Randomized Trial of Estrogen Plus Progestin for Secondary Prevention of Coronary Heart Disease in Postmenopausal Women

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Context.—Observational studies have found lower rates of coronary heart disease (CHD) in postmenopausal women who take estrogen than in women who do not, but this potential benefit has not been confirmed in clinical trials.

Objective.—To determine if estrogen plus progestin therapy alters the risk for CHD events in postmenopausal women with established coronary disease.

Design.—Randomized, blinded, placebo-controlled secondary prevention trial.

Setting.—Outpatient and community settings at 20 US clinical centers.

Participants.—A total of 2763 women with coronary disease, younger than 80 years, and postmenopausal with an intact uterus. Mean age was 66.7 years.

Intervention.—Either 0.625 mg of conjugated equine estrogens plus 2.5 mg of medroxyprogesterone acetate in 1 tablet daily (n = 1380) or a placebo of identical appearance (n = 1383). Follow-up averaged 4.1 years; 82% of those assigned to hormone treatment were taking it at the end of 1 year, and 75% at the end of 3 years.

Main Outcome Measures.—The primary outcome was the occurrence of nonfatal myocardial infarction (MI) or CHD death. Secondary cardiovascular outcomes included coronary revascularization, unstable angina, congestive heart failure, resuscitated cardiac arrest, stroke or transient ischemic attack, and peripheral arterial disease. All-cause mortality was also considered.

Results.—Overall, there were no significant differences between groups in the primary outcome or in any of the secondary cardiovascular outcomes: 172 women in the hormone group and 176 women in the placebo group had MI or CHD death (relative hazard [RH], 0.99; 95% confidence interval [CI], 0.80-1.22). The lack of an overall effect occurred despite a net 11% lower density lipoprotein cholesterol level and 10% higher high-density lipoprotein cholesterol level in the hormone group compared with the placebo group (each P<.001). Within the overall null effect, there was a statistically significant time trend, with more CHD events in the hormone group than in the placebo group in year 1 and fewer in years 4 and 5. More women in the hormone group than in the placebo group experienced venous thromboembolic events (34 vs 12; RH, 2.89; 95% CI, 1.50-5.58) and gallbladder disease (84 vs 62; RH, 1.38; 95% CI, 1.00-1.92). There were no significant differences in several other end points for which power was limited, including fracture, cancer, and total mortality (131 vs 123 deaths; RH, 1.08; 95% CI, 0.84-1.38).

Conclusions.—During an average follow-up of 4.1 years, treatment with oral conjugated equine estrogen plus medroxyprogesterone acetate did not reduce the overall rate of CHD events in postmenopausal women with established coronary disease. The treatment did increase the rate of thromboembolic events and gallbladder disease. Based on the finding of no overall cardiovascular benefit and a pattern of early increase in risk of CHD events, we do not recommend starting this treatment for the purpose of secondary prevention of CHD. However, given the favorable pattern of CHD events after several years of therapy, it could be appropriate for women already receiving this treatment to continue.

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MANY OBSERVATIONAL studies have found lower rates of coronary heart disease (CHD) in women who take postmenopausal estrogen than in women not receiving this therapy.1-5 This association has been reported to be especially strong for secondary prevention in women with CHD, with hormone users having 35% to 80% fewer recurrent events than nonusers.6-12 If this association is causal, estrogen therapy could be an important method for preventing CHD in postmenopausal women. However, the observed association between estrogen therapy and reduced CHD risk might be attributable to selection bias if women who choose to take hormones are healthier and have a more favorable CHD profile than those who do not.13,14 Observational studies cannot resolve this uncertainty.

Only a randomized trial can establish the efficacy and safety of postmenopausal hormone therapy for preventing CHD.
The Heart and Estrogen/progestin Replacement Study (HERS) was a randomized, double-blind, placebo-controlled trial of daily use of conjugated equine estrogens plus medroxyprogesterone acetate (progestin) on the combined rate of nonfatal myocardial infarction (MI) and CHD death among postmenopausal women with coronary disease. We enrolled women with established coronary disease because their high risk for CHD events and the strong reported association between hormone use and risk of these events make this an important and efficient study population in which to evaluate the effect of hormone therapy.

