# Left ventricular reconstruction in ischemic cardiomyopathy

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# Chapter 6

## Left Ventricular Ejection Fraction as Criterion for Implantation of an Implantable Cardioverter-Defibrillator in Heart Failure Patients Undergoing Surgical Left Ventricular Reconstruction

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Pacing Clin. Electrophysiol. 2009 Jul. 32(7):913-7

## ABSTRACT

**Background:** Besides implantation of an implantable cardioverter-defibrillator (ICD), a proportion of patients with left ventricular (LV) dysfunction due to ischemic cardiomyopathy are potential candidates for surgical LV reconstruction (Dor procedure), which changes LV ejection fraction (LVEF) considerably. In these patients, LVEF as selection criterium for ICD implantation may be difficult. This study aimed to determine the value of LVEF as criterium for ICD implantation in heart failure patients undergoing surgical LV reconstruction.

**Methods:** Consecutive patients with end-stage heart failure who underwent ICD implantation and LV reconstruction were evaluated. During admission, two-dimensional (2D) echocardiography (LV volumes and LVEF) was performed before surgery and was repeated at 3 months after surgery. Over a median follow-up of 18 months, the incidence of ICD therapy was evaluated.

**Results:** The study population consisted of 37 patients (59 ± 11 years). At baseline, mean LVEF was 23 ± 5%. Mean left ventricular end-systolic volume (LVESV) and left ventricular end-diastolic volume (LVEDV) were 175 ± 73 mL and 225 ± 88 mL, respectively. At 3-month follow-up, mean LVEF was 41 ± 9%($P < 0.0001$ vs. baseline), and mean LVESV and LVEDV were 108 ± 65 mL and 176 ± 73 mL, respectively ($P < 0.0001$ vs. baseline). During 18-month follow-up, 12 (32%) patients had ventricular arrhythmias, resulting in appropriate ICD therapy. No significant relations existed between baseline LVEF ($P = 0.77$), LVEF at 3-month follow-up ($P = 0.34$), change in LVEF from baseline to 3-month follow-up ($P = 0.28$), and the occurrence of ICD therapy during 18-month follow-up.

**Conclusion:** LVEF before and after surgical LV reconstruction is of limited use as criterium for ICD implantation in patients with end-stage heart failure. (PACE 2009; 32:913–917)



**Keywords:** implantable cardioverter-defibrillator, ischemic cardiomyopathy, left ventricular reconstruction, left ventricular ejection fraction, heart failure, echocardiography

# INTRODUCTION

Randomized trials demonstrated im-proved survival with implantable cardioverter-defibrillator (ICD) therapy in high-risk patients with left ventricular (LV) dysfunction due to ischemic cardiomyopathy.[1–6] In the second Multicenter Automatic Defibrillator Implantation Trial (MADIT II), a relative risk reduction in mortality of 31% was achieved by ICD implanta-tion in patients with previous infarction and LV dysfunction (LV ejection fraction [LVEF] ≤30%) without evidence of ventricular arrhythmias.2 This subsequently resulted in a class I indication for prophylactic ICD implantation in patients meeting the MADIT II criteria (AHA/ACC/NASPE Guidelines), with an exponential growth in the ICD implantation rate.[7] On the other hand, recent analysis of the MADIT II population revealed that only 35% of patients who received an ICD developed ventricular arrhythmias requiring ICD shocks over a 3-year follow-up period.[8] As a consequence, there has been considerable debate about the value of LVEF as a major selection criterium for patient selection in need of ICD implantation.[9]

A substantial number of patients with ischemic cardiomyopathy, LVEF ≤30–40%, and previous anterior myocardial infarction will present with an apical LV aneurysm.[10] These patients are candidates for ICD implantation according to the MADIT II criteria. In addition, some of these patients may eventually be referred for surgical LV reconstruction (Dor procedure), which may result in improvement of the LVEF.[11–13] Particularly in these patients, the LVEF as selection cri-terium for ICD implantation may be difficult.

In the current study, 41 consecutive patients were evaluated who underwent ICD implantation (based on the MADIT II criteria) and LV reconstruction (Dor procedure). LVEF was obtained before surgery and 3 months after surgery. Over a median follow-up of 18 months after surgery, the prevalence of ICD therapy was evaluated.

