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REVIEW ARTICLES

Can Screening Tools for Obstructive Sleep Apnea Predict Postoperative Complications? A Systematic Review of the Literature

Lilia Dimitrov, MBBS; Vladimir Macavei, MBBS, CCST

Respiratory Department, Newham University Hospital, London, UK

Study Objectives: Obstructive sleep apnea (OSA) is a common, underdiagnosed condition that is associated with significant morbidity and mortality in the perioperative setting. Increasing evidence suggests that the utility of preoperative screening tools may go beyond identification of OSA, to the prediction of perioperative complications. The primary objective of this study was to systematically review the literature on all studies assessing whether high risk scores on the STOP-Bang questionnaire, American Society of Anesthesiologists (ASA) checklist, and the Berlin Questionnaire (BQ) are associated with higher rates of postoperative complications.

Methods: A systematic review of English language records was performed using Medline, EMBASE, and PsychInfo with additional studies identified by manual search through reference lists. Only studies that evaluated the ability of the STOP-Bang, the BQ, and ASA checklist to predict postoperative complications in adults were included.

Results: Twelve studies were included in the final review. Eight studies looked at STOP-Bang, 3 at the Berlin Questionnaire, and 2 at the ASA Checklist. Significant differences across study characteristics prevented a meta-analysis and the studies were evaluated qualitatively.

Conclusions: The ASA checklist, Berlin Questionnaire, and STOP-Bang questionnaire may be able to risk stratify patients for perioperative and postoperative complications. Further research is required, with a particular focus on specific surgery types and adjustment of potentially confounding factors in the analysis.

Keywords: OSA, screening questionnaires, STOP-Bang, Berlin Questionnaire, ASA Checklist, postoperative complications

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INTRODUCTION

Obstructive sleep apnea (OSA), the most common form of sleep-disordered breathing (SDB), is characterized by repeated and intermittent closure (complete or partial) of the upper airway during sleep.[1] This results in absent or reduced airflow with subsequent arousal to restore the airway. The term obstructive sleep apnea syndrome is applied when there is associated excessive daytime sleepiness (EDS).

Prevalence among elective surgical patients is higher than in the general population at 45%,[2] reaching nearly 80% in high-risk surgical groups, such as those undergoing bariatric surgery.[3] There is significant perioperative morbidity and mortality associated with OSA. A recent systematic review of over 400,000 patients with OSA undergoing surgery found that the majority of studies showed an increased rate of postoperative complications when compared to patients without OSA.[4] The American Society of Anesthesiologists (ASA) recommends routine preoperative screening for OSA, in recognition of the potential complications.[5] Despite this, the majority of surgical patients with OSA remain undiagnosed at the time of surgery.[2] A recent large matched cohort study found patients undiagnosed with OSA prior to surgery had significantly higher rate of cardiovascular events (cardiac arrests and shock) than those with diagnosed OSA (2.20 versus 0.75, $p = 0.009$).[6]

The gold standard for OSA diagnosis is overnight polysomnography, from which the average number of apnea and hypopnea episodes that occur per hour is calculated. An apnea-hypopnea index (AHI) ≥ 5 is diagnostic. Sleep studies are not used for routine preoperative screening, however, due to various drawbacks such as being expensive, time-consuming, and not always easily accessible.[7] In order to identify individuals at high risk of OSA, a number of risk assessment tools have been used for perioperative screening. These have the benefit of being efficient, cheap, and easy to use, and can be applied to a larger population. The STOP-Bang questionnaire, Berlin Questionnaire, and the ASA Checklist have been validated in the surgical population and are the most commonly used tools.

STOP-BANG is an 8-item screening tool composed of signs, symptoms, and anthropometric measurements. It is an extension of the initial 4-item screening tool STOP Questionnaire.[8] Each item in the tool is given a score of 1 if present, overall stratifying the risk of OSA into low (0–2), moderate (3, 4), and high (5–8).[9] The Berlin Questionnaire is a self-administered 10-item tool divided into 3 categories based on snoring, daytime sleepiness, and comorbidites.[10] A person is considered high risk if they are positive for items in ≥ 2 of the 3 categories. In 2006, the ASA Task Force agreed on a 12-item checklist to be used as a screening tool for OSA in surgical patients. The guidelines were updated in 2014 with the checklist incorporated into the identification and assessment tool for OSA.[5]

Increasing evidence suggests that the clinical use of these screening questionnaires may go beyond identifying patients at high risk of OSA and extend to risk stratifying patients for a number of perioperative and postoperative complications. The primary objective of this study was to perform a systematic review of the literature to identify all studies that evaluate whether these 3 screening tools are able to risk stratify patients for perioperative and postoperative complications.

