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Obstructive sleep apnea in coronary artery bypass grafting patients

Syventävien opintojen kirjallinen työ

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The aim of this work was to study the sleep of patients admitted for coronary artery bypass grafting (CABG). Obstructive sleep apnea (OSA) and coronary artery disease have shared risk factors and OSA can complicate recovery from CABG.

Thirty five CABG-patients with no former diagnosis of sleep apnea underwent polysomnography (PSG) before the surgery. Their mean Body Mass Index (BMI) was 28,4kg/m^2 and mean age 67.5 years. Subjective symptoms were assessed using the Epworth Sleepiness Scale (ESS), The International Restless Legs Syndrome Study Group Rating Scale (IRLS), Depression Scale (DEPS) and The Basic Nordic Sleep Questionnaire (BNSQ).

The mean of apnea-hypopnea index (AHI) was 24,0/h and 62,9% of the patients had moderate or severe sleep apnea. In the supine position, mean AHI was 42.9/h. Patients had on average 16.1 arousals/h. However, in the questionnaires only few reported symptoms associated with OSA, such as daytime sleepiness and morning headache. This study revealed that many CABG-patients have OSA and that they do not present typical symptoms.

Keywords: Obstructive sleep apnea, apnea-hypopnea index, coronary artery bypass grafting, coronary artery disease

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Abstract

Study objectives: To investigate sleep-related problems, particularly the prevalence of obstructive sleep apnea (OSA) and associated subjective symptoms in patients before elective coronary artery bypass surgery (CABG)

Methods: In an ongoing study of patients for elective CABG, five women and 30 men (median age 67.5 years, median BMI 28.2 kg/m^2) underwent polysomnography prior to operation. Subjective symptoms were evaluated with the Epworth Sleepiness Scale (ESS), Depression Scale (DEPS), The International Restless Legs Syndrome Study Group Rating Scale (IRLS) and The Basic Nordic Sleep Questionnaire (BNSQ)

Results: The mean apnea-hypopnea index (AHI) was 24.0/h. Moderate or severe OSA, AHI ≥15, was registered in 62.9 % of patients. OSA was more pronounced in the supine position with a mean AHI of 42.9 /h. Despite elevated AHI values, patients reported only mild symptoms in the sleep quality and daytime functioning questionnaires. Morning tiredness and AHI did not correlate (rs=-0.145; p = 0.407).

Conclusions: We found that 62.9% of patients undergoing elective CABG had moderate to severe OSA reporting only few subjective daytime symptoms.

Keywords: Obstructive sleep apnea (OSA), Apnea Hypopnea Index (AHI), Coronary artery bypass surgery (CABG), coronary artery disease (CAD)

Introduction

Coronary artery disease (CAD) and sleep-related disorders represent significant and increasingly recognized public health concerns due to their high prevalence and profound impact on morbidity and mortality (1). In a Swedish study conducted within a randomly selected cohort, CAD was identified in 42.1 % of the study population with significant coronary stenosis detected in 5.2% of individuals (2). In high-income countries, the prevalence of CAD requiring coronary artery bypass grafting (CABG) is estimated to be approximately 18.3 per 100 000 population (3).

Emerging evidence shows a strong association between obstructive sleep apnoea (OSA) and cardiovascular diseases such as hypertension, atrial fibrillation and CAD (4–6). OSA is particularly prevalent among patients scheduled for CABG, with some studies indicating that over half of these patients have OSA, defined as apnoea-hypopnea index (AHI) ≥15 events/h (7,8). Furthermore, a recent meta-analysis has demonstrated that individuals with OSA have higher incidence of major adverse cardiac and cerebrovascular events (MACCE) including myocardial infarctions (9).

Given the frequent co-occurrence of CAD and sleep disorders, particularly OSA, deeper understanding of the interplay between these conditions is needed. In this study, we collected sleep data from CABG patients to identify typical sleep disorders in patients with severe CAD.

