Introduction and objectives. It has been suggested that high doses of statins can be more effective in reducing the incidence of new cardiovascular events than conventional doses. The present study analyzed the effect of increasing the atorvastatin dose to 80 mg/day on indices of inflammation (C-reactive protein or CRP), thrombogenesis (prothrombin fragment [F1+2]) and fibrinolysis (tissue-type plasminogen activator antigen, t-PA, and its inhibitor PAI-1) in high-risk patients with ischemic heart disease.

Patients and method. We studied 27 patients with high-risk coronary heart disease who had lipid levels above those recommended despite treatment with atorvastatin at 40 mg/day. At baseline, patients were compared with 21 normocholesterolemic subjects without arteriosclerotic disease. Twenty-four patients were reevaluated 3 months after the atorvastatin dose was increased to 80 mg/day.

Results. The CRP, F1+2, t-PA and PAI-1 levels were significantly higher in patients than control subjects (all P < .05). After the atorvastatin dose was increased, significant reductions in CRP, F1+2, and PAI-1 levels were observed (P < .05). There was a significant positive correlation between the reduction in cholesterol level and that in F1+2 (r = 0.46; P = 0.023). No other significant correlations were found.

Conclusions. In a group of patients with high-risk heart disease and elevated lipid levels, increasing the atorvastatin dose led to significant improvements in inflammatory, thrombogenic, and hypofibrinolytic states.

Key words: Hypercholesterolemia. C-reactive protein. Fibrinolysis. Thrombosis.
The use of HMG-CoA reductase inhibitors (statins) in the treatment of dyslipidemia has been shown to improve survival and significantly reduce the appearance of cardiovascular events, both in primary and secondary prevention.1,2 Given these clinical findings, there are clear guidelines on control of lipid levels with statins, but their beneficial effects seem to go beyond lowering cholesterol. Statins also have so-called pleiotropic effects, which improve endothelial function, reduce inflammation, enhance angiogenesis and vasculogenesis, limit oxidative processes, stabilize atherosclerotic plaques, and inhibit the thrombogenic response.3,4 Arteriosclerotic disease has been redefined as a chronic inflammatory disease in which other abnormalities besides lipid deposition occur. These abnormalities range from endothelial cell dysfunction to the formation of plaques and, above all, loss of plaque stability, which may ultimately lead to an acute coronary syndrome.5,6 Evidence of a close relationship between the hemostatic and inflammatory systems is mounting.7,8

Use of high doses of statins has recently been suggested to help reduce low-density lipoprotein cholesterol (LDL-C) levels, and so further limit the appearance of cardiovascular events.9,10 However, apart from the benefit derived by reducing inflammation,11 little information is available on the pleiotropic effects of high doses of statins.

The objective of this study was to analyze the effect of an increase in dose of atorvastatin to 80 mg/day on inflammatory markers (C-reactive protein [CRP]), thrombogenesis (prothrombin fragment 1+2 [F1+2]), and fibrinolysis (tissue-type plasminogen activator antigen, t-PA, and its inhibitor [PAI-1]) in high-risk patients with stable ischemic heart disease.
filled with trisodium citrate to give a final concentra-
tion of 0.011 mo/L. Serum was also obtained. The 
plasma and serum were centrifuged at 4°C and 2200 g 
for 15 minutes and stored at –80°C until subsequent 
processing.

Serum samples were analyzed for total cholesterol, 
LDL-C, high-density lipoprotein cholesterol (HDL-C), 
and triglycerides with a colorimetric enzymatic 
method (Hitachi® 917). Serum CRP was quantitated 
by kinetic nephelometry with an immunochemical sys-
tem (IMMAGE®, Beckman).

Prothrombin fragment 1+2 was measured in citrated 
plasma as a marker of thrombogenesis by ELISA 
(Dade Behring®). Fibrinolysis was assessed by mea-
suring t-PA and PAI-1 antigen levels in citrated plasma 
by ELISA (American Diagnostica®).

Statistical Analysis

Variables were analyzed for a normal distribution 
with the Kolmogorov-Smirnov test. Normally distri-
buted variables were presented as means (SD). Varia-
tables that did not follow a normal distribution were 
expressed as medians (interquartile range) and were 
log-transformed prior to statistical analysis. Qualita-
tive variables were expressed as percentages. The χ² 
test was used for analysis of the association between 
qualitative variables, whereas the Student t test was 
used for the analysis of the association between a 
qualitative variable and another quantitative one. The 
Student t test was also used for analysis of paired 
variables. For analysis of the correlation between 2 
quantitative variables, the Pearson test was used. A 
multivariate analysis with a linear regression model 
Enter technique) was used to study the influence of 
possible confounding variables and independent var-
iables on the quantitative study variables. The statis-
tical analyses were done using the SPSS program, 
version 11.0. A statistically significant association 
was defined as when the level of significance was 
greater than 95%.

RESULTS

The clinical characteristics of the treated patients 
and control patients, as well as the lipid profile at the 
time of inclusion in the study, are shown in Table 1.

The high-risk group of patients had higher levels of 
CRP and F1+2, as well as higher t-PA and PAI-1 antigen 
levels, compared to the control group (Table 1). A sig-
nificant inverse correlation was observed between F1+2 
and HDL-C levels (r=–0.52; P<.001) (Figure 1). In 
contrast, CRP levels did not correlate with the remai-
ning variables analyzed (age, lipid profile, and t-PA 
and PAI-1 antigen levels).

In the linear regression analysis, significant associa-
tion was only found between CRP levels and age and 
hypertension (r²=0.245; P<.001) (Table 2). No other 
association was found with the remaining variables 
(markers studied with sex, age, and cardiovascular risk 
markers).

