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Awake Flexible Bronchoscopy Intubation Practice Among Otorhinolaryngology Surgery: An Observation Study Based on Practice Video Recordings and Clinical Data

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Background: Patients with airway pathologies are at higher risk for difficult intubation, making Awake flexible bronchoscopy intubation (AFBI) an essential technique. This study aimed to describe the baseline characteristics, procedural details, and outcomes of AFBI regarding otorhinolaryngology surgery.

Methods: This single-centre, observational study included 147 adult patients who underwent a standardised AFBI protocol for otorhinolaryngology surgery patients at Eye & ENT Hospital of Fudan University between January 1, 2022 and July 31, 2023. Data were collected from procedural video recordings and clinical database. Baseline characteristics, oxygenation methods, topicalisation, sedation levels, and procedural outcomes were documented. Comparisons between the first-attempt success group and the multiple-attempts success group were further performed.

Results: The median age of the patients was 66.00 years (IQR: 59.00–70.00), and 85.03% were male. The median body mass index (BMI) was 22.20 $kg.m^{-2}$ (IQR: 19.80–24.60) and the most common indication for AFBI was pathological obstruction of the supraglottic region (79.59%). Nasal cannula was the most frequently used oxygenation method (94.56%). The minimum SpO_2 during the procedure was 95.00% (IQR: 92.00–97.00), and median procedure duration was 20.45 minutes (IQR: 18.55–24.41). Lidocaine was the most commonly used topical anesthetic (78.23%, median dose: 3.27 $mg.kg^{-1}$, IQR: 2.79–3.94), followed by a combination of lidocaine and tetracaine (20.41%). Dexmedetomidine was administered 100% of cases (median dose: 0.71 $\mu g.kg^{-1}$, IQR: 0.51–0.88), and fentanyl was used in 97.28% of cases (median dose: 0.87 $\mu g.kg^{-1}$, IQR: 0.72–1.00). One hundred and twenty-eight (87.07%) were successfully intubated on the first attempt, while 19 (12.93%) required multiple attempts. Patients in the multiple-attempts group had a longer procedure duration [23.33 minutes (IQR: 20.80–26.86) vs 20.01 minutes (IQR: 18.33–24.09), $P = 0.007$].

Conclusion: This study highlights the high first-attempt success rate of the optimized AFBI protocol. Tailored airway management strategies are essential, particularly for older patients, to ensure safety and procedural outcomes.

Keywords: ATI, difficult airway, laryngeal obstruction, difficult intubation

Introduction

Aging-related physiological changes, including the development of thyroid masses and other airway pathologies, can significantly impair neck rotation and range of motion (ROM), thereby complicating tracheal intubation.[1] Structural and functional changes associated with aging contribute to anatomical variations that can further hinder successful intubation, even lead to life-threatening "can't intubate, can't ventilate" (CICV) scenarios in extreme cases.[2–5] Awake tracheal

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intubation (ATI), particularly using flexible bronchoscopy, remains the gold standard for managing anticipated difficult airways, as it preserves spontaneous ventilation and provides real-time visualization of the airway.[6] In clinical practice, videolaryngoscopy has become a common and effective tool for airway management.[7] However, in patients with distorted anatomy or high CICV risk such as those with laryngeal or hypopharyngeal tumors, severe trismus, cervical spine immobility, prior radiation therapy, or a history of difficult intubation, ATI is often the preferred approach.[8,9] Despite its advantages, Awake flexible bronchoscopy intubation (AFBI) is selectively performed due to challenges including the need for patient cooperation, longer procedural time, specialized training, and reduced effectiveness in the presence of bleeding or secretions.

Several cohort studies on AFBI have reported clinical outcomes such as incidence rates, success rates, and complications.[8,10–12] It has been observed that difficult airways in head and neck pathologies account for a significant portion of intubation failures, especially among the patients where the risk of airway pathologies.[8,11,13] Furthermore, substantial variations exist in AFBI practices, particularly in drug management and procedural protocols, across different medical centres.[9,14,15] It is important to comprehensively report the detailed procedures and clinical outcomes of AFBI specifically among head and neck surgery patients. Additionally, multiple intubation attempts have been identified as a significant risk factor for ATI related complications,[8,10,12] emphasizing the importance of closely monitoring and analysing AFBI procedures in this patient population.

