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Left Ventricular Post-Infarct Remodeling

Implications for Systolic Function Improvement and Outcomes in the Modern Era

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ABSTRACT

OBJECTIVES This study sought to investigate the impact of post-infarct left ventricular (LV) remodeling on outcomes in the contemporary era.

BACKGROUND LV remodeling after ST-segment elevation myocardial infarction (STEMI) is associated with heart failure and increased mortality. Pivotal studies have mostly been performed in the era of thrombolysis, whereas the long-term prognostic impact of LV remodeling has not been reinvestigated in the current era of primary percutaneous coronary intervention (PCI) and optimal pharmacotherapy.

METHODS Data were obtained from an ongoing registry of patients with STEMI (all treated with primary PCI). Baseline, 3-month, 6-month, and 12-month echocardiograms were analyzed. LV remodeling was defined as a ≥20% increase in LV end-diastolic volume at 3, 6, or 12 months post-infarct. The impact of LV remodeling on outcomes was analyzed.

RESULTS A total of 1,995 patients with STEMI were studied (mean age 60 ± 12 years, 77% men), 953 (48%) of whom demonstrated remodeling in the first 12 months of follow-up. After a median follow-up of 94 (interquartile range: 69 to 119) months, 225 (11%) patients had died. There was no difference in survival between remodelers and nonremodelers ($p = 0.144$). However, LV remodelers were more likely to be admitted to hospital for heart failure than were nonremodelers ($p < 0.001$).

CONCLUSIONS In the contemporary era, in which STEMI is treated with primary PCI and optimal pharmacotherapy, almost one-half of patients demonstrate LV post-infarct remodeling. However, there is no difference in long-term survival between LV remodelers and nonremodelers, and LV remodelers experience a higher rate of heart failure hospitalization, which indicates the need to intensify preventative strategies in these patients.
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Left ventricular (LV) remodeling after ST-segment elevation myocardial infarction (STEMI) is caused by an inflammatory response, mediated by various cells and cytokines, ultimately leading to degradation of the myocardial extracellular matrix and slippage of muscle bundles in the infarcted area (1). This leads to wall thinning, infarct expansion, increased wall stress, and LV remodeling. Post-infarct remodeling is associated with larger infarct size, transmural infarction, microvascular obstruction, myocardial hemorrhage, and advanced patient age (2,3). Angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARB), mineralocorticoid antagonists, more rapid reperfusion, and the degree of ST-segment resolution on a 12-lead electrocardiogram (ECG) are associated with less LV remodeling post-infarct (4).

LV remodeling post-infarct has been associated with heart failure, functional mitral regurgitation, ventricular arrhythmias, and increased mortality

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ABBREVIATIONS AND ACRONYMS

ACE = angiotensin converting enzyme inhibitor

ARB = angiotensin receptor blocker

ARNI = angiotensin receptor-blocker-neprilysin inhibitor

LV = left ventricle

LVEDV = left ventricular end-diastolic volume

LVEF = left ventricular ejection fraction

LVESV = left ventricular end-systolic volume

PCI = percutaneous coronary intervention

STEMI = ST-segment elevation myocardial infarction

WMSI = wall motion score index

(5-7), although much of the outcome data emanate from the era of thrombolysis, before the advent of primary percutaneous coronary intervention (PCI) and optimal medical therapy (4). Primary PCI has revolutionized the management of STEMI and dramatically improved outcomes (8). In contrast to pharmacological thrombolysis, LV function often improves after primary PCI, despite the development of LV remodeling in some patients (9,10).

Neither the interaction of LV post-infarct remodeling with systolic LV function nor the long-term prognostic impact of such remodeling have been echocardiographically investigated in the current era of primary PCI and optimal pharmacotherapy. We therefore analyzed data from a large, contemporary registry of patients with STEMI, who were treated with primary PCI for the impact of LV remodeling post-infarct on LV systolic function in the first 12 months after the event and its effect on mortality and hospitalization.

METHODS

STUDY POPULATION AND DATA COLLECTION. Clinical, angiographic and echocardiographic data of patients presenting to the Leiden University Medical Center with a STEMI and managed with primary PCI are systematically collected in an ongoing registry since February 2004. Patients are treated according to a standardized, institutional protocol (MISSION!), which is based on contemporary European Society of Cardiology guidelines and includes primary PCI performed within 90 min of the first medical contact (11). Per protocol, comprehensive echocardiography is performed within 48 h of admission, as well as at the 3-, 6-, and 12-month outpatient visits.

Demographics, cardiovascular risk factors, and comorbidities were collected. Survival data were collected via municipal registries and telephonic follow-up, while data on heart failure hospitalization were acquired by medical record review, as well as telephonic follow-up. Heart failure hospitalization was defined as admission for worsening heart failure symptoms requiring intravenous diuretic therapy. As all data used for the present study were acquired for clinical purposes and handled anonymously, written, informed consent on a patient level was waived by the Institutional Review Board (C13.029).

