Elevated Risk of Motor Vehicle Accident for Male Drivers with Obstructive Sleep Apnea Syndrome in the Tokyo Metropolitan Area

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Previous studies have suggested that patients with obstructive sleep apnea syndrome (OSAS) are at an increased risk of motor vehicle accidents (MVAs). This study is the first systematic investigation of MVA risk among Japanese drivers with obstructive sleep apnea syndrome (OSAS). We investigated the rate of MVAs in the preceding 5 years and dozing off at the wheel in Japanese male OSAS drivers (n = 616, mean [s.d.] age: 46.3 [10.1] years old) and age-matched male controls (n = 600), and the characteristics of OSAS patients who experienced multiple MVAs as well as the effectiveness of continuous positive airway pressure (CPAP) treatment in reducing MVA risk. The odds ratio of MVA in the OSAS group compared to a general population was 2.36. Multivariate logistic regression analysis revealed that MVA was significantly associated with either subjective sleepiness beyond normal limits (Epworth sleepiness scale: ESS ≥ 11) or serious respiratory disorders (apnea hypopnea index: AHI ≥ 40). AHI scores were significantly higher in the group with multiple MVAs than in those with a single MVA, despite the ESS score in the former group being significantly lower. CPAP treatment was effective for reduction of MVA. The MVA rate among OSAS patients in the research area was significantly higher than that among the controls. Subjective excessive daytime sleepiness and severity of OSAS are independently associated with the occurrence of MVA. In conclusion, early diagnosis and treatment of OSAS drivers especially with serious respiratory disorder should be made to prevent multiple MVAs. ——-obstructive sleep apnea syndrome; nasal CPAP treatment; motor vehicle accident; prevalence; subjective sleepiness.


Previous studies have suggested that patients with obstructive sleep apnea syndrome (OSAS) are at an increased risk of motor vehicle accidents (MVAs), presumably due to increased sleepiness and its related deterioration of driving performance (George et al. 1987; Findley et al. 1988; Aldrich 1989; George and Smiley 1999; Teran-Santos et al. 1999; George 2001). Several studies have found that MVA are more common amongst people with OSAS compared to matched controls (George and Smiley 1999; Horstmann et al. 2000; Lloberes et al. 2000) because of subjective daytime sleepiness brought about by sleep-disordered breathing (Young et al. 1997; Teran-Santos et al. 1999; Powell et al. 2002; George 2003). The articles mentioned above were performed on non-Asian populations, i.e. Caucasians/Blacks. However, comparison of the rate of MVA between OSAS patient group and the general population has not been reported for Asian countries. When compared with Caucasians, Asians are reported to be less obese, but to have greater severity of OSAS (Li et al. 1999; Li et al. 2000). Bixler et al. (2005) suggested that the presence of excessive daytime sleepiness (EDS) is independently associated with obesity. When considering these findings, there may be differences in the conditions of sleepiness-related vehicular accidents between Asian and Caucasian patients with OSAS. In addition, factors associated with the occurrence of MVA, characteristics of the drivers with multiple MVAs, and the effectiveness of continuous positive airway pressure (CPAP), a widely accepted first-line treatment of the disorder (Sullivan et al. 1981), on reduction of MVA in Asian OSAS patients remain unclear. Systematic study to clarify these issues is important for reduction of MVA that is a common cause of injury and premature death (Van der Weyden 1999).

In this study, we compared the rate of both MVA and dozing off at the wheel between OSAS drivers and age-matched control drivers, and analyzed risk factors for MVA.
among drivers in the Tokyo metropolitan area with OSAS. We also investigated the characteristics of drivers with OSAS who experienced multiple MVAs as well as the effectiveness of long-term CPAP treatment on the risk of MVAs.

Methods

Subjects and Methods

The ethics committee of Neuropsychiatric Research Institute approved this study, and all the patient subjects gave their written informed consent to take part in this investigation.

This study was a cross-sectional retrospective study regarding MVA by OSAS patients, and a prospective long-term follow-up study regarding the change in the rate of MVAs during more than 5 years of CPAP treatment. Subjects of the former retrospective study were consecutive outpatients who visited the Sleep Disorder Clinic in Tokyo from November 1999 to October 2000. They consisted of 616 male patients with OSAS (Apnea hypopnea index: AHI ≥ 5, mean [s.d.] AHI: 44.0 [27.9], age: 46.3 [10.1] years old, BMI: 27.4 [4.7] kg/m²). All of them had been habitually driving in the Tokyo metropolitan area.