The quality of AFBI performance relies heavily on both technical and non-technical skills, requiring all participants to maintain a high level of concentration throughout the procedure. This complexity makes it challenging for practitioners to independently analyse procedural details in real time. To address this challenge, we have established a comprehensive data collection system that includes AFBI scenario recordings, endoscopic videos, and electronic medical records. This unified and standardised recording system enables a detailed review of procedural parameters and patient reactions, providing a thorough and objective assessment of all aspects of AFBI operations.

In summary, this study aims to comprehensively analyze the procedural details, patient characteristics and reflexes, and clinical outcomes of AFBI performed on otorhinolaryngology patients at our centre. By utilizing a unified and standardized data collection system that includes video recordings, endoscopic views, and electronic medical records, this study seeks aims to deliver a comprehensive, objective and detailed assessment of AFBI practices. The findings will contribute to improving the quality and safety of AFBI procedures, particularly for patients with challenging airways, and will serve as a valuable resource for refining clinical protocols and guiding future research in airway management.

Methods

This single-centre, observational study utilised EENTPM database from the Eye & ENT Hospital of Fudan University. Ethical approval was granted by the ethics committee of the Eye & ENT Hospital of Fudan University (2020116).The study was also registered with the Chinese Clinical Trial Registry (ChiCTR2000036862). The study's performance adhered to the guidelines outlined in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)[16] recommendations for the design and reporting of observational research and also complied with principles of Declaration of Helsinki.

Study Setting and Subjects

This study included all patients over 18 years old who underwent AFBI for otorhinolaryngology surgery at the Eye & ENT Hospital of Fudan University between January 1, 2022 and July 31, 2023. The exclusion criteria involved the absence or incomplete AFBI scenario recordings, endoscopic video recordings, and missing data within the electronic medical records (EMR).

AFBI Procedure Protocol

Our centre developed a standardised AFBI protocol for otorhinolaryngology surgery patients, influenced by the Difficult Airway Society guidelines for ATI in adults (2021),[9] addressing sedation, topicalisation, oxygenation, and performance. All AFBI supervisor physicians had completed standardised ATI training through the All-in-One Airway Training Program in China (http://www.linaatp.com).

The protocol of AFBI was described below:

- **Patient and equipment preparation**: On the day of surgery, the patient was transferred to the area of the procedure once all the equipment, like patient monitor, FB, anesthesia machine, required medications like opioids and sedatives, and emergency airway trolley had been verified and checked. Before starting the procedure, the patient was monitored using electrocardiography (ECG), non-invasive blood pressure (NIBP), and pulse oximetry (SpO_2).
- **Oxygenation**: The oxygenation method included a nasal cannula (2–4 L/minute O_2) and high-flow nasal oxygen (HFNO), or mask.
- **Topicalisation**: Lidocaine or tetracaine (2%, 2 mL per time) was chosen for administering local anesthesia to the nasal cavity (specifically for nasal intubation), oropharynx, laryngopharynx, or endotracheal areas separately. If the anesthesiologist performing the AFBI determined that enhanced local anesthesia was needed for any area, additional doses were administered, and the effectiveness was reassessed.
- **Sedation and adjunct systemic medications**: Administering a dose of 0.5–1 $\mu g.kg^{-1}$ dexmedetomidine was recommended to achieve optimal sedation for procedural cooperation while retaining spontaneous breathing and partial consciousness. The administration of intravenous fentanyl and lidocaine was based on the clinical judgment of the operator performing the AFBI. The prescribed doses were 0.5–1 μg/kg for fentanyl and 0.5–1.0 mg/kg for lidocaine, respectively.
- **Performance**: Following sedation and airway topicalisation, the flexible bronchoscope was introduced into the trachea via the nasal or oral route. Finally, the tracheal lumen presence was visualized in fiberoptic bronchoscopy view, and the correct catheter position was confirmed by capnography.

