

Comparison Of Preoperative And Postoperative Hemodynamic Variability In Obstructive Sleep Apnea Vs Non-Obstructive Sleep Patients: A Prospective Cohort Study

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Abstract

Background: Obstructive Sleep Apnea (OSA) is a prevalent condition involving periodic closure of the airway specifically upper airway during sleep, resulting in hypoxemia, sympathetic excitation, and autonomic dysfunction. Such changes can be detrimental for the cardiovascular system during surgery. Nevertheless, studies comparing intraoperative variability of the hemodynamics between OSA patients and patients without OSA are sparse.

Aim: To compare heart rate, blood pressure, and oxygen saturation variability both preoperatively and postoperatively among OSA and non-OSA patients going through elective non-cardiac surgeries under general anesthesia.

Methodology: In this prospective observational study, 118 adult participants undergoing elective non-cardiac surgery were enrolled. The risk of OSA was determined with STOP-BANG criteria and stratified into low, moderate,

and high-risk participants. Data on demographic characteristics, comorbid conditions, and American Society of Anesthesiologists (ASA) classification were noted. Heart rate, systolic, and diastolic blood pressure, and SpO₂ were taken before surgery and

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after surgery. Three time points of postoperative changes were evaluated using repeated measures analysis of variance. The independent sample t-test and effect size estimation were done for OSA vs. non-OSA groups.

Results: The Mean age of subjects was 45.74 ± 11.65 years with almost an equal proportion of gender distribution. Most patients had ASA II category (66.1%), with hypertension being the most frequent co-morbid condition in 49.2% patients. Patients at higher risk for OSA based on STOP-BANG score constituted 43.2% in our study. Prior to surgery, OSA patients showed statistically higher values of heart rate ($p < 0.001$), systolic blood pressure ($p = 0.003$), and diastolic blood pressure ($p = 0.001$) compared to non-OSA patients, whereas preoperative oxygen saturation value was not statistically significant among two groups. After surgery, differences between both groups were seen for heart rate and diastolic blood pressure measurements at later time intervals (T2, T3), whereas systolic blood pressure and SpO₂ were statistically comparable in two groups.

Conclusion: Patients with OSA exhibit a higher degree of pre-existing cardiovascular pathology, as shown by an elevated resting heart rate and blood pressure, which play a role in producing selective postoperative variations in the cardiovascular system, primarily the heart rate and diastolic blood pressure. It should be noted that overall perioperative cardiovascular variability does not differ much between patients with OSA and those without OSA.

Introduction

Obstructive Sleep Apnea (OSA) is a condition that occurs when an individual has chronic breathing difficulties during their sleep, which result from the collapse of the upper respiratory airway, causing repeated hypoxemia, hypercapnia, sleep disturbance, and arousals. OSA is a growing problem in the global population due to the fast rising incidence of this disease and its associations with cardiovascular and metabolic disorders, neurocognitive deficits, and perioperative risks. Recent findings have indicated that approximately one billion adults around the world suffer from this disease, with many cases going undetected, particularly in less developed nations (Chambers et al., 2022). Additionally, the condition may be more prevalent in people undergoing surgery since they might experience additional stressors and anesthesia.

Moreover, the effects of OSA are not limited to its influence on sleep physiology. Repeated episodes of airway blockage at night create a chronic state of periodic hypoxia, endothelial dysfunction, oxidative stress, systemic inflammation, sympathetic nervous system hyperactivity, and dysregulated autonomic control of the cardiovascular system. These pathophysiological processes play an crucial part in the development of hypertension, arrhythmias, coronary artery disease, heart failure, cerebrovascular disease, and cardiovascular death (DiCaro et al., 2024; Pintilie et al., 2025). In recent years, numerous studies have showed cardiovascular diseases are prevailing and OSA is one of the independent risk factor for that. As noted by DiCaro et al. (2024), recurrent sympathetic peaks during OSA periods cause significant changes in pressure of the blood and heart rate, increasing the likelihood of perioperative cardiovascular instability.

Variability in hemodynamics, especially blood pressure and heart rate, has been a focal point for researchers due to its significance in identifying cardiovascular stress as well as perioperative risk. Variability in BPV and HRV indicates homeostasis and adaptability within the autonomic nervous system. Increased variability has been linked to endothelial damage, poor organ perfusion, complications after surgery, stroke, heart attack, and mortality (Stevens et al., 2016). Likewise, increased blood pressure variability was identified by de la Sierra et al. (2023) as a predictive parameter of poor cardiovascular outcomes, especially in susceptible individuals.

In patients suffering from OSA, autonomic dysregulation seems to be key in contributing to hemodynamic instability. Hypoxia during repeated apneas and poor

quality sleep result in persistent sympathetic arousal and decreased parasympathetic tone, which ultimately leads to cardiovascular system instability. Abdelnabi (2023) pointed out that the changes in heart rate variability are associated with cardiovascular pathologies and may be used as an indicator of autonomic dysregulation. In more recent research, Ashinze et al. (2025) underlined the significance of HRV assessment in cardiac surgery and perioperative medicine since the changes in HRV reflect cardiovascular system stress response.

Recent research also indicates that there is a marked beat-to-beat variability in the blood pressure of patients with OSA. As reported by Pal et al. (2021), the beat-to-beat variability in blood pressure was much higher in patients with OSA than in non-OSA patients, reflecting the inability of the body to regulate its blood pressure automatically. This finding is clinically relevant since anesthetic drugs used during surgery, opioids, sedative agents, and surgical stress can exacerbate this problem.

Perioperative period becomes especially important in OSA patients due to possible increase in the collapsibility of their upper airways, decreased respiratory effort, and worsening of hypoxemia caused by anesthetic and postoperative analgesic effects. As a result, there is higher predisposition to respiratory depression, oxygen desaturation, development of arrhythmias, myocardial ischemia, and hemodynamic instability in those with OSA. Chan et al. (2022) were able to prove that patients suffering from unrecognized OSA have higher risks for postoperative cardiovascular complications based on their research conducted within the framework of POSA trial.

In the same vein, studies by Chaudhry et al. (2024) have revealed that individuals suffering from OSA have a substantially elevated risk of developing complications after undergoing surgery, which includes cardiovascular instability, respiratory problems, prolonged stays in the hospital, and intensive care admission.

Beyond the physiological effects of obstructive sleep apnea syndrome, perioperative hemodynamic variability has independently been found to be a risk factor for poor outcomes following surgery. Shen et al. (2024) found that greater perioperative blood pressure variability was related to the incidence of postoperative delirium among patients going through cardiac surgery. In this manner, perioperative hemodynamic variability may impair brain perfusion, ultimately leading to poor postoperative recovery.

Despite the growing literature on OSA and perioperative outcomes in the international scientific community, there is a scarcity of prospective research comparing preoperative and postoperative hemodynamic variability in patients with OSA and without OSA. Moreover, existing literature tends to address respiratory problems more often than dynamic cardiovascular conditions like heart rate variability and blood pressure variability during surgery. In developing nations like Pakistan, the literature addressing perioperative hemodynamic variability among OSA patients is even less common.

Another problem arising from under-diagnosing OSA in South Asians is that most of the patients undergoing surgical procedures may suffer from undetected OSA and thus be at risk of developing cardiovascular problems during their surgical procedures because of their unstable hemodynamics. Identifying the unstable hemodynamics of patients suffering from OSA can help in reducing complications.

Problem Statement

As we know that obstructive sleep apnea (OSA) is prevalent among patients who undergo surgery. However, most cases of OSA are not identified prior to elective non-cardiac surgery. This condition leads to intermittent hypoxemia, increased sympathetic activity, and alterations in heart rate, blood pressure, and oxygen saturation, which could be exacerbated by anesthesia, analgesics, and manipulation of the airway. Despite the fact that hemodynamic fluctuations play a critical role in cardiovascular instability, there has been a lack of comparative studies examining the

presence of hemodynamic instability pre-and-postoperatively in patients with and without OSA. Such gaps make it difficult to conclude whether there should be any difference in the care for OSA patients.

