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Original Article

Attention deficits detected in cognitive tests differentiate between sleep apnea patients with or without a motor vehicle accident

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ABSTRACT

Objectives: Obstructive sleep apnea (OSA) is associated with an increased motor vehicle accident (MVA) risk. Conventional measures of OSA severity do not predict individual risk. Cognitive function tests have failed to incorporate outcomes in risk prediction. We aimed to identify markers of cognitive function for MVA risk prediction in OSA.

Methods: OSA patients [$n = 114$, 75% male, median age 51 (43–61) years, body mass index (BMI) 30 (27–33) kg/m^2, apnea–hypopnea index 25 (6–49) n/h, and Epworth Sleepiness (ESS) score 11 (8–16)] were recruited from a sleep laboratory. Two cognitive function tests, the Attention Network Test (ANT) and a modified Oxford Sleep Resistance Test (OSLER) test (GOSLING), were assessed.

Results: OSA patients with ($n = 11$) or without ($n = 103$) a MVA record in the Swedish traffic accident registry were identified. In patients with a MVA, 64% were commercial drivers. In patients with a MVA history, more lapses [42 (5–121) vs. 5 (1–25), $P = 0.02$] and fewer responses [238 (158–272) vs. 271 (256–277), $P = 0.03$] to stimuli in the ANT were found. In the GOSLING, the number of lapses was higher (29 (10–97) vs. 7 (2–19), $P = 0.01$) and the reaction time was longer [462 (393–551) vs. 407 (361–449) ms, $P = 0.05$]. OSA severity and ESS score poorly predicted MVAs ($P > 0.2$).

Conclusions: We have demonstrated that deficit in sustained attention, assessed by daytime neurocognitive function tests, was associated with MVA risk in OSA patients. We were unable to detect an association between MVA history and severity of OSA or the ESS score. The findings provide a rationale for further development of objective MVA risk assessment tools in OSA.

1. Introduction

Obstructive sleep apnea (OSA) is characterized by episodes of repetitive upper airway collapse during sleep leading to recurrent hypoxia and microarousals from sleep. The common clinical features of OSA include excessive daytime sleepiness (EDS) [1] and deficits in attention [2,3].

The prevalence of motor vehicle accidents (MVAs) has been shown to be two- to threefold higher in patients with OSA [4], and OSA treatment has been shown to be associated with a significant reduction of incident MVA [5]. Despite the strong association between OSA and MVA risk, the challenging task to identify individual patients at risk remains in clinical practice as MVAs occur only in a minority of OSA patients [6].

OSA severity in terms of apneic events failed to consistently predict MVA risk in a recent meta-analysis [4,7]. EDS, operationalized by the Epworth Sleepiness Scale (ESS) score [8], provided only weak prediction of risk [7,9]. The Multiple Sleep Latency Test (MSLT) and the Maintenance of Wakefulness Test (MWT) [10] accurately define sleep propensity and capacity to maintain wakefulness during daytime, but their capacity in terms of MVA prediction has been debated [11]. Moreover, these tests are cumbersome and labor-intense and therefore less suitable for MVA risk assessment in clinical routine. Non-electroencephalography (EEG)-based functional tests applied in the context of MVA risk prediction in OSA include driving simulators [12,13], real-time driving, and reaction time (RT) tests such as the Oxford Sleep Resistance Test (OSLER) [14] and the Psychomotor Vigilance Test (PVT) [15]. Deficits in attention in the general population are associated with impaired driving skills; however, an association between such deficits and documented MVA has not previously been investigated in OSA, a condition associated with increased risk of neurocognitive impairment.

The aim of the current study was to retrospectively assess the possible association between poorer performance in two neurocognitive tests and MVA in a nationwide traffic accident registry in patients with OSA.

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Table 1
Characteristics of the three sub-cohorts included in the main study cohort ($n = 114$).

	Sub-cohort I $N = 58$	Sub-cohort II $N = 43$	Sub-cohort III $N = 13$	P-value	All $N = 114$
Male, *n* (%)	34 (58.6)	40 (93.0)	11 (84.6)	0.001	85 (74.6)
Age, years	53 (44–62)	53 (42–61)	53 (42–56)	0.8	51 (43–61)
BMI, kg/m²	28 (25–33)	31 (29–33)	28 (26–33)	0.1	30 (27–33)
AHI, n/h	11 (2–34)	43 (26–62)	18 (12–35)*	<0.001	25 (6–49)
ODI, n/h	8 (1–27)	35 (22–61)	13 (5–30)	<0.001	21 (5–41)
ESS score	12 (7–16)	12 (9–17)	9 (4–13)	0.08	11 (8–16)
MVA, *n* (%)	8 (14)	2 (5)	1 (8)	0.2	11

Statistics: Data are presented as median (IQR). Nonparametric Mann–Whitney U test and Pearson's chi-squared test were used for between-group differences. *AHI based on PG recording.
Abbreviations: BMI = body mass index, AHI = apnea–hypopnea index, ODI = oxygen desaturation index, ESS = Epworth Sleepiness Scale, MVA = motor vehicle accident.

