PET Tracers Used in Clinical Practice in Europe

Practical Reference Document — Pharmacokinetics • Indications • Theranostics

> **Purpose of the document.** This document presents the list of PET (Positron Emission Tomography) tracers used in European clinical practice, whether they hold a centralised EMA marketing authorisation, a national marketing authorisation (ANSM, AFMPS, AIFA, Swissmedic, HAS), or are produced under a regulated hospital preparation (magistral preparation). It also includes theranostic agents used for patient-selection imaging and for radioligand therapy.

Scope

Tracers marketed or used in European clinical practice, covering: centralised EMA authorisation, national authorisation, regulated hospital preparation. Tracers used strictly for research are flagged as such.

Reference frameworks

EANM/SNMMI guidelines (2018–2024) + SFMN (French practice) + EMA EPAR + Swissmedic + HAS + AFMPS (Belgium).

Document structure

- Appendix — Acronyms, abbreviations and initialisms.
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- Table 2 — List by clinical indication / principal pathology.
- Table 3 — Theranostic pairs (diagnostic + therapeutic).
- Practical notes — Cross-cutting rules (fasting, hydration, delays, theranostics).

Tracer status — legend

Status	Definition
EMA MA	Centralised European marketing authorisation (covers EU/EEA).
National MA	National marketing authorisation in at least one EU/EEA/CH state (availability varies by country).
Hospital preparation	Regulated magistral preparation / established clinical use without centralised EMA MA.
Research	Clinical trials, compassionate access, academic programmes.

> **Limitations of centralised EMA MA.** For centrally authorised products, the authorisation covers the EU/EEA, but effective marketing and reimbursement remain national. Several tracers widely used in European practice (PSMA-1007, FET, FAPI, certain DOTATATE) hold only national MAs or regulated magistral preparations. Their use is legal and standardised, but varies between Member States.

Appendix — Acronyms, abbreviations and initialisms

Document applicable across the EU / EEA / Switzerland — European and national references.

Acronym	Meaning	Category
EMA	European Medicines Agency.	Authority
EPAR	European Public Assessment Report — EMA public assessment report.	EMA document
EEA	European Economic Area — EU + Iceland, Liechtenstein, Norway.	Framework
MA	Marketing authorisation.	Framework
SmPC	Summary of Product Characteristics.	Document
AFMPS	Federal Agency for Medicines and Health Products (Belgium).	Authority (BE)
HAS	French National Authority for Health.	Authority (FR)
ANSM	French National Agency for Medicines and Health Products Safety.	Authority (FR)

Acronym	Meaning	Category
BfArM	Bundesinstitut für Arzneimittel und Medizinprodukte (Germany).	Authority (DE)
AIFA	Italian Medicines Agency.	Authority (IT)
AEMPS	Spanish Agency of Medicines and Medical Devices.	Authority (ES)
Swissmedic	Swiss Agency for Therapeutic Products.	Authority (CH)
MHRA	Medicines and Healthcare products Regulatory Agency (United Kingdom).	Authority (UK)
INAMI	National Institute for Health and Disability Insurance (Belgium).	Reimbursement (BE)
EANM	European Association of Nuclear Medicine — European scientific society.	Scientific society
SNMMI	Society of Nuclear Medicine and Molecular Imaging (USA).	Scientific society
SFMN	French Society of Nuclear Medicine.	Scientific society (FR)
IAEA	International Atomic Energy Agency.	International organisation
PET	Positron Emission Tomography.	Modality
TEP	Tomographie par émission de positons — French equivalent of PET.	Modality
PET/CT	PET combined with computed tomography (CT).	Modality
SPECT	Single-Photon Emission Computed Tomography.	Modality
MIBI	Methoxy-isobutyl-isonitrile (99mTc-MIBI).	SPECT tracer
RLT	Radioligand Therapy — internal vectorised radiotherapy.	Therapeutic
PRRT	Peptide Receptor Radionuclide Therapy.	Therapeutic
PSMA	Prostate-Specific Membrane Antigen — prostate theranostic target.	Target
SSTR	Somatostatin Receptor — NET theranostic target.	Target
FAP	Fibroblast Activation Protein — emerging stromal target (FAPI).	Target (research)
GRPR	Gastrin-Releasing Peptide Receptor.	Target (research)
CXCR4	Chemokine Receptor type 4.	Target (research)
NIS	Sodium-Iodide Symporter — target for radioactive iodine.	Target
mCRPC	metastatic Castration-Resistant Prostate Cancer.	Pathology
NET	Neuroendocrine Tumour.	Pathology
TNE	Tumeur neuroendocrine — French equivalent of NET.	Pathology
GEP-NET	Gastro-Entero-Pancreatic Neuroendocrine Tumour.	Pathology
HCC	Hepatocellular carcinoma.	Pathology
CUP	Cancer of Unknown Primary.	Pathology
FTD	Frontotemporal Dementia.	Pathology
MCI	Mild Cognitive Impairment.	Pathology
DLB	Dementia with Lewy Bodies.	Pathology
FUO	Fever of Unknown Origin — prolonged unexplained fever.	Pathology
LVAD	Left Ventricular Assist Device.	Device
MBq	Megabecquerel — unit of radioactivity (1 MBq = 10^6 disintegrations/s).	Unit
T½	Physical half-life of the radionuclide.	Pharmacokinetics
SUV	Standardised Uptake Value — standardised tracer uptake.	Quantification
GFR	Glomerular filtration rate.	Biology
CBC	Complete blood count.	Biology
VISION	Pivotal trial leading to EMA MA of 177Lu-PSMA-617 (Pluvicto®).	Clinical trial