ECHOCARDIOGRAPHIC DATA ACQUISITION. All patients underwent transthoracic echocardiography in the left lateral decubitus position with a commercially available echocardiography system (VIVID 7 or E9, GE Healthcare, Milwaukee, Wisconsin). Echocardiographic data were acquired and digitally archived for off-line analysis (EchoPac 202, GE Healthcare). The LV end-systolic volume (LVESV), LV end-diastolic volume (LVEDV), and LV ejection fraction (LVEF) were calculated with Simpson's method from 2-dimensional, apical, 2-chamber, and 4-chamber views (12). LV mass was calculated with the linear method (12), while the wall motion score index (WMSI) was defined as the sum of individually scored segments divided by a total of 16. The intraobserver and interobserver variability of LVEDV were assessed in 60 randomly selected patients. The intraclass correlation coefficient for intra- and inter-observer variability of LVEDV was 0.86 (95% confidence interval: 0.76 to 0.91; $p < 0.001$) and 0.88 (95% confidence interval: 0.80 to 0.92; $p < 0.001$) respectively. The bias and 95% limits of agreement for intraobserver variability of LVEDV were -5.4 $\pm$ 40 ml, whereas the bias and 95% limits of agreement for interobserver variability of LVEDV were -4.9 $\pm$ 38 ml.

LV REMODELING: DEFINITION. The presence of LV remodeling was defined as an increase in the LVEDV of ≥20% at any time during the first 12 months post-STEMI (9). Temporal patterns of LV remodeling were defined as: 1) if present at 3 months post-STEMI, early LV remodeling; 2) at 6 months, mid-term LV remodeling; and 3) 12 months, late LV remodeling. Classification into 1 of these 3 temporal groups excluded inclusion into any of the other 2 groups. Based on the presence of remodeling at any time (early, midterm, late) the study population was divided into remodelers and nonremodelers. Subgroup analysis for outcomes was performed according to the following categories of baseline LV systolic function: LVEF <40%, LVEF 40% to 49%, and LVEF ≥50% (Online Appendix) (13).

STATISTICAL ANALYSIS. Continuous data are presented as mean $\pm$ SD when normally distributed and as median (interquartile range) when not normally distributed. Categorical data are presented as frequencies and percentages. Continuous variables were compared with Student's *t*-tests or Mann-Whitney *U* tests, as appropriate. Categorical variables were analyzed with chi-square tests. Changes in LVEDV and LVEF over time were compared between groups using linear mixed models. Survival analyses were performed with the Kaplan-Meier method and differences between groups were compared with a log-rank test. A Cox proportional hazards model was constructed to investigate the association between LV post-infarct remodeling and heart failure

hospitalization, including parameters known to influence post-infarct readmission. To evaluate the sensitivity of our analyses to body mass, outcomes were evaluated with LVEDV indexed for body mass (in kg). SPSS for Windows version 23.0 (IBM Corporation, Armonk, New York) was used for performing all the analyses. All statistical tests were 2 sided, and a p value <0.05 was considered significant.

RESULTS

A total of 1,995 patients were analyzed (mean age 60 ± 12 years, 77% men). Baseline clinical characteristics are summarized in **Table 1**. The baseline echocardiographic characteristics are displayed in Online Table 1. The mean LVEDV for the overall population was 106 ± 33 ml at baseline, 115 ± 39 ml at 3 months after the index event, 114 ± 38 ml at 6 months, and 110 ± 38 ml at 12 months.

TABLE 1 Baseline Clinical Characteristics

	Remodelers (n = 953)	Nonremodelers (n = 1,042)	Overall Population (N = 1,995)	p Value
Age, yrs	61 ± 12	60 ± 11	60 ± 12	0.249
Male	729 (76)	798 (77)	1,527 (77)	0.963
Hypertension	359 (38)	342 (33)	701 (35)	0.050
Dyslipidemia	210 (22)	191 (18)	401 (20)	0.086
Current smoker	436 (46)	498 (48)	934 (47)	0.208
Ex-smoker	103 (11)	122 (12)	225 (11)	0.525
Family history of IHD	397 (42)	447 (43)	844 (42)	0.834
Diabetes mellitus	114 (12)	93 (9)	207 (10)	0.026
Previous infarct	67 (7)	91 (9)	158 (8)	0.371
Systolic BP, mm Hg	137 ± 26	135 ± 26	136 ± 26	0.303
Diastolic BP, mm Hg	82 ± 16	82 ± 17	82 ± 16	0.957
Killip class				
I	914 (96)	1,001 (96)	1,915 (96)	0.858
II	21 (2)	20 (2)	41 (2)	0.655
III	7 (1)	5 (1)	12 (1)	0.462
IV	11 (1)	16 (1)	27 (1)	0.462
Peak cTnT, μg/l	4.4 (1.9–9.0)	2.9 (1.2–6.1)	3.5 (1.4–7.3)	<0.001
eGFR, ml/min/1.73 m^2	98.2 ± 33.2	99.2 ± 33.2	98.7 ± 33.2	0.571
Infarct location LAD or LMS	428 (45)	440 (42)	868 (44)	0.240
Multivessel CAD	508 (53)	565 (54)	1,073 (54)	0.664

Values are mean ± SD, n (%), or median (interquartile range).