ATI Procedural Video and Clinical Digital Data Collection System

The ATI procedural video recording system included a wide-angle camera for recording the intubation process, patient's cough and gag reflexes, vital signs monitoring screen and the view from the video flexible bronchoscope (see Supplementary Figures 1 and 2).

Additional detailed clinical data were collected using standardised forms documenting baseline characteristics such as age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, severity of laryngeal obstruction, and clinical indications for AFBI. Additionally, the forms recorded details regarding the administration of topicalisation and adjunct systemic medications, oxygenation methods, procedural characteristics, and changes in the patient's vital signs. A designated anesthetic nurse was responsible for data documentation.

The procedure duration was defined as the time elapsed from the patient entering the procedural location to when the tube entered the trachea along with the presence of capnographic waveform. The difficulty score of AFBI given by the chief operator was defined as 1 being easy and 5 as the extremely difficult attempt. Operator experience is defined as <10 cases refers to operators who had performed fewer than 10 ABFI procedures prior to the study, ≥10 but <50 cases refers to operators who had performed between 10 and 49 AFBI procedures prior to the study, ≥50 but <100 cases refers to operators who had performed between 50 and 99 AFBI procedures prior to the study, ≥100 cases refers to operators who had performed 100 or more AFBI procedures prior to the study.

Reaction of cough and gag grades during the procedure were defined as: Grade 0: no reaction; Grade 1: minimal coughing and gagging <3 times that does not hinder intubation; Grade 2: mild cough and gag lasting for <1 min hindering intubation; Grade 3: persistent coughing and gagging with defensive movement of head or hands. Secretion Grades were assessed using a 4-point scale, as follows: Grade 0: no visible secretion; Grade 1: small amount of secretion that does not require any oropharyngeal suction; Grade 2: moderate amount of secretion that can be completely removed by oropharyngeal suction; Grade 3: large amount of secretion that requires oropharyngeal suction more than two times during the procedure. An allergic reaction was defined as swelling, mucosal irritation, or rashes associated with topical anesthetics, sedative agents, or lubricants. Desaturation was defined as a peripheral oxygen saturation (SpO_2) of ≤90%. Arrhythmia was defined as a sinus tachycardia or premature contractions, while bradycardia was defined as a heart rate of less than 60 beats per minute.

Ramsay Sedation Scale (RSS) was used to observe the sedation level of the patients.[17] Sedation levels and hemodynamic changes, including heart rate, mean blood pressure, and SpO_2, were documented at several key time points during the procedure. These points were defined as follows: T1, the beginning of the procedure; T2, after the application of local anesthetics to the oral cavity; T3, after local anesthetics were applied to the supraglottic region; T4, after local anesthetics were applied to the subglottic region; T5, after the successful insertion of the endotracheal tube (ETT); and T6, at the end of the procedure. This structured monitoring provided a comprehensive evaluation of the patient's sedation and hemodynamic status at each critical stage of the intubation process.

Statistical Analysis

Statistical analysis was performed with R Software, Version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria). Data are presented as n (proportion), medians (interquartile ranges [IQR]), or mean (SD). Comparisons between the first-attempt success group and the multiple-attempt (≥2 times) success group were made using the χ^2 test and unpaired two sample *T*-test for categorical variables and Mann–Whitney rank test for continuous variables, respectively. Differences were considered significant if *P*-values were less than 0.05 (two-tailed).

Results

From January 1, 2022, to July 31, 2023, a total of 147 cases undergoing AFBI were included in the analysis. Table 1 provides a detailed overview of the baseline characteristics. The median age of the patients was 66.00 years (IQR: 59.00–70.00), and the median BMI was 22.20 $kg.m^{-2}$ (IQR: 19.80–24.60). The majority of AFBIs were performed in male patients (85.03%). The most common indication for AFBI was pathological obstruction of the supra-glottic region, accounting for 117 cases (79.59%). Other indications included limited neck movement in 8 cases (5.44%), limited mouth opening in 6 cases (4.08%), and pathological obstruction of the sub-glottic region in 16 cases (10.88%). Among the 147 cases, 128 patients (87.07%) were successfully intubated on the first attempt, while 19 patients (12.93%) required multiple attempts. Compared to the first-attempt success group, multiple attempts were more frequently observed in patients with laryngeal obstruction (12.50% vs 42.10%), ($P = 0.003$, Table 1).