Acronym	Meaning	Category
NETTER-1	Pivotal trial leading to EMA MA of 177Lu-DOTATATE (Lutathera®).	Clinical trial
PSMAfore	Trial evaluating 177Lu-PSMA-617 in the pre-taxane setting; EMA extension withdrawn in 2026.	Clinical trial

Table 1 — Alphabetical list of tracers

Doses, delays and preparations conform to EANM/SNMMI guidelines (2018–2024). The half-life (T½) is indicated in the first column.

Tracer / Status	Adult dose	Patient preparation	Delay	Main indications
[11C] Acetate T½ 20 min *Hospital preparation*	5–10 MBq/kg (typ. 550–740 MBq)	No systematic standardised preparation; fasting often required locally.	Very early acquisition (5–15 min after injection).	Well-differentiated hepatocellular carcinoma, prostate (historical use), tumours with lipid metabolism. On-site cyclotron required. *Note: 11C tracer — availability limited to centres with an on-site cyclotron.*
[13N] Ammonia (13NH3) T½ 10 min *Hospital preparation*	10–20 MBq/kg (typ. 740 MBq)	Fasting 4–6 h. Stop caffeine/theobromine 24 h. Pharmacological stress (regadenoson, adenosine, dipyridamole).	Immediate dynamic acquisition (rest then stress).	Myocardial perfusion under stress/rest with absolute quantification of flow (mL/min/g) and coronary reserve. Microvascular disease. *Note: on-site cyclotron required.*
[11C] Choline T½ 20 min *Hospital preparation*	5–8 MBq/kg (typ. 550 MBq)	Hydration and voiding before acquisition. No strict fasting.	Early pelvis 5 min, whole-body 5–20 min, delayed ~60 min if doubt.	Prostate cancer (historical use, replaced by PSMA), hepatocellular carcinoma, parathyroid (depending on expertise). *Note: on-site cyclotron required.*
[18F] Choline (fluorocholine) T½ 110 min *National MA*	3–5 MBq/kg (typ. 250 MBq)	Oral hydration, voiding. Fasting not always required. No exercise 24 h beforehand.	Pelvis 5–15 min, delayed 60 min possible.	Primary/recurrent hyperparathyroidism (current first-line indication), well-differentiated hepatocellular carcinoma, prostate cancer (historical use). *Note: availability varies by country (national MA).*
[15O] Water T½ 2 min *Hospital preparation*	300–800 MBq	On-site cyclotron mandatory. Strict pharmacological cardiac stress. Standard caffeine preparation.	Immediate dynamic acquisition.	Reference for absolute quantification of perfusion (myocardium, brain). Physiological research. Ultra-specialised practice. *Note: ultra-specialised practice (very short T½).*
[68Ga] Edotreotide (DOTATOC) — SomaKit TOC® T½ 68 min *EMA MA*	100–200 MBq	No fasting. Stop long-acting somatostatin analogues 3–4 weeks beforehand. Short-acting octreotide stopped 24 h beforehand. Hydration/voiding.	40–90 min (optimal 60 min).	Well-differentiated G1–G2 NETs (GEP, bronchial, paragangliomas, SSTR+ meningiomas). PRRT selection. Theranostic pair with 177Lu-DOTATATE. *Note: formal EMA MA for SomaKit TOC / DOTATOC (well-differentiated GEP-NET). DOTATATE and DOTANOC: established clinical use but variable national/local status — should not be equated with SomaKit TOC.*