METHODS

Study Participants

The design, methods, and baseline findings of the study have been published.16 Briefly, participants were postmenopausal women younger than 80 years with established coronary disease who had not had a hysterectomy. Postmenopausal was defined as age at least 55 years and no natural menses for at least 5 years, or no natural menses for at least 1 year and serum follicle-stimulating hormone (FSH) level more than 40 IU/L, or documented bilateral oophorectomy, or reported bilateral oophorectomy with FSH level more than 40 IU/L and estradiol level less than 92 pmol/L (25 pg/mL). Established coronary disease was defined as evidence of 1 or more of the following: MI, coronary artery bypass graft surgery, percutaneous coronary revascularization, or angiographic evidence of at least a 50% occlusion of 1 or more major coronary arteries.

Women were excluded for the following reasons: CHD event within 6 months of randomization; serum triglyceride level higher than 3.39 mmol/L (300 mg/dL); use of oral, parenteral, vaginal, or transdermal sex hormones within 3 months of randomization; serum triglyceride levels were determined by the Liprotein Analytical Laboratory at Johns Hopkins Hospital.17

Randomization and Blinding

The randomization code was prepared using computer-generated random numbers. Eligible participants were assigned with equal probability to the 2 treatment groups using tamper-proof blocked randomization stratified by clinical center. At each center, women who met the entry criteria were logged to which procedures at the clinics conformed with those described in the procedure manual during annual site visits. All data were entered twice and checked by computer algorithms.

Outcome Ascertainment

The CHD events (nonfatal MI or CHD death) that occurred between the date of randomization and the closeout date were the primary outcome of the trial. Nonfatal MI could be either symptomatic or silent, and CHD death could be a fatal documented MI, sudden death within 1 hour of onset of symptoms, un-
observed death that occurred out of the hospital in the absence of other known cause, or death due to coronary revascularization procedure or congestive heart failure. The diagnosis of nonfatal MI was based on an algorithm that took into account 3 categories of clinical information from the acute event: ischemic symptoms, ECG abnormalities, and elevated cardiac enzyme levels. The diagnosis could also be made if there was evidence of fresh MI at autopsy. All ECGs obtained electronically were compared with the ECG obtained at baseline for changes indicating new MI.

Secondary cardiovascular outcomes included coronary artery bypass graft surgery, percutaneous coronary revascularization, hospitalization for unstable angina, resuscitated cardiac arrest, congestive heart failure, stroke or transient ischemic attack, and peripheral arterial disease. Other prespecified secondary outcomes were total mortality; cancer death; non-CHD, noncancer death; breast, endometrial, and other cancer; deep vein thrombosis; pulmonary embolism; hip and other fracture; and gallbladder disease.

The primary and secondary outcomes of HERS were addressed at each follow-up contact. Suspected outcome events were reported within 24 hours to the Coordinating Center, which had primary responsibility for the outcome database, and to Wyeth-Ayerst Research as a cross-check. Clinics obtained and sent to the Coordinating Center specified documentation that included (depending on the suspected event) hospital discharge summaries, ECGs, cardiac enzyme levels and other test results, and reports of tissue pathology, procedures, and x-ray examinations. Data from all deaths and suspected primary outcome events were reviewed and classified according to prespecified criteria by an independent Morbidity and Mortality Subcommittee blinded to treatment assignment. Secondary events were classified by Coordinating Center physicians blinded to treatment assignment. Every event (whether primary or secondary) was classified independently by 2 reviewers, and discordant classifications were resolved in discussions between the reviewers. Problematic potential primary events were discussed on conference calls or meetings involving the entire subcommittee.

Vital status is known for all 2763 women, and all deaths are included in this report. We are still in the process of collecting hospital records and adjudicating recent events. Included in this report are 99% of all primary CHD events reported to have occurred by the close-out visit (April-July 1998) and 97% of all secondary events. Adjudication is final for 96% of included primary events (the remaining classifications are provisional), and it is final for 90% of included secondary events.

