Comparison between MRI & MCE in predicting myocardial viability in acute myocardial infarction

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Comparison between MRI & MCE in predicting myocardial viability in acute myocardial infarction

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Abstract

Comparison between MRI & MCE in predicting myocardial viability in acute myocardial infarction

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Background: The aim of this study was to compare the diagnostic accuracy between contrast enhanced Magnetic Resonance Imaging (MRI) and myocardial contrast echocardiography (MCE) in predicting myocardial viability after acute myocardial infarction (AMI). Also, we wanted to determine the transmural extent of delayed hyperenhancement in cardiac MRI which could optimally predict improvement in contractile function.

Method: Twenty-one patients who presented with first attack of myocardial infarction and successfully revascularized underwent MRI and MCE within 7 days. The two-dimensional (2D) echocardiography was performed to assess wall motion abnormality after successful revascularization and repeated to assess wall motion recovery 8 weeks later. The transmural extent of infarction and wall motion recovery were determined using a 16 segment model.

Results: Improvement in segmental contractile function was inversely related

to the transmural extent of delayed hyperenhancement in MRI. Transmural extent of delayed hyperenhancement less than 50% of the whole wall thickness predicted myocardial viability with 82.4% of sensitivity and 90.7% of specificity. Perfusion analysis with MCE predicted myocardial viability with 86.3% of sensitivity and 59.3% of specificity.

Concordance between MCE and MRI for the identification of myocardial viability was 78.3% (kappa = 0.42).

Conclusion: Both the cardiac MRI and the MCE showed comparable sensitivity but MRI showed superior specificity in predicting myocardial viability compared to MCE. The judicious use of either modality with consideration for issues such as the cost of examination and the patient status will be helpful in assessing the effectiveness of therapy and prognosis in patients with acute myocardial infarction.

Keywords: acute myocardial infarction, myocardial viability, MRI, delayed hyperenhancement, MCE, perfusion defect

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I. Introduction

The recognition of stunned myocardium early after acute myocardial infarction (AMI) has important prognostic and therapeutic implications.[1] Diagnostic modalities such as nuclear stress imagings and the dobutamine stress echocardiography have been used extensively for clinical assessment of myocardial viability. Recently, due to their superior resolution and sensitivity, extensive researches are being done regarding the use of magnetic resonance imaging (MRI) and myocardial contrast echocardiography (MCE) for the clinical assessment of myocardial viability.

Contrast-enhanced magnetic resonance imaging(MRI) using an extracellular contrast agent such as gadolinium-diethylenetriamine pentaacetic acid

(Gd-DTPA) has been applied extensively for the evaluation of myocardial injury after AMI.[2-5] In a recent series of studies using canine infarction models, it has been shown that hyperenhancement on T1-weighted delayed contrast-enhanced magnetic resonance imaging (DCE-MRI) only occurred in necrotic, irreversibly injured myocardium, irrespective of the age of the infarct.[6-7] The high signal intensity is related to a regionally increased concentration of the contrast agent, most likely caused by ischemia-related changes in the volume of distribution and contrast kinetics.[8-10] The regional extent of hyperenhancement has been shown to predict functional improvement of stunned myocardium, both in a canine model and also, recently in patients with reperfused myocardial infarction (MI).[4,5,11] However, evidence is still limited, and earlier reports have produced conflicting results on the significance of contrast patterns after MI. Several investigators have demonstrated that the hyperenhanced region overestimates the actual necrotic region, and that it contains residual viable myocardium that may recover function when adequately reperfused. [2,12,13]

With myocardial contrast echocardiography (MCE), viability is assessed by defining the presence or absence of an intact microcirculation. Following successful reperfusion of an infarct-related artery, exclusion of microbubbles from regions of microvascular disruption forms the basis for the “no reflow”

or “low reflow” zones. Accordingly, the degree of contrast enhancement following reperfusion can be used to determine the extent of viability.[14]