Tracer / Status	Adult dose	Patient preparation	Delay	Main indications
[18F] FDG (Fludeoxyglucose) T½ 110 min *EMA MA*	2–4 MBq/kg (typ. 250–400 MBq)	Fasting 4–6 h (standard oncology). For cardiac inflammation/endocarditis/ sarcoidosis: low-carbohydrate/high-fat diet + prolonged fasting. For myocardial viability: glucose/insulin loading or hyperinsulinaemic euglycaemic clamp depending on protocol. Glycaemia < 200 mg/dL (ideally < 140). Oral hydration 1 L. No exercise 24 h. Rest in heated room 15 min.	60 min (oncology). 90–120 min (vasculitides).	Oncology gold standard (solid cancers + lymphomas): Hodgkin/non-Hodgkin, lung, head & neck, oesophagus, colorectal, melanoma, sarcomas, triple-negative/HER2+ or high-grade breast cancer, pancreas, metastases of unknown origin. Multiple myeloma/plasmacytoma. Differentiated thyroid cancer that is dedifferentiated or iodine-negative with elevated thyroglobulin. Gynaecological cancers (cervix, endometrium, ovary). Testicular/seminoma cancer with residual mass. Search for primary. Neurology (dementias, epilepsy). Cardiology (viability, sarcoidosis). Infection/inflammation (FUO, vasculitides, endocarditis, sarcoidosis, prosthesis infection, infected cardiac devices, systemic inflammatory diseases IgG4, polymyalgia rheumatica/Horton). *Note: WARNING: myocardial viability = glucose-loading preparation to PROMOTE FDG uptake; cardiac inflammation/sarcoidosis = ketogenic diet to SUPPRESS physiological myocardial uptake. These two preparations are not interchangeable.*
[18F] FET (fluoroethyl-tyrosine) T½ 110 min *National MA*	3 MBq/kg (typ. 200 MBq)	No universal strict fasting. Oral hydration.	Dynamic acquisition 0–40/50 min or static 20–40 min.	Gliomas: differential diagnosis, non-enhancing extension, indirect grading, biopsy/ radiotherapy guidance, recurrence vs radionecrosis, treatment follow-up. Brain metastases (per protocol). *Note: national status varies by country.*
[18F] Florbetaben — Neuraceq® T½ 110 min *EMA MA*	300 MBq (±20%)	No fasting. Patient at rest prior to injection.	90 min ± 5.	Cerebral β-amyloid plaque imaging. Differential diagnosis of cognitive impairment / suspected Alzheimer's disease.
[18F] Florbetapir — Amyvid® T½ 110 min *EMA MA*	370 MBq (±20%)	No fasting. Patient at rest.	30–50 min.	β-amyloid plaque imaging. First amyloid radiopharmaceutical approved by EMA (2013). Aid to differential diagnosis of dementia.
[18F] Flortaucipir — Tauvid® T½ 110 min *EMA MA*	370 MBq	No fasting. Patient at rest.	80 min.	Tau protein imaging (paired helical filaments). Aid to assessment of Alzheimer-type tau pathology. Differential Alzheimer's vs other dementias.
[18F] Fluciclovine — Axumin® T½ 110 min *EMA MA*	370 MBq (±20%)	Avoid exercise 24 h. Short fasting per SmPC. No injection in the arm on the operated side.	3–5 min (early image ++).	Recurrence of prostate cancer after curative treatment (rising PSA). Indicated especially if PSMA is unavailable or contraindicated.
[18F] Fluorodopa (FDOPA) T½ 110 min *EMA MA*	2–4 MBq/kg (typ. 200 MBq)	Fasting 4–6 h (amino acids). Management of L-Dopa/carbidopa depending on indication and local protocol. Carbidopa not systematic: useful in certain NET protocols, to be avoided/adapted for insulinoma/hyperinsulinism.	Parkinsonian syndromes: ~90 min. Neuro-oncology/ gliomas: early acquisition 10–30 min per protocol. Oncology NET: 60 min. Insulinoma: 90 min.	"Movement" neurology: Parkinson's disease, parkinsonian syndromes. Neuro-oncology: gliomas, brain metastases. Oncology NET: insulinoma, pheochromocytoma, paraganglioma, medullary thyroid. Paediatric congenital hyperinsulinism. *Note: delays and preparation differ between neurological, neuro-oncological and NET indications.*