# METHODS

## Patients and Study Protocol

For this study, 41 consecutive patients with end-stage heart failure who underwent ICD implantation and LV reconstruction according to the Dor procedure[14,15] were evaluated. During admission (baseline), before surgery, two-dimensional (2D) echocardiography was performed in all patients and LV volumes and LVEF were assessed. All patients underwent ICD implantation based on LVEF ≤30%. A combined ICD-

cardiac resynchronization therapy (CRT) device was implanted in 16 patients. All patients underwent LV reconstruc-tion according to the Dor approach. 2D echocardiography (including assessment of LV volumes and LVEF) was repeated at 3 months after surgery in the outpatient clinic. During a median (25th and 75th percentiles) follow-up after surgery of 18 (11, 43) months, the occurrence of ICD therapy was registered. Four patients died within 1 month after surgery due to sepsis (n = 1) or progression of heart failure (n = 3) and therefore did not have a complete follow-up assessment. These patients were excluded from the study. The final study population therefore comprised 37 patients who all underwent ICD implantation, Dor procedure, and had complete follow-up assessment.

## Echocardiography

Patients were imaged in the left lateral decubitus position using a commercially available system (Vivid Seven, General Electric-Vingmed, Milwaukee, WI, USA). Standard images were obtained using a 3.5-MHz transducer, at a depth of 16 cm in the parasternal (long- and short-axis images) and apical (two- and four-chamber images) views. Standard 2D and color Doppler data, triggered to the QRS complex, were saved in cine-loop format. LV volumes (end-systolic [LVESV] and end-diastolic [LVEDV]) and LVEF were calculated from the conventional apical two- and four-chamber images, using the biplane Simpson's technique.[16]

All echocardiographic measurements were obtained by two independent observers without knowledge of the clinical status of the patient. Inter- and intraobserver agreements for assessment of LV volumes were 90 and 93% for LVESV, and 92 and 93% for LVEDV, respectively.

## ICD Implantation

A dual-chamber ICD device for primary prevention was subcutaneously implanted under local anesthesia.[17] Implantation of an endocardial lead system was performed in all patients. No complications occurred during ICD implantation. After implantation, a defibrillation test was performed under conscious sedation (using midazolam and fentanyl). The ICD was programmed for both ventricular tachycardia and ventricular fibrillation detection and therapy using three zones: a monitor zone, an antitachycardia pacing (ATP) zone, and a ventricular fibrillation zone. In each patient, cutoff rates were programmed according to individual needs. All ICD events were individually analyzed by experienced and blinded physicians during regular pacemaker checkups. ICD therapy was defined as appropriate ATP and/or shock therapy.

## Surgical Technique

LV reconstruction was performed in all patients by means of endoventricular circular patch plasty as previously described by Dor et al.[14,15] All procedures were performed under normothermic conditions with intermittent antegrade warm blood cardioplegia. The LV was opened through the infarcted area. An endocardial encircling suture (Fontan stitch) was placed approximately at the transitional zone between scarred and normal tissue, giving preference to the resulting ellipsoidal shape of the left ventricle over the exact transitional zone. A balloon containing 55 $mL/m^2$ body surface area saline was introduced into the LV, and the Fontan stitch was tightened to approximate the ventricular wall to the balloon. An oval Dacron patch was tailored and used to close the residual orifice. The excluded scar tissue was closed over the patch to ensure hemostasis. Care was taken to eliminate the entire septal scar and to delineate a new LV apex with the goal to restore the normal elliptical shape.

## Statistical Analysis

Summary statistics for all continuous variables are presented as means ± standard deviation. Categorical data are summarized as frequencies and percentages. Comparison of continuous data was performed using the paired and unpaired Student's *t*-test when appropriate. Categorical data were compared using $^2$ analysis.

Logistic regression analysis was applied to evaluate the relation between (change in) LVEF and the occurrence of ICD therapy during follow-up. Hazard ratios (HR) with 95% confidence intervals (CI) were provided. For all tests, a P value $<0.05$ was considered statistically significant.

# RESULTS

## Baseline Data of the Study Population

The study population consisted of 37 patients (30 men, mean age 59 ± 11 years). Clinical characteristics of the study population are summarized in Table I. All patients had a history of myocardial infarction and were in sinus rhythm.