In summary, the majority of AFBIs were performed in male patients with supra-glottic obstruction, and most cases were successfully intubated on the first attempt.

Table 1 Baseline Characteristics of the Study Population

	Overall	First Attempt Success	Multiple Attempts Success	*P*-Value
	(n = 147)	(n = 128)	(n = 19)	
Age (year)	66.00 (59.00–70.00)	66.00 (59.00–70.00)	67.00 (50.00–75.50)	0.644
Sex (male)	125 (85.03%)	111 (86.72%)	14 (73.68%)	0.254
ASA physical status				0.214
1	7 (4.76%)	7 (5.47%)	0	
2	129 (87.76%)	113 (88.28%)	16 (84.21%)	
3	11 (7.48%)	8 (6.25%)	3 (15.79%)	
BMI (kg/m^{-2})	22.20 (19.80–24.60)	22.15 (19.75–24.33)	23.60 (20.35–25.05)	0.396
Laryngeal obstruction	24 (16.33%)	16 (12.50%)	8 (42.10%)	0.003
Indication of AFBI				0.884
Limited neck movement	8 (5.44%)	7 (5.47%)	1 (5.26%)	
Limited mouth opening	6 (4.08%)	5 (3.91%)	1 (5.26%)	
Pathological obstruction of supra-glottic	117 (79.59%)	103 (80.47%)	14 (73.68%)	
Pathological obstruction of sub-glottic	16 (10.88%)	13 (10.16%)	3 (15.79%)	

Note: Values are presented as n (%) or median (Interquartile Range).
Abbreviations: ASA, American Society of Anesthesiologist; BMI, Body mass index; AFBI; Awake fibreoptic bronchoscopy intubation.

Details of Topicalisation and Adjunct Systemic Medications During AFBI

The use of topical and systemic medications during awake flexible bronchoscopy intubation was outlined in Table 2. Lidocaine was the most commonly used topical anesthetic, applied in 78.23% of cases, with a median dose of 3.27 mg.kg^{-1} (IQR: 2.79–3.94). A combination of lidocaine and tetracaine was used in 20.41% of cases, with median doses of 1.45 mg.kg^{-1} (IQR: 0.70–1.73) for lidocaine and 0.57 mg.kg^{-1} (IQR: 0.34–0.77) for tetracaine. Tetracaine alone was rarely used (1.36%), with a median dose of 2.08 mg.kg^{-1} (IQR: 1.86–2.29). Dexmedetomidine was administered in all cases (100%), with a median dose of 0.71 μg.kg^{-1} (IQR: 0.51–0.88). Fentanyl was used in 97.28% of cases, with a median dose of 0.87 μg.kg^{-1} (IQR: 0.72–1.00). Systemic lidocaine was administered in 41.49% of cases, with a median dose of 0.97 mg.kg^{-1} (IQR: 0.83–1.05).

When comparing the two groups, the use of intravenous lidocaine, dexmedetomidine, and fentanyl was similar between the first-attempt and multiple-attempt success groups, with no significant differences in dosing. However, systemic lidocaine was used more frequently in the multiple-attempt success group (57.89% vs 39.06%), though this difference was not statistically significant ($P = 0.192$, Table 2).

In summary, lidocaine was the most frequently used topical anesthetic, while dexmedetomidine and fentanyl were the systemic medications, with consistent dosing among the administered population.