Methods

Subjects

This single-centre study was initiated in February 2023 at the Wellbeing Services County of Southwest Finland and patient recruitment is currently ongoing. All participants undergoing elective CABG in Turku University Hospital were invited to participate in the study. Polysomnography (PSG) was scheduled immediately following the provision of study information and the acquisition of informed consent. The mean time between PSG and surgery was 16.1 days (SD 13.9). Patients with known OSA with continuous positive airway pressure (CPAP) therapy, and patients who underwent other cardiac procedures in addition to CABG, were excluded from the study. Ethical approval for study was granted by Ethics Committee of Turku University Hospital (ETMK 27/1801/2022). The study is registered at ClinicalTrials.gov NCT06453538.

Baseline demographic and clinical data were collected before PSG registration: age, weight, height, body mass index (BMI), other diseases, current medication use, and medical history. Laboratory samples included: Plasma full blood count, potassium, sodium, creatinine, troponin-T, CK-MB mass, ProBNP and serum-CRP, lipid profile, fasting plasma glucose and glycated haemoglobin B-HbA1c. An electrocardiogram (ECG) recording was obtained preoperatively to evaluate arrhythmias.

Subjective sleep quality

To evaluate subjective sleep quality, participants completed validated questionnaires: Epworth Sleepiness Scale (ESS) (12), Depression Scale (DEPS) (13), the International Restless Legs Syndrome Study Group Rating Scale (IRLS) (14) and The Basic Nordic Sleep Questionnaire (BNSQ) (15). Two questions from BNSQ were used (Figure 1 and Figure 2)

Polysomnography

PSG recordings were conducted in the Sleep Research Centre of Turku University, Turku, Finland. All participants underwent standard overnight PSG using a commercially available system (NOX A1 and NOX A1s ®, manufactured by Nox Medical ehf Reykjavik, Iceland). The recordings included electroencephalography (EEG; C3/A2, C4/A1, O1/A2, and O2/A1), electrooculography (EOG), a chin electromyogram (EMG), a two-electrode ECG recording, bilateral leg EMG, and body position monitoring. Oxygen saturation (SpO_2) was assessed using a wrist-worn pulse oximeter. Thoracic and abdominal respiratory efforts were monitored with respiratory belts, and nasal airflow was measured using nasal pressure transducers. Snoring was recorded via microphone.

Sleep stages and arousals were scored in 30-second epochs based on EEG, EOG, and chin EMG signals, following standard American Academy of Sleep Medicine (AASM) guidelines (16). The same guidelines were used to score respiratory events (obstructive apneas, mixed apneas, central apneas and hypopneas). Hypopneas were identified using the recommended

AASM definition: a ≥30 % reduction in airflow lasting at least 10 seconds and a ≥3 % oxygen desaturation.

Statistics

Data was collected and saved to Noxturnal software versions 5.1.3, 6.3 and later updated 7.1.1. SPSS 29.0.2.0 was used for statistical analyses. Categorical variables were summarized as counts and percentages. Normality of the data was assessed using the Shapiro-Wilk test. Normally distributed values are reported as mean with standard deviation (SD), and asymmetrically distributed values in median with interquartile range (IQR). Correlation coefficients were calculated using Pearson's method, as the variables were normally distributed. A p-value of <0.05 was considered statistically significant.

Results

Subject characteristics

A total of 40 patientes were included in the study and of those 35 were included in the statistical analysis . Five patients were excluded due to less than four hours of recorded sleep. Thirty patients were men, five women. Mean age was 67.5 years (SD 5.8) and mean BMI 28.4 kg/m² (SD 4.73). Of all patients, 22 (64,7 %) were non-smokers, 8 (23,5%) were current smokers and 4 (11,8%) were former smokers, one did not report smoking status. Before surgery, 91.4% of patients had sinus rhythm. Three of the patients had atrial fibrillation. At the three months follow-up, two patients had died and two had heart failure. All subject characteristics are presented in Table 1.

Sleep quality

Mean Epworth Sleepiness Scale (ESS) score was 5.6 (SD 3.9), mean depression scale DEPS 5.3 (SD 5.1) and median International Restless Legs Syndrome Scale (IRLS) 0.0 (IQR 7).