Rationale of the Study

OSA represents a critical perioperative risk factor due to its ability to induce episodes of hypoxia, sympathetic spikes, and variations in heart rate, blood pressure, and oxygen saturation.(DiCaro, Lei et al.,2024) These changes tend to be exacerbated by anesthesia and opioid medications, resulting in an increased possibility of airway obstruction and complications related to surgery.(Pintilie, Marcu et al., 2025) Variability in blood flow dynamics is already known to be a marker of unfavorable cardiovascular events, but many patients undergoing non-cardiovascular surgery do not receive a diagnosis of OSA before their operations. Despite the clear risk, there is very little literature available comparing hemodynamic variability in OSA and non-OSA patients before and after surgery.

Scope of the Study

In this research, the comparison is made between hemodynamic variability (heart rate, blood pressure, oxygen saturation) before and after surgery between OSA and non-OSA patients who underwent elective non-cardiac surgery. The patients are adults who were evaluated using the STOP-BANG tool, and data is collected from their preoperative period until 24 hours postoperatively. This research excludes any emergency surgeries, cardiac surgeries, and thoracic surgeries.

Significance of the Study

The importance of this research is determined by the known but poorly understood connection between obstructive sleep apnea syndrome (OSA), intermittent hypoxemia, the activation of the sympathetic nervous system, and increased postoperative cardiovascular complications. Although this association is known, quite a few surgical patients with OSA still lack proper diagnosis before surgery, and hence, are inadequately assessed preoperatively with regard to the risks associated with their cardiovascular condition (Chaudhry et al., 2024). Increased hemodynamic variability as an independent risk factor for cardiovascular diseases such as stroke and myocardial infarction has been gaining more attention. No previous studies have examined the difference in perioperative hemodynamic variability between patients with and without OSA directly.

Research Objective

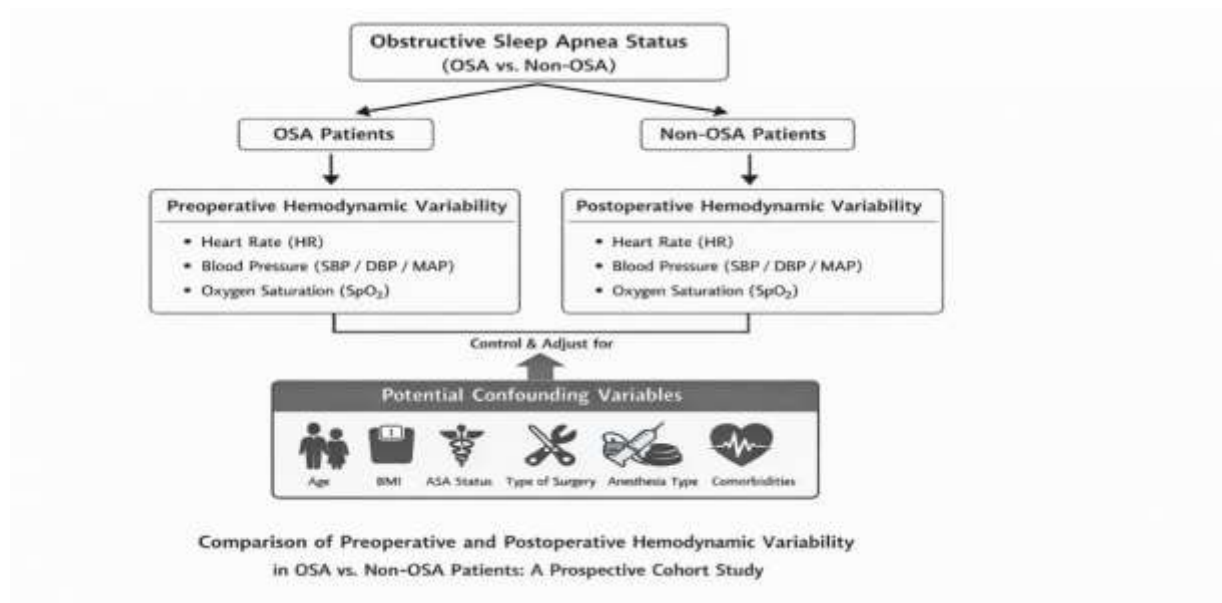
To compare preoperative and postoperative HR, BP, and saturation of oxygen variability between OSA and non-OSA patients undergoing elective surgery

Research Question

Does obstructive sleep apnea affect perioperative hemodynamic parameters like (HR, BP, and oxygen saturation variability in patients undergoing elective surgery compared to non-OSA patients?

Conceptual Model

Conceptual model of this research study is as under;



Link with SDGs

This research relates to SDG 3: Ensure healthy lives and promote well-being for all at all ages, specifically Target 3.4, Target 3.8, and Target 3.d concerning the reduction of premature deaths due to non-communicable diseases, the achievement of universal access to affordable healthcare services, and the strengthening of health risk management. Obstructive Sleep Apnea (OSA) is an important non-communicable disease that involves cardiovascular disorders and perioperative risks. Through investigating the changes in hemodynamic variations before and after the operations among OSA and non-OSA individuals who had undergone elective surgeries, this study can lead to greater understanding and effective strategies in perioperative risk assessment and anesthesia care.

Operational Definitions

Obstructive Sleep Apnea: Operational definition of Obstructive Sleep Apnea is patients who have been diagnosed prior to surgery on the basis of documented clinical diagnosis and/or screening tests like the STOP-Bang score of ≥ 3 and/or findings by polysomnogram showing mild, moderate, or severe OSA.

Non Obstructive Sleep Apnea: Non-OSA includes patients under general anesthesia who do not have any clinical history of OSA, a STOP-Bang score of less than 3, and no history of sleep disordered breathing on prior medical records.

Hemodynamic Variability: The term hemodynamic variability describes variations in physiological variables related to the cardiovascular system, which include the systolic blood pressure, diastolic blood pressure, and heart rate. The measurements are taken at various time points throughout the perioperative period. The variability can be measured by comparing preoperative and postoperative measurements.

Preoperative Hemodynamic Status: Hemodynamic status preoperatively is the baseline value for systolic/diastolic blood pressure and heart rate that have been measured within an hour before anesthesia induction while in a resting state.

Postoperative Hemodynamic Status: Hemodynamics during the postoperative period includes blood pressure and pulse rate measured during the initial 24 hours following surgery, using fixed time intervals in the PACU or surgical ward.

LITERATURE REVIEW

Overview

Aim of this literature search is to evaluate the current state of knowledge about obstructive sleep apnea (OSA), hemodynamic variability during surgery, and their connection to cardiac outcomes. This review will identify the underlying mechanisms that are responsible for the development of OSA and explain the impact of this condition on the cardiovascular system due to such physiological disturbances as hypoxemia, sympathetic stimulation, endothelial dysfunction, and autonomic dysfunction. In addition, it will investigate the existing research findings related to hemodynamic variability, specifically blood pressure variability (BPV) and heart rate variability (HRV), and their role as novel predictors of negative cardiovascular events and outcomes after surgery.

Search Strategy

A literature review was performed to find the relevant literature for OSA, perioperative hemodynamic variability, and cardiovascular events in surgery patients. The databases accessed for this search include PubMed/MEDLINE, Google Scholar, ScienceDirect, SpringerLink, Wiley Online Library, and the Cochrane Library. The keywords used for searching are “obstructive sleep apnea,” “perioperative outcomes,” “hemodynamic variability,” “blood pressure variability,” “heart rate variability,” and “cardiovascular events.” The eligible literature comprises peer-reviewed primary research, systematic reviews, and meta-analysis studies that include adult surgery patients. Non-English literature, pediatric research, case studies, and non-peer-reviewed studies were not included.