Details of Oxygenation Supplementation and AFBI Performance

The oxygen supplementation methods and procedural performance during awake flexible bronchoscopy intubation were summarized Table 3. The majority of patients (94.56%) received oxygen via nasal cannula, followed by HFNO and mask, each used in 2.72% of cases. The minimum SpO_2 during the procedure was 95.00 (IQR: 92.00–97.00). The median duration of the procedure was 20.45 minutes (IQR: 18.55–24.41). Most procedures involved two or three operators (95.92%), and 40.14% of cases were performed by operators with experience of ≥100 AFBI cases. The operation

Table 2 Details of Topicalisation and Adjunct Systemic Medications During Awake Flexible Bronchoscopy Intubation

	Overall	First Attempt Success	Multiple Attempts Success	*P*-Value
	(n = 147)	(n = 128)	(n = 19)	
Topical Anesthesia				
Lidocaine				
n (%)	115 (78.23%)	101 (78.91%)	14 (73.68%)	0.828
Dose (mg/kg^{-1})	3.27 (2.79–3.94)	3.24 (2.80–3.85)	3.28 (2.71–4.06)	0.771
Tetracaine				
n (%)	2 (1.36%)	2 (10.5%)	0	>0.999
Dose (mg/kg^{-1})	2.08 (1.86–2.29)	2.08 (1.86–2.29)	0	
Lidocaine &Tetracaine				
n (%)	30 (20.41%)	25 (19.53%)	5 (26.32%)	0.704
Lidocaine Dose (mg/kg^{-1})	1.45 (0.70–1.73)	1.45 (0.68–1.80)	1.13 (0.78–1.55)	0.465
Tetracaine Dose (mg/kg^{-1})	0.57 (0.34–0.77)	0.55 (0.34–0.76)	0.70 (0.46–0.78)	0.713
Systemic Medications				
Dexmedetomidine				
n (%)	147 (100.00%)	128 (100.00%)	19 (100.00%)	>0.999
Dose (μg/kg^{-1})	0.71 (0.51–0.88)	0.71 (0.51–0.88)	0.75 (0.52–0.94)	0.325
Fentanyl				
n (%)	143 (97.28%)	124 (96.88%)	19 (100.00%)	>0.979
Dose (μg/kg^{-1})	0.87 (0.72–1.00)	0.87 (0.73–0.99)	0.81 (0.71–1.00)	0.690
Lidocaine				
n (%)	61 (41.49%)	50 (39.06%)	11 (57.89%)	0.192
Dose (mg/kg^{-1})	0.97 (0.83–1.05)	0.96 (0.83–1.04)	0.99 (0.91–1.23)	0.220

Note: Values are presented as n (%) or median (Interquartile Range).

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Table 3 Details of Oxygen Supplementation, Awake Flexible Bronchoscopy Intubation Performance

	Overall	First Attempt Success	Multiple Attempts Success	*P*-Value
	(n = 147)	(n = 128)	(n = 19)	
Oxygenation method				0.573
Nasal cannula	139 (94.56%)	121 (94.53%)	18 (94.74%)	
HFNO	4 (2.72%)	4 (3.12%)	0	
Mask	4 (2.72%)	3 (2.34%)	1 (5.26%)	
Minimum SpO_2 (%)	95.00 (92.00–97.00)	95.00 (92.00–97.00)	93.00 (91.00–97.00)	0.392
Duration of procedure (mins)	20.45 (18.55–24.41)	20.01 (18.33–24.09)	23.33 (20.80–26.86)	0.007
Number of operators				0.165
2	60 (40.82%)	55 (42.97%)	5 (26.32%)	
3	81 (55.10%)	69 (53.91%)	12 (63.16%)	
4	6 (4.08%)	4 (3.12%)	2 (10.53%)	
Operator experience				0.749
<10 cases	40 (27.21%)	35 (27.34%)	5 (26.32%)	
≥10 but <50 cases	15 (10.20%)	12 (9.38%)	3 (15.79%)	
≥50 but <100 cases	33 (22.45%)	28 (21.88%)	5 (26.32%)	
≥100 cases	59 (40.14%)	53 (41.41%)	6 (31.58%)	
Operation difficulty score	3.00 (2.00–4.00)	3.00 (2.00–4.00)	3.00 (2.50–4.00)	0.314
Procedural location				>0.999
Preparation room	140 (95.24%)	122 (95.31%)	18 (94.74%)	
Operation room	7 (4.76%)	6 (4.69%)	1 (5.26%)	
Operator position				0.380
Head end position	131 (89.12%)	113 (88.28%)	18 (94.74%)	
Face-to-face position	11 (7.48%)	11 (8.59%)		
Change of position	5 (3.40%%)	4 (3.12%)	1 (5.26%)	
Intubation route				>0.999
Oral	139 (94.56%)	121 (94.53%)	18 (94.74%)	
Nasal	8 (5.44%)	7 (5.47%)	1 (5.26%)	
Size of the ETT	5.50 (5.50–5.50)	5.50 (5.50–5.50)	5.50 (5.50–5.50)	0.077
Depth of the ETT (cm)	23.00 (22.00–23.00)	23.00 (22.00–23.00)	23.00 (22.00–23.00)	0.214

