The role of OPRM1 polymorphism in the etiology of alcoholism

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Abstract

Background. Numerous studies have investigated the association between the OPRM1 A118G polymorphism (rs1799971) and alcohol dependence, but the results have been inconsistent. The endogenous opioid system has been implicated in the development of alcohol dependence for its prominent role in the central rewarding mechanism.

Objectives. The aim of this study was to evaluate the role of the A118G polymorphism of the OPRM1 gene in the pathogenesis of alcohol dependence syndrome (ADS).

Material and methods. The OPRM1 (rs1799971) polymorphism was investigated in an association study of a group of ADS patients (n = 177) and in subgroups (delirium tremens and/or seizures, age at onset <26 years, dissocial alcoholics, positive familial history of alcoholism, delirium tremens, and seizures). The control group consisted of healthy volunteers, with matched gender and age, and with psychiatric disorders excluded (n = 162).

Results. Our research shows that there are differences in the genotypes and alleles of the OPRM1 polymorphism in the case-control study. Furthermore, we observed associations in our homogeneous subgroups — in the group of patients with ADS and accompanying delirium tremens and/or seizures at the genotype level, as well as in the subgroup of patients under 26 years of age with an early onset of dependence.

Conclusions. It is strongly possible that the G allele described in numerous studies can be associated with a response to treatment, but not typology, or the very predisposition toward alcoholism. It is necessary to carry out further research which would embrace a larger group of patients; it should be divided into other homogeneous subgroups, including, e.g., naltrexone pharmacotherapy.

Key words: alcohol dependence, OPRM1 gene, opioid system
Introduction

The history of research on the opioid system dates back to the period of interest in the physiological effects of morphine, which is one of the alkaloids found in poppy seeds, or more precisely, opium. Thanks to the experiments carried out 38 years ago, morphine-binding receptors have been discovered.1,2 As part of the research, 3 basic types of opioid receptors — μ, δ, κ (mu, delta and kappa) — were singled out. Opioid receptors are mainly present in the central nervous system, in the cellular membrane of neurons. They can also be found in some types of smooth muscles, as well as the digestive tract, immune system cells, uterus, heart, and lungs.

The abovementioned receptors are essential for signal cascades, which are responsible for the feeling of pain, the regulation of motor and psychophysical functions, and mood control. Numerous studies have indicated the modulatory effects of opioid receptors on the frequency and intensity of drinking relapse.3,4 In medical circles, these findings have aroused hopes for the development of effective therapies for addiction, tailored to the needs of individual patients.

Research results have also proven that endogenous opioid peptides play a role in alcohol-related mechanisms. A single dose of alcohol promotes the secretion of β-endorphins and enkephalins, which stimulate opioid receptors. A lower level of β-endorphins may be a direct consequence of chronic alcohol abuse.5

It has also been proven that alcohol stimulates opioid peptide secretion and activates the reward system in the brain, thereby developing alcohol dependence. Accordingly, drugs which affect the opioid system may influence many behaviors associated with getting and consuming natural rewards (water, food or sex) and chemical rewards (alcohol, opiates or nicotine).

The μ-opioid receptor (OPRM1) has been repeatedly investigated with special attention paid to its relationship with alcohol dependence syndrome (ADS), addiction to psychoactive substances, schizophrenia, obesity, Alzheimer’s disease, palliative treatment, and sensitivity to pain. Many authors have indicated serious and numerous relationships between the effects of opioids and alcohol.6–11

In 2003, O’Brien’s team conducted a study in which a response to naltrexone was associated with a specific genetic variant of the μ-opioid receptor.12 The alcoholics with this genetic variant who were administered naltrexone were able to function without alcohol for a long time, had shorter periods of intensive drinking and could abstain from drinking (or drink very little), which made them less likely to relapse to addiction after their therapy. Individuals who respond to naltrexone show some similarities: a very strong craving for alcohol and a family history of alcoholism. They start drinking when they are young and have a so-called “strong head”. On a biochemical level, their endorphin response is stronger than in those who do not respond to naltrexone.13

The aim of this study was to evaluate the role of the A118G polymorphism of the OPRM1 gene in the pathogenesis of ADS.