Tracer / Status	Adult dose	Patient preparation	Delay	Main indications
[18F] Fluoroestradiol (FES) — EstroTep® (Europe/France) — Cerianna® (US name) T½ 110 min *EMA MA*	222 MBq (±20%)	No fasting. Stop tamoxifen/ fulvestrant 8–12 weeks beforehand (oestrogen-receptor competition). Aromatase inhibitors allowed.	60–80 min.	ER+ metastatic breast cancer: mapping of ER expression, lesional heterogeneity, aid to decision when biopsy is impossible/difficult or not representative, selection of hormone therapy. Indication should be restricted to cases where the result influences hormonal strategy. Endometrium/ovary = research only, not routine clinical use. *Note: in Europe/France, indication centred on ER+ metastatic breast cancer; do not present endometrium/ovary as routine.*
[18F] Flutemetamol — Vizamyl® T½ 110 min *EMA MA*	185 MBq (±20%)	No fasting. Patient at rest.	90 min ± 20.	β-amyloid plaque imaging. Assessment of cognitive impairment / suspected Alzheimer's disease. Binary reading (positive/negative).
[68Ga] Gallium chloride — 68Ge/ 68Ga generator T½ 68 min *EMA MA*	Precursor — not administered directly	—	—	Radiolabelling precursor for authorised kits (edotreotide, gozetotide, etc.). Several generators with EMA MA.
[68Ga] Gozetotide (PSMA-11) — Locametz® / Illuccix® T½ 68 min *EMA MA*	1.8–2.2 MBq/ kg (typ. 111–185 MBq)	No fasting. Oral hydration 500 mL pre-injection. Bladder emptying immediately before acquisition. Furosemide per pelvic protocol.	50–100 min (optimal 60 min).	Prostate cancer: high-risk staging, biochemical recurrence (low PSA), therapeutic selection for 177Lu-PSMA-617 (Pluvicto®). Theranostic pair.
[11C] Methionine T½ 20 min *Hospital preparation*	5–10 MBq/kg (typ. 550 MBq)	Fasting 4–6 h per centre. No premedication.	Acquisition 10–20 min after injection.	Adult/paediatric gliomas: tumour extension, targeted biopsy, radiotherapy planning, recurrence vs radionecrosis. Non-glial brain tumours. *Note: on-site cyclotron required.*
[18F] Piflufolastat — Pylclari® (Europe) — Pylarify® (US name) — = DCFPyL T½ 110 min *EMA MA*	333 MBq (±10%)	No fasting. Oral hydration 500 mL pre-injection. Bladder emptying before acquisition.	60–120 min (optimal 60 min).	Prostate cancer: initial high-risk staging, biochemical recurrence. EMA MA 2023 (Pylclari®, Curium).
[18F] PSMA-1007 T½ 110 min *National MA*	3–4 MBq/kg (typ. 250 MBq)	No fasting. Oral hydration. Bladder emptying possible (predominantly hepatobiliary excretion — less critical).	90–120 min (optimal 90 min).	Prostate cancer. Predominantly hepatobiliary excretion (less urinary activity — useful for pelvis). *Note: clinical practice with national MA; availability varies by country; no centralised EMA MA.*
[82Rb] Rubidium chloride — 82Sr/ 82Rb generator T½ 76 sec *EMA MA*	10 MBq/kg stress + rest	Fasting 4–6 h. Stop caffeine/theobromine 24 h. Pharmacological stress (regadenoson, adenosine, dipyridamole).	Immediate acquisition (90 sec post-injection).	Stress/rest myocardial perfusion. Advantage: no cyclotron required (generator). Coronary artery disease evaluation — perfusion / ischaemia / coronary reserve. Myocardial viability relies on FDG + perfusion imaging. *Note: does not assess viability (FDG role).*
[18F] Sodium fluoride (Na18F) T½ 110 min *National MA*	1.5–3.7 MBq/ kg (typ. 150–250 MBq)	No fasting. Oral hydration 0.5–1 L. Bladder emptying before acquisition.	45–60 min.	High-resolution bone imaging: osteoblastic/ mixed bone metastases (prostate, breast, lung), oncologic bone pain, osteomyelitis. PET alternative to 99mTc-HDP/MDP.

Table 2 — List by clinical indication

Organised by pathology / clinical area. For each indication, tracers are listed in order of priority (1st line first).

Clinical indication	Tracers (priority order)	Practical notes
ONCOLOGY		
FDG-avid cancers (majority of solid cancers)	• [18F] FDG	Hodgkin/non-Hodgkin lymphomas, lung, head & neck, oesophagus, colorectal, melanoma, sarcomas, triple-negative/HER2+ or high-grade breast cancer, pancreas, metastases of unknown origin, multiple myeloma, dedifferentiated/iodine-negative differentiated thyroid cancer, gynaecological cancers (cervix, endometrium, ovary), testicular cancer/seminoma with residual mass, search for primary. Limited in mucinous tumours, low-grade tumours, well-differentiated HCC.
Prostate cancer	• [68Ga] Gozetotide (PSMA-11) • [18F] Piflufolastat • [18F] PSMA-1007 • [18F] Fluciclovine • [18F] Choline (fluorocholine) • [11C] Choline • [18F] FDG	PSMA = first line (high-risk staging, recurrence). Choline retained when PSMA unavailable. Fluciclovine if PSMA contraindicated. FDG if dedifferentiation suspected (PSMA−/FDG+ discordance).
Hepatocellular carcinoma (HCC)	• [18F] Choline (fluorocholine) • [11C] Acetate • [18F] FDG	Sensitivity depends on differentiation. Dual tracer (FDG + choline) sometimes useful. Pre-transplant work-up or recurrence per local protocol.
Well-differentiated G1–G2 neuroendocrine tumours	• [68Ga] Edotreotide (DOTATOC) • [18F] Fluorodopa (FDOPA) • [18F] FDG	SSTR-PET = gold standard. FDOPA as alternative or complement (insulinoma, paediatric hyperinsulinism). Combination SSTR + FDG if high Ki-67 or heterogeneous disease (NETPET score). Search for NET primary, bronchial/thymic NETs and SSTR+ meningiomas. Distinguish the SomaKit TOC EMA indication from specialised clinical uses of DOTATATE/DOTANOC.
Poorly differentiated G3 NETs	• [18F] FDG	Dedifferentiation = loss of SSTR + ↑ glycolysis. FDG essential for stratification.
Pheochromocytoma / paraganglioma	• [68Ga] Edotreotide (DOTATOC) • [18F] Fluorodopa (FDOPA) • [18F] FDG	Choice based on genotype (SDHx, VHL, RET, NF1), location, metastatic disease, therapeutic project. SSTR often very high-performing in SDHx and metastatic disease. 131I-MIBG (non-PET) as alternative.
Medullary thyroid cancer	• [18F] Fluorodopa (FDOPA) • [18F] FDG • [68Ga] Edotreotide (DOTATOC)	Choose according to calcitonin, CEA, doubling time and planned treatment.
Dedifferentiated / iodine-negative differentiated thyroid cancer	• [18F] FDG	FDG indicated for iodine-negative fixation with elevated thyroglobulin.
ER+ breast cancer (metastatic characterisation)	• [18F] Fluoroestradiol (FES) • [18F] FDG	FES = mapping of ER expression, heterogeneity, aid when biopsy is impossible. Indication centred on ER+ metastatic disease when the result influences hormonal strategy. Anti-ER treatments reduce uptake. Liver sometimes difficult to interpret.
Primary / recurrent hyperparathyroidism	• [18F] Choline (fluorocholine) • [11C] Choline	Localisation of adenoma/hyperplasia before surgery, especially if ultrasound/MIBI imaging is negative or for redo surgery. Superior to classical MIBI scintigraphy.
Gliomas / brain tumours	• [18F] FET (fluoroethyl-tyrosine) • [11C] Methionine • [18F] Fluorodopa (FDOPA) • [18F] FDG	FET and FDOPA = EANM standard for gliomas (recurrence vs radionecrosis, stereotactic planning, treatment follow-up). FDG limited by cortical uptake.