Notes: Values are presented as n (%) or median (Interquartile Range).
Abbreviations: HFNO, high-flow nasal oxygen; Minimum SpO_2, minimum pulse oxygen saturation; ETT, endotracheal tube.

difficulty score was rated as 3.00 (IQR: 2.00–4.00). Procedures were predominantly performed in the preparation room (95.24%) with the operator positioned at the head end (89.12%). The oral intubation route was used in 94.56% of cases, and the median size and depth of the endotracheal tube (ETT) were 5.50 (IQR: 5.50–5.50) and 23.00 cm (IQR: 22.00–23.00), respectively (Table 3).

When comparing the two groups, the multiple-attempt success group had a slightly lower minimum SpO_2 [93.00 (IQR: 91.00–97.00) vs 95.00 (IQR: 92.00–97.00) $P = 0.392$] and a significantly longer procedure duration [23.33 minutes (IQR: 20.80–26.86) vs 20.01 minutes (IQR: 18.33–24.09), $P = 0.007$]. Other variables, including oxygenation methods, operator experience, and intubation route, were similar between groups.

In summary, nasal cannula was the most common oxygenation method, and the procedure was typically performed in the preparation room with consistent operator positioning and intubation techniques across the study population.

Cough and Gag Reflex, Secretion Grades, and Adverse Events Related to AFBI

Table 4 summarizes the events associated with AFBI, including cough and gag reflex grades, secretion grades, and adverse events. Pre-intubation, most patients exhibited no reflex (Grade 0: 134 [91.16%]), while 13 (8.84%) showed mild reflex (Grade 1). During intubation, the majority of patients experienced mild reflex (Grade 1: 134 [91.16%]), with 13 (8.84%) displaying moderate reflex (Grade 2). After intubation, 121 (82.31%) patients had no reflex (Grade 0), 23

Table 4 Details of Related Events Associated with Awake Flexible Bronchoscopy Intubation

	Overall	First Attempt Success	Multiple Attempts Success	*P*-Value
	(n = 147)	(n = 128)	(n = 19)	
Cough and gag grade				
Pre-intubation				<0.001
0	134 (91.16%)	123 (96.09%)	11 (57.89%)	
1	13 (8.84%)	5 (3.91%)	8 (42.11%)	
During intubation				<0.001
0	0	0	0	
1	134 (91.16%)	125 (97.66%)	9 (47.37%)	
2	13 (8.84%)	3 (2.34%)	10 (52.63%)	
3	0	0	0	
After intubation				0.013
0	121 (82.31%)	108 (84.38%)	13 (68.42%)	
1	23 (15.65%)	19 (14.84%)	4 (21.05%)	
2	3 (2.04%)	1 (0.78%)	2 (10.53%)	
3	0	0	0	
Secretion grade				0.169
0	64 (43.54%)	57 (44.53%)	7 (36.84%)	
1	53 (36.05%)	48 (37.50%)	5 (26.32%)	
2	28 (19.05%)	22 (17.19%)	6 (31.58%)	
3	2 (1.36%)	1 (0.78%)	1 (5.26%)	
Change of more experienced operator	11 (7.48%)	6 (4.69%)	5 (26.32%)	0.004
Change of ETT size	3 (2.04%)	0	3 (15.79%)	<0.001
Allergic reaction	1 (0.68%)	1 (0.78%)	0	>0.999
Desaturation	8 (5.44%)	7 (5.47%)	1 (5.26%)	>0.999
Bradycardia	9 (6.12%)	8 (6.25%)	1 (5.26%)	>0.999
Arrhythmia	1 (0.68%)	1 (0.78%)	0	>0.999

