Echocardiography

Early Assessment of Left Ventricular Viability of Dyskinesia and Akinesia Myocardium in Patients with Acute Myocardial Infarction: Real-time Contrast Echocardiography Versus Low-dose Dobutamine Echocardiography

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Purpose: Low-dose dobutamine echocardiography (LDDE) has been demonstrated as an accurate imaging modality to identify viability after acute myocardial infarction (AMI), but LDDE has its limitations. Myocardial contrast echocardiography (MCE) is a good tool to assess microvascular perfusion. This study was undertaken to compare the effect of real-time MCE and LDDE in early assessment of left ventricular (LV) viability of dyskinesia and akinesia myocardium in patients with AMI.

Methods: Forty-five patients had 2-dimensional echocardiography, MCE and LDDE within 1 week after AMI attack. Two-dimensional echocardiography for evaluation of LV viability was performed within 4 months after discharge.

Results: Totally 260 segments of dyskinesis or akinesis were analyzed. MCE visualized perfusion segments, either homogenous or patchy contrast opacification and had a sensitivity of 81.4%, specificity of 76.7%, accuracy of 79.4%, positive predictive value of 82.8% and negative predictive value of 75.0% in predicting LV viability. The accuracy was comparable with LDDE (79.4% vs. 76.8%, p = 0.52), although MCE had higher sensitivity (81.4% vs. 68.9%, p < 0.005) and LDDE had higher specificity (76.7% vs. 87.6%, p < 0.01). Average time for MCE study was lower than that of LDDE (374 ± 177 seconds vs. 785 ± 216 seconds, p < 0.001). MCE studies were performed and completed without any complication when compare to 6.7% complication rate in the LDDE studies (p < 0.001).

Conclusions: Real-time MCE is more time-saving and safer than LDDE. MCE also has comparable accuracy with LDDE for early assessing of LV viability in patients with AMI, despite the limitation of attenuation artifacts in the infero-posterior segments.

Key Words: Acute myocardial infarction • Low-dose dobutamine echocardiography • Myocardial contrast echocardiography

INTRODUCTION

After acute myocardial infarction (AMI), injured myocardium can be viable following early reperfusion.1 How to differentiate reversible from irreversible injured myocardium would be very helpful for management and prognosis of patients after AMI.2,3
Several imaging modalities were used to assess left ventricular viability, but most were expensive, cumbersome and needed radioactive isotopes. Low-dose dobutamine echocardiography (LDDE) has been demonstrated as an accurate imaging modality to identify viability after myocardial infarction, which can be performed at bedside. However, LDDE cannot be used for patients after AMI who are already requiring inotropic support. Furthermore, being time-consuming and the risk of ischemia under dobutamine stress were also limitations for LDDE applied in patients after AMI.

Intracoronary myocardial contrast echocardiography (MCE) was widely reported to detect viability in previous studies. Intravenous MCE provides clinical convenience, but the limitation of large variable results were shown to predict viability via trigger and power Doppler mode. A recently developed real-time power modulation mode may provide a continuous real-time MCE image, which may improve the assessment of viability in patients with AMI. However, comparison data of real-time intravenous MCE using power modulation mode versus LDDE for assessing the viability after first AMI was limited, especially in non-anterior wall AMI.

The main purpose of this study was to compare real-time power modulation mode MCE versus LDDE in early assessment of LV viability of dyskinesia and akinesia myocardium in patients with AMI.

MATERIALS AND METHODS

Patients

We prospectively studied 49 patients with first Q-wave AMI hospitalized in our institution. Inclusion criteria included: typical anginal pain lasting more than 30 minutes; ST-segment elevation ≥ 0.2 mV in ≥ 2 contiguous electrocardiogram leads at the emergency department; biochemical evidence of peak creatine kinase > 2X above normal upper limit; and wall motion abnormalities by echocardiography at admission. Criteria for exclusion included post-infarct angina, in-hospital reinfarction, persistent left ventricular (LV) failure, significant ventricular arrhythmias, significant valvular disease or primary myocardial diseases, allergy to blood products and previous myocardial infarction. Two patients died during follow-up periods and 2 patients were lost to follow-up. Therefore, totally 45 patients completed the study.

