

ENHANCING DIFFICULT AIRWAY PREDICTION IN OBESE PATIENTS: INTEGRATING STOP-BANG WITH ADDITIONAL AIRWAY ASSESSMENT TOOLS

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ABSTRACT

Objective: To determine the diagnostic accuracy of the STOP-BANG questionnaire for predicting difficult mask ventilation (DMV) in obese adults undergoing elective surgery, and to evaluate whether combining STOP-BANG with conventional bedside airway assessment variables improves predictive performance beyond STOP-BANG alone.

Study Design: Cross-sectional diagnostic accuracy study.

Place and Duration of Study: Department of Anaesthesiology, Sindh Institute of Urology & Transplantation (SIUT), Karachi, Pakistan, from March 2026 to June 2026.

Methodology: Adults aged 18–60 years with body mass index (BMI) ≥ 30 kg/m² and American Society of Anesthesiologists (ASA) physical status II–III scheduled for elective surgery under general anaesthesia with endotracheal intubation were consecutively recruited. Preoperative assessment included STOP-BANG scoring (using Asian-specific thresholds), modified Mallampati score (MMS), thyromental distance (TMD), mouth opening, upper lip bite test (ULBT), BMI, and neck circumference. The attending airway provider remained blinded to the STOP-BANG score. Directly observed intraoperative airway outcomes served as the reference standard. Diagnostic accuracy of STOP-BANG ≥ 3 was evaluated via sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall accuracy, receiver operating characteristic (ROC) analysis, and a disjunctive combined screening model (STOP-BANG ≥ 3 OR MMS III/IV).

Results: Among 233 obese surgical patients, STOP-BANG ≥ 3 was present in 74 (31.8%). DMV occurred in 50 (21.5%) and difficult tracheal intubation (DTI) in 38 (16.3%); 26 patients (52.0%) with DMV also experienced DTI. For DMV, STOP-BANG ≥ 3 yielded sensitivity 72.00%, specificity 79.23%, PPV 48.65%, NPV 91.19%, and overall diagnostic accuracy 77.68%, with an area under the ROC curve (AUC) of 0.81. Combining STOP-BANG ≥ 3 with MMS III/IV increased sensitivity to 88.00% and NPV to 95.62%.

Conclusion: STOP-BANG ≥ 3 demonstrated good diagnostic discrimination for DMV in obese surgical patients, functioning effectively as a rule-out screening tool due to its high NPV. Combining STOP-BANG with bedside physical assessments significantly enhanced predictive sensitivity, supporting a multimodal risk-stratification approach prior to induction.

KEYWORDS: Airway management, Difficult intubation, Obesity, STOP-BANG, Mask ventilation, Preoperative assessment.

INTRODUCTION

Safe airway management depends on maintaining oxygenation and ventilation while securing the trachea when indicated. Difficult face-mask ventilation is clinically important because inadequate ventilation after induction can rapidly lead to hypoxaemia, particularly in patients with reduced functional residual capacity. Obesity further increases the physiological consequences of apnoea and is associated with anatomical features that may impair both mask ventilation and laryngoscopy. Large neck circumference, snoring, obstructive sleep apnoea (OSA), higher Mallampati class, and restricted mandibular or oral dimensions have all been associated with difficult airway management.

Prediction remains imperfect because no single bedside test consistently identifies difficult airway management, and normative values for several anatomical predictors vary across populations. In obese populations, combinations of anthropometric and oropharyngeal measures may provide greater discrimination than any isolated variable. Studies evaluating thyromental measures, ultrasound-based airway assessment, neck-circumference ratios, upper-lip-bite-

test-based composite indices, and population-specific norms for mouth opening have shown that the predictive performance of individual bedside tests varies with the population studied and the normative threshold applied. A systematic review and meta-analysis identified increased neck circumference, OSA, snoring, obesity, male sex, Mallampati III–IV, limited mouth opening, and short thyromental distance among significant risk factors for difficult mask ventilation.

STOP-BANG is a brief screening questionnaire originally developed for identifying patients at increased risk of OSA. Its components include snoring, tiredness, observed apnoea, high blood pressure, BMI, age, neck circumference, and sex, with one point assigned for each affirmative item; a total score of 3 or more is commonly used to define increased risk. Validation studies and society guidelines have demonstrated good sensitivity for detecting OSA using this threshold, and several perioperative studies have suggested an association between higher STOP-BANG scores and difficult airway events. However, the diagnostic value of STOP-BANG specifically for difficult mask ventilation and tracheal intubation in an obese South Asian surgical population remains insufficiently characterised.

