

Myocardial Perfusion Imaging

Pages with reference to book, From 1 To 2

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Myocardial perfusion imaging can safely be said to be the most widely used diagnostic procedure in the field of nuclear cardiology. Evaluation of patients with known or suspected ischemic heart disease is and will remain the main stay and major focus of activity in the field of nuclear cardiology. The history of myocardial perfusion imaging can be traced back to late sixties and early seventies when K-43¹ and other potassium analogues e.g. Cesium-129 (Ce- 129)² and Rubidium-81 (Rb-81)³ were used. However, clinical use of myocardial perfusion imaging gained widespread acceptance only after the introduction of Thallium-201 (Tl-201)⁴ yet another potassium analogue. Exercise Tl-201 myocardial scintigraphy has since then become an important non-invasive method for not only detecting but also evaluating the extent and severity of underlying coronary artery disease. Myocardial perfusion imaging with Tl-201 can be performed with either planer or tomographic (SPECT) imaging techniques. Planer imaging involves acquisition of images in multiple, mostly three views. SPECT images are acquired in a 180 degrees arc around the patient and subsequently reconstructed with the computer to study the relative distribution of tracer within the myocardium in various planes. The initial uptake of Tl-201 is proportional to the regional myocardial blood flow, being essentially linear at low and moderate flow levels⁴. However, at higher blood flow levels, it deviates from linearity. The clinical application of stress myocardial perfusion imaging for the detection of coronary artery disease is well established and documented. The sensitivity and specificity of planer Tl-201 stress imaging for detection of coronary artery disease by visual analysis has been reported to be 83% and 90% respectively⁵. This sensitivity is enhanced with the quantitation of initial myocardial distribution and washout of Tl-201. Though SPECT imaging increases the sensitivity to above 90%, this occurs at the expense of specificity which then ranges between 60-70%.⁵ Apart from the detection of coronary artery disease Tl-201 myocardial imaging has also been used for risk stratification⁶. The presence and extent of jeopardized viable myocardium reflected in transient (reversible) Tl-201 defects has been found to predict future cardiology events. Such patients have higher incidence of cardiac events during the follow-up than do patients with fixed (irreversible) defects. In addition, increased lung uptake of Tl-201, as an indirect marker of left ventricular dysfunction has been shown to have significant adverse prognostic implications. In patients with uncomplicated acute myocardial infarction, Tl-201 scanning with sub-maximal stress at the time of discharge, is reported to have greater sensitivity for predicting future cardiac events than exercise electrocardiography and coronary angiography⁷. Due to this established prognostic value in patients with coronary disease, Tl-201 perfusion imaging has been found to be of use in preoperative risk stratification and assessment of peri-operative risk in patients undergoing major non-cardiac surgeries, particularly peripheral vascular surgery⁸. Tl-201 dipyridamole imaging prior to peripheral vascular disease surgery can distinguish between patients at high risk from low risk for ischaemic peri-operative cardiac complications. Presence of transient (reversible) Tl-201 defects identifies patients at substantially increased risk of peri-operative cardiac events. Other applications of myocardial perfusion imaging are assessment of myocardial viability and detection of re-stenosis after coronary artery bypass surgery and angioplasty. Because of constraints imposed by its physical characteristic such as low energy (68-80 KeV) resulting in photon attenuation, long half life limiting the maximum injected dose to only 2-3 mCi, and need for it to be produced in a cyclotron, Tl-201 has all along been considered to be a rather poor tracer for gamma camera imaging. This has consequently stimulated the development of Technetium-99m (Tc-99m) labelled agents which are presently being considered to be the optimal isotope for imaging. Tc-99m hexakis, 2 methoxyisobutyl isonitrilic (Sestamibi)⁹ is a member of

isonitrile family exhibiting the best characteristics among all the members of family. Like Tl-201, the initial myocardial accumulation is proportional to regional blood flow. However, once in myocardium it exhibits little redistribution over time. Because of initial high liver uptake, which clears rapidly, images are optimally acquired between 1-2 hours after injection. Since Sestamibi concentrates in myocardium and does not undergo significant redistribution, two separate injections are required to distinguish stress induced defects from resting defects. Different protocols have been designed for the acquisition of these studies.^{10,11} These include 2 day protocol (Rest-Stress or Stress-Rest) and same day protocol. The ideal protocol is needed to be tailored according to the need of individual institution. The diagnostic accuracy of Tc-99m Sestamibi for the detection of coronary artery disease has been compared with that of Tl-201 and similar sensitivity and specificity has been found with planer imaging¹². When SPECT imaging was used, similar sensitivity and a trend toward higher specificity has been found with Sestamibi.¹³ The finding of similar sensitivity and specificity for Sestamibi and Tl-201 is somewhat surprising given the improved physical characteristic of Tc-99m over Tl-201 and higher image quality obtained by the former agent. However, in most of the studies the scintigraphic acquisition were not randomized between Sestamibi and Tl-201. Moreover, most studies have included only small numbers of highly selected patients. All studies used a visual qualitative analysis of images. Improved results with Sestamibi are likely to emerge with quantification. Tc-99m tetrofosmin is a neutral lipophilic compound belonging to a family of compounds known as boronic acid technetium dioxime compounds (BATO compounds)¹⁴. It undergoes rapid blood clearance after injection and has myocardial extraction intermediate between that of Tl-201 and Sestamibi. It has short myocardial residence time and washes off rapidly thus necessitating the acquisition of images immediately (within 1 or 2 minutes) after stress. Myocardial tetrofosmin uptake has an excellent correlation with microsphere assessed coronary artery blood flow. The linearity between tetrofosmin and coronary blood flow appears to hold even during large increase in coronary blood flow¹⁵. Tc-99m Tetrofosmin is the newest agent used in perfusion imaging¹⁶. This agent demonstrates faster hepatobiliary clearance than Sestamibi which may be an advantage for clinical imaging as it may allow an earlier imaging after injection of radiopharmaceutical than is possible with Sestamibi. It is not, however, still approved for clinical use in USA. The availability of newer agents have evoked considerable debate about the best available choice. All have their definite advantages and disadvantages. At present the available data do not conclusively demonstrate superiority of one agent over other. Sestamibi provides images of higher quality than those produced by Tl-201 and can be used for diagnostic purpose interchangeably with Tl-201. One distinct advantage of Sestamibi is its role in the assessment of thrombolytic therapy. Rapid planer imaging with Tetrofosmin appears to provide same diagnostic information as Tl-201 planer imaging. However, more studies are needed to define its distinct role. One main advantage of Tl-201 over Tc-99m labelled agents is its great experience worldwide backed by a wealth of data that has established its diagnostic and prognostic value. This has been further enhanced by its potential of detection of viable jeopardized myocardium. While Tc-99m labelled agents have similar diagnostic efficacy as Tl-201, it remains to be seen whether all prognostic indicators validated with respect of Tl-201 will apply to these newer agents.

