SHORT REPORT

Apolipoprotein E polymorphism in German patients with frontotemporal degeneration

M Riemenschneider, J Diehl, U Müller, H Förstl, A Kurz

J Neurol Neurosurg Psychiatry 2002;**72**:639–641

Objectives: The apolipoprotein E (apoE) polymorphism, designated as ε2, ε3, ε4, is a genetic risk factor associated with several forms of dementia. Inconclusive results have been reported in patients with frontotemporal degeneration which prompted this study of the apoE polymorphism in a German sample with frontotemporal degeneration.

Methods: the frequencies of the ε2 and ε4 alleles and the effect of these alleles on the age at onset in 52 patients with frontotemporal degeneration who underwent a thorough diagnostic examination and in 182 cognitively healthy age matched controls were assessed. Genotype comparisons between the groups were performed using multiple logistic regression analysis. Ages at onset according to the apoE genotype were compared by linear regression analysis.

Results: In patients with frontotemporal degeneration apoE ε2 and ε4 allele frequencies were 9.6% each, whereas the corresponding frequencies in controls were 9.6% and 9.9%, respectively. There was no significant difference in either ε2 or ε4 allele frequency between the groups. Age at onset was highest in patients with the ε2/ε3 genotype (61.3 years) followed by patients with the ε3/ε3 (58.3 years) and was lowest in patients with the ε3/ε4 genotype (56.4 years) but the differences failed to reach statistical significance.

Conclusion: Allelic variants of the apoE gene do not modulate occurrence or age at onset in this sample of German patients with frontotemporal degeneration.

Frontotemporal degenerations make up a heterogeneous group of diseases that involve lobar atrophy of the frontal and temporal cortex. Besides dementia with motor neuron disease, three different syndromes including frontotemporal dementia and the progressive language disorders, semantic dementia and primary progressive aphasia can be distinguished.[1] Frontotemporal dementia is clinically characterised by early personality changes and impairments of language and executive function together with non-cognitive symptoms such as hyperorality and repetitive behaviours. Primary progressive aphasia refers to a progressive non-fluent aphasia which remains the only symptom at the beginning of the disease. Semantic dementia is characterised by fluent dysphasia with loss of word and object meaning.[2] At postmortem examination, two histopathological forms, the most frequent unspecific type and the much rarer Pick type may be distinguished.[3] In both pathologies amyloid plaques and neurofibrillary tangles are usually absent.

The aetiology of frontotemporal degeneration remains unclear but the occurrence of a family history of dementia in about half of all cases suggests a genetic background.[1] Such predisposing genetic factors have been successfully identified in families with frontotemporal dementia with parkinsonism which showed exonic missense mutations or intronic splice site mutations in the tau gene located on chromosome 17.[4] In addition, linkage to chromosome 3 has been reported in another family.[5] As in Alzheimer's disease, frontotemporal degeneration may be a genetically heterogeneous disorder and both causative as well as risk modifying genes may be involved.

The apoE gene has been discussed as a possible risk modifying gene in frontotemporal degeneration. Several studies, however, showed inconclusive results. Some authors showed increased ε4 allele frequencies in frontotemporal degeneration[6–8] which were not confirmed by other groups using mostly histopathologically characterised cases.[9–13] Looking exclusively at patients with Pick-type frontotemporal degeneration several[9 14 15] but not all[10] groups found an increased frequency of the apoE ε4 allele. Also, a gene-dose dependent effect of the ε4 allele on the age at onset[6 9 11] was not a universal finding.[13 16] Very recently the apoE ε2 allele has also been suggested as a risk factor for frontotemporal degeneration.[17] Because some of the previous studies included relatively small patient samples and no data are available on German patients with frontotemporal degeneration, we examined the apolipoprotein E ε2 and ε4 allele frequencies as well as their effect on the age at onset.

