Egyptian Journal of Occupational Medicine, 2019; 43 (2) : 283-296

ACCIDENTS RELATED TO OBSTRUCTIVE SLEEP APNEA AMONG COMMERCIAL DRIVERS: A CLINIC BASED STUDY

By

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Abstract

Introduction: Egypt is ranked the 3rd country in the world with the highest mortality rates due to road traffic accidents. Epidemiological studies have confirmed that obstructive sleep apnea (OSA) is associated with an increased risk of motor vehicle crashes (MVC) and early death. OSA is an important health and safety issue in the workplace because of its frequency, co-morbidities and potential to impair worker's performance. **Aim of work:** To estimate the prevalence of accidents among commercial drivers with suspected OSA and to identify the risk factors of road traffic accidents (RTA) by comparing drivers with accidents versus (vs) no accidents. **Materials and methods:** Nested case-control study was carried upon (150) commercial drivers suspected to have OSA attended the Sleep Disordered Breathing (SDB) Unit and accepted to participate in the study during two years starting from November 2016 . Data was collected using a questionnaire included socio-demographic characteristics, occupational, medical and driving histories as well as history of sleep related accidents or near accident and mean daily sleep duration. Clinical examination, laboratory tests were done (invasive and noninvasive blood gases) and sleep questionnaires (ESS, FOSQ-10, Berlin questionnaire and STOP BANG questionnaire) were completed. **Results:** The prevalence of accidents was (46.0%) among the studied drivers. The prevalence of OSA was statistically significantly higher among those with accidents (81.2%) than those without accidents (60.5%) and the significant independent predictors of accidents among drivers were

having 1st class license, shift work, rapid eye movement sleep (REM) % and OSA. **Conclusion:** The prevalence of OSA was higher among those with accidents than those without accidents and OSA was independent significant predictor of RTA.
Keywords: Obstructive Sleep Apnea, Drivers, Sleep disorders, Berlin questionnaire, STOP BANG questionnaire and Motor vehicle crashes.

Introduction

Road traffic accidents (RTA) are the principal cause of global mortality and morbidity worldwide; killing about 1.3 million people and injuring from 20 to 50 million each year. From the public health concern, Egypt is ranked the 3rd country in the world with the highest mortality rates due to road traffic accidents (Morsy et al., 2015), current estimates for Egypt show a road traffic fatality rate of 42 deaths / 100,000 population, which is considered one of the highest rates in the Eastern Mediterranean Region. Traffic accidents are also the cause of 1.8 % of all deaths and 2.4 % of all disability-adjusted life years (DALYs) lost in Egypt (Puvanachandra et al., 2012).

Falling asleep during driving accounts for a considerable proportion of motor vehicle accidents (Horne and Reyner, 1999 ; Morsy et al., 2017) and the risk of occupational accidents increases by 50% among men with obstructive sleep apnea (OSA), (Ulfberg et al., 2000) . Sleep problems constitute a significant problem among Egyptian youths in Mansoura (Ahmed et al., 2018). A five years study found that 8.9% of patients with OSA had been involved in one or more vehicle accidents due to falling asleep while driving (Shiomi et al., 2002). Consequently, epidemiological studies have confirmed that OSA is associated with an increased risk of motor vehicle crashes (MVC) and early death (Osorio et al., 2015). OSA is a chronic disease which is under-diagnosed (Costa et al., 2015), adversely affecting work performance and is associated with a high injury rate (Heaton et al., 2010). It is characterized by recurrent attacks of apnea and intermittent hypoxemia during sleeping, arousals, and excessive daytime sleepiness (American Academy of Sleep Medicine, 2014).

Obstructive sleep apnea is considered a major disorder that negatively affects the general health (Morsy , 2018). Although OSA is not an occupational disease, it was inevitable that it would manifest as an important health and safety issue in the workplace because of its frequency, co-morbidities (Morsy et al., 2012 and Alkhiary et al., 2017) and potential to impair worker 's performance (Kales and Czeisler, 2016).

There is a lack of knowledge about the contribution of OSA to RTA in Egypt. This study estimates the prevalence and predictors of accidents among commercial drivers with suspected OSA referred to the sleep disorders clinic.

Aim of work

To estimate the prevalence of accidents among commercial drivers with suspected OSA referred to the sleep disorders clinic, Mansoura University Hospital and to identify the risk factors of RTA by comparing drivers with accidents vs. no accidents

Materials and methods

- Study design: Nested case-control study: A cross-sectional study was done to estimate the prevalence of RTA followed by comparing cases with RTA vs. no RTA to find out the risk factors of accidents.

