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Short Report: Treatment

Effects of rosuvastatin and atorvastatin on glycaemic control in Type 2 diabetes—the CORALL study

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Abstract

Aims To examine whether high-dose statin therapy in Dutch European patients with Type 2 diabetes and dyslipidaemia influenced variables of glycaemic control.

Methods The CORALL study, which was a 24-week, open-label, randomized, parallel-group, phase IIIb, multi-centre study, was designed to compare the cholesterol-lowering effects of rosuvastatin compared with atorvastatin in patients with Type 2 diabetes. Fasting plasma glucose levels and HbA1c levels were collected at baseline and at 6 and 18 weeks.

Results Treatment with the highest dose of statins, i.e. atorvastatin 80 mg and rosuvastatin 40 mg at 18 weeks from baseline, was associated with increase in HbA1c levels; baseline 5.7 ± 1.1 mmol/l (7.4 ± 1.0%) to 6.1 ± 1.4 mmol/mol (7.7 ± 1.3%) (range 5.0–11.9) for atorvastatin (P = 0.003) and from baseline 6.0 ± 1.1 mmol/mol (7.6 ± 1.0%) to 6.3 ± 1.3 mmol/mol (7.9 ± 1.2%) (range 5.7–12.3) for rosuvastatin (P < 0.001). Mean fasting plasma glucose increased from baseline 8.7 ± 2.4 mmol/l to 9.5 ± 3.0 mmol/l upon treatment with atorvastatin 20 mg (P = 0.002) and 9.0 ± 3.0 mmol/l after treatment with 80 mg (not significant compared with baseline). The mean fasting plasma glucose did not change after treatment with rosuvastatin (9.1 ± 2.7 mmol/l at baseline, 8.9 ± 2.7 mmol/l with 10 mg, 9.4 ± 2.9 mmol/l with 40 mg).

Conclusions Glycaemic control deteriorated in patients with diabetes following high-dose statin therapy. Future controlled studies are needed to verify these findings and, if confirmed, determine whether such changes represent a true decline in glycaemic control. Presently, it appears that, based on the overwhelming prospective trial data available, the preventive effect of statin therapy supersedes that of the slight increase in HbA1c.

Keywords advanced glycation end products, diabetes mellitus, HbA1c, statins

Introduction

3-Hydroxyl-3-methylglutaryl-coenzyme A (HMG-CoA) reductase inhibitors (statins) protect against cardiovascular disorders such as coronary heart disease and ischaemic cerebrovascular disease. Several large-scale studies have reported that high-risk patients, for example those with existing cardiovascular disease and Type 2 diabetes mellitus, show a considerable clinical benefit from statin treatment, and clinical guidelines recommend prescription of statins in such patients irrespective of baseline serum cholesterol levels [1–4]. Statins have an acceptable safety and tolerability profile [5].

However, recently a well-conducted meta-analysis of randomized trials reported a 9% higher risk of development of diabetes in statin users compared with placebo (odds ratio 1.09; 95% CI 1.02–1.17) [6]. Furthermore, in a recently published pooled analysis of data from five statin trials, high-dose statin therapy was associated with a 12% more risk of new-onset diabetes compared with moderate-dose statin therapy [7]. High-dose atorvastatin treatment compared with placebo in the Stroke Prevention by Aggressive Reduction in Cholesterol Levels (SPARCL) trial was even associated with a 44% increased risk of new-onset diabetes [8].

Deterioration of glycaemic control has been observed after initiation of atorvastatin therapy in patients with Type 2 diabetes.
diabetes mellitus in Japan [9,10]. In a retrospective study, Takano et al. compared the effect of atorvastatin and pravastatin on glycaemic control in patients with diabetes [9]. HbA1c increased from 51 ± 10 mmol/mol (6.8 ± 0.9%) to 55 ± 12 mmol/mol (7.2 ± 1.1%) (P < 0.001) only in the atorvastatin group after 3 months of treatment. Somewhat similar findings have been observed in a prospective study in people with diabetes as well as those without diabetes [12,13]. One of the mechanisms for the detrimental effects of statins on glucose metabolism, at least of atorvastatin, could be the decreased expression of insulin-sensitive solute carrier family 2 (facilitated glucose transporter), member 4 (SLC2A4, formerly known as GLUT4) [10].

As part of the CORALL study [14], we examined whether 18 weeks of high-dose statin therapy in Dutch European patients with Type 2 diabetes and dyslipidaemia influenced variables of glycaemic control.

