

Research letters

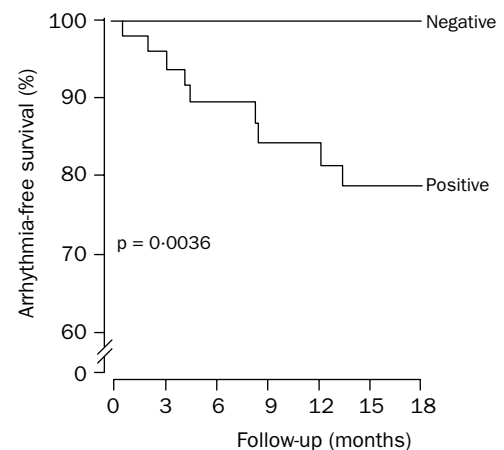
Predictive value of T-wave alternans for arrhythmic events in patients with congestive heart failure

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Measurement of microvolt level T-wave alternans in the surface electrocardiogram is a novel way to assess the risk of ventricular arrhythmias. Seven tests of arrhythmic risk, including T-wave alternans, were undertaken in 107 consecutive patients with congestive heart failure and no history of sustained ventricular arrhythmias; the patients were followed up for arrhythmic events during the next 18 months. Of the patients with events, 11 had positive and two indeterminate T-wave alternans results; there were no arrhythmic events among patients with negative T-wave alternans results. Of the seven tests, only T-wave alternans was a significant ($p=0.0036$) and independent predictor of arrhythmic events.

About half of deaths in patients with congestive heart failure are sudden, resulting from ventricular arrhythmias.¹ Randomised trials have shown that the implantable cardioverter/defibrillator decreases mortality in patients with previous spontaneous or inducible sustained ventricular arrhythmia.^{2,3} However, use of these devices in all patients with congestive heart failure has not yet been shown to be beneficial and would not be feasible for economic reasons. Therefore, we need non-invasive ways to identify those patients who are at highest risk and would benefit from prophylactic treatment. Measurement of μV level T-wave alternans in the surface electrocardiogram (ECG) has been introduced as a new way to assess risk of ventricular arrhythmias.^{4,5} T-wave alternans is a subtle change in T-wave morphology that occurs in each alternate beat. T-wave alternans is thought to reflect the occurrence of localised action-potential alternans, which creates dispersion of recovery, which in turn promotes the development of re-entrant arrhythmias.⁵

We measured T-wave alternans during exercise stress by the spectral analysis method^{4,5} (CH 2000 system, Cambridge Heart, Bedford, USA). The outcome of the T-wave alternans investigation was prospectively defined as: positive, if sustained alternans was present with heart rate at onset of 70% or less of maximum predicted heart rate; negative, if the record did not meet the criteria for a positive outcome and if there was 1 min of artefact-free recording without significant alternans with a heart rate of 105 bpm or higher or within 5 bpm of the maximum heart rate (which had to be ≥ 80 bpm); and indeterminate, otherwise. Other tests of arrhythmic risk, as previously reported³ with prespecified cut-off points, were: left-ventricular ejection fraction 0.30 or less; baroreceptor sensitivity 3.0 ms per mm Hg or less; signal-averaged ECG; and from 24 h ECG monitoring; presence of non-sustained ventricular tachycardia; mean RR 700 ms or less; and SD of normal to normal beat intervals measure of heart-rate variability 70 ms or less. The results of all tests were interpreted by readers not aware of clinical events. Time-dependent Cox's proportional-hazards univariate and multivariate analyses were done in conjunction with a two-sided likelihood ratio test and the Bonferroni correction for



Numbers at risk

Negative	33	30	27	21	16	14	11
Positive	52	45	40	32	30	26	24

Kaplan-Meier analysis of event-free survival for patients with positive or negative results for T-wave alternans outcome. Rate of arrhythmic events at 18 months is 0.21 (SE 0.06) among patients with positive results and zero among those with negative results.

multiple comparisons. Patients were enrolled and followed up until 13 endpoint events had occurred in total.

We studied 107 consecutive patients with congestive heart failure of New York Heart Association class II or III, left-ventricular ejection fraction 0.45 or less, no myocardial infarction within the previous 6 weeks, no active ischaemia requiring revascularisation, no atrial fibrillation, and no history of sustained ventricular arrhythmias. 86 patients were male, the mean age was 56 years (SD 10), mean left-ventricular ejection fraction was 0.28 (0.07), and 67 had coronary-artery disease. 77 patients were receiving digoxin, 99 inhibitors of angiotensin-converting enzyme, 80 diuretics, 45 β -blockers, and 18 amiodarone. Mean follow-up was 14.6 months. Of the 13 prespecified arrhythmic endpoints, seven patients died suddenly, five had sustained ventricular tachycardia, and one was resuscitated from ventricular

Measure	Number positive/ number negative*	Events	Relative risk (SE)	p
TWA	52/33	11	∞	0.0036†
LVEF	73/34	13	4.8 (4.9)	0.05
NSVT	30/72	11	3.2 (2.1)	0.06
BRS	56/46	12	2.4 (1.6)	0.19
SDNN	31/70	11	1.9 (1.2)	0.29
Mean RR	24/77	11	1.3 (0.9)	1.00
SAECG	17/47	5	0	0.21

TWA=T-wave alternans; LVEF=left-ventricular ejection fraction; NSVT=non-sustained ventricular tachycardia; BRS=baroreceptor sensitivity; SDNN=SD of normal to normal beat intervals; SAECG=signal-averaged ECG. *Number of patients initially positive/negative for measure; remainder of 107 patients had indeterminate results. †Statistically significant; cut-off established by Bonferroni adjustment 0.007.

Performance of measures of arrhythmic risk at 18 months of follow-up