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Possible Myocardial Stunning after Cardiac Arrest

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Summary. **Serial left ventricular ejection fraction measurements in 23 post-cardiac arrest patients who had either ventricular fibrillation or ventricular tachycardia were analyzed to look for the occurrence of myocardial stunning. Our pilot study is the first to show trends that myocardial stunning does occur after cardiac arrest, which indicates that the use of an ejection fraction obtained soon after cardiac arrest is perhaps not the best approach for the assessment of a long-term prognosis.**

Key words—Myocardial stunning, cardiac arrest, sudden cardiac death, left ventricular ejection fraction.

INTRODUCTION

A condition termed myocardial stunning is characterized by prolonged post-ischemic myocardial dysfunction with the eventual return of normal contractile activity.[1] The dysfunction may be completely reversible after reperfusion and take anywhere from hours to days for full recovery. Clinically, myocardial stunning is commonly observed in patients after they have experienced ischemic events, such as after coronary artery angioplasty, unstable angina, exercise/stress-induced angina/ischemia, after reperfusion for acute myocardial infarction, after cardiopulmonary bypass graft surgery, and after cardioversion (of stunned) atrial muscle from atrial tachyarrhythmias.[2,3,4,5] Sudden cardiac death occurs commonly in the United States, ranging from approximately 400,000 to 450,000 per year.[6] It is usually due to ventricular fibrillation (VF) and ventricular tachycardia (VT), but less commonly from bradycardia and heart block. Approximately 100,000 to 150,000 people survive an episode of sudden cardiac death per year. The Antiarrhythmics versus implantable defibrillators (AVID) trial compared antiarrhythmic-drug therapy with the implantation of defibrillators in such patients resuscitated from near-fatal ventricular arrhythimias.[7] Despite its high incidence, the occurrence of myocardial stunning immediately following cardiac arrest has never been systematically studied in this population. The objective of this pilot study was to investigate whether myocardial stunning occurs at the time of cardiac arrest.

METHODS

The medical records of 159 consecutive patients admitted after cardiac arrest to the University of Rochester Medical Center between July 1999 and May 2000 were reviewed. (Annually, over one hundred patients are admitted to the University of Rochester Medical Center for cardiac arrest.) Patients selected for the study were those who had either ventricular fibrillation or ventricular tachycardia requiring cardioversion, and who had a documented assessment of the left ventricular ejection fraction (LVEF) more than once following their index cardiac arrest. We assumed that in this patient population, there was a total lack of perfusion or transient ischemia of their entire myocardium. None of these patients received reperfusion therapy such as coronary artery bypass graft surgery, coronary angioplasty, or thrombolytic therapy during our study period. The methods used for estimating the LVEF for this study were one of the following three methods: car-

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Abbreviations—AICD, automatic implantable cardioverter defibrillator; AVID, antiarrhythmics versus implantable defibrillators study; VF, ventricular fibrillation; LVEF, left ventricular ejection fraction; EF, ejection fraction; VT, ventricular tachycardia.

diac echocardiography, radionuclide cardiac motion study, or left ventriculography. Changes in LVEF were plotted as a function of time after cardiac arrest.

We defined myocardial stunning as statistically significant increase in follow-up LVEF value compared with initial LVEF measurement obtained soon after cardiac arrest. For the purpose of computing the statistical significance, LVEF measurements performed soon after the cardiac arrest event and at a later date were grouped according to the following time period criteria: ≤ 5 days following cardiac arrest (EF 1), and >5 days after cardiac arrest (EF 2). These two groups of ejection fraction (EF) values were compared with each other using Student's paired t-test, with a statistical significance level preset at 0.05.

Of the 159 patient records reviewed, a total of 19 patients met these LVEF assessment criteria for this study. All of these 19 patients were implanted with an automatic implantable cardioverter defibrillator (AICD). This group was thus termed the AICD group.

An additional 4 patients out of 27 patients participating in the AVID investigation (Antiarrhythmics Versus Implantable Defibrillator) from the University of Rochester Medical Center satisfied the LVEF criteria.[7] This group was termed the AVID group. Thus, the total population for this pilot study consisted of 23 patients (19 AICD patients and 4 AVID patients).

RESULTS

Although the initial number of patient records that we reviewed was 159, we were only able to use data for a total of 19 AICD patients that met our criteria of multiple LVEF assessments. Four out of 27 AVID study patients from University of Rochester Medical Center satisfied the LVEF criteria and were included in the study. The EF 1 and EF 2 for all 23 patients in this study are graphed in Fig. 1. The mean time period was 2 days post-cardiac arrest for EF 1 and 115 days post-cardiac arrest for EF 2. The results show trends that myocardial stunning occurs after cardiac arrest.