METHODS

A review protocol was formulated initially to set out the methods to be used in the review. This was not changed during the process of conducting this systematic review. The review protocol can be accessed by direct communication with the corresponding author.

Eligibility Criteria

Participants

Adults (over 18) undergoing any type of surgery. We did not restrict participants to having a diagnosis of OSA as we wanted to assess the ability of the screening tools to predict operative complications.

Study Design

Experimental and observational studies (case-control, cohort, cross-sectional) were included. All studies that assessed the ability of STOP-Bang, Berlin Questionnaire, and the ASA Checklist to risk stratify patients for perioperative and postoperative complications, or both were included. The search was limited to these 3 questionnaires as they have been validated in the surgical population. Studies that were purely validating questionnaires but not assessing ability to predict operative complications were not included. If, however, the secondary aim of a study was to evaluate the ability of a questionnaire to predict operative complications then these studies were included. Studies that involved differential treatment or interventions targeting the high risk for OSA groups were excluded in order to assess the ability of the questionnaire to predict operative complications. We included both prospective and retrospective studies.

Outcome Measures

As there have not been many studies in this field, we decided not to restrict the studies to particular operative complications but include all complications. This extended to timing of surgical complications therefore perioperative and postoperative complications or both were included.

Identification and Selection of Studies

The databases used to identify studies were PUBMED, MEDLINE, and EMBASE. The full search items are available on request from the corresponding author. The search was restricted to English language only studies. All studies published in or before February 2016 were included. The selection of studies included unpublished data from conference proceedings.

The process of study selection is outlined in **Figure 1**. The searches were first conducted in February 2016 and last in May 2016. The studies were initially screened by relevance for the title, then by abstract, then by whole article. Eight studies were not included, as full-text articles could not be accessed (these were conference abstracts). This process yielded 11 studies which met the eligibility criteria and were included in the review. An additional study was included following manual searches through reference lists of reviews and primary research articles.

Data Extraction

A data extraction sheet based on the Cochrane Consumers and Communication Review Group's data extraction template was developed. Data were extracted by reviewer LD and VM. There were no disagreements in opinion requiring a third reviewer. In brief, data extraction included type of questionnaire, study design, sample size, number of participants classified as high or low risk for OSA, participant characteristics, country of study, study outcome, adjustments, and type of surgery. Due to the significant differences in the characteristics of eligible studies across these domains, a meta-analysis was not performed and the studies were evaluated qualitatively.

Quality Assessment

All studies that reached the full-text processing stage were systematically evaluated for bias using the Cochrane Risk of Bias Assessment Tool. This process included analysis of participant baseline characteristics with a particular focus on any confounding factors such as preoperative or postoperative treatment with continuous positive airway pressure (CPAP). Limitations regarding blinding, study design, and generalizability were also considered.

