

Radiopharmaceuticals for myocardial perfusion imaging: SPECT & PET

Adães, R.¹; Fernandes, M.²; Pereira, E.²; Sousa, E.¹
 1 – Lisbon School of Health and Technology, polytechnic institute of Lisbon
 2 – Nuclearmed – Nuclear Medicine Institute

Introduction and Objective (1)

Myocardial perfusion imaging (MPI) is used on a daily basis to assess 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 assess 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.

Comparison Analysis (1-6)

Radiopharmaceutical	Half-Life	Photon Energy (keV)	Image Technique	First Pass Extraction (%)	Sensitivity (CAD)	Specificity (CAD)
²⁰¹ Thallium Chloride	72,912 h	69-80, 135, 167		88	92 %	90 %
^{99m} Tc-Sestamibi	6,01 h	140		66	89 %	66 %
^{99m} Tc-Tetrofosmine	6,01 h	140	SPECT	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		80	98 %	100 %
⁸² Rubidium Chloride	76 seg	511		65	90 %	88 %
¹⁵ O- Water	122,24 seg	511	PET	100	Clinical Trials	Clinical Trials
¹⁸ F-FDG	109,77 min	511		N.A	92 % recovery of regional function	63 % recovery of regional function

PET (2,6)

¹³ Amonia - ¹³ NH₃

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

⁸² Rubidium Chloride - ⁸²Rb

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

¹⁵ Oxygen – H₂O

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

¹⁸F-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 ¹⁸F-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

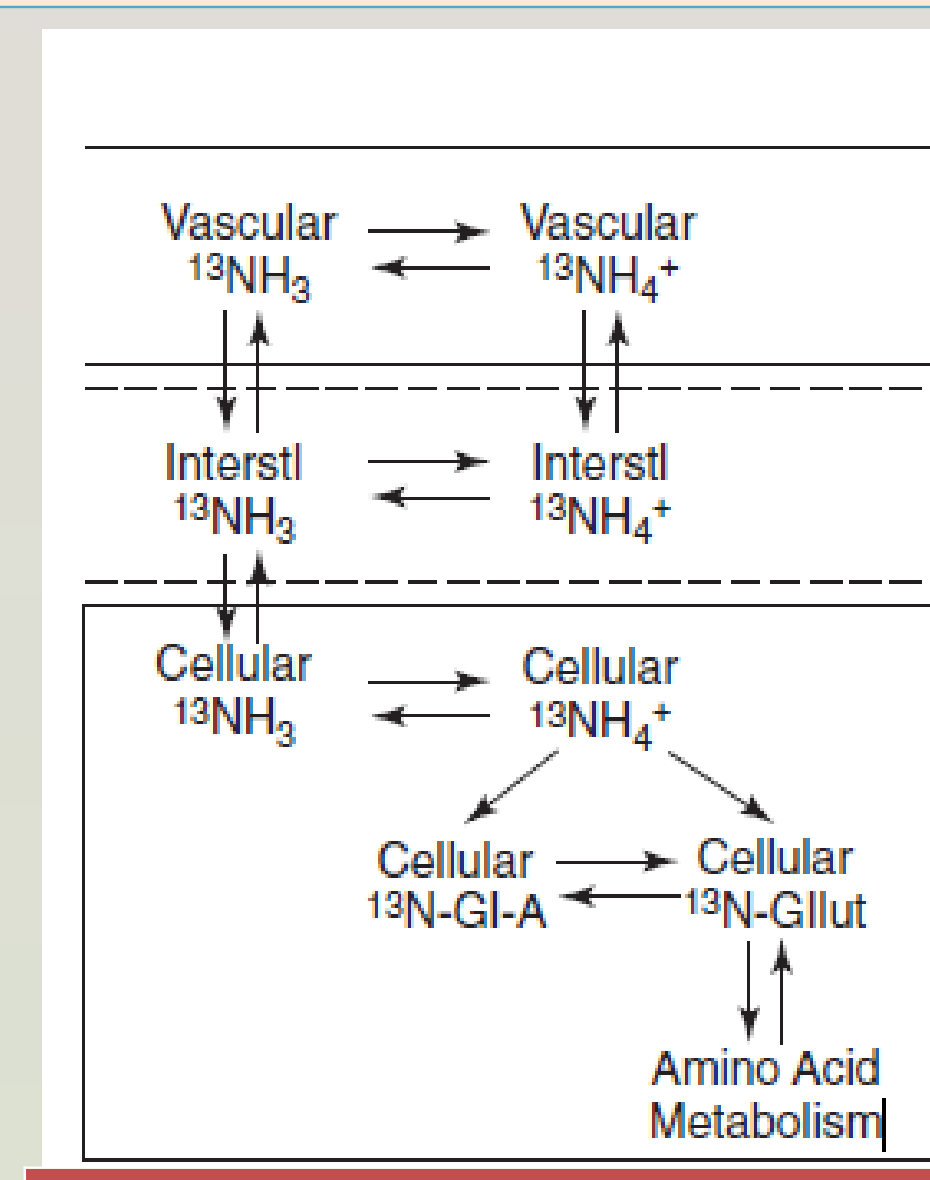


Fig. 1 - ¹³N-Ammonia uptake.