Local evidence is particularly relevant because the performance of airway tests may vary with patient anthropometry and population characteristics. A study conducted at a tertiary care university hospital in Karachi, using the Cormack–Lehane grade as the reference standard, found that the ratio of height to thyromental distance and the upper lip bite test performed substantially better than the modified Mallampati test for predicting difficult laryngoscopy. Other recent studies have highlighted the potential value of combining established bedside tests with obesity-specific measurements rather than relying on a single screening tool.

The present study was designed to evaluate the diagnostic accuracy of STOP-BANG for difficult mask ventilation among obese adults undergoing elective surgery and to examine whether STOP-BANG provides useful additional predictive information when interpreted alongside conventional physical airway parameters.

METHODOLOGY

This cross-sectional diagnostic accuracy study was conducted at the Department of Anaesthesiology, Sindh Institute of Urology & Transplantation (SIUT), Karachi, from March 2026 to June 2026. The study population comprised male and female adults aged 18–60 years with BMI ≥ 30 kg/m² and ASA physical status II or III scheduled for elective surgery under general anaesthesia with planned endotracheal intubation. Consecutive sampling was used. Patients who declined participation, had ASA IV or V status, neuromuscular disease, facial abnormality, cardiothoracic or head-and-neck surgery, emergency surgery, previously diagnosed OSA by polysomnography, airway-related anatomical deformity, previous neck irradiation, or mouth opening below two fingerbreadths were excluded. Written informed consent was obtained prior to enrolment.

The target sample size was calculated as 233 patients based on diagnostic-accuracy estimates reported by Khan and Ahmed for STOP-BANG in predicting difficult mask ventilation, using a 12% margin of error and a 95% confidence level. Eligible participants underwent standard preoperative airway assessment. STOP-BANG was scored using South Asian anthropometric thresholds: BMI > 27.5 kg/m² and neck circumference > 39 cm in men or > 35 cm in women. Because all enrolled participants met the inclusion criterion of BMI ≥ 30 kg/m², every participant received 1 point on the STOP-BANG BMI item, effectively testing score discrimination on an adjusted 1–8 total scale range.

Modified Mallampati classification was assessed with the patient seated upright, mouth maximally open, and tongue protruded without phonation. Thyromental distance was measured from the mentum to the thyroid notch with head fully extended and mouth closed. Mouth opening was measured as maximum inter-incisor distance. The upper lip bite test was graded according to the ability of the lower incisors to reach and bite the upper lip. Neck circumference was measured at the level of the thyroid cartilage.

During induction, standard monitoring was applied. Preoxygenation was performed for 3 minutes. Induction was performed with nalbuphine 100 µg/kg and propofol 2 mg/kg, followed by atracurium 0.6 mg/kg after initial assessment of ventilation. Face-mask ventilation was observed in the sniffing position by a qualified anaesthetist with at least 3 years of experience under consultant supervision, blinded to the STOP-BANG score. Tracheal intubation was performed with a Macintosh laryngoscope, with tube placement confirmed by end-tidal carbon dioxide, chest movement, and auscultation.

Mask ventilation was dichotomised a priori: difficult and very difficult categories were classified as difficult mask ventilation (DMV). The directly observed intraoperative airway outcome recorded on the study proforma served as the reference standard.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 29.0. Continuous variables were summarised as mean $\pm$ standard deviation (SD) or median (interquartile range), and categorical variables as frequencies and percentages. Differences between groups were assessed using independent samples t-tests and Chi-square or Fisher's exact tests as appropriate. Diagnostic accuracy of STOP-BANG ≥ 3 was calculated via sensitivity, specificity, PPV,

NPV, and overall diagnostic accuracy. ROC curve analysis was performed to calculate the AUC for STOP-BANG as a continuous predictor. To test multimodal screening performance, a disjunctive combined model (STOP-BANG ≥ 3 OR MMS III/IV) was evaluated. A two-sided $p < 0.05$ was considered statistically significant. Ethical approval was granted by the institutional Ethics Review Committee of SIUT (Approval Reference: ERC-2025/A-587).

RESULTS

Participant Flow and Baseline Characteristics

A total of 233 obese surgical patients were evaluated. The mean age was 44.6 ± 10.2 years, and 136 (58.4%) were female. The mean BMI was 34.8 ± 3.6 kg/m². ASA physical status II was present in 124 patients (53.2%) and ASA III in 109 (46.8%). Patients with STOP-BANG ≥ 3 were significantly older and had higher mean BMI, weight, and neck circumference than those with STOP-BANG < 3 ($p < 0.01$ for all). Full baseline characteristics are presented in Table 1.

