Prevalence, Prognosis, and Implications of Isolated Minor Nonspecific ST-Segment and T-Wave Abnormalities in Older Adults

Cardiovascular Health Study

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Background — The prevalence and prognostic significance of isolated minor nonspecific ST-segment and T-wave abnormalities (NSSTTAs) in older adults are poorly understood.

Methods and Results — Cardiovascular Health Study participants free of both clinical cardiovascular disease and major ECG abnormalities were included. We examined the prospective association of isolated minor NSSTTAs (defined by Minnesota Codes 4–3, 4–4, 5–3, and 5–4) with total, cardiovascular, and coronary mortality and incident nonfatal myocardial infarction. Among 3224 participants (61.9% women; mean age, 72 years), 233 (7.2%) had isolated NSSTTAs at baseline. Covariates associated with isolated NSSTTAs included older age, nonwhite race (20.5% of blacks versus 4.8% of whites; \(P<0.001\)), diabetes, and higher blood pressure and body mass index but not the presence of subclinical cardiovascular disease. After 39 518 person-years of follow-up, the presence of isolated NSSTTAs was associated with significantly increased risk for coronary heart disease mortality (multivariable-adjusted hazards ratio, 1.76; 95% CI, 1.18 to 2.61) but not with incident nonfatal myocardial infarction (multivariable-adjusted hazards ratio, 0.71; 95% CI, 0.43 to 1.17). The association of isolated NSSTTAs with coronary death was independent of subclinical atherosclerosis and left ventricular mass measures. In secondary analyses, among those with cardiac death, there was a significantly higher rate of primary arrhythmic death (32.3% versus 15.4%; \(P=0.02\)) in participants with isolated NSSTTAs versus those without NSSTTAs.

Conclusions — Isolated NSSTTAs are common in older Americans and are associated with significantly increased risk for coronary death. However, isolated NSSTTAs are not associated with incident nonfatal myocardial infarction, suggesting that they are associated particularly with increased risk for primary arrhythmic death. (Circulation. 2008;118:2790-2796.)

Key Words: death, sudden ■ electrocardiography ■ epidemiology ■ myocardial infarction ■ prognosis ■ risk

Minor ECG abnormalities, especially minor nonspecific ST-segment and T-wave abnormalities (NSSTTAs), are common in asymptomatic individuals and often occur in the absence of other ECG abnormalities.1–3 Isolated minor NSSTTAs generally represent very minor or upsloping ST-segment depression and flat or minimally inverted T waves. In middle-aged individuals, these isolated NSSTTAs are associated with increased relative risks for cardiovascular disease (CVD) and coronary heart disease (CHD) mortality.1–7 The risks associated with isolated NSSTTAs are independent of other CVD risk factors, and the magnitude of increased risk is similar to that associated with elevated levels of traditional CVD risk factors such as smoking, diabetic status, hypercholesterolemia, and hypertension.8–10 However, studies of the prevalence of and the association between isolated NSSTTAs and CVD have been carried out disproportionately in middle-aged, white male populations. Data are sparse regarding the prevalence of isolated NSSTTAs in individuals ≥65 years of age,1,11–13 and no studies have reported gender and race differences in older adults. Furthermore, the risks for CVD and mortality associated with isolated NSSTTAs in older adults are poorly described, and the mechanisms by which isolated NSSTTAs may be associated with increased risk are unclear.1

Clinical Perspective p 2796

The Cardiovascular Health Study (CHS) is a large, observational cohort of white and black men and women ≥65 years of age. The CHS participants are free of clinical cardiovascular disease and major ECG abnormalities. Among a cohort of 3224 participants, 233 (7.2%) had isolated minor NSSTTAs at baseline. Covariates associated with isolated NSSTTAs included older age, nonwhite race, diabetes, higher blood pressure, and body mass index but not the presence of subclinical cardiovascular disease. After 39 518 person-years of follow-up, the presence of isolated NSSTTAs was associated with significantly increased risk for coronary heart disease mortality but not with incident nonfatal myocardial infarction. The association of isolated NSSTTAs with coronary death was independent of subclinical atherosclerosis and left ventricular mass measures. In secondary analyses, among those with cardiac death, there was a significantly higher rate of primary arrhythmic death in participants with isolated NSSTTAs versus those without NSSTTAs.
years of age. Given its well-characterized cohort, standardized assessment of ECGs using Minnesota Code (MC) criteria, longitudinal follow-up, and careful documentation of risk factors and CVD events, CHS provides a unique opportunity to assess the prevalence of isolated minor NSSTTAs, to identify differences across gender and race, to examine whether isolated minor NSSTTAs are associated with increased risk of fatal and nonfatal CVD and CHD events in older adults, and to explore potential mechanisms for this association.