Material and methods

The OPRM1 (rs1799971) polymorphism (Fig. 1) was investigated in an association study of a group of ADS patients (n = 177) and its subgroups (delirium tremens and/or seizures, age at onset <26 years, dissocial psychoses, positive familial history of alcoholism, delirium tremens, and seizures). The patients were screened for other psychiatric disorders. We used the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA) for patient phenotyping.

The control group consisted of healthy volunteers, with matched gender and age, and with psychiatric disorders excluded by using Primary Care Evaluation of Mental Disorders Patient Health Questionnaire (PRIME-MD) (n = 162) (Table 1).

Table 1. Statistical characteristics of age in patients with ADS and in controls.

| Group          | n    | Mean [years] | SD [years] | Range [years] |
|----------------|------|--------------|------------|---------------|
| ADS (men)      | 177  | 33           | 8.8        | 20–61         |
| Controls (men) | 162  | 38           | 15.8       | 18–80         |

ADS – alcohol dependence syndrome; SD – standard deviation.

Genotyping using a real-time polymerase chain reaction apparatus

The genome DNA for the analysis was isolated from the leukocytes of circumferential blood using a salting method. Genotyping of the selected polymorphism in the OPRM1 gene was performed with the real-time polymerase chain reaction (PCR) method based on the use of fluorescent oligonucleotide probes, which hybridize with unique DNA sequences. The analysis of the OPRM1 gene polymorphisms was performed with a LightCycler 2.0 (Roche Diagnostics, Pleasanton, USA), using the melting curve analysis for specific alleles. Genotyping results after the completion of the reaction were analyzed using LightCycler software v. 4.1 (Roche Diagnostics).

Statistical analysis

Differences between the controls and the ADS subjects were tested with the χ² test and were considered significant when type 1 error was <5%, using Statistical Package for Social Sciences (SPSS) v. 9.0 for Windows (Microsoft Corp., Armonk, USA). The Hardy-Weinberg equilibrium was calculated using SAS v. 8.02 for Windows (SAS Institute, Cary, USA).
Results

We examined 162 alcohol-dependent patients vs 177 cases and found that there were differences in genotypes and alleles of the \textit{OPRM1} polymorphism. What is more, we observed associations in our homogeneous subgroups – in the group of patients with ADS and accompanying delirium tremens and/or seizures (Table 2) at the genotype level, as well as in the subgroup of patients under 26 years of age with an early onset of dependence (Table 2).

Discussion

In 2007, Van den Wildenberg et al. stated that heavy-drinking individuals with a copy of the G allele are more prone to experiencing cue-induced craving after exposure to an alcoholic beverage.\(^\text{14}\) Interestingly, carriers of at least 1 rs1799971(G) allele appear to have stronger cravings for alcohol than carriers of 2 rs1799971(A) alleles, and are thus hypothesized to be at a higher risk for alcoholism. On the basis of the abovementioned studies, we can conclude that these findings have several implications. Firstly, individuals with a copy of the G allele seem to be more sensitive to cue-induced subjective cravings for alcohol than individuals homozygous for the A allele.\(^\text{14}\) Another interesting aspect of the literature in this respect is a study performed by Anton et al., in which among over 200 alcoholics treated with naltrexone, rs1799971(G) carriers receiving the drug had a higher percentage of abstinent days and a lower percentage of heavy drinking days (\(p = 0.04\)) compared to those receiving a placebo, whereas rs1799971(A;A) homozygotes showed no differences connected with medication. Upon treatment with naltrexone, 87% of rs1799971(G) carriers had a good clinical outcome, compared to only 55% of individuals with the (A;A) genotype.\(^\text{15}\)

Although the association between a polymorphism of the \textit{OPRM1} receptor gene and adolescent alcohol misuse was tested by Ray et al., our findings provide the first evidence that the A118G single-nucleotide polymorphism (SNP) of the \textit{OPRM1} gene is associated with alcohol use disorder (AUD) diagnoses during adolescence, as well as with a greater number of alcohol-related problems among adolescent drinkers.\(^\text{4}\) Those who carried the G allele turned