Of the respondents about BSQN 25.7% (n = 9) reported experiencing morning tiredness less than once a month. Another 28.6% (n = 10) reported feeling tired less than once a week, and 22.9% (n = 8) experienced tiredness on one to two mornings per week. Additionally, 17.1% (n = 6) reported tiredness on three to five mornings per week, while 5.7% (n = 2) reported feeling tired every morning or almost every morning. Figures 1 and 2

The mean polysomnography analysis duration was 461.5 minutes (SD 100.7), with a mean total sleep time (TST) 350.8 minutes (SD 50.1). The mean sleep latency was 26.4 minutes (SD 19.9), and the REM 179.5 minutes (SD 101.4). Wakefulness After Sleep Onset (WASO) was 129.9 minutes (SD 49.7), and mean sleep efficiency 68.9 % (SD 12.2).

Sleep-disordered breathing

The mean AHI was 24.0/h. Mild OSA (AHI 5-14.9/h) was registered in 28,6% (n=10) of patients, moderate OSA (AHI 15–29.9/h) in 25.7% of patients and severe OSA (AHI ≥ 30/h) in 37.1% (n=13) of patients.

Obstructive respiratory events were common in the supine position, with a mean AHI of 42.9 /h (SD 29.7). The median oxygen saturation (SpO_2) throughout the recording was 92.5, % (IQR 83.0-96.6). Median time spent in saturation below 90 % of total sleep time was 4.7% (IQR 0-99.4).

Arousal index was 16.1 arousals/h (SD 8.5). The mean respiratory related arousal index was 6.1/h (SD 7.9), the mean spontaneous arousal index was 5.1 /hour (SD 3.1) and the mean periodic limb movement-related arousal index was 2.7/hour (SD 4.1). Snoring was common, occurring on average during 35.3 % (SD 23.4) of the night in recorded polysomnography. PSG results are fully presented in Table 3.

Correlations between questionnaire-based sleep quality and polysomnography parameters

Two questions regarding daytime sleepiness were selected from BSQN. The survey inquired about subjective daytime sleepiness, and the results were compared with AHI findings in polysomnography. The correlation between the total AHI per hour and subjective daytime sleepiness was (r_s=-0.59; $p = 0.737$), indicating no statistically significant correlation. Additionally, there was no statistically significant correlation between the response to the question "Have you felt tired in the morning (felt like you haven’t rested properly during sleep) in the past three months?" and the recorded AHI (r_s=-0.145; $p = 0.407$) Figure 3.

Discussion

Based on our study, OSA is highly prevalent among patients undergoing elective CABG, even if the patients are unaware of their OSA. From registered patients 62.9% had moderate or severe OSA, despite the absence of subjective symptoms. Furthermore, the objective sleep quality of some patients was notably poor, yet it did not correlate with their perceived sleep quality.

Compared to a similar elective CABG study by Fan et al., our findings revealed more severe OSA. Both AHI and ODI were higher in our study population (AHI 12.1/h vs. 24.0/h, ODI 11.7/h vs. 12.1/h). Interestingly, despite more severe sleep-disordered breathing, the total ESS score of 5.6 was lower in our study compared to the ESS score of 9 reported by Fan et al.(17).

It is likely that genetic factors in the Finnish population increase the risk of CAD and sleep disorders. A retrospective observational study by Palomäki et al., based on nationwide healthcare registry data, indicated that 24.7% of the 65-74 age group had OSA, and 63% of diagnosed OSA patients had multimorbid conditions, particularly metabolic diseases (18). The odds ratio between cardiovascular diseases and sleep apnea was 2.09 for all patients, 1.45 for men, and 1.93 for women, highlighting the susceptibility of the Finnish population to CAD and OSA (18).

Despite poorer sleep architecture and more severe respiratory disturbances, patients reported neither impaired sleep quality nor daytime fatigue (Figures 1&2, Table 2). This discrepancy between objective and subjective findings may reflect reduced susceptibility to sleep disturbances in elderly or chronically ill individuals. Unfortunately, sex differences could not be assessed due to the small number of female participants. Nevertheless, the clinical implications of this study are noteworthy, as the presence of OSA is often not known to the patient during the preoperative consultation. Since our findings suggest that OSA is very common in CABG patients, it is imperative that physicians actively screen for the presence of OSA in this patient population.