MRI and MCE both have certain inherent advantages and disadvantages when used for assessment of myocardial viability in AMI. The advantage of using MCE is that the easy access to the examination allows for the examination to be performed at bedside at any time with relative ease. The disadvantage is that the examination would be difficult in patients with poor echo window. The advantage of using cardiac MRI is the high resolution and excellent quality of the images that are obtained. The disadvantages are its high cost and inflexibility in scheduling the examination due to the length of the examination along with limitation in the number of machines available. Also, MRI may not be performed in certain subset of patients with contraindications such as claustrophobics or hemodynamically unstable patients. Furthermore, the relationship between delayed hyperenhancement and myocardial viability is still controversial and studies regarding the degree of hyperenhancement that optimally predicts myocardial viability has yet to be reported. Therefore, in this study, we sought to determine the assessment of delayed hyperenhancement in cardiac MRI and perfusion defect in MCE, performed early after coronary intervention in patients with AMI, for predicting the recovery of systolic function and determining myocardial viability. Also, we wanted to compare the sensitivity and specificity of the

examination and determine the clinical feasibility of the examinations as diagnostic tools.

II. METHODS AND MATERIALS

Study design

Patients who presented with first attack of myocardial infarction and successfully revascularized underwent MRI and MCE within 7 days. MRI and MCE were performed to assess delayed hyperenhancement and microvascular integrity. The two-dimensional (2D) echocardiography was performed to assess wall motion abnormality after successful revascularization and repeated to assess wall motion recovery 8 weeks later.

Patient population

Patients were eligible for the study if they were admitted with AMI according to standard electrocardiogram (ECG) and enzymatic criteria. Only patients with evidence of successful reperfusion were included. Exclusion criteria were hemodynamic instability, any relative or absolute contraindications for MRI examination, underlying cardiomyopathy, valvular heart disease and recurrent myocardial infarcion. Twenty-one patients were enrolled. The clinical characteristics of the patients are listed in Table 1.

(Table 1) Patient Characteristics

Number of patients : 21

Number of Male : 17

Mean Age (yrs) : 58 ± 11

Ejection fraction baseline (%) : 51 ± 9

Primary PTCA : 13

Infarct related artery : LAD – 12, LCx – 3, RCA – 5, Vasospasm – 1

Days between symptoms to PTCA : 3 ± 2

Days between PTCA and MRI : 7 ± 3

Days between PTCA and MCE : 6 ± 3

(PTCA : Percutaneous transluminal coronary angioplasty , LAD : Left anterior descending artery, LCx : Left circumflex artery, RCA : Right coronary artery)

MRI

All MRI procedures were performed with the patient in supine position in a 1.5-T clinical scanner (Intera, **Ph**ilips, Netherlands) using a five-element phased array cardiac receiver coil. The ECG-gated images were acquired during repeated breath-holds of varying duration depending on heart rate (~18 s). Cine images using a segmented gradient-echo sequence (10-mm slice thickness) were obtained in multiple short-axis views every 10 mm covering

the whole left ventricle (LV). Ten to 15 min after injection of a gadolinium-based contrast agent (Omniscan, Nycomed, Cork, Ireland; 0.2 mmol/kg) DCE images were acquired in the same orientation as the cine images using a segmented inversion-recovery gradient-echo pulse sequence (repetition time/echo time ≒ 5.4/1.6 ms, flip angle 15°, matrix 512 * 512 and a typical voxel size of 0.68 * 0.68 * 10 mm, inversion time [TI] 250 to 300 ms). The baseline study was performed 7 ± 3 days after admission, with follow-up at 13 ± 3 weeks. The DCE images were acquired only during the baseline study.

