Description

Positron emission tomography (PET) images biochemical and physiologic functions by measuring concentrations of radioactive chemicals that have been partially metabolized in a particular region of the body. Radiopharmaceuticals used for PET are generated in a cyclotron (nuclear generator) and then introduced into the body by intravenous injection or respiration.

PET scans coupled position-emitting radionuclide tracers to other molecules, such as glucose, ammonia, or water. The radionuclide tracers simultaneously emit two high-energy photons in opposite directions that can be simultaneously detected (referred to as coincidence detection) by a PET scanner, which comprises multiple stationary detectors that encircle the region of interest.

A variety of tracers are used for PET scanning, including oxygen 15, nitrogen 13, carbon 11, and fluorine 18. The radiotracer most commonly used in oncology imaging has been fluorine 18, coupled with fluorodeoxyglucose (FDG), which has a metabolism related to glucose metabolism. While FDG has traditionally been used in cancer imaging, it potentially has many other applications.
OBJECTIVE

The objective of this evidence review is to determine whether use of fluorine 18 fluorodeoxyglucose positron emission tomography improves the net health outcome in individuals with epilepsy, suspected chronic osteomyelitis, suspected Alzheimer disease, suspected large vessel vasculitis, and other noncardiac and nononcologic conditions (eg, central nervous system, pulmonary, and musculoskeletal diseases).

POLICY STATEMENT

Positron emission tomography (PET) using 2-[fluorine-18]-fluoro-2-deoxy-D-glucose (FDG) may be considered medically necessary in:

1. The assessment of select patients with epileptic seizures who are candidates for surgery (see Policy Guidelines section)
2. The diagnosis of chronic osteomyelitis.

The use of FDG-PET for all other miscellaneous indications is investigational, including, but not limited to:

- Central Nervous System Diseases
  - Autoimmune disorders with central nervous system manifestations, including:
    - Behet syndrome
    - lupus erythematosus
  - Cerebrovascular diseases, including:
    - arterial occlusive disease (arteriosclerosis, atherosclerosis)
    - carotid artery disease
    - cerebral aneurysm
    - cerebrovascular malformations (arteriovenous malformation and Moya-Moya disease)
    - hemorrhage
    - infarct
    - ischemia
  - Degenerative motor neuron diseases, including:
    - amyotrophic lateral sclerosis
    - Friedreich ataxia
    - olivopontocerebellar atrophy
    - Parkinson disease
    - progressive supranuclear palsy
    - Shy-Drager syndrome
    - spinocerebellar degeneration
    - Steele-Richardson-Olszewski syndrome

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- Tourette syndrome

- Dementias, including:
  - Alzheimer disease
  - multi-infarct dementia
  - Pick disease
  - frontotemporal dementia
  - dementia with Lewy bodies
  - presenile dementia

- Demyelinating diseases, such as multiple sclerosis

- Developmental, congenital, or inherited disorders, including:
  - adrenoleukodystrophy
  - Down syndrome
  - Huntington chorea
  - kinky-hair disease (Menkes disease)
  - Sturge-Weber syndrome (encephalofacial angiomatosis) and the phakomatoses

- Miscellaneous
  - chronic fatigue syndrome
  - sick building syndrome
  - posttraumatic stress disorder

- Nutritional or metabolic diseases and disorders, including:
  - acanthocytosis
  - hepatic encephalopathy
  - hepatolenticular degeneration
  - metachromatic leukodystrophy
  - mitochondrial disease
  - subacute necrotizing encephalomyelopathy

- Psychiatric diseases and disorders, including:
  - affective disorders
  - depression
  - obsessive-compulsive disorder
  - psychomotor disorders

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schizophrenia

- Pyogenic infections, including:
  - aspergillosis
  - encephalitis

- Substance abuse, including the central nervous system effects of alcohol, cocaine, and heroin

- Trauma, including brain injury and carbon monoxide poisoning

- Viral infections, including:
  - HIV/AIDS
  - AIDS dementia complex
  - Creutzfeldt-Jakob disease
  - progressive multifocal leukoencephalopathy
  - progressive rubella encephalopathy
  - subacute sclerosing panencephalitis

- Mycobacterium infection
- Migraine
- Anorexia nervosa
- Assessment of cerebral blood flow in newborns
  - Vegetative vs locked-in syndrome