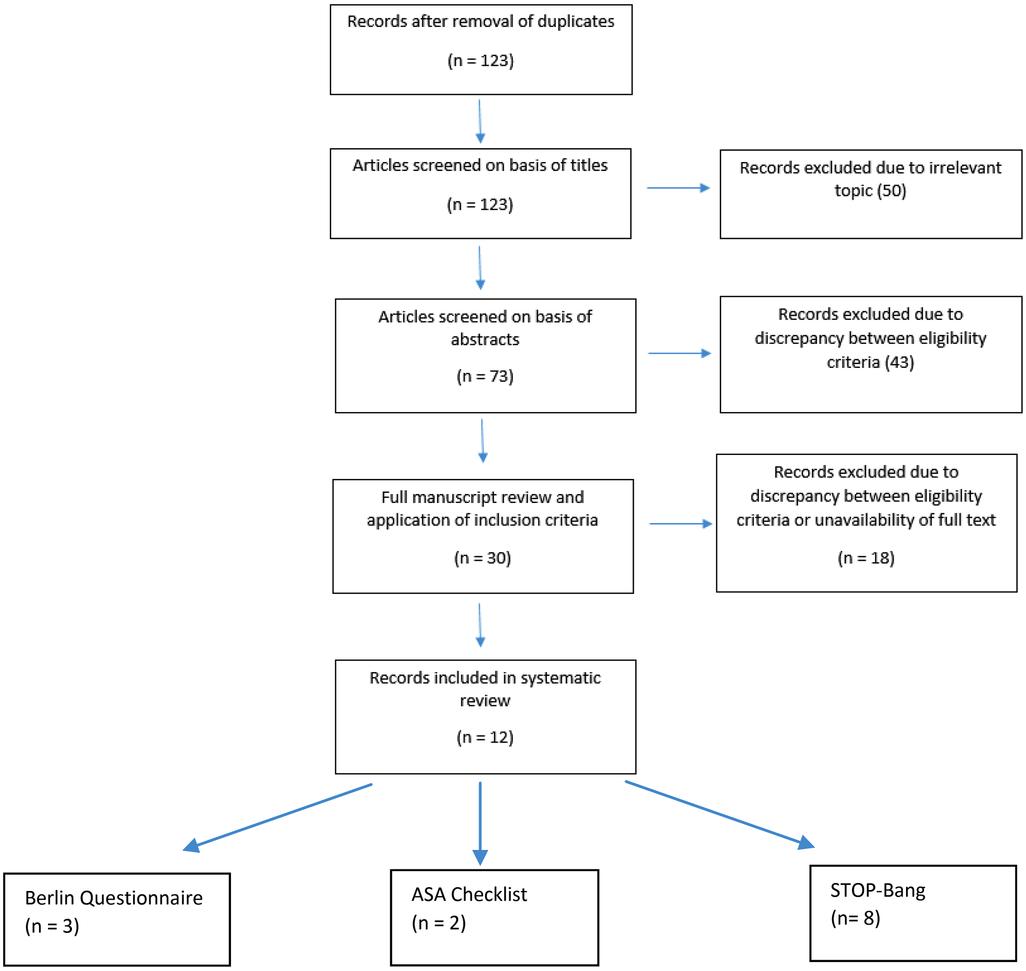
RESULTS

We identified 12 studies that examined whether OSA screening tools were able to risk stratify patients for perioperative and postoperative complications. The studies, characteristics, and results are presented in **Table 1** and have been organized into questionnaire type. The results for each tool will be presented separately. Overall sample sizes ranged between 61 and 5,342. Ten of the identified studies were cohort studies and 2 were case-control studies. Seven of the studies were retrospective and 5 were prospective.

STOP-BANG

Nine studies were found that addressed the ability of the STOP-Bang tool to risk stratify patients for surgical complications. One study was excluded as baseline characteristics were not available for participants.[11] Four studies were carried out in Europe,[12–15] 2 in the US,[16,17] and 2 in Singapore.[18,19] Samples sizes ranged from 127 to 5,342. Of the 8 studies, 4 were prospective[12,14–16] and 4 were retrospective.[13,17–19] All studies included were cohort studies. The primary outcomes of 3 studies focused on complications relating to airway management.[12,15,16] All 3 looked at difficult intubation, and 2 of these additionally looked at difficult mask ventilation.

Figure 1—Flow diagram of study selection.



Postoperative cardiac and/or pulmonary complications were the primary outcomes of 4 studies.[12–14,17] One study assessed critical care admissions,[19] and another study focused on unexpected perioperative and early postoperative complications.[18] High risk of OSA was classified as a STOP-Bang score ≥ 3 in 5 of the studies,[13–17] a score ≥ 5 in one study,[12] and 2 studies did not pool patients into high and low risk categories.[18,19]

Airway Management

Corso's multicenter study demonstrated that adults admitted for elective surgery who were classified as high risk for OSA had an increased frequency of difficult intubations compared to those at low risk (20% versus 9%, OR 1.86, CI 1.37–2.51) and difficult mask ventilations (23% versus 7%, OR 2.06, CI 1.51–2.83).[12] Of note, a higher cutoff point for high risk of OSA was used than in other studies (STOP-Bang ≥ 5). BMI and ASA ≥ 3 were also found to be independently associated with difficult mask ventilation and postoperative complications whereas age was not. There were significant differences between the high and low risk OSA groups with the former being older, overrepresented by males, people with a BMI ≥ 30, and patients with ASA grade III and IV (**Table 2**).

Acar et al. also found difficult intubation was more prevalent in patients with a high risk for OSA (13.3% vs 2.6%, $p = 0.004$).[15] Patients designated high risk were significantly more likely to be older, weigh more, have a higher BMI, have a larger neck circumference, have more comorbidities, belong to male gender, and have a lower preoperative oxygen saturation. Furthermore, they were also more likely to have higher Mallampati scores, and larger tonsils. Independent risk factors for difficult intubation were raised BMI, weight, neck circumference, and Mallampati scores. No adjustments were made for these factors when looking at high and low risk associations with intubation difficulty.