The Dor procedure was combined with coronary artery bypass grafting in 19 patients, mitral valve repair in 26 patients, and tricuspid valve repair in 15 patients. Rethoracotomy was needed in three patients due to substantial loss of blood. The Dor procedure was uncomplicated in all other patients.

**Table I.**
Clinical Characteristics of the Study Population (n = 37)

| Variable | Value |
|---|---|
| Age (years) | 59 ± 11 |
| Gender (M/F) (%) | 30/7 (81/19) |
| Previous MI (%) | 37 (100) |
| NYHA class | 3.1 ± 0.6 |
| QRS duration (ms) | 124 ± 30 |
| Risk factors for CAD | |
| Diabetes (%) | 4 (11) |
| Hypertension (%) | 10 (27) |
| Hyperlipidemia (%) | 10 (27) |
| Smoking (%) | 18 (49) |
| Family history of CAD (%) | 12 (32) |
| Medication at baseline | |
| β-Blocker (%) | 31 (84) |
| ACE inhibitor/ARB (%) | 28 (76) |
| Anticoagulants (%) | 33 (89) |
| Statin (%) | 28 (76) |
| Antiarrhythmics (%) | 15 (41) |

ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker; CAD = coronary artery disease; NYHA = New York Heart Association; MI = myocardial infarction.

## Echocardiography

At baseline, all patients had a LVEF ≤30%with a mean LVEF of 23 ± 5%. Mean LVESV and LVEDV were 175 ± 73 mL and 225 ± 88 mL, respectively. Between baseline and 3-month follow-up, mean LVESV (175 ± 73 mL vs. 108 ± 65 mL; $P < 0.0001$) and LVEDV (225 ± 88 mL vs. 176 ± 73 mL; $P < 0.0001$) decreased significantly. During echocardiography at 3-month follow-up, mean LVEF of 41 ± 9% was demonstrated ($P < 0.0001$ vs. baseline).

## ICD Therapy during Follow-Up

During a median follow-up of 18 (11, 43) months after surgery, registered ventricular arrhythmias resulting in appropriate ICD therapy occurred in 12 (32%) patients. Six patients had appropriate shocks delivered by the ICD. In the other six patients, episodes in which ATP was applied were demonstrated during follow-up.

As demonstrated by logistic regression analysis, no significant relation existed between baseline LVEF and the occurrence of ICD therapy during 18 months of follow-up (HR 1.02, 95%CI 0.88–1.19, $P = 0.77$). In addition, no significant relation

was demonstrated between LVEF at 3-month follow-up and the occurrence of ICD therapy during follow-up (HR 0.96, 95% CI 0.89–1.04, P = 0.34). Furthermore, there was no significant relation between the change in LVEF from baseline to 3-month follow-up and the occurrence of ICD therapy during follow-up (HR 0.99, 95% CI 0.98–1.01, P = 0.28).

## DISCUSSION

The results of the present study can be summarized as follows: (1) considerable improvement in LVEF with reduction in LV volumes is demonstrated at 3-month follow-up in heart failure patients undergoing LV reconstruction (Dor procedure); (2) appropriate ICD therapy occurred in 32% of patients after ICD implantation during 18-month follow-up; (3) neither LVEF at baseline and at 3-month follow-up nor the change in LVEF during 3-month follow-up was related to the occurrence of ICD therapy during 18-months follow-up.

After the onset of symptomatic heart failure, morbidity and mortality are reported to be high.[18–24] Data from early studies (e.g., the Framingham Heart Study) demonstrated a 1-year survival of 55–70% in patients with newly diagnosed symptomatic heart failure.[19,20,23] Subsequent studies demonstrated improvement in mortality with recent developments in medical therapy. Still, mortality in heart failure patients remains high.[25,26] Jong et al. studied over 38,000 consecutive patients from Canada with a first admission for heart failure between 1994 and 1997.[25] The crude 30-day and 1-year mortality rates were 11.6 and 33.1%.

