Triple Inversion Recovery Imaging of Myocardial Infarction

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Introduction

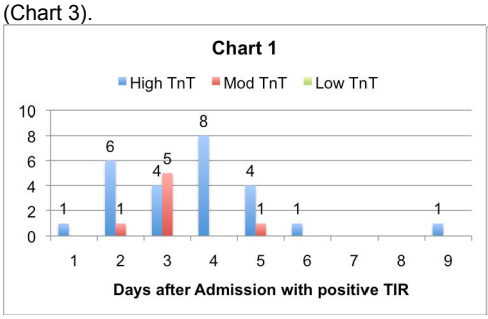
Triple inversion recovery (TIR) black blood sequences were developed to provide short-tau inversion recovery (STIR) imaging of the myocardium improving the identification of increased tissue water content while minimizing cardiac motion artifacts (1). While delayed contrast enhancement cardiac MR (DE-MR) of the myocardium is the current gold standard for determining the viability of myocardium, acute myocardial infarction (MI) can be also identified with the TIR sequence (1). DE-MR requires intravenous administration of gadolinium chelates, which may be contraindicated in patients with severe renal disease due to the association of GBCA in the development of nephrogenic systemic fibrosis (NSF) (2). The goal of this study was to determine whether TIR imaging could accurately identify the extent of non-viable myocardium relative to DE-MR and provide a non-contrast viability alternative in patients with severe renal disease in the setting of acute myocardial infarction.

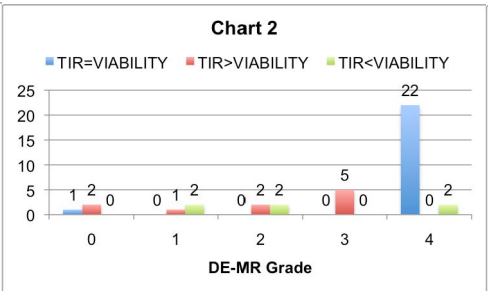
Methods

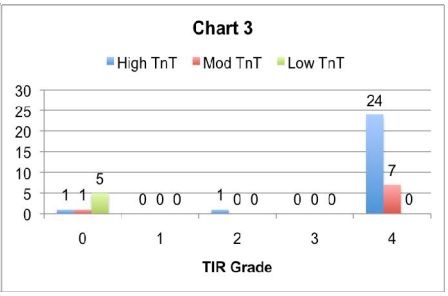
We retrospectively reviewed consecutive cardiac MR studies obtained for myocardial viability during 2009. Only patients with new onset of chest pain within 14 days of admission were included. The MR studies were performed on a 1.5 Tesla magnet utilizing a multichannel cardiac surface coil. The TIR was performed in the left ventricular short axis with breath-hold 2D triple inversion-recovery fast spin-echo sequences (TR=2 RR, TE 80 msec., Inversion Time= 551msec., Voxel size=0.68 x 0.68 x 8mm). DE-MR was performed with breath-hold 2D inversion-recovery T1-weighted gradient-echo sequences (TR=3.8 msec., TE 1.6 msec., Flip angle=15 degrees, Voxel size=1.3x1.3x10mm). Patients with glomerular filtrations rates (GFR) greater than 30 mL/min/1.73m2 were administered 0.1mmol/kg Gd-BOPTA. Following the intravenous administration of contrast, a short axis view of the mid left ventricle was obtained with a range of inversion times. The optimal inversion time was selected when signal of the majority of the myocardium was nulled. This was followed by a set of short axis viability images from the base of the left ventricle to the apex at a minimum of a 10-minute delay. The presence of contrast enhancement or TIR hyperintensity greater than adjacent liver, which involved the subendocardium was defined as an infarct pattern. The transmural extent of MI defined by DE-MR and TIR hyperintensity was graded by visual inspection: 0-25%=grade 1, 26-50%=grade 2, 51-75%=grade 3, 76-100%=grade 4. The coronary artery distribution of abnormal myocardium was recorded for each sequence and correlated with the coronary catheterization findings demonstrating the coronary artery stenosis greater than 70%, thrombus and reduced perfusion. The ECG, Troponin-T (TnT) levels, elapsed time from symptoms to therapeutic intervention and from time of admission to DE-MR were recorded for each subject. The TnT levels were designated as high if greater than 1.0ng/mL, moderate if less than1.0ng/mL but greater than 0.1ng/mL and low if less than 0.1ng/mL.