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Table 2. Frequencies of genotypes and alleles of the investigated \textit{OPRM1} (rs1799971) polymorphism in alcoholics (\(n = 177\)) and in the control group (\(n = 162\))

| Groups                        | n | Genotypes | p-value | Alleles | p-value |
|-------------------------------|---|-----------|---------|---------|---------|
|                               |   | A/A n (%) | A/G n (%) | G/G n (%) | A n (%) | G n (%) |
| Controls                      | 162| 119 (0.73) | 40 (0.25) | 3 (0.02) | –       | 46 (0.28) |
| Cases                         | 177| 146 (0.82) | 29 (0.16) | 2 (0.02) | 0.13    | 321 (0.91) |
| Delirium tremens and/or seizures | 51| 45 (0.88)  | 4 (0.08)  | 2 (0.04) | 0.02*   | 94 (0.92)  |
| AOO <26                       | 122| 104 (0.85) | 18 (0.15) | 0 (0.0)  | 0.03*   | 226 (0.93) |
| Dissocial alcoholics           | 63 | 52 (0.82)  | 10 (0.16) | 1 (0.02) | 0.35    | 114 (0.9)  |
| Positive familial history of alcoholism | 56| 47 (0.84)  | 8 (0.16)  | 0 (0.0)  | 0.22    | 103 (0.92) |
| Delirium tremens               | 32 | 27 (0.84)  | 3 (0.1)   | 2 (0.06) | 0.07    | 57 (0.89)  |
| Seizures                      | 31 | 27 (0.87)  | 3 (0.1)   | 1 (0.03) | 0.17    | 57 (0.89)  |

\(\text{AOO <26 – age of onset less than 26 years; p-values of the } \chi^2 \text{ test for genotypes; } * \text{ statistical significance.}\)
to drinking to enhance the positive affect more strongly than those who were homozygous for the A allele, and drinking to enhance the positive affect mediated the association between OPRM1 and alcohol-related problems.16

The meta-analysis performed by Chen et al. in 2012 shows a list of 12 independent studies with 1,900 cases and 2,382 controls – 5 studies were conducted in Asians and 7 in Caucasians. Ethnicity-specific meta-analyses revealed that the A118G polymorphism significantly correlated with the risk for alcohol dependence in Asians, but not in Caucasians.17 However, in central Sweden – according to Bart et al. – the functional variant 118G allele in exon 1 of OPRM1 was associated with an increased attributable risk of alcohol dependence.18

Numerous researchers have associated the OPRM1 gene and its polymorphic variant with a response to naltrexone. In the study performed by Bart et al., the results indicate that individuals with at least 1 copy of the G allele reported a lower alcohol craving and a stronger alcohol-induced “high” across rising breath alcohol concentrations.19 Naltrexone was found to blunt the effects of alcohol on stimulation, positive mood, craving, and enjoyment. The effects of naltrexone on blunting the alcohol-induced “high” were stronger among individuals with the G allele.5 Rommelspacher et al. found little evidence in relation to these associations and concluded that there was no significant difference in the frequency of the Asp40 allele between the control subjects and the alcohol-dependent subjects with a family history of parental alcoholism, subjects with early-onset alcohol dependence or alcohol-dependent subjects with severe withdrawal symptoms. Their results provide only some evidence for an allelic association of the Asn40Asp SNP with alcohol dependence.19

Conclusions

In light of the abovedescribed findings we can say the results are unambiguous – we observed a frequent occurrence of the A allele in the control group and in selected homogeneous subgroups.

It is strongly possible that the G allele described in numerous studies can be associated with a response to treatment, but not with typology or the very predisposition toward alcoholism. It is necessary to carry out further research which would embrace a larger group of patients; it should be divided into other homogeneous subgroups, including, e.g., how the patients respond to naltrexone pharmacotherapy.20

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