MCE

Real time MCE was performed using a Sonos 5500 ultrasound system (Philips Ultrasound, Andover, Massachusetts) with transmission and receiving frequencies of 1.0 and 3.0 MHz, respectively. Images were acquired in the apical two-, three-, and four-chamber views. The minimal mechanical index less than 0.3 was used and the acoustic focus was placed at the level of the mitral valve and adjusted to the apex when needed to exclude near-field artifacts. A dynamic range of 20 dB was used and compression was set at 80. For each patient, settings were kept constant for all stages. After acquisition of baseline images, PESDA (perflourocarbon-exposed sonicated dextrose albumin) was administered intravenously as a continuous infusion

(0.5 ml·min_1) and adjusted to produce optimal opacification without far-field attenuation. After high mechanical index (≥ 1.5) bursting of microbubbles real time images were acquired to allow incremental replenishment of microbubbles into the tissue in the ultrasound imaging sector following each high-power pulse.[15]

2D echocardiography

Wall motion was assessed by 2D echocardiography in the apical two-, three-, and four-chamber imaging planes. Wall motion was assessed using tissue harmonic imaging before contrast infusion.

Data analysis

The transmural extent of infarction and wall motion recovery were determined using a 16 segment model. For analysis of the images in MRI, the transmural extent of delayed hyperenhancement (TEH) was manually measured and calculated by dividing the hyperenhanced area by the total area of the predefined segment. The transmural extent of delayed hyperenhancement (THE) was then scored as follows: 1 = 0%, 2 = 1% to 25%, 3 = 26% to 50%, 4 = 51 to 75%, 5 = 76% to 100% hyperenhancement.[4]

Myocardial perfusion in MCE was analyzed by the following method. Scores were graded as 2 = normal (full enhancement of myocardium with microbubbles at the 10th endsystolic cardiac cycle after high mechanical bubble destruction), 1 = reduced (partial or reduced opacification compared with the normal), or 0 = absent (no opacification)

Resting wall motion in each segment at 2D echocardiography was scored as 1 = normal, 2 = mild to moderate hypokinesis, 3 = severe hypokinesis, 4 = akinesis or 5 = dyskinesis. The presence of contractile reserve was defined by an improvement of ≥ 1 grade at follow up echocardiography.

Statistical analysis

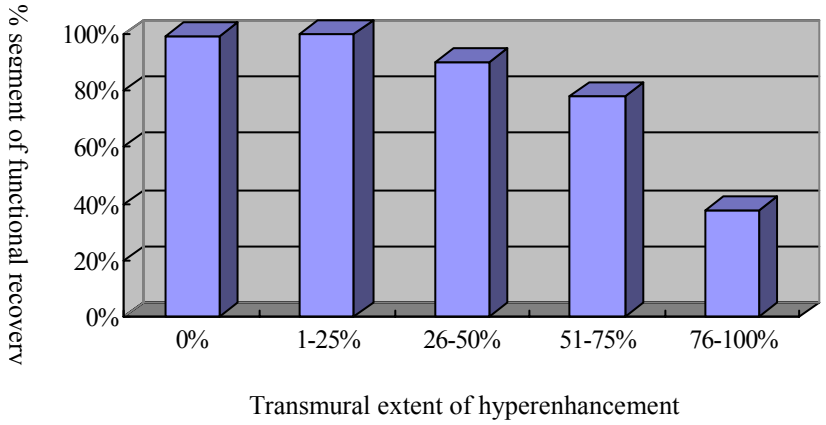
The independent samples *t* test and ANOVA were used to compare means within the study group or between subgroups.

III. Results

A total 336 segments (16 segments per patient) were available for analysis.

MRI – Thickness of delayed hyperenhancement and recovery of resting systolic function 130 segments showed regional delayed hyperenhancement. Segments that improved (79 segments) had lower mean segmental extent of delayed hyperenhancement score than segments that did not improve (51 segments) (1.2 ± 1.6 vs. 1.8 ± 2.0; p=0.227). The functional change according to transmural extent of delayed hyperenhancement (TEH) is shown in Figure 1. When the viable myocardium was arbitrarily defined as less than 25% of transmural extent of hyperenhancement, MRI predicted myocardial viability with sensitivity of 76.5% and specificity of 94.4% respectively. When the viable myocardium was defined as less than 50% of transmural extent of hyperenhancement, the sensitivity was 82.4% and the specificity was 90.7% respectively. Also, with the definition of the viable myocardium as less than 75% of transmural extent of hyperenhancement, the MRI showed sensitivity of 91.5% and specificity of 75.9% for predicting myocardial viability (Table 2).