Toshniwal et al. looked at difficult airway management in 3 groups of morbidly obese patients undergoing bariatric surgery: previously diagnosed OSA, STOP-Bang ≥ 3, and STOP-Bang < 3.[16] Those with confirmed OSA, and those with unconfirmed OSA but STOP-Bang scores ≥ 3 were at a higher risk for difficult airway management compared to those at low risk for OSA ($p < 0.001$). Neck circumference was significantly larger in the high risk STOP-Bang group compared to low risk group. Otherwise the groups were similar in terms of age, sex and ASA status.

Table 1—Overview of studies addressing whether the three preoperative screening tools can risk stratify patients for perioperative and postoperative complications.

Study, Country	n (% male)	Mean Age (SD)	Study Design	Surgery Type	Outcomes	Groups (n patients)	Results
STOP-Bang							
Vasu 2010, USA	135 (44.4)	57.9 (± 14.4)	Cohort Retrospective	Elective, including head and neck.	Postoperative pulmonary + cardiac complications LOS	HR ≥ 3 (56) LR < 3 (79)	HR patients had higher postoperative complications (14.1% vs 4.2%, p = 0.4) & LOS (3.6 vs 2.1 days, p = 0.003).
Seet 2015, Singapore	5,432 (65.9)	40.8 (± 19.1)	Cohort Retrospective	Elective, excluding ophthalmic + emergency surgery.	Unexpected intro-op + early postoperative adverse events	Score 0 (1,069) Score 1–2 (3,878) Score 3–4 (409) Score 5–6 (67) Score 7–8 (9)	Higher STOP-bang scores associated with HR of unexpected intra + early postoperative event Score 3 OR 3.6 (CI 2.1–6.3)** Score 4 OR 3.4 (CI 1.8–6.5)** Score 5 OR 6.4 (CI 2.7–15.0)** Score ≥ 6 OR 5.6 (CI 2.1–15.4)**
Chia 2013, Singapore	5,432 (65.9)	40.8 (± 19.1)	Cohort Retrospective	Elective, excluding ophthalmic + emergency surgery	Postoperative Critical Care Admission	Score 0 (1,098) Score 1 (2,718) Score 2 (1,131) Score 3 (278) Score 4 (131) Score 5 (42) Score ≥ 6 (34)	Higher STOP-Bang scores associated with critical care admission. Score 3 OR 1.4 (CI 0.7–2.6) Score 4 OR 2.2 (CI 1.1–4.6)* Score 5 OR 3.2 (CI 1.2–8.1)* Score ≥ 6 OR 5.1 (CI 1.8–14.9)*
Proczko 2014, Poland	693 (70.1)	OSA confirmed 44.5 (± 7) HR 46.3 (± 5.3) LR 46.0 (± 5.8)	Cohort Retrospective	Bariatric surgery, excluding emergency.	Pulmonary complications LOS	OSA confirmed (99) HR ≥ 3 (182) LR < 3 (412)	↑LOS** + pneumonia* in HR vs confirmed OSA. ↑ risk of HTN,** LOS,** pneumonia + reintubation* in HR vs LR.
Corso 2014, Italy	3,452 (53.1)	LR 58.9 (17.5) HR 63.9 (13.8)	Cohort Prospective	Elective surgery, excluding regional anaesthesia.	Postoperative complications within 48 hours Difficult intubation Difficult mask ventilation	LR < 5 (2,997) HR ≥ 5 (455)	HR OSA at increased risk of postoperative complications (OR 3.98, CI 1.69- 9.37), difficult intubation (OR 1.86, CI 1.37–2.51) & difficult mask ventilation (OR 2.06, CI 1.51–2.83).
Toshniwal 2014, USA	117 (NA)	Confirmed: 38.9 HR 39.45 LR 38.6	Cohort Prospective	Bariatric surgery	Difficult airway/mask ventilation, blade insertion, intubation. Poor cord Visualisation	Confirmed (42) HR ≥ 3 (51) LR < 3 (24)	HR of difficult airway in confirmed OSA and HR group**
Acar 2014, Turkey	200 (40.5)	46.6 ± 15.7	Cohort Prospective	Elective surgery under GA.	Difficult intubation	HR ≥ 3(83) Lr < 3 (117)	HR OSA had significantly more difficult intubations (13.3% vs 2.6%).*
Pereira 2013, Portugal	340 (42.9)	HR: 63 LR: 47	Cohort Prospective	Elective surgery excluding cardiac + neurological	Respiratory complications Delirium LOS	HR ≥ 3 (179) LR < 3 (161)	HR patients were more likely to suffer with mild postop hypoxemia 9% vs. 3%, p = 0.012)* and have a greater LOS (median 5 days vs. 3 days, p = 0.01)*
BQ							
Amra 2014, Iran	61 (79)	58.6 ± 11.1	Cohort Prospective	CABG	Fever, AF, admission and re-admission to the ICU, re-intubation, duration of intubation, LOS	HR (25) LR (36)	HR patients had a significantly longer duration of intubation (0.75 ± 0.60 vs. 0.41 ± 0.56 days, p = 0.03)*
Mungan 2013, Turkey	73 (58.9)	Not given	Case-control Prospective	CABG	POAF	Not given	A significant proportion of patients with POAF were high risk BQ than those without POAF (58% vs 34%; p = 0.044)*
Chung 2008, Canada	211 (50.2)	56 ± 13	Cohort	General surgery, gynaecology, orthopedics, urology, plastic surgery, ophthalmology, or neurosurgery	Respiratory, cardiac, neurological complications. Prolonged O_2 therapy, additional monitoring, ITU admission.	HR (134) LR (77)	No complications significantly associated with HR of OSA.
ASA							
Chung 2008, Canada	211 (50.2)	56 ± 13	Cohort retrospective	General surgery, gynaecology, orthopedics, urology, plastic surgery, ophthalmology, or neurosurgery	Respiratory, cardiac, neurological complications. Prolonged O_2 therapy, additional monitoring, ITU admission.	HR (140) LR (77)	HR had greater postoperative respiratory complications (36 versus 7, p < 0.05)* + mild desaturations (30 versus 6, p < 0.05)*
Munish 2012, USA	613 (NA)	LR 61.94 ± 12.9 HR 61.5 ± 12.8	Case Control	All patients who underwent surgery under GA including emergency surgery.	Reintubation Mechanical ventilation Secondary: POAF, MI, haemodynamic instability, duration of PACU, LOS, readmission within 24 hours.	HR (306) LR (307)	Higher risk of OSA was associated with an increased risk of hypoxia (16.8% vs. 10.2%)* and reintubation (4.9% vs. 0.9%)**

