the RCR by members of the ICSCNM (in alphabetical order):

- Dr Clare Beadsmoore, Consultant Radiologist and Radionuclide Radiologist, Norfolk and Norwich University Hospital;
- Dr John Buscombe, Imminent Past President of the British Nuclear Medicine Society;
- Dr Jeanette Dickson, President, RCR;
- Prof Sabina Dizdarevic, Intercollegiate Standing Committee for Nuclear Medicine Chair and Principal Lead Consultant in Imaging and Nuclear Medicine, University Hospitals Sussex NHS Foundation Trust;
- Dr Amy Eccles, Consultant in Nuclear Medicine, Guy’s and St. Thomas’ Hospitals; RCR radionuclide radiology advisor;
- Dr Cathryn Edwards, Registrar, RCP;
- Dr Charlotte Fowler, Guy’s and St. Thomas’ Hospitals, Nuclear Medicine Specialty Advisory Committee Chair;
- Ms Louise Fraser, UK Health Security Agency representative;
- Dr Mark Gaze, Clinical Oncology representative, RCR;
- Prof Andrew Goddard, President, RCP;
- Prof Richard Graham, Deputy Medical Director and Consultant Radiologist, Royal United Hospitals Bath NHS Foundation Trust; Current President of the British Nuclear Medicine Society;
- Dr Prasad Guntur, Consultant Radiologist/Nuclear Medicine/PETCT, Ninewells Hospital and Medical School, Dundee;
- Dr Sai Han, RCP/RCPE representative and Consultant in Nuclear Medicine, Glasgow Royal Infirmary;
- Dr Stephen Harden, Medical Director for Education and Training, RCR;
- Prof Geeta Menon, Lead Dean for Nuclear Medicine/Postgraduate Dean for Health Education England South London;
- Ms Sue Mitchell, PET-CT Lead, Cancer Programme of Care – Specialised Commissioning, NHSE/I;
- Dr Shaunak Navalkissoor, Consultant Physician in Nuclear Medicine, Royal Free London Foundation NHS Trust;
- Dr William Ramsden, Vice-President, Clinical Radiology, RCR;
- Prof Sobhan Vinjamuri, Joint Specialty Committee for Nuclear Medicine at the Royal College of Physicians (Chair) and Consultant in Nuclear Medicine, Royal Liverpool University Hospital;
- Dr Wai Lup Wong, Consultant Radiologist (Nuclear Medicine), East and North Hertfordshire NHS Trust – PET-CT guardian

Professor Barrington acknowledges support from the National Institute for Health and Care Research (NIHR) [RP-2-16-07-001]. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.
The ICSCNM wishes to acknowledge Dr Sergejs Magers for his significant contribution in co-editing the document.

Furthermore, we would like to thank Emma Burgum (RCR), as well as Louise Abrahams and Heidi Shuttle (University Hospitals Sussex NHS Foundation Trust), for their administrative support.
Appendix.
PET-CT illustrations

- $^{18}$F-fluoride in prostate cancer.
- $^{18}$F-choline in prostate cancer.
- $^{18}$F-FDG in limbic encephalitis.
- $^{18}$F-FDG PET-CT in assessment of infected cardiac pacemaker.
Evidence-based indications for the use of PET-CT in the United Kingdom 2022

The Royal College of Radiologists, Royal College of Physicians, British Nuclear Medicine Society, Administration of Radioactive Substances Advisory Committee

www.rcr.ac.uk

$^{68}$Ga-labelled PSMA ligand PET-CT in prostate cancer.

$[^{18}F]$FDG PET-CT in paediatric soft tissue sarcoma.

© The Royal College of Radiologists, July 2022.

This material has been produced by The Royal College of Radiologists (RCR) for use internally within the specialties of clinical oncology and clinical radiology in the United Kingdom. It is provided for use by appropriately qualified professionals, and the making of any decision regarding the applicability and suitability of the material in any particular circumstance is subject to the user’s professional judgement.

While every reasonable care has been taken to ensure the accuracy of the material, RCR cannot accept any responsibility for any action taken, or not taken, on the basis of it. As publisher, RCR shall not be liable to any person for any loss or damage, which may arise from the use of any of the material. The RCR does not exclude or limit liability for death or personal injury to the extent only that the same arises as a result of the negligence of RCR, its employees, Officers, members and Fellows, or any other person contributing to the formulation of the material.