Methods

Study Sample
Methods of selection and recruitment of the CHS cohort have been described in detail.14 Briefly, CHS is a population-based, prospective, observational study designed to identify risk factors for the onset and progression of CVD and CHD in older adults. Participants were identified from Medicare eligibility lists in 4 US communities: Washington County, Maryland; Forsyth County, North Carolina; Sacramento County, Calif; and Allegheny County, Pennsylvania. Eligible participants were ≥65 years, gave informed consent, and were expecting to live in a defined geographic area for at least 3 years. Excluded individuals were wheelchair bound, institutionalized, receiving active cancer treatment, or in hospice care. Prevalent coronary artery disease, stroke, and heart failure were not exclusion criteria for the main study. An original cohort of 5201 individuals was recruited in 1989 to 1990, and an additional 687 blacks were recruited in 1992 to 1993; therefore, data were available from 5888 study participants. The study was periodically reviewed and approved by Institutional Review boards at participating institutions, and the present study was approved by the Institutional Review Board at Northwestern University.

Clinical Assessment and Measurements
At study enrollment, clinically evident CVD was determined as described previously.16 Baseline risk factors for CVD, including diabetes mellitus status, fasting blood chemistry and lipid tests, blood pressure, and anthropometric and other objective measurements, were obtained according to standardized procedures.14 The ankle-arm index (the ratio of ankle to brachial systolic blood pressure) and common and internal intima-media thickness of the carotid artery were measured at baseline by carotid artery duplex sonography in both cohorts.17 Left ventricular (LV) mass index was determined from the ECG voltage product18 and divided by height in meters raised to the 2.7th power. Digitally recorded 12-lead ECGs were obtained at rest using standardized procedures at the baseline examination for both cohorts. ECGs were analyzed electronically, with manual overreading by trained cardiologists to ensure quality control, at the ECG Reading Center (EPICARE, Wake Forest University). ECGs were classified by MC19 and Novacode20 criteria using variables derived from the median complex of the Marquette measurement matrix. CHS investigators have created a composite index for subclinical CVD that combines measures from different vascular beds.21 We used a modified version of this composite index that is defined as “present” in subjects with no prior adjudicated history of CVD if any of the following were present at baseline: ankle-arm index ≤0.90; internal carotid wall thickness >80th percentile, common carotid wall thickness >80th percentile, or carotid stenosis ≥25%; major ECG abnormality (excluded for this analysis as detailed below); or Rose Questionnaire positive for angina or intermittent claudication.21

ECG Analysis and Exclusions
We focused on minor nonspecific ST-segment and T-wave changes described by MCs 4–3, 4–4, 4–5, and 5–4, defined briefly as follows: ST junction depression <0.5 mm (MC 4–3); ST junction depression >1 mm and ST segment ascending, ie, upsloping (MC 4–4); T wave flat, diphasic, or inverted <1 mm (MC 5–3); and T-wave amplitude positive and ratio of T- to R-wave amplitude ≥1.20, ie, flattened T wave (MC 5–4).19 Defining criteria for NSSTTAs are provided in detail in Table 1.

