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Prognostic Value of Viable Myocardium in Patients with Non-Q-wave and Q-wave Myocardial Infarction

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This study assessed the amount and prognostic value of myocardial viability in patients with non-Q-wave myocardial infarction (NQMI) and Q-wave myocardial infarction (QMI). A total of 175 patients with MI and an ejection fraction ≤ 45% underwent dobutamine stress echocardiography. On the basis of clinical criteria and myocardial viability, 110 patients were revascularized. The amount of viable myocardium and the clinical outcome were compared in the NQMI and QMI groups. Patients with NQMI exhibited a larger amount of viable myocardium compared with those with QMI. The mortality rate was 6% in patients with NQMI with viable myocardium and subsequent revascularization, 33% in patients with NQMI without viable myocardium or revascularization, 27% in patients with QMI with viable myocardium and subsequent revascularization, and 33% in patients with QMI without viable myocardium or revascularization. In conclusion, our data suggest that patients with NQMI and viable myocardium have the best prognosis after revascularization.

KEY WORDS: Viable myocardium; Non-Q-wave myocardial infarction; Q-wave myocardial infarction; Revascularization; Survival

Introduction

Left ventricular (LV) function is an important determinant of survival in patients with coronary artery disease (CAD). Severe LV systolic dysfunction is a predictor of high mortality in these patients.[1 – 3] Such dysfunction may be due to viable, hibernating myocardium rather than irreversible scarring;[4] the potential reversibility of chronic LV dysfunction is an important clinical consideration when assessing such patients for revascularization,[5,6] as this procedure may substantially improve LV function in a subset of patients.[6 – 8]

Myocardial infarction (MI) may be categorized electrocardiographically as Q-wave MI (QMI) or non-Q-wave MI (NQMI). QMI is frequently associated with transmural infarction and NQMI with non-transmural infarction. Pathophysiological and clinical differences between NQMI and QMI have been identified.[9,10] The infarct size may be smaller in NQMI than in QMI,[10,11] but NQMI is often associated with a higher incidence of late cardiac events.[12,13] There is little published data on the relationship between

myocardial viability and clinical outcome in patients with NQMI. The purpose of this study was to assess the amount and prognostic value of viable myocardium in patients with QMI and NQMI.

Patients and methods

PATIENT SELECTION

The study groups were selected from patients evaluated and managed at our institution. Patients with a previous MI referred between 1996 and 2003 for coronary angiography and potential coronary revascularization who met the following criteria were enrolled into the study:

(i) An LV ejection fraction (EF) ≤ 45% as assessed by echocardiography;
(ii) Presence of CAD, defined as ≥ 70% stenosis in at least one major epicardial coronary artery;
(iii) Recent MI (> 1 month) with or without Q-wave;
(iv) The ability to evaluate regional wall motion abnormalities of all 16 myocardial segments with echocardiography;
(v) No valvular heart disease or the need for aneurysmectomy;
(iv) No malignant disease or terminal organ disease.

After approval of the local ethical committee, all patients gave written consent to dobutamine stress echocardiography, coronary angiography and revascularization procedures.

DOBUTAMINE STRESS ECHOCARDIOGRAPHY

Treatment with β-blockers was stopped 24 h before the test. Standard transthoracic echocardiography and dobutamine stress echocardiography (DSE) were performed with the patient in the left lateral decubitis position. After resting images were obtained, each patient was initially administered with 5 μg/kg per min dobutamine intravenously with an infusion pump for 5 min. Parasternal long-axis view, parasternal short-axis view, parasternal short-axis views at the base, papillary muscle and apical two- and four-chamber views were recorded on VHS videotape at rest and during administration of dobutamine for subsequent off-line analysis. The electrocardiogram (ECG) was monitored continuously during dobutamine infusion, and the blood pressure was recorded at each stage. After 5-min infusion of dobutamine at 5 μg/kg per min the dose was increased to 10 μg/kg per min. The procedure described above was then repeated and the same recordings were made again. Follow-up echocardiography was performed 3 months after coronary revascularization or medical treatment.

