MYOCARDIAL MICROINFARCT MEASURMENTS ON MRI, MDCT AND HISTOPATHOLOGY

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Objectives

Measurement of large homogeneous infarct on delayed contrast enhanced (DE) MR and CT has been validated experimentally against hstopathological morphometry prior to their application in patients. Experimental MR and CT studies on large homogeneous infarct showed that the size of differentially enhanced infarct is closely related to histopathology. On the other hand, measurement of microinfarct using currently available diagnostic modalities is limited by their low spatial resolution. The objectives of this study were to use DE-MRI and DE-MDCT imaging and light microscopy, as a gold standard method, to determine the relationship and the limits of agreement for measuring myocardial microinfarct.

Methods

Coronary artery microembolization was performed in 14 pigs, under X-ray fluoroscopy. Animals received either $16mm^3$ (n=7) or $32mm^3$ (n=7) of 40-120µm microemboli. The volumes of microemboli matched that recovered from patients using distal filtration devices (1). The volumes were calculated using the following equation: $V=(4*\pi*r^3)/3$, where r is the mean radius of microemboli is 80µm. Pathologists found at autopsy that 89% of microemboli are lodged in coronary microvessels that are less than 120µm in diameter and 73% of these microemboli are recovered from the territory subtended by the LAD coronary artery (2). Clinical MRI (1.5T) and MDCT (64-slice) scanners were used 3 days after microembolization to measure microinfarct size. MR Gd-DTPA (0.15mmol/kg) and CT iohexol (350mg/ml) contrast media were used to enhance microinfarct, which was measured by semi-automatic threshold method (+3SD of remote myocardium) using *ImageJ*. Light microscopy was used for measurement of microinfarct size and area at risk of microeinfarction (AAR). Histopathologic slides (5µm) were prepared from 3 short-axis LV rings (~ 8mm, 16mm and 24mm from the apex) and stained with H&E stain. The slides were photographed under light microscopy using *NIS Elements-F* and assembled into a single image using *Adobe Photoshop CS4*.

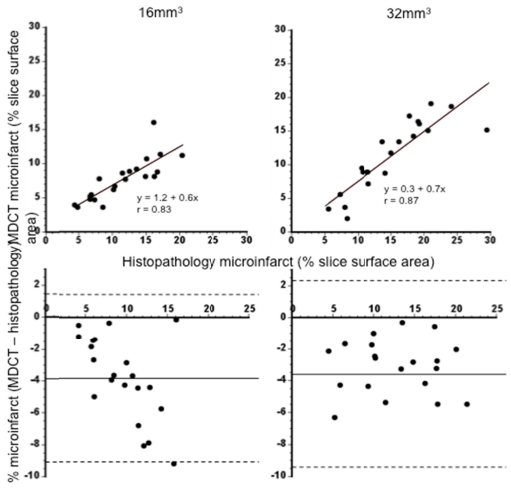
Results

DE-MRI and DE-MDCT images showed heterogeneous enhancement pattern randomly distributed across the territory subtended by the LAD coronary artery. The pattern of enhancement of microinfarct differs from the principle of the large homogeneous infarct wave-front pattern initiated in the endocardium postulated by Reimer et al (3). Microinfarct/remote myocardium signal intensity/attenuation ratio after delivering 40-120µm microemboli was similar to homogeneous large infarcts (1.6±0.1 versus 1.6±0.2) (4).

The table below shows the area at risk of microinfarction and microinfarct size on MRI, MDCT and histopathology. There was no significant difference in the extent of the territory subtended by the LAD coronary artery (area at risk of microembolization) on histopathology between animals that received $16mm^3$ and received $32mm^3$ volume**.** DE-MRI and DE-MDCT systematically underestimated both the area at risk of microinfarction and microinfarct size compared with histopathology. The figure below shows the close relationship between MRI, MDCT and histopathology in measuring the microinfarct sizes, while Bland-Altman analysis demonstrates the bias ± 2SD for quantifying microinfarction size.

Microemboli Volumes	Area at risk (AAR) of microembolization	Microinfarct size
MRI		
$16mm^3$	33±2* (-21%)	7.8±0.6* (-25%)
$32mm^3$	34±2* (-11%)	11.9±0.3*+ (-17%)
MDCT		
$16mm^3$	32±1* (-24%)	7.2±0.6* (-31%)
$32mm^3$	32±1* (-13%)	10.7±1.0*+ (-23%)
Histopathology		
$16mm^3$	42±2	10.5±0.9
$32mm^3$	38±2	14.3±0.9+

All data of microinfarct size and AAR were obtained from 3 apical slices within the microinfarcted region. *P<0.01 compared to histopathology, +P<0.01 compared to $16mm^3$ microemboli volume.



Mean of % microinfarct measured on MDCT and histopathology

Discussion and Conclusions

Major cardiology and interventional societies in the United States recently acknowledged the deleterious effects of coronary microemboli on LV function and arrhythmia (5). Kwong et al demonstrated that infarct of less than 2% of LV mass causes adverse cardiac effects (6). Our cardiac MRI and MDCT imaging data showed systematically underestimation of true microinfarct size and area at risk of microinfarction compared with the gold-standard histopathology. Thus, the underestimation of microinfarct should be considered in evaluating microinfarct on MRI and CT. The underestimation is related to multiple factors, namely difference in spatial resolution between the imaging modalities and light microscopy, mismatch between the slices obtained for each modality and histopathology and volume averaging effect (5mm versus 5µm).

References

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