Recording and analysis of polysomnography (PSG) were performed within one month after the initial visit according to the recommendations for definition of the disorder and measurement techniques published by the American Academy of Sleep Medicine (1999). Obstructive apneas were defined as the absence of airflow for >10 s, and hypopneas were defined as a 50% decrease in airflow associated with a > 3% or more of oxygen desaturation or an arousal in the context of ongoing respiratory effort and involuntary movements during sleep (American Academy of Sleep Medicine 1999). The complete records were scored manually for sleep stage, arousals, and respiratory events.

Based on medical records and the answers to questionnaires conducted at their initial visit, we retrospectively investigated their demographic variables such as age and sex, scores on the Epworth sleepiness scale (ESS: Johns 1991), experience of self-reported MVA in the preceding 5 years (Young et al. 1997) and/or dozing off at the wheel in the preceding year. The form of the question was: “Have you had motor vehicle accident(s) including property damage accident in the preceding 5 years?”, and “Have you dozed off at the wheel including only for a second in the preceding year?” The period studied by the questionnaire regarding the existence of dozing off at the wheel was limited to the previous year to avoid recall bias as suggested by McCartt (1996) and Maycock (1997).

In order to obtain control data, we conducted a questionnaire survey with similar content during two weeks of November 2000 on drivers who visited the Tokyo Metropolitan Driver and Vehicle Licensing Center in order to renew their driver’s license. The survey requested information regarding self-reported experience of MVAs in the preceding 5 years, dozing off at the wheel in the last year, habitual sleep length, and their height and weight. We obtained data from 883 male drivers (mean [s.d.] age: 39.2 [12.4]). Among these, six hundred data were randomly extracted to match the age of the OSAS drivers.

Based on the results of PSG diagnosis for 616 patients, CPAP was prescribed for 365 patients with an AHI of 20 or more per hour according to the National Health Insurance standard in Japan, and 291 of these patients (79.7%) continued to use the device for more than 5 years. We prospectively investigated MVA in these patients after starting CPAP treatment. Mean [s.d.] AHI of 291 patients before CPAP treatment was 61.6 [22.8], and mean [s.d.] duration of CPAP use was 72.0 [7.6] months. We compared MVA rate between the control and OSAS groups both before and during CPAP treatment.

Statistical Analyses

An unpaired t test was used for the comparison of continuous variables between the control and OSAS groups. Dichotomous variables were analyzed using a χ² test.

The factors associated with MVA were examined with the aid of a series of logistic regression analyses. Independent variables were converted into categorical data: age, usual length of nocturnal sleep, ESS score, and AHI score. Age and usual length of nocturnal sleep were divided for a median. ESS and AHI scores were divided into each severity category with reference to previous studies (George and Smiley 1999; Teran-Santos et al. 1999; Connor et al. 2002; Howard et al. 2004). All variables were initially examined in univariate models. To control confounding factors and to determine the main correlates, we then performed multivariate logistic regression analyses for all variables that showed a significant correlation in univariate models.

A one-way analysis of variance (ANOVA) and Scheffe’s post hoc analysis was used to compare both AHI and ESS score among three groups categorized by the number of MVA.

Results

Sample characteristics

Mean [s.d.] age was 46.3 [10.1] years old in the OSAS group and 45.5 [9.8] years old in the control group (t1214 = 1.50, ns). Mean [s.d.] BMI was significantly higher in the OSAS group than in the control group (OSAS group: 27.4 [4.7], control group: 23.4 [2.9], t1192 = 17.5, P < 0.0001).

Comparison of MVA between OSAS and control group

The proportion of the subjects with MVA in the preceding 5 years was significantly higher in the OSAS group than in the control group (OSAS group: 12.2%, control group: 4.7%, χ² = 22.1, P < 0.0001). Experience of dozing off at the wheel was also significantly higher in the OSAS group compared with the control group (OSAS group: 57.8%, control group: 8.2%, χ² = 337.0, P < 0.0001). The odds ratio (95% confidence interval) of both MVA and dozing off at the wheel was 2.36 (1.62-3.44) and 13.20 (10.01-17.41) in the OSAS group compared to control group.