For analysis, the left ventricle was divided into a standard 16-segment model as recommended by the American Society of Echocardiography.[14] Wall motion at rest was scored using a four-grade scoring system: 1, normal; 2, hypokinesia; 3, akinesia; 4, dyskinesia. The wall motion score index (WMSI) was calculated as the sum of the segmental wall motion scores divided by the number of scored segments. Wall thickening was assessed at a distance of ≥ 1 cm from the adjacent segment to minimize the effect of tethering.[15] Dysfunctional segments were defined as viable if they exhibited functional improvement of at least 1 grade with any dose of dobutamine, and a patient was considered to have myocardial viability if two or more segments demonstrated improvement during DSE.[16,17]

The LV volume and EF were calculated as an average of three consecutive heart cycles using the biplane Simpson's method recommended by the American Society of Echocardiography.[14] Regional wall motion analysis and EF calculations were performed

from videotapes in our centre by two experienced readers who were blinded to the patients' data.

CORONARY ANGIOGRAPHY

Selective coronary angiography was performed using Judkin's technique. The severity of coronary stenoses was expressed as a percentage of the luminal diameter narrowing; significant CAD was defined as ≥ 70% diameter stenosis of at least one major coronary artery.

CORONARY REVASCULARIZATION

Coronary revascularization was performed by coronary artery bypass grafting (CABG) or percutaneous transluminal coronary angioplasty (PTCA) with stenting within 2 weeks of the DSE investigation.

FOLLOW-UP

Follow-up survival data were obtained by chart review, by contacting patients by post or telephone or a combination of these methods. Clinical follow-up of all patients was performed at our institution. The end-point of the study was total mortality.

STATISTICAL ANALYSIS

All data are reported as the mean ± SD. The characteristics of the patient groups were compared using analysis of variance, the standard *t*-test and the χ^2 test; a *P*-value < 0.05 was considered to be statistically significant. Patient groups were compared for nominal variables using the Bonferroni correction, for which a *P*-value < 0.01 was required for statistical significance. Differences in survival between patient groups were compared using Kaplan–Meier survival curves, and statistical significance was determined by the log-rank test. Independent predictors of mortality were determined by Cox proportional hazard analysis.

Results

The study selection criteria were met by 232 patients; however, follow-up data could not be obtained for 57 patients and therefore the final study group consisted of 175 patients (12 women and 163 men). The mean age of patients was 58 ± 8 years (range 36 – 74 years) and the mean LVEF was 39 ± 5%. Sixty-three patients (36%) had a history of smoking, and 84 (48%) were being treated for hypertension, 82 (47%) for hyperlipidaemia and 49 (28%) for diabetes.

On the basis of clinical criteria and myocardial viability, 110 patients were revascularized: 81 underwent coronary artery bypass grafting and 29 underwent percutaneous transluminal coronary angioplasty. No MI or unstable angina occurred in the period between DSE and revascularization. The selection for revascularization was made by the patient's physician.

Based on the presence of a Q-wave on ECG and revascularization status, patients were classified into four groups: group A consisted of patients with NQMI who demonstrated myocardial viability during DSE and subsequently underwent revascularization ($n = 69$), group B consisted of patients with NQMI who did not demonstrate myocardial viability and did not undergo revascularization ($n = 20$), group C consisted of patients with QMI and viable myocardium who underwent revascularization ($n = 41$), and group D consisted of patients with QMI who did not have myocardial viability and did not undergo revascularization ($n = 45$).

The baseline characteristics of the various groups are given in Table 1. The four groups had similar values for baseline LVEF, WMSI, mean number of dysfunctional segments per patient, CAD risk factors and medications. There were no statistically significant differences between the groups except for the presence of three-vessel disease at baseline.