The two main causes of death in patients with heart failure are sudden death and progression of pump failure.[27,28] Several studies suggested a stable pattern with 30–50% of all cardiac deaths in patients with heart failure being categorized as sudden deaths.[24,28–32] In the MADIT II trial, 31% of the cardiac deaths occurred within 1 hour of onset of symptoms, 36% occurred more than 1 hour after symptom onset, and 33% were unwitnessed.[8] Furthermore, the MADIT II trial demonstrated a relative risk reduction in mortality of 31% by ICD implantation in patients with previous infarction and LV dysfunction (LVEF ≤30%) without evidence of ventricular arrhythmias.[2] A class I indication for prophylactic ICD implantation in patients meeting the MADIT II criteria (AHA/ACC/NASPE Guidelines) was the consequence.[7] On the other hand, recent analysis of the MADIT II population revealed that only 35% of patients who received an ICD developed ventricular arrhythmias requiring ICD shocks over a 3-year follow-up period.[8] Consequently, there has been much discussion concerning

the value of LVEF as a major selection criterium for patient selection in need of ICD implantation.[9]

In addition to optimal pharmacological treatment and potential ICD implantation, LV reconstruction may be considered in patients with heart failure and extensive akinesia or dyskinesia of the anterior wall.[11–14] In 1989, Dor and colleagues introduced a surgical approach to restore LV geometry.[14] Over the years, several studies described the advantageous effects of the Dor procedure on LV geometry and function, including substantial increase in LVEF.[11–13] In the present study, mean LVEF increased considerably from 23% before surgery to 41% at 3 months after the Dor procedure ($P < 0.0001$). The majority of patients referred for LV reconstruction may be candidates for ICD implantation as well, according to the MADIT II criteria. In these patients, the LVEF as selection criterium for ICD implantation may be even more difficult as LV reconstruction leads to increase in LVEF. This underscores the dilemma of ICD implantation based on LVEF in this specific group of patients.

In the current study, all patients had LVEF ≤30% at baseline and received an ICD, according to the MADIT II criteria. During median follow-up of 18 months after surgery, appropriate ICD therapy was noted in 32% of patients. The relatively high incidence of appropriate ICD therapy can be explained by a decreased overall clinical condition of the patient population and possibly by increased electrical heterogeneity following surgery, resulting in ventricular arrhythmias. Moreover, the current observations are in line with the MADIT II trial showing that 35% of patients received appropriate ICD shocks over a 3-year follow-up period.[2]

In the present study, LVEF at baseline was not predictive for the occurrence of ICD therapy during follow-up. In addition, a significant relation could not be demonstrated between LVEF at 3-month follow-up and the occurrence of ICD therapy during 18-month follow-up. Furthermore, no significant relation was demonstrated between the change in LVEF from baseline to 3-month follow-up and the occurrence of ICD therapy during 18 months of follow-up.

The small group of patients form an important limitation. Furthermore, it cannot be ruled out that concomitant surgical procedures (coronary artery bypass grafting, valve surgery) during the Dor procedure might have influenced the change in LVEF after the procedure. However, this study is the first to report on the relation between LVEF in the period around surgical LV reconstruction and the occurrence of ICD therapy during follow-up. Future studies should include larger numbers of

patients and should focus more on the impact of the surgical procedure on the occurrence of (inappropriate) ICD therapy during follow-up.

## CONCLUSION

The findings of the present study suggest that LVEF before and after surgical LV reconstruction is of limited use as criterium for ICD implantation in patients with end-stage heart failure.

This study was supported by an unrestricted research grant from St. Jude Medical.

Dr. Bax receives research grants from GE Healthcare, BMS, Boston Scientific, Medtronic, St. Jude, and Edwards Lifesciences.

Dr. Schalij receives research grants from Boston Scientific, Medtronic, and Biotronik.