A Systematic review and meta-analysis explored the association between OSA and complications post operation along with the potential benefit of OSA diagnosis before surgery and CPAP therapy in preventing postoperative complications. According to results from a literature search in various databases and the inclusion of 46 studies, it was discovered that the in patients having OSA was linked to a higher rate of postoperative complications including cardiopulmonary problems, ICU admission, delirium, and extended length of hospital stay. Moreover, the presence of more severe OSA resulted in worse results. As indicated by subgroup analysis, OSA diagnosis and CPAP therapy were likely to minimize certain postoperative risks. The research concluded that OSA was an important factor in postoperative complications (Wang, S., et al. 2022).

The research by Chaudhry, R. A., Zarmer, L., West, K., and Chung, F. (2024) reveals that OSA greatly contributes to perioperative risks, including cardiopulmonary issues, because of increased susceptibility to anesthesia, sedation, and opioid drugs that increase airway collapse and breathing impairment. Study demonstrated that patients with OSA are vulnerable to postoperative respiratory problems, especially under the influence of neuromuscular blockade and opioids. However, perioperative interventions, such as regional anesthesia, multimodal pain management, oxygen administration, and continuous positive airway pressure treatment, can potentially lower complication frequencies and enhance the patient experience. On the whole, the research proves that OSA poses numerous obstacles in perioperative care due to multiple factors, and despite the suggested measures of preoperative assessment, individualized anesthesia procedures, and postoperative care, the lack of proper diagnosis, the heterogeneity of OSA cases, and the limited evidence on the cost-effectiveness of treatments calls for more sophisticated instruments and protocols in perioperative care.

Undiagnosed obstructive sleep apnea (OSA) was established to be linked with an increased likelihood of developing cardiovascular complications within 30 days of major non-cardiac surgery, with the most severe cases showing the greatest

vulnerability to developing complications. The relationship between OSA and adverse effects is dose-dependent; in addition, patients who developed cardiovascular problems experienced more postoperative hypoxemia than patients without complications. Severe OSA was determined to be a predictor of cardiovascular complications, but more research needs to be done to see if there are any methods to minimize this risk during surgery (Chan et al., 2022).

Patients with high-risk OSA, defined by preoperative screening methods like the STOP-Bang questionnaire and also the Step-2 model, were found to have an higher risk of developing postoperative complications and increased lengths of hospital stays in elective non-cardiac surgeries in adults. High-risk patients had significantly greater chances of having postoperative complications than those categorized as low-risk. There was no significant disparity in predicting performance among the two screening methods used to determine patient risks. This study indicated that both STOP-Bang and Step-2 scoring methods work effectively in detecting patients at higher risk of complications in the perioperative period. The need for preoperative screening of OSA is, therefore, paramount in managing patient risks after surgery (Roesslein et al., 2026).

Management of obstructive sleep apnea (OSA) during perioperative settings poses great difficulties because of the condition's relationship with high airway collapsibility, hypersensitivity to sedatives and opiates, and higher chances of developing respiratory and cardiac problems after surgery. The best ways to manage OSA include conducting preoperative screenings to detect the disease, planning anesthesia intraoperatively to avoid excessive respiratory depression, and utilizing non-opiate pain relief procedures such as regional anesthesia. Positive airway pressure therapy is also suggested after surgery as a way of decreasing complications and ensuring safety. In general, structured pathways for managing OSA in perioperative settings are necessary for achieving the best results; however, variations in OSA severity and underdiagnosis pose difficulties (Seet & Chung, 2021).

Among very old patients suffering from deteriorated chronic diseases, it is recognized that an enhancement in arterial stiffness and an increase in blood pressure and heart rate variability are strong predictors of 1-year mortality. As per a study conducted on a group of very old patients above the age of 80 years, through non-invasive 24-hour monitoring it was found that variables like aortic pulse wave velocity, systolic blood pressure variability, and diminished heart rate variability were significantly related to mortality despite controlling for various clinical factors. Thus, it can be said that hemodynamic variability and arterial stiffness are two strong predictors of mortality among this particular vulnerable group (de la Sierra et al., 2023).

It was found that there exists a considerable difference in beat-to-beat blood pressure variation (BPV) among patients suffering from OSA and reflects the autonomic dysfunction with distinct gender differences (Pal et al., 2021). The results reveal that an increase in BPV, mainly diastolic BPV, is associated with females suffering from OSA, whereas abnormalities like an increase in QRS duration are seen among males. Furthermore, a positive correlation existing between BPV and heart rate variation in healthy individuals does not exist among OSA patients. These alterations in BPV can be explained by a lack of baroreflex sensitivity and possible damage to vessels among such patients.

Blood pressure variability (BPV) during the perioperative period has been shown to be one of the critical factors contributing to the formation of postoperative delirium in cardiac surgery patients. In a study conducted on a sizable sample of adult patients who underwent cardiac surgery, changes in BPV, in particular, an increase in BPV during the postoperative period, including systolic, diastolic, and mean arterial blood pressure values, have been demonstrated to be strongly correlated with the incidence of delirium. Specifically, indicators of BPV, including average real variability (ARV), have been proven to be independently linked with the outcome of postoperative

periods, implying the role of hemodynamic instability in neurologic complications. Thus, stabilizing BP in the perioperative period, especially in the postoperative stage, seems to lower the probability of developing delirium (Shen et al., 2024).

According to a study conducted by Abdelnabi (2023), low (HRV) is highly correlated with various risk factors and diseases that affect the cardiovascular system, such as high blood pressure, diabetes, coronary artery disease, congestive heart failure, and myocardial infarction. HRV was emphasized in the review as a very significant noninvasive indicator of cardiovascular risk and concluded that a low level of heart rate variability leads to greater morbidity and mortality associated with cardiovascular diseases. However, even though some procedures have a beneficial effect on the HRV, additional studies need to be performed before introducing HRV into regular practice. According to Ashinze (2025), the clinical significance of (HRV) during heart surgery is essential in the evaluation and management of perioperative risk. The article pointed out that low HRV indicates dysautonomia, with an increased probability of complications such as arrhythmias, hemodynamic instability, sepsis, and myocardial dysfunction. Moreover, it was suggested that current developments such as artificial intelligence and wearables could be used to enhance monitoring and management based on HRV and perioperative decisions.

Maier et al. (2022) performed a systematic review and meta-analysis which revealed that individuals with obstructive sleep apnea (OSA) had significantly higher muscle sympathetic nerve activity (MSNA), which correlates with increasing OSA severity and high blood pressure. In addition, there was also a significant correlation of MSNA with systolic and diastolic blood pressure, suggesting higher sympathetic activation among patients with OSA. Moreover, the use of continuous positive airway pressure (CPAP) was found to be capable of reducing MSNA and blood pressure, but lack of evidence did not allow establishing a correlation between these decreases. Thus, it can be stated that an increase in sympathetic activity is one of the major mechanisms leading to the risk of developing cardiovascular diseases in OSA patients.

The results of a review conducted by Fagerlund and Franklin (2021) on the benefits of perioperative CPAP therapy based on RCTs in patients with obstructive sleep apnea were reviewed. These studies showed that perioperative use of CPAP leads to better postoperative oxygenation, decrease in reintubation rate, and mechanical ventilation while reducing the number of episodes of apnea, hypopnea, and associated hypoxemia. Nevertheless, lack of adherence to treatment regimens in patients was one of the significant limitations in evaluating the efficacy of the procedure.