Clinical indication	Tracers (priority order)	Practical notes
Bone and bone metastases	• [18F] Sodium fluoride (Na18F) • [18F] FDG • [68Ga] Gozetotide (PSMA-11) • [18F] Choline (fluorocholine)	NaF very sensitive but non-specific (fracture, osteoarthritis, inflammation). PSMA / choline if prostate origin. Work-up of oncologic bone pain.
Hodgkin / non-Hodgkin lymphomas	• [18F] FDG	FDG = gold standard for initial staging, interim/end-of-treatment evaluation, suspected recurrence (Deauville).
Multiple myeloma / plasmacytoma	• [18F] FDG	FDG for extension work-up, focal lesions, treatment follow-up.
Gynaecological cancers (cervix, endometrium, ovary)	• [18F] FDG	Extension work-up, recurrence, follow-up.
Testicular cancer / seminoma	• [18F] FDG	Evaluation of residual mass post-chemotherapy depending on context.
Search for primary (cancer of unknown primary)	• [18F] FDG	FDG = global mapping strategy.
Prostate cancer — historical tracers	• [11C] Choline • [18F] Choline (fluorocholine) • [11C] Acetate	Historical use before the PSMA era — retained when PSMA is unavailable or for comparative studies.
NEUROLOGY		
Alzheimer's disease (differential diagnosis)	• [18F] Florbetapir • [18F] Florbetaben • [18F] Flutemetamol • [18F] Flortaucipir • [18F] FDG	Amyloid imaging: binary read +/−. Excludes or confirms amyloid pathology. Tau for stratification. FDG for Alzheimer / FTD / DLB / vascular differentiation. Positive amyloid PET ≠ isolated diagnosis. Confirmation of amyloid pathology in specialised pathways for eligibility to anti-amyloid treatments (depending on country, memory clinics, CSF availability and reimbursement).
Parkinson's disease / parkinsonian syndromes	• [18F] Fluorodopa (FDOPA)	Study of the presynaptic nigrostriatal dopaminergic pathway. PET-FDOPA more sensitive than SPECT but less available. Alternative to 123I-FP-CIT SPECT (DaTSCAN®).
Dementia with Lewy bodies	• [18F] Fluorodopa (FDOPA) • [18F] FDG	Characteristic dopaminergic + metabolic pattern.
Dementias (FTD, MCI, mixed)	• [18F] FDG	Characteristic hypometabolic pattern: posterior (Alzheimer), frontal (FTD), parietal (atypical AD). Cross-reference with clinic, neuropsychology, MRI.
Refractory focal epilepsy (pre-surgical work-up)	• [18F] FDG	Identification of the epileptogenic focus during the interictal period (hypometabolism).
CARDIOLOGY		
Coronary artery disease (ischaemia, perfusion)	• [82Rb] Rubidium chloride • [13N] Ammonia • [15O] Water	PET perfusion progressively replaces MIBI SPECT. 82Rb = generator advantage. Quantification of flow and coronary reserve. Microvascular disease. Obese patients or equivocal SPECT.
Myocardial viability (dysfunctional territory)	• [18F] FDG	Preparation designed to PROMOTE myocardial FDG uptake: carbohydrate/insulin loading/ hyperinsulinaemic euglycaemic clamp per protocol. Not to be confused with the ketogenic diet used to SUPPRESS myocardial uptake in inflammation. Identification of perfusion-metabolism "mismatch" = viability (revascularisation targets).
Cardiac sarcoidosis	• [18F] FDG	Strict ketogenic preparation (suppression of physiological myocardial uptake). Wall inflammation → focal uptake.