## REFERENCES

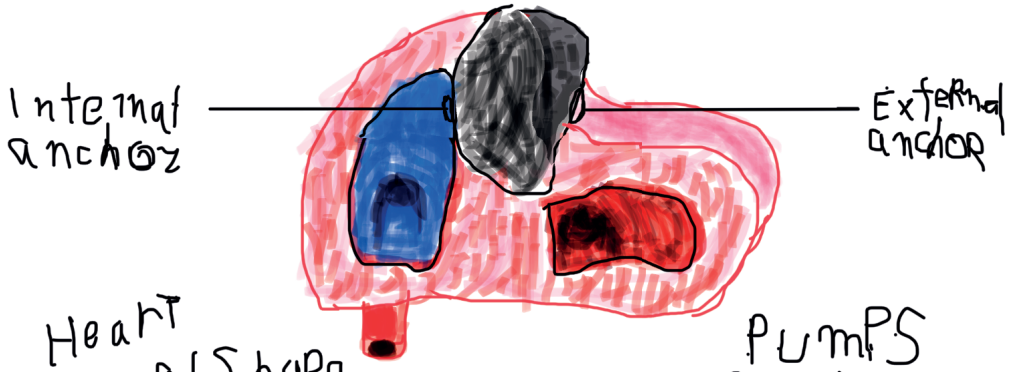

1. Moss AJ, Hall WJ, Cannom DS, Daubert JP, Higgins SL, Klein H, Levine JH, et al. Improved survival with an implanted defibrillator in patients with coronary disease at high risk for ventricular arrhythmia. Multicenter Automatic Defibrillator Implantation Trial Investigators. N Engl J Med 1996; 335:1933– 1940.
2. Moss AJ, Zareba W, Hall WJ, Klein H, Wilber DJ, Cannom DS, Daubert JP, et al. Prophylactic implantation of a defibrillator in patients with myocardial infarction and reduced ejection fraction. N Engl J Med 2002; 346:877–883.
3. Bardy GH, Lee KL, Mark DB, Poole JE, Packer DL, Boineau R, Domanski M, et al. Amiodarone or an implantable cardioverterdefibrillator for congestive heart failure. N Engl J Med 2005; 352: 225–237.
4. Buxton AE, Lee KL, Fisher JD, Josephson ME, Prystowsky EN, Hafley G. A randomized study of the prevention of sudden death in patients with coronary artery disease. Multicenter Unsustained Tachycardia Trial Investigators. N Engl J Med 1999; 341:1882–1890.
5. Ezekowitz JA, Armstrong PW, McAlister FA. Implantable cardioverter defibrillators in primary and secondary prevention: A systematic review of randomized, controlled trials. Ann Intern Med 2003; 138:445–452.
6. Lee DS, Green LD, Liu PP, Dorian P, Newman DM, Grant FC, Tu JV, et al. Effectiveness of implantable defibrillators for preventing arrhythmic events and death: A meta-analysis. J Am Coll Cardiol 2003; 41:1573–1582.
7. Gregoratos G, Abrams J, Epstein AE, Freedman RA, Hayes DL, Hlatky MA, Kerber RE, et al. ACC/AHA/NASPE 2002 guideline update for implantation of cardiac pacemakers and antiarrhythmia devices: Summary article. A report of the American College of Cardiology/ American Heart Association Task Force on Practice Guidelines (ACC/AHA/NASPE Committee to Update the 1998 Pacemaker Guidelines). J Cardiovasc Electrophysiol 2002; 13:1183–1199.
8. Greenberg H, Case RB, Moss AJ, Brown MW, Carroll ER, Andrews ML. Analysis of mortality events in the Multicenter Automatic Defibrillator Implantation Trial (MADIT-II). J Am Coll Cardiol 2004; 43:1459–1465.
9. Moss AJ. Should everyone with an ejection fraction less than or equal to 30% receive an implantable cardioverter-defibrillator? Everyone with an ejection fraction < or = 30% should receive an implantable cardioverter-defibrillator. Circulation 2005; 111:2537–2549.
10. Mills NL, Everson CT, Hockmuth DR. Technical advances in the treatment of left ventricular aneurysm. Ann Thorac Surg 1993; 55:792–800.
11. Dor V. Left ventricular aneurysms: The endoventricular circular patch plasty. Semin Thorac Cardiovasc Surg 1997; 9:123–130.
12. Di Donato M, Sabatier M, Dor V, Gensini GF, Toso A, Maioli M, Stanley AW, et al. Effects of the Dor procedure on left ventricular dimension and shape and geometric correlates of mitral regurgitation one year after surgery. J Thorac Cardiovasc Surg 2001; 121:91–96.
13. Dor V, Saab M, Coste P, Sabatier M, Montiglio F. Endoventricular patch plasties with septal exclusion for repair of ischemic left ventricle: Technique, results and indications from a series of 781 cases. Jpn J Thorac Cardiovasc Surg 1998; 46:389–398.

