Plasminogen Activator Inhibitor Genotype and Brain Infarction

To the Editor:

Roest et al.1 reported a nested case-control study that assessed the relation between 4G/5G polymorphism in the plasminogen activator inhibitor (PAI-1) gene and cardiovascular and cerebrovascular mortality in women. The authors found that 4G/4G homozygotes had a decreased risk of dying from stroke compared with 5G/5G homozygotes (relative risk, 0.4; 95% confidence interval [CI], 0.2 to 0.7); the relative risk was 0.7 (95% CI, 0.4 to 1.1) for 4G/5G heterozygotes.

The authors raised 2 important issues. First, because the diagnosis was not always confirmed by CT scan or MRI, they could not distinguish brain infarcts (BIs) from hemorrhages, which are very different from a pathophysiological perspective. Thus, the possibility that misclassification may have introduced some bias cannot be discarded. The authors think that this is unlikely because the incidence of brain hemorrhages was higher than that of BIs; however, it is also true that the case fatality of hemorrhages was higher than that of BIs. Because it is likely that any gene associated with stroke will have small effects, it is difficult to draw any conclusions about the impact of misclassification. Second, these findings are somewhat unexpected because the 4G allele is associated with increased PAI-1 transcription. The authors concluded that PAI-1 may contribute to cerebrovascular disease via pathways other than fibrinolysis, and that additional studies are needed.

We studied the relationship between 4G/5G polymorphism and BI in the Etude du profil Génétique de l’Infarctus Cérébral (GÉNIC) case-control study, which examined 461 cases with MRI-proven BI and 461 matched hospital controls (61.6% men; median age, 69 years; range, 20 to 85 years).2 The distributions of genotypes in cases were as follows: 4G/4G, 27.1%; 4G/5G, 48.4%; and 5G/5G, 24.5%. The distribution in controls was as follows: 4G/4G, 28.0%; 4G/5G, 53.1%; and 5G/5G, 18.9%. When considering 5G/5G homozygotes as the reference group, the odds ratios (ORs) were 0.7 (95% CI, 0.5 to 1.0) for 4G/4G homozygotes and 0.7 (95% CI, 0.5 to 1.0) for 4G/5G heterozygotes. Carrying at least one 4G allele was associated with an OR of 0.7 (95% CI, 0.5 to 1.0); adjustment for hypertension, diabetes, smoking, and cholesterol did not modify these findings. This association was not modified by sex (P=0.25), although it was stronger in men (OR, 0.6; 95% CI, 0.4 to 0.9) than women (OR, 0.9; 95% CI, 0.5 to 1.4). After stratification by median age, the relation was stronger for younger subjects (OR, 0.5; 95% CI, 0.3 to 0.8) than for older subjects (OR, 0.9; 95% CI, 0.6 to 1.4; interaction, P=0.05).

Only patients with ischemic cerebrovascular disease were studied in the GÉNIC study, and we also found that 4G carriers were at decreased risk of BI (lethal or nonlethal). These results are similar to those reported by Roest et al.1, and this association remains to be understood.

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Response

The findings by Elbaz et al confirm our observations.1 Moreover, a comparable but nonsignificant reduced stroke incidence in relation to the plasminogen activator inhibitor (PAI-1) 4G polymorphism was reported previously by Catto et al.2 In a pooled analysis of the results of all published studies on the relationship between PAI-1 4G5G genotype and stroke, the genotype distribution in stroke incidence cases is as follows: 4G4G, 296 (26.1%); 4G5G, 559 (49.3%); and 5G5G, 278 (24.5%). The distribution in controls is as follows: 4G4G, 344 (30.1%); 4G5G, 587 (51.3%); and 5G5G, 213 (18.6%). Using 5G5G as the reference group, the odds ratios are 0.66 (95% CI, 0.52 to 0.84) for 4G4G homozygotes and 0.73 (95% CI, 0.59 to 0.90) for 4G5G heterozygotes. The findings of this pooled analysis are suggestive of a protective role of plasminogen activation inhibition in cerebrovascular morbidity and mortality.

The 4G polymorphism is located in the promoter region of the PAI-1 gene and is responsible for increased transcription of PAI-1 and increased production of PAI-1. Thus, the 4G polymorphism may lead to reduced plasminogen activation to plasmin.

Until recently, it was believed that PAI-1 was a potential predictor of an increased risk of cerebrovascular disease via the inhibition of fibrinolysis. The findings that the PAI-1 4G polymorphism is related to a reduced risk of cerebrovascular disease argues against this view. Further evidence against this hypothesis comes from findings that plasma levels of tissue-type plasminogen activator and urokinase-type plasminogen activator. Therefore, the PAI-1 4G polymorphism may lead to reduced plasminogen activation to plasmin.

The mechanism that relates plasminogen activation to cerebrovascular disease probably reflects a nonfibrinolytic function of plasmin. Increased plasminogen activation may lead to increased laminin degradation in extracellular brain tissue and, hence, a reduced resistance of the brain against both ischemic and hemorrhagic damage.3

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