**Research design and methods**

The CORALL study was a 24-week, open-label, randomized, parallel-group, phase IIIb, multi-centre study. The first 6 weeks of the study was a dietary lead-in period, after the patients who fulfilled all inclusion criteria and none of the exclusion criteria were randomized to receive either rosuvastatin or atorvastatin. The study was designed to compare the cholesterol-lowering effects of rosuvastatin with atorvastatin in patients with Type 2 diabetes. Subjects were evaluated for efficacy on an intention-to-treat analysis, which contained all randomized subjects with known baseline data. A detailed description of the CORALL study has been previously reported [14]. Four hundred and sixteen subjects with dyslipidaemia and Type 2 diabetes mellitus were enrolled in the study; of those, 263 patients fulfilled the entry criteria and were randomized to either rosuvastatin (n = 131) or atorvastatin (n = 132). The patients were treated with either rosuvastatin 10 mg or atorvastatin 20 mg for 6 weeks, followed by force titration to rosuvastatin 20 mg (if initially on rosuvastatin 10 mg) or atorvastatin 40 mg (if initially on atorvastatin 20 mg) for 6 weeks and, finally, for another 6 weeks, the patients were treated with rosuvastatin 40 mg (if initially on rosuvastatin 20 mg) or atorvastatin 80 mg (if initially on atorvastatin 40 mg). Fasting plasma glucose and HbA1c levels were collected at baseline and at 6 and 18 weeks. HbA1c was measured in a central laboratory by high-performance liquid chromatography (Bio-Rad Variant II Automated Glycosylated Hemoglobin Analyzer; Bio-Rad Laboratories, Hemel Hempstead, UK) with a normal range 26–44 mmol/mol (4.5–6.2%). Plasma glucose levels were analysed by the hospitals’ central laboratories, with normal reference range as measured by high-performance liquid chromatography, and plasma glucose measured by the hexokinase method.

**Statistical analysis**

SPSS version 16.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Data are given as mean ± sd. The statistical analysis of the data was carried out with the paired results obtained at baseline and at 6 weeks and 18 weeks after initiation of rosuvastatin or atorvastatin medication using the Wilcoxon matched-pairs signed-ranks test and repeated measures analysis of variance (ANOVA). P-values below 0.05 were considered statistically significant.

**Results**

Table 1 depicts the baseline characteristics, with typical age, BMI and blood pressure distribution for this population. No significant change in body weight was observed during the study (data not shown). The percentage of patients reaching target LDL cholesterol values of < 2.5 mmol/L (European Atherosclerosis Society guideline) was 77.7, 83.1 and 90.0% with rosuvastatin after 6 weeks (10 mg), 12 weeks (20 mg) and 18 weeks (40 mg), respectively, whereas this goal was reached by 70.5, 80.0 and 87.5% with atorvastatin (40 mg), respectively.

**Table 1** Baseline characteristics of patients

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>Rosuvastatin n = 131</th>
<th>Atorvastatin n = 132</th>
<th>Total n = 263</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (men/women)</td>
<td>59/72</td>
<td>63/69</td>
<td>122/141</td>
</tr>
<tr>
<td>Age (years)</td>
<td>61 ± 9</td>
<td>59 ± 10</td>
<td>60 ± 10</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>31.8 ± 6.1</td>
<td>31.0 ± 6.0</td>
<td>31.4 ± 6.1</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>145 ± 20</td>
<td>148 ± 17</td>
<td>147 ± 19</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>82 ± 8</td>
<td>83 ± 8</td>
<td>83 ± 8</td>
</tr>
<tr>
<td>HbA1c (mmol/mol) (%)</td>
<td>60 ± 11</td>
<td>57 ± 11</td>
<td>58 ± 11</td>
</tr>
<tr>
<td>Mean fasting plasma glucose (mmol/l)</td>
<td>7.6 ± 1.0</td>
<td>7.4 ± 1.0</td>
<td>7.5 ± 1.0</td>
</tr>
<tr>
<td>Diet only</td>
<td>3 (2)</td>
<td>2 (2)</td>
<td>5 (2)</td>
</tr>
<tr>
<td>Oral blood glucose-lowering agents</td>
<td>40 (31)</td>
<td>47 (35)</td>
<td>87 (33)</td>
</tr>
<tr>
<td>Insulin</td>
<td>88 (67)</td>
<td>83 (63)</td>
<td>171 (65)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>79 (60)</td>
<td>86 (65)</td>
<td>165 (63)</td>
</tr>
</tbody>
</table>

Baseline data are mean ± sd or absolute number (%). There were no significant differences between both treatment groups.
Six weeks’ treatment with atorvastatin 20 mg or rosvuastatin 10 mg did not change the HbA1c levels significantly [HbA1c levels of 58 ± 12 mmol/mol (7.5 ± 1.1%) in both treatment groups] as compared with baseline [HbA1c 60 ± 11 mmol/mol (7.6 ± 1.0%) for rosvuastatin and 57 ± 11 mmol/mol (7.4 ± 1.0%) for atorvastatin, respectively] (Fig. 1). However, treatment with the highest dose of statins, i.e. atorvastatin 80 mg and rosvuastatin 40 mg at 18 weeks from baseline was associated with statistically significant increase in HbA1c levels: 61 ± 14 mmol/mol (7.7 ± 1.3%) [range 31–107 mmol/mol (5.0–11.9%)] for atorvastatin (P = 0.003) and 63 ± 13 mmol/mol (7.9 ± 1.2%) [range 39–111 mmol/mol (5.7–12.3%)] for rosvuastatin (P < 0.001), respectively, as compared with baseline (Fig. 1). The change in LDL cholesterol and HbA1c were not related.