Table 1: Demographic and baseline clinical characteristics of the study population (N = 233).

Parameter	Total Cohort (N = 233)	STOP-BANG < 3 (n = 159)	STOP-BANG ≥ 3 (n = 74)	p-value
Age (years), mean $\pm$ SD	44.6 ± 10.2	42.1 ± 9.8	50.0 ± 8.9	< 0.001
Gender, n (%)				< 0.001
— Male	97 (41.6%)	51 (32.1%)	46 (62.2%)	
— Female	136 (58.4%)	108 (67.9%)	28 (37.8%)	
Height (m), mean $\pm$ SD	1.62 ± 0.09	1.60 ± 0.08	1.66 ± 0.10	< 0.001
Weight (kg), mean $\pm$ SD	91.3 ± 12.5	86.5 ± 9.4	101.6 ± 12.8	< 0.001
BMI (kg/m ²), mean $\pm$ SD	34.8 ± 3.6	33.8 ± 2.8	36.9 ± 4.2	< 0.001
ASA Status, n (%)				0.004
— ASA II	124 (53.2%)	95 (59.7%)	29 (39.2%)	
— ASA III	109 (46.8%)	64 (40.3%)	45 (60.8%)	
Neck Circumference (cm), mean $\pm$ SD	38.4 ± 3.1	37.1 ± 2.2	41.2 ± 3.0	< 0.001

Outcome Prevalence and STOP-BANG Distribution

STOP-BANG ≥ 3 was identified in 74 patients (31.8%), while 159 (68.2%) had a score < 3 . DMV occurred in 50 patients (21.5%), and DTI occurred in 38 (16.3%). Among the 50 patients with DMV, 26 (52.0%) also experienced DTI. Preoperative physical airway grades and intraoperative findings are listed in Table 2.

Table 2: Preoperative physical airway assessments and intraoperative airway findings.

Assessment Tool / Parameter	Category / Classification	Frequency (n)	Percentage (%)
Modified Mallampati Score	Class I	82	35.2%
	Class II	110	47.2%
	Class III	31	13.3%
	Class IV	10	4.3%
Thyromental Distance	Grade 1 (> 6.5 cm)	134	57.5%
	Grade 2 (6.0–6.5 cm)	67	28.8%
	Grade 3 (< 6.0 cm)	32	13.7%
Upper Lip Bite Test	Class I	128	54.9%
	Class II	70	30.1%
	Class III	35	15.0%
Mask Ventilation Grading	Easy	148	63.5%
	Moderately difficult	35	15.0%
	Difficult	38	16.3%
	Very difficult	12	5.2%
Intubation Grading (Cormack–Lehane)	Grade I	122	52.4%
	Grade IIa	48	20.6%
	Grade IIb	25	10.7%
	Grade III	28	12.0%
	Grade IV	10	4.3%

Diagnostic Performance for Difficult Mask Ventilation

For DMV, STOP-BANG ≥ 3 correctly identified 36 true positives, with 38 false positives, 14 false negatives, and 145 true negatives (Table 3). This corresponded to a sensitivity of 72.00% (95% CI: 57.51–83.77%), specificity of

79.23% (95% CI: 72.68–84.82%), PPV of 48.65% (95% CI: 36.83–60.62%), NPV of 91.19% (95% CI: 85.83–95.08%), and overall accuracy of 77.68% (95% CI: 71.82–82.80%). The ROC AUC for STOP-BANG was 0.81 ($p < 0.001$).

Table 3: Diagnostic contingency table of STOP-BANG ≥ 3 for difficult mask ventilation.

STOP-BANG Category	DMV Present (n = 50)	DMV Absent (n = 183)	Total
High Risk (≥ 3)	36 (True Positive)	38 (False Positive)	74
Low Risk (< 3)	14 (False Negative)	145 (True Negative)	159
Total	50	183	233

Combined Screening Model Analysis

Comparative diagnostic parameters for individual physical tests and the multimodal screening rule are detailed in Table 4. The disjunctive model (STOP-BANG ≥ 3 OR MMS III/IV) demonstrated a sensitivity of 88.00%, specificity of 71.58%, PPV of 45.83%, NPV of 95.62%, and overall accuracy of 75.11%. Restricted mouth opening (≤ 4.0 cm) demonstrated a sensitivity of 34.00% for DMV.