In this and on many other clinical trials women are underrepresented. Multiple reasons are found behind this phenomenon. Women are often forgotten in recruiting protocols which comes partially lack of female trial leaders among CAD research field (20). Also, gender-related physiological differences might affect for small amount of women. In a register study Asraf et al. compared gender differences in CAD patients from 2005-2019 in United States. Women are underrepresented in CABG for several reasons: their CAD symptoms are often atypical, they present later to medical care, their coronary anatomy makes PCI more feasible than CABG, and in NSTEMI cases they are more frequently managed conservatively without invasive procedures. Unfortunately, women have a higher perioperative risk and mortality than men after CABG (21).

It is possible that PSG results are not comparable with subjectively assessed sleep quality. We collected answers about sleep quality during the last three months, not from the registered night. Sleep state misperception is common when people are evaluating sleep quality and especially sleep latency as well as the under-estimation of the number of awakenings. Night-to-night variability is well established (22). Ahmadi et al. found that PSG results may variate between nights; they found that in two-night recordings, AHI differed by an average of 5 events/hour, and nearly half of the patients had a higher AHI on the second night (23). There is a possibility that registered patients in

our study could sleep second night better concerning sleep quality, but apnea parameters could be worse.

Strengths and limitations

In this prospective clinical research, we used polysomnography for sleep quality and sleep disordered breathing, which is considered as golden standard to diagnose sleep disorders. Questionnaires were validated and those screened symptoms during three last months to avoid night to night variability. This study focuses to reveal sleep quality on CABG cohort which is clinically relevant and affects a large number of patients.

Due to the semi-urgent nature of the patients' care for surgery, we were able to register only one night of PSG before the CABG. It is possible that the "first-night effect" could have influenced the results, as sleep quality is typically worse on the first night, potentially leading to an underestimation of sleep-related breathing disturbances in a single-night PSG (23). Despite the high AHI and poor sleep quality observed, our results are comparable to other studies. Typically, semi-urgent patients are recorded in a hospital environment or sleep laboratory, and due to the circumstances, only one night of recording is feasible.

Conclusions

Sleep disturbances are prevalent among patients undergoing elective CABG. In our study, 62.9 % of the registered patients were diagnosed with OSA. The WASO and sleep efficiency metrics were worse than those previously reported in populations with CAD population. Despite the poor sleep quality and the presence of OSA, patients reported only mild subjective symptoms. The high prevalence of OSA in patients undergoing elective cardiac surgery suggests that clinicians should consider the possibility of this condition during preoperative planning. It is also plausible that there is an association between poorer sleep quality without symptoms and its impact on recovery and morbidity later in life.

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Table 1. Subject characteristics

N=35	Mean/Median	SD/IQR	Men/Women (n=30/5)
BMI, kg/m^2	28,2	4,6	27,8/30,1
Age on operation day	67,5	7,8	68,0 /63,0
Diabetes			2/6
Hypertension			24/4
Hypercholesterolemia			26/4
NYHA	0,7	2	
Smoking			
	Non-smokers: 22(62.9 %) Smokers: 8 (22.9 %) Quitters: 4 (11.4 %)		
Smoking pack years	27,7	21	

BMI; Body Mass Index (kg/m²). NYHA; New York Heart Association functional classification; assesses heart failure severity from 1 (no symptoms) to 4 (symptoms at rest). Smoking pack-years; A measure of smoking exposure, calculated as the number of packs smoked per day multiplied by the number of years smoked. SD; standard deviation; a measure of variability around the mean, IQR; interquartile range; range between the 25th and 75th percentiles.