Clinical indication	Tracers (priority order)	Practical notes
Endocarditis on prosthesis / intracardiac material infection	• [18F] FDG	Includes infection of implantable cardiac devices, intracardiac material, LVAD and valvular prosthesis. Strict metabolic preparation essential.
INFLAMMATION / INFECTION		
Fever of unknown origin (FUO)	• [18F] FDG	Second-line examination after negative work-up. Global mapping.
Large-vessel vasculitides (Horton, Takayasu)	• [18F] FDG	Waiting delay extended to 90–120 min (EANM 2018). Visual score on aortovascular scoring.
Prosthesis infection (vascular, orthopaedic, valvular) and implantable devices	• [18F] FDG	↑ sensitivity for chronic infections. Reduced specificity if recent post-op inflammation (< 6 weeks). Includes implantable cardiac devices / LVAD / intracardiac material where relevant.
Spondylodiscitis / osteomyelitis	• [18F] FDG • [18F] Sodium fluoride (Na18F)	Sensitivity > 90%. Differentiation from degenerative or tumoural changes.
Systemic sarcoidosis	• [18F] FDG	Multi-organ extension work-up (cardiac, lymph node, mediastinal, parenchymal).
Paediatric congenital hyperinsulinism	• [18F] Fluorodopa (FDOPA)	Differentiation of focal vs diffuse form (without carbidopa).

Table 3 — Theranostic pairs and therapeutic agents

Diagnostic + therapeutic couples in clinical practice and in research, with their European level of standardisation. Sorted by status then by biological target.

Iodine (NIS)

Historical clinical standard — National MA

DIAGNOSTIC	THERAPEUTIC
123I-NaI scintigraphy + 131I-NaI diagnostic	131I-NaI (sodium iodide-131)

INDICATIONS: Benign hyperthyroidism: Graves' disease, toxic multinodular goitre, toxic adenoma; differentiated thyroid cancer, papillary or follicular.

NOTES: Daily routine in nuclear medicine.

MIBG / noradrenergic system

Historical clinical standard — National MA / variable availability

DIAGNOSTIC	THERAPEUTIC
123I-MIBG scintigraphy/SPECT	131I-MIBG — variable national MAs

INDICATIONS: MIBG+ pheochromocytoma/paraganglioma; MIBG+ paediatric neuroblastoma.

NOTES: SPECT-therapy pair, not PET. Prior selection by 123I-MIBG imaging.

Osteoblastic bone (223Ra)

EMA MA — Clinical standard

DIAGNOSTIC	THERAPEUTIC
Bone scintigraphy 99mTc-HDP/MDP 18F-NaF PET (possible)	223Ra-dichloride (Xofigo®) — EMA MA, alpha emitter

INDICATIONS: mCRPC prostate cancer with symptomatic bone metastases, without known visceral metastases, progressing after at least two systemic lines or if not eligible for another systemic option.

NOTES: ALSYMPCA 2013. Alpha therapy targeting osteoblastic bone; guided by bone imaging, but not a strict PET ligand-receptor pair.

PSMA

EMA MA — Clinical standard

DIAGNOSTIC	THERAPEUTIC
68Ga-PSMA-11 / gozetotide: Locametz® / Illuccix® — EMA MA 18F-piflufolastat / Pylclari® — EMA MA 18F-PSMA-1007: clinical use with national MA or local status depending on country	177Lu-vipivotide tetraxetan (Pluvicto®) — EMA MA

INDICATIONS: Diagnostic: prostate cancer, initial staging of high-risk forms, localisation of recurrence with rising PSA after treatment, and patient selection for PSMA radioligand therapy. Therapy: PSMA+ mCRPC prostate cancer after AR-axis hormone therapy and taxane-based chemotherapy, in accordance with European MA and national access.

NOTES: 2026 European indication: PSMA+ mCRPC after next-generation hormone therapy and taxane(s). VISION = pivotal trial. The EMA extension request for pre-taxane use, derived from PSMAfore, was withdrawn on 24/04/2026: do not present it as a validated European MA in the pre-taxane setting.

Hepatic radioembolisation (90Y / 166Ho)

Procedural / locoregional theranostics — Clinical standard

DIAGNOSTIC	THERAPEUTIC
99mTc-MAA SPECT/CT (simulation) + post-therapy 90Y PET	90Y microspheres (SIR-Spheres®, TheraSphere®); 166Ho microspheres (QuiremSpheres®)

INDICATIONS: Hepatocellular carcinoma (HCC) and selected liver metastases, particularly of colorectal or neuroendocrine origin.