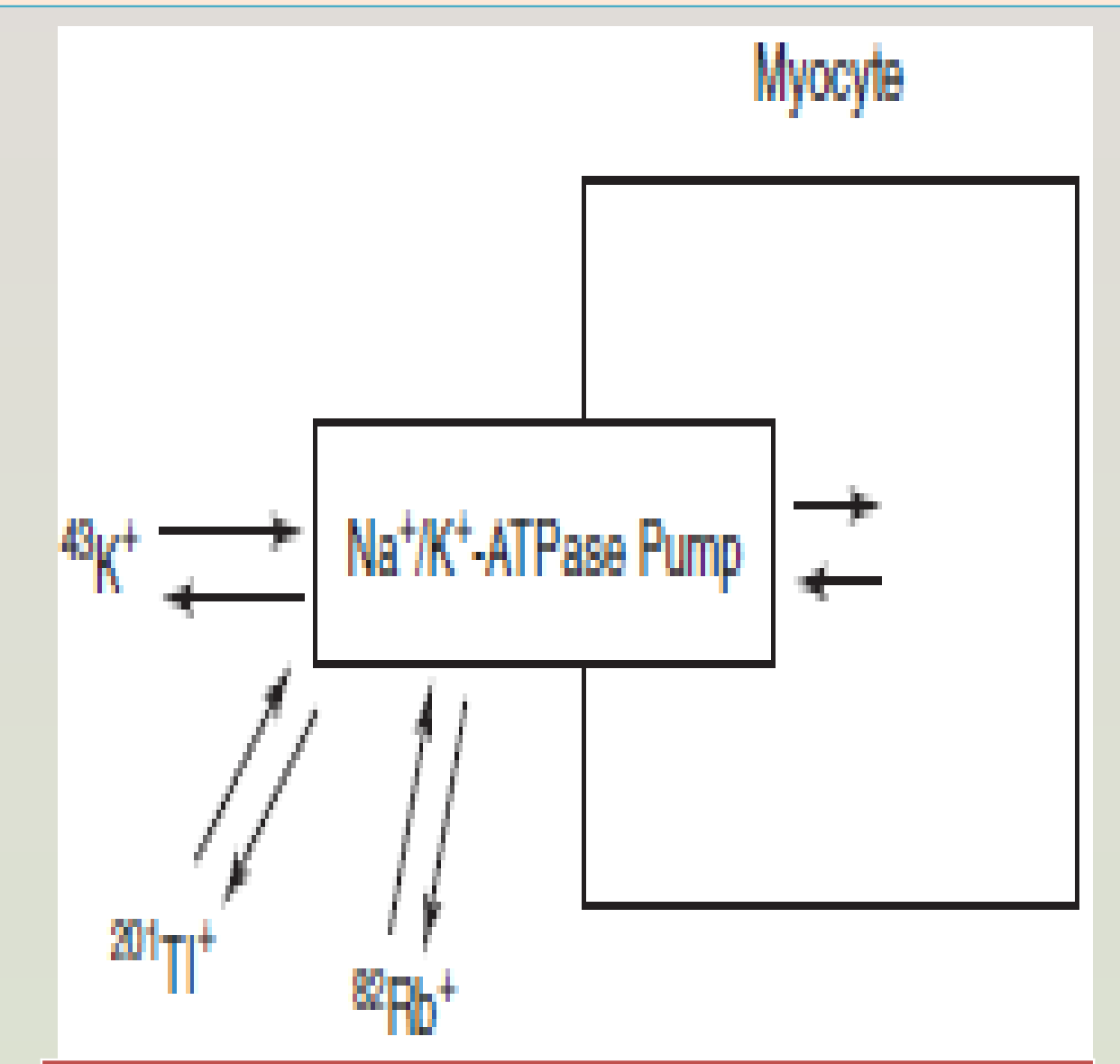
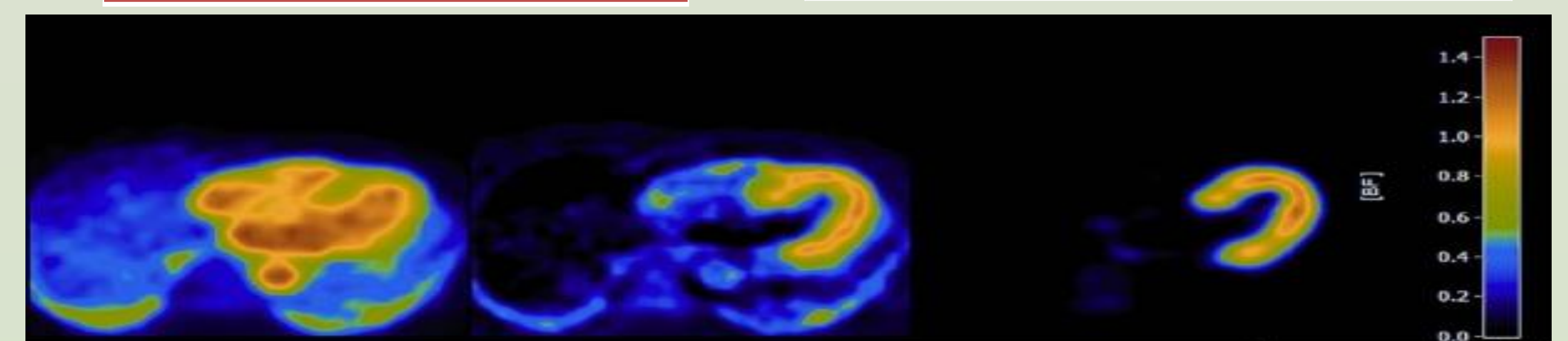
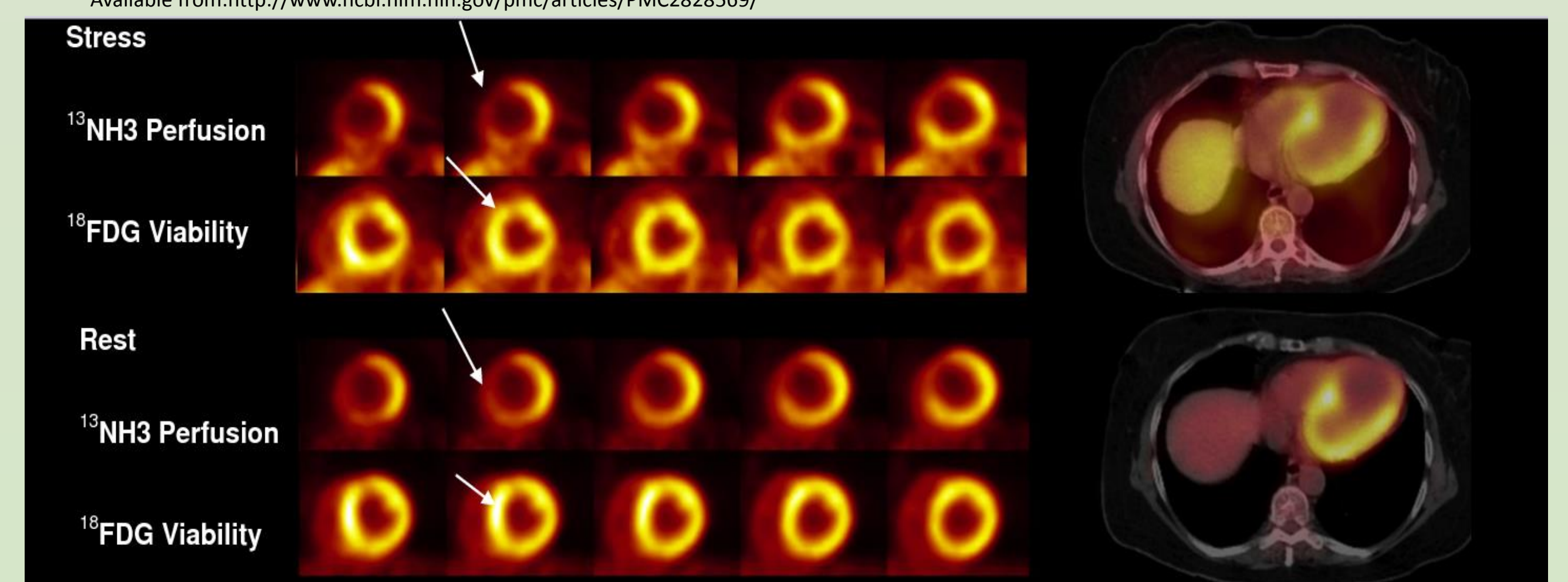


Fig. 2 - ⁸²Rb, ²⁰¹Tl and ⁴³K uptake.



Img. 3 - PET - MPI with ¹⁵Oxygen – 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 ¹³NH₃ and ¹⁸F-FDG study for viability
 From: http://www.docstoc.com/docs/85993815/cardiac_case_studies

Conclusion

Both techniques 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.

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