Thallium-199: a new radiopharmaceutical for myocardial perfusion imaging

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Abstract

The efficacy of a new radionuclide, thallium-199 for myocardial scintigraphy was compared with conventional thallium-201 imaging. Owing to the short half-life of thallium-199 (7.4 hours), when the injected dose of thallium-199 was increased to 200 MBq, the total dose reaching the critical organs was 3.6–15.5 times lower than with conventional nuclide, thallium-201. Studies were performed in a total of 177 patients. The patients were divided into two groups (a) 17 patients with acute myocardial infarction and (b) 160 patients undergoing coronary angiography: 55 patients with no significant coronary artery disease and 105 patients with coronary disease. The sensitivity of the test was 92% with a specificity of 82% and overall predictive accuracy of 84%. Myocardial images obtained with low and high energy collimators have similar predictive accuracy. Perfusion defects were detected more frequently with increasing severity of angina. Myocardial infarction was characterized by persistent defects and myocardial ischaemia by redistribution of thallium. Thallium-199 myocardial scintigraphy performed at rest can be used for the diagnosis of acute myocardial infarction and for the determination of infarct site and extent. Thallium-199 is a new myocardial imaging agent, with a predictive accuracy for the diagnosis of coronary artery disease similar to thallium-201, but a significantly reduced total body dose permits repeat studies with a reduced radiation dose for the patient.

Introduction

Thallium-199 is a new myocardial imaging agent for the assessment of myocardial perfusion. Images obtained are indistinguishable from scans obtained with thallium-201, allowing the performance of high quality stress and redistribution myocardial images [1].

Thallium-199 is the main by-product of the bombardment of gold foil by alpha particles, which may be generated by low energy accelerators, with an initial energy of 27–28 MeV. Purification of thallium-199 chloride is rapid, taking approximately 50 min (thallium-200 content less than 1.5%, other nuclides less than 0.01%) and the gold foil may be reused on multiple occasions. Data is available demonstrating the stability of the isotope over 14 hours, thereafter the thallium-200 content rises to approximately 4%. Thallium-199 has a half-life of 7.4 hours, resulting in significant reduction in the dosage of radiation to the patient. Even with the higher concentration of thallium-200 (4%), the total body dose is only approximately 20% of that with thallium-201. This has obvious advantages for the patient’s safety and thus allows repeat studies to be performed.

Thallium-201 imaging is an established technique for the evaluation of myocardial perfusion [2, 3]. However, this isotope suffers from various disadvantages, including a relatively long physical half-life (and thus a high patient radiation dose) and high cost. Thallium-199, with its advantages to the patient’s safety with reduced radiation dose and the ease of production, is a novel agent with obvious potentials for the assessment of myocardial perfusion.

Initial data suggests that the radiokinetic properties of thallium-199 are similar to those of thallium-201. Preliminary spectrophotometric and phantom data con-
firm that images can be obtained using standard Gamma camera [4]. We report on our initial clinical experience with this isotope for the assessment of patient with coronary artery disease, and a comparison with standard thallium-201 imaging.

Method

Isotope preparation

Thallium-199: The methodology has previously been described in detail, but in brief, gold foil is bombarded with alpha particles, which may be produced in a low energy cyclotron (27–28 MeV) [5]. The foil is then heated and the by-products dissolved in a 0.9% solution of sodium chloride. This gives a relatively pure form of the isotope, with thallium-200 content of less than 1.5% and other nuclides less than 0.01%. The isotope is stable over 14 hours, with a maximum content of 4% thallium-200 at that time [6].

Thallium-201 was obtained from the Kazakh Institute of Nuclear Physics, where this radiopharmaceutical was produced using standard technology [7].

Patients population

Studies were performed in a total of 177 patients, of whom 112 were men and the ages ranged from 37 to 79, with the mean of 50 years. The patients were divided into two groups (a) 17 patients with acute myocardial infarction and (b) 160 patients undergoing coronary angiography.

Patients with myocardial infarction
Seventeen patients, 15 males aged 37–79 years (mean age 59 years), were imaged within 48 hours of onset of chest pain. The diagnosis of myocardial infarction was based on typical symptoms, electrocardiographic change with confirmation from cardiac enzymes and technetium-99 pyrophosphate scans [8]. Pyrophosphate scans were obtained 24–48 hours following the thallium-199 image using 400 MBq of technetium in anterior, 45-degree left anterior oblique and left lateral projections using an Omega 500 Gamma camera (Technicare) fitted low energy collimator. Scans were analysed by two experienced observers unaware of any other clinical findings.

160 patients underwent coronary angiography
Ninety-seven were male and the age range was 39–58 years (mean 50 years). Coronary angiography was performed by the Judkins technique and angiograms were analysed by two independent observers unaware of any other clinical findings. A 50% reduction in luminal diameter of any major coronary artery was considered significant. Using this criterion, 55 patients were found to have no significant coronary artery disease. Of the 105 with coronary disease, 31 had single vessel disease, 29 had two vessel disease, 36 had three vessel disease and 9 had left main disease. Thirty-six patients had electrocardiographic and clinical evidence of previous myocardial infarction; in 19 the site was anterior, 10 inferior and 7 posterior. All patients had stable angina pectoris and no patient had associated valve disease, congenital abnormalities or uncontrolled hypertension. Patients were examined prior to being commenced on appropriate drug therapy.

Informed written consent was obtained from each patient and the study was approved by Pharmacology Committee of Ministry of Health of Russia.