- Place and duration of the study: Sleep Disordered Breathing (SDB) Unit in the Chest Department – Mansoura University Hospital during two years starting from November 2016.

- Study sample: A convenience sample of all commercial drivers suspected to have OSA attended the Sleep Disordered Breathing (SDB) Unit and accepted to participate in the study. The drivers were 172 and only 150 were fulfilling the eligibility criteria and accepted to participate and completed the questionnaires with response rate (87.2%). Exclusion criteria: The drivers with congenital anomalies and facial deformities (acromegally, retrognasthia, micrognasthia, midface hypoplasia) were excluded.

- Study methods:

1- Self administrated questionnaire was used to collect data included personal, medical , occupational and driving histories as well as history of sleep related accidents or near accident and mean daily sleep duration.

2-Full clinical examination:

All studied group were subjected to general examination and local chest examination.

3-Anthropometric measurement: Weight, standing height and Body Mass Index (BMI) was calculated.

4-Epworth Sleepiness Scale (ESS): It was used for measuring daytime sleepiness by measuring probability for dozing in eight different active and passive situations where each situation scored 0-3 according to the possibility of dozing as the following: (0 = Never doze, 1 = Slight chance of dozing, 2 = Moderate chance of dozing, 3 = High chance of dozing) (Johns, 1991). Then the collected score ≥ 10 indicate daytime sleepiness.

5- Functional Outcome of Sleep Questionnaire -10 (FOSQ-10): It was used after taken the permission of the driver to measure the effect of excessive daytime sleepiness on multiple activities of everyday living (Chasens et al., 2009).

6- Berlin Questionnaire:

This questionnaire is used to detect patients with high, low or no risk for obstructive sleep apnea. It contains 3 categories where each category if scored positive take one point and sum of points for 3 categories is interpreted as the following: If the score is equal to or more than (2) it means high risk for OSA (Netzer et al., 1999).

7-STOP BANG Questionnaire (Chung et al., 2008):

This test is used for screening the patients for OSA. It consists of 8 items: S= snoring, T= tiredness, O= observed apnea during sleep, P= high blood pressure, B= body mass index ≥ 35kg/m2, A= age ≥ 50 years, N= neck circumference ≥40 cm, G= gender (male gender is positive). Each positive item gets one point and the sum is interpreted as High risk of OSA: ≥3.

8-Invasive and noninvasive blood gases assessments:

A) Arterial blood gases (awake in sitting position): was done to exclude hypoventilation causes; arterial blood was obtained from the radial artery. Before a radial artery puncture, adequacy of collateral circulation to the hand from ulnar artery was established using the modified Allen’s test; then blood collected anaerobically while the patient was breathing room air; the specimen adequately anti coagulated, and a sample volume of 2-4 ml was taken. The sample was analyzed as soon as possible using blood gas analyzer with special attention to pH of the blood, arterial partial pressure of oxygen (PaO2) (mmHg), arterial partial pressure of carbon dioxide (PaCO2) (mmHg), bicarbonate level (HCO3) (mmol/L), and O2 saturation in arterial blood (SaO2%) (Ruppel, 2009).

B) Finger Pulse Oximetry using (NONIN Medical, Inc. GO_2 ™)

For diagnosis of OSA, each participant underwent Polysomnography: In laboratory, attended, full night polysomnography using (SONMOscreenTM plus, SOMNOmedics, Germany) with American Academy of Sleep Medicine (AASM) standard montage, studies were interpreted according to the manual scoring criteria available in the period of the study (Iber et al., 2007; Berry et al., 2012).

Definition of important polysomnographic indices used in statistics: (Iber et al., 2007)

- **Sleep efficiency:** (in percent) is usually defined as: the total sleep time (TST)× 100/ the total recording time (TRT) .
- **Basal oxygen saturation:** the level of oxygen saturation during wakefulness while subject is supine.
- **Minimal oxygen saturation:** Minimum oxygen saturation during sleep.
- **Oxygen desaturation index (ODI):** is the number of times of sleep that the blood's oxygen level drops by 3 % or more from baseline and divided by TST (in minutes) X 60.
- **Deep sleep percentage:** Percentage of TST occupied by N3 stage (deep sleep stage) = (Time in N3 stage (in minutes) divided by TST in minutes X100).
- **Rapid eye movement sleep percentage (REM):** Percentage of TST occupied by REM stage (rapid eye movement sleep) = (Time in REM stage (in minutes) divided by TST in minutes X100).
- **Arousal index:** number of arousals per hour of sleep and divided by TST (in minutes) X 60.