(Fig 1) Functional outcome of dysfunctional segments according to baseline transmural extent of hyperenhancement.



(Table 2) The sensitivity and specificity of extent of hyperenhancement on MRI in predicting myocardial viability.

Extent of hyperenhancement	< 25%	< 50%	< 75%
Sensitivity	76.5%	82.4%	91.5%
Specificity	94.4%	90.7%	75.9%

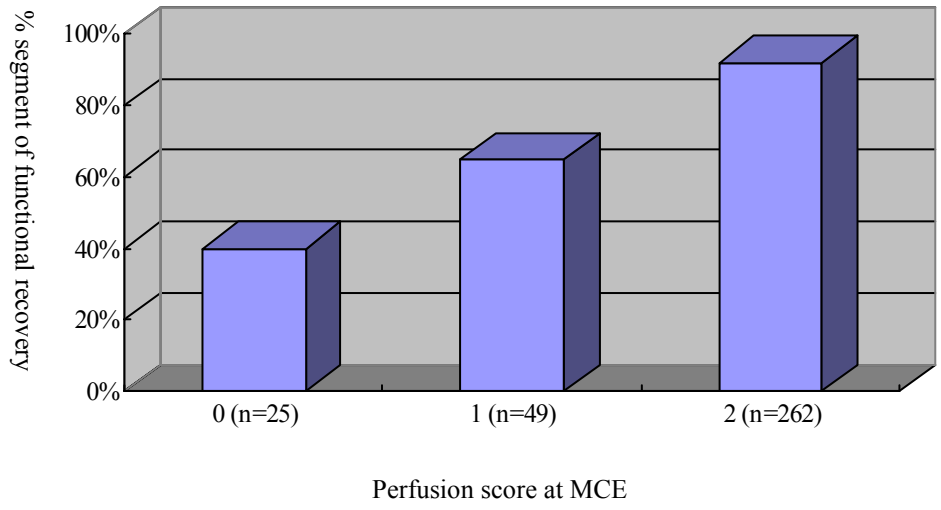
MCE – Myocardial perfusion and recovery of resting systolic function

Seventy-four segments showed either delayed perfusion or no perfusion within 7 days after revascularization. The percentage of segments that

showed improved wall motion scores 8 weeks after revascularization according to MCE-derived myocardial perfusion is shown in Figure 2.

If segments showing normal perfusion on MCE are defined as viable myocardium, the sensitivity is 86.3% and specificity is 59.3% respectively. But, if we predict segments with normal perfusion or delayed perfusion early after revascularization as viable myocardium, sensitivity of MCE in predicting myocardial viability is 96.7% and specificity is 27.8% respectively. (Table 3)

(Fig 2) Functional outcome of dysfunctional segments according to baseline MCE-derived myocardial perfusion.



(Table 3) Sensitivity and specificity of MCE for the prediction of wall motion improvement

Degree of perfusion	Normal perfusion	Normal + delayed perfusion
Sensitivity	86.3%	96.7%
Specificity	59.3%	27.8%

MCE and MRI in prediction of myocardial viability

Segments with normal perfusion on MCE early after revascularization showed improvement in contractile function 8 weeks later with sensitivity of 86.3% and specificity of 59.3%. Segments showing less than 50% extent of delayed hyperenhancement on MRI showed viability with sensitivity of 82.4% and specificity of 90.7%. Concordance between MCE and MRI for the identification of myocardial viability was 78.3% (kappa = 0.42) (Table 4)

(Table 4) Sensitivity and specificity in the prediction of myocardial viability

	MCE	MRI
Sensitivity	86.3%	82.4%
Specificity	59.3%	90.7%

(MCE : perfusion score = 2, MRI : transmural extent of delayed hyperenhancement less than 50% of the whole wall thickness)

Ⅳ. Discussion

This study shows that MRI and MCE can be used to predict viable myocardium in patients with AMI.

