**Original Article**

# Role of Neck Circumference in Road Traffic Accidents of Commercial Bus and Truck Drivers

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Received: 1/4/2014 Accepted: 2/25/2014

**Abstract**

**Introduction:** Sleepiness may predispose drivers to road traffic accidents. Obstructive Sleep Apnea Syndrome is the most common medical cause of sleepiness. Hence increased neck circumference (NC) and obesity are known as obstructive sleep apnea syndrome risk factors, meanwhile NC has been known as an index for such an adverse risk factor. This study was conducted to assess OSAS role in occurrence of road traffic accidents in sleeping drivers of commercial heavy vehicles.

**Materials and Methods:** Seven hundred sixteen truck and bus drivers randomly selected who referred to occupational medicine clinic for routine annual examination. In addition, drivers who had one road accident during study period consists case and other drivers consists control group, respectively. Subjects also completed demographic and driving variables (e.g. type of vehicles) and Epworth Sleepiness Scale questionnaire. We measured Neck Circumference and chance of road accident by Receiver Operating Characteristic Curve (ROC).

**Results:** Mean of NC in sleepy drivers and drivers who had road accidents was significantly higher than other drivers ($P< 0.05$). Drivers who had night driving had significantly higher road accident in comparison with others (odds: 3.83; CI: 1.36-10.77; $P=0.01$). Marital status ($P< 0.05$) and road accident ($P< 0.001$) had significant association with sleepiness occurrence. According to ROC curve analysis, 43.18 centimeters as cut off point for positive results, was higher sensitivity and specificity for prediction of road accidents.

**Conclusion:** Drivers who have sleepiness and especially OSAS have more chance to involve an accident. By measuring of NC as OSAS, predictor may be able to reduce the risk of road accidents between commercial drivers.

**Keywords:** Sleep Apnea, Obstructive, Neck, Accidents, Traffic

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## Introduction

Sleepiness is one of the major causes of traffic road accidents and crashes [1-2]. Sleepiness and sleep disorders prevalence had been considered in recent epidemiological studies [1, 3-4]. The most common medical cause of sleepiness is Obstructive Sleep Apnea syndrome (OSAS) which is known with transient cessation of breathing during sleep, excessive daytime sleepiness being one of its major symptoms and is diagnosed with polysomnography [5]. Increased neck circumference (NC) and obesity had been reported as OSAS risk factors [6-7].

In previous studies had been reported that OSAS in drivers who had accidents was higher in comparison with other drivers [8-12]. Another studies reported that sleep disorders such as OSAS have also been shown to increase the crash risk of motor vehicle drivers by two to seven fold [13]. OSAS had high prevalence among commercial drivers and estimated that between 12% and 28% of them were affected [14-17]. Most of studies reported that OSAS cause impairments in attention/ vigilance, executive function, and memory and psychomotor function [18]. This is an obvious concern to driving, which is a complex task requiring simultaneous or divided attention to multiple spheres such as the roadway, other vehicles, acceleration, deceleration, steering, and navigation of the overall trip route, etc. [19].

The precise measure of crash risk related to a diagnosis of sleep apnea or other measures of daytime sleepiness and driver sleep health, has yet to be quantified. Recently, the relationship between role of neck circumference and traffic accidents has assumed great importance. Therefore this study was designed to investigate the role of neck circumference in road traffic accidents of commercial bus and truck drivers.

## Materials and Methods

### Study samples

Seven hundred sixteen truck and bus drivers between June 2009 and February 2011 were included respectively into the present case-control study. Study was approved in ethical research committee of Shahid Sadoughi University of medical sciences and health services. All drivers signed consent informs and fully understand about the study purpose and methods. Study participants were male, lived in Yazd province, and were randomly selected from drivers who referred to occupational medicine clinic for routine annual examination. Drivers were excluded from the study if they have narcolepsy, Insomnia, epilepsy, depression, history of opium, alcohol and psychotropic drugs. Drivers who had one road accident during study period (2 years of study) consists case and other drivers consists control group, respectively.

We classified driving accidents into the three groups: Mild (less than 100 dollars damage), Moderate (more than 100 dollars) and Sever accidents (more than 100 dollars damage with driver damage). Accident damages were divided into the own vehicle, opponent vehicle and both vehicles.