The effect of a BOSTN bundle perioperative management intervention for obstructive sleep apnea (OSA) on patients admitted to a hospital was assessed by Raub et al. (2020). Patients at increase risk for OSA (≥ 2 BOSTN score) were linked with significantly lower odds of receiving postoperative invasive mechanical ventilation (adjusted odds ratio [aOR] 0.89; 95% confidence interval [CI], 0.80–0.98) and significantly lower duration of hospitalization (aOR 0.87; 95% CI, 0.84–0.91); however, they exhibited a higher risk of post-extubation desaturation (aOR 1.34; 99.3% CI, 1.21–1.48). On balance, the researchers suggested that perioperative screening and management protocols could enhance specific postoperative results, despite the fact that high-risk OSA patients are still more vulnerable to hypoxic problems.

Saha and Seraji (2022) performed a cross-sectional study on the perioperative results of patients with obstructive sleep apnea (OSA) that covered 200 surgical cases within four years. They noted that most of their participants were female patients who belonged to the age group of middle-aged individuals, and they presented with symptoms of sleepiness. Moreover, the most used anesthesia was sevoflurane. The researchers emphasized that there is a requirement for better awareness about OSA in clinical practice, and standard guidelines should be developed for the same purpose.

In the paper by Anas et al. (2024), the preoperative fasting status and hemodynamic variation during surgery under general anesthesia were assessed among patients. It

was found that the patients fasted for a long period of time, with the mean fasting duration being about 10 hours. From the perioperative data analysis, it was found that there was a small but statistically significant difference in the heart rate at the induction and recovery periods ($p = 0.02$); however, no statistically significant difference was found in the systolic and diastolic blood pressures. The conclusion made by the authors is that even though the fasting period is still practiced, the heart rate has a slight variation, which makes it important in the discussion on the preoperative fasting guidelines and perioperative hemodynamic stability (Anas et al., 2024).

Literature Gap

One important gap in the current body of knowledge is that very few prospective comparative studies have been performed on preoperative and postoperative hemodynamic variability among OSA and non-OSA patients. Existing studies have primarily concentrated on perioperative outcomes or cardiac complications and not on dynamic perioperative hemodynamic variability. There is an obvious lack of information from South Asian or Pakistani populations. The increasing burden of OSA and obesity among these populations makes their inclusion important. Lack of locally relevant information restricts the application of internationally produced results. This is one major reason behind conducting this particular study.

METHODOLOGY

Study Design

A Prospective Cohort Study design was used.

Research Type

The research is quantitative, comparative, analytical, and observational. Quantitative Involves numerical measurements like (HR, BP, SpO₂). Comparative compares OSA and non-OSA groups. Analytical involves tests associations between OSA status and hemodynamic variability. While Observational involves patients observed without any experimental manipulation.

Sample Size

Using the formula for comparing two independent means the sample size was calculated as;

$$n = \frac{\left(2 \left(\frac{Z\alpha}{2} + Z\beta \right)^2 \sigma^2 \right)}{\Delta^2}$$

To compare two independent means calculation of sample size took place using the formula to establish the differences in hemodynamic and oxygen saturation variability between OSA and non-OSA patients. Sample size determination was carried out at a significance level of 5% ($\alpha = 0.05$; $Z\alpha/2 = 1.96$) and a statistical power of 95% ($Z\beta = 1.645$). Estimates were made taking into account the data obtained from the literature sources regarding the standard deviation (σ) of 10 mmHg and clinically important difference (Δ) of 7 mmHg of blood pressure variability. Thus, the size of the sample for the study was determined to be 54 subjects per group. Adding 10% due to expected loss, the sample size became equal to 59 subjects per group (118 in total).

Sampling Technique

Convenience sampling Technique was used. The subjects were divided into two distinct groups depending on their STOP-BANG score and diagnosis. The OSA group

comprised subjects whose STOP-BANG score was greater than 3 or had been diagnosed with OSA. On the other hand, the non-OSA group was made up of subjects whose STOP-BANG score was less than 3 or did not have any OSA diagnosis.

Study Setting

The study was conducted in LRH a tertiary care hospital in Peshwar.

Inclusion Criteria

- A)** Patients aged 18 to 65 Years.
- B)** Patients undergoing elective surgical procedures under general anesthesia.
- C)** Patients who give written informed consent to participate in the research
- D)** Obstructive Sleep Apnea Group: STOP-BANG > 3 or confirmed diagnosis of OSA.
- E)** Non Obstructive Sleep Apnea Group: STOP-BANG < 3 and no clinical suspicion of OSA.

Exclusion Criteria

Emergency surgeries or patients requiring postoperative ICU admission for reasons unrelated to OSA.

Patients with known cardiovascular, renal, or endocrine disorders affecting hemodynamics.

Patients undergoing emergency surgery.

Patients with severe pulmonary disease (e.g., COPD Gold stage III–IV, severe asthma exacerbation).

Patients with neurological or psychiatric disorders affecting cognition or cooperation.

Patients on chronic medications affecting heart rate or blood pressure variability (e.g., beta-blockers, antiarrhythmics) unless stable and deemed appropriate.

Pregnant women.

Patients who refuse to participate or withdraw consent.

Data Collection Tool

Pre-designed structured data sheet and automated non-invasive SpO₂, BP and HR Variations monitoring system.

Ethical Considerations

The data was collected from LRH hospital following approval by the CUSIT Research Committee and LRH Institutional Review Board for conducting research ethically.

Data Collection Procedure

Preoperative Evaluation

The preoperative evaluation for OSA was done by using the STOP-BANG questionnaire for all elective non-cardiac surgeries. Depending on the results obtained from the questionnaire, the participants were classified into two different groups. In the OSA group, the patients had a STOP-BANG score of more than 3 or had been diagnosed with OSA. The non-OSA group comprised patients whose STOP-BANG score was less than 3.

3.10.2 Baseline Measurements

Baseline HR, BP, and oxygen saturation SpO₂ were determined prior to the induction of anesthesia under resting conditions using routine monitoring techniques such as ECG, NIBP, and pulse oximetry. The short-term variability in the hemodynamic parameters was quantified using standard statistical methods, where HRV and BPV were determined as the standard deviation (SD) of the parameters, and oxygen saturation (SpO₂) variability was also quantified as the SD.

Postoperative Monitoring

The postoperative measurements of heart rate (HR), blood pressure (BP), and oxygen saturation (SpO₂) were done according to the predetermined times, which include right after surgery (0 hours), 6 hours after surgery, and 12 hours after surgery. The measurements were taken using identical equipment for monitoring (electrocardiogram, blood pressure measurement, and pulse oximetry).

Data Recording

All data was entered into a predesigned data collection case report form. Each patient's preoperative and postoperative measurements was recorded separately and identified with unique study codes to maintain confidentiality.

Data Comparison

Preoperative and postoperative hemodynamic and oxygen saturation variability was analyzed within each group (pre vs post) and between groups (OSA vs non-OSA). Statistical analysis was assess whether significant differences exist in HR, BP, and SpO₂ variability associated with OSA status.

Statistical Analysis

Software

Data was analyzed using IBM SPSS version 27.0.

Data Presentation

Continuous data (HR, BP, SpO₂) was shown as mean $\pm$ standard deviation (SD).Categorical data (gender, ASA class) was shown as frequency (%).

Testing for Normality

For determining the normality of the data, Shapiro-Wilk test was performed;

Group	Shapiro–Wilk p-value	Normality
OSA	> 0.05	Normal
Non-OSA	> 0.05	Normal

Comparisons

Selection of appropriate statistical test in the comparison between the OSA and non-OSA groups was made based on the distribution of the data. When the data had a normal distribution, parametric tests like the independent samples t-test and ANOVA were utilized to conduct comparisons among groups. However, when there was no normal distribution of the data, non-parametric tests such as the Mann-Whitney U test were used.