METHODS

The study refers to 52 white patients with frontotemporal degeneration and to 182 cognitively healthy controls which were recruited from a university memory clinic from 1994 to 2001. Within the frontotemporal degeneration group 43 patients had frontotemporal dementia, five had semantic dementia, and four patients had primary progressive aphasia. Most subjects of the control group were cognitively unimpaired spouses of patients from the memory clinic (table 1). Information on age at onset of the disease was obtained from an informant. After informed consent had been obtained blood samples of each patient were taken by venepuncture. The study protocol was approved by the review board of the medical faculty, Technische Universität München. All patients enrolled in this study, including those with frontotemporal dementia, primary progressive aphasia, and semantic dementia, met the consensus criteria for frontotemporal degeneration.[18] All patients underwent a thorough psychiatric, neurological, and neuropsychological evaluation, and there was a second examination in 25 patients by an independent psychiatrist 2 to 3 years later according to the above mentioned criteria[18] to improve diagnostic accuracy. The diagnosis of frontotemporal degeneration was confirmed in all 25 patients. The diagnostic investigation also included an informant interview, a chemistry survey, structural MRI imaging, and functional imaging using either ^{99m}Tc HMPAO

Abbreviations: apoE, apolipoprotein E

Table 1 Description of the study group, apolipoprotein E genotypes, and allele frequencies

			Apo E genotypes						Apo E allele frequencies %		
Subjects (n)	Age	Onset	ε4/ε4	ε3/ε4	ε2/ε4	ε3/ε3	ε2/ε3	ε2/ε2	ε4	ε3	ε2
FTD (52) M (28):F (24)	61.7 (7.7)	58.7 (7.6)	–	8	2	35	6	1	9.6	80.8	9.6
Controls (182) M (85):F (97)	63.6 (9.3)	–	1	31	3	117	28	2	9.9	80.5	9.6

Data are presented as mean (SD).

SPECT or ^{18}FDG PET. Visual rating of functional images helped to classify patients with frontotemporal degeneration, as every patient with FTD had marked frontal or anterior temporal hypometabolism. Cognitive impairment was assessed using the Cambridge cognitive examination[19] or, from 1998, the Consortium to Establish a Registry of Alzheimer's Disease Neuropsychological Battery (CERAD-NP)[20] which was completed by the following tests: verbal fluency, Boston naming test, Tower of Hanoi, Stroop colour-word interference, Wisconsin card sorting test, clock drawing, and Rey-Osterrieth figure drawing.

DNA was extracted from blood samples using standard procedures and the apoE genotype was determined as described previously.[21]

Variations in ε2 allele or ε4 allele frequencies between patients and controls were analysed using the χ^2 test and logistic regression analysis with age and sex as covariates. The effect of the ε2 and ε4 gene dosage on age at onset was investigated by Student's *t* test and by multiple linear regression analysis.

Due to the low frequency of patients who were homozygous for the ε2 allele (n=1) and controls who were homozygous for the ε2 (n=1) and ε4 (n=1) allele those were collapsed with heterozygous subjects into one group.

RESULTS

Clinical characteristics including age and sex distribution of patients and controls are summarised in table 1. The mean age and sex distribution of both cohorts did not differ significantly. Eighty per cent of patients had onset of the disease before the age of 65.

The frequencies of the ApoE ε4 and ε2 alleles in the patients were 9.6% each. The corresponding frequencies in controls were 9.9% for the apoE ε4 allele and 9.6% for the apoE ε2 allele. In patients with frontotemporal degeneration neither the ε4 nor the ε2 allele frequency differed significantly from the corresponding frequencies in controls even when correcting for age and sex (table 1). It is noteworthy that none of the patients were homozygous for the ε4 allele.

In our sample ages at onset were 56.4 (SD 6.7) years in eight patients with the ε3/ε4 genotype, 58.3 (SD 7.8) years in 35 patients homozygous for the ε3 allele, and 61.3 (SD 7.9) years in seven patients collapsed to the ε2/ε3 genotype. Although ages at onset were lower in patients with the ε4 allele and higher in patients with the ε2 genotype no significant differences were found in comparison with patients with the ε3/ε3 genotype.