In a combined set of AICD VF and VT patients (n=19), the mean EF 1 was 0.338 with a variance of 0.030, which improved to a mean EF 2 of 0.412 with a variance of 0.029 (p=0.01, Table 1). In the AICD VF patient group (n=15), the mean EF 1 was 0.356 with a variance of 0.035, and the mean EF 2 was 0.422 with a variance of 0.032 (p=0.051, Tables 1 and 2). In the AICD VT patient group (n=4), the mean EF 1 was 0.270 with a variance of 0.010, whereas the mean EF 2 was 0.378 with a variance of 0.024 (p=0.084, Table 1). In a combined VF group of AICD VF and AVID VF (n=19), the mean EF 1 was 0.340 with a variance of 0.029, and the mean EF 2 was 0.428 with a variance of 0.028 (p=0.012, Table 2). In a combined group of all AICD and AVID patients (n=23), the mean EF 1 was 0.328 with a variance of 0.026, and the mean EF 2 was 0.414 with a variance of 0.026 (p=0.002, Table 2 and Fig. 1).

CASE REPORTS

Case 1

In a 65-year-old college professor with coronary artery disease, the cardiac event of VF occurred while the patient was teaching in class. Cardiopulmonary resuscitation was started "within 3 min by a student as best as he could." Emergency medical service arrived 4 min later and the patient was cardioverted after a total pulseless time of 7 min. The patient suffered anoxic encephalopathy. This patient's EF 1 (1 day after cardiac arrest) was 21%, which improved later to an EF 2 (one and a half years after cardiac arrest) of 40-45%.

Case 2

A 77-year-old patient with one-vessel coronary artery disease involving the left anterior descending artery developed a VF cardiac arrest while at her doctor's

Table 1. EF changes* as a function of time after VT/VF (Only AICD† patients)

Group	Arrhythmia	No. of cases	EF 1	EF 2	P value
AICD	VF and VT	19	0.338±0.030	0.412±0.029	0.010
AICD	VF	15	0.356±0.035	0.422±0.032	0.051
AICD	VT	4	0.270±0.010	0.378±0.024	0.084

*Mean±Variance, †AICD, all implanted with AICD and having two LVEF measurements satisfying the study criteria.