*p < 0.05, **p < 0.001. AF, atrial fibrillation; ASA, American Society of Anesthesiologists; BQ, Berlin Questionnaire; CABG, coronary bypass graft; CI, confidence interval; CVA, cerebrovascular accident; GA, general anaesthesia; HR, high risk; LOS, length of stay; LR, low risk; MI, myocardial infarction; MR, moderate risk; OR, odds ratio; OSA, obstructive sleep apnea; POAF, postoperative atrial fibrillation; RR, respiratory rate; SD, standard deviation.

Other Complications

Cardiopulmonary postoperative complications were the primary outcomes of 3 studies.[12,14,17] Corso et al. found that patients at high risk for OSA were at a higher risk for respiratory and cardiac postoperative complications (OR 3.98, CI 1.69–9.37) compared to those scoring < 5 on the STOP-Bang questionnaire.[12] Similarly, Vasu et al. found patients with scores ≥ 3 had higher respiratory and cardiac postoperative complications (19.6% versus 1.3%, p < 0.001).[17] Significantly higher odds of postoperative complications remained once adjusted for obesity, age and ASA grade. No statistical analysis of the baseline characteristics of the high-risk and low-risk groups were made. Morbidly obese patients undergoing bariatric surgery with scores ≥ 3 had longer postoperative stays (4.1 versus 2.5, p < 0.0001) and more instances of postoperative pneumonia and reintubations following surgery than those

Table 2—Quality measures of the included studies.

Study	Blinded	Baseline Differences between Groups (HR versus LR)	Adjustments
STOP-Bang			
Vasu 2010	Team reviewing records blind to OSA status	Not examined	Age, ASA class ≥ 3, obesity
Seet 2015	Not specified	Not applicable	Age, ASA class, history of OSA, asthma, uncontrolled hypertension.
Chia 2013	Not specified	Not applicable	History of OSA, ASA class, asthma, age, (17 variables in total but the others not specified)
Proczko 2014	Not specified	Fewer hypertensive patients	Nil
Corso 2014	Not blinded	Proportion > 60, more males, higher BMI, higher ASA grade.	Age, gender, BMI, ASA class.
Toshniwal 2014	Anesthetist blinded	Neck circumference	Nil
Acar 2014	Not specified	Higher BMI, bigger neck circumference, male, older, more comorbidities, lower preoperative saturations, higher Mallampati score, bigger tonsils	Nil
Pereira 2013	Anesthetist blinded	Older, male, higher BMI, higher ASA grade, higher risk surgery, IHD, CCF, CVA, insulin requiring diabetes, HTN, dyslipidemia, COPD, major surgery,	gender, intra-abdominal surgery, major surgery, cardiovascular high-risk surgery, general anesthesia and/or combined anesthesia, use of neuromuscular relaxants and postoperative residual neuromuscular blockade
Berlin Questionnaire			
Amra 2014	Not specified	higher BMI, hypertension, dyslipidemia,	Nil
Mungan 2013	Not specified	No baseline differences	Nil
Chung 2008	Not specified	Information not given	Nil
ASA			
Chung 2008	Not specified	Information not given	Nil
Munish 2015	Partial	Higher prevalence of coronary artery disease, HTN and diabetes mellitus, higher Mallampati airway class	Nil