NOTES: Procedural theranostics: 99mTc-MAA simulation, pulmonary shunt assessment, pre-therapy dosimetry and post-therapy verification. This is not a molecular ligand-receptor pair comparable to PSMA or SSTR.

SSTR (somatostatin)

EMA MA for SomaKit TOC® + Lutathera®; DOTATATE/DOTANOC: variable national/local status

DIAGNOSTIC	THERAPEUTIC
68Ga-DOTATOC / edotreotide / SomaKit TOC® — EMA MA 68Ga-DOTATATE and 68Ga-DOTANOC: established clinical use, variable national/local status depending on country	177Lu-oxodotreotide (Lutathera®) — EMA MA

INDICATIONS: Diagnostic: well-differentiated gastro-entero-pancreatic neuroendocrine tumours, extension work-up, restaging and PRRT selection. Therapy: well-differentiated G1–G2 GEP-NETs, SSTR+, unresectable or metastatic, progressive, according to European MA and national access. Other SSTR+ tumours per specialised context.

NOTES: Formal EMA MA: SomaKit TOC® / edotreotide and Lutathera®. NETTER-2 is positive, but the EMA extension request for first-line use has been withdrawn: do not present Lutathera® as a validated first-line treatment in Europe.

PSMA — variant (I&T)

Academic / variable access

DIAGNOSTIC	THERAPEUTIC
68Ga-PSMA-11 or 18F-PSMA	177Lu-PSMA-I&T

INDICATIONS: Same PSMA target and clinical indication close to Pluvicto®, but different molecule, without EMA MA; use in expert centres, hospital preparations, compassionate access or trials.

NOTES: Variable access by country; do not present as a regulatory equivalent of Pluvicto®.

SSTR — variants (90Y-DOTATOC)

Academic / variable access

DIAGNOSTIC	THERAPEUTIC
68Ga-DOTA-SSA PET	90Y-DOTATOC / 90Y-DOTATATE; 177Lu-DOTATOC (variants)

INDICATIONS: SSTR+ NETs — local protocols / compassionate / research.

NOTES: Historical / academic — variable access by country; less standardised than Lutathera®.

Alpha theranostics (225Ac-PSMA)

Research / very limited compassionate access in expert centres

DIAGNOSTIC	THERAPEUTIC
68Ga-PSMA-11; 18F-PSMA	225Ac-PSMA-617; 225Ac-DOTATATE (research)

INDICATIONS: Prostate cancer / NETs resistant to β^- therapy (177Lu) — often after 177Lu failure.

NOTES: Limitations: 225Ac availability, salivary toxicity, haematological toxicity, and absence of routine EMA MA.

CXCR4

Research

DIAGNOSTIC	THERAPEUTIC
68Ga-Pentixafor (research)	177Lu/90Y-Pentixather (research)

INDICATIONS: Lymphomas, leukaemias, multiple myeloma, CXCR4+ solid tumours.

NOTES: Academic programmes (Würzburg).

Copper-64/67 (SSTR)

Research (Europe)

DIAGNOSTIC	THERAPEUTIC
64Cu-DOTATATE (Detectnet®) — FDA MA 2020, no EMA	67Cu-DOTATATE / 67Cu-SARTATE (research, phase I trials)

INDICATIONS: NETs — alternative to the 68Ga/177Lu couple.

NOTES: Research-only in Europe; 64Cu-DOTATATE is approved in the USA for diagnostic use but does not hold an EMA MA. Logistical advantage linked to the longer half-life of 64Cu.

FAPI / FAP (tumour stroma)

Research / clinical trials

DIAGNOSTIC	THERAPEUTIC
68Ga-FAPI; 18F-FAPI (research)	177Lu-FAPI / 90Y-FAPI / 225Ac-FAPI (research)

INDICATIONS: Solid tumours rich in FAP (pancreas, cholangiocarcinoma, sarcomas, desmoplastic breast, diffuse gastric).

NOTES: No routine EMA MA as of 12/05/2026; restrict to clinical trials or expert access. Do not integrate into European routine clinical practice.

GRPR (bombesin)

Research

DIAGNOSTIC	THERAPEUTIC
68Ga-RM2 / 68Ga-NeoBOMB1 (research)	177Lu-RM2 (research, phase I-II trials)

INDICATIONS: Breast cancer (GRPR receptors); hormone-naïve prostate cancer.

NOTES: Phase I-II studies ongoing.

Terbium-161 (PSMA, SSTR)

Research

DIAGNOSTIC	THERAPEUTIC
Same diagnostic vectors as PSMA / SSTR (68Ga, 18F)	161Tb-PSMA / 161Tb-DOTATOC (research)

INDICATIONS: Indications explored in research on the same targets as 177Lu therapies: PSMA+ mCRPC prostate and SSTR+ NETs. Potential interest for micrometastases.

NOTES: 161Tb = β^- + Auger electrons (dual action).