Variability Analysis

HR variability (HRV): Standard Deviation (SD)

BP variability (BPV): Standard Deviation (SD)

SpO₂ variability: Standard Deviation (SD)

Correlation / Regression

Correlation between STOP-BANG score and variability using Pearson or Spearman.

Regression may adjust for age, gender, BMI if needed.

Significance

A p value of < 0.05 was considered statistically significant.

RESULTS

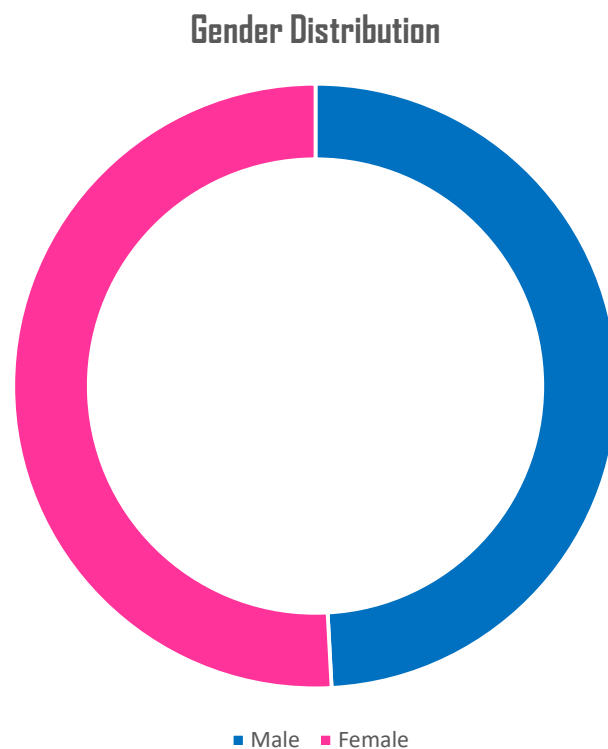
The statistical results for the participants age reveal that the age of the subjects ranged between 18 and 64 years. The mean age was 45.74 years, with a standard deviation of 11.648, which indicates a moderately high degree of variability among the ages of the subjects.

Table 1: Age of the Participants

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	118	18	64	45.74	11.648
Valid N (listwise)	118				

From the gender analysis, there were 60 (50.8%) women while the male respondents stood at 58 (49.2%). From the data above, we can see that the samples collected had an equal gender composition.

Figure 1: Gender Distribution



In terms of the distribution of patients based on ASA physical status classification, most patients were found to be classified under ASA II, accounting for 78 patients (66.1%). In addition, there were 37 patients (31.4%) who were classified under ASA I, whereas 3 patients (2.5%) were classified under ASA III. This means that most patients had mild or moderate systemic disease.

Table 2: ASA Status

ASA Status					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	37	31.4	31.4	31.4
	2	78	66.1	66.1	97.5
	3	3	2.5	2.5	100.0
	Total	118	100.0	100.0	

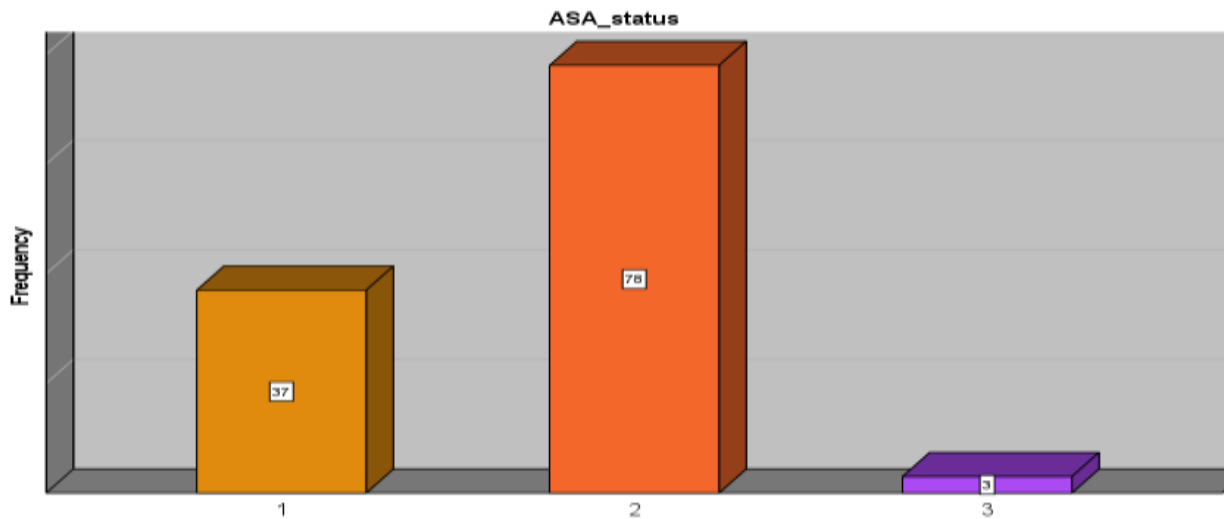


Figure 2: Illustrate the ASA status of the study participants

Regarding the frequency of comorbidities in the study population, the following results were obtained. Hypertension (HTN) was the most frequent type of comorbidity, recorded in 58 patients (49.2%). Participants with no comorbidities comprised 37 patients (31.4%), whereas ischemic heart disease (IHD) was found in only 1 patient (0.8%). The number of patients with diabetes mellitus (DM) was 21 (17.8%), while other comorbidities were noted in 1 patient (0.8%).

Table 3: Comorbidities

Comorbidities					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	None	37	31.4	31.4	31.4
	HTN	58	49.2	49.2	80.5
	DM	21	17.8	17.8	98.3
	IHD	1	.8	.8	99.2
	Other	1	.8	.8	100.0
	Total	118	100.0	100.0	

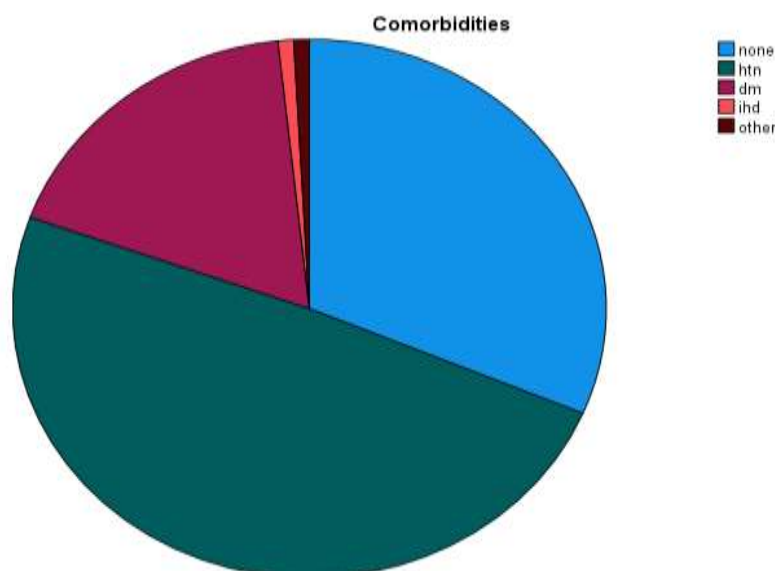


Figure 3: Demonstrate the presence of comorbidities in the study participants

In the current study (n = 118), 52.5% of the participants were less than 50 years old, while 47.5% of the participants were more than 50 years old. 57.6% of the participants snored, while 42.4% did not have a history of snoring. Daytime tiredness, fatigue, or sleepiness was seen in 59.3% of the participants, while 40.7% did not have any of these conditions. 71.2% of the participants had high blood pressure, while 28.8% of the participants did not have any high blood pressure. Concerning BMI, 73.7% of the participants had a BMI less than 35 kg/m², while 26.3% of the participants had a BMI of more than 35 kg/m².