ASA, American Society of Anesthesiologists; BMI, body mass index; CCF, congestive cardiac failure; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; HR, high risk; HTN, hypertension; IHD, ischemic heart disease; LR, low risk; OSA, obstructive sleep apnea.

with scores < 3.[13] Patient's baseline characteristics were uniform across groups, with the only exception being that those with low risk of OSA had a greater prevalence of hypertension.

One study focused on pulmonary complications.[14] Pereira et al. found that patients undergoing surgery who were at high risk of OSA were significantly more likely to suffer with mild/moderate postoperative hypoxemia in Post-Anesthesia Care Unit (PACU) (9% vs. 3%, $p = 0.012$). No other postoperative respiratory complications were significant. High risk groups also were found to have longer length of stay (median 5 days vs. 3 days, $p = 0.01$). Patients that were high risk were more likely to have surgery classified as "major" which could be pertinent in terms of the high rate of complications. Furthermore, when there was adjustment for univariate predictors, high risk for OSA was not identified as an independent predictor of adverse respiratory events.

Unlike other studies, patients from in both studies by Chia and Seet were not categorized into high or low risk based on scores, but individual scores were analyzed.[18,19] Chia et al. found a STOP-BANG score ≥ 4 to be associated with a higher risk of postoperative admission to critical care.[19] Other independent risk factors for critical care admission included history of OSA, ASA ≥ 2, asthma, and age > 60 years. The same patient sample was used by Seet et al., who found that patients with STOP-Bang scores ≥ 3 were at risk of unexpected intraoperative complications and early postoperative complications when compared to those with a score of 0 (OR 3.6, CI 2.1–6.3, $p < 0.001$).[18] The odds ratio increased gradually with STOP-BANG score (**Table 1**).[18] Other independent predictors of complications were age, ASA grade > 1, and hypertension. Interestingly, a preexisting diagnosis of OSA was not found to increase risk of complications. This however may be explained by the very small number of patients with a diagnosis of OSA (2.2%).

Berlin Questionnaire

Three studies were found that addressed the ability of the Berlin Questionnaire to risk stratify patients for surgical complications.[11,20,21] Two of the studies were conducted in patients undergoing coronary bypass grafting (CABG), whereas the third included a broader range of surgeries. Sample sizes, primary outcomes, and patient demographics are summarized in **Table 1**. High risk of OSA was classified as scoring positive in ≥ 2 of the 3 categories.

Chung et al. found that patients at high risk of OSA according to the Berlin Questionnaire did not have a greater risk of complications than those deemed low risk.[11] This study looked at respiratory, cardiac, and neurological complications, in addition to intensive care unit (ICU) admissions, additional monitoring, and prolonged oxygen therapy. Two studies looked at complications following CABG.[20,21] In a prospective study of 61 patients undergoing CABG in a center in Iran, patients at high risk for OSA using the Berlin Questionnaire screening tool had longer duration of intubation (0.75 ± 0.60 vs. 0.41 ± 0.56 days, $p = 0.03$).[20] Patients at high risk were more likely to have a higher BMI, and suffer from certain comorbidities (hypertension, dyslipidemia, and pulmonary disease). Mungan et al. showed that high risk OSA patients were at a greater risk of developing postoperative AF (POAF) in this case-control study.[21] There was a higher prevalence of high risk for OSA in the POAF group (58% vs 34%; $p = 0.044$).

The American Society of Anesthesiologists Checklist

Only 2 studies were included that assessed the ability of the ASA checklist to predict postoperative complications.[11,22] A summary of study characteristics are displayed in **Table 1**.