Cross-cutting practical notes

Patient preparation — general rules

- **Hydration** — oral 0.5–1 L pre-injection systematic. Bladder emptying before acquisition for urinary-excreted tracers.
- **Glycaemia** — FDG: systematic measurement (ideal target < 140 mg/dL, acceptable < 200 mg/dL). No measurement for other tracers.
- **Thermal comfort** — rest in a room heated to 22–24 °C, from 15 min before to 30 min after injection (reduces brown fat activation).
- **Venous access** — contralateral arm in operated breast cancer (axillary clearance). Good-calibre venous access.

Standard acquisition delays

- **FDG** — 60 min (oncology); 90–120 min (vasculitides, chronic inflammation).
- **PSMA-11, DOTATOC/DOTATATE (68Ga)** — 60 min (optimal).
- **PSMA-1007, Piflufolastat (18F)** — 90–120 min (ideal 90 min).
- **Fluciclovine (18F)** — 3–10 min post-injection (very early image).
- **Amyloid tracers (18F)** — florbetapir 30–50 min; florbetaben/flutemetamol ~90 min; flortaucipir ~80 min.
- **FDOPA** — parkinsonian syndromes ~90 min; neuro-oncology/gliomas earlier; NET ~60 min; carbidopa not systematic, depending on indication.
- **11C tracers (acetate, choline, methionine)** — very early acquisition (5–20 min); on-site cyclotron mandatory.

Fasting — FDG: 4–6 h (oncology). 12 h + ketogenic diet for cardiac inflammation/endocarditis/sarcoidosis. Myocardial viability: glucose/insulin preparation or hyperinsulinaemic euglycaemic clamp. PSMA/choline/amyloid: no fasting. FDOPA: fasting 4–6 h depending on indication; carbidopa per protocol.

Theranostics — key rules

- **Patient selection** — always prior and mandatory (PSMA for Pluvicto®, SSTR for Lutathera®). Criteria: uptake intensity, lesion distribution, fraction of tumour expressing the target.
- **Post-therapy dosimetry** — SPECT/CT imaging 24–48 h post-injection. Calculation of absorbed doses per lesion and at-risk organs (kidneys, bone marrow).
- **Nephroprotection** — amino acid infusion (lysine + arginine) with Lutathera® (30 min before to 4 h after). Not required for Pluvicto®.
- **Clinical follow-up** — haematological monitoring (CBC, platelets) before each cycle. Quarterly renal monitoring (GFR). Prophylactic antiemetics systematic.

Points of attention by tracer family

- **FDG** — Standardise fasting, glycaemia, muscle rest, waiting delay and reconstruction for quantitative follow-up. Essential distinction: myocardial viability = promote FDG uptake (carbohydrate loading); cardiac inflammation = suppress myocardial uptake (ketogenic diet).
- **PSMA** — In advanced disease, look for PSMA-negative lesions on CT/MRI/FDG. A PSMA−/FDG+ discordance may modify RLT eligibility.
- **SSTR** — Positive SSTR PET is central before PRRT. Combination with FDG helps detect a dedifferentiated component.
- **Amyloid / Tau** — These tracers document a molecular pathology, but not a clinical diagnosis alone. Indication to be set at a memory clinic or specialised context.
- **Choline / acetate** — Historical tracers in prostate, often replaced by PSMA, but retained interest in HCC and parathyroid for fluorocholine.

- **Cardiac** — The value of cardiac PET lies in dynamic quantification; caffeine/stress preparation and FDG metabolic protocol must be strict.

Expected developments 2026–2028

Strong growth in clinical trials on therapeutic radiopharmaceuticals (3 trials in 2018 → 80 in H1 2025, EMA Horizon Scanning). Axes of innovation: alpha emitters (225Ac), new isotopes (67Cu, 161Tb), inflammatory and neurological targets, vector-agnostic linkers, new theranostic indications (FAPI, GRPR, CXCR4). To date, flurpiridaz, FAPI, GRPR, CXCR4, 64Cu/67Cu and 161Tb are not integrated into the European routine clinical tracer list: until a clear MA or national clinical access is documented, they are to be classified as emerging / research.

Sources and references

- EMA/82413/2026 — Radiopharmaceuticals — EU-IN Horizon Scanning Report (April 2026).
- EMA EPAR — Pylclari, Locametz, SomaKit TOC, Axumin, Amyvid, Neuraceq, Vizamyl, Tauvid, Lutathera, Pluvicto, Xofigo.
- EANM Procedure Guidelines — FDG PET/CT v2.0, PSMA PET v2.0, SSTR PET, amyloid PET, amino-acid PET brain tumours, FDOPA PET, cardiac PET, paediatric PET, theranostics.
- SFMN — Good clinical practice in nuclear medicine.
- HAS France — Opinions on radiopharmaceuticals.
- Swissmedic — SwissPAR; AFMPS (Belgium); AIFA, AEMPS, BfArM; etc.
- Official SmPCs — ema.europa.eu, ansm.sante.fr, afmps.be.
- IAEA / EANM — Technical guidance for PET/CT procedures and standardisation.