Cardiac Positron Emission Tomography: Current Clinical Practice

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KEYWORDS

• PET • Imaging • Myocardial perfusion
• Myocardial viability • Sarcoidosis
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With the increase in availability of positron emission tomography (PET), and its clinical growth in other medical fields, the clinical use of PET myocardial imaging has also grown. PET imaging has had two major clinical cardiac applications: (1) cardiac PET imaging is an accurate and well-validated tool for the assessment of myocardial perfusion and blood flow in coronary artery disease (CAD) or suspected CAD and its affect on ventricular function;[1–4] (2) PET is used for the assessment of metabolism and viability of myocardial tissue in the presence of congestive heart failure (CHF) or systolic dysfunction due to CAD, in which fluorodeoxyglucose (FDG) PET is known to be the most sensitive clinical noninvasive method.[1,5] This article focuses on these clinical applications.

MYOCARDIAL PERFUSION TRACERS FOR POSITRON EMISSION TOMOGRAPHY

According to their physical properties, myocardial PET blood flow tracers can be divided into two basic categories: (1) inert freely diffusible tracers, such as ^{15}O-water ($H_2{}^{15}O$), and (2) physiologically retained tracers, such as N-13-ammonia ($^{13}NH_3$) and rubidium-82 (^{82}Rb), which are the two most commonly available PET radiotracers used for the clinical assessment of myocardial perfusion.[2–4] The main features of PET flow tracers are summarized in **Table 1**.

^{82}Rb is produced from a strontium-82 (^{82}Sr)/^{82}Rb generator, which can be eluted every 10 minutes. The half-life ($T_{1/2}$) of ^{82}Sr is 25.5 days, which results in a generator life of 4 to 8 weeks. The short $T_{1/2}$ of ^{82}Rb (76 seconds) enables repeated and sequential perfusion studies but requires a delivery system that is linked directly to the patient for tracer administration and then rapid image acquisition shortly after tracer administration. ^{82}Rb has the highest kinetic energy of the commonly used PET tracers but the associated long positron range reduces spatial resolution with PET imaging.

^{82}Rb is a monovalent cationic analog of potassium and has similar biologic activity to thallium-201 (^{201}Tl). Myocardial uptake of ^{82}Rb requires active transport by way of the sodium/potassium adenosine triphosphate transporter. In animal models, the net retention is approximately 50% to 60% at rest and decreases to 30% at peak flow.[6] The retention fraction can be altered by acidosis and acute hypoxia.[7] As a potassium analog, ^{82}Rb is also taken up in the stomach, which can sometimes interfere with interpretation in the inferior wall.

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Table 1
Positron emission tomography myocardial perfusion tracers

Pharmaceutical	Radioisotope	Physical Half-Life	Production Method	Parent Compound Physical Half-Life	Physiology	Primary Application	Average Positron Energy (MeV)[a]	RMS Positron Range (mm)
Water	O-15	122 sec	Cyclotron	—	Diffusible	Perfusion	0.74	1.02
Ammonia	N-13	10 min	Cyclotron	—	Diffusible/ retained	Perfusion	0.49	0.57
Acetate	C-11	20 min	Cyclotron	—	Extracted/ metabolized	Oxidative metabolism	0.39	0.39
FDG	F-18	110 min	Cyclotron	—	Extracted/ retained	Metabolism/ viability	0.25	0.23
Rubidium	Rb-82	76 sec	$^{82}Sr/^{82}Rb$ generator	^{82}Sr = 25.5 d	Extracted/ retained	Perfusion	1.48	2.60

Abbreviation: RMS, Root-mean square.

[a] From www.nndc.bnl.gov/mird (May 2008).

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