Factors associated with MVA and dozing off at the wheel

Univariate logistic regression analyses were performed for 4 independent variables: age, usual sleep length, ESS, and AHI, all of which were converted into categorical data. Among these variables, two items (ESS and AHI) exhibited significant correlation with MVA. The two significant variables in the univariate models were submitted to a multivariate model. Adjusted ORs and their 95% CIs in the final model are shown in Table 1. Multivariate logistic regression analysis revealed that the existence of MVA was significantly associated with increase in both ESS score (ESS score ≥ 16: OR = 3.56, 95% CI: 1.85-6.84, P < 0.001; ESS
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Table 1. Univariate and multivariate logistic regression results of associated factors of motor vehicle accident (MVA).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total n</th>
<th>MVA n</th>
<th>%</th>
<th>Univariate relative risk (95% CI)</th>
<th>p</th>
<th>Multivariate relative risk (95% CI)</th>
<th>p</th>
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<td>Age</td>
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<td></td>
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</tr>
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<td>305</td>
<td>39</td>
<td>12.8</td>
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<td></td>
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<tr>
<td>≥ 47</td>
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<td>ns</td>
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<td>≥ 11, &lt; 16</td>
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<td>28</td>
<td>12.3</td>
<td>1.97 (1.05 - 3.70)</td>
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<td>1.87 (0.99 - 3.53)</td>
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<td>22.7</td>
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<td>3.56 (1.85 - 6.84)</td>
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<td>≥ 40</td>
<td>319</td>
<td>51</td>
<td>16.0</td>
<td>2.17 (1.30 - 3.62)</td>
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<td>1.75 (1.03 - 2.98)</td>
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</table>

*1 Relative risks approximated with odds ratios. CI denotes confidence intervals
*2 Epworth Sleepiness Scale before treatment
*3 Apnea hypopnea index before treatment

Table 2. Univariate and multivariate logistic regression results of associated factors of dozing off at the wheel.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total n</th>
<th>dozing off n</th>
<th>%</th>
<th>Univariate relative risk (95% CI)</th>
<th>p</th>
<th>Multivariate relative risk (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
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<td>Age</td>
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<td>Usual sleep length</td>
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<td>ns</td>
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<td>≥ 11, &lt; 16</td>
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<td>3.91 (2.68 - 5.70)</td>
<td>&lt; 0.0001</td>
<td>3.79 (2.59 - 5.55)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>≥ 16</td>
<td>132</td>
<td>113</td>
<td>85.6</td>
<td>11.2 (6.44 - 19.3)</td>
<td>&lt; 0.0001</td>
<td>9.87 (5.66 - 17.2)</td>
<td>&lt; 0.0001</td>
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<td>AHI</td>
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<td>48.1</td>
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<td>319</td>
<td>213</td>
<td>66.8</td>
<td>2.16 (1.56 - 3.00)</td>
<td>&lt; 0.0001</td>
<td>1.68 (1.18 - 2.40)</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

*1 Relative risks approximated with odds ratios. CI denotes confidence intervals
*2 Epworth Sleepiness Scale before treatment
*3 Apnea hypopnea index before treatment

score ≥ 11: OR = 1.87, 95% CI: 0.99-3.53, P = 0.05) and AHI score (AHI ≥ 40: OR = 1.75, 95% CI: 1.03-2.98, P < 0.05). The occurrence of dozing off at the wheel was also associated with increase in both ESS score (ESS score ≥ 11: OR = 3.79, 95% CI: 2.59-5.55, P < 0.0001; ESS score ≥ 16: OR = 9.87, 95% CI: 5.66-17.2, P < 0.0001) and AHI score (AHI ≥ 40: OR = 1.68, 95% CI: 1.18-2.40, P < 0.01; Table 2). However, neither age nor usual sleep length was associated with the existence of both MVA and dozing off at the wheel.