BP = blood pressure; CAD = coronary artery disease; cTnT = cardiac troponin T; eGFR = estimated glomerular filtration rate; IHD = ischemic heart disease; LAD = left anterior descending coronary artery; LMS = left main stem.

LV REMODELING AND SYSTOLIC FUNCTION: CHANGES DURING FIRST 12 MONTHS

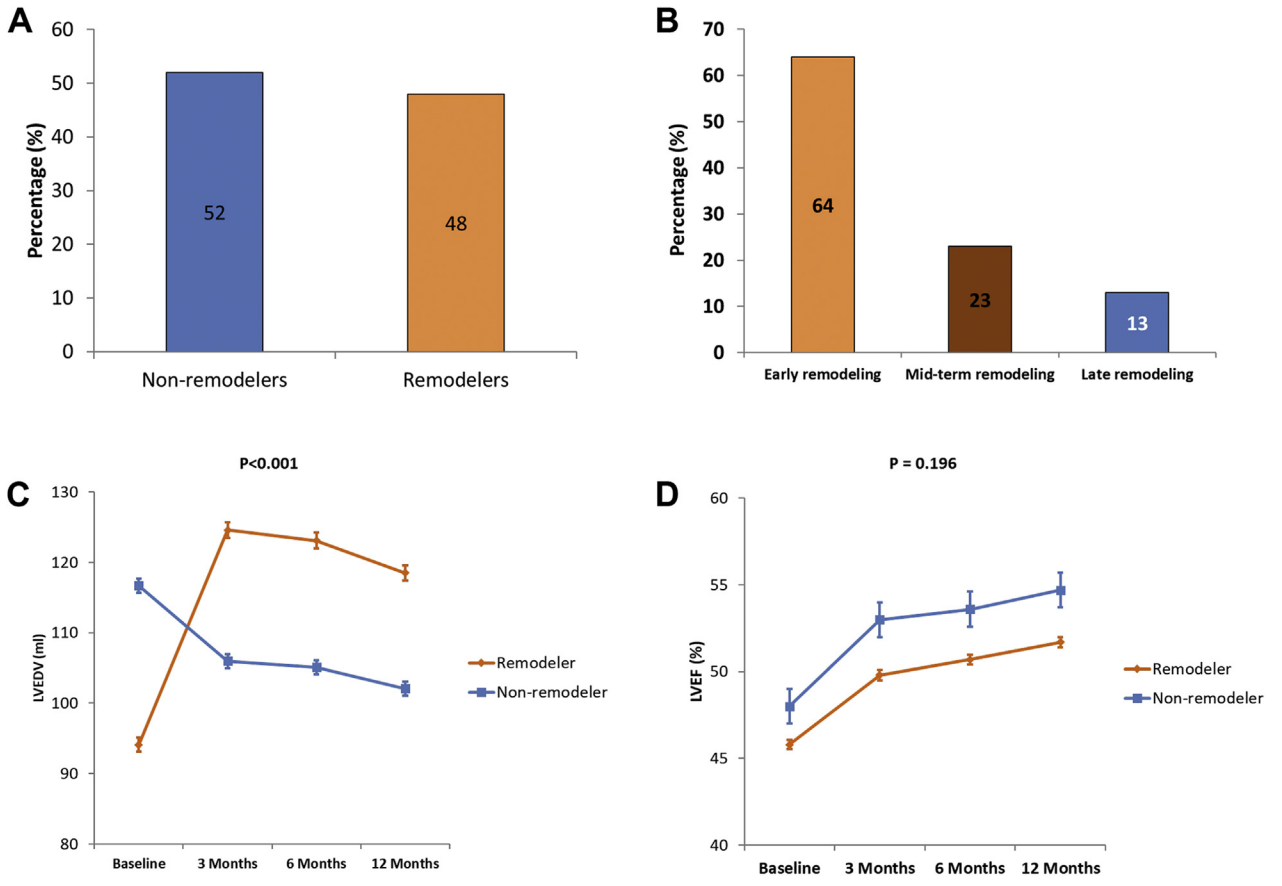
Of the 1,995 patients, 953 (48%) were classified as remodelers and 1,042 (52%) were classified as nonremodelers (**Figure 1A**). Of the 953 remodelers, 613 (64%) experienced early remodeling, 216 (23%) experienced midterm remodeling, and 124 (13%) experienced late remodeling (**Figure 1B**). Remodelers were characterized by smaller baseline LVEDV, smaller LVESV, lower LVEF, and higher WMSI. Discharge pharmacotherapy are summarized in Online Table 2. No significant differences in discharge medication were seen between remodelers and nonremodelers.