- Pulmonary Diseases
  - Adult respiratory distress syndrome
  - Diffuse panbronchiolitis
  - Emphysema
  - Obstructive lung disease
  - Pneumonia

- Musculoskeletal Diseases
  - Spondylodiscitis
  - Joint replacement follow-up

- Other
  - Giant cell arteritis
  - Vasculitis
  - Vascular prosthetic graft infection

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In patients with epileptic seizures, appropriate candidates are patients with complex partial seizures who have failed to respond to medical therapy and have been advised to have a resection of a suspected epileptogenic focus located in a region of the brain accessible to surgery. Further, for the purposes of this review, conventional noninvasive techniques for seizure localization must have been tried with results suggesting a seizure focus but not sufficiently conclusive to permit surgery. The purpose of the positron emission tomography (PET) examination should be to avoid subjecting the patient to extended preoperative electroencephalographic recording with implanted electrodes or to help localize and minimize the number of sites for implanted electrodes to reduce the morbidity of that procedure.

A PET scan involves 3 separate activities: (1) manufacture of the radiopharmaceutical, which may be manufactured on site or at a regional center with delivery to the institution performing PET; (2) actual performance of the PET scan; and (3) interpretation of the results.

Experimental or investigational procedures, treatments, drugs, or devices are not covered (See General Exclusion Section of brochure).

Following the U.S. Food and Drug Administration's (FDA) approval of the Penn-PET in 1989, a number of PET scan platforms have been cleared by the FDA through the 510(k) process. These systems are intended to aid in detecting, localizing, diagnosing, staging and restaging of lesions, tumors, disease and organ function for the evaluation of diseases, and disorders such as, but not limited to, cardiovascular disease, neurologic disorders, and cancer. The images produced by the system can aid in radiotherapy treatment planning and interventional radiology procedures.

FDG has been FDA approved for use as a diagnostic imaging agent in oncology, cardiology and epileptic seizures.

In December 2009, the FDA issued guidance for Current Good Manufacturing Practice for PET drug manufacturers\(^1\); and, in August 2011, issued similar Current Good Manufacturing Practice guidance for small businesses compounding radiopharmaceuticals.\(^2\) An additional final guidance document, issued in December 2012, required all PET drug manufacturers and compounders to operate under an approved new drug application (NDA) or abbreviated NDA, or investigational new drug application, by December 12, 2015.\(^3\)

In 1994, the FDG radiotracer was originally approved by the FDA through the NDA (20-306) process. The original indication was for "the identification of regions of abnormal glucose metabolism associated with foci of epileptic seizures." Added indications in 2000 were for "Assessment of glucose metabolism to assist in the evaluation of malignancy..." and "Assessment of patients with coronary artery disease and left ventricular dysfunction..." Multiple manufacturers have approved NDAs for FDG.\(^4\)

See related evidence reviews 6.01.26 and 6.01.51 for oncologic indications and 6.01.20 for cardiac indications for FDG.

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Rationale

Summary of Evidence

For individuals who have epileptic seizures who are candidates for surgery who have positron emission tomography (PET) using 2-[fluorine-18]-fluoro-2-deoxy-D-glucose (FDG) (FDG-PET), the evidence includes systematic reviews (following the publication of three TEC Assessments). The relevant outcomes are symptoms, change in disease status, functional outcomes, health status measures, QOL, hospitalizations, medication use, and resource utilization. The TEC Assessments and Program in Evidence-based Care PET recommendation report all concluded that FDG-PET accurately localizes the seizure focus compared with appropriate reference standards. A recent systematic review suggested it was difficult to discern the incremental value of FDG-PET in patients who have focally well localized by ictal scalp electroencephalography and MRI. The evidence on whether FDG-PET has a predictive value for a good surgical outcome is mixed. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have suspected chronic osteomyelitis who receive FDG-PET, the evidence includes meta-analyses and a prospective study published after the meta-analyses. The relevant outcomes are test accuracy and validity, other test performance measures, change in disease status, functional outcomes, quality of life (QOL), and hospitalizations. One systematic review and meta-analysis from 2013, 9 studies revealed that FDG-PET and FDG-PET plus CT were useful for diagnosing suspected osteomyelitis in the foot of patients with diabetes. The results of another meta-analysis (2005) showed that FDG-PET was the most accurate mode (pooled sensitivity, 96%; pooled specificity, 91%) for diagnosing chronic osteomyelitis. The results appear to be robust across fairly diverse clinical populations, which strengthen the conclusions. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have suspected Alzheimer disease (AD) who receive FDG-PET to diagnose the disease, the evidence includes systematic reviews of observational studies. The relevant outcomes are test accuracy and validity, other test performance measures, symptoms, QOL, and hospitalizations. The studies included in the reviews were generally of poor quality. There is no standard cutoff for PET positivity for diagnosing AD, and many studies have not included postmortem confirmation of AD as the reference standard, leading to uncertainty about estimates of performance characteristics. FDG-PET may have high sensitivity and specificity for diagnosing AD, but there is little evidence comparing the performance characteristics of clinical diagnosis using PET with the clinical diagnosis not using PET; therefore, the incremental value of adding PET to the standard clinical diagnosis is unclear. No studies have reported on clinical outcomes of patients diagnosed with and without FDG-PET. For individuals who have suspected Alzheimer disease who receive FDG-PET to determine the prognosis of their disease and to differentiate the disease from other dementias, the evidence includes systematic reviews of observational studies and a retrospective study assessing clinical utility. The relevant outcomes are test accuracy and validity, other test performance measures, symptoms, QOL, and hospitalizations. The studies included in the reviews were generally of poor quality. The evidence is insufficient to determine the effects of the technology on health outcomes for these indications.