Statistical Power and Analyses

We estimated that we needed to enroll 2340 women, assuming a primary CHD event rate in the placebo group of 5% per year, a combined non-CHD death and loss to follow-up rate of 2% per year, crossovers from active to placebo of 5%, 4%, and 3% in the first 3 years and 2% per year thereafter, crossovers from placebo to active of 1% each year, and average follow-up of 4.75 years. We assumed that half the reduction in primary CHD events would operate through nonlipid mechanisms (and therefore be immediate), and half would operate through lipid changes (and therefore begin after a 2-year lag period). These assumptions resulted in 90% power at a 2-tailed a of .05 to detect an intention-to-treat effect size of 24%. In the actual study, the event rate was only 3.3%, compliance was less than expected, and treatment duration averaged 4.1 years. The chief reason for the shorter-than-expected treatment duration, despite ending the study at the planned time, was the fact that most women were enrolled toward the end of the recruitment period. The reduction in power caused by these deviations from prescheduled assumptions was partially offset by the fact that we recruited 18% more participants than planned.

The primary analysis compares the rate of CHD events among women assigned to active medication with the rate among women assigned to placebo using an unadjusted Cox proportional hazards model for time to first CHD event; this is equivalent to the log rank test. The analysis was by intention to treat, categorizing participants according to randomized treatment assignment regardless of compliance. Participants who asked to drop out of the study and had not had a nonfatal MI were censored for nonfatal events at their last visit (this occurred for 31 women in the hormone group and 38 women in the placebo group); however, vital status was assessed at the end of the trial for 100% of the cohort, and all deaths are included in this report.

Secondary analyses used multivariate proportional hazards models to investigate study findings. Possible confounders were used to randomize treatment assignment regardless of compliance. Participants who asked to drop out of the study and had not had a nonfatal MI were censored for nonfatal events at their last visit (this occurred for 31 women in the hormone group and 38 women in the placebo group); however, vital status was assessed at the end of the trial for 100% of the cohort, and all deaths are included in this report.

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RESULTS

Between January 1993 and September 1994, the 20 HERS clinical centers enrolled 2763 women; 1380 were assigned to the hormone group and 1383 to the placebo group (Figure 1). Participants ranged in age from 44 to 79 years, with a mean of 66.7 years (SD, 6.7 years) at baseline. Most participants were white (89%) and had completed high school (80%). Examination of the distribution of these and other variables revealed no significant differences between the treatment groups at baseline (Table 1).
Table 1.—Baseline Characteristics of HERS Participants (n=2763) by Treatment Group*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Estrogen-Progestin (n=1380)</th>
<th>Placebo (n=1383)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, mean±SD, y</td>
<td>67±7</td>
<td>67±7</td>
<td>.32</td>
</tr>
<tr>
<td>White, %</td>
<td>86</td>
<td>90</td>
<td>.14</td>
</tr>
<tr>
<td>Education, mean±SD, y</td>
<td>13±3</td>
<td>13±3</td>
<td>.84</td>
</tr>
<tr>
<td>CHD risk factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smoker, %</td>
<td>13</td>
<td>13</td>
<td>.84</td>
</tr>
<tr>
<td>Diabetes on oral medication or insulin, %</td>
<td>19</td>
<td>18</td>
<td>.44</td>
</tr>
<tr>
<td>Systolic blood pressure, mean±SD, mm Hg</td>
<td>135±19</td>
<td>135±19</td>
<td>.88</td>
</tr>
<tr>
<td>Diastolic blood pressure, mean±SD, mm Hg</td>
<td>73±10</td>
<td>73±10</td>
<td>.89</td>
</tr>
<tr>
<td>LDL cholesterol, mean±SD, mmol/L (mg/dL)</td>
<td>3.75±0.96 (145±37)</td>
<td>3.75±0.98 (145±38)</td>
<td>.83</td>
</tr>
<tr>
<td>HDL cholesterol, mean±SD, mmol/L (mg/dL)</td>
<td>1.29±0.34 (50±13)</td>
<td>1.29±0.34 (50±13)</td>
<td>.41</td>
</tr>
<tr>
<td>Triglyceride, mean±SD, mmol/L (mg/dL)</td>
<td>1.90±0.72 (168±64)</td>
<td>1.86±0.72 (165±64)</td>
<td>.25</td>
</tr>
<tr>
<td>Time since last menstrual period, mean ± SD, y</td>
<td>18±8</td>
<td>18±8</td>
<td>.31</td>
</tr>
<tr>
<td>Body mass index &gt;27 kg/m², %</td>
<td>57</td>
<td>55</td>
<td>.44</td>
</tr>
<tr>
<td>Exercise &gt;3 times weekly, %</td>
<td>39</td>
<td>38</td>
<td>.72</td>
</tr>
<tr>
<td>No. of drinks per week, mean±SD</td>
<td>1.4±4</td>
<td>1.3±4</td>
<td>.83</td>
</tr>
<tr>
<td>General health poor or fair, %</td>
<td>24</td>
<td>24</td>
<td>.94</td>
</tr>
<tr>
<td>Postmenopausal estrogen use, %‡</td>
<td>24</td>
<td>23</td>
<td>.43</td>
</tr>
<tr>
<td>CHD manifestations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signs of congestive heart failure, %‡</td>
<td>10</td>
<td>9</td>
<td>.38</td>
</tr>
<tr>
<td>Q-wave myocardial infarction, %</td>
<td>17</td>
<td>17</td>
<td>.94</td>
</tr>
<tr>
<td>Percutaneous coronary revascularization, %</td>
<td>45</td>
<td>45</td>
<td>.96</td>
</tr>
<tr>
<td>Coronary artery bypass graft surgery, %</td>
<td>42</td>
<td>41</td>
<td>.64</td>
</tr>
<tr>
<td>Medication use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin, %</td>
<td>78</td>
<td>78</td>
<td>.73</td>
</tr>
<tr>
<td>β-Blockers, %</td>
<td>33</td>
<td>32</td>
<td>.72</td>
</tr>
<tr>
<td>Lipid-lowering medications, %</td>
<td>45</td>
<td>47</td>
<td>.26</td>
</tr>
<tr>
<td>Calcium channel blockers, %</td>
<td>55</td>
<td>55</td>
<td>.83</td>
</tr>
<tr>
<td>Angiotensin-converting enzyme inhibitors, %</td>
<td>17</td>
<td>18</td>
<td>.57</td>
</tr>
<tr>
<td>Diuretics, %</td>
<td>28</td>
<td>28</td>
<td>.79</td>
</tr>
<tr>
<td>Multivitamins, %</td>
<td>29</td>
<td>30</td>
<td>.45</td>
</tr>
</tbody>
</table>