In LV remodelers, the mean LVEDV increased from 94 ± 28 ml at baseline to 125 ± 42 ml at 3 months, 123 ± 41 ml at 6 months, and 118 ± 41 ml at 12 months. In contrast, in nonremodelers, the LVEDV decreased from 117 ± 34 ml at baseline to 106 ± 34 ml at 3 months, 105 ± 34 ml at 6 months, and 102 ± 33 ml at 12 months (p < 0.001) (**Figure 1C**). The mean LVEF for the overall population was 47 ± 9% at baseline, 51 ± 10% at 3 months post-STEMI, 52 ± 10% at 6 months, and 53 ± 10% at 12 months. There were no differences in LVEF changes between remodelers and nonremodelers (p = 0.196) (**Figure 1D**).

LV REMODELING AND ALL-CAUSE MORTALITY. During a median follow-up of 94 (interquartile range: 69 to 119) months, 225 (11%) of patients died. Patients with LV remodeling demonstrated a cumulative event rate of 5%, 11%, and 19% for all-cause mortality at 40, 80, and 120 months, respectively. Similarly, patients without LV remodeling demonstrated cumulative event rates of 4%, 9%, and 16% for the same intervals (log-rank test; p = 0.144) (**Figure 2**). There was no significant difference in the event rate between remodelers and nonremodelers in those patients with a baseline LVEF <40% (log-rank test; p = 0.870) (Online Figure 1), an LVEF 40% to 49% (log-rank test; p = 0.672) (Online Figure 2), or an LVEF ≥50% (log-rank test; p = 0.272) (Online Figure 3).

LV REMODELING AND HEART FAILURE HOSPITALIZATION. During the follow-up, 90 (5%) patients were admitted to hospital for heart failure. Patients with LV remodeling experienced more frequent heart failure hospitalizations compared with nonremodelers (log-rank test; p < 0.001) (**Figure 3**). In patients with LV remodeling, the cumulative event rates for hospitalization for heart failure were 6%, 7%, and 9% at 40, 80, and 120 months, respectively. In contrast, in patients without LV remodeling, the cumulative event rates were 2%, 3%, and 4% for the identical time points. In the patient group with an LVEF <40%, remodelers experienced a higher rate of heart failure hospitalization than did nonremodelers (log-rank test; p = 0.02) (Online Figure 4). The same pattern was observed in those with an LVEF 40% to 49% (log-rank test; p = 0.004) (Online Figure 5). In contrast, the cumulative event rates were not statistically different between remodelers and nonremodelers in

FIGURE 1 Echocardiographic Outcomes After ST-Segment Elevation Myocardial Infarction

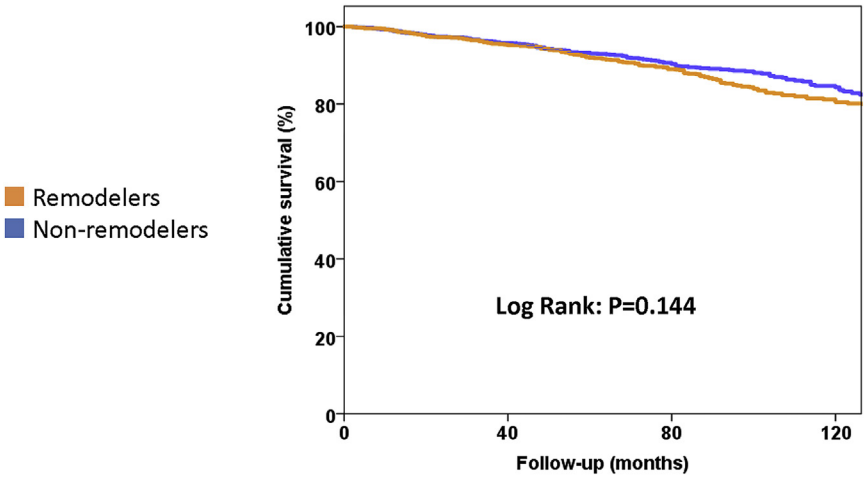


(A) Distribution of patients with and without left ventricular post-infarct remodeling. Percentage of patients classified as left ventricular remodelers and nonremodelers during the first year after ST-segment elevation myocardial infarction (STEMI). **(B)** Distribution of temporal remodeling patterns. Patients demonstrating early, midterm, and late remodeling after STEMI, expressed as a percentage of all patients undergoing remodeling during the first year. **(C)** Changes in left ventricular volumes, according to remodeling status. Changes in mean left ventricular end-diastolic volume (LVEDV) over the first year after STEMI in remodelers and non-remodelers (remodelers include early, midterm, and late remodelers). **Vertical bars** represent SE of the mean (SEM). **(D)** Changes in left ventricular systolic function, according to remodeling status. Changes in percentage mean left ventricular ejection fraction (LVEF) over the first year after STEMI in remodelers and nonremodelers. **Vertical bars** represent SEM.