Hyperenhancement after recent MI.

In accordance with previously studies, we demonstrated that the extent of delayed hyperenhancement on MRI after revascularization is good predictor of myocardial viability. Previous experimental studies utilizing the current standard high resolution MRI technique have demonstrated that hyperenhanced areas correlate exclusively with irreversibly damaged, necrotic myocardium at various time intervals after infarction and irrespective of the status of the infarct-related artery.[6,7] Hillenbrand et al.[11] used a canine infarction model to evaluate functional recovery after various occlusion times and found that both the likelihood of improvement and change in absolute wall thickening were predicted by the transmural extent of hyperenhancement. Rehwald et al.[10] showed that elevations in Gd-DTPA concentration only occur in regions with histologically proven irreversible ischemic damage. Choi et al.[4] studied 24 patients one week and 16 ± 6 weeks after infarction and found that the transmural extent of hyperenhancement strongly predicted functional improvement. Gerber et al. [5] evaluated 20 patients with contrast-enhanced MRI and myocardial tagging and found that improvement

in circumferential shortening was inversely related to the regional extent of hyperenhancement at delayed imaging. When compared with a previous study done by Choi et al.[4], we demonstrated more segments with >75% transmural thickness of hyperenhancement showing improved wall motion at follow-up (35% vs. 5%), despite the fact that the majority of these segments had severe residual dysfunction. Hillenbrand et al.[11] also found some improvement (12%) in segments with extensive enhancement in their canine experiment. Results of the highly detailed experimental studies make it unlikely that Gd-DTPA accumulates in reversibly damaged myocardium, although one cannot entirely exclude the possibility that distribution of Gd-DTPA in human and canine infarcts is different. In fact, Oshinski et al.[16] found that MRI overestimated infarct size in a rat model of reperfused infarction when images were acquired too early after contrast injection. Although the extent of delayed hyperenhancement that defines viability has yet to be clarified, our study showed that most segments with less than 50% extent of hyperenhancement were viable 2 months after the baseline examination with excellent sensitivity and specificity(sensitivity: 82.4%, specificity: 90.4%). Although further research is needed regarding this topic, it is our opinion that using the cut off value of less than 50% extent of hyperenhancement will be most accurate in predicting myocardial viability and future functional recovery of the myocardium.

MCE

Myocardial contrast echocardiography is well suited for assessing the integrity of the microcirculation and, hence, for determining the extent of myocardial necrosis early after AMI . Intravenous microbubble administration and intermittent high-power imaging algorithms were used to evaluate regional perfusion. Myocardial viability was determined by analyzing both the peak intensity at the long PI and the change in acoustic intensity with prolongation of the PI.[17] Because of reactive hyperemia and variability of microvascular blood flow in the risk area during the first few hours or days after the resumption of epicardial blood flow, the assessment of viability with MCE was delayed for several days after revascularization.[18,19]

In patients with acute or recent MI, the absence of microvascular perfusion determined by MCE predicts lack of recovery of resting left ventricular systolic function, irrespective of whether or not infarct related arterial patency is achieved.[20]

In accordance with prior studies, we found that resting wall motion invariably did not recover when myocardial perfusion was absent after revascularization, however, the presence of perfusion during MCE early after AMI has not been completely reliable for predicting recovery of resting function.[21] These findings do not necessarily imply a weakness in the imaging technique, but instead, reflect changes that occur in the presence of

subendocardial infarction or patchy myocardial infarction. When perfusion was present but delayed, reflecting partial infarction, resting wall motion at 8 weeks was variable. The presence of viability in the epicardial portions of the left ventricle overlying the infarct bed is also beneficial for maintaining normal left ventricular shape and preventing adverse left ventricular remodeling.

Therefore the measurement of exertional systolic performance, instead of the resting systolic function, may have resulted in a higher sensitivity and specificity of MCE.