Table 2. Sleep Quality

Sleep quality questionnares	Mean/Median	SD/ IQR
ESS	5,6	3,9
DEPS	5,3	5,1
IRLS	3,8	6,7

Sleep measurements	Minutes	SD/IQR
Analysis duration	350,8	50,1
Sleep duration	461,5	100,7
Sleep latency	26,4	19,9
REM latency	179,5	101,4
WASO	129,9	49,7
Sleep efficiency	68,9	12,2
All arousals /h	16,1	8,5
Spontaneous arousals /h	5,1	3,1
Respiratory arousals /h	6,1	7,9
PLMS, /h	27,24	35,9

Sleep Stage Parameters	% of Sleep duration	SD/IQR
N1	16,0	10,9(0,9–47,6)
N2	49,4	48,5
N3	17,0	15,1(2,3–50,9)
REM	14,3	7

ESS; Epworth Sleepiness Scale, DEPS; depression scale,
IRLS; The International Restless Legs Syndrome Study Group Rating Scale, WASO;
Wake After Sleep Onset, PLMS; The Periodic Limb Movement,
REM latency; time interval between sleep onset and the first occurrence of (REM)rapid eye movem ent sleep, WASO; wake after sleep onset,
PLMS; Periodic Limb Movements in Sleep recorded during polysomnography, N1; stage 1 sleep; N2; stage 2 sleep, N3; stage 3 sleep

Table 3. Respiratory parameters

Respiratory parameters	Mean/median	SD/IQR
AHI	24.0	26.6(0.4–65.0)
AHI 5–15 /h, n=10	8.4	5.2(6.5–15)
AHI 15- 30/h, n=9	20.1	7.2(15.2–29.9)
AHI <30/h, n=13	39.1	16.2(31.6–65.0)
Oxygen Desaturation Index (ODI) /h	24,1	15,8
Central apneas /h	0,9	2,9
AHI, Supine /h	42,9	29,7
AHI, REM /h	28,4	21,3
Obstuctive apneas during REM sleep /h	2,5	12,7(0–73)
Mean SpO_2 during REM Sleep	92	3,1(14,6–95,4)
Lowest SpO_2 in REM sleep	84	6,6
REM SpO_2 < 90 % /min	6,2	32(0–100)
Snore % of Sleep	35,3	23,4
Flow Limitation % of Sleep	10,1	6,1
Periodic limb movement in sleep /h	27,3	36

AHI; Apnea-Hypopnea Index, SpO_2; peripheral atrial oxygen saturation, REM; Rapid Eye Movement sleep