2. Materials and methods

2.1. Study population

The study cohort ($n = 114$) was assembled at the Sahlgrenska University Hospital Sleep Center. The patients were included from three sub-cohorts of patients comprising the following: (1) patients from a clinical OSA cohort ($n = 58$), (2) subjects recruited from a pharmacotherapy study [16] in OSA ($n = 43$), and (3) a study of public transport operators [17] diagnosed with clinically relevant OSA ($n = 13$) (Table 1). All patients were untreated and participated in a standardized neurocognitive test procedure in the research laboratory between the years 2006 and 2011. Data on gender, age, body mass index (BMI, kg/m²), and ESS score were obtained. The study was approved by the regional ethical review board in Gothenburg. Oral and written informed consent was obtained from all study participants.

2.2. Assessment of daytime sleepiness and OSA

The standardized ESS [8] was used to define general daytime sleepiness. A score of ≥11 was considered as EDS.

Ambulatory polysomnography (PSG) was measured in 99 (87%) patients (Embla® A10, Denver, CO, USA). PSG recordings were analyzed according to the 2007 American Academy of Sleep Medicine (AASM) criteria [18]. Polygraphy recording (PG, Embletta X10 system, Denver, CO, USA) was performed in the remaining 15 patients. Apneic and hypopneic events were scored when a minimum event duration of 10 s was found. Hypopnea, measured by the nasal cannula, was scored when either a ≥ 50% reduction of airflow followed by a ≥ 3% oxygen desaturation or a ≥ 30% reduction of airflow followed by a ≥ 4% oxygen desaturation was recorded [18]. In PG, the apnea–hypopnea index (AHI) was defined as the number of apneas/hypopneas during the recording session defined by lights off and lights on. The corresponding AHI in a PSG study was calculated as the number of apneas and hypopneas per hour of total sleep time. The oxygen desaturation index (ODI) was defined as a ≥ 4% reduction in oxygen saturation [18]. Mild, moderate, and severe OSA was diagnosed according to AHI ≥5 to <15, ≥ 15 to <30, and ≥30 events/h of sleep, respectively. Patients not fulfilling the OSA diagnosis based on an AHI ≥5 n/h had been diagnosed based on a respiratory disturbance index (RDI, sum of AHI and the respiratory effort-related arousal or RERA index) of ≥5/h (if ESS ≥11) ($n = 11$) or an RDI of ≥15/h ($n = 10$) [19].

2.3. Assessment of neurocognitive function

Two different types of neurocognitive tests were performed to assess simple and complex measures of vigilance, sustained attention as well as executive function over time on the day following the sleep study. All patients were comfortably seated in a bed in front of a computer monitor, located in a dark, noise-reduced room. The Gothenburg Sleep Resistance test (GOSLING) [17], a modified version of the OSLER [14], is a simple RT test during which sustained attention is assessed over 20 min. The patient was instructed to press a computer mouse button in response to a 1-s low-intensity stimulus that appeared on a computer monitor. Each stimulus appeared at random intervals of 3 and 10 s to reduce the anticipatory effect. When measuring the speed and number of responses to stimuli, simple RT (milliseconds, ms), number of lapses, consecutive number of lapses, and total number of responses could be evaluated. A lapse was identified when the response time following a stimulus was >2 s, and seven consecutive lapses were an indication of sleep onset and the test would automatically be terminated.

The Attention Network Test (ANT) [20,21] addresses attention related to task fatigue. Three dimensions of attention – alerting, orienting, and executive function – are assessed during the 27-min test. The stimuli presented on the screen are arrows pointing in either the same (congruent > > >>> or < < <<<) or a different (incongruent < < >>< or >><>>) direction. The stimulus is preceded by either a cue or no cue. In addition, the location of the cue in relation to the central fixation point varies randomly. The cue can be presented in relation to the location of the upcoming target (spatial), above, below, or at the fixation point to alert subjects to when but not where the stimuli could be expected (temporal cue). The alerting effect is measured as RT between no cue and central cue at 400 ms. The difference in RT between spatial and temporal cue measures the orienting effect at 200 ms. Conflict (executive function) is defined as the difference in RT between congruent and incongruent stimuli, and it reflects how accurately and efficiently the direction of the arrows are recognized and responded to [21,22].

2.4. National traffic accident registry data – STRADA

Individual information on retrospective MVA history between the years 2001 and 2012 was obtained from the Swedish Traffic Accident Data Acquisition (STRADA) [23] registry. The registry contains nationwide standardized information (>500,000 accidents) reported by the Swedish traffic police at the accident scene and the major emergency hospitals. The present study includes information on MVA and severity of personal injury following the MVA. Patients were cross-analyzed with the STRADA. The number of MVAs per patient and the type of vehicle involved in the accident were obtained.

2.5. Statistics

All statistics were performed using PASW Statistics 17.0.2 (SPSS Inc., Chicago, IL, USA). Nonparametric independent-samples Mann–Whitney U test was used for ordinal scale data as well as for comparison of between-group differences. Pearson's chi-squared test was used to assess associations between quantitative data, and binary logistic regression was used for categorical response variables and