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Predictive Value of STOP-BANG on OSAS-Related Complications Following Coronary Artery Bypass Grafting

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BACKGROUND: The time and conditions may not be suitable for performing polysomnography (PSG) before urgent or emergent surgeries, for example, a coronary artery bypass graft. Unavailability in many centers, critical clinical situation, and inability to arrange a timely scheduled appointment are other limitations for PSG. In this study, we aimed to investigate if the STOP-BANG Questionnaire may predict obstructive sleep apnea syndrome (OSAS) related postoperative pulmonary alterations during coronary artery surgery. METHODS: Sixty-one subjects who were scheduled to undergo elective isolated coronary artery bypass graft surgery and were consulted for preoperative pulmonary assessment were recruited to the study. The STOP-BANG Questionnaire was used with the subjects; then their relationship with postoperative complications was assessed. RESULTS: Results of the STOP-BANG Questionnaire revealed that 36.1% of subjects were at high risk for OSAS. Three groups were established according to the STOP-BANG Questionnaire (low risk, group 1; moderate risk, group 2; high risk, group 3) and study parameters, including PEEP value in ventilator, detection of apnea at ventilator, CPAP time after extubation, S_{pO_2} 1 h after extubation, postoperative hypoxemia, need for CPAP, and ICU length of stay revealed significant relationships among these groups. CONCLUSIONS: The STOP-BANG Questionnaire may predict the OSAS risk and OSAS-related pulmonary complications for patients who are candidates for a coronary artery bypass graft and unable to be evaluated with PSG before surgery due to technical or time-related limitations. *Key words: obstructive sleep apnea syndrome; preoperative pulmonary assessment; postoperative complications; STOP-BANG.* [Respir Care 0;0(0):1–•. © 0 Daedalus Enterprises]

Introduction

Obstructive sleep apnea syndrome (OSAS) is a public health problem, characterized by repeated obstruction of the upper airways when sleeping and the consequent snoring, blockade of breathing while sleeping, and excessive daytime sleepiness. Its prevalence in the general population has been reported as 2–25%; most cases remained undiagnosed.[1] Sedation and anesthesia performed during surgery increase the susceptibility of upper airway collapse. The American Society of Anesthesiologists recommends OSAS screening during the preoperative period.[2] Regardless of the type of surgery, it is recommended that necessary precautions be taken by establishing a diagnosis in patients with OSAS before surgery, when a direct association with postoperative complications is present.[2] The accepted method for the diagnosis of sleep apnea is polysomnography (PSG).[3] Nevertheless, PSG may not be performed in many patients with suspected OSAS due to its

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The authors have disclosed no conflicts of interest.

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unavailability in many centers, the time required for the procedure itself, and an inability to arrange a timely appointment.[4] Time and conditions may also not be suitable for performing PSG before urgent or emergent surgeries, for example, coronary artery bypass grafting.

The risk of coronary artery disease is known to be increased in patients with OSAS.[5,6] Therefore, we believe that any presence of OSAS should be thoroughly investigated during the preoperative workup for coronary surgery. In a patient who has no risk factors for coronary artery disease, OSAS may be a risk factor if the patient has no previous OSAS diagnosis. One study showed that most subjects with OSAS who underwent surgery for any reason were unaware of their OSAS at the time.[7] We suggest that some questionnaires (Berlin Questionnaire, American Society of Anesthesiologists Checklist, and the STOP-BANG [snoring, tiredness during daytime, observed apnea, high blood pressure, body mass index, age, neck circumference, gender] Questionnaire) may be used to predict the risk of OSAS in such patients, especially if time and conditions are not suitable for performing PSG.[8]

The STOP-BANG Questionnaire was originally developed in the surgical population but has been validated in many patient populations. It is more valuable for preoperative assessment than the Berlin Questionnaire, which is complex and time consuming. In an urgent situation, it is impractical to calculate an exact score in the Berlin Questionnaire, which has 2–5 parameters for each of 10 questions. Furthermore, the questions require full co-operation of the patient which may be impossible in many clinical scenarios. The American Society of Anesthesiologists checklist is another option for this aim; however, the STOP-BANG Questionnaire is considered the easier questionnaire between the two.[9] The tonsils and the upper airway need to be checked when using the American Society of Anesthesiologists checklist, which is more time consuming and sometimes impractical.