For the present analysis, we wished to study isolated NSSTTAs in individuals without definite clinical cardiac disease. We excluded participants with documented prior myocardial infarction (MI; n = 562), coronary bypass graft surgery (n = 247), coronary angioplasty (n = 95), congestive heart failure (n = 275), or angina (n = 964). In total, 1264 participants were excluded with prevalent cardiac disease at baseline. To study isolated NSSTTAs, we next excluded, in a hierarchical fashion, participants with ECG findings typically associated with secondary ST-T changes: MC 1–1 and 1–2 (pathological Q waves, n = 129), MC 3–2 with STTAs (LV hypertrophy with STTAs, n = 133), MC 6–1 (complete atrioventricular block, n = 0), MC 6–4 (Wolff-Parkinson-White pattern, n = 2), MC 6–8 (artificial pacemaker, n = 49), MC 7–1 (left bundle-branch block, n = 58), MC 7–2 (right bundle-branch block, n = 168), MC 7–4 (other intraventricular block with QRS duration ≥120 ms, n = 86), MC 8–2 (persistent ventricular rhythms, n = 0), and MC 8–3 (atrial fibrillation, n = 87). Next, we excluded 596 participants with major STTAs (MC 4–1, 4–2, 5–1, or 5–2), 93 participants who were receiving digitalis glycosides at the baseline examination, and 9 remaining participants with suppression codes for reading NSSTTAs. Therefore, 3224 participants with no major ECG abnormalities were analyzed in the present study.

Adjudication of Outcome Events
The present investigation includes data on nonfatal and fatal CVD and CHD events through June 30, 2006.22 The mean duration of follow-up among nondecedents was 15.1±1.1 years (median, 15.5 years; interquartile range, 15.2 to 15.8 years). Participants reported primarily clinical outcomes every 6 months. In addition, comprehensive information was collected for incident CVD events and death, including clinic and hospital records, death certificates, autopsy reports, local obituaries, interviews of next of kin, and physician questionnaires. To augment the detection of deaths and hospitalizations, data from the Health Care Financing Administration database were compared with the CHS events database. Through these methods, as well as through interviews of contacts and proxies for participants lost to follow-up, we accounted for vital status in 100% of our participants.

A CHS Events Committee, comprising a panel of physicians, adjudicated all incident events and deaths using standardized criteria described in detail elsewhere.22 MI was classified using an algorithm that included clinical history of cardiac chest pain, cardiac enzymes, and ECG changes.22 Incident nonfatal MI is defined as an MI that did not result in death within 4 weeks of the event. All subjects with definite fatal MI were excluded from the incident nonfatal MI category. All deaths were classified by the CHS Events Committee into 1 of 5 groups: (1) atherosclerotic CHD; (2) cerebrovascular disease; (3) atherosclerotic disease other than CHD (other arteriosclerotic CVD such as abdominal aortic aneurysm or ischemic

Table 1. MC Definitions for Minor NSSTTAs

<table>
<thead>
<tr>
<th>MC</th>
<th>Definition</th>
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<tbody>
<tr>
<td>4–3</td>
<td>No ST-J depression as much as 0.5 mm but ST-segment downward sloping and ST-segment or T-wave nadir at least 0.5 mm below P-R baseline in any of leads I, II, aVL, or V6 to V6</td>
</tr>
<tr>
<td>4–4</td>
<td>ST-J depression of ≥1.0 mm and ST-segment upward sloping or U shaped in any of leads I, II, aVL, or V6 to V6 lead aVL when R-wave amplitude is ≥5.0 mm</td>
</tr>
<tr>
<td>5–3</td>
<td>T-wave amplitude of 0 (flat), negative, or diphasic (negative-positive type only) with &lt;1.0-mm negative phase in lead I, II, V1 to V6, or lead aVL when R-wave amplitude in the corresponding leads was ≥1.0 mm</td>
</tr>
<tr>
<td>5–4</td>
<td>T-wave amplitude positive and T- or R-wave amplitude ratio of &lt;1:20 in any of leads I, II, aVL, or V6 to V6 when R-wave amplitude in the corresponding leads was ≥1.0 mm</td>
</tr>
</tbody>
</table>
Table 2. Baseline Characteristics

