Randomized, Placebo-Controlled Trial of Dalteparin for the Prevention of Venous Thromboembolism in Acutely Ill Medical Patients

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Background—Considerable variability exists in the use of pharmacological thromboprophylaxis among acutely ill medical patients, partly because clinically relevant end points have not been fully assessed in this population. We undertook an international, multicenter, randomized, double-blind, placebo-controlled trial using clinically important outcomes to assess the efficacy and safety of dalteparin in the prevention of venous thromboembolism in such patients.

Methods and Results—Patients (n=3706) were randomly assigned to receive either subcutaneous dalteparin 5000 IU daily or placebo for 14 days and were followed up for 90 days. The primary end point was venous thromboembolism, defined as the combination of symptomatic deep vein thrombosis, symptomatic pulmonary embolism, and asymptomatic proximal deep vein thrombosis detected by compression ultrasound at day 21 and sudden death by day 21. The incidence of venous thromboembolism was reduced from 4.96% (73 of 1473 patients) in the placebo group to 2.77% (42 of 1518 patients) in the dalteparin group, an absolute risk reduction of 2.19% or a relative risk reduction of 45% (relative risk, 0.55; 95% CI, 0.38 to 0.80; \( P = 0.0015 \)). The observed benefit was maintained at 90 days. The overall incidence of major bleeding was low but higher in the dalteparin group (9 patients; 0.49%) compared with the placebo group (3 patients; 0.16%).

Conclusions—Dalteparin 5000 IU once daily halved the rate of venous thromboembolism with a low risk of bleeding.

Key Words: anticoagulants ■ embolism ■ heparin ■ prevention ■ thrombosis

Venous thromboembolism is a major cause of morbidity and mortality1–6 in hospitalized patients, including those with acute medical illnesses.7,8 Approximately 75% of venous thromboemboli occur among these acutely ill nonsurgical patients. Nevertheless, thromboprophylaxis use in medical patients is not universally accepted or adopted, even though medical patients are at risk for venous thromboembolism.9–12 Additionally, even when prophylaxis is used, it may be inadequate to prevent venous thromboembolism.13,14 Current guidelines for the prevention of venous thromboembolism in medical patients are based mostly on a reduction in asymptomatic isolated calf vein thrombosis detected by venography.15 This has resulted in inconsistent recommendations and variable interpretation and application of guidelines.16,17 Thus, there was a need for a further placebo-controlled study to examine the effect of thromboprophylaxis on clinically relevant end points using compression ultrasonography to screen all patients at a suitably early time point. The Prospective Evaluation of Dalteparin Efficacy for Prevention of VTE in Immobilized Patients Trial (PREVENT) was designed to examine the efficacy and safety of the low-molecular-weight heparin dalteparin in the prevention of clinically important venous thromboembolic events in medical patients.

Methods

PREVENT was a randomized, double-blind, placebo-controlled, multicenter, multinational trial. The study methodology has been described previously in detail.18

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In memory of Amiram Eldor, Tel-Aviv, Israel.

*A complete list of the PREVENT Study Investigators appears in the Appendix.

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TABLE 1. Patient Randomization and Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Dalteparin, n (%)</th>
<th>Placebo, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomized</td>
<td>1856 (100)</td>
<td>1850 (100)</td>
</tr>
<tr>
<td>Patients receiving ≥1 dose of study drug</td>
<td>1848 (99.6)</td>
<td>1833 (99.1)</td>
</tr>
<tr>
<td>Patients included in primary analysis</td>
<td>1518 (81.7)</td>
<td>1473 (79.7)</td>
</tr>
<tr>
<td>Patients not included in primary analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compression ultrasonography not evaluable</td>
<td>155 (8.4)</td>
<td>172 (9.4)</td>
</tr>
<tr>
<td>Compression ultrasonography not performed (death, adverse events, protocol violation, protocol-specific withdrawal criteria, consent withdrawn, lost to follow-up)</td>
<td>175 (9.5)</td>
<td>188 (10.3)</td>
</tr>
<tr>
<td>Patients evaluable for venous thromboembolism at day 90</td>
<td>1615 (87.0)</td>
<td>1583 (85.6)</td>
</tr>
</tbody>
</table>

Study Population

Patients were considered for inclusion if they were ≥40 years of age with an acute medical condition requiring a projected hospitalization of ≥4 days and had ≥3 days of prior immobilization.