Patients at high risk of OSA based on the ASA Checklist were found to be more likely to suffer from respiratory complications (36 versus 7, $p < 0.05$) and mild desaturations postoperatively (30 versus 6, $p < 0.05$).[11] Munish et al. used a matched case-control design with high and low risk for OSA matched for age, gender, ethnicity, and ASA.[22] The cases did however have significantly more comorbidities (coronary artery disease, hypertension, diabetes) and higher Mallampati scores. Higher risk of OSA was associated with an increased risk of hypoxia (16.8% vs. 10.2%, $p < 0.01$) and reintubation (4.9% vs. 0.9%, $p < 0.001$) and overall they were at higher risk of a composite adverse events (25.4% vs. 17.4%, $p < 0.01$). A potential confounder however is that a significant proportion of those identified as high risk were on CPAP (79.6% versus 20.4%, $p < 0.001$) prior to matching patients.

DISCUSSION

The studies described in this systematic review suggest that the STOP-Bang questionnaire, ASA checklist and Berlin Questionnaire may have some clinical utility in predicting a range of perioperative and postoperative complications. High-risk status for OSA based on the STOP-Bang questionnaire is associated with a number of airway complications including difficult mask ventilation and intubation.[12,15,16] High STOP-Bang scores are also linked with critical care admission, cardiopulmonary postoperative complications, and longer stays in hospital. POAF and longer intubation following CABG surgery is significantly more common in high-risk patients based on the Berlin Questionnaire.[20,21] Both studies that have looked at the ASA checklist and postoperative complications have shown an increased frequency in a number of postoperative respiratory complications.[11,22] The evidence presented here however is not robust enough to concretely conclude that any of the 3 tools discussed here are able to independently risk stratify patients for perioperative and/or postoperative complications. There is significant heterogeneity between the surgical populations included in different studies, the outcomes assessed, and inclusion criteria for participation.

Limitations: Confounders

Several studies did not compare baseline characteristics between high and low risk OSA groups at all.[11,18,19] In those that did, baseline characteristics frequently differed between high and low risk for OSA groups.[12,14,15,20,22] This is unsurprising, given that high and low risk status is conferred by the presence of specific features within each screening tool. Adjustments for other potential prognostic factors were made in only 5 of the 12 studies. In one of these studies, high risk OSA was no longer associated with adverse respiratory events[14]; suggesting that any association can be explained by additional cofounding factors, for example, patients at high risk for OSA using the STOP-Bang were more likely to have undergone major surgery, compared to low risk.[14] It would also be useful to know whether purely being high or low risk for OSA according to a questionnaire predicts perioperative complications or whether only certain features of the questionnaires are prognostic. Again no subgroup analysis of this was performed in any of the studies reviewed here. Some particular confounders will be examined in turn below.

Firstly, some studies included patients with known OSA,[18,19,22] with 4 other studies not explicitly stating whether known OSA patients were included.[14,17,20,21] Patients with OSA diagnosis may have received preoperative and/or postoperative CPAP which could influence rates of complications. In the study by Munish et al. which looked at the ability of the ASA checklist to predict postoperative complications, significant proportion of those identified as high risk were on CPAP prior to enrolling in the study (79.6% versus 20.4%, $p < 0.001$), with further patients started on CPAP during the study.[22] Only 3 studies specify that no patients in high or low risk groups used home oxygen.[11,12,20] The administration of CPAP preoperatively has been correlated with a reduction in cardiopulmonary complications postoperatively. [6,23] Patients with OSA undergoing surgery not treated with home CPAP preoperatively are more likely to suffer from upper airway obstruction and hypoxemia, requiring CPAP in the postoperative setting.[24] 2 studies included a third group of patients with confirmed OSA as a comparator against high and low risk groups.[13,16]

Inclusion criteria for surgery type varied substantially across studies. In particular, some studies included head and neck surgeries,[12,14,17–19] while others did not. Emergency surgery was included in a single study but the authors did not specify if high and low risk groups had significant differences in frequency of emergency surgery therefore we cannot conclude if this is a potential confounder.[22] Two studies looked at CABG only,[20,21] and a further 2 studies looked at bariatric surgery alone.[13,16] In such situations, it is very difficult to make any conclusions about risk of complications according to OSA type that can be generalized, as the types of procedures will be associated with particular risk profiles. There is emerging evidence that questionnaires may vary in ability to detect OSA depending on the patient group being studied. For example, the Berlin Questionnaire has been found to be less accurate in predicting OSA in CABG patients compared to patients undergoing abdominal surgery.[25] This may also extend to ability to predict postoperative complications.

Type of anesthesia also significantly differed with 7 studies only including general anesthesia (GA),[12,13,15,16,20–22] while 3 included broader types,[11,17,19] and 2 did not specify. included broader types.[18,19] There was also variation in use of neuromuscular blockade. Subgroup analysis for anesthesia or surgery type was not performed in most of the studies therefore we cannot rule out that these may be confounding the results.