Study protocol

All patients had initial resting 2-dimensional echocardiographic imaging with MCE. They then promptly underwent LDDE during hospitalization within 1 week after AMI attack. Within 4 months after discharge, they received follow-up resting 2-dimensional echocardiography study. A clinical history of risk factors, such as diabetes mellitus, hypertension, smoking and hyperlipidemia, was determined from detailed chart review. The Committee on Human Research of our hospital had approved our study protocol.

Low-dose dobutamine echocardiography

Within 1 week after AMI attack, LDDE protocol was performed in all patients with continuous electrocardiographic, blood pressure and 2-dimensional echocardiographic monitoring. Beta-blocker was held 24 hours before the LDDE. Two-dimensional echocardiography was performed before, during, and after dobutamine infusion in left decubitus position. A commercial echocardiographic machine (SONOS 5500 imaging system, Philips Medical Systems, Andover, Massachusetts, USA) equipped with S3 transducer was used. Tissue harmonic imaging was performed in order to optimize endocardial border visualization. We used the standard apical 4-chamber, 2-chamber and long-axis views, and parasternal long- and short-axis views at the level of the papillary muscle. After initial resting 2-dimensional echocardiographic images were recorded, dobutamine was infused and begun at 5 µg/kg/min for 5 minutes (stage 1) and at 10 µg/kg/min for another 5 minutes (stage 2). Echocardiographic images were acquired at the end of stage 1 and 2 of LDDE, and at recovery phase 6 minutes after stopping the dobutamine infusion. All echocardiographic images were recorded by super-VHS videotape and acquired in 2.3 GB magneto-optical disk in quad-screen cineloop format with simultaneous display of initial resting, end of stages 1 and 2 of LDDE and recovery to facilitate review and interpretation.

We used a standardized 17-segment model of the LV to evaluate LV wall motion. Each segment was graded on a 4-point scale (0 = normal or hyperkinesia; 1 = hypokinesia; 2 = akinesia; 3 = dyskinesia). Mean wall
motion score index (WMSI) was defined by dividing the sum of the included wall motion scores by the number of included segments. The mean WMSI was calculated for non-perfusion segments, perfusion segments, non-contractile reserve segments and contractile reserve segments, respectively, at the initial stage and at 4-month follow-up. LV end-diastolic volume, LV end-systolic volume, and LV ejection fraction were measured by a modified Simpson’s biplane method from apical 4-chamber views at baseline and follow-up. Images from each echo study in each view were displayed side-by-side for subsequent wall motion analysis. We analyzed only akinesia or dyskinesia segments at initial resting echocardiography in order to assess LV viability.14,15 The presence of LV viability was defined as ≥ 1 dyssynergic segment having wall motion score decrease ≥ 1 during dobutamine infusion compared with initial resting echocardiography in order to calculate the sensitivity, specificity, positive prediction value, negative prediction value and accuracy. Average time for LDDE studies included baseline echocardiography, stage 1 and stage 2. These LDDE images were analyzed by 2 independent experienced observers blinded to the patients’ clinical data and again by each observer 4 weeks later. Inter-observer variability for the magnitude of LDDE agreement was 7.9%, and intra-observer variability was 6.4%.

**Myocardial contrast echocardiography**

Within 1 week after AMI attack, MCE and initial resting 2-dimensional echocardiography were performed in all patients during continuous electrocardiographic, blood pressure and 2-dimensional echocardiographic monitoring. Harmonic power modulation mode was performed with the same scanner. Some of the specific instrumentation settings that were kept constant during subsequent image acquisitions included a low mechanical index of 0.1, gain of less than 70% and maximal line density. These setting allowed a frame rate of more than 20 Hz during MCE study. Focus was set at mitral valve.

