

# Alcohol Consumption and Prognosis in Patients With Left Ventricular Systolic Dysfunction After a Myocardial Infarction

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<b>OBJECTIVES</b>	We assessed the influence of alcohol intake on the development of symptomatic heart failure (HF) in patients with left ventricular (LV) dysfunction after a myocardial infarction (MI).
<b>BACKGROUND</b>	In contrast to protection from coronary heart disease, alcohol consumption has been linked to cardiodepressant effects and has been considered contraindicated in patients with HF.
<b>METHODS</b>	The Survival And Ventricular Enlargement (SAVE) trial randomized 2,231 patients with a LV ejection fraction (EF) <40% following MI to an angiotensin-converting enzyme inhibitor or placebo. Patients were classified as nondrinkers, light-to-moderate drinkers (1 to 10 drinks/week), or heavy drinkers (>10 drinks/week) based on alcohol consumption reported at baseline. The primary outcome was hospitalization for HF or need for an open-label angiotensin-converting enzyme inhibitor. Analyses were repeated using alcohol consumption reported three months after MI.
<b>RESULTS</b>	Nondrinkers were older and had more comorbidities than light-to-moderate and heavy drinkers. In univariate analyses, baseline light-to-moderate alcohol intake was associated with a lower incidence of HF compared with nondrinkers (hazard ratio [HR] 0.71; 95% confidence interval [CI] 0.57 to 0.87), whereas heavy drinking was not (HR 0.91; 95% CI 0.67 to 1.23). After adjustment for baseline differences, light-to-moderate baseline alcohol consumption no longer significantly influenced the development of HF (light-to-moderate drinkers HR 0.93; 95% CI 0.75 to 1.17; heavy drinkers HR 1.25; 95% CI 0.91 to 1.72). Alcohol consumption reported three months after the MI similarly did not modify the risk of adverse outcome.
<b>CONCLUSIONS</b>	In patients with LV dysfunction after an MI, light-to-moderate alcohol intake either at baseline or following MI did not alter the risk for the development of HF requiring hospitalization or an open-label angiotensin-converting enzyme inhibitor. (J Am Coll Cardiol 2004;43:2015–21) © 2004 by the American College of Cardiology Foundation

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Alcohol consumption appears to have both beneficial and adverse cardiac effects. Multiple observational studies have demonstrated a protective effect of light-to-moderate alcohol consumption on overall mortality, with a benefit largely derived from a reduction in fatal coronary heart disease (1–4). This benefit has also been demonstrated in studies of patients with known coronary artery disease (CAD) (5–7), although not all studies in this population have been positive (8).

In contrast, the consumption of excessive amounts of alcohol is a well-known cause of congestive cardiomyopathy (9), with some degree of cardiac dysfunction seen in up to one-third of patients with chronic alcoholism (10). In these

patients with alcohol-induced cardiac dysfunction, reduction of alcohol intake is a crucial component of therapy, as several studies have shown that major clinical improvement and normalization of left ventricular (LV) function can be achieved after abstinence (11,12).

Given the demonstrated risks and benefits of alcohol consumption, the effects of continued alcohol consumption in patients who have LV systolic dysfunction following an acute myocardial infarction (MI) are unclear. With the potential for CAD progression and possible re-infarction, these patients may derive a significant benefit from the protective effects of alcohol consumption; alternatively, patients with preexisting LV dysfunction may be more susceptible to the cardiotoxic effects of alcohol. Given this potential risk, the American College of Cardiology/American Heart Association Guidelines for the Evaluation and Management of Chronic Heart Failure (13) state that alcohol consumption should be avoided in patients at high risk for the development of chronic heart failure (HF). In a retrospective exploratory analysis, we used the Survival And Ventricular Enlargement (SAVE) trial to examine the influence of alcohol consumption in a cohort of patients

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**Abbreviations and Acronyms**

CAD	= coronary artery disease
CI	= confidence interval
CV	= cardiovascular
HF	= heart failure
HR	= hazard ratio
LV	= left ventricular
MI	= myocardial infarction
NYHA	= New York Heart Association
SAVE	= Survival And Ventricular Enlargement trial
SOLVD	= Studies Of Left Ventricular Dysfunction

who were at high risk for the development of chronic HF and its complications after sustaining an MI.