Inclusion criteria were acute congestive heart failure, acute respiratory failure that did not require ventilatory support, infection without septic shock, acute rheumatologic disorders, or inflammatory bowel disease. Except for congestive heart or acute respiratory failure, patients had to have ≥1 additional risk factors for venous thromboembolism: age ≥75 years, cancer, previous venous thromboembolism, obesity, varicose veins and/or chronic venous insufficiency, hormone replacement therapy, history of chronic heart failure, chronic respiratory failure, or myeloproliferative syndrome. Patients were ineligible if they had acute coronary syndrome within the previous month, a major surgical or invasive procedure performed in the previous month or to be undertaken within the next 2 weeks, bacterial endocarditis, immobilized lower limb because of a cast or fracture, stroke within 3 months, high risk of bleeding, a platelet count <100×10^9/L, hepatic failure, myeloproliferative syndrome, or myelodysplastic syndrome.

Risk factors, n (%)<br>
- Age ≥75 y: 611 (33.1) vs 615 (33.6)<br>- Cancer: 85 (4.6) vs 105 (5.7)<br>- Previous deep vein thrombosis or pulmonary embolism: 62 (3.4) vs 80 (4.4)<br>- Obesity: 558 (30.2) vs 560 (30.6)<br>- Varicose veins: 487 (26.4) vs 530 (28.9)<br>- Hormone therapy: 33 (1.8) vs 30 (1.6)<br>- Chronic heart failure: 925 (50.1) vs 946 (51.6)<br>- Myeloproliferative syndrome: 5 (0.3) vs 9 (0.5)<br>- Chronic respiratory failure: 176 (9.5) vs 183 (10.0)<br

BMI indicates body mass index.

*Patients could have >1 reason for inclusion.

Secondary end points were all-cause mortality by days 14, 21, and 90; objectively verified symptomatic deep vein thrombosis or asymptomatic proximal deep vein thrombosis on day 21; major and minor bleeding, drug-related allergic reactions, and thrombocytopenia by day 21; and symptomatic venous thromboembolism at day 90. Bleeding and thrombocytopenia were assessed at days 21 and 14 to capture events that may have been occult during the treatment period and whose recognition may have been delayed.

Symptomatic venous thromboembolism required confirmation by objective imaging or autopsy. Patients who did not have a confirmed symptomatic venous thromboembolism underwent compression ultrasonography between days 21 and 24. All examinations were videotaped and sent to a central reading facility.

Safety outcomes included death, hemorrhage, thrombocytopenia, and all suspected drug-related adverse reactions.

Bleeding was classified as major if it was intraocular, spinal, epidural, intracranial, or retroperitoneal; if hemoglobin decreased by ≥2 g/dL; if transfusion of ≥2 U of blood or significant medical or surgical intervention was required; or if it resulted in death. All other bleeding was classified as minor.

All clinical end points were centrally adjudicated by a blinded Clinical Events Committee.

Statistical Analysis

Assuming an incidence of clinically relevant venous thromboembolism and sudden death at day 21 of 8% in the placebo group and hypothesizing a 50% reduction in the dalteparin group, 1471 patients were needed in each treatment group for 90% power to detect a difference at α=0.001. To compensate for nonevaluable patients, we planned to enroll 1650 patients per treatment group. The primary analysis was based on the adjudicated events.
The primary end point was analyzed on the intention-to-treat population with observed cases using a Cochran-Mantel-Haenszel test stratified by geographic region. The Breslow-Day test was used to test for homogeneity of strata. Randomized patients who had a documented clinical end point or an evaluable compression ultrasonography examination by day 21 were included in the primary end-point analysis. However, the entire enrolled cohort was eligible for evaluation of symptomatic secondary end points. Patients who received dose of study drug were included in the safety analysis. An independent data-monitoring committee performed periodic safety reviews.

Results

Study Population
Between July 2001 and April 2002, 3706 patients were enrolled at 219 study centers in 26 countries. Eight patients randomized in the dalteparin group and 17 in the placebo group did not receive study medication. Patients were also excluded from the primary end-point analysis if the compression ultrasound examination at day 21 was either not evaluable (155 and 172 patients in the dalteparin and placebo groups, respectively) or not performed (175 and 188 patients in the dalteparin and placebo groups, respectively). Thus, 1518 and 1473 patients in the dalteparin and placebo groups, respectively, were assessed for the primary end point (Table 1). The mean number of injections was 12.6 in both patient groups, indicating a high degree of compliance with the intended regimen.

Patient Characteristics
Baseline characteristics were similar in both groups (Table 2). One third of patients were years of age. Patients were discharged from hospital at a median of 13 days after randomization in both groups. The median duration of treatment of 14 days did not differ between groups.

Thromboembolic Events
The incidence of the primary end point was 2.77% (42 of 1518 patients) in the dalteparin group and 4.96% (73 of 1473 patients) in the placebo group, a risk reduction of 45% (relative risk, 0.55; 95% CI, 0.38 to 0.80; \( P = 0.0015 \); Table 3).

By day 90, the incidence of symptomatic venous thromboembolism was 0.93% in the dalteparin group and 1.33% in the placebo group, a relative risk reduction of 30% (relative risk, 0.70; 95% CI, 0.36 to 1.35; Table 3).