For individuals who have suspected large vessel vasculitis (LVV) who receive FDG-PET, the evidence includes five systematic reviews of observational studies. The relevant outcomes are test accuracy and validity, other test performance measures, symptoms, morbid events, QOL, hospitalizations, and treatment-related morbidity. Most studies included in the reviews were small and lacked controls. The reported performance characteristics were heterogeneous but reviewers were unable to determine the source of heterogeneity. Studies comparing PET with the true reference standard of biopsy or angiography are rare. There are no consensus criteria to define the presence of vascular inflammation by FDG-PET in LVV, and different parameters with visual and semiquantitative methods have been reported. Studies demonstrating changes in management based on PET results or improvements in clinical outcomes are lacking. The evidence is insufficient to determine the effects of the technology on health outcomes.

For individuals who have diverse noncardiac or nononcologic conditions (eg, central nervous system, pulmonary, and musculoskeletal diseases) who receive FDG-PET, the evidence includes a few systematic reviews. The relevant outcomes are overall survival, symptoms, change in disease status, functional outcomes, health status measures, QOL, hospitalizations, medication use, and resource utilization. Many studies cited in the reviews were small, retrospective, and published in the 1990s to early 2000s; further, many studies did not directly compare a modality with another in the same patient group-nor did they correlate PET results in individual patients with improved clinical outcomes. Additional studies are needed to demonstrate FDG-PET results can change management, and therefore improve patient outcomes to support the utility of FDG-PET. The evidence is insufficient to determine the effect of the technology on health outcomes.

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**SUPPLEMENTAL INFORMATION**

**Practice Guidelines and Position Statements**

**American Academy of Neurology**

Evidence-based practice parameters from the American Academy of Neurology are summarized in Table 1.

**Table 1. Practice Parameters on Diagnosis of Dementia**

<table>
<thead>
<tr>
<th>Practice Parameter</th>
<th>Date</th>
<th>PET Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of dementia</td>
<td>2004: reaffirmed</td>
<td>PET imaging not recommended for routine use in diagnostic evaluation of dementia (LOR: moderate clinical certainty)</td>
</tr>
<tr>
<td>Early detection of dementia</td>
<td>2003: reaffirmed</td>
<td>Not addressed</td>
</tr>
<tr>
<td>Diagnosis of new-onset PD</td>
<td>2006: reaffirmed</td>
<td>Evidence insufficient to support or refute FDG-PET as a means of distinguishing PD from other parkinsonian syndromes</td>
</tr>
<tr>
<td></td>
<td>2013; retired 2016</td>
<td></td>
</tr>
<tr>
<td>Evaluation of depression, psychosis, and dementia in PD</td>
<td>2006; retired 2018</td>
<td>Not addressed</td>
</tr>
<tr>
<td>Mild cognitive impairment</td>
<td>2001; 2017; 2018</td>
<td>Not addressed</td>
</tr>
</tbody>
</table>

FDG: fluorine 18 fluorodeoxyglucose; LOR: level of recommendation; PD: Parkinson disease; PET: positron emission tomography.