Table 4: Comparative diagnostic performance of STOP-BANG and bedside physical parameters for difficult mask ventilation.

Test / Screening Model	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
STOP-BANG (≥ 3)	72.00	79.23	48.65	91.19	77.68
MMS (Class III/IV)	48.00	90.71	58.54	86.46	81.55
TMD (Grade 3, < 6 cm)	42.00	93.99	65.63	85.57	82.83
ULBT (Class III)	44.00	92.90	62.86	85.86	82.40
Multimodal Model (STOP-BANG ≥ 3 OR MMS III/IV)	88.00	71.58	45.83	95.62	75.11

DISCUSSION

The theoretical basis for applying STOP-BANG to airway prediction rests on shared pathophysiological mechanisms: snoring, male sex, elevated BMI, and increased neck circumference directly correlate with upper airway collapsibility, submandibular fat deposition, and reduced pharyngeal cross-sectional area. In our cohort of 233 obese surgical patients, STOP-BANG ≥ 3 achieved useful discrimination for DMV, yielding an AUC of 0.81, a sensitivity of 72.00%, and an NPV of 91.19%.

A critical methodological consideration in evaluating these findings is the structural effect of inclusion criteria on score dynamics. Because enrolment was limited to patients with BMI ≥ 30 kg/m², 100% of the study cohort automatically scored affirmative on the STOP-BANG BMI criterion (> 27.5 kg/m² using Asian cut-offs). This structural feature compressed the functional range of the score to 1–8 points, effectively establishing a higher baseline score for all participants. In unselected general surgical cohorts—such as that reported by Khan and Ahmed, where STOP-BANG ≥ 3 yielded 65.5% sensitivity and 81.2% specificity—BMI serves as an active discriminator. In an exclusively obese cohort, the score relies on the remaining seven items to differentiate airway risk, which explains why single-threshold screening produces a substantial false-positive rate (38/74, 51.35%) and a modest PPV (48.65%).

Despite this range compression, STOP-BANG exhibited superior sensitivity (72.00%) for DMV compared to conventional isolated bedside parameters, such as MMS Class III/IV (48.00%), TMD Grade 3 (42.00%), and ULBT Class III (44.00%). However, individual physical anatomical tests maintained higher specificity (90.71–93.99%). Integrating STOP-BANG with physical examination in a disjunctive multimodal screening model (STOP-BANG ≥ 3 OR MMS III/IV) substantially elevated screening sensitivity to 88.00% and NPV to 95.62%. This aligns with broader evidence indicating that composite risk models outperform isolated anatomical tests in obese cohorts.

In clinical practice, these findings argue against using STOP-BANG as an isolated diagnostic test for difficult airway management. Instead, a STOP-BANG score ≥ 3 should serve as a high-sensitivity screening alert that mandates detailed secondary physical airway evaluation and triggers advanced airway preparedness—including the availability of video laryngoscopy, second experienced operators, and ramped positioning. Conversely, a negative screen (STOP-BANG < 3) carries a high NPV (91.19%), providing reassurance regarding mask ventilability.

Strengths and Limitations: Strengths of this study include prospective, consecutive recruitment, rigorous assessor blinding to preoperative STOP-BANG scores, and head-to-head evaluation against intraoperative reference outcomes within an underrepresented South Asian obese surgical population. Limitations include the single-centre design and exclusion of emergency procedures, ASA IV–V patients, and known OSA cases. Furthermore, full 2x2

contingency metrics for DTI were not evaluated due to power constraints, and structural baseline scoring on the BMI item limits direct equivalence with general population studies.

CONCLUSION

In obese adults undergoing elective surgery, STOP-BANG ≥ 3 provides good diagnostic discrimination for difficult mask ventilation (AUC = 0.81, NPV = 91.19%). Combining STOP-BANG ≥ 3 with modified Mallampati class III/IV improves screening sensitivity to 88.00% and NPV to 95.62%. These findings support integrating STOP-BANG into a multimodal preoperative airway assessment protocol rather than relying on the questionnaire as a standalone diagnostic tool.

DECLARATIONS

Ethical Approval: Approved by the Ethics Review Committee of the Sindh Institute of Urology & Transplantation (Reference: ERC-2025/A-587).

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Conflict of Interest: The authors declare no conflict of interest.

Authors' Contributions: [Insert author initials] contributed to study conceptualisation, protocol design, data collection, statistical analysis, and manuscript drafting. All authors read and approved the final manuscript.

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