Furthermore, the American Society of Anesthesiologists requires, as part of its assessment, PSG data. Assessment with the STOP-BANG Questionnaire does not require PSG, which is often difficult to conduct in patients who require coronary artery bypass graft surgery.[10] With the STOP-BANG Questionnaire, up to 100% sensitivity has been reported to detect patients at high risk. Acar et al[10] suggested that this questionnaire was used for OSAS screening in a Turkish population with a sensitivity of 95–100%. Sensitivity of the STOP-BANG Questionnaire as a screening test for OSAS is 94–95%.[11,12] We chose the STOP-BANG Questionnaire due its simplicity and validation, particularly in surgical populations.

Preoperative questionnaires to predict OSAS were previously used in preoperative periods of several types of surgical interventions.[13-15] There has not yet been a study regarding preoperative use of such questionnaires to predict a diagnosis of OSAS without performing PSG in patients undergoing coronary artery surgery. Therefore, our study aimed to investigate whether STOP-BANG Questionnaire, used to determine sleep apnea risk, would also predict OSAS-related postoperative pulmonary complications in subjects undergoing coronary artery surgery.

QUICK LOOK

Current knowledge

Patients with obstructive sleep apnea syndrome (OSAS) are known to be at increased risk for coronary artery disease. Postoperative complications are more likely to be seen in patients diagnosed with OSAS, and the American Society of Anesthesiologists recommends OSAS screening in the preoperative period. The accepted method for the diagnosis of sleep apnea is polysomnography (PSG); however, time and conditions may not be suitable for performing PSG before urgent or emergent surgeries, for example, coronary artery bypass grafting.

What this paper contributes to our knowledge

Our study revealed that intra- and postoperative risks and complications, such as OSAS-induced hypoxia and an increased CPAP requirement might be successfully predicted through a simple STOP-BANG Questionnaire. Patients who are in an unsuitable clinical condition for PSG may be evaluated with this questionnaire in a practical and easy manner.

Methods

Patients who were scheduled to undergo elective isolated coronary artery bypass grafting surgery and consulted for preoperative pulmonary assessment between June 2016 and December 2016 in our cardiovascular surgery clinic were eligible for the study. The institutional review board of our hospital approved this study. Enrolled subjects had neither a comorbidity nor a previously established OSAS diagnosis. Patients with comorbid conditions, emergency cases, those with pathological finding in preoperative chest radiographs, and those with a history of smoking were excluded from the study because all these criteria may influence postoperative complications (Figure 1).

The STOP-BANG Questionnaire was used with the subjects at bedside during the routine preoperative pulmonary investigation performed by the physician (OED) from the Department of Chest Diseases. Results of the questionnaire were collected separately from usual medical data.

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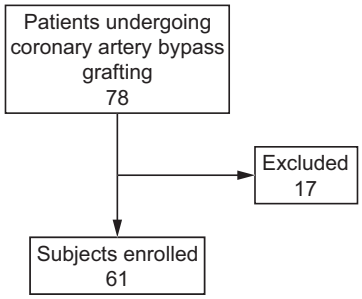

Fig. 1. Flow chart.

ICU physicians and surgical team members were blinded to the outcomes of the STOP-BANG Questionnaire assessments. Postoperative follow up (eg, extubation, need for CPAP, discharge to the ward) of the subjects was managed primarily by ICU physicians in accordance with standard clinical protocols.

Coronary Artery Bypass Grafting Surgical Procedure

In our cardiovascular surgery unit, the same surgical team performed surgical interventions in a standard manner. With the subject under general anesthesia, a median sternotomy was performed. Grafts (internal mammary artery, great saphenous vein, and radial artery) were harvested under full systemic heparinization (heparin 300 IU/kg). After ascending aortic arterial and 2-stage right atrial venous cannulation, a cardiopulmonary bypass was established. Combined intermittent ante- and retrograde crystalloid cardioplegia was administered after cross-clamping of the ascending aorta. Distal and proximal anastomoses were performed under single-aortic clamping. The lungs were ventilated with low tidal volume (3 mL/kg) during cardiopulmonary bypass.