Results

A total 39 patients met inclusion criteria (25 males, 14 females, average age =55 years). 38 patients (97%) had ECG evidence of ST elevation on admission and 36 (95%) were confirmed to have corresponding severe coronary artery disease on catheterization. 1 patient (3%) with non-ST elevation had occlusion of the circumflex artery on catheterization. The electrocardiogram matched the distribution of MR abnormalities in 38 patients (97%). A total of 5 patients had low TnT, 8 with moderate TnT and 26 with high TnT. A total of 36 patients had DE-MR abnormalities and 32 patients had TIR abnormalities. 38 patients (97%) had abnormality on either TIR or DE-MR or both. Only 1 patient (3%) had no abnormalities on the TIR or DE-MR and was noted to be reperfused within 90 minutes of symptoms. 2 patients (7%) were noted to have transmural abnormalities on TIR with no corresponding DE-MR abnormalities and were noted to be reperfused at 2 and 3 hours from time symptoms, respectively. 26 grade 3 or 4 DE-MR lesions (67%) had corresponding grade 4 TIR signal in the presence of only moderate or high TnT (p=0.78). CE-MR studies were performed from 1 to 9 days after admission with abnormalities seen on TIR sequence seen up to 9 days (Chart 1). There were no patients with low TnT with TIR abnormalities (see Chart 1). 22 patients (56%) had matching grade 4 abnormalities (Chart 2) and had moderate or high TnT levels. 6 patients (15%) in which the DE-MR abnormality was greater than the TIR had grade 1 or 2 abnormality or low TnT. A total of 3 patients had grade 4 TIR abnormalities compared to grade 0 or 2 on DE-MR and was identified in patients with moderate TnT. A total of 32 patients (82%) with TIR abnormality had moderate or high TnT levels (Chart 3).







Discussion/Conclusion

DE-MR is the technique of choice for prognosis and preoperative evaluation prior to revascularization procedures in patients with known myocardial ischemia/infarction and can determine the likelihood of benefit from coronary artery bypass (3). This technique however, has become restricted in patients with renal dysfunction (2). To bridge this gap we evaluated the ability of a non-contrast sequence (TIR) to determine the transmural extent of MI in a population of patients with acute chest pain.

Our study shows that TIR abnormalities are present up to 9 days after acute onset of chest pain in patients with high TnT levels and up to 5 days in patients with moderate TnT levels indicating that myocardial edema persists during the typical course of initial hospitalization.

Our data shows that grade 4 TIR correlated with acute high-grade (grade 3 and 4) MI in 67% of patients. TIR imaging, however, has a tendency compared to DE-MR to increase the grade of acute MI, potentially altering management in 8% of the patients with low-grade (grade 1 and 2) MI with corresponding high-grade TIR abnormalities. We attribute this tendency to the presence of reversible myocardial edema in the viable peri-infarct region (4). The absence of TIR abnormalities in 18% of patients was only associated with grade 1 or 2 acute MI, chronic MI as indicated by low TnT or rapidly treated acute ischemia. Thus the absence of TIR findings in patients with initial cardiac symptoms with moderate or high levels of TnT, suggests low-grade or absent infarction and the possibility of a good functional outcome in the distribution of abnormal catheterization and ECG findings. TIR imaging alone however, cannot adequately predict viability in patients with chronic MI.

An unexpected finding in this study was the discovery of 1 patient where reperfusion occurred within 1.5 hours of symptoms and which there were no abnormalities on either DE-MR or TIR. This case suggests that even more rapid reperfusion may also prevent reversible myocardial edema and implicate a timing threshold for optimal therapeutic intervention. A larger series of cases, however, will be needed to verify this finding.

References:

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