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**Driver interview and sleep apnea testing**

A questionnaire was made by researchers for gathering demographic and driving related variables of study participants. The questionnaire collects information about the driver's characteristics including demographics, sleep quantity and quality. Primary we screened sleepiness drivers with self-reported standardized, validated sleepiness questionnaire the Epworth Sleepiness Scale [20]. The ESS is now the most commonly tools for assessment sleepiness in studies, which were performed in subjects with sleep disorders [21-23]. In it, the subject is asked to rate their likelihood of falling asleep in eight everyday situations over the previous month on a scale of 0–3 (0 = no chance of dozing, 1 = slight chance of dozing, 2 = moderate chance of dozing, 3 = high chance of dozing). The ESS score is the sum of the eight item scores and ranges from 0 to 24. Higher ESS scores indicate greater daytime sleepiness [21-22].

Driving related variables such as type of vehicle, driving in city or out of the city and in the night time, driving and sleep duration per day, driving distance per week mean and maximum of driving speed were collected. Neck circumference (NC) was measured for study participants.

**Statistical analysis**

We used SPSS ver16.0 for statistical analysis and all two tailed P-values less than 0.05 were considered as significant. For statistical calculations, the Chi square and student t-test were used for qualitative and quantitative results, respectively. We classified drivers into the two groups: with and without road accident and odds ratio were calculated for detection role of each variable in accident occurrence. Multivariate logistic regression analysis was performed for assessment impact of study variables on driving accident in study participants. Cigarette smoking, driver place, night driving, BMI, sleep duration were included into the model. Variables that were remained into the model were known as independent predictor of road accident occurrence.

**ROC curve calculation**

In the present study, we measured Neck circumference (NC) and for calculating of sensitivity and specificity of this measurement, we used having road accident as gold standard and try to find better NC to have suitable prediction for next road accidents in other drivers. The areas under the receiver operating characteristic curve (ROC) were calculated as a measure of predictive chance of road accident in participated drivers. An index of 0.5 indicates no discrimination ability, whereas a value of 1 indicates perfect discrimination. The cut-off points of NC increase and decrease were identified according to the corresponding plotted curves. The difference between proportions was evaluated by the chi-square test with Yates' correction, when necessary.

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## Results

### Demographic variables

Mean of driving experiences and EES score in drivers who had traffic accident were significantly higher than other drivers. Marital status and cigarette smoking in participated drivers had significant association with occurrence of traffic accidents. Mean of NC in patients involved in road accident (38.01±1.79) was not significantly higher than other drivers (37.75±2.83, P=0.19). Details of study variable comparison were presented in Table 1.

**Table 1:** Comparison of demographic and basal variables between all of participated drivers

| | | | | |
|---|---|---|---|---|
| **Marital** | Single | 15 (5.9%) | 59 (12.8%) | 0.00* |
| | Married | 239 (94.1%) | 403 (87.2%) | |
| **education** | Lower than diploma | 183 (72%) | 331 (71.6%) | 0.49* |
| | Higher than diploma | 71 (28%) | 131 (28.4%) | |
| **Smoking** | Yes | 106 (41.7%) | 121 (26.2%) | 0.00* |
| | No | 148 (58.3%) | 340 (73.8%) | |
| **Drivers** | Camion | 238 (93.7%) | 420 (90.9%) | 0.12* |
| | Bus | 16 (6.3%) | 42 (9.1%) | |
| **Driving experience** | | 16.22±6.92 | 14.58±9.15 | 0.01** |
| **Body Mass Index** | | 25.94±3.06 | 25.81±4.03 | 0.65** |
| **Age** | | 40.43±9.43 | 39.02±9.82 | 0.06** |
| **Sleep time per day** | | 7.94±0.88 | 7.93±0.88 | 0.86** |
| **EES score** | | 6.13±3.33 | 4.29±3.09 | 0.00** |
| **Neck circumference** | | 38.01±1.79 | 37.75±2.83 | 0.18** |

**p-value* calculated with Chi-square test

***p-value* calculated with student sample t-test

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**Driving related variables among drivers with and without sleepiness**

Finally, amongst 716 drivers, 91 drivers had more than 10 EES score. Marital status and road accident had significant association with sleepiness occurrence. Mean of age, BMI, NC and driving experience in sleepy drivers had significantly higher than other drivers.