Perfluorocarbon-exposed sonicated dextrose albumin (PESDA) solution, a “second-generation” contrast agent, was used. The solution was prepared by following the steps below. Eight ml of perfluoropropane gas was hand-agitated with a 3:1 mixture of D5W and 5% human albumin. It was then electromechanically sonicated for 80 seconds. Boluses of 0.3 to 0.6 mL PESDA solutions were injected intravenously and followed by a 5-mL saline push. The saline push lasted over 20 seconds, with a rate of 1 mL/sec. Minimal amount of contrast agent was used to avoid blooming and attenuation artifacts, but it was just enough to achieve myocardial opacification. “Flash” imaging, manually triggered by transient high mechanical index imaging, was used at peak contrast intensity (5 frames) to destroy microbubbles within myocardium in order to exclude artifact and observe myocardial replenishment. Real-time MCE images were stored into super VHS videotape, and 10-20 beats following flash imaging were acquired with apical 4-chamber, 2-chamber and long-axis views on a magneto optical disk. Nonstandard apical views were used to overcome localized area of attenuation.

The same 17-segment model of the LV for LDDE was also used in MCE studies.13 Perfusion image of each segment was graded on a 3-point scale (0 = homogeneous contrast opacification, 1 = reduced or patchy contrast opacification, 2 = no contrast opacification).4,7,16 Perfusion defects were excluded in normal contracting segments. Artifacts that were differentiated from perfusion defects prior to final analysis included attenuation, poor window, contrast destruction and other artifacts. The presence of LV viability was defined as homogenous or patchy contrast opacification in at least 1 view, i.e. perfusion score = “0” or “1”.16 Average time for MCE study included baseline 2-dimensional and contrast echocardiography. The MCE images were analyzed by 2 independent experienced observers blinded to the patients’ clinical data and again by each observer 4 weeks later. Inter-observer variability was 8.1% and intra-observer variability was 6.7%.

The definition of concordant MCE and LDDE results was in agreement for the assessment of viability by both studies (non-perfusion and non-contractile reserve segments or perfusion and contractile reserve segments).7

**Follow-up resting 2-dimensional echocardiography**

Clinical and echocardiographic evaluations were performed in all patients within 4 months after discharge. The presence of LV viability was defined as ≥ 1 dyssynergic segment at initial resting 2-dimensional echocardiography having wall motion score decreased ≥ 1 during follow-up. The analysis method was the same as for LDDE.
Statistics

Categorical data are presented as absolute values and percentages. Continuous variable are expressed as mean values ± standard deviation. Chi-squared test was used to compare categorical data. Two-tailed Student t-test was performed for comparison of continuous variable. Sensitivity, specificity, accuracy, negative and positive predictive value for prediction of LV viability were determined for MCE, for LDDE and for concordant MCE with LDDE. A p-value of < 0.05 was considered statistically significant.

RESULTS

Baseline characteristics

During the periods from July 2002 to April 2003, 45 patients were included in our study (mean age 62.7 ± 15.4 years; 42 male and 3 female) (Table 1). In our patient group, 40% had hypertension (n = 18), 35.6% had diabetes mellitus (n = 16), 73.3% had hyperlipidemia (n = 33) and 73.3% were current or ex-smokers (n = 33). The 2 groups of anterior wall (n = 31) and non-anterior wall infarction (n = 14) were not statistically different in baseline features (Table 1). We collected a total of 276 dyskinesia or akinesia segments at initial resting 2-dimensional echocardiography. However, 5.8% (n = 16) of the segments were inadequately visualized by MCE. Finally, there were 260 dyskinesia or akinesia segments for analysis, including 183 dyskinesia or akinesia segments of anterior wall infarction and 77 dyskinesia or akinesia segments of non-anterior wall infarction.