<table>
<thead>
<tr>
<th></th>
<th>No Major or Minor ECG Abnormalities (n=2991)</th>
<th>Isolated Minor NSSTTAs (n=233)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y*</td>
<td>72.0±5.3</td>
<td>72.7±5.3</td>
<td>0.03</td>
</tr>
<tr>
<td>Female sex (n=1995), %</td>
<td>61.6</td>
<td>66.1</td>
<td>0.17</td>
</tr>
<tr>
<td>Race, %</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>White (n=2727)</td>
<td>86.8</td>
<td>56.7</td>
<td></td>
</tr>
<tr>
<td>Black (n=478)</td>
<td>12.7</td>
<td>42.1</td>
<td></td>
</tr>
<tr>
<td>Other (n=19)</td>
<td>0.53</td>
<td>1.29</td>
<td></td>
</tr>
<tr>
<td>Diabetic† (n=414), %</td>
<td>12.3</td>
<td>20.2</td>
<td>0.001</td>
</tr>
<tr>
<td>Current smoker (n=399), %</td>
<td>12.5</td>
<td>10.3</td>
<td>0.32</td>
</tr>
<tr>
<td>Total cholesterol, mg/dL</td>
<td>213.1±38.5</td>
<td>212.2±38.9</td>
<td>0.72</td>
</tr>
<tr>
<td>HDL cholesterol, mg/dL</td>
<td>56.2±16.1</td>
<td>56.8±16.3</td>
<td>0.59</td>
</tr>
<tr>
<td>Systolic BP, mm Hg</td>
<td>133.9±20.5</td>
<td>141.5±21.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diastolic BP, mm Hg</td>
<td>70.7±10.9</td>
<td>73.6±11.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td>26.4±4.6</td>
<td>28.1±5.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>C-reactive protein, mg/L‡</td>
<td>2.3 (1.1–4.1)</td>
<td>2.7 (1.4–4.4)</td>
<td>0.03</td>
</tr>
<tr>
<td>CC-IMT, mm§</td>
<td>1.00 (0.89–1.12)</td>
<td>1.05 (0.96–1.16)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ECG LV mass index‡</td>
<td>37.4 (33.8–41.6)</td>
<td>40.3 (36.6–45.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Any subclinical CVD§ (n=1726), %</td>
<td>53.3</td>
<td>57.1</td>
<td>0.26</td>
</tr>
</tbody>
</table>

HDLC indicates high-density lipoprotein; BP, blood pressure; and CC-IMT, common carotid intima-media thickness.

*Mean±SD unless otherwise indicated.
†Defined according to American Diabetes Association guidelines based on fasting glucose >126 mg/dL, current use of insulin, or oral hypoglycemic medication.
‡Median (25th to 75th percentiles).
§Defined by presence of ankle-arm index ≤0.90, CC-IMT >80th percentile, carotid stenosis ≥25%, or Rose angina or claudication positive.

bowel); (4) other CVD (such as valvular heart disease or pulmonary embolism); and (5) all other deaths. The term CVD mortality is used to denote death resulting from causes 1 through 4. CHD mortality (cause 1) included death resulting from (1) definite fatal MI (no known nonatherosclerotic cause and definite MI within 4 weeks of death), (2) definite fatal CHD (no known nonatherosclerotic cause of death and 1 or both of the following: chest pain within 72 hours of death or history of chronic ischemic heart disease in the absence of valvular heart disease or nonischemic cardiomyopathy), and (3) possible fatal CHD (no known nonatherosclerotic cause and death certificate consistent with CHD death). Participants with CVD death, excluding those with death from cerebrovascular disease (ie, cause 1, 3, or 4), were subsequently classified according to mechanism of death into the following groups: (1) primary arrhythmic (death within 5 minutes in otherwise asymptomatic individual), (2) secondary arrhythmic/mechanical (death with preceding symptoms of heart disease but no evidence of chronic myocardial pump failure), (3) congestive heart failure (death resulting from shock or low-output syndrome), (4) cardiac procedure (death related to CABG or angioplasty), (5) multiple mechanism (death in an individual with severe chronic heart failure who died of ventricular arrhythmia), and (6) hemorrhage from thrombolytic therapy.

