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Clinical Applications of Myocardial Metabolic Imaging

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Abstract

To maintain mechanical function, the heart requires a high rate of oxygen intake in order to give enough energy to balance the mechanical function's demands. When the oxygen supply is insufficient to meet the demand, metabolic alterations can occur, both reversible and permanent. In Coronary Artery Disease (CAD), where oxygen delivery is restricted due to severe stenosis or occlusion of major coronary arteries, such an imbalance is most common. Energy is also necessary to preserve the potential to regulate ion concentration in the cells in the membrane.

The myocardium's principal energy sources are glucose and free fatty acids, both of which require enzyme conversion before being broken down. The term "substrate" can be used to denote "heart fuel." The heart's ability to absorb various substrates is influenced by the fuel's arterial concentration. Due to the suppression of glucose oxidation in the fasting state, where plasma free fatty acids are high, free fatty acid absorption in the heart is similarly high. When glucose and/or insulin levels are high, such as in the post-prandial state, glucose oxidation increases but fatty-acid utilisation is suppressed. Chemical energy is converted into mechanical energy by the myocardium [1]. Because metabolism and heart function are intricately intertwined, energy substrate metabolism could be a possible target of such innovative medicines to enhance failing heart function [2].

Metabolic Imaging

Metabolic imaging with single photon emission tomography (SPECT) and positron emission tomography (PET) have been widely used for the evaluation of pathophysiology of CAD and heart failure. fluorodeoxyglucose (FDG) is a glucose analogue (one hydroxyl group is replaced with a F) that is used to assess myocardial glucose utilisation. F In proportion to glucose, FDG enters the myocyte. Unlike glucose, F FDG-6-phosphate is metabolically sequestered by the myocyte after phosphorylation. As a result, the rate of exogenous glucose utilisation is reflected by F FDG myocardial absorption.

The absorption and metabolism of long-chain fatty acids are reflected in myocardial C palmitate kinetics. After C palmitate is etherified to acyl-coenzyme A (acyl-CoA), a fraction enters the mitochondria via the carnitine shuttle. Following that, -oxidation breaks down long-chain fatty acids into two-carbon fragments, which are then oxidised via the tricarboxylic acid (TCA) cycle and released as 11C carbon dioxide from the myocardium (CO2). 15-(p-[iodine-123] iodophenyl) pentadecanoic acid (IPPA) is a straight-chain fatty acid that is promptly eliminated from the myocardium as iodine-123 benzoic acid. 15-(p-[iodine-123] iodophenyl)-3-(R,S) methyl-pentadecanoic acid (BMIPP) is a methyl branched-chain fatty acid with a modified branched chain. The activation of fatty-acid metabolism by CoA is reflected in BMIPP absorption in the myocardium, which indirectly indicates cellular adenosine triphosphate (ATP) generation.

The TCA cycle's turnover rate represents the total pace of cardiac oxidative metabolism. C acetate is nearly completely metabolised to CO2 via the TCA cycle. In the mitochondria, acetate is transformed to acetyl–CoA, which subsequently enters the TCA cycle. Almost majority of the acetate extracted by the myocardium (80%–90%) is oxidised. C clearance from the heart represents oxidative metabolism's 11CO2 generation as well as cardiac oxygen demand (MVO2).

C acetate PET, when combined with a non-invasive measurement of cardiac function (such as echocardiography or magnetic resonance imaging [MRI]), can be used to examine myocardial energetics and efficiency, as shown in the equation below:

WMI = SVI x SBP x HR/k, where WMI is the work metabolic index, SVI is the stroke volume index determined by echocardiography or MRI, SBP is systolic blood pressure, HR is heart rate, and k is the mono-exponential (kmono) rate constant for 11C clearance from the myocardium following 11C acetate administration.

Conclusion

This method has become a blossoming and booming specialism in China, with rising uses of MRI in numerous perspectives. In the year 2000, the Chinese Society of MRI in Medicine was founded as a platform for communication among Chinese radiologists and allied professionals with the goal of improving understanding and implementation of sophisticated MRI techniques.

As a result, there is a growing need in China to compile and publish a national MRI guideline that includes scanning sequence selection, examination method standardisation, and diagnostic guidance. To offer evidence for the use of MRI guidelines in clinical practise, a prospective, multi-center study might be done. Fortunately, the Chinese Ministry of Health has approved and is implementing a large-scale project to produce a national MRI guideline.

Furthermore, the best use of the newly developed quantitative MRI parameters in clinical practise necessitates a thorough systemic evaluation, which includes matching modalities to the most appropriate physiologic parameters, assessing the ability to standardise modalities and algorithms across multiple platforms and institutions, and validating quantitative MRI parameters as the most appropriate imaging biomarkers against histological and immunological data.

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