TABLE 1:
Comparison of characteristics of patient groups with previous non-Q-wave myocardial infarction (NQMI) or Q-wave myocardial infarction (QMI)

	Group A (n = 69)	Group B (n = 20)	Group C (n = 41)	Group D (n = 45)
Age (years)	57 ± 7	59 ± 8	58 ± 9	59 ± 10
Male gender	65 (94%)	18 (90%)	37 (90%)	43 (96%)
Diabetes mellitus	19 (28%)	7 (35%)	11 (27%)	12 (28%)
Smoking	25 (36%)	8 (40%)	14 (34%)	16 (35%)
Hypertension	31 (45%)	10 (55%)	21 (51%)	20 (44%)
Three-vessel CAD	32 (46%)[a]	9 (45%)[a]	24 (58%)	27 (60%)
Rest WMSI	2.12 ± 0.46	2.03 ± 0.51	2.07 ± 0.41	2.10 ± 0.43
Rest LVEF	39 ± 6%	37 ± 8%	38 ± 6%	39 ± 7%
No. of dysfunctional segments	7.5 ± 2.9	7.2 ± 2.7	7.8 ± 3.0	7.7 ± 2.6
No. of viable segments	6.1 ± 2.6	0.8 ± 0.5	2.8 ± 1.4	0.6 ± 0.5
No. of improved segments	5.1 ± 2.2	0.4 ± 0.5	2.3 ± 1.2	0.3 ± 0.5
LVEF at 3rd month	49 ± 6%	38 ± 7%	42 ± 7%	38 ± 8%

Values are the number and percentage of patients or the mean ± SD.
Group A, patients with NQMI with viable myocardium and subsequent revascularization; group B, patients with NQMI without viable myocardium and revascularization; group C, patients with QMI with viable myocardium and subsequent revascularization; group D, patients with QMI without viable myocardium and revascularization; CAD, coronary artery disease; WMSI, wall motion score index; LVEF, left ventricular ejection fraction.
[a]$P < 0.05$ versus groups C and D.

FUNCTIONAL RECOVERY AFTER REVASCULARIZATION

Dysfunctional but viable myocardium was more common in the patients with NQMI than in those with QMI, and the mean number of viable segments was higher in the NQMI group than the QMI group (Table 2). The number of dysfunctional segments was similar in the two groups before DSE (Fig. 1).

Revascularized patients with QMI or NQMI demonstrated functional recovery within 3 months after revascularization, but, due to a greater number of improved segments, the LVEF was higher and the WMSI lower in the NQMI group than the QMI group; these differences were statistically significant.

SURVIVAL

Among the 175 patients there were 36 deaths (21%). The mortality rate was 6% in group A, 33% in group B, 27% in group C and 33% in group D. Fig. 2 shows survival in the four groups over time. Differences in survival between patients in group A and the other three groups increased over time, becoming significant by the end of the follow-up time ($P < 0.01$).

Myocardial viability and LVEF after 3 months were the most important independent predictors of mortality in all patients (Table 3). In NQMI patients, the absence of myocardial viability was a significant predictor of mortality.

TABLE 2:
Comparison of characteristics of patients with non-Q-wave myocardial infarction (NQMI = group A + B) or Q-wave myocardial infarction (QMI = group C + D)

	NQMI	QMI	*P*-value
No. of dysfunctional segments	7.4 ± 2.8	7.8 ± 2.3	NS
No. of viable segments	4.9 ± 2.4	2.1 ± 0.9	< 0.01
No. of improved segments	4.1 ± 1.9	1.3 ± 0.7	< 0.01
Revascularization by PTCA	16 (18%)	13 (15%)	NS
LVEF at 3rd month	46 ± 9%	40 ± 8%	< 0.01
WMSI at 3rd month	1.33 ± 0.52	1.79 ± 0.44	< 0.01

Values are the number and percentage of patients or the mean ± SD.
PTCA, percutaneous transluminal coronary angioplasty; NS, not significant.