14. Dor V, Saab M, Coste P, Kornaszewska M, Montiglio F. Left ventricular aneurysm: A new surgical approach. Thorac Cardiovasc Surg 1989; 37:11–19.
15. Dor V, Sabatier M, Di Donato M, Montiglio F, Toso A, Maioli M. Efficacy of endoventricular patch plasty in large postinfarction akinetic scar and severe left ventricular dysfunction: Comparison with a series of large dyskinetic scars. J Thorac Cardiovasc Surg 1998; 116:50–59.
16. Schiller NB, Shah PM, Crawford M, DeMaria A, Devereux R, Feigenbaum H, Gutgesell H, et al. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. American Society of Echocardiography Committee on Standards, Subcommittee on Quantitation of Two-Dimensional Echocardiograms. J Am Soc Echocardiogr 1989; 2:358–367.
17. van Rugge FP, Savalle LH, Schalij MJ. Subcutaneous single-incision implantation of cardioverter-defibrillators under local anesthesia by electrophysiologists in the electrophysiology laboratory. Am J Cardiol 1998; 81:302–305.
18. Cowie MR, Wood DA, Coats AJ, Thompson SG, Suresh V, Poole- Wilson PA, Sutton GC. Survival of patients with a new diagnosis of heart failure: A population based study. Heart 2000; 83:505–510.
19. Ho KK, Anderson KM, Kannel WB, Grossman W, Levy D. Survival after the onset of congestive heart failure in Framingham Heart Study subjects. Circulation 1993; 88:107–115.
20. Rodeheffer RJ, Jacobsen SJ, Gersh BJ, Kottke TE, McCann HA, Bailey KR, Ballard DJ. The incidence and prevalence of congestive heart failure in Rochester, Minnesota. Mayo Clin Proc 1993; 68:1143– 1150.
21. Vasan RS, Larson MG, Benjamin EJ, Evans JC, Reiss CK, Levy D. Congestive heart failure in subjectswith normal versus reduced left ventricular ejection fraction: Prevalence and mortality in a populationbased cohort. J Am Coll Cardiol 1999; 33:1948–1955.
22. Schocken DD, Arrieta MI, Leaverton PE, Ross EA. Prevalence and mortality rate of congestive heart failure in the United States. J Am Coll Cardiol 1992; 20:301–306.
23. MacIntyre K, Capewell S, Stewart S, Chalmers JW, Boyd J, Finlayson A, Redpath A, et al. Evidence of improving prognosis in heart failure: Trends in case fatality in 66 547 patients hospitalized between 1986 and 1995. Circulation 2000; 102:1126–1131.
24. Mosterd A, Cost B, Hoes AW, de Bruijne MC, Deckers JW, Hofman A, Grobbee DE. The prognosis of heart failure in the general population: The Rotterdam Study. Eur Heart J 2001; 22:1318–1327.
25. Jong P, Vowinckel E, Liu PP, Gong Y, Tu JV. Prognosis and determinants of survival in patients newly hospitalized for heart failure: A population-based study. Arch Intern Med 2002; 162:1689–1694.
26. Goldberg RJ, Ciampa J, Lessard D, Meyer TE, Spencer FA. Longterm survival after heart failure: A contemporary population-based perspective. Arch Intern Med 2007; 167:490–496.
27. The CONSENSUS Trial Study Group. Effects of enalapril on mortality in severe congestive heart failure. Results of the Cooperative North Scandinavian Enalapril Survival Study (CONSENSUS). N Engl J Med 1987; 316:1429–1435.
28. The SOLVD Investigators. Effect of enalapril on survival in patients with reduced left ventricular ejection fractions and congestive heart failure. N Engl J Med 1991; 325:293–302.

29. The SOLVD Investigators. Effect of enalapril on mortality and the development of heart failure in asymptomatic patients with reduced left ventricular ejection fractions. N Engl J Med 1992; 327: 685–691.
30. MERIT-HF Study Group. Effect of metoprolol CR/XL in chronic heart failure: Metoprolol CR/XL Randomised Intervention Trial in CongestiveHeart Failure (MERIT-HF). Lancet 1999; 353:2001–2007.
31. Kannel WB, Wilson PW, D'Agostino RB, Cobb J. Sudden coronary death in women. Am Heart J 1998; 136:205–212.
32. Pfeffer MA, Braunwald E, Moye LA, Basta L, Brown EJ Jr, Cuddy TE, Davis BR, et al. Effect of captopril on mortality and morbidity in patients with left ventricular dysfunction after myocardial infarction. Results of the survival and ventricular enlargement trial. The SAVE Investigators. N Engl J Med 1992; 327:669–677.

Less Invasive Treatment

# Live Therapy

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