the group with an LVEF ≥50% (log-rank test; $p = 0.471$) (Online Figure 6). To investigate the association between LV post-infarct remodeling and heart failure hospitalization, a Cox proportional hazards model was constructed, containing variables known to influence readmission of such patients (Table 2). On multivariable analysis, LV post-infarct remodeling was independently associated with an increased risk of hospitalization for heart failure (hazard ratio: 2.66; 95% confidence interval: 1.69 to 4.19; $p < 0.001$).

SENSITIVITY ANALYSES. When LVEDV was indexed for body mass, 948 (48%) of patients demonstrated LV remodeling. Early, midterm, and late remodeling occurred in 610 (64%), 216 (23%), and 122 (13%) remodelers respectively, when indexing LVEDV for body mass. No significant difference in mortality was seen between LV remodelers and nonremodelers when using an indexed LVEDV value (log-rank test; $p = 0.131$). Patients with LV remodeling experienced more frequent heart failure hospitalizations compared with nonremodelers (log-rank test; $p < 0.001$). LV post-infarct remodeling (indexed to body mass) remained independently associated with an increased risk of heart failure hospitalization (hazard ratio: 2.69; 95% confidence interval: 1.71 to 4.24; $p < 0.001$).

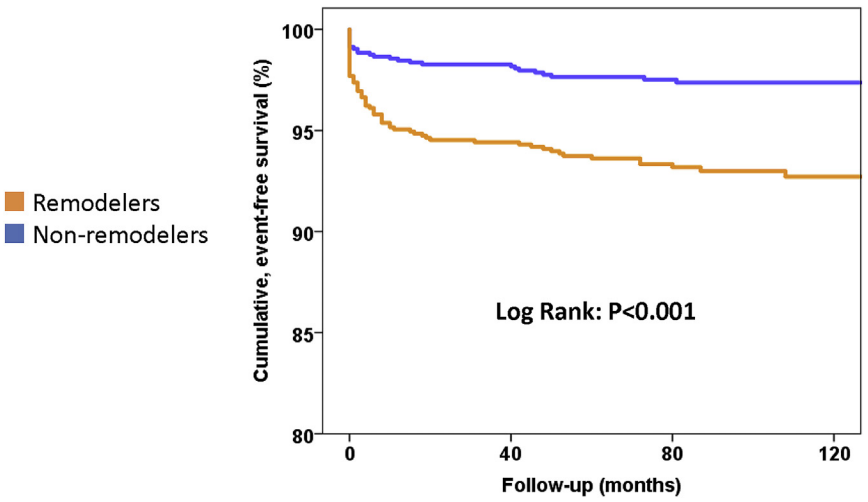
FIGURE 2 Kaplan-Meier Survival Curves, According to Remodeling Status



Patients at risk:				
Remodelers	953	908	599	240
Non-remodelers	1042	997	679	241

Survival curves for time to cumulative survival, according to the presence or absence of left ventricular remodeling in the first year after ST-segment elevation myocardial infarction.

FIGURE 3 Kaplan-Meier Curves for Heart Failure, According to Remodeling Status



Patients at risk:				
Remodelers	953	866	579	229
Non-remodelers	1042	982	667	238

Survival curves for freedom from heart failure hospitalization, according to the presence or absence of left ventricular remodeling in the first year after ST-segment elevation myocardial infarction.

TABLE 2 Univariate and Multivariate Cox Proportional Hazards Model for Heart Failure Hospitalization

	Univariate Analysis			Multivariate Analysis		
	HR	95% CI	p Value	HR	95% CI	p Value
LV post-infarct remodeling	2.81	1.78–4.42	<0.001	2.66	1.69–4.19	<0.001
Age	1.02	1.01–1.04	0.010	1.02	1.00–1.04	0.050
Female	0.98	0.77–1.25	0.887	–	–	–
eGFR	1.00	0.99–1.01	0.703	–	–	–
Diabetes mellitus	2.51	1.53–4.11	<0.001	2.11	1.28–3.49	0.003
Moderate-severe MR (at baseline)	2.01	1.12–3.62	0.020	1.69	0.93–3.07	0.084

CI = confidence interval; eGFR = estimated glomerular filtration rate; HR = hazard ratio; LV = left ventricular; MR = mitral regurgitation.