**American Academy of Orthopaedic Surgeons**

The American Academy of Orthopaedic Surgeons (2010) published evidence-based, consensus guidelines. Fluorine 18 fluorodeoxyglucose positron emission tomography (FDG-PET) was considered:

"an option in patients in whom diagnosis of periprosthetic joint infection has not been established and are not scheduled for reoperation. (Strength of recommendation: limited [quality of the supporting evidence is unconvincing, or well-conducted studies show little clear advantage of one approach over another])"

**American College of Radiology**

Evidence- and consensus-based appropriateness criteria from the American College of Radiology are summarized in Table 2.

**Table 2. Appropriateness Criteria for Miscellaneous Indications of FDG-PET/CT**

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<table>
<thead>
<tr>
<th>Appropriateness Criteria</th>
<th>Last Reviewed</th>
<th>FDG-PET/CT Criteria</th>
</tr>
</thead>
</table>
| Suspected osteomyelitis, septic arthritis, or soft tissue infection (excluding spine and diabetic foot) | 2017  | - Usually not appropriate for (1) suspected osteomyelitis with soft tissue or juxta-articular swelling with cellulitis and a skin lesion, injury, wound, ulcer, or blister; or (2) suspected osteomyelitis with pain and swelling of cellulitis associated with site of previous nonarthroplasty hardware.  
- Usually not appropriate for suspected osteomyelitis with soft-tissue or juxta-articular swelling with a history of surgery, though "this is promising new technology but data are limited." |
| Diagnosis of dementia[^72]                                                                | 2001, reaffirmed 2004 | PET imaging not recommended for routine use in diagnostic evaluation of dementia (LOR: moderate clinical certainty)                                                                                               |
| Diagnosis of new onset-PD[^76]                                                            | 2006: reaffirmed 2013; retired 2016 | Evidence insufficient to support or refute FDG-PET as a means of distinguishing PD from other parkinsonian syndromes                                                                                               |
| Evaluation of depression, psychosis, and dementia in PD[^72]                              | 2006  | Not addressed                                                                                                                                                                                                   |
| Dementia and movement disorders[^73]                                                       | 2016  | May be appropriate in patients with possible or probable AD and to differentiate suspected FTD, LBD, CJD, or vascular dementia; usually not appropriate in patients with suspected HD, clinical features of PD or hemochromatosis, or motoneuron disease |
| Imaging after total knee arthroplasty[^74]                                                 | 2017  | Usually not appropriate for routine follow-up of asymptomatic patient, in work-up for suspected periprosthetic infection, or for evaluation of prosthetic loosening |
| Seizures and epilepsy[^75]                                                                | 2014  | Usually appropriate for surgical planning in medically refractory epilepsy; may be appropriate for new-onset seizure unrelated to trauma in adults (age ≥18 y) and for posttraumatic (subacute or chronic), new-onset seizure; otherwise, usually not appropriate for new-onset seizure |
| Crohn disease[^76]                                                                        | 2014  | Usually not appropriate                                                                                                                                                                                          |
| Fever without source - child[^77]                                                         | 2015  | May be appropriate. This procedure should not be used as the initial study. Consider if extensive clinical and imaging work-up is negative.                                                                      |

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[^71]: Last Reviewed 2017
[^72]: Last Reviewed 2001, reaffirmed 2004
[^73]: Last Reviewed 2016
[^74]: Last Reviewed 2017
[^75]: Last Reviewed 2014
[^76]: Last Reviewed 2014
[^77]: Last Reviewed 2015

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Suspected osteomyelitis of the foot in patients with DM

Usually not appropriate for initial imaging. May be appropriate for soft-tissue swelling with or without ulcer, suspected osteomyelitis or early neuropathic arthropathy changes of the foot in patients with DM, suspected osteomyelitis of the foot in patients with DM with or without neuropathic arthropathy, and additional imaging following radiographs.

AD: Alzheimer disease; CJD: Creutzfeldt-Jakob disease; CT: computed tomography; DM: diabetes mellitus; FDG: fluorine 18 fluorodeoxyglucose; FTD: frontotemporal dementia; HD: Huntington disease; LBD: Lewy body disease; LOR: level of recommendation; PD: Parkinson disease; PET: positron emission tomography.

