Radiopharmaceuticals for myocardial perfusion imaging: SPECT & PET

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Introduction and Objective (1)

Myocardial perfusion imaging (MPI) is used on a daily basis to access coronary blood flow in patients that are suspected or have known Coronary Artery Disease (CAD). A Single Photon Emission Computed Tomography (SPECT) or and Positron Emission Tomography (PET) scan are used to access regional blood flow quantification either at rest or stress, the imaging acquisition is connected to an Electrocardiogram (ECG) and it is able to determine and quantify other myocardial parameters like myocardial wall thickness and wall motion.

PET is not used so broadly due to its high procedure cost, the proximity with cyclotron, where are produced the majority of radiopharmaceuticals used in PET, due to their short half-life.

This work is intended to carry out a review of the tests relating to radiopharmaceuticals that are used in clinical practice in SPECT or PET for assessment of myocardial perfusion, also focusing very promising radiopharmaceuticals that are under investigation or in clinical trials with great potential for conventional nuclear medicine or PET, proceeding to a comparative analysis of both techniques and respective radiopharmaceuticals used.

PET (2,6)

^{13} Amonia - $^{13}NH_3$

- High extraction from the blood flow
- Liver uptake can interfere on the inferior wall quantification
- Absolute quantification of myocardial perfusion

^{82} Rubidium Chloride - ^{82}Rb

- Generator produced radioisotope
- Potassium analogue
- Enters in the cell through the Sodium/Potassium pump and its ATP dependent

^{15} Oxygen – H_2O

- Short half-life (2 min)
- High extraction from the blood flow
- Absolute perfusion quantification, not dependent of the blood flow

^{18}F-FDG

- Half-life of 110 min allows good diagnostic images
- This tracer is used to check the viability in the myocardial cells.
- With a low blood flow, some regions change their metabolism to the Glucose metabolism enabling ^{18}F-FDG Uptake Identifies regions that are able to get back to normal with revascularization .

SPECT (1,3,5)

^{201} Thallium Chloride

- 12% of each decay emits gamma photons with energies between 135 – 170 keV and 88 % emits X-Ray photons between 69 – 80 keV
- Long half-life (73 hours) and high X-Ray emission the administrated activity to 150 MBq (poor image quality)
- Its resemblance with Potassium allows it to redistribute in the myocardial tissue providing information of viable tissue

^{99m}Tc – Sestamibi

- Widely used in MPI, the uptake is directly related to the blood flow and tissue viability
- Gets trapped in mitochondria, no redistribution
- Half-life of 6,01 hours enables the use of higher administrated activities and better image quality
- High liver uptake may be a problem on assessing left ventricle inferior wall

^{99m}Tc – Tetrofosmin

- Widely used in MPI, the uptake is directly related to the blood flow and tissue viability
- Liver clearance faster than Sestamibi
- Used in stress and rest protocols

^{99m}Tc – Teboroxime

- Highest extraction in the first pass of all (>90%)
- Very unstable, the washout from the cardiac tissue happens 20 minutes prior to the injection
- Multiple detector SPECT without Gated, only

^{99m}Tc-N-NOET

- Comparable to 210Tl, its uptake is proportional to the blood flow
- Redistributes later in the cardiac tissue, no need for a second injection of the tracer

Comparison Analysis (1-6)

Radiopharma-ceutical	Half-Life	Photon Energy (keV)	Image Technique	First Pass Extraction (%)	Sensivity (CAD)	Specificity (CAD)
^{201}Thallium Chloride	72,912 h	69-80, 135, 167	SPECT	88	92 %	90 %
^{99m}Tc-Sestamibi	6,01 h	140		66	89 %	66 %
^{99m}Tc-Tetrofosmine	6,01 h	140		60	87,16 %	81,48 %
^{99m}Tc-Teboroxime	6,01 h	140		> 90	Clinical Trials	Clinical Trials
^{99m}Tc-N-NOET	6,01 h	140		75 - 85	Clinical Trials	Clinical Trials
^{13}N-Ammonia	9,965 min	511	PET	80	98 %	100 %
^{82}Rubidium Chloride	76 seg	511		65	90 %	88 %
^{15}O- Water	122,24 seg	511		100	Clinical Trials	Clinical Trials
18F-FDG	109,77 min	511		N.A	92 % recovery of regional function	63 % recovery of regional function

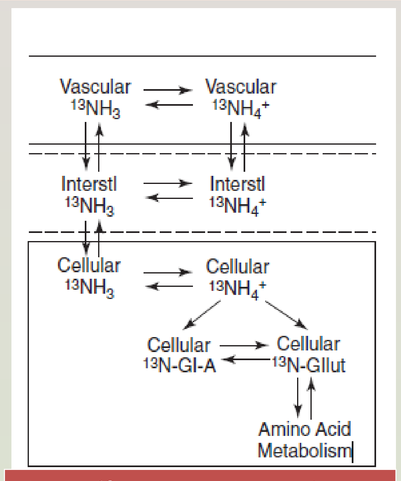


Fig. 1 - ^{13}N-Ammonia uptake.