DISCUSSION

This study of 52 German patients with frontotemporal degeneration showed no differences in apoE ε2 or ε4 allele frequencies between patients and age matched non-demented controls. Thus our findings are consistent with previous studies using mostly patients characterised by histopathology.[9–13] The ε2 and ε4 allele frequencies obtained in this study are within the range of the other studies. By comparison with other studies from northern Germany the ε2 allele frequency was a little higher and the ε4 allele frequency a little lower in controls than reported.[22 23] However, the frequencies came close to a Tyrolean study[24] which might be explained by the close geographical vicinity probably indicating a similar genetic background. Our results are at variance with one population based study from The Netherlands[6] which used the Lund and Manchester criteria[3] for clinical diagnosis of frontotemporal degeneration. They reported that the ε4 allele frequency (25%) in patients with frontotemporal degeneration was significantly increased compared with controls (15%) which was mainly due to an increase of apoE ε4 homozygotes. In our sample, however, no patient with frontotemporal degeneration was homozygous for the apoE ε4 allele.

The application of different diagnostic criteria (Lund and Manchester criteria[3] versus Consensus criteria[18]) is unlikely to be the reason for the discrepancy; therefore differences in patient composition are more likely to be responsible. As several studies reported a higher ε4 allele frequency in patients with Pick's disease[9 14 15] (although a recent report could not replicate this[13]), a higher proportion of patients with Pick's disease enclosed may account for the discrepancy. Clinically, it is difficult to distinguish between frontotemporal dementia and Pick's disease and hence we did not try to differentiate between both entities. The most likely factor—admixture of misdiagnosed patients with Alzheimer's disease—may account for the higher ε4 allele frequencies in patients with frontotemporal degeneration. Although the diagnosis of frontotemporal degeneration was established clinically in this study re-examination in about half of our patients, extensive neuropsychological testing, and functional imaging might have led to an improvement in diagnostic accuracy. Misdiagnosis of patients with Alzheimer's disease in our patient sample would have resulted in significantly higher apoE ε4 allele frequencies compared with the control group, which was not found. In addition, we could not replicate recent findings of a significantly increased apoE ε2 allele frequency in patients with frontotemporal degeneration.[17] Although the diagnoses in nine out of 11 patients were confirmed by histopathology the sample size is small and thus may be influenced by spurious effects.

In agreement with two recent findings[13 16] but by contrast with other reports[6 9 11] we were unable to show any effects of the apoE ε4 or ε2 allele on age at onset. However, due to the low apoE ε4 and ε2 allele frequencies in our patient cohort, we cannot rule out the possibility that apoE ε4 or ε2 alleles may influence the age at onset of the disease even without being a significant genetic risk factor.

CONCLUSIONS

Our data suggest that allelic variants of the apoE gene do not modulate occurrence or age at onset of frontotemporal dementia in a sample of German patients. Therefore other not yet identified genes may act as genetic susceptibility factors in frontotemporal degeneration.

Authors' affiliations
M Riemenschneider, Neurochemistry and Neurogenetics Laboratory, Department of Psychiatry and Psychotherapy, Technische Universität München, Germany
J Diehl, H Förstl, A Kurz, Department of Psychiatry and Psychotherapy, Technische Universität München, Germany
U Müller, Department of Human Genetics, Justus Liebig Universität Giessen, Germany

Correspondence to: Dr M Riemenschneider, Neurochemistry and Neurogenetics Laboratory, Department of Psychiatry and Psychotherapy, Technische Universität München, Ismaningerstrasse 22, 81675 Munich, Germany; m.riemenschneider@lrz.tu-muenchen.de