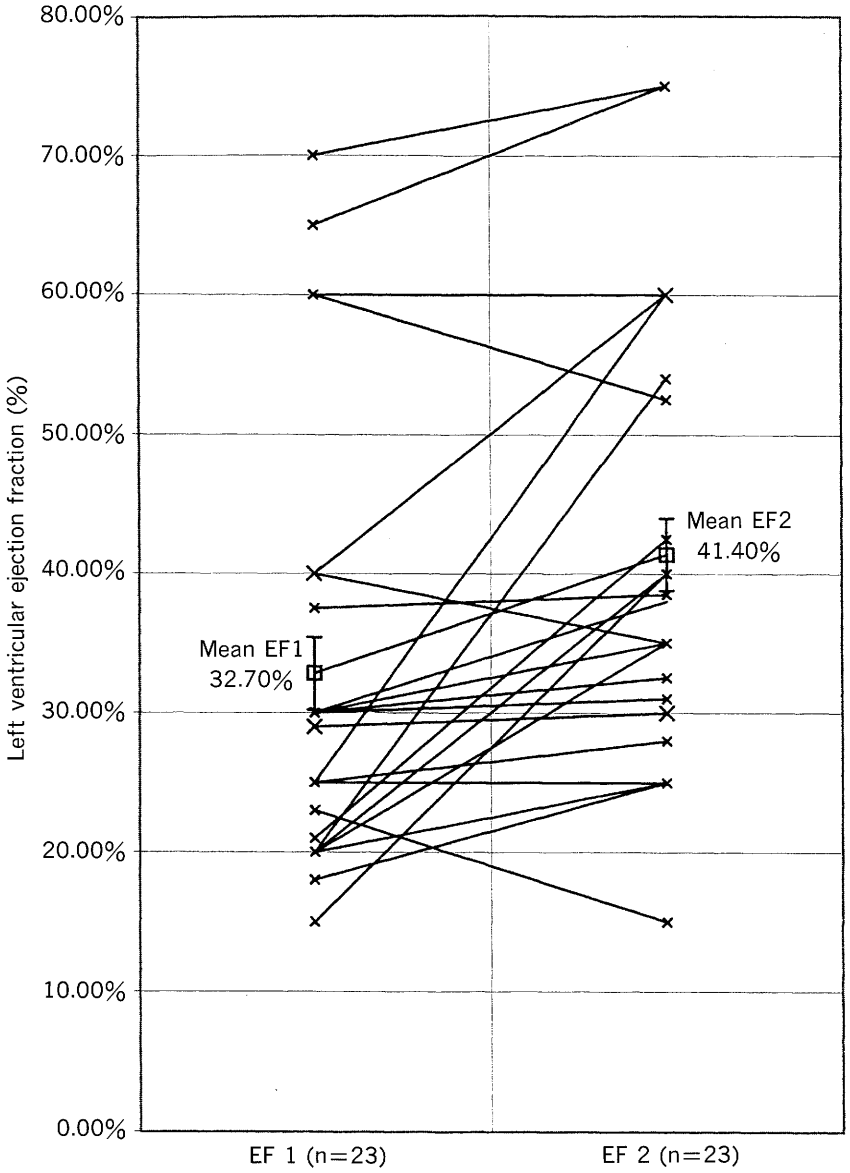

Fig 1. Change in LV ejection fraction from 5 days or less after (EF 1) and to more than 5 days (EF 2) after cardiac arrest in 23 patients. Each line represents a patient. Mean EF 1 and EF 2 values are also presented.

Table 2. EF changes* as a function of time after VT/VF (AICD† and AVID patients)

Group	Arrhythmia	No. of cases	EF 1	EF 2	P value
AICD	VF	15	0.356±0.035	0.422±0.032	0.051
AVID	VF‡	4	0.279±0.005	0.451±0.018	0.16
AVID VF+AICD VF	VF	19	0.340±0.029	0.428±0.028	0.012
AVID+AICD	VF and VT	23	0.328±0.026	0.414±0.026	0.002

*Mean±Variance, †AICD, all implanted with AICD and having two LVEF measurements satisfying the study criteria. ‡AVID study patients with VF from University of Rochester Medical Center only.

office. Her physician immediately initiated cardiopulmonary resuscitation (CPR) and the patient was promptly cardioverted into normal sinus rhythm. The patient's EF 1 (1 day after cardiac arrest) was 60%, and her EF 2 (1 year after cardiac arrest) remained at 60%.

DISCUSSION

Myocardial stunning is characterized by prolonged mechanical dysfunction following a brief episode of ischemia, though this may be completely reversible after reperfusion. It is typically observed in the clinical setting in patients after they have experienced ischemic cardiac events. An ejection fraction is commonly used as a form of prognostic tool in patients after experiencing cardiac arrest. The result of this pilot study indicates trends that myocardial stunning probably does occur in patients who have had VF or VT requiring cardioversion, and in a combined set comprised of VF and VT patients, the data clearly demonstrates statistically significant changes in the ejection fraction following cardiac arrest, thus supporting the occurrence of myocardial stunning in these patients.

As a corollary, this leads to the implication that the use of an ejection fraction obtained immediately after cardiac arrest is perhaps not the best approach for the assessment of a long-term prognosis. The ejection fraction on a later date after the myocardium is "unstunned" may more closely reflect the "true" ejection fraction and may have a better prognostic value.

It was also incidentally noted during this pilot study that the extent of myocardial stunning appears to be related to the accessibility of rapid medical care. In case 1, the patient with the total pulseless time of 7 min had a depressed EF 1 that had improved by the time EF 2 was measured. However, the patient in case 2 who had a cardiac arrest in the physician's office had access to immediate quality CPR and cardioversion. This patient's EF 1 and EF 2 were identical and were not depressed at any time, presumably due to lack of ischemia to cause any myocardial stunning.

One of the shortcomings of this investigation was that this was a retrospective study. Bias, notably selection bias, is a major concern to keep in mind while making conclusions from any retrospective study. Another shortcoming is the relatively small sample size of this study. Of the 159 AICD patients reviewed, only 19 patients met the study criteria for multiple LVEF measurements. Many of the 159 patients that did not qualify for the study had multiple serial ejection fraction measurements. However, many of the measurements did not meet the time frame criteria for EF 1 or EF 2. Although the study demonstrated statistically significant changes in the ejection fraction in the combined VF and VT patient set, as in any study with a relatively small sample size, the results may not accurately represent the greater population of patients with VF and VT.

A future large-scale prospective study addressing the occurrence of myocardial stunning at the time of cardiac arrest is necessary. Important questions to be addressed by future studies include: does myocardial stunning occur with cardiac arrest; if it does take place, what is the shortest duration of pulseless cardiac arrest necessary to precipitate myocardial stunning; what is the shortest duration of pulseless cardiac arrest beyond which there is no improvement in the depressed cardiac function and thereby no myocardial stunning occurs; and, between the ejection fraction measurements made immediately after and that obtained long after cardiac arrest, which measurement has a better long-term prognostic value? Although this pilot study did not investigate the possible relationship between the patients' different medical regimens and the occurrence of myocardial stunning, we may be able to benefit from future studies that address this issue.

In conclusion, this pilot study show trends that myocardial stunning occurs in patients after cardiac arrest. The use of an ejection fraction obtained soon after cardiac arrest is perhaps not the best approach for the assessment of a long-term prognosis.

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