**METHODS**

**Enrollment and data collection.** The database used for this investigation was that of the SAVE trial, whose design (14) and primary analysis (15) have been described in detail. Briefly, SAVE was a randomized, multicenter double-blind placebo controlled trial in 2,231 patients conducted in 45 centers in the U.S. and Canada between 1987 and 1992. This trial was designed to test the hypothesis that the long-term administration of an angiotensin-converting enzyme inhibitor (captopril) to survivors of acute MI with reduced systolic function would lessen deterioration in cardiac performance and thereby improve both mortality and other clinical outcomes. Patients 21 to 80 years of age with a LV ejection fraction of 40% or less, as measured by radionuclide ventriculography, who survived a minimum of three days after a confirmed acute MI were eligible for enrollment. All patients provided informed consent.

Upon entry into the SAVE trial, participants were asked to classify their pattern of alcohol use three weeks before MI into five categories: 0, 1 to 4, 5 to 10, 11 to 20, and >20 drinks/week. Outpatient visits were then scheduled two weeks after randomization, at intervals of three months during the first year, and at intervals of four months during the remainder of the trial. At these visits, participants were again asked to classify their pattern of alcohol use since their last visit. For the purpose of our study, patients were classified as nondrinkers (0 drinks/week), light-to-moderate drinkers (1 to 10 drinks/week), and heavy drinkers (>10 drinks/week).

In addition to analyses using the level of alcohol consumption reported at baseline, we performed analyses using alcohol consumption reported three months after the index MI in order to determine the association of continued alcohol consumption on the development of HF. There was a moderate correlation between individual alcohol consumption reported at three months and the level reported at 6 and 12 months (Spearman coefficient 0.67 and 0.58, respectively,  $p < 0.001$  for both). This correlation was slightly stronger than the correlation between alcohol con-

sumption at baseline and at 6 and 12 months (Spearman coefficient 0.55 and 0.58, respectively,  $p < 0.001$  for both).

In addition to drinking status, other baseline variables were assessed, including age, gender, hypertension, body mass index (calculated from self-reported weight and height), and LV ejection fraction as measured by radionuclide ventriculography. Patients were also classified into groups based on smoking status, New York Heart Association (NYHA) functional classification (I to IV), Killip class, history of diabetes mellitus, baseline medication use, and treatment (captopril) assignment.

**Definition of end points.** The primary outcome of this analysis was the development of chronic HF, defined as the occurrence of HF requiring hospitalization or requiring the use of open-label angiotensin-converting enzyme inhibitors for symptomatic treatment. Additional outcomes included total mortality, combined HF and total mortality, recurrent MI, and cardiovascular (CV) mortality. Myocardial infarction was identified by the primary investigator or the Mortality Classification Committee and was independently reviewed to confirm elevated creatine kinase levels, which were considered positive if the levels were two times the upper limit of normal in the absence of positive results for the myocardial isoform or 1.5 times the upper limit in the presence of the myocardial isoform. Cardiovascular mortality included death from atherosclerotic heart disease (death resulting from LV dysfunction, acute MI, sudden death, and cardiac procedures) and other vascular causes. The Mortality Classification Committee assigned the causes of death based on blinded review.

**Statistical analysis.** Age, LV ejection fraction, and body mass index were analyzed as continuous variables and are presented as mean  $\pm$  SD. Global differences in baseline demographics among the three alcohol usage subgroups were ascertained using chi-square tests for ordinal data and one-way analysis of variance for continuous variables. The differences in the crude incidence of cardiovascular outcomes were also compared with chi-square tests. Two-sided values of  $p < 0.05$  were considered significant.

Cox proportional hazards models were used to assess the association between alcohol consumption and the outcome of interest. A univariate and a multivariate model were created to identify both the unadjusted and adjusted risk of the outcome of interest. The multivariate model included age, gender, LV ejection fraction, prior MI, history of hypertension, history of diabetes mellitus, body mass index, prior tobacco use, NYHA functional classification, Killip class, beta-blocker use at time of randomization, thrombolytic therapy with qualifying MI, and treatment (captopril) assignment. As described earlier, analyses were performed using alcohol consumption at baseline and repeated using alcohol consumption reported 3 months following the index MI. In the model using self-reported alcohol consumption at 3 months, only end points of interest that occurred after 90 days from enrollment (after the ascertainment of alcohol consumption information) were included. Patients who had