During the follow-up period, 32 patients (71.1%) received coronary angiography after follow-up echocardiography was completed. No patient received revascularization procedure before the 4-month follow-up evaluation. The results showed single-vessel disease in 16, double-vessel disease in 9 and triple-vessel disease in 7 patients. Infarcted-related arteries of non-anterior wall

<table>
<thead>
<tr>
<th>Table 1. Baseline characteristics of the study population</th>
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<tbody>
<tr>
<td>Anterior wall infarction</td>
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<tr>
<td>n = 31</td>
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<tr>
<td>Male (No)</td>
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<td>Age (years old)</td>
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<tr>
<td>Body weight (Kilograms)</td>
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<td>Body surface area (m²)</td>
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<tr>
<td>Hypertension (No)</td>
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<tr>
<td>Diabetes mellitus (No)</td>
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<tr>
<td>Hyperlipidemia (No)</td>
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<tr>
<td>Current &amp; Ex-smoker (No)</td>
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<tr>
<td>Killip classification</td>
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<tr>
<td>Peak CK (IU/liter)</td>
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<tr>
<td>Peak MB fraction (IU/liter)</td>
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<tr>
<td>Symptom-onset time to peak CK (minutes)</td>
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<tr>
<td>Post thrombolytic agents (No)</td>
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<td>Symptom-onset time to thrombolysis (minutes)</td>
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<tr>
<td>Primary PTCA (No)</td>
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<tr>
<td>Symptom-onset time to primary PTCA (minutes)</td>
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<tr>
<td>Admission mean BP (mmHg)</td>
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<tr>
<td>Admission HR (beats/min)</td>
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<tr>
<td>Peak stress HR at LDDE</td>
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<tr>
<td>Dyskinesia and akinesia segment (No)</td>
</tr>
<tr>
<td>LVEDV/BSA (ml/m²)</td>
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<td>LVEF (%)</td>
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* Comparing each variable of anterior wall vs. non-anterior wall infarction. Chi-squared tests were used for comparison of categorical data. Two-tailed Student t-test was performed for comparison of continuous variables.

BP = blood pressure; BSA = body surface area; CK = creatine kinase; HR = heart rate; LDDE = low dose dobutamine echocardiography; LVEDV = left ventricular end-diastolic volume; LVEF = left ventricular ejection fraction; NS = non-significance; PTCA = percutaneous transluminal coronary angioplasty, WMSI = Wall motion score index.
Infarction were left circumflex coronary artery in 2 (20%) and right coronary artery in 8 patients (80%).

**Myocardial contrast echocardiography**

Figure 1 is an example of real-time MCE and the follow-up echocardiograms is a patient with acute anterior myocardial infarction. Most artifacts preventing assessment of MCE (n = 16) occurred in the basal infero-posterior wall (68.8%). Other artifacts were noted in the lateral wall (25.0%) and anterior wall (6.2%). Of the 260 total dyskinesia or akinesia segments in which contrast could be adequately assessed, homogeneous contrast opacification was seen in 125 (48.1%) segments, reduced or patchy contrast opacification in 28 (10.8%) segments, and no contrast opacification in 107 (41.1%) segments. Of the 183 dyskinesia or akinesia segments in anterior wall infarction, homogeneous contrast opacification was seen in 83 (45.4%) segments, reduced or patchy contrast opacification in 22 (12.0%) segments and no contrast opacification in 78 (42.6%) segments. Of the 77 dyskinesia or akinesia segments in non-anterior wall infarction, homogeneous contrast opacification was seen in 42 (54.5%) segments, reduced or patchy contrast opacification in 6 (7.8%) segments and no contrast opacification were seen in 29 (37.7%) segments. Perfusion segment, either homogeneous or patchy contrast opacification, could predict LV viability with a sensitivity of 81.4%, specificity of 76.7%, accuracy of 79.4%, positive predictive value of 82.8% and negative predictive value rate of 75.0%. Also, mean WMSI of perfusion segments during follow-up echocardiography were significantly better than those of non-perfusion segment (1.60 vs. 0.33, \( p < 0.001 \)) (Figure 2). MCE studies were performed and completed without any complication. Average time for MCE study was 374 ± 102 seconds.