Dalteparin reduced the rate of venous thromboembolism in all major subgroups (the Figure).

### TABLE 3. Venous Thromboembolic Events

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Dalteparin, n/N (%)</th>
<th>Placebo, n/N (%)</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venous thromboembolism and sudden death</td>
<td>42/1518 (2.77)</td>
<td>73/1473 (4.96)</td>
<td>0.55 (0.38–0.80)</td>
</tr>
<tr>
<td>Sudden death</td>
<td>5/1829 (0.27)</td>
<td>3/1807 (0.17)</td>
<td>1.65 (⋯)</td>
</tr>
<tr>
<td>Pulmonary embolism, fatal</td>
<td>0/1829 (0.00)</td>
<td>2/1807 (0.11)</td>
<td>0.00 (⋯)</td>
</tr>
<tr>
<td>Pulmonary embolism, symptomatic</td>
<td>5/1759 (0.28)</td>
<td>4/1740 (0.23)</td>
<td>1.22 (⋯)</td>
</tr>
<tr>
<td>Deep vein thrombosis: distal, symptomatic</td>
<td>3/1759 (0.17)</td>
<td>4/1739 (0.23)</td>
<td>0.74 (⋯)</td>
</tr>
<tr>
<td>Deep vein thrombosis: proximal, symptomatic</td>
<td>2/1759 (0.11)</td>
<td>7/1739 (0.40)</td>
<td>0.28 (⋯)</td>
</tr>
<tr>
<td>Deep vein thrombosis: proximal, asymptomatic</td>
<td>27/1507 (1.79)</td>
<td>53/1453 (3.65)</td>
<td>0.48 (0.31–0.77)</td>
</tr>
<tr>
<td>Secondary end point at day 14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All-cause mortality</td>
<td>8/1846 (0.43)</td>
<td>7/1831 (0.38)</td>
<td>1.13 (0.41–3.12)</td>
</tr>
<tr>
<td>Secondary end point at day 21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep vein thrombosis: proximal and symptomatic distal</td>
<td>32/1508 (2.12)</td>
<td>64/1464 (4.37)</td>
<td>0.49 (0.32–0.74)</td>
</tr>
<tr>
<td>All-cause mortality</td>
<td>43/1829 (2.35)</td>
<td>42/1807 (2.32)</td>
<td>1.01 (0.66–1.54)</td>
</tr>
<tr>
<td>Secondary endpoint at day 90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptomatic venous thromboembolism (all deep vein thrombosis and pulmonary embolism)</td>
<td>15/1615 (0.93)</td>
<td>21/1583 (1.33)</td>
<td>0.70 (0.36–1.35)</td>
</tr>
<tr>
<td>All symptomatic pulmonary embolism</td>
<td>5/1615 (0.31)</td>
<td>6/1583 (0.38)</td>
<td>0.82 (0.25–2.67)</td>
</tr>
<tr>
<td>All symptomatic deep vein thrombosis</td>
<td>10/1614 (0.62)</td>
<td>15/1579 (0.95)</td>
<td>0.65 (0.29–1.45)</td>
</tr>
<tr>
<td>All-cause mortality</td>
<td>107/1747 (6.12)</td>
<td>103/1715 (6.01)</td>
<td>1.02 (0.78–1.33)</td>
</tr>
</tbody>
</table>

RR indicates relative risk. Only 1 event per patient (most severe) was recorded. 95% CIs were not produced if <5 patients in either treatment group experienced an event.
There was no significant difference in mortality at 14, 21, or 90 days (Table 4). By day 90, 210 patients had died, 107 (6.12%) in the dalteparin group and 103 (6.01%) in the placebo group. By day 21, major bleeding had occurred in 12 patients, 9 (0.49%) receiving dalteparin and 3 (0.16%) receiving placebo ($P=0.15$; Fisher’s exact test; Table 4). Two patients in the dalteparin group and 1 in the placebo group died of hemorrhage. The proportion of patients reporting ≥1 adverse events was similar in both treatment groups (39.7% and 39.8% in the dalteparin and placebo groups, respectively).

**Discussion**

Thromboprophylaxis with dalteparin resulted in a 45% reduction ($P=0.0015$) in the primary end point, a composite of venous thromboembolism and sudden death at day 21. Overall, thromboprophylaxis with dalteparin for 14 days resulted in the prevention of 22 events per 1000 patients treated. This benefit was observed in a broad population of medical patients and was achieved with a low risk of major bleeding.