After completion of coronary grafting, a terminal hot shot cardioplegia was given and the cross-clamp was removed. The cardiopulmonary bypass was terminated, and heparin was reversed with intravenous protamine (1.1 mg for each milligram of heparin). The sternum was closed by using sternal wires in a figure-eight fashion. All extubation and discharge procedures were followed in accordance with the same clinical protocol. The institutional criteria for extubation were the following: the subject was awake and hemodynamically stable, with no excessive bleeding, which may require further reoperation; the ability of the subject to breathe through a T-piece for at least 30 min ($F_{IO_2} < 0.40$ and a breathing frequency of <25 breaths/min, an arterial blood P_{aO_2} >70 mm Hg, a P_{aCO_2} of <40 mm Hg, and a pH >7.35, without metabolic acidosis). Other criteria included a tidal volume of 6 mL/kg, a peak negative inspiratory pressure of less than −20 cm H_2O and a mandatory chest radiograph before extubation to rule out pulmonary complications.

A prerequisite for discharge to the ward was the establishment of the patient's hemodynamic stability. The subjects who were extubated, tolerated oral intake uneventfully, had no drainage, mobilized comfortably, and cooperated with full consciousness could be referred to general care. Subjects who were hemodynamically stable and who did not develop postoperative complications (eg, infection, sternal dehiscence) during their stay in the general ward were discharged after 4 d of follow-up.

Pulmonary Assessment

Besides preoperative routine anamnesis, a physical examination and tests (comorbid conditions, history of smoking, body mass index, lung function tests, plain chest radiographs, computed tomography records, arterial blood gases, saturation values), the subjects were assessed for time to extubation, ICU length of stay, PEEP values and detection of apnea during invasive mechanical ventilation, postoperative CPAP use, and hypoxia (cases with mean unoxygenated $S_{pO_2} < 90\%$ at 1, 3, and 24 h on postoperative day 1).

Questionnaire

The STOP-BANG Questionnaire used for screening of sleep apnea was used when assessing the subjects. The STOP-BANG Questionnaire is a simple validated 8-item instrument that asks about symptoms of snoring, tiredness, and observed apnea, and a history of high blood pressure.[16] It also includes a section to document the body mass index, age, neck circumference, and sex. The STOP-BANG test is shown in Table 1. The STOP-BANG Questionnaire was categorized as mild, intermediate, and high according to the scores of 0–2 (group 1), 3–4 (group 2), and 5–8 (group 3), respectively. Parameters compared among groups 1, 2, and 3 according to the STOP-BANG Questionnaire included the following: duration invasive ventilation, PEEP, and F_{IO_2} levels, detection of apnea during ventilation, S_{pO_2} 1 h after extubation, postoperative hypoxemia, atelectasis, prolonged mechanical ventilation, need for CPAP, and ICU length of stay.

Statistical Method

Statistical analyses were performed by using SPSS version 22.0 (SPSS, Chicago, Illinois). Three STOP-BANG Questionnaire groups were (see previous section) compared in terms of postoperative pulmonary follow-up and changes within their questionnaire groups. Normality was analyzed by using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Descriptive statistics were presented as

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Table 1. STOP-BANG Questionnaire

Questions	Response	
STOP		
Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?	Yes	No
Do you often feel tired, fatigued, or sleepy during the daytime?	Yes	No
Has anyone observed you stop breathing during your sleep?	Yes	No
Do you have or are you being treated for high blood pressure?	Yes	No
BANG		
Body mass index > 35 kg/m^2?	Yes	No
Age > 50 y?	Yes	No
Neck circumference of > 16 inches (40 cm)?	Yes	No
Male gender?	Yes	No
Total score*		

* High risk of OSAS: yes, 5–8; intermediate risk of OSAS: yes, 3–4; low risk of OSAS: yes, 0–2.
STOP-BANG = Snoring, tiredness during daytime, observed apnea, high blood pressure, body mass index, age, neck circumference, gender
OSAS = obstructive sleep apnea syndrome

mean ± SD, median (minimum-maximum) according to continuously variable distribution, and number and percentage for categorical data. In analysis of continuous variables for mean comparisons of > 2 independent groups, analysis of variance was used for normal distributed data, and the Kruskal-Wallis test was used for non-normal distributed data. Post hoc tests were used for pairwise comparisons after variance analysis to identify the group(s) that created the difference. Associations among categorical variables were investigated by using the chi-square test. In addition, the Cramer V and contingency coefficient were calculated by using the chi-square test for the level of association among categorical variables. Associations between continuous variables were assessed by using the Spearman correlation coefficient. Statistical significance was set at a level of $P < .05$.