**Table 2:** Comparison of driving related variables between drivers with and without sleepiness

| | | | | |
|---|---|---|---|---|
| **Marital status** | Single | 70 (11.2%) | 4 (4.4%) | 0.04* |
| | Married | 555 (96.9%) | 87(100%) | |
| **education** | Lower than diploma | 449 (71.8%) | 65 (71.4%) | 0.93* |
| | Diploma and higher | 176 (29.2%) | 26(28.6%) | |
| **Cigarette smoking** | Yes | 192 (30.8%) | 35(38.5%) | 0.14* |
| | No | 432 (69.2%) | 56(61.5%) | |
| **Type of accident** | Mild | 51(25.4%) | 11(20.8%) | 0.77* |
| | Moderate | 96(47.8%) | 28(52.8%) | |
| | Moderate and | 54(26.8%) | 14(27.4%) | |
| **Type of vehicle** | Camion | 574(91.8%) | 84 (92.3%) | 0.88* |
| | Bus | 51(8.2%) | 7 (7.7%) | |
| **Driving place** | City | 79(12.6%) | 12(13.2%) | 0.74* |
| | Roads | 543(87.4%) | 79(86.8%) | |
| **Driving at night** | Yes | 481 (77%) | 70 (76.9%) | 0.93* |
| | No | 144 (23%) | 21(23.1%) | |
| **Road accident** | Yes | 201(32.2%) | 53(58.2%) | 0.00* |
| | No | 424(67.8%) | 38(41.8%) | |
| **Age** | | 38.86±9.62 | 44.11±9.44 | 0.00** |
| **Driving experience (year)** | | 14.51±8.18 | 19.62±9.16 | 0.00** |
| **Body Mass Index** | | 25.70±3.73 | 26.93±3.37 | 0.00** |
| **Driving time per day (hours)** | | 8.81±1.90 | 8.62±2 | 0.38** |
| **Sleep time per day** | | 7.93±0.8 | 7.94±1.27 | 0.93** |
| **Driving distance per week (Km)** | | 3606.8±1967.3 | 3450.5±1236.1 | 0.46** |
| **Neck Circumference** | | 37.77±2.55 | 38.36±2.12 | 0.04** |

**p-value* calculated with Chi-square test

***p-value* calculated with student sample t-test

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Among 91 drivers, had more than 10 EES score, 53 drivers involved in one accident and 38 drivers had no history of accident in study period. Driving in the nighttime had significant association with road accident occurrence in participated drivers (P=0.01). Drivers who had night driving had significantly higher road accident in comparison with others (odds: 3.83; CI: 1.36-10.77; P=0.01).