Statistical Analysis
Baseline characteristics were compared between participants with and without isolated NSSTTAs by use of χ² tests for categorical variables and t tests or Wilcoxon rank-sum tests for continuous variables as appropriate. We then compared event rates (Kaplan-Meier cumulative incidence) of the outcomes of interest, including all-cause death, CVD death, CHD death, incident MI, incident stroke, and non-CVD death in those with and without isolated NSSTTAs, using log-rank tests. To examine the prospective association between isolated NSSTTAs and outcomes, we used Cox proportional-hazards regression models. Proportional-hazards assumptions were checked and found to be appropriate. Three models were fitted to assess the association between isolated NSSTTAs and each outcome: adjusted for age, sex, and race (model 1); adjusted for model 1 covariates plus diabetes status, smoking status, and baseline levels of total cholesterol, high-density lipoprotein cholesterol, systolic and diastolic blood pressures, body mass index, creatinine, and C-reactive protein (model 2); and adjusted for model 2 covariates plus common carotid intima-media thickness and ECG LV mass index (model 3). Multivariable-adjusted models for CHD death were also fitted to examine for potential differences in subgroups by sex, race, and presence of subclinical CVD. Multiplicative interaction terms between isolated NSSTTAs and each of these stratifying covariates were entered into separate models with the main effect covariates to examine for interactions. In addition, in secondary analyses, rates of CVD death by mechanism were compared in those with and without isolated NSSTTAs with χ² tests. All analyses were performed with STATA/SE 8.0 (STATA Corp, College Station, Tex). Values of P<0.05 were considered statistically significant.

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

Results
The study sample consisted of 3224 participants, of whom 61.9% were women, with a mean age of 72 years; 233 (7.2%) participants had isolated minor NSSTTAs (see Table 1) at baseline in the absence of other ECG abnormalities. Of the 233 participants with any isolated NSSTTAs (MC 4–3, 4–4, 5–3, or 5–4), 6 had ST-segment deviation (MC 4–3 or 4–4), 217 had T-wave abnormalities (MC 5–3 or 5–4), and 10 had both. Thus, T-wave abnormalities made up the vast majority...
of isolated NSSTTAs. Baseline characteristics stratified by the presence of isolated NSSTTAs are shown in Table 2. Those with isolated NSSTTAs were slightly older, were more likely to be diabetic, and had higher blood pressure, body mass index, common carotid intima-media thickness, and ECG LV mass index at baseline. The prevalence of NSSTTAs was significantly higher, >4 times more prevalent, in blacks compared with whites (20.5% and 4.8%, respectively).

During 39,518 person-years of follow-up, there were 1592 deaths resulting from all causes, including 502 caused by CVD (of which 295 were due to CHD) and 1090 caused by non-CVD causes. There were 368 incident nonfatal MIs (in 37,571 person-years) and 433 incident strokes (in 37,191 person-years). The Figure displays the unadjusted event rates for each end point stratified by the presence of isolated NSSTTAs at baseline. Participants with isolated NSSTTAs had a significantly higher rate of all-cause mortality, which was due largely to significantly higher rates of CVD death, particularly CHD death. Of interest, there was no significant difference in the rate of incident nonfatal MI despite the significant difference in CHD death.

After adjustment for clinical covariates (Table 3), there was no substantial attenuation in the hazards ratio for any end point. After adjustment for clinical covariates, the presence of subclinical atherosclerosis, and LV mass index, there were still no substantial changes in the hazards ratios. Isolated NSSTTAs were most strongly associated with CHD death, followed by all-cause death, and had greater common carotid intima-media thickness at baseline (Table 1), the hazards ratios for CHD death associated with isolated NSSTTAs were similar for those with common carotid intima-media thickness and LV mass index above and below the median, with no significant interactions (data not shown).

Given the association between isolated NSSTTAs and CHD death, in secondary, hypothesis-generating analyses, we examined data on the mechanism of cardiac death. Participants with cardiac death (CVD death resulting from causes other than cerebrovascular death) were subsequently classified according to the most important mechanism that contributed to cardiac death. In Table 4, rates of the different mechanisms of cardiac death are stratified by the presence and absence of isolated NSSTTAs. A significantly greater proportion of participants with isolated NSSTTAs had primary arrhythmia as the most important mechanism contributing to their cardiac death compared with those without NSSTTAs had greater common carotid intima-media thickness and LV mass index at baseline (Table 1), the hazards ratios for CHD death associated with isolated NSSTTAs were similar for those with common carotid intima-media thickness and LV mass index above and below the median, with no significant interactions (data not shown).