Mean fasting plasma glucose increased from baseline 8.7 ± 2.4 to 9.5 ± 3.0 mmol/l upon treatment with atorvastatin 20 mg (P = 0.002) and 9.0 ± 3.0 mmol/l after treatment with 80 mg atorvastatin (not significant compared with baseline). The mean fasting plasma glucose did not change significantly after treatment with rosvuastatin (9.1 ± 2.7 mmol/l at baseline, 8.9 ± 2.7 mmol/l with rosvuastatin 10 mg, 9.4 ± 2.9 mmol/l with rosvuastatin 40 mg).

**Discussion**

Among Dutch Caucasian patients with dyslipidaemia and Type 2 diabetes, we found that (high-dose) statin therapy leads to a small but significant increase of HbA1c levels. Caucasian patients with Type 2 diabetes mellitus have been included in many statin studies, but the effect of statin therapy on glycaemic control has only been scarcely reported. In the Collaborative Atorvastatin Diabetes Study (CARDS) the patients with Type 2 diabetes treated with atorvastatin 10 mg over 4 years had a mean HbA1c of 67 mmol/mol (8.3%) [at baseline 63 ± 15 mmol/mol (7.87 ± 1.42%)] and the patients on placebo had a mean of 65 mmol/mol (8.1%) [at baseline 62 ± 15 mmol/mol (7.81 ± 1.39%)] [1]. These results should be interpreted with care, because the glycaemic control variables refers to only those patients who reached the 4-year point. This might either under- or overstate any effect of atorvastatin on glycaemic control. Although the initial dose of atorvastatin therapy was higher in our study (20 mg), no change in HbA1c levels as compared with baseline was observed. It may be that the relatively short time course (6 weeks) of initial atorvastatin therapy was the reason for the difference with CARDS, although it cannot be excluded that there are dose–response effects. A randomized, double-blind, double-dummy, multi-centre, phase IIIb, parallel-group study to compare the efficacy and safety of rosvuastatin (10 mg and 20 mg) and atorvastatin (10 mg and 20 mg) in patients with Type 2 diabetes mellitus (ANDROMEDA) study, the mean HbA1c increased from 52 mmol/mol (6.9%) at baseline to 56 mmol/mol (7.3%) at week 16 with rosvuastatin 20 mg/day, and from 53 mmol/mol (7.0%) at baseline to 56 mmol/mol (7.3%) at week 16 with atorvastatin 20 mg/day [13]. The difference with our study is that, in ANDROMEDA, the statin therapy was given at a fixed dose during a fixed time course.

In the Atorvastatin in Factorial with Omega-3 EE90 Risk Reduction in Diabetes (AFFORDD) study, an increase in HbA1c of 1.5 mmol/mol (0.3%) (P < 0.0001) after atorvastatin (20 mg/day) intervention, but no significant change in the Omega-3 EE90 (2 g/day) intervention after 4 months [14].

There are a few limitations to this study that need to be addressed. The most important limitations are that we did not have a placebo-control arm and the relatively short duration of this study. Furthermore, this study was not powered to find a difference in the glycaemic control. In addition, it may be questioned whether the HbA1c increase is a real consequence of worsening of glycaemic control, as neither CARDS nor ANDROMEDA reported an increase in dose of blood glucose-lowering agents, which may be the case when doctors or participating patients witness an increase in blood glucose levels.

In conclusion, this short-term study of intensive statin therapy in patients with diabetes suggests a small but significant increase of HbA1c in statin recipients. Future controlled studies are needed to verify these findings and, if confirmed, determine whether such changes represent a true decline in glycaemic control, or some other mechanism perhaps linked to reduced oxidative potential. Furthermore, whether this change remains in the longer term, and has long-term implications, needs to be studied before making any judgment on clinical relevance of these observations. Presently, it appears that, based on the overwhelming prospective trial data available, the preventive effect of statin therapy supersedes that of the slight increase in HbA1c.

**Competing interests**

BHRW was principal investigator of the CORALL study, which has been financially supported by Astra Zeneca, The
authors of this paper independently analysed the data and wrote the entire manuscript. The sponsor has reviewed the study manuscript, but the review had no influence on the contents of the manuscript or its conclusions. The principal investigator fully controlled the decision to submit for publication.

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References