**Table 3**: Comparison of driving related variables between sleepy drivers of case and control groups

| | | | | | |
|---|---|---|---|---|---|
| **Marital status** | Single | 2 (3.8%) | 2 (5.3%) | 0.7 (0.9-5.25) | 0.74* |
| | Married | 51 (96.9%) | 36(100%) | | |
| **education** | Lower than diploma | 37 (69.8%) | 28 (73.7%) | 0.83 (0.33-2.09) | 0.69* |
| | Diploma and higher | 16 (30.2%) | 10(26.3%) | | |
| **Cigarette smoking** | Yes | 24 (45.3%) | 11(28.9%) | 2.03 (0.8-4.92) | 0.13* |
| | No | 29 (54.7%) | 27(71.1%) | | |
| **Type of vehicle** | Camion | 48(90.6%) | 36 (94.7%) | 0.53 (0.1-2.9) | 0.45* |
| | Bus | 5(9.4%) | 2 (5.3%) | | |
| **Driving place** | City | 7(13.2%) | 5(13.2%) | 1.01 (0.29-3.44) | 0.15* |
| | Roads | 46(86.8%) | 33(86.8%) | | |
| **Driving at night** | Yes | 46 (86.8%) | 24(43.2%) | 3.83 (1.36-10.77) | 0.01* |
| | No | 7(13.2%) | 14(56.8%) | | |
| **OSAS** | Yes | 16(30.2%) | 10(26.3%) | 0.83 (0.32-2.09) | 0.69* |
| | No | 37(69.8%) | 28(73.7%) | | |
| **Age (year)** | | 43.45±9.83 | 45.03±9.16 | - | 0.44** |
| **Driving experience (year)** | | 18.96±7.31 | 20.53±11.28 | - | 0.43** |
| **Body Mass Index** | | 26.81±3.05 | 27.09±3.82 | - | 0.24** |
| **Driving time per day (hours)** | | 8.71±2.12 | 8.5±1.86 | - | 0.70** |
| **Sleep time per day (hours)** | | 7.73±1.44 | 8.23±0.91 | - | 0.06** |
| **Driving distance per week (Km)** | | 3537.7±123.58 | 3450.5±123.61 | - | 0.43** |
| **Driving speed (Km/hours)** | | 79.52±7.02 | 78.89±7.22 | - | 0.28** |
| **Neck Circumference** | | 38.52±2.22 | 38.13±2.01 | - | 0.38** |

**p-value* calculated with Fisher Exact test. ***p-value* calculated with student sample t-test

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We considered road accident as final and gold standard result for assessment of NC measurements. For ROC curve analysis, we considered NC of drivers with and without road accident. According to our ROC curves, we determined that if we consider 43.18 centimeters for NC as cut off point for positive results, we had higher sensitivity and specificity for predicting of road accidents.

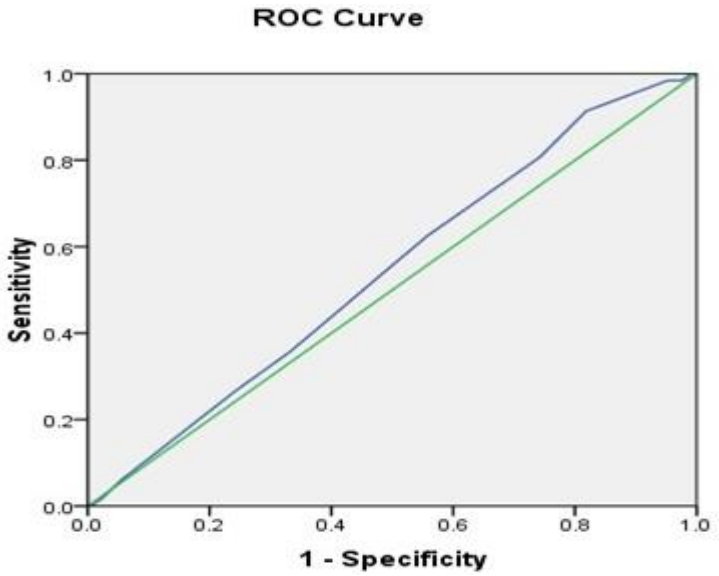


**Figure1:** ROC curve analyses of NC measurements in a population of 91 drivers involved in accident versus 625 drivers without road accident

## Discussion

Mean of NC in sleepy drivers and drivers who had road accidents was significantly higher than other drivers. Sleep disorders is one of the main sources of sleepiness and even daytime fatigue and drivers with OSAS had excessive symptoms [4, 24]. Sleepiness increased the risk of road accidents. In one study on Ontario more than 58% of study drivers had sleepiness [25]. In developed countries, sleep-related crashes represent up to 20% of all road accidents [1, 26-27]. Generally sleepiness is common phenomena between drivers [28]. Our study showed that frequency of OSAS was higher among drivers that were involved in accident. Similar with other studies, sleepiness was one of the main accident causes in our study. In one study reported that 19% of tractor-trailers drivers had fallen asleep at the wheel at least once during the previous month [29]. Near to 40% of long-haul drivers and 21% of short-haul drivers had problems staying alert on at least 20% of their drives [30].

In our study, mean of ESS scores in drivers that involved with accident was significantly higher than other drivers. Similar studies reported that ESS fails to identify drivers with higher accident risk [31-32]. Our study had similar findings. ESS is a validate tool for sleepiness assessment [33-34] but its questions were not enough related to evaluate driving performance [8, 31-32].

