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Original Article

Sleep-disordered breathing is associated with disturbed cardiac repolarization in patients with a coronary artery bypass graft surgery

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ABSTRACT

Background: The development of malignant ventricular arrhythmias due to abnormal cardiac repolarization is a major complication after coronary artery bypass graft surgery (CABG). Sleep-disordered breathing (SDB) is linked to prolonged cardiac repolarization in non-surgical patients. This study evaluates cardiac repolarization in patients with and without SDB who underwent CABG.

Methods: 100 patients who had received CABG (84% men, age 68 ± 10 years, body-mass-index [BMI] 28.7 ± 4.2 kg/m^2) were retrospectively evaluated. Polygraphy was recorded the night before CABG. SDB was defined as an apnea-hypopnea index (AHI) of ≥15/h and differentiated into central (CSA) and obstructive (OSA) sleep apnea. Cardiac repolarization was assessed by means of T-peak-to-end (TpTe) and QTc-intervals and TpTe/QT-ratios derived from 12-lead electrocardiography (ECG).

Results: 37% of patients had SDB, 14% CSA and 23% OSA. Before CABG, patients with CSA and OSA had longer TpTe intervals than those without SDB (TpTe: CSA 100 ± 26 vs. OSA 97 ± 19 vs. no SDB 85 ± 14 ms, $p = 0.013$). QTc intervals and TpTe/QT ratios differed between the two groups (QTc: 444 ± 54 vs. 462 ± 36 vs. 421 ± 32 ms, $p < 0.001$; TpTe/QT ratio: 0.24 ± 0.04 vs. 0.23 ± 0.05 vs. 0.21 ± 0.03, $p = 0.045$). SDB was associated with abnormal cardiac repolarization independent of known risk factors for cardiac arrhythmias, such as age, sex, BMI, N-terminal-pro-brain-natriuretic-peptide (NT-proBNP), and heart failure (TpTe: B-coefficient [95%–CI]: 16.0, [7.6–24.3], $p < 0.001$; QTc: 27.2 [9.3–45.1], $p = 0.003$; TpTe/QT ratio: 2.9 [1.2–4.6], $p < 0.001$).

Conclusion: Independent of known risk factors for cardiac arrhythmias, SDB was significantly associated with abnormal cardiac repolarization before CABG. Data suggest that SDB may contribute to an increased risk of ventricular arrhythmias after CABG.

1. Introduction

Coronary artery bypass graft surgery (CABG) is the most common procedure in cardiac surgery [1,2]. The development of malignant ventricular arrhythmias is a major complication after CABG that may lead to sudden cardiac death (SCD). Known risk factors for the development of cardiac arrhythmias after CABG are advanced age, male sex, obesity, and structural heart disease [3,4].

Sleep-disordered breathing (SDB) after CABG affects approximately 50% of patients [5,6]. SDB is characterized by phases of intermittent apnea or hypopnea during sleep and can be differentiated into central sleep apnea (CSA) and obstructive sleep apnea (OSA) [7,8]. The apnea-hypopnea index (AHI), that indicates the average number of apneas and hypopneas per hour of sleep, is one of the parameters that represent the severity of SDB. SDB is

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Abbreviations

AHI	Apnea-hypopnea index
ANOVA	Analysis of Variance
BPM	Beats per minute
BMI	Body-mass-index
CABG	Coronary artery bypass graft surgery
CI	Confidence interval
COPD	Chronic obstructive pulmonary disease
CSA	Central sleep apnea
ECG	Electrocardiography
LSD	Least significant difference
MI	Myocardial infarction
NT−proBNP	N-terminal-pro-brain-natriuretic-peptide
OSA	Obstructive sleep apnea
PCI	Percutaneous coronary intervention
SCD	Sudden cardiac death
SD	Standard deviation
SDB	Sleep-disordered breathing
STEMI	ST elevation myocardial infarction
TpTe	T-peak-to-end-interval
TSH	Thyroid-stimulating hormone
LV	Left ventricular

characterized by intermittent hypoxia and is associated with repetitive arousals from sleep, activation of the sympathetic nervous system and development of oxidative stress. In contrast to CSA, OSA is marked by negative intrathoracic pressure swings that increase ventricular transmural pressure. These changes contribute to myocardial remodeling [9].