This study provides added evidence of the benefits of thromboprophylaxis with low-molecular-weight heparin in medical patients. MEDENOX showed a reduction in asymptomatic venous thrombosis, driven largely by venographically detected distal vein thromboses. However, the clinical relevance of distal deep vein thrombosis is uncertain. Thromboprophylactic studies performed in patients undergoing surgery have established that low-molecular-weight heparins reduce asymptomatic deep vein thrombosis and pulmonary embolism. In contrast, available evidence for implementing routine prophylaxis of venous thromboembolism in acutely ill medical patients is sparse, and this strategy has not been universally accepted. Both symptomatic proximal or calf deep vein thrombosis and asymptomatic proximal deep vein thrombosis are widely accepted as clinically relevant. Symptomatic and asymptomatic proximal deep vein thromboses are closely linked to the risk of pulmonary embolism.

The population enrolled in PREVENT was a lower-risk population than that reported in MEDENOX in terms of venous thromboembolism and mortality. In MEDENOX, the overall rate of venous thromboembolism was attributed mostly to asymptomatic distal deep vein thrombi, an end point not included in PREVENT because of its uncertain clinical relevance. If we limit the comparison to examining similar events, the overall risk in PREVENT was still somewhat lower than in MEDENOX. Proximal deep vein thrombosis occurred in 4.9% of MEDENOX placebo patients and 3.7% of PREVENT placebo patients. The overall mortality at 90 days was 13.9% in MEDENOX placebo patients and 6.01% in PREVENT placebo patients. Whereas MEDENOX established that a low-molecular-weight heparin may be beneficial in a higher-risk medical population, PREVENT has extended this observation to a lower-risk population and therefore should encourage more widespread application of thromboprophylaxis in an even broader medical population.

This study differs from previous studies of thromboprophylaxis in medical patients in that compression ultrasonography was used to assess efficacy. Compression ultrasonography was used as the diagnostic technique because this noninvasive approach has in many countries almost completely supplanted contrast venography in clinical practice.

### Safety Outcomes

There was no significant difference in mortality at 14, 21, or 90 days (Table 4). By day 90, 210 patients had died, 107 (6.12%) in the dalteparin group and 103 (6.01%) in the placebo group. By day 21, major bleeding had occurred in 12 patients, 9 (0.49%) receiving dalteparin and 3 (0.16%) receiving placebo ($P=0.15$; Fisher’s exact test; Table 4). Two patients in the dalteparin group and 1 in the placebo group died of hemorrhage. The proportion of patients reporting ≥1 adverse events was similar in both treatment groups (39.7% and 39.8% in the dalteparin and placebo groups, respectively).

### Table 4. Adverse Events (Safety Population)

<table>
<thead>
<tr>
<th>Event</th>
<th>Dalteparin, n (%)</th>
<th>Placebo, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mortality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 14</td>
<td>8 (0.43)</td>
<td>7 (0.38)</td>
</tr>
<tr>
<td>Day 21</td>
<td>43 (2.35)</td>
<td>42 (2.32)</td>
</tr>
<tr>
<td>Day 90</td>
<td>107 (6.12)</td>
<td>103 (6.01)</td>
</tr>
<tr>
<td><strong>Hemorrhage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatal, day 21</td>
<td>2 (0.11)</td>
<td>1 (0.05)</td>
</tr>
<tr>
<td>Major, day 14</td>
<td>8 (0.43)</td>
<td>0 (0.00)</td>
</tr>
<tr>
<td>Major, day 21</td>
<td>9 (0.49)</td>
<td>3 (0.16)</td>
</tr>
<tr>
<td>Minor, day 14</td>
<td>16 (0.87)</td>
<td>5 (0.27)</td>
</tr>
<tr>
<td>Minor, day 21</td>
<td>19 (1.03)</td>
<td>10 (0.55)</td>
</tr>
<tr>
<td><strong>Thrombocytopenia</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 14</td>
<td>10 (0.54)</td>
<td>6 (0.33)</td>
</tr>
<tr>
<td>Day 21</td>
<td>10 (0.54)</td>
<td>8 (0.44)</td>
</tr>
</tbody>
</table>
Central adjudication of videotaped results limited the impact of interinvestigator differences. We found no difference between treatment groups in total mortality, but the study was not designed or powered to show a mortality difference. This is in agreement with previous similar studies, which did not establish a significant effect of low-molecular-weight heparins on total mortality. Most deaths were due to underlying medical conditions, and the causes of death were similar in both groups.

In summary, this large, randomized controlled trial of thromboprophylaxis in medically ill patients showed that dalteparin 5000 IU daily reduced clinically important venous thromboembolism with a low risk of bleeding. This benefit was seen in medical patients with identifiable risk factors for venous thromboembolism. These findings should encourage routine thromboprophylaxis of medically ill patients who are hospitalized for ≥4 days and lower the incidence of venous thromboembolism in this large group of patients, resulting in improved clinical outcomes.

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