Diagnosis of OSA depended on the diagnostic criteria of the third international classification of sleep disorders (ICSDs) (American Academy of Sleep Medicine, 2014).

Consent

Written consent was obtained from each driver sharing in this study after assuring confidentiality.

Ethical approval

The research procedures were conducted in accordance with the principles of the Declaration of Helsinki. The study was approved by Institutional

Review Board (IRB) of Faculty of Medicine, Mansoura University with code number (R/18.11.324).

Data management

Data was analyzed using SPSS version 16 for Windows® (SPSS Inc, Chicago, IL, USA). Qualitative variables were presented as number and percent. Chi-square test of significance was for comparison between groups. Quantitative data were described using median (minimum and maximum) for non parametric data and mean ± standard deviation for parametric data after testing normality using Kolmogrov-Smirnov test. In normally distributed variables unpaired t-test (t) was used. In abnormally distributed variables independent Mann-Whitney test was used. For detection of independent factors we used binary logistic regression model. p ≤0.05 was considered statistically significant.

Discussion

Results

Table 1: Demographic and job features of participating drivers according to their exposure to accidents.

Driver characteristics	Accidents No (%)	NO accidents No (%)	Significance tests	Odds ratio (95% CI)##
Total	69(46.0)	81(54.0)		
Age(years):25-40(r) ¶	22(31.9)	28(34.6)		1
>40	47(68.1)	53(65.4)	t=0.45, p=0.7	1.1(0.6-2.2)
Mean ± SD	45.5±10.4	44.8±8.8		
BMI(kg/m^2)				
Mean ± SD	40.2±6.2	38.8±6.9	t=1.31, p=0.2	
Cigarette smokers				
Never smoke(r) ¶	35(50.7)	44(54.3)	c^2=0.19, p=0.7	1
Current/ex- smokers	34(49.3)	37(45.7)		1.2(0.6-2.2)
Vehicle type:				
Taxi, Truck& Tractor	44(63.8)	50(61.7)	c^2=0.33,p=0.7	1.2(0.5-2.6)
Bus ,mini & micro	12(17.4)	14(17.3)	c^2=0.21, p=0.8	1.1(0.4-3.2)
Tricycle (r) ¶	13(18.8)	17(21.0)		1
Driving experience(years):				
≤15 (r) ¶	20(29.0)	30(37.0)	c^2=1.1, p=0.3	1
>15	49(71.0)	51(63.0)		1.4(0.7-2.9)

License class: 1st 2nd 3rd **Tricycle(r) ¶**	22(31.9) 18(26.1) 26(37.7) 3(4.3)	9(11.1) 23(28.4) 30(37.0) 19(23.3)	c^2=3.7,**p=0.0002*** c^2=2.3, **p=0.02*** c^2=2.5, **p=0.01***	15.5(3.7-65.6) 5(1.3-19.4) 5.5(1.5-20.7) 1
Shift work Yes NO (r)¶	 37(53.6) 32(46.4)	 26(32.1) 55(67.9)	 c^2=7.1, **p=0.008***	 2.4(1.3-4.8) 1
Total sleep hours/day Mean ± SD	 6.9±1.8	 7.5±1.6	 t=2.23, **p=0.03***	
Driving hours/day Median(min-max)	 8(1-13)	 8(2-18)	 Z=0.22, p=0. 8	
Nodding while driving Yes NO(r)¶	 52(75.4) 17(24.6)	 44(54.3) 37(45.7)	 c^2=7.2, **p=0.007***	 2.6(1.3-5.2) 1

##CI: Confidence Interval c2 : chi square test t: student t test Z of Mann-Whitney test
¶(r): reference group *: Statistically significant

Table (1) showed that the prevalence of accidents was (46.0%) among the studied drivers and the accidents were statistically significantly higher among drivers who had 1st, 2nd or 3rd class license than those with tricycle license: OR& 95% CI=15.5(3.7-65.6), 5(1.3-19.4) and 5.5(1.5-20.7), respectively. Drivers who had shift work and nodding while driving (OR:2.4 times and 2.6 times ,respectively) were more likely to experience accidents than those who didn't have shift work and nodding while driving:(95% CI=1.3-4.8 and 1.3-5.2, respectively).Total daily sleep hours were significantly higher among drivers without accidents (7.5hrs. ±1.6) than those who developed accidents (6.9 hrs. ±1.8).

Table 2: Comparison of clinical and polysomnographic parameters between drivers with and without accidents.