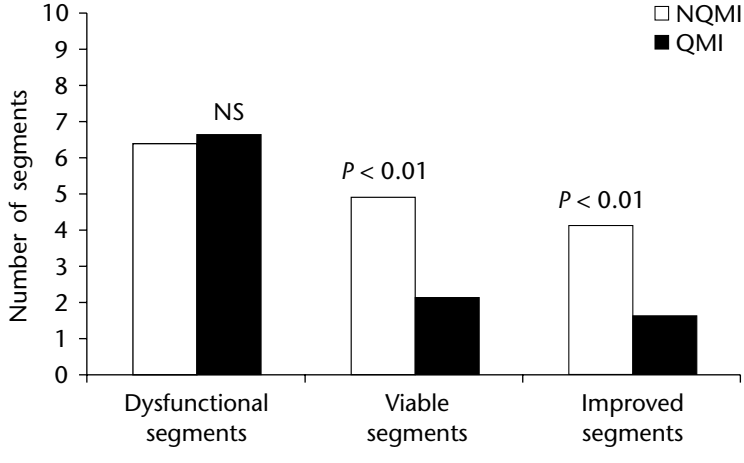

FIGURE 1: Comparison of mean number of dysfunctional segments at baseline, viable segments detected by dobutamine stress echocardiography and improved segments after revascularization in patients with previous non-Q-wave myocardial infarction (NQMI = group A + B) or Q-wave myocardial infarction (QMI = group C + D)

Discussion

This study was performed in patients with previous MI and moderate to severe LV dysfunction. Patients with CAD and LV dysfunction have a high mortality and morbidity, and ischaemic LV dysfunction is the most common cause of heart failure and other adverse cardiac events, including arrhythmia, ischaemic events and death. Recent studies suggest that, compared with medical therapy, revascularization may improve survival and quality of life in patients with severe LV dysfunction.[18] The mortality of revascularization is high in these patients; therefore the correct selection of patients for revascularization is very important.

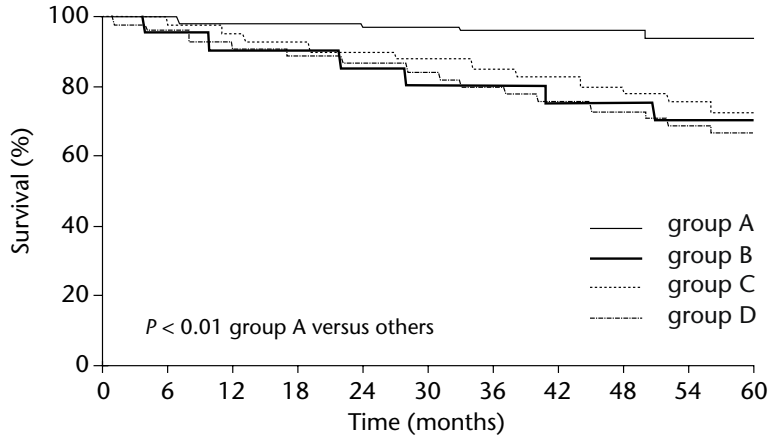

FIGURE 2: Comparison of survival in patients with non-Q-wave myocardial infarction (NQMI) with viable myocardium and subsequent revascularization (group A), patients with NQMI without viable myocardium and revascularization (group B), patients with Q-wave myocardial infarction (QMI) with viable myocardium and subsequent revascularization (group C), and patients with QMI without viable myocardium and revascularization (group D)

TABLE 3:
Independent predictors of mortality in patients with previous non-Q-wave myocardial infarction (NQMI) or Q-wave myocardial infarction (QMI)

Variable	Risk ratio (95% CI)	*P*-value
Age	1.07 (0.90 – 1.10)	NS
Three-vessel disease	1.15 (1.0 – 1.90)	NS
LVEF	0.92 (0.80 – 1.10)	NS
Non-group A patient	3.20 (1.0 – 11.0)	< 0.01

CI, confidence interval; LVEF, left ventricular ejection fraction; group A, patients with NQMI with viable myocardium and subsequent revascularization.