![Real-time myocardial contrast echocardiographic (MCE) images](image)

**Figure 1.** Real-time myocardial contrast echocardiographic (MCE) images of a patient with first acute anterior wall myocardial infarction at end-systole (A) and end-diastole (B). Black arrowheads showed mid-septal, apical-septal and apex segments without contrast enhancement, i.e. non-viable myocardium. Follow-up 2-dimensional echocardiograms at end-systole (C) and end-diastole (D) were acquired 4 months later. White arrowheads show area with scar formation, which corresponds to the area without opacification of the MCE images. Small white arrows show attenuation in basal lateral segment.
Low-dose dobutamine echocardiography

During LDDE, contractile reserve was seen in 119 (45.8%) segments, including 72 segments (39.3%) in patients after anterior wall infarction and 47 segments (61.0%) in patients after non-anterior wall infarction. Contractile reserve could predict LV viability with a sensitivity of 68.9%, specificity of 87.6%, accuracy of 76.8%, positive predictive value of 88.4% and negative predictive value of 67.3%. At the same time, mean WMSI of contractile reserve segments during follow-up echocardiography were significantly better than that of non-perfusion segments ($p < 0.001$).

Concordant MCE with LDDE

The accuracy of MCE was comparable with that of LDDE (79.4% vs. 76.8%, respectively, $p = 0.52$), although MCE had a higher sensitivity (81.4% vs. 68.9%, $p < 0.005$) and LDDE had a higher specificity (76.7% vs. 87.6%, $p < 0.01$).

We identified the results of concordant MCE with LDDE, which meant that non-perfusion and non-contractile reserve segments both indicated nonviable myocardium, while perfusion and contractile reserve segments both indicated viable myocardium. Such results were seen in 202 (77.7%) segments, including 144 (78.7%) segments in anterior wall infarction and 58 (75.3%) segments in non-anterior wall infarction. Concordant MCE with LDDE could predict LV viability with a sensitivity of 84.1%, specificity of 88.9%, accuracy of 86.4%, positive predictive value of 90.4% and negative predictive value rate of 81.7%. The concordant MCE with LDDE had better results than MCE or LDDE alone in all included patients.
0.21) and accuracy ($p = 0.07$) in concordant MCE with LDDE compared to MCE alone, and specificity ($p = 0.84$) and positive predictive value ($p = 0.37$) in concordant MCE with LDDE compared to LDDE alone (Figure 4).

**Anterior wall versus non-anterior wall AMI**

In patients with anterior wall infarction (Table 2), MCE had significantly higher sensitivity ($p < 0.005$) and negative predictive value ($p < 0.01$) to assess LV viability than those of LDDE. However, LDDE has higher specificity ($p < 0.05$) compared with MCE. Concordant MCE with LDDE showed superior results than MCE or LDDE alone in specificity, accuracy, negative and positive predictive value, but not in sensitivity.

In patients with non-anterior wall infarction, MCE showed significantly poorer results than LDDE in all variables (Table 2). However, concordant MCE with LDDE had better results than MCE or LDDE alone, although it did not reach statistic significance when compared to LDDE alone.

**Follow-up 2-dimensional echocardiography**

Follow-up 2-dimensional echocardiography showed that the segments with viability presented in 148 (56.9%) dyskinesia or akinesia segments at initial resting echocardiography, which included 101 (55.2%) segments in anterior wall infarction and 47 (61.0%) in non-anterior wall infarction. The LV end diastolic volume index ($LVEDV/\text{body surface area}$) showed a total of $58.3 \pm 8.3$ liters/m². While patients with anterior wall infarction had $59.9 \pm 5.8$ liters/m², patients with non-anterior wall infarction showed a $LVEDV$ index of $55.5 \pm 5.2$ liters/m². The mean LV ejection fraction revealed $51.5 \pm 9.0\%$ in total cases, $50.2 \pm 8.7\%$ in patients with anterior wall infarction and $54.1 \pm 9.6\%$ in patients with non-anterior wall infarction.