*HERS indicates Heart and Estrogen/progestin Replacement Study; CHD, coronary heart disease; LDL, low-density lipoprotein; and HDL, high-density lipoprotein. P values are for difference between treatment groups by t test or x². ‡Presence of jugular venous distention more than 8 cm H₂O, S₃ heart sound, rales, or pitting peripheral edema.

At the end of the first year, the proportion who reported taking study medication was 82% in the hormone group and 91% in the placebo group; by the end of the third year, these proportions had declined to 75% and 81%. Pill counts revealed 79% of the women in the hormone group to be taking at least 80% of their study medication at the end of year 1 and 70% to be doing so at the end of year 3 (Figure 2). Among women who stopped taking HERS medications, 110 (8%) of those assigned to the placebo group and 36 (3%) of those assigned to the hormone group reported taking open-label oral or transdermal estrogen.

During the closeout period (April-July 1998), vital status was ascertained for all 2763 randomized women. Follow-up percentages were nearly the same in the 2 randomized groups (Figure 1).

**Primary CHD Outcome**

Primary CHD events occurred in 172 women in the hormone group (33.1/1000 women per year) and in 176 women in the placebo group (33.6/1000 women per year) (relative hazard [RH], 0.99; 95% confidence interval [CI], 0.80-1.22) (Table 2). These primary events were composed of CHD deaths (RH, 1.24; 95% CI, 0.87-1.75) and nonfatal MIs (RH, 0.91; 95% CI, 0.71-1.17). None of these differences was statistically significant. The 71 CHD deaths in the hormone group and the 58 CHD deaths in the placebo group were distributed, respectively, as follows: sudden death within 1 hour of onset of symptoms, 19 and 20; myocardial infarction, 19 and 16; congestive heart failure, 9 and 6; coronary artery bypass graft surgery, 5 and 2; and other CHD death, 19 and 14.

Survival curves for the primary CHD outcome and its components (Figure 3) correspond with the findings in Table 2. The curves for CHD death diverged during the second year of observation. The curves for nonfatal MI diverged during the first year, then converged and crossed during the third year. This possible change in the RH with time since randomization is further examined in Table 3. The point estimates for the primary outcome in the hormone group compared with the placebo group are 1.32 in year 1, 1.90 in year 2, 0.87 in year 3, and 0.67 in years 4 and 5 (P = .009 for trend in log RH) within the first year; the RH was 2.30 for the first 4 months, 1.46 for the second 4 months, and 1.18 for the third 4 months (P = .33 for trend). The difference over time was most pronounced for the nonfatal MI component of the primary CHD outcome (Table 3 and Figure 3).