**Table 1.** Characteristics of SAVE Participants According to Level of Alcohol Consumption Reported at Baseline

Characteristics	Nondrinkers (n = 1,276)	Light-to-Moderate Drinkers (n = 717)	Heavy Drinkers (n = 235)
Age (yrs)*	60 ± 10	59 ± 11	55 ± 11
Women (%)*	296 (23)	90 (13)	4 (1.7)
Mean EF ± SD	31.0 ± 6.7	31.0 ± 6.6	31.2 ± 6.9
Previous MI (%)*	487 (38)	247 (34)	757 (24)
History of diabetes mellitus (%)*	376 (29)	96 (13)	20 (8.5)
History of hypertension (%)*	575 (45)	260 (36)	95 (40)
Current smoker (%)*	496 (39)	289 (40)	138 (59)
Body mass index (kg/m <sup>2</sup> ) ± SD*	27.2 ± 5.1	26.5 ± 4.2	26.4 ± 4.6
NYHA (%)*			
Class I	783 (61)	502 (70)	184 (78)
Class II/III/IV	493 (39)	215 (30)	51 (22)
Killip class ≥ 2 (%)†	525 (41)	257 (36)	101 (43)
Thrombolytic therapy (%)*	384 (30)	264 (37)	82 (35)
Medication use within 24 h of randomization (%)			
Aspirin	741 (60)	432 (63)	135 (60)
Beta-blockers	441 (36)	255 (38)	92 (40)
Treatment (captopril) (%)	624 (49)	366 (51)	124 (53)

\*p ≤ 0.01; †p = 0.04.

EF = ejection fraction; MI = myocardial infarction; NYHA = New York Heart Association; SAVE = Survival And Ventricular Enlargement trial.

developed the end point of interest before 90 days from enrollment were excluded from the specific analysis.

Further analyses were performed using a Cox proportional hazards model and the reported categories of alcohol consumption time-varying variables.

## RESULTS

**Baseline characteristics.** At initial enrollment, the pattern of alcohol consumption was available in 2,228 of the total 2,231 participants of the SAVE trial. The majority of participants were nondrinkers (n = 1,276, 57%) with a significant percentage of light-to-moderate drinkers (n = 717, 32%) and a smaller percentage of heavy drinkers (n = 235, 11%). The baseline demographics in the three groups are described in Table 1. At baseline, nondrinkers were older, more likely to be women, less likely to be smokers, and had a higher incidence of prior MI, diabetes mellitus, and hypertension. In addition, nondrinkers had a higher body mass index, NYHA functional classification, and Killip class, and were less likely to receive thrombolytic therapy in association with their qualifying MI.

**Development of HF.** A total of 456 patients developed HF during a mean follow-up of 42 months. The crude incidence of HF was 22.5% in nondrinkers, 16.6% in light-to-moderate drinkers, and 21.3% in heavy drinkers. In univariate analysis, the risk of the development of HF was lower in the light-to-moderate drinkers compared with nondrinkers (hazard ratio [HR] 0.71, 95% confidence interval [CI] 0.57 to 0.87, p < 0.01). The unadjusted HR for heavy drinkers was not statistically different from nondrinkers. After adjusting for baseline differences in age, gender,

LV ejection fraction, prior MI, history of hypertension, history of diabetes mellitus, body mass index, current tobacco use, NYHA functional classification, Killip class, beta-blocker use at time of randomization, thrombolytic therapy with qualifying MI, and treatment assignment, the risk of developing HF was similar in the three groups (Table 2).

**Secondary end points.** As described in Table 2, the unadjusted and adjusted HRs for death, recurrent MI, and CV death were not statistically different among nondrinkers, light-to-moderate drinkers, and heavy drinkers. Compared with nondrinkers, light-to-moderate drinkers had a lower crude incidence of the combined end point of death or HF, with an unadjusted HR of 0.78 (95% CI 0.66 to 0.91), but the risk reduction was no longer statistically significant after adjustment for baseline differences. Additionally, no statistical difference was noted in the combined end point of death and HF between heavy drinkers and nondrinkers.