**DISCUSSION**

This study demonstrated that microvascular perfusion evaluated by the power modulation mode of real-time MCE was quicker and safer than contractile reserve evaluated by LDDE in assessing LV viability in patients with first myocardial infarction. In patients with first AMI, MCE had higher sensitivity (81.4% vs. 68.9%, $p < 0.005$) and negative predictive value (75.0% vs. 67.3%, $p < 0.05$). However, LDDE had higher specificity (76.7% vs. 87.6%, $p < 0.01$) for assessing LV viability. The accuracy (79.4% vs. 76.8%, $p = 0.52$) and positive predictive value (82.8% vs. 88.4%, $p = 0.08$) between MCE and LDDE were not statistically different. If MCE provided inconclusive results, concordant MCE with LDDE would give more information.

**Table 2.** Comparison of sensitivity, specificity, accuracy, positive predictive value and negative predictive value for assessment of left ventricular viability by myocardial contrast echocardiography (MCE), low-dose dobutamine echocardiography (LDDE) and concordant MCE with LDDE in patients after anterior wall and non-anterior wall infarction

<table>
<thead>
<tr>
<th></th>
<th>Anterior wall infarction</th>
<th></th>
<th>Non-anterior wall infarction</th>
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<tbody>
<tr>
<td></td>
<td>MCE</td>
<td>LDDE</td>
<td>$p$ value</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>87.9%</td>
<td>63.8%</td>
<td>$&lt; 0.005$</td>
</tr>
<tr>
<td>Specificity</td>
<td>80.0%</td>
<td>89.5%</td>
<td>$&lt; 0.05$</td>
</tr>
<tr>
<td>Accuracy</td>
<td>84.4%</td>
<td>75.4%</td>
<td>NS</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>84.3%</td>
<td>88.1%</td>
<td>NS</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>84.4%</td>
<td>66.9%</td>
<td>$&lt; 0.01$</td>
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<tr>
<td></td>
<td>MCE</td>
<td>LDDE</td>
<td>$p$ value</td>
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<tr>
<td>Sensitivity</td>
<td>68.9%</td>
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<td>$&lt; 0.05$</td>
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<tr>
<td>Specificity</td>
<td>67.6%</td>
<td>82.4%</td>
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<tr>
<td>Accuracy</td>
<td>68.4%</td>
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<tr>
<td>Positive predictive value</td>
<td>79.2%</td>
<td>88.9%</td>
<td>$&lt; 0.05$</td>
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<tr>
<td>Negative predictive value</td>
<td>54.8%</td>
<td>68.3%</td>
<td>$&lt; 0.01$</td>
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NS = non-significance.
Microvascular perfusion by MCE for assessing LV viability can provide information on prognosis and need for further protection from ischemia injury. MCE with trigger mode was demonstrated to predict LV viability with sensitivity of 59-96%, specificity of 18-76%, and accuracy of 47-72%. There is a large variability, which may be caused by timing and intensity of myocardial contrast and timing of follow-up echocardiography. However, there were low specificity and positive predictive value in trigger mode MCE, because trigger mode would increase tissue artifact and induce false-positive contrast effect.

Real-time MCE with low mechanical index, including power modulation mode and power-pulse inversion mode, is capable of filtering the tissue artifact. It allows simultaneous evaluation of contractile function and microvascular perfusion and evaluation of myocardial blood flow volume or rate. Consensus is still lacking about the criteria for assessing microvascular perfusion by real-time myocardial contrast echocardiography. Our protocol used the same semi-quantitative scoring system with homogeneous contrast opacification, reduced or patchy contrast opacification and no contrast opacification as previous studies. To avoid bias, we interpreted the baseline wall motion scores by the initial resting 2-dimensional echocardiography and microvascular reperfusion by MCE images. Since the aim of this study was to compare the effectiveness of real-time MCE to LDDE in assessing the viability in AMI patients, this study did not compare the real-time MCE with trigger-mode MCE. Of the above 2 modes of MCE studies, which is better in predicting myocardial viability needs further investigations.