Table 4: Distribution of STOP Bang Clinical Variables

Variable	Category	Frequency (n)	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Age	< 50 years	62	52.5	52.5	52.5
	> 50 years	56	47.5	47.5	100.0
Snore	No	50	42.4	42.4	42.4
	Yes	68	57.6	57.6	100.0
Tiredness Fatigue Sleepiness	No tiredness	48	40.7	40.7	40.7
	Yes tiredness	70	59.3	59.3	100.0
High Pressure	No high blood pressure	34	28.8	28.8	28.8
	Yes high blood pressure	84	71.2	71.2	100.0
BMI	< 35 kg/m ²	87	73.7	73.7	73.7
	> 35 kg/m ²	31	26.3	26.3	100.0
Stop Breathing During Sleep	No	88	74.6	74.6	74.6
	Yes	30	25.4	25.4	100.0
Neck Circumference	0	106	89.8	89.8	89.8
	1	12	10.2	10.2	100.0

In this study, the STOP-BANG score was evaluated for 118 subjects. The lowest score was 0, while the highest score was 7; the average score was 3.47, and the standard deviation was 1.88.

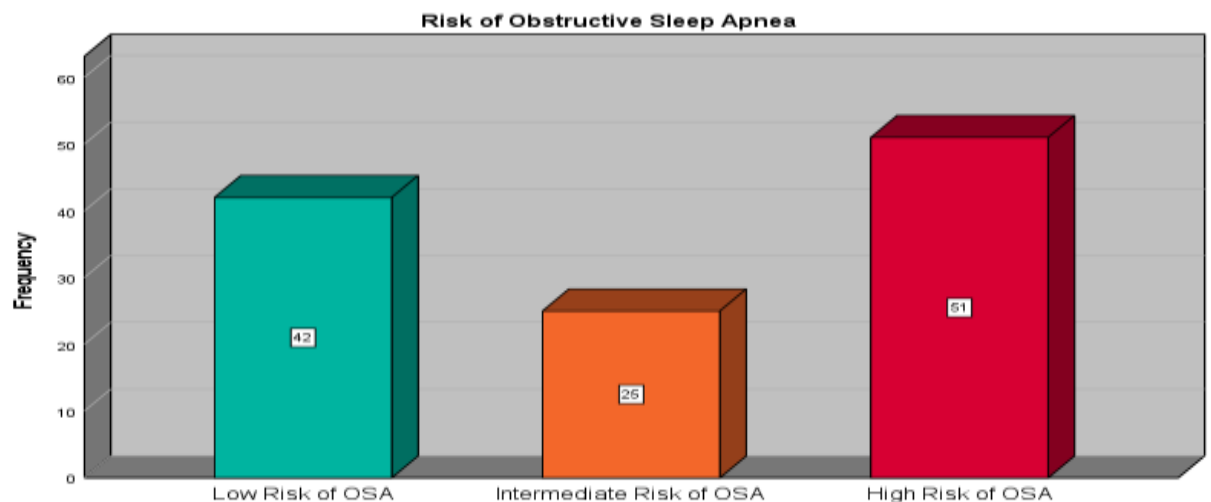
Table 5: Descriptive statistics of STOP Bang Score

STOP BANG SCORE					
	N	Minimum	Maximum	Mean	Std. Deviation
STOP BANG	118	0	7	3.47	1.880
Valid N (listwise)	118				

According to the results of the study, 35.6%, 21.2%, and 43.2% of the total participants were found to be at low, intermediate, and high risks, respectively, based on the application of the STOP-BANG criteria for the stratification of OSA risks. Generally, the highest number of participants was found to belong to the high-risk group, followed by low and intermediate risks.

Table 6: Risk of OSA based on STOP Bang Score

Risk of OSA					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low Risk of OSA	42	35.6	35.6	35.6
	Intermediate Risk of OSA	25	21.2	21.2	56.8
	High Risk of OSA	51	43.2	43.2	100.0
	Total	118	100.0	100.0	

Figure 4:

The total number of participants involved in the analysis was 118. The mean HR variability was 9.76 ± 6.70 , with a minimum value of 1 and a maximum value of 46. The mean SBP variability was 12.69 ± 7.91 , with a minimum value of 2 and a maximum value of 40. The mean DBP variability was 8.08 ± 4.90 , with a minimum value of 2 and a maximum value of 29. The mean SpO₂ variability was the lowest at 1.99 ± 1.82 , with a minimum value of 0 and a maximum value of 11.

Table 7: Hemodynamic Variability

Hemodynamic Variability					
	N	Minimum	Maximum	Mean	Std. Deviation
HR_variability	118	1	46	9.76	6.696
SBP_variability	118	2	40	12.69	7.907
DBBP_variability	118	2	29	8.08	4.900
SPO2_variability	118	0	11	1.99	1.815
Valid N (listwise)	118				

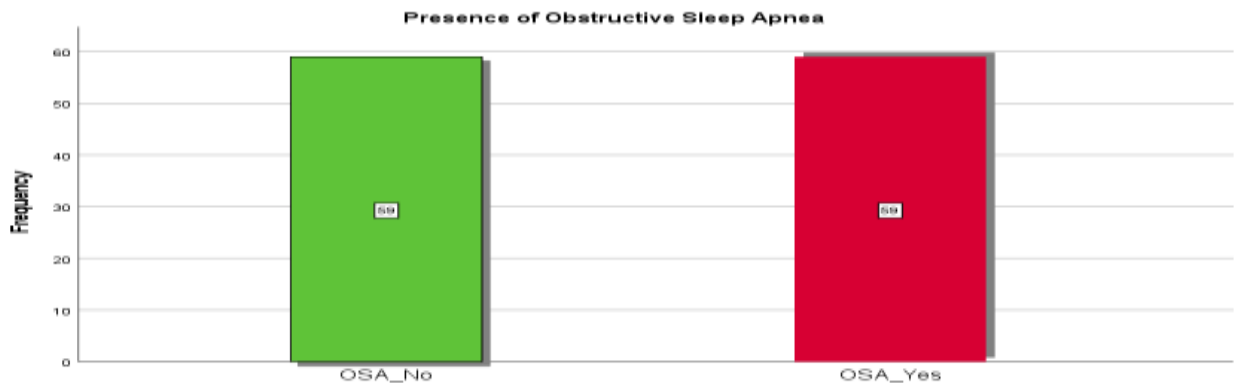
The distribution of patients according to their obstructive sleep apnea (OSA) status. From a total of 118 patients, 59 (50.0%) were categorized as non-OSA (No), while 59 (50.0%) were categorized as OSA patients (Yes). The distribution of patients is similar between the two groups.

Table: Presence of OSA

Presence of OSA					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	OSA_No	59	50.0	50.0	50.0
	OSA_Yes	59	50.0	50.0	100.0

Total	118	100.0	100.0	
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Figure 4: Presence of OSA



From the group statistics, there were significant variations in baseline preoperative hemodynamic variables between the OSA and Non-OSA groups. Obstructive sleep apnea (OSA) patients were noted to have relatively higher mean preoperative heart rates compared to non-OSA individuals (92.75 ± 13.52 bpm vs 83.43 ± 13.19 bpm). This was similarly observed for preoperative systolic blood pressure, which was relatively higher in OSA patients compared to Non-OSA individuals (131.42 ± 16.53 mmHg vs 121.48 ± 18.42 mmHg). The trend was also observed in preoperative diastolic blood pressure, where OSA patients recorded relatively higher readings compared to Non-OSA individuals (85.13 ± 12.59 mmHg vs 76.74 ± 13.04 mmHg). On the other hand, OSA patients had relatively low SpO₂ levels compared to non-OSA individuals ($97.28 \pm 2.37\%$ vs $97.72 \pm 1.59\%$).