In an as-treated analysis limited to women who had been at least 80% compliant with study medication by pill count, the RH comparing the primary CHD outcome in the hormone and placebo groups was 0.87 (95% CI, 0.67-1.11), lower than the intention-to-treat analysis but not statistically significant. For women who stopped taking HERS medications, risk of primary CHD events was elevated in the...
groups in any of the other cardiovascular outcomes that we evaluated (Table 2). The survival curve for time to first occurrence of any coronary revascularization procedure or hospitalization for definite unstable angina (Figure 4) appeared to diverge, with lower rates in the hormone-treated group, although this difference did not achieve statistical significance (RH, 0.89; P = .15).

**Plasma Lipids**

By the end of the first year of treatment, mean LDL cholesterol levels had decreased by 14% from baseline to a level of 3.23 mmol/L (125 mg/dL) in the hormone group and by 3% to 3.62 mmol/L (140 mg/dL) in the placebo group (P < .001 for difference between groups) (Figure 5). During the same period, mean HDL cholesterol levels had increased by 8% to 1.40 mmol/L (54 mg/dL) in the hormone group and decreased by 2% to 1.27 mmol/L (49 mg/dL) in the placebo group (p < .001). Mean triglyceride levels had increased by 10% to 2.04 mmol/L (181 mg/dL) in the hormone group and by 2% to 1.93 (170 mg/dL) in the placebo group (P < .001).

In proportional hazards analysis, high LDL cholesterol and low HDL cholesterol levels at baseline predicted subsequent primary CHD events in both univariate and multivariate (controlling for other baseline risk factors) models, but high triglyceride levels predicted primary CHD events only in univariate analyses. Changes in LDL cholesterol, HDL cholesterol, and triglyceride levels over the first year of the study were not significantly associated with subsequent primary CHD events, but the point estimates were in the expected direction and there was limited power to examine this effect.

More women in the placebo group than in the hormone group began treatment with lipid-lowering drugs, primarily statins, during the trial (22% vs 18%; P = .004), probably because the higher LDL cholesterol levels in placebo-treated women compared with hormone-treated women were noted by the women’s personal physicians. Adjustment for this difference using regression analysis did not substantially change the overall estimate of the between-group difference in risk of primary CHD events (RH, 0.94; 95% CI, 0.76-1.17).

**Other Secondary Outcomes**

Cancer deaths and other deaths were nearly identical in the 2 study groups. Total mortality in the hormone group was not significantly different from that in the placebo group (131 vs 123 women; RH, 1.08; 95% CI, 0.84-1.38) (Table 4; Figure 6).

Confirmed venous thromboembolic events occurred in 34 women in the hormone group (6.3/1000 woman-years) and...
in 12 women in the placebo group (2.2/1000 woman-years) (RH, 2.89; 95% CI, 1.50-5.58; \( P = .002 \)) (Table 4). More women in the hormone group experienced deep vein thromboses (25 vs 8; \( P = .004 \)) and pulmonary emboli (11 vs 4; \( P = .08 \)); 2 of the pulmonary emboli, both in the hormone group, were fatal. The RH in the hormone group relative to the placebo group remained elevated over the 4 years of observation but declined somewhat during the study (Table 3).

Gallbladder disease occurred in 84 women in the hormone group and in 62 women in the placebo group (RH, 1.38; 95% CI, 1.00-1.92). Gallbladder surgery accounted for 89% of these events, and the rest were symptomatic cholelithiasis. None of the gallbladder events was fatal.

There were no significant differences between the treatment groups in the rates of breast cancer, endometrial cancer, other cancers, or fracture (Table 4).

**COMMENT**

In this clinical trial, postmenopausal women younger than 80 years with established coronary disease who received estrogen plus progestin did not experience a reduction in overall risk of nonfatal MI and CHD death or of other cardiovascular outcomes. How can this finding be reconciled with the large body of evidence from observational and pathophysiologic studies suggesting that estrogen therapy reduces risk for CHD?