Received 14 May 2001
In revised form 2 October 2001
Accepted 25 October 2001

REFERENCES

1 **Neary D**, Snowden JS, Mann DMA. The clinical pathological correlates of lobar atrophy. *Dementia* 1993;**4**:154–9.
2 **Levy M**, Miller B, Cummings J. Frontal and frontotemporal dementia. In: Growdon J, Rossor M, eds. *The dementias*. Boston: Butterworth Heinemann, 1998:45–65
3 **Brun A**, Englund E, Gustafson L, *et al*. Clinical, neuropsychological and neuropathological criteria for fronto-temporal dementia. *J Neurol Neurosurg Psychiatry* 1994;**57**:416–18.
4 **Hutton M**, Lendon C, Rizzu P, *et al*. Association of missense and 5′-splice-site mutations in tau with the inherited dementia frontotemporal degeneration P-17. *Nature* 1998;**393**:702–5.
5 **Brown J**, Ashworth A, Gydesen S, *et al*. Familial non-specific dementia maps to chromosome 3. *Hum Mol Genet* 1995;**4**:1625–8.
6 **Stevens M**, van-Duijn CM, de-Knijff P, *et al*. Apolipoprotein E gene and sporadic frontal lobe dementia. *Neurology* 1997;**48**:1526–9.
7 **Helisalmi S**, Linnaranta K, Lehtovirta M, *et al*. Apolipoprotein E polymorphism in patients with different neurodegenerative disorders. *Neurosci Lett* 1996;**205**:61–4.
8 **Czech C**, Monning V, Tienari PJ, *et al*. Apolipoprotein E-epsilon 4 allele and Alzheimer's disease. *Lancet* 1993;**342**:1309.
9 **Farrer L**, Abraham C, Volicer L, *et al*. Allele epsilon 4 of apolipoprotein E shows a dose effect on age at onset of Pick disease. *Exp Neurol* 1995;**136**:2162–70.
10 **Gomez-Isla T**, West HL, Rebeck GW, *et al*. Clinical and pathological correlates of apolipoprotein E ϵ4 in Alzheimer's disease. *Ann Neurol* 1996;**39**:62–70.
11 **Minthon L**, Hesse C, Sjögren M, *et al*. The apolipoprotein E ϵ4 allele frequency is normal in fronto-temporal dementia, but correlates with age at onset of disease. *Neurosci Lett* 1997;**226**:65–7.
12 **Geschwind D**, Karrim J, Nelson S, *et al*. The apolipoprotein E ϵ4 allele is not a significant risk factor for frontotemporal dementia. *Ann Neurol* 1998;**44**:134–8.
13 **Pickering-Brown S**, Owen F, Isaacs A, *et al*. Apolipoprotein E ϵ4 allele has no effect on age at onset or duration of disease in cases of frontotemporal dementia with Pick- or microvacuolar-type histology. *Exp Neurol* 2000;**163**:452–6.
14 **Schneider JA**, Gearing M, Robbins RS, *et al*. Apolipoprotein E genotype in diverse neurodegenerative disorders. *Ann Neurol* 1995;**38**:131–5.
15 **Kálmán J**, Juhász A, Majtényi K, *et al*. Apolipoprotein E polymorphism in Pick's disease and in Huntington's disease. *Neurobiol Aging* 2000;**21**:555–8.
16 **Houlden H**, Rizzu P, Stevens M, *et al*. Apolipoprotein E genotype does not affect the age of onset of dementia in families with defined tau mutations. *Neurosci Lett* 1999;**260**:193–5.
17 **Lehmann D**, Smith A, Combrinck M, *et al*. Apolipoprotein E ϵ2 may be a risk factor for sporadic frontotemporal dementia. *J Neurol Neurosurg Psychiatry* 2000;**69**:404–5.
18 **Neary D**, Snowden J, Gustafson L, *et al*. Frontotemporal lobar degeneration: a consensus on clinical diagnostic criteria. *Neurology* 1998;**51**:1546–54.
19 **Roth M**, Tym E, Mountjoy CQ, *et al*. CAMDEX. A standardized instrument for the diagnosis of mental disorder in the elderly with special reference to the early detection of dementia. *Br J Psychiatry* 1986;**149**:698–709.
20 **Welsh KA**, Butters N, Mohs RC, *et al*. The Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Part V. A normative study of the neuropsychological battery. *Neurology* 1994;**44**:609–14.
21 **Zivelin A**, Rosenberg N, Peretz H, *et al*. Improved method for genotyping apolipoprotein E polymorphisms by a PCR-based assay simultaneously utilizing two distinct restriction enzymes. *Clin Chem* 1997;**43**:1657–9.
22 **Utermann G**, Steinmetz A, Weber W. Genetic control of human apolipoprotein E polymorphism: comparison of one and two dimensional techniques of isoprotein analysis. *Hum Genet* 1982;**60**:344–51.
23 **Menzel HJ**, Kladetzky RG, Assmann G. Apolipoprotein E polymorphism and coronary artery disease. *Arteriosclerosis* 1983;**3**:310–15.
24 **Hallmann DM**, Boerwinkle E, Saha N, *et al*. The apolipoprotein E polymorphism: A comparison of allele frequencies and effects in nine populations [[see comments]]. *Am J Hum Genet* 1991;**49**:338–49.