Table 8: Parameters Baseline Variation

Parameters Baseline Variations					
	OSA_Yes/No	N	Mean	Std. Deviation	Std. Error
Preop_HR	Non_OSA_Patients	59	83.4310	13.19238	1.73225
	OSA_Patients	59	92.7500	13.51537	1.74483
Preop_SBP	Non_OSA_Patients	59	121.4828	18.41933	2.41858
	OSA_Patients	59	131.4167	16.52968	2.13397
Preop_DBP	Non_OSA_Patients	59	76.7414	13.04050	1.71230
	OSA_Patients	59	85.1333	12.59199	1.62562
Preop_Spo2	Non_OSA_Patients	59	97.7241	1.58715	.20840
	OSA_Patients	59	97.2833	2.37281	.30633

Comparison of preoperative hemodynamics was done via independent samples t-test. Assumption of equal variances was tested using Levene's test. For HR, SBP, and DBP, equal variances were assumed ($p > 0.05$); whereas for SpO₂, unequal variances were assumed ($p < 0.05$). Level of significance was set at $p < 0.05$. Results showed that there were significant differences among various preoperative hemodynamic parameters between OSA and non-OSA patients. The preoperative heart rate of OSA patients was significantly higher than those who did not suffer from OSA by 9.32 beats per minute ($t = -3.789$, $p < 0.001$). The same trend can be noticed in the difference in preoperative systolic blood pressure between these two groups, as the difference between the means is significantly high (9.93 mmHg; $t = -3.086$, $p = 0.003$). Additionally, the difference in preoperative diastolic blood pressure between the OSA and non-OSA groups was found to be significantly higher (8.39 mmHg; $t = -$

3.556, $p = 0.001$). However, no statistically significant difference in preoperative oxygen saturation was noticed between the groups ($t = 1.190$, $p = 0.237$), even though patients with OSA were found to have slightly lower mean oxygen saturation levels.

Table 9: Independent Samples t-test

Independent Sample t Test							
Variable		t	df	p	Mean Difference	95% CI Lower	95% CI Upper
Preoperative Heart Rate (HR)		-3.79	116	< .001	-9.32	-14.19	-4.45
Preoperative Systolic Blood Pressure (SBP)		-3.09	116	.003	-9.93	-16.31	-3.56
Preoperative Diastolic Blood Pressure (DBP)		-3.56	116	.001	-8.39	-13.07	-3.72
Preoperative Oxygen Saturation (SpO ₂)		1.19	103.34	.237	0.44	-0.29	1.18

The analysis of effect sizes showed the magnitude of differences between OSA and non-OSA patients in the selected preoperative variables. Preoperative heart rate revealed a moderate to large negative effect (Cohen's $d = -0.698$, 95% CI: -1.068 to -0.324). That is, OSA patients had higher heart rates than non-OSA patients. A similar trend was seen for preoperative systolic blood pressure, which had a moderate negative effect (Cohen's $d = -0.568$, 95% CI: -0.935 to -0.199). Diastolic blood pressure exhibited a moderate negative effect as well (Cohen's $d = -0.655$, 95% CI: -1.024 to -0.283). Finally, preoperative oxygen saturation had a small effect (Cohen's $d = 0.218$, 95% CI: -0.145 to 0.579) and was non-significant. Thus, the differences in heart rate and blood pressure levels were significant and had clinical significance for OSA patients. Oxygen saturation did not differ much and showed minimal clinical significance.

Table 10: Independent Sample Effect Sizes

Independent Samples Effect Sizes					
		Standardizer ^a	Point Estimate	95% Interval Lower	Confidence Upper
Preop_HR	Cohen's d	13.35764	-.698	-1.068	-.324
	Hedges' correction	13.44478	-.693	-1.061	-.322
	Glass's delta	13.51537	-.690	-1.069	-.305
Preop_SBP	Cohen's d	17.48375	-.568	-.935	-.199
	Hedges' correction	17.59782	-.564	-.929	-.197
	Glass's delta	16.52968	-.601	-.975	-.222
Preop_DBP	Cohen's d	12.81434	-.655	-1.024	-.283
	Hedges' correction	12.89794	-.651	-1.018	-.281
	Glass's delta	12.59199	-.666	-1.044	-.284
Preop_Spo2	Cohen's d	2.02521	.218	-.145	.579
	Hedges' correction	2.03842	.216	-.144	.575
	Glass's delta	2.37281	.186	-.177	.547

The repeated measure ANOVA was applied for the evaluation of differences in post-operative hemodynamic parameters in relation to the OSA presence among groups at three time points (T1, T2, and T3). Heart rate was found to differ significantly between two groups only at T2 ($F = 13.794$, $p < 0.001$) and T3 ($F = 6.916$, $p = 0.010$) but not at T1 ($F = 2.211$, $p = 0.140$). No statistically significant between-group differences were established for systolic blood pressure at all three time points: T1 ($p = 0.638$), T2 ($p = 0.300$), and T3 ($p = 0.076$). Diastolic blood pressure revealed significant differences only between groups at T2 ($F = 8.909$, $p = 0.003$) and T3 ($F = 20.425$, $p < 0.001$) but not T1 ($p = 0.072$). Oxygen saturation differed significantly at only T1 ($F = 5.829$, $p = 0.017$). The differences were not statistically significant at T2 and T3. Concerning the use of supplementary oxygen, significant results could be seen at T1 ($F = 7.531$, $p = 0.007$) and T2 ($F = 4.073$, $p = 0.046$), while no statistical difference could be seen at T3. In summary, there seems to be more marked differences between OSA and non-OSA subjects in relation to heart rate and diastolic blood pressure towards the end of the post-operative period, with similar readings concerning systolic blood pressure and oxygen saturation, as shown in the table below;

Table 11: ANOVA For Post-operative variables

ANOVA						
		Sum Squares	df	Mean Square	F	Sig.
Postop_T1_HR	Between Groups	444.346	1	444.346	2.211	.140
	Within Groups	23317.078	116	201.009		
	Total	23761.424	117			
Postop_T2_HR	Between Groups	3515.722	1	3515.722	13.794	.000
	Within Groups	29564.278	116	254.864		
	Total	33080.000	117			
Postop_T3_HR	Between Groups	466.591	1	466.591	6.916	.010
	Within Groups	7825.926	116	67.465		
	Total	8292.517	117			
Postop_T1_SBP	Between Groups	95.187	1	95.187	.223	.638
	Within Groups	49508.779	116	426.800		
	Total	49603.966	117			
Postop_T2_SBP	Between Groups	225.460	1	225.460	1.084	.300
	Within Groups	24125.828	116	207.981		
	Total	24351.288	117			
Postop_T3_SBP	Between Groups	691.907	1	691.907	3.194	.076
	Within Groups	25124.847	116	216.594		
	Total	25816.754	117			

Postop_T1_DBP	Between Groups	855.220	1	855.220	3.287	.072
	Within Groups	30180.178	116	260.174		
	Total	31035.398	117			
Postop_T2_DBP	Between Groups	982.093	1	982.093	8.909	.003
	Within Groups	12787.805	116	110.240		
	Total	13769.898	117			
Postop_T3_DBP	Between Groups	1255.952	1	1255.952	20.425	.000
	Within Groups	7132.836	116	61.490		
	Total	8388.788	117			
Postop_T1_Spo2	Between Groups	85.923	1	85.923	5.829	.017
	Within Groups	1710.017	116	14.742		
	Total	1795.941	117			
Postop_T2_Spo2	Between Groups	8094.642	1	8094.642	1.233	.269
	Within Groups	761373.333	116	6563.563		
	Total	769467.975	117			
Postop_T3_Spo2	Between Groups	.237	1	.237	.102	.751
	Within Groups	270.814	116	2.335		
	Total	271.051	117			
Postop_T1_supplemental_o2	Between Groups	.401	1	.401	7.531	.007
	Within Groups	6.183	116	.053		
	Total	6.585	117			
Postop_T2_supplemental_o2	Between Groups	.131	1	.131	4.073	.046
	Within Groups	3.733	116	.032		
	Total	3.864	117			
Postop_T3_supplemental_o2	Between Groups	.000	1	.000	.	.
	Within Groups	.000	116	.000		
	Total	.000	117			

DISCUSSION

This research investigated the connection between the risk of OSA and hemodynamic variables before and after elective non-cardiac surgery. As a whole, it can be stated that patients with OSA showed statistically significant higher values of preoperative heart rate and blood pressure than those without OSA; nevertheless, there were no statistically significant differences in oxygen saturation. Postoperatively, group comparisons varied depending on time, and heart rate and diastolic blood pressure demonstrated statistically significant differences at certain intervals.