Results

Forty-four of 61 subjects (72.1%) were men and the age of the population was 63.0 ± 8.2 y. Body mass index was 28.3 ± 3.8 kg/m^2, and lung function tests showed an FEV_1% of 91.5% ± 17.9%, FVC% of 87.3% ± 17.9%, and FEV_1: FVC of 85.5 ± 7.8. P_{aO_2} values of the subjects were 81.9 ± 13.1 mm Hg. The preoperative saturation was 95.8 ± 1.8%. Neck circumference was found to be 33.7 ± 4.8 cm. Snoring was present in 59% of subjects, witnessed apnea in 23%, and daytime sleepiness in 49.2%. The STOP-BANG Questionnaire groups did not differ with respect to age ($P = .45$), duration of surgery ($P = .78$), and body mass index ($P = .49$).

Nineteen subjects (31.1%) had a STOP-BANG Questionnaire score of 0–2 (group 1), 32.8% subjects had a STOP-BANG Questionnaire score of 3–4 (group 2), and the remaining 36.1% had a STOP-BANG Questionnaire score of 5–8 (group 3). The duration of mechanical ventilation was not statistically significant different among the STOP-BANG Questionnaire groups 1, 2, and 3 (12.8, 10.6, and 10.4 h, respectively; $P = .37$). PEEP was statistically different among the STOP-BANG Questionnaire groups (4.3, 4.0, and 5.8 mm Hg, respectively; $P = .02$, $P = .01$), which was driven by the difference between group 2 and group 3 ($P = .01$, $P = .01$). The STOP-BANG Questionnaire groups did not significantly differ in terms of F_{IO_2} values on invasive ventilation (55, 51, and 54%, respectively; $P = .41$). The STOP-BANG Questionnaire groups had significant differences in detected apnea during invasive ventilation (5.3, 15.8, and 45.5%, respectively); $P = .008$, $P = .01$). A statistically significant difference was found among the STOP-BANG Questionnaire groups in terms of 1-h postextubation saturations (97.2, 96.9, and 92.3%, respectively; $P < .001$), which were driven by the differences between group 1 and 3 ($P = .003$), and between groups 2 and 3 ($P = .001$, $P = .01$). The STOP-BANG Questionnaire groups also significantly differed in postextubation CPAP duration (4, 7.5, and 37 h, respectively; $P = .01$, $P = .041$). Post hoc analyses showed the difference was between groups 1 and 3 ($P = .041$) and between group 2 and 3 ($P = .02$). ICU length of stay was 2.4 d in group 1, 2.3 d in group 2, and 3.4 d in group 3 ($P = .01$), which was driven by the differences between groups 2 and 3 ($P = .02$) and between groups 1 and 3 ($P = .049$). The STOP-BANG Questionnaire groups did not statistically differ in the duration of the surgery ($P = .78$).

Analyses of postoperative pulmonary complications that compared the STOP-BANG Questionnaire groups revealed a significant difference in hypoxemia ($P < .001$), which was observed in 5.4% of the subjects in group 1, 5% in group 2, and 77.3% in group 3 on postoperative day 1. Groups did not significantly differ in terms of atelectasis (15.8, 40, and 45.5%, respectively; $P = .11$, $P = .09$) nor in terms of mechanical ventilation (21.1, 40.0, 54.5%, respectively; $P = .09$, $P = .11$). The STOP-BANG Questionnaire groups showed a significant difference in CPAP requirement (10.5, 10.0, and 54.5%, respectively), ($P = .001$). Postoperative complications and follow-up parameters within the STOP-BANG Questionnaire groups are outlined in Table 2.