### Table 3. Multivariable-Adjusted Hazards Ratios for Different Outcomes Among Participants With Isolated Minor NSSTTAs Compared With Those With No Major or Minor ECG Abnormalities

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause death</td>
<td>1.21 (1.01–1.46)</td>
<td>1.18 (0.97–1.43)</td>
<td>1.20 (0.98–1.46)</td>
</tr>
<tr>
<td>CVD death</td>
<td>1.65 (1.22–2.23)</td>
<td>1.53 (1.12–2.08)</td>
<td>1.53 (1.12–2.10)</td>
</tr>
<tr>
<td>CHD death</td>
<td>1.83 (1.25–2.68)</td>
<td>1.72 (1.16–2.55)</td>
<td>1.76 (1.18–2.61)</td>
</tr>
<tr>
<td>Incident nonfatal MI</td>
<td>0.77 (0.48–1.25)</td>
<td>0.70 (0.42–1.15)</td>
<td>0.71 (0.43–1.17)</td>
</tr>
<tr>
<td>Incident stroke</td>
<td>1.39 (0.99–1.94)</td>
<td>1.32 (0.94–1.86)</td>
<td>1.28 (0.90–1.81)</td>
</tr>
<tr>
<td>Non-CVD death</td>
<td>1.02 (0.80–1.31)</td>
<td>1.02 (0.79–1.31)</td>
<td>1.05 (0.81–1.35)</td>
</tr>
</tbody>
</table>

Model 1: adjusted for age, sex, and race. Model 2: adjusted for age, sex, race, diabetes status, smoking status, baseline level of total cholesterol, high-density lipoprotein cholesterol, systolic and diastolic blood pressures, body mass index, creatinine, and C-reactive protein. Model 3: adjusted for all covariates in model 2 plus common carotid intima-media thickness and ECG left ventricular mass index.

### Table 4. Mechanism of Cardiac Death Stratified by Presence or Absence of Isolated NSSTTAs

<table>
<thead>
<tr>
<th>Cardiac deaths, n</th>
<th>No Major or Minor ECG Abnormalities</th>
<th>Isolated Minor NSSTTA</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac deaths, n</td>
<td>292</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Primary arrhythmic death,* %</td>
<td>15.4</td>
<td>32.3</td>
<td>0.02</td>
</tr>
<tr>
<td>Secondary arrhythmic death,† %</td>
<td>45.9</td>
<td>35.5</td>
<td>0.27</td>
</tr>
<tr>
<td>CHF,* † %</td>
<td>20.9</td>
<td>16.1</td>
<td>0.64</td>
</tr>
<tr>
<td>Cardiac procedure,§ %</td>
<td>3.4</td>
<td>6.5</td>
<td>0.32</td>
</tr>
<tr>
<td>Multiple mechanism,</td>
<td>14.0</td>
<td>9.7</td>
<td>0.78</td>
</tr>
<tr>
<td>Hemorrhage from thrombolytic therapy, %</td>
<td>0.3</td>
<td>0</td>
<td>&gt;0.99</td>
</tr>
</tbody>
</table>

*Defined as death within 5 minutes in an otherwise asymptomatic individual.
†Defined as death with preceding symptoms of heart disease but no evidence of chronic myocardial pump failure.
§Defined as death resulting from shock or low-output syndrome.
|§|Defined as death related to CABG or angioplasty.
|§|Defined as death caused by ventricular arrhythmia in an individual with known severe chronic heart failure.
isolated NSSTTAs. Rates of other mechanisms of cardiac death were similar between those with and without isolated NSSTTAs. Adjustment for age, race, and sex did not alter these findings.

Discussion

Principal Findings

To the best of our knowledge, these results are among the first to examine the prognostic significance of isolated NSSTTAs for CVD end points in older adults. In this large cohort of older Americans followed up for more than a decade, we observed that isolated minor NSSTTAs were fairly common and were associated with increased risk for all-cause mortality, with nearly a doubling of risk for CHD death specifically. However, isolated NSSTTAs are not associated with increased risk for incident nonfatal MI. The increased risk for CHD death associated with isolated NSSTTAs is present even after adjustment for important clinical covariates and the presence of subclinical atherosclerosis or LV mass index. The risk appears similar for men and women, for whites and blacks, and for those with and without subclinical atherosclerosis or higher LV mass index.