In summary, results of this study indicate that the degree of myocardial salvage can be determined by MRI and MCE early after revascularization at a time when viability cannot be accurately assessed by contractile function because of postischemic stunning.

V. Conclusion

In conclusion, both the cardiac MRI and the MCE showed comparable sensitivity but MRI showed superior specificity in predicting myocardial viability compared to MCE. The judicious use of either modality with consideration for issues such as the cost of examination and the patient status will be helpful in assessing the effectiveness of therapy and prognosis in patients with acute myocardial infarction.

VI. References

1. Lee KS, Marwick TH, Cook SA, et al. Prognosis of patients with left ventricular dysfunction, with and without viable myocardium after myocardial infarction: relative efficacy of medical therapy and revascularization. Circulation 1994;90:2687− 94.

2. Rogers WJJ, Kramer CM, Geskin G, et al. Early contrast-enhanced MRI predicts late functional recovery after reperfused myocardial infarction. Circulation 1999;99:744− 50.

3. Dendale P, Franken PR, Block P, Pratikakis Y, De Roos A. Contrast enhanced and functional magnetic resonance imaging for the detection of viable myocardium after infarction. Am Heart J 1998;135:875− 80.

4. Choi KM, Kim RJ, Gubernikoff G, Vargas JD, Parker M, Judd RM. Transmural extent of acute myocardial infarction predicts long-term improvement in contractile function. Circulation 2001;104:1101− 7.

5. Gerber BL, Garot J, Bluemke DA, Wu KC, Lima JA. Accuracy of contrast-enhanced magnetic resonance imaging in predicting improvement of regional myocardial function in patients after acute myocardial infarction. Circulation 2002;106:1083− 9.

6. Kim RJ, Fieno DS, Parrish TB, et al. Relationship of MRI delayed contrast enhancement to irreversible injury, infarct age, and contractile function. Circulation 1999;100:1992– 2002.

7. Fieno DS, Kim RJ, Chen EL, Lomasney JW, Klocke FJ, Judd RM. Contrast-enhanced magnetic resonance imaging of myocardium at risk: distinction between reversible and irreversible injury throughout infarct healing. J Am Coll Cardiol 2000;36:1985– 91.

8. Kim RJ, Chen EL, Lima JA, Judd RM. Myocardial Gd-DTPA kinetics determine MRI contrast enhancement and reflect the extent and severity of myocardial injury after acute reperfused infarction. Circulation 1996;94:3318– 26.

9. Judd RM, Lugo-Olivieri CH, Arai M, et al. Physiological basis of myocardial contrast enhancement in fast magnetic resonance images of 2-day-old reperfused canine infarcts. Circulation 1995;92:1902– 10.

10. Oshinski JN, Yang Z, Jones JR, Mata JF, French BA. Imaging time after Gd-DTPA injection is critical in using delayed enhancement to determine infarct size accurately with magnetic resonance imaging. Circulation

2001;104:2838–42.

11. Hillenbrand HB, Kim RJ, Parker MA, Fieno DS, Judd RM. Early assessment of myocardial salvage by contrast-enhanced magnetic resonance imaging. Circulation 2000;102:1678– 83.

12. Kramer CM, Rogers WJ Jr., Mankad S, Theobald TM, Pakstis DL, Hu YL. Contractile reserve and contrast uptake pattern by magnetic resonance imaging and functional recovery after reperfused myocardial infarction. J Am Coll Cardiol 2000;36:1835– 40.

13. Saeed M, Lund G, Wendland MF, Bremerich J, Weinmann H, Higgins CB. Magnetic resonance characterization of the peri-infarction zone of reperfused myocardial infarction with necrosis-specific and extracellular nonspecific ontrast media. Circulation 2001;103:871– 6.

14. Ragosta M, Camarano G, Kaul S, et al : Microvascular integrity indicates myocellular viability in patients with recent myocardial infarction: New insights using myocardial contrast echocardiography. *Circulation* 1994;89:2562–2569.