**Alcohol consumption post-MI and outcomes.** At the scheduled follow-up assessment two weeks post-MI, the pattern of alcohol intake had changed, with a substantial increase in the total number of nondrinkers (84%) and a reduction of both light-to-moderate drinkers (15%) and heavy drinkers (1%). At three months post-MI, alcohol consumption information was available for 2,036 patients. Among these patients, 71% (n = 1,437) were nondrinkers, 26% (n = 532) were light-to-moderate drinkers, and 3% (n = 67) were heavy drinkers. Of the 195 patients without alcohol consumption information, 120 had died, two were lost to follow-up, and 73 had no information regarding continued alcohol intake. Overall, the general pattern of

**Table 2.** Baseline Alcohol Consumption and Adverse Cardiovascular Outcomes

	Nondrinkers (n = 1,276)	Light-to-Moderate Drinkers (n = 717)	Heavy Drinkers (n = 235)
Heart failure			
Number (%)	287 (22.5)	119 (16.6)	50 (21.3)
Unadjusted HR (95% CI)	Reference	0.71 (0.57–0.87)*	0.91 (0.67–1.23)
Adjusted HR (95% CI)†	Reference	0.93 (0.75–1.17)	1.25 (0.91–1.72)
Total mortality			
Number (%)	300 (23.5)	150 (20.9)	51 (21.7)
Unadjusted HR (95% CI)	Reference	0.87 (0.72–1.06)	0.91 (0.67–1.22)
Adjusted HR (95% CI)	Reference	1.04 (0.85–1.28)	1.19 (0.87–1.62)
Mortality/heart failure			
Number (%)	468 (36.7)	213 (29.7)	84 (35.7)
Unadjusted HR (95% CI)	Reference	0.78 (0.66–0.91)*	0.94 (0.75–1.19)
Adjusted HR (95% CI)	Reference	0.97 (0.82–1.15)	1.22 (0.95–1.56)
Recurrent MI			
Number (%)	175 (13.7)	95 (13.2)	33 (14.0)
Unadjusted HR (95% CI)	Reference	0.94 (0.74–1.21)	1.03 (0.71–1.49)
Adjusted HR (95% CI)	Reference	1.11 (0.86–1.44)	1.34 (0.91–1.97)
Cardiovascular mortality			
Number (%)	249 (19.5)	129 (18.0)	42 (17.9)
Unadjusted HR (95% CI)	Reference	0.90 (0.73–1.12)	0.90 (0.65–1.25)
Adjusted HR (95% CI)	Reference	1.10 (0.88–1.37)	1.16 (0.82–1.64)

\*p < 0.01. †Model includes age, gender, left ventricular ejection fraction, prior myocardial infarction (MI), history of hypertension, history of diabetes mellitus, body mass index, tobacco use, New York Heart Association classification, Killip class, beta-blocker use at the time of randomization, thrombolytic therapy with the qualifying myocardial infarction, and treatment (captopril) assignment.  
 CI = confidence interval; HR = hazard ratio.

alcohol consumption in the cohort appeared to stabilize at the three-month visit (Fig. 1).

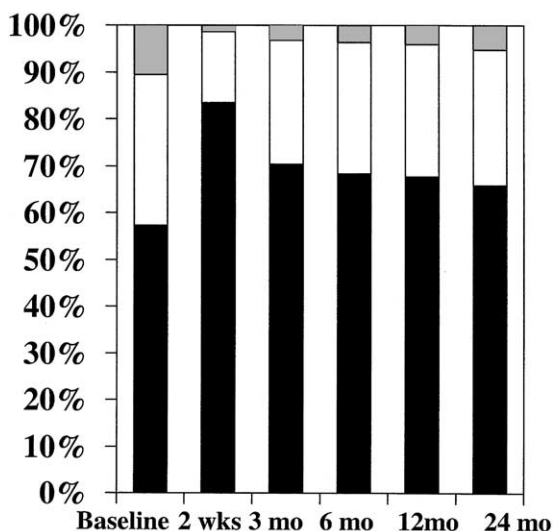
Using only end points that occurred after 90 days following enrollment, 316 patients developed HF. The unadjusted HR for the development of HF was lower in light to-moderate drinkers (HR 0.70, 95% CI 0.53 to 0.91) compared with nondrinkers, but after adjustment for baseline differences, the difference was no longer statistically significant (Table 3). No statistically significant hazard was found

in heavy drinkers, although the number of participants in this category was small. The development of the secondary outcomes using alcohol consumption reported three months post-MI are shown in Table 3.

Findings were similar when alcohol consumption was modeled as a time-varying variable in a Cox proportional-hazards model. For both the outcomes of HF and the combined outcome of HF and total mortality, light-to-moderate alcohol consumption was associated with a lower unadjusted hazard ratio (HR 0.74 [95% CI 0.59 to 0.94] and HR 0.76 [95% CI 0.63 to 0.91], respectively), but after adjustment for the variables in the previous model described, the benefit was no longer present (HR 1.02 [95% CI 0.80 to 1.31]; HR 0.99 [95% CI 0.82 to 1.19]). Using time-varying analyses, no statistically significant benefit or hazard was seen in heavy drinkers for the outcomes of HF and the combined outcome of HF and total mortality in both unadjusted (HR 0.78 [95% CI 0.54 to 1.14] and HR 0.84 [95% CI 0.63 to 1.10], respectively) and adjusted models (HR 1.15 [95% CI 0.78 to 1.71] and HR 1.13 [95% CI 0.84 to 1.51], respectively).