Potential Mechanisms

Previous investigators speculated that isolated NSSTTAs might signify the presence of subclinical coronary disease or elevated LV mass, but they lacked data to assess these postulated mechanisms. Our study benefited from the design of the CHS, which allowed examination of the presence of isolated NSSTTAs with MC criteria, of the prognosis associated with isolated NSSTTAs, and of possible mechanisms by which isolated NSSTTAs may increase risk for adverse outcomes. In CHS, adjustment for subclinical atherosclerosis measures and LV mass had little effect on the size of the association between isolated NSSTTAs and CVD end points.

These data add to a growing body of literature suggesting that the mechanism of association between isolated NSSTTAs and increased risk for fatal CHD may not be attributed solely to the presence of underlying subclinical coronary atherosclerosis. Newman et al showed previously that major ECG abnormalities were not significantly associated with the presence or extent of coronary artery calcification in the CHS cohort.

The present finding that isolated NSSTTAs were associated with increased risk for CHD death in particular, but not with incident nonfatal MI, would suggest the hypothesis that a proximate mechanism of arrhythmia may be one of the causes of the association, not coronary atherosclerosis or increased LV mass alone. That the association was statistically independent of subclinical atherosclerosis and LV mass also supports the hypothesis that the risk of isolated NSSTTAs may be mediated through arrhythmias. We tested this hypothesis with the analyses examining mechanisms of cardiac death because CHS did not allow heart failure or sudden cardiac death to be coded as causes of death (these were defined by protocol as mechanisms, but not underlying causes, of death). Although these were secondary analyses, we found a significantly higher rate of primary arrhythmic death in participants with isolated NSSTTAs compared with those without NSSTTAs. Congestive heart failure does not appear to drive the association between NSSTTAs and CHD mortality given that the rates of cardiac death that resulted from a congestive heart failure mechanism were not increased in patients with NSSTTAs compared with those without NSSTTAs. Taken together, these data suggest the hypothesis that isolated NSSTTAs may be a marker of increased risk for arrhythmic death in asymptomatic elderly persons, and future adequately powered studies are warranted to test this hypothesis with a well-defined end point of sudden cardiac death.

Whereas several studies have reported increased risk for CVD and CHD mortality in younger cohorts independently of traditional cardiovascular risk factors, the mechanisms by which isolated NSSTTAs might confer increased risk remain poorly understood. Isolated NSSTTAs have been ascribed to transient physiological phenomena such as ingestion of food, change in posture, or emotional distress. Other postulated explanations for isolated NSSTTAs have included hyperventilation, central nervous system lesions, abnormalities in LV wall motion in the absence of coronary artery disease, persistent juvenile pattern, electrocardiograph disturbances, use of drugs (ie, digitalis, antiarrhythmic, and psychotropic drugs), or athletic ability. None of these postulated mechanisms, however, appears to explain the significant independent association between isolated NSSTTAs and fatal CHD that has been observed in this and other large population-based studies. Furthermore, after exclusions were applied to define isolated minor NSSTTAs in the present study sample, no participants had evidence of Brugada syndrome or a recently described pattern of early repolarization that may be associated with sudden cardiac arrest. The present study suggests that the presence of isolated NSSTTAs in older individuals, regardless of mechanism, may be cause for concern.

Current Study in Context

Previous studies of middle-aged individuals have established that minor ECG abnormalities are associated with higher risk for mortality, especially CVD and CHD mortality, and, to a lesser extent, with increased risk for nonfatal CVD and CVD events. In a recent systematic review of the literature, it was noted that the prevalence of isolated minor NSSTTAs (MC 4–3, 4–4, 5–3, or 5–4) ranged from 3.6% to 10.3% in middle-aged white men, and it appeared to be consistently higher among women, blacks, and older individuals, although data are limited. The investigators had observed a higher prevalence of CVD risk factors in subjects with NSSTTAs, as we did. Few studies have reported the prevalence of isolated NSSTTAs in older adults, and none has examined the association of isolated NSSTTAs with CVD or CHD mortality or nonfatal events in older adults without clinical CHD. The sole prior report of outcomes in older adults from the CHS found that isolated NSSTTAs are associated with increased risk for incident heart failure.