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In ROC curve analysis, 43.18 centimeters was determined as cut-point for NC and this cut point better predict road accident in drivers. Previous studies reported that sleep specialist must examined each of commercial drivers separately and drivers who had past sleep disorders such as OSAS and NC higher than 43.18 cm in men and 40.64 cm with BMI more than 35 $kg/m^2$ were considered as at risk population for road accidents [35].

NC and obesity were two more common OSAS risk factors [6-7]. It seemed that obesity might reduce the size of the pharynx and increases its collapsibility. NC is better marker of central fat deposit in comparison with BMI and in recent studies had been reported as an important predictor of snoring and obstructive sleep apnea [4, 36].

Our study had some limitations; firstly, we did not match age and driving experiences between participated drivers. Next study with controlling confounding variables will recommend. Secondly, our study were not multicentre or national study and our findings were limited into the research environment and it is hard to enterprise them into the global community of drivers. National or multicenter study will be recommended.

## Conclusion

Drivers who have sleepiness and especially OSAS had more chance to involve an accident. Measuring of NC as OSAS predictor might have role in reducing risk of road accidents between commercial drivers.

## Acknowledgment

The researchers appreciate all drivers for their contribution and all persons helped us to perform this study.

## References

1. Connor J, Whitlock G, Norton R, et al. The role of driver sleepiness in car crashes: a systematic review of epidemiological studies. Accid Anal Prev. 2001;33(1): 31-41.

2. Hakkanen H, Summala H. Sleepiness at work among commercial truck drivers. Sleep. 2000;23(1):49-57.

3. Ohayon, MM, Caulet, M, Philip, et al. How sleep and mental disorders are related to complaints of daytime sleepiness. Arch Intern Med. 1997;157(22): 2645-52.

4.Sharwood L N., Elkington J, Stevenson,et al. Assessing sleepiness and sleep disorders in Australian long-distance commercial vehicle drivers: self-report versus an "at home" monitoring device. Sleep. 2012;35(4), 469-75.

5. McNamara SG, Grunstein RR, Sullivan CE. Obstructive sleep apnoea. Thorax. , 1993; 48(7): 754-64.

6. Moreno CR, Carvalho FA, Lorenzi C, et al. High risk for obstructive sleep apnea in truck drivers estimated by the Berlin questionnaire: prevalence and associated factors. Chronobiol Int.2004;21(6): 871-9.

7. Horstmann S, Hess CW, Bassetti C, et al. Sleepiness-related accidents in sleep apnea patients. Sleep. 2000;23(3): 383-9.

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8. Sharwood LN, Elkington J, Stevenson M, et al. Severe obstructive sleep apnea and long distance truck driving: A case report. Open Journal of Preventive Medicine. 2012;2(2): 157-61.

9. MasaJF, Rubio M, Findley LJ. Habitually sleepy drivers have a high frequency of automobile crashes associated with respiratory disorders during sleep. Am J Respir Crit Care Med. 2000;162(4 Pt 1): 1407-12.

10. Lloberes P, Levy G, Descals C, et al. Self-reported sleepiness while driving as a risk factor for traffic accidents in patients with obstructive sleep apnoea syndrome and in non-apnoeic snorers. Respir Med. 2000;94(10): 971-6.

11. George CF. Sleep apnea, alertness, and motor vehicle crashes. Am J Respir Crit Care Med. 2007;176(10), 954-6.

12. Pack AI, Maislin G, Staley B,et al. Impaired performance in commercial drivers: role of sleep apnea and short sleep duration. Am J Respir Crit Care Med. 2006;174(4): 446-54.

13. Young T, Blustein J, Finn L. Sleep-disordered breathing and motor vehicle accidents in a population-based sample of employed adults.1997; Sleep 20: 608-13.

14. Talmage J, Hudson T, Hegmann K,et al. Consensus criteria for screening commercial drivers for obstructive sleep apnea: evidence of efficacy . J Occup Environ Med. 2008; 50(1): 324-9.