Characteristics of subjects with multiple MVAs

Fig. 1 shows comparisons of AHI (left panel) and ESS (right panel) among three groups categorized according to the self-reported number of MVA. There were significant differences in both AHI and ESS scores among three groups (AHI: F_{2,567} = 7.2, P < 0.001; ESS: F_{2,567} = 15.9, P < 0.0001). AHI was significantly higher in the group with two or more MVAs than in the group with only one MVA episode (P < 0.05), and the group without MVA (P < 0.01). However, there were no significant differences in AHI between the group with only one episode of MVA and the group without MVA. With regard to ESS score, the value in the group with only one episode of MVA was higher than those in both the groups without MVA (P < 0.0001) and with two or
more MVAs ($P = 0.05$). However, there was no significant difference in ESS score between the group without MVA and the group with two or more MVAs.

**Effectiveness of CPAP on MVA**

Fig. 2 shows a comparison of the proportion with MVA among control subjects and OSAS patients treated with CPAP both at baseline and at follow-up. There was a significant difference in the proportion among these three groups ($\chi^2 = 53.0, P < 0.0001$). Residuals analysis revealed that the proportion of subjects who experienced MVA was significantly higher in Pre-CPAP OSAS patients compared with the control group and OSAS group at the follow-up period ($P < 0.01$). However, there was no significant difference in the rate between the control group and the CPAP-treated OSAS group at follow-up.

**Discussion**

In this study, drivers with OSAS had a higher rate of both MVA in the preceding 5 years and dozing off at the wheel in the past year than control drivers. Several studies have shown a 2-12-fold greater rate of MVA in patients with OSAS than in subjects without OSAS (George et al. 1987; Findley et al. 1988; Haraldsson et al. 1990; Carter et al. 2003). Our study showed that the odds ratio of having MVA was 2.36 and dozing off at the wheel was 13.20 in the group of drivers with OSAS. From a meta-analysis conducted by Sassani et al. (2004), the odds ratio of motor vehicle collision with OSAS between 1999 and 2001 ranged from 1.71 to 6.31. Given that the fixed combined odds ratio was 2.52 (1.84-3.45) in his report, risk of MVA among OSAS drivers in this study area was considered to be almost similar to those in Western countries.

Previous results regarding the relationship between MVA risk and ESS score are conflicting (Noda et al. 1998; Barbé et al. 1998; Masa et al. 2000; Powell et al. 2002; George et al. 2003). However, our findings revealed that self-reported measures of sleepiness could be useful to iden-
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The effectiveness of CPAP treatment for the reduction of MVA was revealed by this study. Consistent with a report by George et al. (2001), MVA rate in OSAS patients during more than 5 years of CPAP treatment was nearly the same as that in the control group. However, 20.3% of patients to whom CPAP was prescribed discontinued the treatment during the 5-year follow-up period. It is important to encourage the regular use of CPAP in patients with OSAS, with a thorough explanation regarding the effectiveness of this treatment for the reduction of MVA.

This study does have some limitations. First, all subjects are male. Further study of subjects of both genders is necessary. Second, there may be recall and/or sampling bias in our study, because the data was collected based on self-reports, and the control data was obtained from drivers who visited the Driver and Vehicle Licensing Center in order to renew their driver’s license on a voluntary basis. The best way of collecting data is via insurance companies. However, in Japan, we are unable to use data for confidentiality reasons. Despite a possibility of these biases, our study revealed that the rate of MVA was clearly higher in OSAS than in control group. Third, in the logistic regression analysis, the other variables, such as years with driving license, annual mileage, education, economic, social was not used, because our question form did not obtain them. Accuracy of self-reporting might be affected by educational and economic level.

This study is the first systematic investigation of MVA risk among Asian drivers with OSAS. The rate of both MVA and dozing off at the wheel by drivers with OSAS was significantly higher than controls in the study area, similar to findings in Europe and the United States. Subjective sleepiness beyond normal limits (ESS ≥ 11) and serious respiratory symptoms (AHI ≥ 40) were independently associated with the occurrence of MVA. Checking both ESS and AHI is required to assist the reduction of accidents in the Tokyo metropolitan area. In particular, early diagnosis of severe OSAS among drivers should be established to allow intervention and treatment to prevent multiple MVAs.

Acknowledgments

We wish to express our thanks to Yasuro Takahashi MD, PhD (Sleep Disorder Clinic, Neuropsychiatric Research Institute) for his help in this study. The authors are indebted to Prof. J. Patrick Barron of the International Medical Communication Center of Tokyo Medical University for his review of this manuscript.

References