Previous studies reported that real-time MCE could predict LV viability with sensitivity of 69-93%, specificity of 74-95%, and accuracy of 78-90%. Our study demonstrated that real-time MCE can predict LV viability with a sensitivity of 81.4%, specificity of 76.7%, accuracy of 79.4%, positive predictive value of 82.8% and negative predictive value of 75.0%. The results were compatible to previous studies. The high sensitivity may be due to the time delay from cell injury to destruction of capillary network, the extent of cellular degeneration and interstitial fibrosis in risk areas. Another reason might be attributed to our regarding of patchy and focal contrast opacification as viable myocardium, because present but reduced perfusion may reflect partial infarction and viability at follow-up.

Our data showed that real-time MCE has accuracy compatible with LDDE in early assessment of LV viability, although LDDE has higher specificity. Furthermore, average time for MCE study was lower than LDDE (374 ± 102 seconds vs. 785 ± 216 seconds, respectively, p < 0.001). MCE studies were performed without any complication. However, in the LDDE studies, 2 patients (4.5%) suffered from headache and 1 patient (2.2%) suffered from increasing chest tightness. MCE can be safely performed at bedside soon after AMI, even within 6 hours of AMI onset and in critically ill patients who already require inotropic support or are exhibiting complex ventricular ectopy without risk of myocardial damage. However, LDDE is time-consuming and cannot performed in AMI patients who already need inotropic support and those with complex ventricular arrhythmias. Besides, there is a potential risk of myocardial ischemia in patients soon after AMI. In summary, MCE is a simple, noninvasive, easily accessible, and safe modality to early assess LV viability in patients after AMI.

We also demonstrated that the segments with microvascular perfusion or contractile reserve had better LVWMSI at follow-up than those segments without microvascular perfusion or contractile reserve (Figures 2 and 3). The later segments might need further rescue intervention or medical therapy to prevent adverse remodeling. In the 2 mortality cases after anterior wall infarction, the first 1 received primary angioplasty but with 8 segments of no contrast enhancement by MCE and the other did not receive thrombolysis or angioplasty with 7 segments of no contrast enhancement. The lack of contrast enhancement suggests the absence of myocardial perfusion, which has been reported to be associated with subsequent complications.

Results of our study disclosed that LDDE may be a better choice than real-time MCE in assessment of LV viability in patients after first non-anterior wall infarction. Roxy et al. reported MCE by trigger mode at 4.6 ± 1.5 days after AMI had positive predictive value of 47% and negative predictive value of 71%. Increased tissue artifact and blooming effect showed by the trigger mode was responsible for the low positive predictive value. In our data, real-time MCE had a negative predictive value of 54.8% and positive predictive value of 79.2%. The lower negative predictive value can be attributed to the attenuation artifacts in the inferior or posterior LV segments, even with use of nonstandard
view to overcome the problem. However, no previous report described the sensitivity, specificity or accuracy of MCE in assessing the viability with a focus on the non-anterior wall myocardial infarction. Our data showed that real-time MCE had a sensitivity of 68.9%, specificity of 67.6% and accuracy of 68.4% for predicting the viability of myocardium, which were lower than those obtained from LDDE. It is possible that the attenuation artifacts contributed to these results. This study showed that concordant MCE with LDDE had a better result than either MCE or LDDE alone. Indeed, real-time MCE is able to evaluate LV perfusion and function more comprehensively: it has an increased sensitivity, specificity, accuracy, negative and positive predictive value compared to that of LDDE for assessing viability. In our opinion, MCE combined with LDDE is a powerful image modality to assess the LV viability in first non-anterior wall myocardial infarction.

Follow-up 2-dimensional echocardiography of this study was performed within 4 months after chest pain. Most functional recovery occurs in the first few weeks after AMI, and most studies used 2-3 months for follow-up periods. We used a longer duration of 4 months for follow-up echocardiography, and this would be advantageous for identifying of LV viability. Vanoverschelde et al. claimed that further delay of the follow-up period may only improve a little the positive predictive value.