**DISCUSSION**

In a group of survivors with LV dysfunction after MI, light-to-moderate alcohol consumption both at baseline and three months after the MI did not increase the risk of chronic HF, defined as hospitalization for HF or need for an open-label angiotensin-converting enzyme inhibitor. The unadjusted risk of HF was lower in light-to-moderate drinkers compared with nondrinkers but, after adjustment



**Figure 1.** Composition of cohort at baseline and at follow-up visits according to level of reported alcohol consumption. Gray bars = heavy drinkers, white bars = light-to-moderate drinkers, black bars = nondrinkers.



**Table 3.** Level of Alcohol Consumption Reported Three Months Post MI and Adverse Cardiovascular Outcomes

	Nondrinkers	Light-to-Moderate Drinkers	Heavy Drinkers
<b>Heart failure</b>			
Number (%)	237/1,355 (17.5)	69/516 (13.4)	10/64 (15.6)
Unadjusted HR (95% CI)	Reference	0.70 (0.53–0.91)*	0.81 (0.43–1.52)
Adjusted HR (95% CI)†	Reference	0.93 (0.71–1.23)	1.21 (0.64–2.31)
<b>Total mortality</b>			
Number (%)	274/1,437 (19.1)	74/532 (13.9)	7/67 (10.5)
Unadjusted HR (95% CI)	Reference	0.69 (0.54–0.90)*	0.48 (0.23–1.02)
Adjusted HR (95% CI)	Reference	0.91 (0.70–1.19)	0.66 (0.31–1.41)
<b>Mortality/heart failure</b>			
Number (%)	386/1,355 (28.5)	109/516 (21.1)	12/64 (18.8)
Unadjusted HR (95% CI)	Reference	0.69 (0.55–0.85)*	0.60 (0.34–1.06)
Adjusted HR (95% CI)	Reference	0.88 (0.71–1.10)	0.85 (0.47–1.52)
<b>Recurrent MI</b>			
Number (%)	145/1,391 (10.4)	50/524 (9.5)	8/64 (12.5)
Unadjusted HR (95% CI)	Reference	0.89 (0.64–1.22)	1.10 (0.54–2.24)
Adjusted HR (95% CI)	Reference	1.04 (0.75–1.46)	1.30 (0.63–2.67)
<b>Cardiovascular mortality</b>			
Number (%)	215/1,437 (15.0)	62/532 (11.7)	7/67 (10.4)
Unadjusted HR (95% CI)	Reference	0.74 (0.56–0.99)‡	0.62 (0.29–1.32)
Adjusted HR (95% CI)	Reference	1.00 (0.75–1.34)	0.87 (0.40–1.87)

\*p < 0.01; ‡p = 0.04. †Model includes age, gender, left ventricular ejection fraction, prior MI, history of hypertension, history of diabetes mellitus, body mass index, tobacco use, New York Heart Association classification, Killip class, beta-blocker use at the time of randomization, thrombolytic therapy with the qualifying MI, and treatment (captopril) assignment.  
Abbreviations as in Table 2.

for significant baseline differences between the two groups, the HR was no longer statistically significant, suggesting that the additional comorbidities in the nondrinkers may have accounted for the results. Additionally, light-to-moderate alcohol consumption was neither beneficial nor detrimental in the outcomes of total mortality, total mortality and/or HF, recurrent MI, and CV mortality. No significant benefit or risk was associated with heavy alcohol use, but the low number of individuals and events in this group prohibit definitive conclusions.

**Alcohol consumption, coronary heart disease, and HF.**

Previous studies in populations free of CV disease have demonstrated an approximately 20% to 30% reduction in total mortality associated with light-to-moderate alcohol consumption (1–4). The benefit is largely related to a reduction in coronary heart disease in light-to-moderate drinkers compared with nondrinkers. Potential mechanisms for this finding include the beneficial effects of alcohol on high-density lipoprotein cholesterol (16–18), platelet activation (19), and hemostatic markers (20).