Analysis of the association between hypoxemia and the CPAP requirement showed that the CPAP requirement was 47.4% in subjects with hypoxemia, whereas it was 16.7% in subjects without hypoxemic ($P = .02$). A positive correlation was also observed between detection of apnea during invasive ventilation and CPAP requirement. Although those who required CPAP were

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Table 2. Postoperative Complications and Follow-up Parameters of 3 Groups by Using the STOP-BANG Questionnaire

Variables	STOP-BANG Groups				
	1	2	3	Total	*P*
Apnea during invasive ventilation, *n* (%)	1 (5.3)	3 (15.8)	10 (45.4)	14 (23.3)	.008
Postoperative hypoxia, *n* (%)	1 (5.3)	1 (5)	17 (77.3)	19 (31.1)	<.001
Postoperative atelectasis, *n* (%)	3 (15.8)	8 (40.0)	10 (45.5)	21 (34.4)	.11
Postoperative prolonged ventilation, *n* (%)	4 (21.1)	8 (40)	12 (54.5)	24 (39.3)	.09
Need for postoperative CPAP, *n* (%)	2 (10.5)	2 (10.0)	12 (55.5)	16 (26.2)	.001
Need for postextubation CPAP, *n*	2	2	12	16	.001
Total, *n*	19	20	22	61	
Duration of invasive ventilation (mean ± SD), h	12.8 ± 14.5	10.6 ± 3.2	10.4 ± 1.6	11.2 ± 8.3	.37
PEEP on invasive ventilation, mean ± SD, mm Hg	4.3 ± 1.3	4.0 ± 0.8	5.9 ± 1.8	4.8 ± 1.6	.002
F_{IO_2} on invasive ventilation, mean ± SD	0.55 ± 0.83	0.51 ± 0.99	0.54 ± 0.86	0.53 ± 0.89	.41
Postextubation CPAP time, mean ± SD, h	4 ± 4	7.5 ± 11.4	37 ± 9.5	25.6 ± 17.8	.01
ICU LOS, mean ± SD, d	2.4 ± 0.8	2.3 ± 0.6	3.4 ± 1.4	2.7 ± 1.1	.01

STOP-BANG = snoring, tiredness during daytime, observed apnea, high blood pressure, body mass index, age, neck circumference, gender

Table 3. Sensitivity of STOP-BANG Questionnaire in Predicting Postoperative Complications That May Develop Secondary to OSAS

Complication	STOP-BANG Questionnaire Scores Sensitivity (95% CI)
Hypoxemia	89.5 (65.5–98.2)
Prolonged mechanical ventilation	50.0 (29.6–70.4)
Need for CPAP	75 (47.4–91.7)
Nocturnal apnea in ventilator	71.4 (42.0–90.4)

STOP-BANG = snoring, tiredness during daytime, observed apnea, high blood pressure, body mass index, age, neck circumference, gender

47.4% in those subjects with apnea during invasive ventilation, it was 21.7% in those with no apnea during invasive ventilation ($P = .007$). There was no association between hypoxia and atelectasis ($P = .37$), when hypoxia was present 23.8% of subjects with atelectasis and 35% of subjects with no atelectasis. The duration of postoperative CPAP and length of stay in the ICU was strongly correlated ($r = 0.76$, $P = .001$). In the sensitivity analyses, the STOP-BANG Questionnaire scores had a higher sensitivity in predicting postoperative hypoxia, nocturnal apnea at ventilator and CPAP requirement (Table 3).

Discussion

In the peri- and postoperative periods, apnea during invasive ventilation, high ventilator PEEP requirement, decreased postextubation 1-h saturation, an increased need for postoperative CPAP, hypoxia, and increased ICU length of stay, which may all be secondary to OSAS, were seen in the peri- and postoperative periods in the subjects at high risk for OSAS, as determined in our study by the STOP-BANG Questionnaire. This questionnaire detected 36% of the subjects as being at high risk.

To our knowledge, there has been no study regarding the questionnaires that may be used for determination of OSAS risk before coronary surgery.[13,14,17] Several studies were performed to identify the preoperative OSAS risk by using various methods in some surgical interventions other than coronary surgery. Frey and Pilcher[14] reported the OSAS risk to be >70% before bariatric surgery. In fact, this type of surgery may be used for the treatment of OSAS, when indicated for cases who had typically increased risk of OSAS.[17] Chung et al[13] found 24% of the subjects at risk for OSAS as determined by preoperative Berlin questionnaire. Vasu et al[18] used the STOP-BANG Questionnaire to assess OSAS risk before elective surgical interventions and detected it as 41%. We gained significant clinical bebefit with using STOP-BANG questioneirre in identifying the OSAS risk. We found the OSAS risk to be 36% in the preoperative period of coronary artery surgery.