**Contrast With Findings of Observational Studies**

Observational studies may be misleading because women who take postmenopausal hormones tend to have a better CHD risk profile\(^1\,2\) and to obtain more preventive care\(^1\,4\) than nonusers. The consistency of the apparent benefit in the observational studies could simply be attributable to the consistency of this selection bias. The lower rate of CHD in hormone users compared with nonusers persists after statistical adjustment for differences in CHD risk factors,\(^5\) but differences in unmeasured factors remain a possible explanation.

The discrepancy between the findings of HERS and the observational studies may also reflect important differences between the study populations and treatments. Most of the observational studies of postmenopausal hormone therapy enrolled postmenopausal women who were relatively young and healthy and who took unopposed estrogen.\(^1\,4\,5\) In contrast, participants in HERS were older, had coronary disease at the outset, and were treated with estrogen plus progestin. However, some observational studies did examine women with prior CHD, and all of these reported a beneficial association with postmenopausal hormone therapy.\(^6\,12\) Similarly, some observational studies did examine the effect of postmenopausal estrogen plus progestin therapy on CHD risk in women, and these generally reported a lower rate of CHD events in hormone users that is similar to that reported for estrogen alone\(^4\,5\,22\). However, details in these studies about the specific progestin formulations and dosing regimens used are limited.

**Possible Adverse Effects of Medroxyprogesterone Acetate**

Several potential mechanisms whereby estrogen therapy might reduce risk for CHD have been proposed, including fa-
Table 4.—Death and Secondary Noncardiovascular Outcomes by Treatment Group

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Estrogen-Progestin (n=1380)</th>
<th>Placebo (n=1383)</th>
<th>RH (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHD death</td>
<td>71</td>
<td>58</td>
<td>1.24 (0.87-1.75)</td>
<td>.23</td>
</tr>
<tr>
<td>Cancer death</td>
<td>19</td>
<td>24</td>
<td>0.80 (0.44-1.46)</td>
<td>.47</td>
</tr>
<tr>
<td>Non-CHD, noncancer death</td>
<td>37</td>
<td>36</td>
<td>1.04 (0.66-1.64)</td>
<td>.87</td>
</tr>
<tr>
<td>Un adjudicated death</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total deaths</td>
<td>131</td>
<td>123</td>
<td>1.08 (0.84-1.36)</td>
<td>.56</td>
</tr>
<tr>
<td>Venous thromboembolic event</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>25</td>
<td>8</td>
<td>3.18 (1.43-7.04)</td>
<td>.004</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>11</td>
<td>4</td>
<td>2.79 (0.89-8.75)</td>
<td>.08</td>
</tr>
<tr>
<td>Any thromboembolic event</td>
<td>34</td>
<td>12</td>
<td>2.89 (1.50-5.58)</td>
<td>.002</td>
</tr>
<tr>
<td>Cancer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breast</td>
<td>32</td>
<td>25</td>
<td>1.30 (0.77-2.19)</td>
<td>.33</td>
</tr>
<tr>
<td>Endometrial</td>
<td>2</td>
<td>4</td>
<td>0.49 (0.09-2.68)</td>
<td>.41</td>
</tr>
<tr>
<td>Other</td>
<td>63</td>
<td>58</td>
<td>1.10 (0.77-1.57)</td>
<td>.60</td>
</tr>
<tr>
<td>Any cancer</td>
<td>96</td>
<td>87</td>
<td>1.12 (0.84-1.50)</td>
<td>.44</td>
</tr>
<tr>
<td>Fracture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td>12</td>
<td>11</td>
<td>1.10 (0.49-2.50)</td>
<td>.82</td>
</tr>
<tr>
<td>Other</td>
<td>119</td>
<td>129</td>
<td>0.93 (0.73-1.20)</td>
<td>.59</td>
</tr>
<tr>
<td>Any fracture</td>
<td>130</td>
<td>138</td>
<td>0.95 (0.75-1.21)</td>
<td>.70</td>
</tr>
<tr>
<td>Gallbladder disease</td>
<td>84</td>
<td>62</td>
<td>1.38 (1.00-1.92)</td>
<td>.05</td>
</tr>
</tbody>
</table>

*RH indicates relative hazard; CI, confidence interval; and CHD, coronary heart disease. Each row represents the number of women with the designated event; women with more than 1 type of event may appear in more than 1 row.