Limitations

The use of semi-quantitative scoring system for MCE and LDDE is the first limitation of our study. Quantitative analysis using videodensitometric analysis might have improved the result. Currently, there is no commercialized available quantitative software in our instrument. The second limitation is that only 71.1% of patients had follow-up coronary angiography. Thirdly, the studied patients were heterogeneous in the methods of reperfusion: thrombolysis, primary percutaneous transluminal coronary angioplasty, and those without reperfusion therapy. Because not all patients can be sent to the hospital within 12 hours after AMI attack, this heterogeneous character can reflect the actual situation of patients who underwent different treatment strategies. LV viability appears to be related directly to early reperfusion therapy after the onset of coronary occlusion. However, we cannot draw a conclusion in this regard due to the small number of patients in this study. Further study including more patients might be needed to confirm this theory.

Our slow bolus method of contrast is another limitation of this study. Continuous infusion with contrast could ensure constant concentrations. We used slow push and continued until all images had been acquired in that view; thus, we were able to maintain relatively stable contrast concentrations during the MCE study. Furthermore, the slow bolus method has the benefit of time-saving, rapid, convenience and smaller fluid loading, which are especially important in patients with AMI.

We enrolled the akinesia and dyskinesia segments at initial resting echocardiography for assessing LV viability, which is another limitation. This study did not enroll the hypokinesia segments because these segments still had contractile function, which were considered to be viable myocardium.

CONCLUSIONS

Our study demonstrated that real-time MCE can comprehensively evaluate microvascular perfusion, despite the limitation of attenuation artifacts in the inferior or posterior LV segments at MCE image. Real-time MCE is capable of assessing the LV viability of dyskinesia and akinesia myocardium with safer and more time-saving than LDDE in patients with acute myocardial infarction. Real-time MCE has comparable accuracy with LDDE in assessing LV viability.

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早期評估急性心肌梗塞病患無法收縮及收縮困難的左心室心肌之存活性：比較即時造影劑超音波和低劑量 dobutamine 心臓超音波

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背景 低劑量 dobutamine 心臓超音波被證實為應用於評估首次罹患急性心肌梗塞病患之左心室心肌存活性的準確影像工具之一，但是，除了無法應用於已使用強心劑之病患及耗時的缺點外，dobutamine 用於急性心肌梗塞病患患者引發進一步心肌缺氧之危險。即時造影剝超音波是評估微型血管灌流之利器。本研究之目的是想比較即時造影剝超音波和低劑量 dobutamine 心臓超音波，用於評估首次罹患急性心肌梗塞病患無法收縮及收縮困難的左心室心肌之存活性。

方法 共四十五位首次罹患急性心肌梗塞病患在胸痛發作後的一週內，進行二度空間心臓超音波，即時造影剝超音波之檢查，及低劑量 dobutamine 心臓超音波。四個月後所有病患予以追蹤二度空間心臓超音波，用以評估無法收縮及收縮困難的左心室心肌之存活性。

結果 我們共分析 260 個收縮困難或無法收縮的心肌區域，經即時造影剝超音波檢查，呈現均勻分部或塊狀顯影之區域可用於預測左心室心肌存活性的敏感度為 81.4%，特異性為 76.7%，準確度為 79.4%，正向預測值 81.8%為及負向預測值為 75%，此準確性與低劑量 dobutamine 心臓超音波不相上下 (79.4% vs. 76.8%, p = 0.52)，而即時造影剝超音波檢查有較高之敏感度 (81.4% vs. 68.9%, p < 0.005)，低劑量 dobutamine 心臓超音波有較高之特異性 (76.7% vs. 87.6%, p < 0.01)。即時造影剝超音波檢查平均耗時較少 (374 ± 102 seconds vs. 785 ± 216 seconds, p < 0.001)，且無任何併發症。而在 dobutamine 心臓超音檢查中，4.5%病人罹患頭痛及 2.2%病患有胸悶之症狀 (p < 0.001)。

結論 即時造影剝超音波雖然受到下壁或後壁“衰退現象”的限制，但仍可早期評估急性心肌梗塞病患之左心室心肌存活性，其準確性與低劑量 dobutamine 心臓超音波不相上下。同時，即時造影剝超音波可以更安全及省時的應用於早期評估左心室心肌存活性。

關鍵詞：急性心肌梗塞、低劑量 dobutamine 心臓超音波、即時造影剝超音波。