In studies of patients with known CAD, the beneficial effects of alcohol consumption have been less conclusive. Although most studies have demonstrated that patients with a history of prior MI derive a benefit with light-to-moderate alcohol consumption (5–7), additional studies (8), including this study of the SAVE population, have failed to demonstrate a significant benefit in secondary prevention.

The influence of alcohol consumption on the development of HF is unclear in both the general population and those with known CAD. Several case-control series have linked excessive alcohol consumption to a dilated cardiomy-

opathy (9,10,21). Although the exact mechanism is unknown, the quantity (10) and duration of alcohol use (22) appear to play a role in the development of LV dysfunction. Importantly, the cessation of alcohol consumption is crucial, as continued excessive alcohol consumption carries an adverse prognosis (23,24) and the cessation of alcohol intake may lead to improvement in LV function (11,12).

In contrast to these smaller case-control studies, two large cohort studies of individuals free of HF at baseline have failed to demonstrate an association between alcohol consumption and increased risk of HF (25,26). In fact, light-to-moderate alcohol consumption lowered the HR for the development of HF in both studies (25,26). In these studies, the effect of alcohol consumption on the development of HF was independent of the development of recurrent MI, suggesting that, in addition to its effects on CAD, alcohol consumption was reducing the development of HF through additional pathways such as a reduction in hypertension (27,28) or beneficial neurohormonal modification (29,30). Importantly, these studies have been limited to those who were free of HF at baseline.

Few studies have examined the influence of continued alcohol consumption on the development of HF in patients with LV dysfunction after an MI. In the Studies Of Left Ventricular Dysfunction Prevention and Treatment trials (SOLVD) database, which excluded patients with a recent MI, light-to-moderate alcohol consumption in participants with ischemic cardiomyopathy was associated with a reduced crude incidence of hospitalization for HF, but, similar to our study, after adjustment for potential confounders the benefit was no longer statistically significant

(31). In SOLVD, HF progression was not increased with light-to-moderate alcohol consumption in patients with ischemic LV dysfunction, although there was a trend toward increased risk of HF hospitalization in those participants with nonischemic LV dysfunction. Additionally, in the SOLVD database, light-to-moderate alcohol intake was associated with a reduction in total mortality, a finding not demonstrated in our study, perhaps related to differences in patient populations. In contrast, in a study of 753 patients admitted to a Veterans Administration facility with HF, the majority of whom had nonischemic LV dysfunction, alcohol consumption was an independent predictor of multiple readmissions for HF (32). Additionally, a study of alcohol consumption in 396 patients with nonischemic LV dysfunction demonstrated a hazard in women, but not in men (33).

Some potential limitations of this analysis should be noted. First, the amount of alcohol consumption is self-reported without specific information regarding the exact quantity, type of alcoholic beverage, or pattern of alcohol consumption. However, prior studies have found that self-reporting can provide reliable estimates of alcohol intake (34), and several studies have suggested that the effects of alcohol consumption may be similar across different types of alcoholic beverages (35,36). Additionally, the category of heavy drinkers includes individuals who may have met the U.S. Dietary Guidelines for moderate drinking (two drinks/day in men) (37). Because the enrollment and follow-up questionnaires grouped individuals reporting 10 to 20 drinks/week together, we could not distinguish these individuals with moderate alcohol intake from those with heavier alcohol consumption. Finally, the sample size does not allow us to definitively exclude a small hazard of light-to-moderate alcohol consumption on the development of HF and, importantly, the small number of heavy drinkers limits the ability to draw conclusions regarding this category.

**Conclusions.** In survivors of an MI with depressed LV function, light-to-moderate alcohol consumption reported at baseline or three months following the MI was associated with a lower crude incidence of subsequent HF and the combined outcome of HF and total mortality, a finding that appeared to be explained by the greater comorbidity in the nondrinkers compared with light-to-moderate drinkers. After adjustment for potential confounders, our study demonstrated neither a benefit nor excess hazard associated with light-to-moderate alcohol consumption. Careful note should be made that the small number of heavy drinkers limits the ability to draw definitive conclusions from this subset.

Because of ethical and practical considerations, a randomized controlled trial of alcohol consumption is not feasible. Therefore, future observational studies will need to examine the issue of alcohol use in patients with reduced LV function and CAD. Although the limited data available support continued discouragement of heavy alcohol use in this population, the totality of evidence suggests that light-

to-moderate alcohol consumption is not associated with altered risk of developing chronic HF in patients with LV dysfunction following MI.

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