The presence of myocardial viability has been shown to predict improvement in LV function after coronary revascularization.[19 – 21] In patients with chronic CAD and severe LV dysfunction, there was increased mortality in patients with dysfunctional but viable myocardium who were treated medically,[8,19 – 21] but in the absence of myocardial viability, mortality was similar in patients who did or did not undergo revascularization.[22 – 25]

In the present study, we investigated whether patients with NQMI have more dysfunctional viable myocardium than patients with QMI. Despite a favourable early prognosis, long-term survival in patients with NQMI is similar to that in patients with QMI.[26] Frequent cardiac events in patients with NQMI strongly suggest that the myocardium may be at high risk due to incomplete reperfusion, which may manifest as stress-induced ischaemic viable

myocardium on DSE. The present study demonstrated that patients with NQMI had more viable myocardium than those with QMI; although baseline LV function was similar, NQMI patients showed more viable segments detected by DSE and more improved segments after revascularization than QMI patients. In addition, the NQMI group had a higher LVEF and lower WMSI than the QMI group after revascularization. These results confirm that patients with NQMI have more myocardium in jeopardy than in those with QMI. Early studies with a small number of patients reported that viable myocardium detected by positron emission tomography (PET) was more common in patients with NQMI than in those with QMI.[27,28] In a larger PET study, Yang *et al.*[29] showed that patients with NQMI had more ischaemic viable myocardium than patients with QMI, and also that the amount of ischaemic viable myocardium was significantly greater in NQMI than in QMI. There was no follow-up period to study functional recovery or survival in these PET studies. In contrast, the present study was a relatively large DSE study in which functional recovery and survival after revascularization were investigated. We showed that the number of improved segments and the LVEF were higher in patients with NQMI than in those with QMI after revascularization.

Although one trial[30] did not demonstrate clinical benefit for an invasive strategy, most studies[29,31] have shown that patients who underwent revascularization had fewer cardiac events than those managed conservatively. The present study demonstrated a high prevalence of viable myocardium in patients with NQMI, and a revascularization-based strategy demonstrated the best survival in these patients. In patients with substantial myocardial viability, LV function may significantly improve after revascularization. Patients with little viability before revascularization have a high rate of early and late cardiac events, including death.[18,32] Patients with viable myocardium have been shown to have a substantially better event-free survival with revascularization compared with medical therapy;[22 – 25] our study confirmed these data. Assessment of myocardial viability should therefore be performed and a subsequent early invasive strategy considered in patients with NQMI who have moderate to severe LV dysfunction.

Dobutamine stress echocardiography can be used for the identification of viable myocardium, and has a high specificity for predicting the recovery of systolic function after revascularization.[33] Owing to its low cost, portability and wide availability, DSE is particularly attractive for the assessment of myocardial viability. Previous studies have demonstrated that, in patients with CAD and severe LV systolic dysfunction who had evidence of myocardial viability on DSE, revascularization improved survival compared with medical therapy. In the present study, there was no difference in survival between those with and without viable myocardium in patients with QMI. The amount of viable myocardium has been shown to be an important predictor of survival in revascularized patients.[23] Other methods used to determine viable myocardium are PET and thallium-201 tomography. DSE has been reported to be more specific for the prediction of recovery of function than myocardial thallium uptake.[34,35] PET has been used in some studies as the gold standard for the detection of viable myocardium, but is relatively expensive and is not widely available.

The present study has several limitations. The number of patients is relatively small, but long-term follow-up data were collected,

allowing the study to provide information about the prognostic value of viable myocardium in NQMI after revascularization. In this study, ECG criteria were used for the identification of NQMI and QMI. DSE alone was used for the identification of viable myocardium and it was not compared with other methods. The decision to perform revascularization was not randomized, but the patient groups did have similar characteristics. Since the study began in 1996 and lasted for 7 years, we were not able to use modern techniques such as digital images rather than videotapes.

In conclusion, our data suggest that patients with NQMI have more viable segments than those with QMI, and that patients with NQMI and viable myocardium have the best prognosis after revascularization. These findings should be confirmed in larger, randomized studies.

Conflicts of interest

No conflicts of interest were declared in relation to this article.

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