Infectious Diseases Society of America

The Infectious Diseases Society of America (IDSA; 2015) published evidence-based, consensus guidelines on the diagnosis and treatment of native vertebral osteomyelitis in adults. The guidelines stated that PET "is highly sensitive for detecting chronic osteomyelitis. A negative PET scan excludes the diagnosis of osteomyelitis, including native vertebral osteomyelitis, as the sensitivity of the test is expected to be very high in view of the high concentration of red marrow in the axial skeleton."

The IDSA (2013) published evidence-based, consensus guidelines on the diagnosis and management of prosthetic joint infections. The guidelines concluded that PET should not be routinely used to diagnose prosthetic joint infection (strength of recommendation: B [based on moderate evidence]; quality of evidence: III [expert opinion and descriptive studies]).

The IDSA (2012) published evidence-based, consensus guidelines on the diagnosis and treatment of diabetic foot infections. The guidelines concluded that the role of FDG-PET in evaluating a diabetic foot infection has not been established.

The IDSA (2018) will be publishing guidelines on the diagnosis and management of bone and joint infections in children.

U.S. Preventive Services Task Force Recommendations

Not applicable.

Medicare National Coverage

The Centers for Medicare & Medicaid Services (CMS; 2004) released a national coverage decision for a subset of patients "with a recent diagnosis of dementia and documented cognitive decline of at least 6 months, who meet diagnostic criteria for both [Alzheimer disease] and frontotemporal dementia, who have been evaluated for specific alternative neurodegenerative diseases or causative factors, and for whom the cause of the clinical symptoms remains uncertain."

The national coverage determination for FDG-PET for dementia and neurodegenerative diseases (220.6.13) states that:

"Medicare covers FDG Positron Emission Tomography (PET) scans for either the differential diagnosis of frontotemporal dementia (FTD) and Alzheimer's disease (AD) under specific requirements; OR, its use in a Centers for Medicare & Medicaid Services (CMS)-approved practical clinical trial focused on the utility of FDG PET in the diagnosis or treatment of dementing neurodegenerative diseases."

Specific requirements for each indication are clarified in the document.

The national coverage determination for FDG-PET for infection and inflammation (220.6.16) states that:

"The CMS is continuing its national noncoverage of FDG PET for the requested indications. Based upon our review, CMS has determined that the evidence is inadequate to conclude that FDG PET for chronic osteomyelitis, infection of hip arthroplasty, and fever
of unknown origin improves health outcomes in the Medicare populations, and therefore has determined that FDG PET for chronic osteomyelitis, infection of hip arthroplasty, and fever of unknown origin is not reasonable...

REFERENCES


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POLICY HISTORY - THIS POLICY WAS APPROVED BY THE FEP® PHARMACY AND MEDICAL POLICY COMMITTEE ACCORDING TO THE HISTORY BELOW:

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<thead>
<tr>
<th>Date</th>
<th>Action</th>
<th>Description</th>
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<tbody>
<tr>
<td>June 2012</td>
<td>New policy</td>
<td></td>
</tr>
<tr>
<td>June 2013</td>
<td>Replace policy</td>
<td>Policy updated with literature search; Sarcoidosis added as not medically necessary indication, no other changes to policy statement.</td>
</tr>
</tbody>
</table>

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<tbody>
<tr>
<td>June 2014</td>
<td>Replace policy</td>
<td>Policy update with literature review. Reference 12 added; no changes to policy statement.</td>
</tr>
<tr>
<td>June 2015</td>
<td>Replace policy</td>
<td>Policy updated with literature review; references 13-14, 19, 25, 28-29, 38-40, 42, 47-49, and 51-60 added; reference 50 updated. Vascular prosthetic graft infection, fever of unknown origin, and inflammation of unknown origin added as not medically necessary indications. Acanthocytosis and assessment of cerebral blood flow in newborns revised but no other changes to policy statements.</td>
</tr>
<tr>
<td>December 2016</td>
<td>Replace policy</td>
<td>Policy updated with literature review; references 1-15, 19-21, 32, 39, 44, and 58 added. Policy statements unchanged. Added “Fluorodeoxyglucose F 18” to the title and “FDG” to the investigational statement.</td>
</tr>
<tr>
<td>December 2018</td>
<td>Replace policy</td>
<td>Policy updated with literature review through July 10, 2018; references 28 and 72 added; reference 18 updated. Policy statements unchanged.</td>
</tr>
<tr>
<td>December 2019</td>
<td>Replace policy</td>
<td>Policy updated with literature review through July 8, 2019; references added. Policy statements unchanged.</td>
</tr>
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