References

1. Hurley, P.J., Cooper, M., Reba, R.C. et al. KCL-43 a new radiopharmaceutical for imaging the heart. *J. Nucl. Med.*, 1971;12:516-19.
2. Romhilt, D.W., Adolph, R.J., Sodd, J.V. et al. Cesium-129 myocardial scintigraphy to detect myocardial infarction. *Circulation*, 1973;48:1242-51.
3. Martin, ND., Zaret, B.L, McGowen, R.L et al. Rubidium-81. A new myocardial scanning agent.

Radiology, 1974;111:651-56.

4. Strauss, H.W., Harrison, K., Langer, I.K. et al. Thallium-201 for myocardial imaging. Relation of Thallium-201 to regional myocardial perfusion. *Circulation*, 1975;51:64 1-45.
5. Zaret, B.L., Wackers, F.J.I. and Soufer, R. Nuclear Cardiology. In: Braunwald E (Ed). Heart disease: a text book of cardiovascular medicine. 4th ed. Vol. I Philadelphia, W.B. Saunders. 1992, pp. 276-311.
6. Brown, K.A., Boucher, C.A., Okada, R.A. et al. Prognostic value of exercise thallium-201 imaging in patients presenting for evaluation of chest pain. *J.Am.Coll.Cardiol.*, 1983;58:423-27.
7. Gibson, R.S., Waston, D.D., Craddock, C.B. et al Prediction of cardiac events after uncomplicated myocardial infarction: a prospective study comparing predischage exercise thallium-201 scintigraphy and coronary angiography. *Circulation*, 1983;68:321-27.
8. Boucher, C.A., Brewster, D.C., Darling, R.C. et al. Determination of cardiac risk by dipyridamole-thallium imaging before peripheral vascular surgery. *N. Engl. J. Med.*, 1985;312:389-94,
9. Wackers, F.J.T., Berman, D.S., Maddahi, J. et al. Technetium-99m hexakis, 2 methoxyisobutyl isonitrile: human biodistribution, dosimetry, safety and preliminary comparison to Tl-201 for myocardial perfusion imaging. *J. Nucl. Med.*, 1989;30:301-11.
10. Taillefer, R., Gagnon, A., Laflamme, L., et al. Same day injection of Tc-99m methoxy isobutyl isonitrile (bexamibi) for myocardial tomographic imaging: comparison between rest-stress and stress-rest injection sequences. *Eur. J. Nucl. Med.*, 1989;15:113-17.
11. Neto, B.S., Coleman, R.E., Johns, R.H. et al. Perfusion and function at rest and treadmill exercise using Technetium-99m sestamibi: Comparison of one and two-day protocols in normal volunteers. *J. Nucl. Med.*, 1990;31:1128-32.
12. Najm, Y.c., Maisey, M.N., Clarke, S.M. et al. Exercise myocardial perfusion scintigraphy with Technetium-99m isobutyl isonitrile: a comparative study with Thallium-201. *Int. J. Cardiol.*, 1990;26:93-101.
13. Kit, H., Maddahi, J., Roy, L.T. et al. Comparison of Technetium-99m methoxy isobutyl isonitrile and Thallium-201 for evaluation of coronary artery disease by planar and tomographic methods. *Am. Heart J.*, 1989; 117:1-11.
14. Seldin, D.W., Johnson, J.J., Blood, D.K. et al. Myocardial perfusion with Technetium-99m SQ.30217. Comparison with Thallium-201 and coronary anatomy. *J. Nucl. Med.*, 1989;30:312-19.
15. Bearland, R., Muzik, O., Nguyen, N. et al. The relationship between myocardial retention of Technetium-99m tetrofosmin and myocardial blood flow. *J. Am. Coll. Cardiol.*, 1992;20:712-19.
16. Jain, D., Mattern, J.A., Sinusas, A. et al. Biokinetics of Tc-99m tetrofosmin, a new myocardial perfusion imaging agent: implications of one day imaging protocol. *J. Nucl. Med.*, 1992;33 Suppl 874. (Abstract).