Viable effects on lipoproteins, coronary atherosclerosis, endothelial function, and arterial thrombosis.\(^{30,31}\) Progestins downregulate estrogen receptors and may also have direct, progestin receptor–mediated effects that oppose these actions of estrogen.\(^{31}\) Medroxyprogesterone acetate may do this to a greater extent than other progestins. In the Postmenopausal Estrogen-Progestin Interventions Trial, medroxyprogesterone acetate blunted the estrogen-associated increase in HDL cholesterol substantially more than did micronized progesterone.\(^{44}\) Oral medroxyprogesterone acetate appears to significantly attenuate the beneficial effects of estrogen on coronary atherosclerosis in nonhuman primates,\(^{32}\) while subcutaneous progesterone does not.\(^{31}\) Animal data also suggest that medroxyprogesterone acetate may inhibit the beneficial effects of estrogen on endothelial-dependent vasodilation,\(^{44}\) but this has not been documented in women.\(^{31}\) Despite these mechanistic data suggesting an adverse effect of medroxyprogesterone acetate, observational studies show a similar reduction in CHD risk in women using medroxyprogesterone acetate plus estrogen as in women taking unopposed estrogen.\(^{4}\)

Possible Differences in the Effects of Therapy Over Time

When the results were examined by year since randomization, the estrogen plus progestin regimen appeared to increase risk for primary CHD events in the first year of therapy but to decrease risk in subsequent years. This time trend should be interpreted with caution. It could simply represent random variation, although the level of statistical significance makes this unlikely. More importantly, between-group contrasts that exclude the first several years are not true randomized comparisons, as the remaining study groups may no longer be comparable if, for example, treatment has caused high-risk individuals to have events early in the study.

On the other hand, the time trend is biologically plausible. The early increase in risk for CHD events might be attributable to an immediate prothrombotic, proarrhythmic, or proischemic effect of treatment that is gradually outweighed by a beneficial effect on the underlying progression of atherosclerosis, perhaps as a result of beneficial changes in lipoproteins. In trials of lipid interventions, the delay before CHD risk is reduced has ranged from 0 to 2 years.\(^{36,41}\) After a lag period, the 11% net reduction in LDL cholesterol and 10% net increase in HDL cholesterol observed in the hormone group would be expected to reduce the risk of CHD events\(^{42}\) and may account for the trend toward a late benefit observed in HERS.

A pattern of early harm and later benefit could account for part of the discrepancy between the results of this trial and observational studies of estrogen and CHD. Attrition of susceptible individuals soon after starting estrogen replacement could increase the prevalence of survivors available for inclusion in observational studies; most observational studies are not designed to observe the onset of therapy or to detect an early adverse effect.

Previous Clinical Trial Evidence

The CHD data from previous hormone trials in women have been summarized\(^{43}\) but are of limited value because the studies were small, short term, and not designed to examine CHD as an outcome. The only large prior trial of estrogen therapy to prevent CHD events was the Coronary Drug Project, which studied very high doses of estrogen (5.0 mg or 2.5 mg of conjugated equine estrogen daily) in men with preexisting CHD. The estrogen arms of this trial were stopped early because of an excess of MIIs, thromboembolic events, and estrogenic symptoms in the 5.0-mg/d group\(^{44}\) and the lack of benefit on the CHD end point and estrogenic symptoms in the 2.5-mg/d group.\(^{45}\) The relevance of this trial of high-dose estrogen in men to postmenopausal hormone therapy in women is uncertain.

Safety and Other Noncardiovascular Outcomes

Venous thromboembolic events were 3 times more common in the hormone group than in the placebo group. Recent observational studies have reported similar relative risks for idiopathic venous thromboembolism among users of both unopposed estrogen\(^{46-49}\) and estrogen plus progestin therapy.\(^{7,49}\) The excess incidence of venous thrombotic events in HERS was 4.1 per 1000 woman-years of observation, an order of magnitude higher than the excess reported in the observational studies; the higher rate is probably a consequence of the facts that women enrolled in HERS were older and had multiple risk factors for venous thrombosis and that only idiopathic events were counted in the observational studies.