DISCUSSION

The principle findings in this study of patients with STEMI undergoing serial echocardiograms in the contemporary era are that during the first year post-infarct, almost one-half (48%) demonstrated LV remodeling and the majority (64%) experienced LV remodeling during the first 3 months. Nonetheless, LV systolic function improved to a similar degree in remodelers and nonremodelers during the first post-infarct year. No significant difference in survival between patients with and without post-infarct LV remodeling was seen, but those who developed LV remodeling post-STEMI experienced higher rates heart failure hospitalization (**Central Illustration**). These outcome analyses were robust to the use of a body mass-indexed LVEDV in a sensitivity analysis.

LV REMODELING: PRESENCE AND TEMPORAL PATTERNS. The prevalence of LV post-infarct remodeling depends on the definition used, that is, with or without a threshold (e.g., LVEDV) increase, as well as with various imaging modalities. When LV post-infarct remodeling is defined as an echocardiographic increase in LVEDV ≥20%, and recognizing different temporal patterns, a frequency (42%) similar to a study by Bolognese et al. (9) was observed (48%).

In contrast, when LV post-post infarct remodeling is defined only at a certain time point (i.e., without taking the dynamic nature of the process into account), it is less common (<40%) (2). Few studies have taken account of the dynamic nature of LV post-infarct remodeling—it may well be that the true prognostic impact can be studied more accurately by assessing the presence increased LVEDV during 1-year follow-up after STEMI. If LV remodeling post-STEMI is categorized at only a single time point (e.g., at 6 months), remodeling that has manifested but reversed before then will not be recognized, even though such a patient has experienced LV post-infarct remodeling.

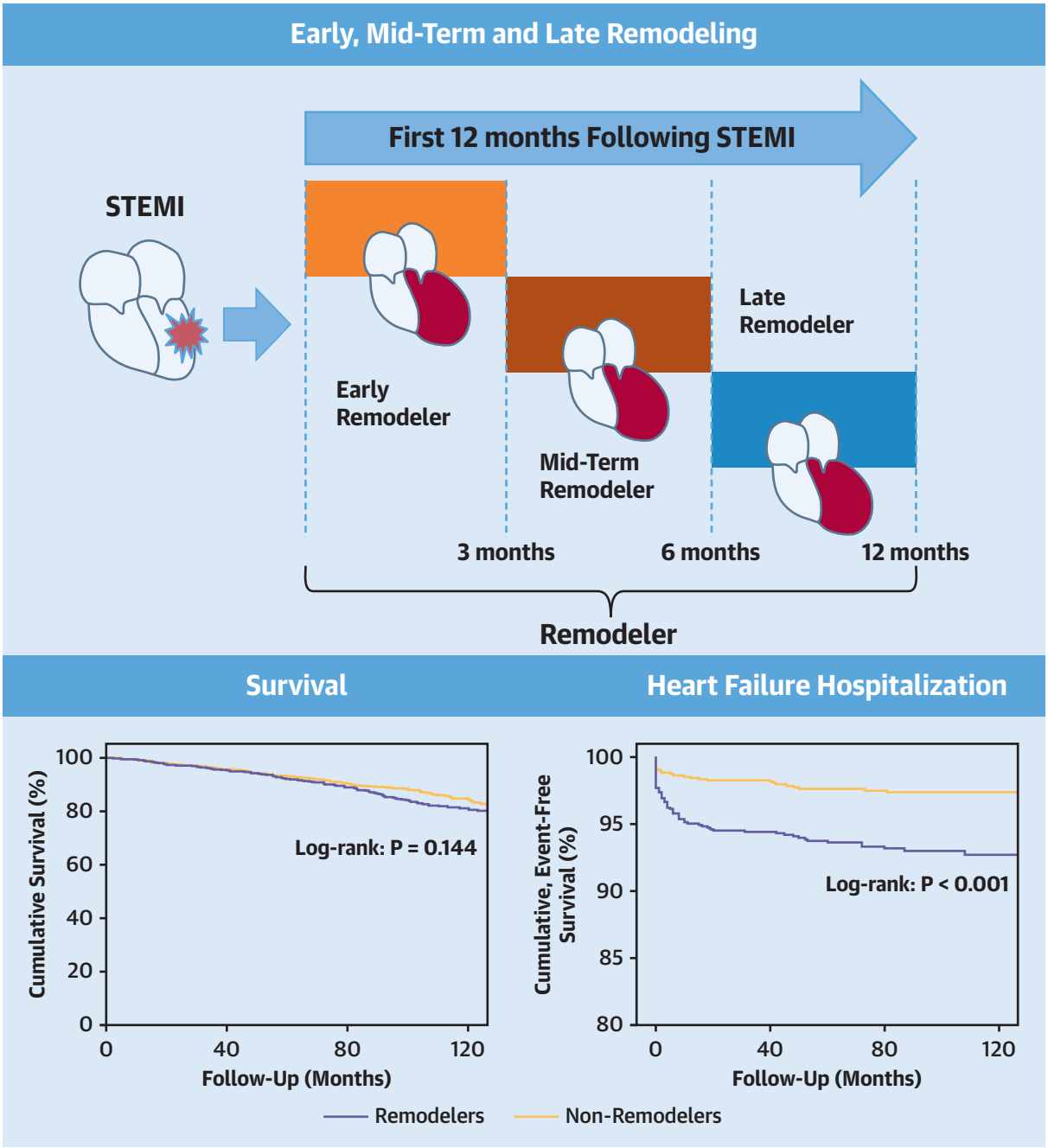
We found the LVEDV at baseline to be larger in remodelers than in nonremodelers. Although post-infarct remodeling is predicted by various factors (e.g., size of the infarct, culprit vessel, microvascular obstruction, intramyocardial hemorrhage), none of these would necessarily lead to a greater LVEDV at baseline. In addition, those patients who have a smaller LVEDV at baseline have greater potential for LV remodeling, as the percentage change in LVEDV will be smaller in an LV that is already dilated before remodeling has occurred.