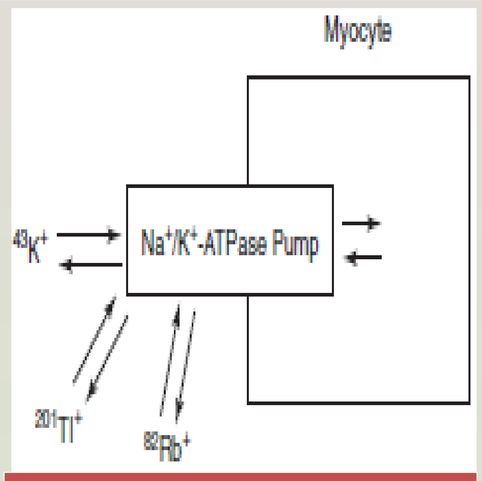
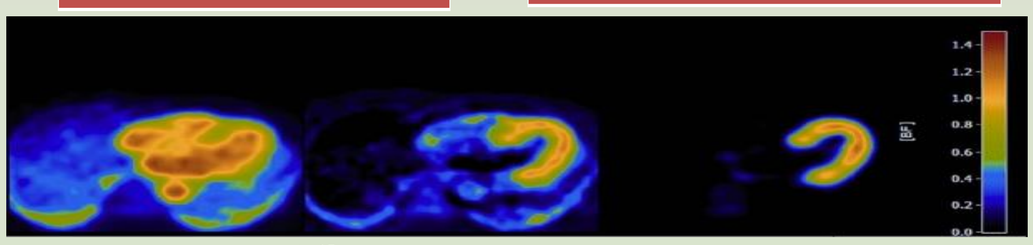
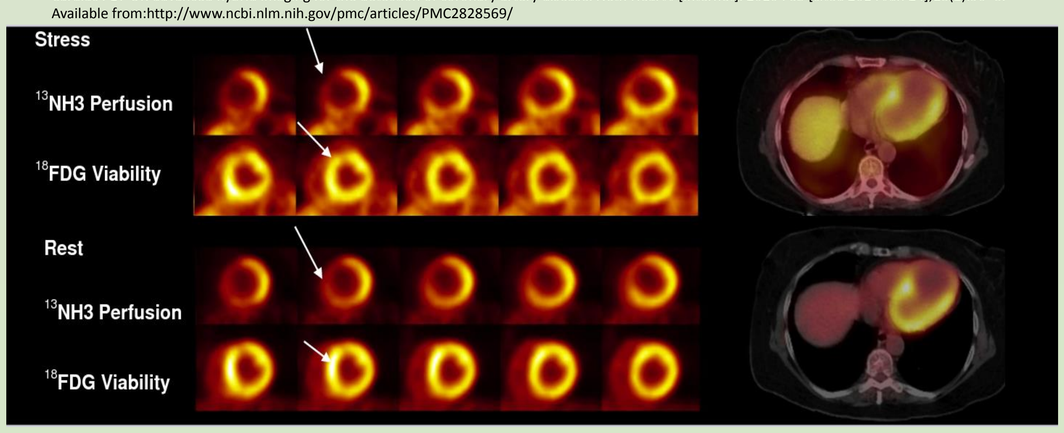


Fig. 2 - ^{82} Rb, ^{201}Tl and ^{43}K uptake.



Img. 3 - PET - MPI with ^{15}Oxygen - From:Knaapen P, de Haan S, Hoekstra OS, Halbmeijer R, Appelman YE, Groothuis JGJ, et al. Cardiac PET-CT: advanced hybrid imaging for the detection of coronary artery disease. Neth Heart J [Internet]. 2010 Feb [cited 2014 Jun 24];18(2):90–8. Available from:http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2828569/



Img. 4 - PET – Comparison between MPI ^{13}NH3 and ^{18}F-FDG study for viability
From:http://www.docstoc.com/docs/85993815/cardiac_case_studies

Conclusion

Both technique have advantages and disadvantages. SPECT radiopharmaceuticals and cameras are easier to access and well known for MPI. PET systems have a better resolution, better contrast although PET radiopharmaceuticals are more expensive to produce and use on a daily basis.

Bibliographic References

(1) Baggish AL, Boucher CA. Radiopharmaceutical Agents for Myocardial Perfusion Imaging. Circulation [Internet]. 2008 10–14 [cited 2014 Jun 2];118(16):1668–74. Available from:http://circ.ahajournals.org/content/118/16/1668
(2) Di Carli M, Lipton M, Cardiac PET and PET/CT Imaging, 2007 Springer Science+Business Media, New York - USA
(3) Germano G, Berman D, Clinical Gated Cardiac SPECT, 2006 Blackwell Publishing, USA
(4) Hilliard N,Radiopharmaceuticals used for myocardial imaging, 1998, University of New Mexico - Albuquerque, New Mexico
(5) Mikołajczak R, Garnuszek P. Radiopharmaceuticals in cardiology. Nucl Med Rev Cent East Eur. 2012;15(1):39–45.
(6)Husain SS. Myocardial Perfusion Imaging Protocols: Is There an Ideal Protocol? J Nucl Med Technol [Internet]. 2007 3–1 [cited 2014 Jun 2];35(1):3–9. Available from:http://tech.snmjournals.org/content/35/1/3

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