Undiagnosed OSAS is estimated to be common. Studies regarding sleep apnea syndrome and its comorbidities reported a higher prevalence of coronary artery disease in patients with OSAS. Moreover, these patients may die from sudden cardiac events.[19] In our study, the subjects in the high-risk group (as identified by the STOP-BANG Questionnaire before coronary artery surgery) had a higher prevalence (36%) of OSAS, which was reported as being lower (2–25%) in a previous study.[1]

Sedation, anesthesia, and use of opioids during surgery have been reported to cause an exacerbation of sleep apnea syndrome in the perioperative period.[1] Sleep apnea is

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associated with postoperative CPAP use and hypoxemia.[1] Untreated OSAS increases the risk of perioperative complications, including a difficult intubation, postoperative respiratory and cardiovascular complications, increased admission to the ICU, a prolonged hospital length of stay, and death. Gupta et al[20] reported postoperative complications of 39% in subjects with OSAS compared with 18% in subjects without OSAS.

Liao et al[21] found these complications in 44% of the subjects with OSAS versus 28% of the subjects without OSAS. Preoperative CPAP use was reported to decrease postoperative complications in subjects with an established OSAS diagnosis.[20] In our study, the postoperative need for CPAP were higher in the high risk group (as defined according to the STOP-BANG Questionnaire score) than those who were not classified as at high risk. Those at high risk for OSAS also had a higher incidence (77%) of postoperative hypoxia compared with subjects who were not at high risk.

The most common cardiovascular postoperative complications in cardiac surgery are related to extracorporeal circulation and its inflammatory reaction. It is well known that extracorporeal circulation affects the lungs and causes alveolar edema, hypoxemia, and atelectasis, which can delay extubation.[22] Our study did not show any difference regarding the incidence of atelectasis among the groups as determined by the STOP-BANG Questionnaire scores. Atelectasis, which may be involved in the etiology of postoperative hypoxia, did not cause an increased rate of hypoxia among subjects in high-risk cases as defined by the STOP-BANG Questionnaire.

To our knowledge, there has been no study in the literature regarding postoperative CPAP use, respiratory failure, increased ICU length of stay, and postoperative pulmonary complications that may be related to OSAS in subjects at high risk for OSAS per preoperative questionnaires in coronary artery surgery. Previous studies showed higher incidences of postoperative complications and hypoxemia and increased hospital length of stay among noncardiac surgical subjects who were diagnosed with OSAS when using preoperative PSG.[23] Vasu et al[18] described a preoperative OSAS risk when using the STOP-BANG Questionnaire and reported higher incidences of postoperative complications in those subjects with a high risk for OSAS. To our knowledge, our study was the first study that used the STOP-BANG Questionnaire in determining the OSAS risk before coronary artery surgery.

A limitation of the study was that it included hypoxia determined by postoperative day 1 S_{pO_2} follow-up rather than respiratory failure determined by postextubation measurements of arterial blood gases during the postoperative period. The S_{pO_2} values of $<90\%$ were regarded as hypoxia. Since P_{aO_2} values during routine postoperative assessment were high, subjects were intermittently deprived of nasal oxygen to measure S_{pO_2} values under the supervision of pulmonology consultants. This limitation resulted from the fact that it is unusual to intervene with the routine postoperative follow-up, and, consequently, to order additional arterial blood gas measurements.

Conclusions

Those patients preoperatively identified to have a high risk for OSAS should be closely monitored for hypoxia and a CPAP requirement during the postoperative period. Preoperative OSAS risk and postoperative complications, such as OSAS-induced hypoxia and increased CPAP requirement, may be predicted through simple questionnaires. The STOP-BANG Questionnaire may be used for determining the OSAS risk before coronary artery bypass graft surgery in PSG-incapable facilities or where no wait time is available for PSG. Our study showed higher incidences of postoperative hypoxia and CPAP use, and increased the ICU length of stay in cases detected to have a high risk for OSAS, as determined by the preoperative STOP-BANG Questionnaire.

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