	Accidents (No=69) Mean ± SD	NO accidents (No=81) Mean ± SD	Significance test	Odds ratio (95% CI)##
ESS	14.9±4.6	10.8±5.7	t=4.8, **p≤0.001****	
FOSQ	24.1±7.9	28.9±8.3	t=3.7, **p≤0.001****	
Basal O_2 saturation	90.6±4.9	91.6±3.7	t=1.5, p=0.15	
Minimal O_2 saturation	72.7±11.9	75.9±14.0	t=1.4, p=0.14	
Oxygen desaturation index Median(min-max)	63(1-97)	32(0-94)	Z=3.4 **p=0.001****	
Deep sleep% Median(min-max)	5(0-113)	8(0-20)	Z=3.8,**p≤0.001****	
REM sleep %	13.9±6.1	18.8±4.1	t=5.9, **P≤0.001****	
Sleep efficiency	84.4±١٦,٣	87.9±5.6	t=3.6,**p≤0.001****	
Arousal index Median(min-max)	65(1-95)	30(0-97)	Z=4.6=, **p≤0.001****	
OSA				
Yes	56(81.2)	49(60.5)	c^2= 7.6, **p=0.006***	2.8(1.3-5.9)
NO(r) ¶	13(18.8)	32(39.5)		1

##CI: Confidence Interval Z of Mann-Whitney test c2: chi square test t: student t test
¶(r): reference group *: Statistically significant **: Highly statistically significant
ESS: Epworth sleepiness scale FOSQ: Functional outcome of sleep questionnaire
OSA: Obstructive sleep apnea REM sleep %: Rapid eye movement sleep percentage

Table (2) revealed that there was statistical significant difference between drivers who experienced accidents and those who didn't regarding :ESS, FOSQ , Oxygen Desaturation index , Deep sleep%, Sleep efficiency and Arousal index . The prevalence of OSA was statistically significantly higher among those with accidents (81.2%) than those without (60.5%). Drivers who had OSA were 2.8 times more likely to experience accidents more than those who didn't have: 95% CI= 2.8(1.3-5.9).

Table 3: Logistic regression analysis of independent predictors of accidents.

	β	p	Adjusted OR (95%CI)
License class: 1st 2nd 3rd Tricycle ¶	2.4 0.8 1.1	**0.003*** 0.3 0.1	10.9(2.3-53.1) 2.3(0.5-10.5) 2.9(0.7-12.3)
Shift work Yes NO ¶	1.1	**0.02***	2.7(1.2-6.4)
REM sleep % (continued)	- 0.2	**≤0.001****	0.8(0.7-0.9)
OSA Yes NO(r) ¶	1.3	**0.008***	3.6(1.4-9.3)
Constant Model c^2 Percent correctly predicted	3.8 c^2= 61.5,**P≤0.001**** 78%		

¶(r): reference group *: Statistically significant **: Highly statistically significant
OSA: Obstructive sleep apnea REM sleep %: Rapid eye movements sleep percentage

Table (3) showed the Binary logistic regression which revealed that the significant independent predictors of accidents among drivers were having 1st class license, shift work, REM sleep % and OSA with adjusted odds ratio (10.9, 2.7, 0.8 and 3.6; respectively). The model predict about 78% of the variability of accidents.

The present study found that the prevalence of accidents was 46.0% among the studied high risk group of commercial drivers (suspected to have OSA) (Table 1). This rate is intermediate when compared to findings in other countries. BaHammam et al., (2014) reported a higher rate (63.4%) in Saudi Arabia. However, a lower rate of 35.3% was reported in Nigeria (Adejugbagbe et al., 2015) .This variation in the accidents prevalence may be referred to the variety of contributing factors that play role; human (driver), vehicular and environmental (infrastructure and climatic) factors.

Shift work was significantly more prevalent among drivers experiencing accidents than those who didn’t (53.6% vs 32.1%) (Table 1) and this can be attributed to that both circadian sleep propensity and sleep pressure due to the prolonged wakefulness resulting in the reduction of vigilance levels thus contributing to accidents occurrence. This was in accordance with Barger et al., (2005) and Lee et al., (2016) who studied shift work effect among drivers and found that it increases the difficulty in keeping their eyes open and consequently increases the risk for driving accidents.

The current research detected that the daily sleeping hours were significantly lower among drivers experiencing accidents than those who didn't (6.9 ±1.8 vs 7.5±1.6 hours) (Table 1) and this result agreed with that of Martiniuk et al., (2013) and Gottlieb and his colleagues (2018) who concluded that insufficient sleep duration was strongly associated with driving accidents. However, Gottlieb et al., (2018) also mentioned in their analysis that it has been argued that some persons are naturally short sleepers and fail to get an optimal sleep duration which is inconsequential in the absence of subjective sleepiness.