More than 80% of CHD deaths occur in adults >65 years of age; a large proportion of these deaths occur outside the hospital; and risk factors associated with CHD mortality have been shown to be somewhat different from risk factors that
predict nonfatal CHD events. The identification of isolated NSSTTAs as a potential risk marker for fatal CHD events is important not only because of the high rates of CHD mortality in older adults but also because ECGs are readily available and frequently obtained for numerous indications other than screening in hospitals and clinics. At present, the US Preventive Services Task Force recommends against routine screening with an ECG in asymptomatic patients. Although our study does not provide evidence to support routine ECG screening in elderly patients, NSSTTAs are prognostically important, and their presence could trigger more intensive management of modifiable risk factors in the interest of reducing overall CHD mortality risk. However, further data like the present study are needed to understand how the presence of isolated minor NSSTTAs, easily detectable by practicing clinicians, could affect routine CVD and CHD risk communication in older adults.

Potential Limitations

The present study was limited by the fact that we analyzed the association between NSSTTAs and fatal and nonfatal CHD and CVD events using a single ECG at baseline. It is well established that NSSTTAs can represent transient physiological changes, and studies have demonstrated that persistent NSSTTAs, present on serial ECGs over time, are more significantly associated with CHD and CVD mortality. In addition, clinically silent MI were not captured as part of the nonfatal MI end point and may represent a possible explanation for the lack of association between NSSTTAs and nonfatal MI. Although the CHS cohort provided a unique opportunity to compare the prevalence and prognostic significance of NSSTTAs across sex and race groups, the power of the race subgroup analysis is limited by the fewer number of black participants. Furthermore, other analyses, including the secondary, hypothesis-generating analyses examining the mechanism of cardiac death between those with and without isolated NSSTTAs, also had somewhat limited power. For example, although we detected a significant difference (P = 0.02) between the proportions with primary arrhythmic death in our sample, we had only 55% power to detect this difference at a 2-sided α level of 0.05. Finally, the CHS cohort represents a group of highly motivated elderly participants who were in regular contact with health professionals and therefore may not represent the general elderly population followed up in a primary care setting. Nonetheless, the important risks we observed suggest that ECGs obtained for any reason be examined carefully for the presence of isolated NSSTTAs in asymptomatic older individuals.

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Disclosures

None.

References


**CLINICAL PERSPECTIVE**

The prevalence and clinical significance of isolated minor nonspecific ST-segment and T-wave abnormalities (NSSTTTAs; characterized by minor or upsloping ST-segment depression or T-wave flattening or inversion <1.0 mm) are poorly characterized in older adults. In the Cardiovascular Health Study, we observed that the prevalence of isolated NSSTTTAs was 7.2% among those ≥65 years of age without major ECG abnormalities. The presence of isolated NSSTTTAs was significantly associated with risk for all-cause mortality and especially coronary mortality (with nearly double the risk) but not nonfatal myocardial infarction. The association was independent of measures of subclinical atherosclerosis burden and left ventricular mass. In secondary analyses, isolated NSSTTTAs appeared to be most strongly associated with primary arrhythmic death, suggesting that they may in part represent arrhythmogenic substrate. Whereas ECGs are not currently recommended as a routine screening measure, these data suggest that ECGs obtained for any clinical reason in older adults should be examined carefully for the presence of isolated NSSTTTAs. More than 80% of coronary deaths occur in adults >65 years of age. Thus, physicians and patients could consider more intensive management of modifiable risk factors in those with isolated NSSTTTAs to prevent fatal events.
Prevalence, Prognosis, and Implications of Isolated Minor Nonspecific ST-Segment and T-Wave Abnormalities in Older Adults: Cardiovascular Health Study
Anita Kumar, Ronald J. Prineas, Alice M. Arnold, Bruce M. Psaty, Curt D. Furberg, John Robbins and Donald M. Lloyd-Jones

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