LV REMODELING AND LV SYSTOLIC FUNCTION: DETERMINANTS AND INTERACTION. Little is known about LV function changes and remodeling in the era of primary PCI (13,14). In contrast to pharmacological thrombolysis, LV function appears to improve in the majority of primary PCI patients, despite the development of LV remodeling (9,10). The results of the current study support these observations, implying that the natural history and prognosis of LV remodeling and systolic dysfunction has changed, in addition to the factors underlying these pathophysiological processes.

Post-infarct remodeling is exacerbated by a larger infarct size, infarct transmurality, microvascular obstruction, myocardial hemorrhage, and advanced patient age (2,3,15). We found higher peak troponin and WMSI values in remodelers (both markers of greater infarct size). The impact of an anteriorly located infarct on LV remodeling is controversial, but was not found to be an independent predictor in a prior cardiac magnetic resonance study of 260 patients (16).

Data on the prevalence of diabetes mellitus in remodelers and nonremodelers are conflicting, although a higher frequency of diabetes mellitus in remodelers has been documented (17). This is consistent with the general increase in post-infarct complications in such patients (18). Infarct transmurality, microvascular obstruction, and the presence of myocardial hemorrhage require cardiovascular magnetic resonance for reliable diagnosis, and as our data included only echocardiography, we were unable to determine the influence of these parameters on LV remodeling. We observed smaller LVEDV and LVESV at baseline in remodelers, perhaps reflecting a greater potential for the development of remodeling at follow-up. In addition, the LVEF was worse in LV remodelers at baseline as compared with nonremodelers, findings that are concordant with previous published data (2).

CENTRAL ILLUSTRATION **Clinical Outcomes of LV Remodeling During the First Year After ST-Segment Elevation Myocardial Infarction**



van der Bijl, P. et al. J Am Coll Cardiol HF. 2020;8(2):131–40.

Classification of left ventricular (LV) remodeling according to the temporal pattern is shown, as well as the impact of remodeling on outcomes (survival and heart failure hospitalization). STEMI = ST-segment elevation myocardial infarction.

Several factors that have been shown to influence the improvement of LV function post-infarct overlap with those that determine LV remodeling (19,20). The most consistent risk factor for less improvement in LV function appears to be the magnitude of enzyme rise, with 2 previous studies also demonstrating an anterior infarct location to be a significant determinant (19,20). In 1 study, diabetes mellitus was identified as a risk factor for worse LV function improvement (19).

LVEF improvement post-infarct may also be influenced by loading conditions. We found no difference in either the frequency or magnitude of hypertension, or the use of afterload-reducing agents (beta-blockers, ACE inhibitors, ARBs) in LV remodelers and nonremodelers. The beneficial, afterload-reducing effects of these drugs on the LVEF post-infarct are therefore likely to be similar in LV remodelers and nonremodelers.

The evolution of functional mitral regurgitation post-infarct is complex, with some patients improving after successful primary PCI, others deteriorating, and some demonstrating a biphasic pattern of early improvement and late worsening (6). However, larger infarct size is associated with both LV post-infarct remodeling and more severe functional mitral regurgitation (6). The higher frequency of significant mitral regurgitation in remodelers could mitigate the detrimental effect of large infarct size on LVEF and therefore lessen the difference in LVEF improvement between remodelers and nonremodelers.

In summary, a similar evolution of LV systolic function improvement is seen in patients with and without LV post-infarct remodeling. Although some determinants of both these processes overlap (e.g., infarct size), other factors (e.g., functional mitral regurgitation) may account for the differential effect on evolution of LV post-infarct remodeling and function in the first year after STEMI.