The current study reported that nodding while driving was statistically more prevalent among drivers experiencing accidents (75.4%) than those who didn›t (54.3%) (Table 1). A lower percentage was recorded in France where Sagaspe et al., (2010) found that about one-third of drivers experienced at least one episode of severe sleepiness at the wheel over a one-year period and concluded that sleepiness at the wheel is a risk factor for traffic accidents and should be considered as strong warning sign predicting future accidents. Also, Tefft (2010) in the United States revealed that 41% of the drivers admitted having nodded off while driving.

The present work agreed with previous finding of Powell et al.,(2007) who proved the association between ESS scores and traffic accidents , as we found that the Mean± SD of the ESS was statistically higher among drivers who experienced accidents than those who didn't (14.9±4.6& 10.8±5.7, respectively) (Table 2). In contrast to our finding, Sagaspe et al., (2010) in France and BaHammam et al., (2014) in Saudi Arabia found no association between pathological ESS scores and driving accidents.

The current study detected that the prevalence of OSA was statistically significantly higher among those with accidents (81.2%) than those without accidents (60.5%) (Table 2).This finding can be explained as OSA increases the day sleepiness and drowsiness that contributes to the occurrence of accidents. Our result was in accordance with that of Talmage et al., (2008) who detected that (94.8%) of the examined commercial motor vehicle drivers had OSA. Also, many studies as Ellen et al., (2006) in their systemic review and BaHammam et al., (2014) in Saudi Arabia, all concurred that OSA displayed a significantly increased risk of involvement in motor vehicle accidents. Ellen et al., (2006) added that improving the drivers' performance was linked to the successful treatment of OSA. However, lower prevalence of OSA (47.1%) was detected by Badawy et al., (2016) in their study among commercial drivers with history of accidents.

The present work pointed to the significantly higher Oxygen Desaturation index and Arousal index (Table 2) among those with accidents than those without accidents [median (min-max): 63(1-97) &65(1-95) vs32(0-94)& 30(0-97),respectively] and this can be refereed to either partial or total upper airway obstruction as an effect of sleep disordered breathing. Also we detected a significantly lower FOSQ, REM sleep %, Sleep efficiency and Deep sleep% among those with accidents than those without accidents. All these findings can be attributed to the OSA among these drivers.

For identification of predictors of accidents in the present study, logistic regression analysis was performed using the significant variables in bivariate analysis and the results as shown in (Table 3) indicated that accidents were more likely to occur among commercial drivers with: 1st class license [AOR=10.9], shift work [AOR=2.7], OSA [AOR=3.6] and reduced REM sleep % [AOR=0.8] .The majority of research studies supported the finding that OSA is a significant risk factor for the traffic accidents (Terán-Santos et al., 1999; Howard et al., 2004 and Ellen et al., 2006), and even Kales and Czeisler, (2016) detected a two-fold increase in the risk of motor vehicle crashes. Also, Tregear et al., (2009) concluded their study that untreated OSA is a significant contributor to motor vehicle crashes.

Regarding shift work and its related increased accident risk, in accordance with our finding, Van Dongen (2006) showed that shift work was studied primarily in terms of external factors negatively affecting work alertness and increased the risk of occupational accidents. Also, Crummy et al., (2008) detected unexpected high proportion of shift work among Australian drivers surviving MVC.

Study Limitations:

There was a bias in selection of cases as they were not taken randomly but they are either self-referred or referred by a physician due to accident or near accidents or significant symptoms of sleep disordered breathing. It is a single center study so the results can't be generalized to all commercial drivers.

Conclusion:

The current study showed that the prevalence of accidents was (46.0%) among the studied drivers and OSA was independent significant predictor of RTA.

Recommendations:

Health education sessions should be regularly offered (at the renewal of their license) for commercial drivers about: getting enough sleep hours at least 7 hours of sleep per day, developing and maintenance of good sleeping habits (eg; sticking to a sleep schedule) and consultation with a physician if they have a sleep disorder or symptoms of a sleep disorder as snoring or feeling sleepy during the day. Further multicenter studies are recommended to express the magnitude of the problem on a larger scale and programs should be carried out for regular OSA screening among commercial drivers.

Conflict of interest

None.

Acknowledgement

The authors would like to acknowledge all the staff of the Sleep Disordered Breathing (SDB) Unit for their help and support. Also, we acknowledge the drivers who agreed to participate in the current study.

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