We found an increased risk of gallbladder disease in the hormone group that is
likely attributable to the estrogen therapy. Metabolic studies indicate that estrogen enhances hepatic lipoprotein uptake and inhibits bile acid synthesis, resulting in increased biliary cholesterol and cholelithiasis.\(^5\)

Observational studies have suggested that therapy with postmenopausal estrogen for 5 years or less is not associated with an increased risk of breast cancer but that longer duration of therapy might be associated with a small increase in risk.\(^6\) The HERS trial was not large enough and therapy did not continue for long enough to address this issue. The incidence of fractures in the hormone group was only slightly lower than in the placebo group. Wide CIs around the fracture risk estimates reveal inadequate statistical power and do not exclude a reduction in risk of hip fracture of as much as 27%.\(^7\) The HERS trial was not large enough and therapy did not continue for the fracture risk estimates revealed inad- equate statistical power and do not exclude a reduction in risk of hip fracture of as much as 51% or a reduction in risk of other fracture of as much as 27%\(^8\).

**Strengths and Limitations of the Trial**

The CHD risk factor profile of women enrolled in HERS is similar to that of a random sample of US women with prob- able heart disease, suggesting that the findings of HERS may be generalized to that population.\(^9\) However, HERS did not evaluate the effect of estrogen plus progestin therapy in women without CHD, and it is not known whether our findings apply to healthy women. It is also not known whether use of a different progestin or of estrogen alone would have been beneficial.

HERS exceeded the recruitment goal by 18%, carried out a successful randomization, collected objective, blindly adju- dicated disease outcome data, and achieved 100% vital status ascertainment. Compliance with hormone treatment, while lower than projected, was sufficient to produce LDL and HDL cholesterol changes that compare favorably with previous studies.\(^10\) The 95% CIs for the effect of treatment assignment on primary CHD events (RH 0.99; 95% CI 0.80-1.22) make it unlikely that HERS missed a benefit of more than 20% for the overall 4.1-year period of observation. However, this statistic does not address the possible late benefit of treatment suggested by the time trend analysis, which is plausible based on the finding of a 1- to 2-year lag period observed in lipid trials;\(^11\) a longer study would be more definitive for investigating this possibility.

**Future Directions**

HERS is the first large trial of the effect of postmenopausal estrogen plus progestin therapy on risk for CHD events. The findings differ from those of observational studies and studies with surrogate outcomes, emphasizing the importance of basing treatment policies on randomized controlled trials.\(^12\) Other randomized trials of postmenopausal hormone therapy are likely to answer some of the questions raised by HERS. The Women’s Health Initiative Randomized Trial\(^13\) includes a group of women who have undergone hysterectomy and receive unopposed estrogen as well as women with intact uteri who receive the same estrogen plus progestin regi- men used in HERS. Participants are not required to have CHD and are generally younger than the HERS cohort. The Women’s Health Initiative Randomized Trial plans to enroll 27,500 women and to report the results in 2005 after 9 years of treatment. Further information will also emerge from HERS as we continue dis- ease event surveillance.

Several interventions have been proven to reduce risk for CHD events in patients with coronary disease, including aspirin, β-blockers, lipid lowering, and smoking cessation.\(^14\) The need for encouraging these interventions for women with coronary disease is illustrated by the facts that 90% of the HERS cohort had LDL cholesterol exceeding 2.59 mmol/L (100 mg/dL) at baseline and that only 32% were receiving β-blockers.

**Conclusions**

First, in the population studied in HERS, ie, postmenopausal women with established coronary disease and an aver- age age of 66.7 years, daily use of con- jugated equine estrogens and medroxy- progesterone acetate did not reduce the overall risk for MI and CHD death or any other cardiovascular outcome during an average of 4.1 years of follow-up. This therapy did increase the risk of ve- nous thromboembolic events and gall- bladder disease.

Second, we did not evaluate the car- diovascular effect of treatment with un- opposed estrogen, commonly used in women who have had a hysterectomy, or other estrogen plus progestin formulations. We also did not study women without coronary disease.

Third, based on the finding of no over- all cardiovascular benefit and a pattern of early increase in risk of CHD events, we do not recommend starting this treat- ment for the purpose of secondary pre- vention of CHD. However, given the fa- vorable pattern of CHD events after several years of therapy, it could be ap- propriate for women already receiving hormone treatment to continue. Ex- ceeding follow-up of the HERS cohort and additional randomized trials are needed to clarify the cardiovascular effects of postmenopausal hormone therapy.

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