Other Limitations

There are only 5 studies that report some form of blinding to OSA group.[11,14,16,17,22] In the study by Toshniwal et al., and Pereira et al., anesthetists were blind to OSA risk group during intubation.[14,16] The medical records reviewing team in the retrospective historical cohort study were also blind to OSA risk group.[17] In prospective studies, lack of blinding may have led to measurement bias between low and high risk groups such as more frequent monitoring leading to higher detection rates or differential treatment. For example, it is explicitly mentioned in Chung et al.'s 2008 study that patients with AHI ≥ 30 were monitored postoperatively in ITU.[11] In retrospective studies, failure of blinding of the record reviewers can bias interpretation of records.

There is also substantial heterogeneity in measurement of outcome between different studies. This is particularly true in the case of the studies assessing difficult intubation. The criteria used in the study by Corso et al. was broad and included impossibility of getting a good view of vocal cords on laryngoscopy, repeated attempts, need for non-standard devices or procedures, or withdrawal of procedure.[12] On the other hand, the definition used by Toshniwal was either Cormack and Lehane class ≥ 3 and need for an intubation aid, or intubation requiring 3 or more attempts.[16] Difficulty is highly subjective and varies with the grade and experience of the operator. In the study by Toshniwal, they tried to control for this by engaging only anesthesiologists with operative airway management in over 100 obese patients; however, no other studies mention similar strategies to reduce operator dependent effects.[16]

With the exception of a single study,[12] the cutoff for high risk of OSA using the STOP-Bang questionnaire was ≥ 3. In practice however, most preoperative clinics use a higher score of ≥ 5. Patients with moderate-to-severe sleep apnea are more at risk perioperatively than those with mild OSA.[25] Therefore there are some concerns as to whether a higher cut-off point may be more appropriate when assessing whether being high risk for OSA according to the STOP-Bang questionnaire correlates with operative complications.

The majority of studies that looked at the ability of prescreening tools to predict postoperative complications relied on accurate reporting in medical records. Future research will require a prospective design with active collection of information to ensure complete data gathering in order to reduce bias.

Limitations at Review Level

In order to ensure that we did not miss any published studies in this systematic review, we used multiple different databases. We must acknowledge, however, the risk that we have not included all studies that have assessed whether the 3 OSA screening questionnaires can predict operative complications. We restricted our search to English only papers, and we were unable to retrieve full text versions of several conference abstracts that met our inclusion criteria. We were also unable to perform a meta-analysis of the results due to the different outcomes, patient characteristics, and non-overlapping inclusion criteria of the studies involved. There is also a risk of publication bias. Only one of the studies found no increased risk of complications.[21]

CONCLUSIONS

In summary, there is evidence that the ASA checklist, Berlin Questionnaire, and STOP-Bang questionnaire may be able to predict some postoperative complications. However, there are some concerns regarding the studies discussed here. There has been inadequate adjustment for potential confounding factors. There are significant differences in inclusion criteria that questions the generalizability of results outside of the specifications of the individual studies. Outcomes involved a substantial degree of assessor judgement and assessors were aware of OSA risk status of patients in the majority of studies.

Of the three screening tools looked at here, the STOP-Bang tool has been investigated across the most number of patients. It is an easy to use tool that has been validated across a broad surgical population. However, due to the low number of studies investigating the ASA Checklist and Berlin Questionnaire, it is difficult to come to any conclusions regarding these two questionnaire. Further studies are required that look at these questionnaires. There is also a more general need across all three questionnaires for research, with a particular focus on specific surgery types and more in-depth statistical analysis of results with attention to subgroup analysis and adjustment of potentially confounding factors.

ABBREVIATIONS

AHI, apnea-hypopnea index
ASA, American Society of Anesthesiologists
BQ, Berlin Questionnaire
CABG, coronary bypass grafting
CPAP, continuous positive airway pressure
EDS, excessive daytime sleepiness
GA, general anesthesia
ICU, intensive care unit
OSA, obstructive sleep apnea
PACU, Post-Anesthesia Care Unit

POAF, postoperative atrial fibrillation
SDB, sleep-disordered breathing

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Address correspondence to: Dr. Vladimir Macavei, Newhan University Hospital, Chest Clinic, Shrewsbury Road Health Centre, Forest Gate, E7 8QP; Tel: 0208 586 5226; Fax: 0207 363 8332; Email: vladimirmacavei@gmail.com

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