LV REMODELING: IMPLICATIONS FOR LONG-TERM OUTCOME. The development of LV post-infarct remodeling has been associated with heart failure, functional mitral regurgitation, ventricular arrhythmias, and increased mortality (5–7,21). LV post-infarct remodeling impacted negatively on survival in the SAVE (Survival and Ventricular Enlargement) trial, in which 2,231 patients with an acute myocardial infarction and LV dysfunction were randomized to an ACE inhibitor or placebo (5,22). Only 17% of patients received primary PCI (percutaneous coronary angioplasty, without vascular scaffolding or stenting), compared with 33% who were thrombolyzed (22). As far as the authors are aware, the impact of LV post-infarct remodeling on mortality has not been echocardiographically investigated in a large cohort since the SAVE trial (22), while the management of STEMI has significantly evolved since then, especially with respect to primary PCI replacing thrombolysis as the primary strategy of reperfusion. In a very recently published paper by Rodriguez-Palomares et al. (23), LV post-infarct remodeling was investigated with cardiac magnetic resonance after primary PCI. After a mean follow-up of 73 months, the primary endpoint (cardiovascular mortality, heart failure hospitalization or ventricular arrhythmias) was achieved in 49 (13%) patients (23). This is comparable to our data, in which 13% of patients died or were admitted for heart failure after a median follow-up of 94 months. Additionally, LV post-infarct remodeling was not independently associated with the primary endpoint in this cardiac magnetic resonance study (23).

Patients in the MISSION! registry were treated with primary PCI and near-universal prescription of statins, ACE inhibitors or ARBs, and thienopyridines, in accordance with contemporary guidelines (11). Taking into account the beneficial effects on STEMI outcome of primary PCI, statins, ACE inhibitors or ARBs, and thienopyridines, it is perhaps not surprising that LV post-infarct remodeling does not carry the same implications for survival as it did in the past (8,22,24–26). Supporting the observation that LV post-infarct remodeling per se is not the primary determinant of mortality is the fact that we observed discordant LV systolic function improvement and LV remodeling patterns in the present study. LV systolic function, as well as the improvement thereof, is known to be a strong predictor of survival post-infarct, also in primary PCI era (13,14,19).

The rate of heart failure hospitalization was increased in LV post-infarct remodelers. This represents an opportunity for intensifying preventative strategies in this group, for example, increased surveillance and the use of an angiotensin receptor neprilysin inhibitor (ARNI), taking into account the particularly beneficial effect of this drug combination in reducing hospitalization for heart failure (27). In a preclinical study, ARNIs attenuated the decline in LVEF post-infarct more than valsartan alone did (28). The efficacy of ARNIs in reducing cardiovascular mortality and heart failure post-infarct are being explored in the PARADISE-MI (Prospective ARNI vs. ACE Inhibitor Trial to Determine Superiority in Reducing Heart Failure Events After MI) trial (NCT02924727).

STUDY LIMITATIONS. This was a single-center, retrospective study, but reflects a large, real-world experience. Echocardiographic analysis was

performed on site, and data were not analyzed in a core laboratory. Characterization of LV post-infarct remodeling by the 2-dimensional sphericity index has been proven to be of value (29). We have not calculated the 2-dimensional sphericity index for our study population. Clinical events were not adjudicated by a central committee, and no systematic data were collected on change in pharmacotherapy over the duration of the follow-up period. Mortality data were only available for all-cause mortality, and subanalyses for cardiac mortality could not be performed. Primary PCI techniques and equipment, as well as the use of pharmacotherapy, have evolved during the time frame of the study, which could not be accounted for.

CONCLUSIONS

In the contemporary era, in which STEMI is treated with primary PCI and optimal pharmacotherapy, almost one-half (48%) of patients demonstrate LV remodeling in the first year post-infarct. The majority (64%) experience LV remodeling during the first 3 months post-infarct. In addition, there is no difference in long-term survival between patients who demonstrate LV post-infarct remodeling and those that do not—in contrast to the era of thrombolysis. However, post-infarct LV remodeling is independently associated with heart failure hospitalization, which may indicate an opportunity to intensify preventative strategies in these patients.

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PERSPECTIVES

COMPETENCY IN MEDICAL KNOWLEDGE: In the current era, in which STEMI is treated with primary PCI and optimal pharmacotherapy, there is no difference in long-term survival between LV remodelers and nonremodelers.

TRANSLATIONAL OUTLOOK: However, LV remodelers experience a higher rate of heart failure hospitalization, which indicates an opportunity for preventative strategies. This could include increased surveillance, as well as the use of ARNIs, which have a very beneficial effect on heart failure hospitalization.

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APPENDIX For supplemental tables and figures, please see the online version of this paper.