Increase in Atorvastatin Dose

Two patients withdrew voluntarily from the study 
after increasing the atorvastatin dose and 1 patient had 
no samples at 3 months. Follow-up was therefore com-
pleted in a total of 24 patients. No patients presented

| TABLE 1. Clinical Characteristics, Lipid Profile, and Biological Markers of Treated Patients and Healthy Controls |
|-----------------|-----------------|-----------------|
| **Patients (n=27)** | **Controls (n=21)** | **P** |
| Men, % | 19 (70.4) | 14 (66.7) | .784 |
| Age, Years | 57.0 (10.3) | 51.3 (10.7) | .009 |
| Hypertension, % | 22 (81.5) | 5 (27.8) | <.001 |
| Diabetes mellitus, % | 7 (25.9) | 1 (5.6) | .000 |
| Smoking, % | | | |
| Active | 5 (18.5) | 8 (38.1) | .013 |
| Ex smoker | 7 (25.9) | 13 (61.9) | |
| Nonsmoker | 15 (55.9) | – | |
| Cholesterol, mg/dL | 236.7±45.2 | 193.1±42.0 | <.001 |
| HDL-C, mg/dL | 42 (39-49) | 48 (42-55) | .002 |
| LDL-C, mg/dL | 160.6±47.3 | 125.6±71.1 | <.001 |
| Triglycerides, mg/dL | 187.3±122.5 | 100.4±35.1 | .005 |
| CRP, mg/dL | 0.30 (0.15-0.60) | 0.10 (0.03-0.35) | .002 |
| F1+2, ng/mL | 0.63 (0.42-0.63) | 0.22 (0.27-0.42) | .013 |
| t-PAag, ng/mL | 14.0±7.8 | 9.3±5.4 | .024 |
| PAI-1ag, ng/mL | 63.6±23.1 | 43.0±20.0 | .006 |

HDL-C indicates high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; F1+2, prothrombin fragment 1+2; t-PAag, tissue-type plasminogen activator antigen; PAI-1ag, tissue-type plasminogen activator inhibitor antigen; CRP, C-reactive protein.
with cardiovascular events during the course of the study. Treatment was well tolerated by all patients and no adverse drug reactions occurred during the 3 months of follow-up. The pharmacological treatment of the patients remained unchanged during the study and no significant change in blood pressure or weight of the patients was found.

The results of the measurements at 3 months are shown in Table 3. A significant reduction in cholesterol and LDL-C levels were observed, although only 7 patients (37.5%) attained the recommended treatment goals for LDL-C. A concentration of HDL-C did not change significantly.

After increasing the dose of atorvastatin, a decrease in CRP levels was detected among treated patients. An improvement in the remaining biological markers was also observed—thrombogenesis was reduced in our patients and fibrinolytic function improved, with a decrease in PAI-1 antigen levels close to the level of significance of t-PA antigen levels (P=.056). A significant correlation was also observed between the decrease in cholesterol levels and the decrease in F1+2 levels (r=0.46; P=.023) (Figure 2). No correlation with the decrease in CRP levels or with the change in the lipid profile was observed.

DISCUSSION

According to the present study of high-risk patients with ischemic heart disease and lipid levels above recommended values, inflammatory processes are present and thrombogenesis and fibrinolytic dysfunction are increased, despite treatment with 40 mg/day of atorvastatin. It should be emphasized that treatment with 40 mg/day of atorvastatin had been unable to lower lipid levels to recommended target values at the start of the study. After increasing the dose to 80 mg/day, significant improvement was
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seen, both in the lipid profile and in the state of inflammation, hypercoagulation, and hypofibrinolysis. However, only a third of our patients attained the treatment goals recommended for LDL-C, possibly because of the inclusion criteria applied. Treatment was very well tolerated by all patients, and no adverse reaction was reported.

Interest in the pleiotropic properties of statins has been growing in recent years. The most studied of these properties is probably the effect on the inflammatory system and significant decreases in CRP levels have been shown. Improved fibrinolytic dysfunction has been demonstrated both in subjects with cardiovascular risk factors, in particular, dyslipidemia and hypertension, and in patients with acute coronary syndrome. Analysis of t-PA antigen levels determines the amount of functionally active t-PA and t-PA complexes bound to PAI-1. Slow clearance of these complexes means that t-PA antigen levels are elevated when fibrinolytic dysfunction is present. On the other hand, t-PA and PAI-1 could even be considered as markers of endothelial damage, given that endothelial cells release both these substances. Several studies have suggested that statins cause an improvement in fibrinolytic function; however, low or medium doses were almost always used (only occasionally have studies reached a dose of 40 mg/day). In the present study, we found that doses of 80 mg/day of atorvastatin decrease PAI-1 and t-PA antigen levels, which is indicative of an improvement in fibrinolytic function. This reduction did not correlate with lipid levels or with the decrease in lipid levels, and so the two effects appear to be independent, in agreement with most of the studies that have been published.

Aggressive treatment with statins is more effective for controlling lipid levels and can also prevent future ischemic events. New studies published recently have suggested that a stricter control of lipid levels is important. Current therapeutic goals might even have to be revised and it might be necessary to consider using statins at high doses. Moreover, some authors have suggested not only changing treatment goals but also basing them on CRP levels and not just on the lipid profile. Such an approach would be a confirmation of previous findings. On the other hand, evidence for the class effect of statins could be based on their differences rather than their ability to decrease CRP levels. Our study and others have shown that statin therapy at these doses has pleiotropic effects, providing further support for beneficial effects of these drugs in addition to their lipid-lowering properties.

CONCLUSIONS

Treatment with atorvastatin at a dose of 80 mg reduces inflammation and thrombin formation, and improves fibrinolytic function compared to the 40 mg dose in high-risk patients with ischemic heart disease. This treatment regimen also improves the lipid profile and is well tolerated.

REFERENCES