After CABG, SDB is associated with an increased risk of major adverse cardiac events, such as death or acute myocardial infarction [6]. Furthermore, SDB is also linked with supraventricular arrhythmias such as atrial fibrillation after CABG [10].

The genesis of ventricular arrhythmias is closely linked to disturbed cardiac repolarization that can be measured by surface electrocardiogram (ECG). Disturbed cardiac repolarization is represented by an elongated interval from the peak of the T wave to the end of the T wave (TpTe), by prolonged QTc, and by a prolonged TpTe/QT ratio [11–13]. QTc interval prolongation before CABG predicts postoperative mortality [14]. Patients with SDB but without cardiac disease show longer TpTe and QTc intervals and a higher TpTe/QT ratio, if SDB is not treated or therapy is discontinued [15]. Thus, patients with SDB are considered to have a higher risk of developing ventricular arrhythmias [16]; however, this topic has not yet been investigated in patients undergoing cardiac surgery. Therefore, our study evaluated cardiac repolarization parameters in patients with and without SDB who underwent CABG.

2. Methods

2.1. Study population

Between October 2014 and March 2015, 103 patients undergoing elective CABG at the Department of Cardiac and Thoracic Surgery at the University Medical Center Regensburg in Germany were tested for SDB the night before CABG surgery. Patients (n = 3) with a history of SDB were excluded from the present study. 100 patients were stratified by the presence and type of SDB (Fig. 1).

2.2. Study design

Variables such as demographics, common comorbidities, cardiac catheterization results, and medication were systemically assessed retrospectively by means of clinical patient records. Perioperative data were collected from the surgical and anesthetic protocols of the patients. Moreover, all diagnostic pre- and postoperatively conducted tests, including echocardiograms, ECG recordings, chest X-rays, as well as laboratory data were taken into account.

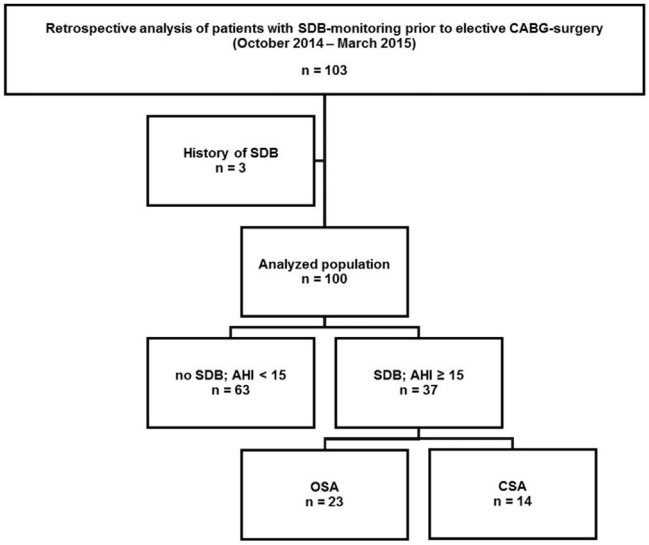

Fig. 1. Flow chart of patient selection. SDB, sleep-disordered breathing; CABG, coronary artery bypass grafting; AHI, apnea-hypopnea index; OSA, obstructive sleep apnea; CSA, central sleep apnea.

This retrospective analysis was reviewed and approved by the Ethics Committee of the University of Göttingen (no. 14/09/11).

2.3. Assessment of SDB

To assess the presence and severity of SDB, polygraphy was conducted the night before CABG surgery using an ApneaLink™ PG system (ResMed Inc., Martinsried, Germany) validated for monitoring SDB in several studies [17–20]. The ApneaLink™ PG system with three sensors (effort, flow, and oximetry) provides thoracic effort, nasal flow, and oxygen saturation. AHI, oxygen desaturation index, minimum, and mean oxygen saturation, and nocturnal heart rate were recorded. Apnea was defined as a decrease in airflow by ≥90% versus baseline for ≥10 s. Hypopnea was defined as a decrease in airflow by ≥30% versus baseline for ≥10 s associated with a ≥4% decrease in oxygen saturation. In contrast to OSA, apneas were classified as CSA if a decrease in airflow coincided with absence of thoracic movements. Patients with SDB were divided into a CSA group with ≥50% CSA of all apneas and into an OSA group with <50% CSA of all apneas. The participants were instructed about the use of the device by trained study personnel. Studies have