One important finding from the study is that the baseline heart rate before surgery was significantly increased in OSA patients than in patients without OSA (92.75 ± 13.52 vs 83.43 ± 13.19 bpm; $p < 0.001$). The same trend was observed for both systolic and diastolic blood pressures. This supports the known pathogenesis of OSA in which intermittent hypoxia and sleep disruption cause sympathetic activation. Earlier research has established a strong link between OSA and sympathetic overactivity, causing an increase in heart rate and BP even while awake (Somers et al., 2021; Lévy et al., 2022). Our results show a significant rise in hemodynamic parameters even before any intervention was performed. This supports the idea that OSA contributes to chronic cardiovascular strain even when patients are preoperative.

Notably, there were no statistically significant differences among groups in terms of their preoperative oxygen saturation ($p = 0.237$), although it was slightly lower in OSA group compared to other groups. These results are partially in line with earlier findings that demonstrate that in most cases, oxygen saturation during the day can be maintained within normal levels in patients with OSA (Punjabi, 2021).

Postoperative results obtained from repeated measures ANOVA revealed that there were group differences across all time points, although not equally. There was a marked difference in heart rate at T2 and T3 compared to T1, implying that autonomic dysfunction is more noticeable among the OSA population in the postoperative period. Diastolic blood pressure differences at T2 and T3 also suggest sympathetic overactivity following surgery. These results are consistent with other studies that have shown surgical stress, anesthesia, and postoperative pain to intensify sympathetically-mediated reactions in patients with pre-existing autonomic dysfunction, like obstructive sleep apnea (OSA) (Chung et al., 2020). The lack of a significant difference in SBP values may be attributable to effective hemodynamic management during the surgery.

Oxygen saturation demonstrated only transient variations at T1, but postoperative hypoxia was not observed. The reasons for this could be associated with the use of oxygen therapy after surgery, which possibly masked any differences caused by hypoxia. Such an observation is consistent with other studies in perioperative settings where hypoxic variability was masked by oxygen therapy in OSA patients (Memtsoudis et al., 2025).

In the current study, 43.2% of patients were identified as high risk for OSA by means of the STOP-BANG scale, whereas 21.2% of patients were at an intermediate risk. This percentage of unreported OSA risk is not unexpected since previous studies among perioperative populations have found OSA to be underdiagnosed (Chung et al., 2020). Hypertension was the most prevalent comorbidity, with a frequency of 49.2%, while diabetes mellitus was secondary. Such findings correspond well to the known epidemiological relationship between OSA and cardiovascular disease. There are many studies that prove that OSA is an important risk factor for hypertension (Peppard et al., 2024).

Unlike several other previous studies, no statistically significant differences were found for heart rate, SBP, DBP, or SpO₂ variations between the OSA and non-OSA groups in this study. The significance of this result lies in the possibility that short-term perioperative hemodynamic variation does not mirror the long-term autonomic nervous system instabilities observed in OSA patients. It is well established that there

exists a relationship between OSA and higher levels of variability in cardiovascular measures on a beat-to-beat basis, especially at night during sleep due to apneas (Parati et al., 2023). Our assessments were made in perioperative settings, where anesthesia, analgesics, and surgery may have minimized the physiological differences between the subjects, as previously demonstrated by Grote et al. (2023).

Conclusively, the current investigation has shown that OSA patients have higher preoperative cardiovascular values as compared to healthy controls, whereas postoperative cardiovascular values depend on the recovery period and are mainly apparent for heart rate and diastolic blood pressure. At the same time, hemodynamic variability in the acute perioperative period did not show significant differences between OSA and control participants possibly because of perioperative control and the administration of supplemental oxygen.

Strength and Limitations of the study:

Strengths of this study include its prospective nature, the direct comparison of hemodynamic variability between OSA and non-OSA patients, and the investigation of a South Asian population which has had little attention paid to this area before. On the other hand, some weaknesses are that the study uses a screening questionnaire to diagnose OSA instead of polysomnography, that there is too small a sample size to have enough statistical power, that there is no stratification of OSA severity, no continuous beat-to-beat analysis, and that only a 24-hour follow up after surgery has been performed. Other weaknesses are that there was no continuous monitoring of the blood pressure but instead a simple oscillometric measurement, and the study was conducted at only one hospital site.

CONCLUSION

The study determined the relationship between the susceptibility to obstructive sleep apnea syndrome and perioperative hemodynamic indicators in patients scheduled for elective surgery without cardiac pathology, considering demographic data, clinical characteristics, the STOP-BANG test, and the cardiovascular complications rate. The mean age of the study group was 45.74 ± 11.65 years, and its gender ratio was nearly equal: 50.8% women and 49.2% men. The leading ASA class was the II one (66.1%), followed by classes I and III (31.4% and 2.5% correspondingly), suggesting the predominance of a mild or moderate condition. Hypertension was the most prevalent coexisting pathology (49.2%), then came diabetes mellitus (17.8%) and ischemic heart disease (0.8%). According to the results of the STOP-BANG test, 43.2% of participants belonged to the category of high-risk OSA susceptibility, 21.2% to intermediate risk, and 35.6% to low-risk one. The hemodynamic profile was characterized by significantly higher pre-operative heart rate, systolic blood pressure, and diastolic blood pressure, but not oxygen saturation in the OSA group when compared to the controls. Postoperatively, there were group-specific time-related differences, with significantly divergent values for heart rate and diastolic blood pressure in later time points (T2 and T3). However, both systolic blood pressure and oxygen saturation levels showed little difference between the groups. In addition, the intra-group hemodynamic variability did not show any difference between the two groups, indicating that short term perioperative variability may not be an adequate measure of autonomic dysregulation among the OSA group. The OSA group demonstrated significantly higher baseline cardiovascular burden as well as certain selective changes in hemodynamics during surgery.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are proposed;

Routine Preoperative Evaluation: Patients undergoing elective non-cardiac surgeries should be evaluated for OSA using standardized screening methods, such as the STOP-Bang score, since 64.4% of the subjects in the study had a risk for OSA that ranged from moderate to high.

Perioperative Monitoring: Patients with a high-risk OSA should undergo close monitoring of heart rate, blood pressure, and oxygen saturation levels, despite the fact that their baseline hemodynamics are comparable to those of non-OSA patients.

Anesthetic Management: The anesthetic management for OSA patients should consider regional anesthesia if possible, and long-acting sedatives and opioids should be avoided.

Respiratory Support Postoperatively: CPAP treatment should be taken into consideration for those OSA patients after surgery, along with oxygen supplementation and upright positioning to keep the airways patent.

Severity Levels in OSA Patients: Future studies on OSA need to classify OSA patients based on severity levels (mild, moderate, severe) instead of considering it as a binary disease since the impact on hemodynamics can vary.

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