Radiopharmaceuticals for myocardial perfusion imaging: SPECT & PET

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)

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

Rubidium Chloride - 82Rb
- Generator produced radiisotope
- Potassium analogue
- Enters in the cell through the Sodium/Potassium pump and its ATP dependent

SPECT (1,5)

- 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

Tc-99m–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

Tc-99m – 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

Tc-99m – 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

Tc-99m – NOET
- Comparable to 210TI, 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)

<table>
<thead>
<tr>
<th>Radiopharmaceutical</th>
<th>Half-Life</th>
<th>Photon Energy (keV)</th>
<th>Image Technique</th>
<th>First Pass Extraction (%)</th>
<th>Sensitivity (CAD)</th>
<th>Specificity (CAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>201Thallium Chloride</td>
<td>72.912 h</td>
<td>69-80, 135, 167</td>
<td>88</td>
<td>92 %</td>
<td>90 %</td>
<td></td>
</tr>
<tr>
<td>99mTc-Sestamibi</td>
<td>6.01 h</td>
<td>140</td>
<td>66</td>
<td>89 %</td>
<td>66 %</td>
<td></td>
</tr>
<tr>
<td>99mTc-Tetrofosmin</td>
<td>6.01 h</td>
<td>140</td>
<td>SPECT</td>
<td>60</td>
<td>87,16 %</td>
<td>81,48 %</td>
</tr>
<tr>
<td>99mTc-Teboroxime</td>
<td>6.01 h</td>
<td>140</td>
<td>&gt; 90</td>
<td>Clinical Trials</td>
<td>Clinical Trials</td>
<td></td>
</tr>
<tr>
<td>99mTc-N-NOET</td>
<td>6.01 h</td>
<td>140</td>
<td>75 - 85</td>
<td>Clinical Trials</td>
<td>Clinical Trials</td>
<td></td>
</tr>
<tr>
<td>82Rb, 85Rb, 511In</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>13N-Ammonia</td>
<td>9,965 min</td>
<td>511</td>
<td>80</td>
<td>98 %</td>
<td>100 %</td>
<td></td>
</tr>
<tr>
<td>82Rubidium Chloride</td>
<td>76 seg</td>
<td>511</td>
<td>65</td>
<td>90 %</td>
<td>88 %</td>
<td></td>
</tr>
<tr>
<td>18F-O- Water</td>
<td>122.24 seg</td>
<td>511</td>
<td>100</td>
<td>Clinical Trials</td>
<td>Clinical Trials</td>
<td></td>
</tr>
<tr>
<td>18F-FDG</td>
<td>109.77 min</td>
<td>511</td>
<td>N.A</td>
<td>92 % recovery of regional function</td>
<td>63 % recovery of regional function</td>
<td></td>
</tr>
</tbody>
</table>

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

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