15. Wei K, Jayaweera AR, Firoozan S, Linka A, Skyba DM, Kaul S. Quantification of myocardial blood flow with ultrasound-induced destruction of microbubbles administered as a constant venous infusion. Circulation 1998;97:473–83.

16. Rehwald WG, Fieno DS, Chen EL, Kim RJ, Judd RM. Myocardial magnetic resonance imaging contrast agent concentrations after reversible and irreversible ischemic injury. Circulation 2002;105:224– 9.

17. Lindner JR, Dent JM, Villanueva FS, Wei K, Sklenar J, Kaul S. Assessment of resting perfusion abnormalities with myocardial contrast echocardiography: theoretical and practical considerations. Am Heart J 2000;139:231–40.

18. Villanueva FS, Glasheen WP, Sklenar J, Kaul S. Characterization of spatial patterns of flow within the reperfused myocardium by myocar-dial contrast echocardiography: implications in determining extent of myocardial salvage. Circulation 1993;88:2596–606.

19. Sakuma T, Hayashi Y, Shimohara A, Shindo T, Maeda K. Usefulness of myocardial contrast echocardiography for the assessment of serial changes in

risk area in patients with acute myocardial infarction. Am J Cardiol 1996;78:1273–7.

20. Ito H, Okamura A, Iwakura K, et al. Myocardial perfusion patterns related to thrombolysis in myocardial infarction perfusion grades after coronary angioplasty in patients with acute anterior wall myocardial infarction. Circulation 1996;93:1993–9.

21. Andra´ssy P, Zielinska M, Busch R, Scho¨mig A, Firschke C. Myocardial blood volume and the amount of viable myocardium early after mechanical reperfusion of acute myocardial infarction: prospective study using venous contrast echocardiography. Heart 2002;87:350–5

급성심근경색환자의 심근 생존능을 예측하는데 있어서 핵자기공명영상과 심근조영초음파의 비교연구

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서혜선

급성심근경색 이후에 심근생존능의 평가는 환자의 치료와 예후를 결정하는데 있어서 중요한 영향을 미칠 수 있다. 심근생존능의 평가방법으로 최근 해상도와 민감도가 좋은 핵자기공명영상(MRI)과 심근조영초음파(MCE)에 대한 많은 연구가 진행되고 있다. 자기공명영상에서 심근에 조영제가 늦게까지 남아있게 될 때(delayed hyperenhancement) 심근의 괴사를 의심해 볼 수가 있고, 실제로 동물실험이나 여러 임상시험에서 증명된 바이다. 하지만 이러한 가정에 대한 반론도 많이 나오고 있고, 어느 두께 정도의 심근에 조영제가 남아있게 될 때 심근의 생존력을 정확히

예측할 수 있는지에 대해서는 아직 연구된 바가 없다. 그래서 저자들은 재관류요법을 받은 급성심근경색 환자를 대상으로 핵자기공명영상과 심근조영초음파를 시행하고, 2개월후에 심장초음파를 시행하여 핵자기공명영상에서 delayed hyperenhancement 정도와, 심근조영초음파에서 관류손상의 정도가 심근의 생존능을 어느정도 예측할 수 있는지 알아보았다. 그 결과, 자기공명영상에서 심근 50% 미만의 두께로 delayed hyperenhancement가 존재할 때 82.4%의 민감도와 90.7%의 특이도를 가지며 심근의 생존능을 예측할 수 있었고, 심근조영초음파에서 정상 관류를 보인 심근은 86.3%의 민감도와 59.3%의 특이도로 2개월뒤에 기능회복을 보였다. 두 방법의 일치도는 78.3%였다.

결론적으로, 심근의 생존능을 평가하는 방법으로 자기공명영상과 심근조영 초음파 모두 적절한 방법임이 증명되었고, 각각 검사의 장단점을 고려하여 급성심근경색 환자에서 적절한 검사가 실시된다면, 환자의 치료결정이나 예후예측에 큰 도움이 될것으로 생각되는 바이다.

핵심단어 : 급성심근경색, 심근생존능, 핵자기공명영상, 심근조영심초음파