15. Howard M, Desai A, Grunstein R. Sleepiness, sleep-disordered breathing, and accident risk factors in commercial vehicle drivers. Am J Respir Crit Care Med. 2004; 170(1): 1014-21.

16. Moreno C, Carvalho F, Lorenzi C. High risk for obstructive sleep apnea in truck drivers estimated by the Berlin questionnaire: prevalence and associated factors. Chronobiol Int. 2004; 21(2): 871-9.

17. Parks P, Durand G, Tsismenakis A,et al. Screening for obstructive sleep apnea during commercial driver medical examinations. J Occup Environ Med.2009; 51(3): 275–82.

18. Aloia M, Arnedt J, Davis J, et al. Neuropsychological sequelae of obstructive sleep apnea-hypopnea syndrome: a critical review. J Int Neuropsychol Soc.2004; 10(5): 772-85.

19. Sharwood L N, Elkington J, Stevenson M,et al. Investigating the role of fatigue, sleep and sleep disorders in commercial vehicle crashes: A systematic review. Journal of the Australasian College of Road Safety. 2011; 22(3): 24-30.

20. Johns M. A New Method for Measuring Daytime Sleepiness: The Epworth Sleepiness Scale. Sleep. 1991; 14(6): 540-5.

21. Johns MW. A measuring daytime sleepiness: the Epworth sleepiness scale. Sleep.1991; 16(5), 50-5.

22. Johns MW. Sleepiness in different situations measured by the Epworth Sleepiness Scale. Sleep. 1994; 17(8): 703-10.

23. Engleman HM, McDonald JP, Graham D, et al. Randomized crossover trial of two treatments for sleep apnea/hypopnea syndrome: continuous positive airway pressure and mandibular repositioning splint. Am J Respir Crit Care Med. 2002;166(6):855-9.

24. Stoohs RA, Guilleminault C, Itoi A, et al. Traffic accidents in commercial long-haul truck drivers: the influence of sleep-disordered breathing and obesity. Sleep. 1994;17(7): 619-23.

25. Vanlaar W, Simpson H, Mayhew D, et al. Fatigue and drowsy driving: a survey of attitudes, opinions, and behaviors. J Saf Res. 2008; 39(3): 303-9.

26. Horne JA, Reyner LA. Driver sleepiness. J Sleep Res. 1995: 4(S2): 23-9.

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27. Philip P, Vervialle F, Le Breton P, et al. Fatigue, alcohol, and serious road crashes in France: factorial study of national data. Br Med J. 2001;322(7290):829-30.

28. MacLean AW, Davies DR., Thiele K. The hazards and prevention of driving while sleepy. Sleep Med Rev. 2003; 7(6):507-21.

29. Braver E, Preusser C, Preusser D,. Long hours and fatigue: a survey of tractor-trailer drivers. J Public Health Policy. 1992; 13(3): 341-66.

30. Hakkanen H, Summala H. Sleepiness at work among commercial truck drivers. Sleep.1999; 23(1): 49-57.

31. Young T, Blustein J, Finn L. Sleep-disordered breathing and motor vehicle accidents in a population-based sample of employed adults. Sleep. 1999; 20(8): 608-13.

32. Masa J, Rubio M, Findley L, Group C. Habitually sleepy drivers have a high frequency of automobile crashes associated with respiratory disorders during sleep. J Respir Crit Care Med.2000 ;162(4): 1407-12.

33. Johns M. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep.1991; 14(6): 540-5.

34. Johns M. Sensitivity and specificity of the multiple sleep latency test (MSLT), the maintenance of wakefulness test and the Epworth sleepiness scale: failure of the MSLT as a gold standard. J Sleep Res.2000; 9(1): 5-11.

35. Hartenbaum N, Collop N, Rosen I, et al. Sleep apnea and commercial motor vehicle operators: statement of the joint task force of the American college of chest physicians, the American college of occupational and environmental medicine and the national sleep foundation. Chest.2006; 130(3): 902-5.

36. Davies RJ, Ali NJ, Stradling JR. Neck circumference and other clinical features in the diagnosis of the obstructive sleep apnoea syndrome. Thorax. 1992; 47(2): 101-5.

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