Figure 1. Question 4; BNSQ

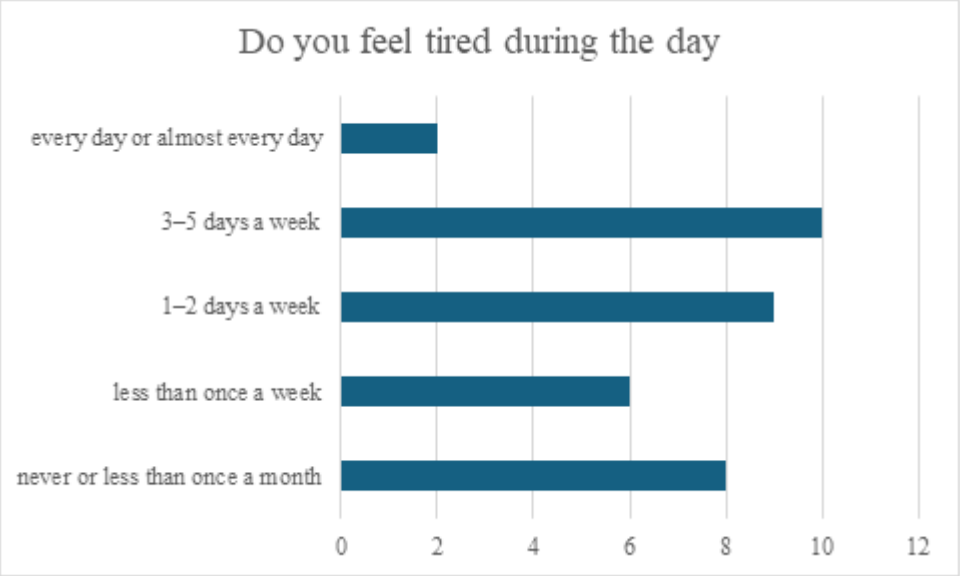


Figure 2. Question 12; BNSQ

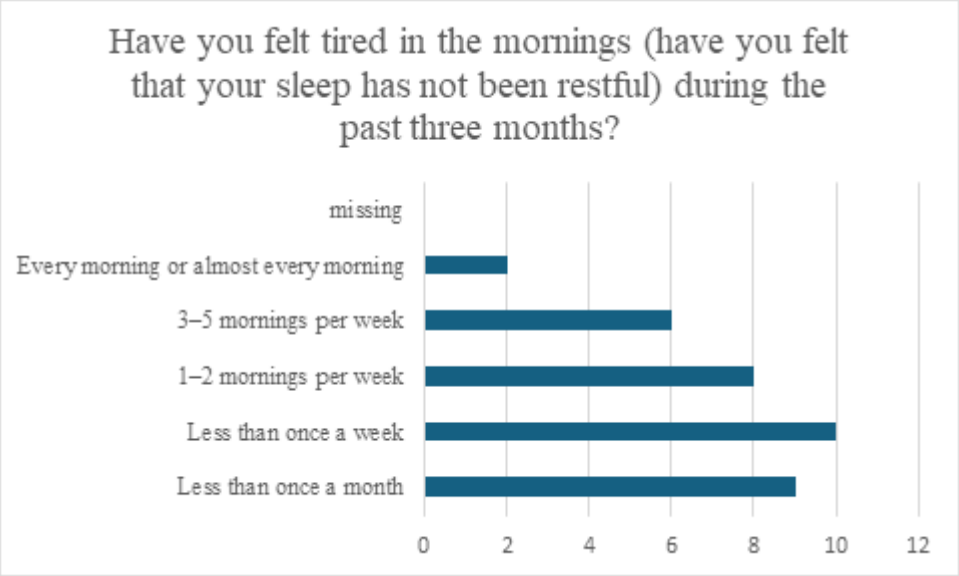
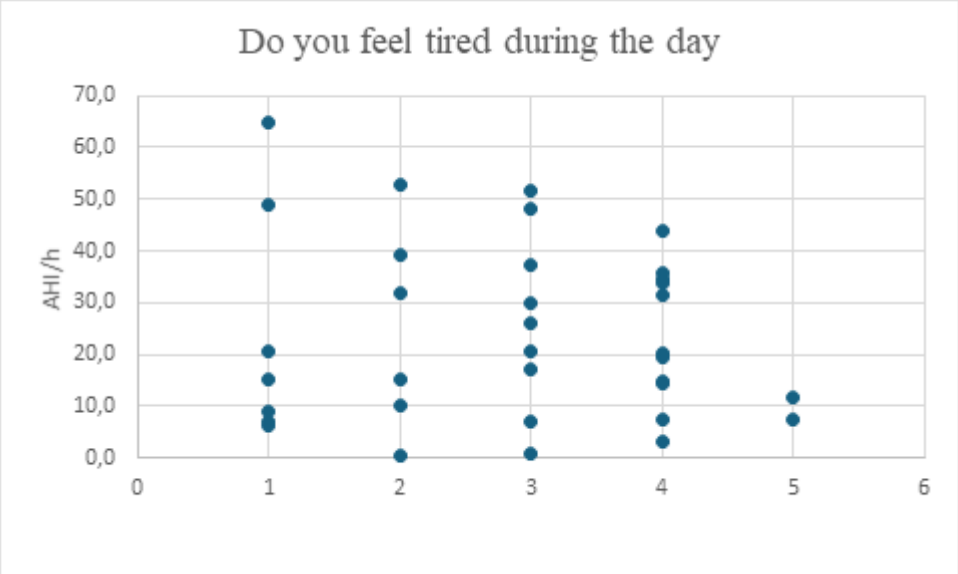


Figure 3. Correlation between AHI and question 4 of BNSQ; Do you feel tired during the day?



The correlation between the total AHI per hour and subjective daytime sleepiness; rs=-0.59; p = 0.737