Notes: Values are presented as n (%). Cough and gag grades during the procedure were defined as: 0: no reaction; 1: minimal coughing and gagging <3 times that do not hinder intubation; 2: mild cough and gag lasting for <1 min hindering intubation; 3: persistent coughing and gagging with defensive movement of head or hands. Secretion Grades were defined as: 0: no visible secretion; 1: small amount of secretion that does not require any oropharyngeal suction; 2: moderate amount of secretion that can be completely removed by oropharyngeal suction; 3: large amount of secretion that requires oropharyngeal suction more than two times during the procedure. Desaturation was defined as $SpO_2 \leq 90\%$.

Abbreviation: ETT, endotracheal tube.

(15.65%) exhibited mild reflex (Grade 1), and 3 (2.04%) showed moderate reflex (Grade 2). Severe reflex (Grade 3) was not observed at any time point. Regarding secretion grades, most patients had no visible secretion (Grade 0: 64 [43.54%]) or scanty secretion not requiring suction (Grade 1: 53 [36.05%]), while moderate secretion requiring suction (Grade 2) was observed in 28 (19.05%), and only 2 (1.36%) required repeated suction due to large amounts of secretion (Grade 3). Adverse events were uncommon, with desaturation (SpO2 ≤ 90%) occurring in 8 (5.44%), bradycardia in 9 (6.12%), mild allergic reaction of mucosal irritation and arrhythmia of sinus tachycardia in 1 (0.68%) patient, respectively. A change to a more experienced operator occurred in 11 (7.48%), and a change in ETT size was required in 3 (2.04%).

When comparing the first-attempt and multiple-attempt groups, patients in the first-attempt group were more likely to have no reflex (Grade 0) pre-intubation (96.09% vs 57.89%, $P < 0.001$) and during intubation (97.66% vs 47.37%, $p < 0.001$). After intubation, the first-attempt group also had a higher proportion of no reflex (84.38% vs 68.42%, $P = 0.048$). The multiple-attempt group required more frequent changes to a more experienced operator (26.32% vs 4.69%, $P = 0.004$) and changes in ETT size (15.79% vs 0, $P < 0.001$). No significant differences were observed in secretion grades ($P = 0.169$) or adverse events, including allergic reaction, desaturation, bradycardia, and arrhythmia ($P > 0.999$ for all, Table 4).

In summary, most patients undergoing AFBI experienced minimal reflexes, low secretion grades, and rare adverse events. First-attempt success was associated with lower reflex grades and fewer procedural adjustments compared to multiple attempts.

Hemodynamic Stability and Sedation Levels During AFBI

The hemodynamic changes and sedation level variations during awake flexible bronchoscopy intubation were noted across six time points (T1–T6) (Figure 1 and Supplementary Tables 1 and 2). Heart rate (HR) remained stable overall, with a slight decrease over time. However, the multiple-attempt success group exhibited significantly higher HR compared to the first-attempt success group at T2 (P = 0.002), T3 (P = 0.045), T4 (P = 0.033), and T5 (P = 0.020). Mean non-invasive blood pressure (MBP) showed a gradual decline across all groups, with no significant differences between the first-attempt and multiple-attempt success groups. Oxygen saturation (SpO_2) remained consistently high (above 97%) throughout the procedure, with no significant differences between groups.

Sedation levels, measured using the RSS, showed that most patients achieved a tranquil state (Score 2) after the application of local anesthetics (T2), with 94.56% of patients overall reaching this level. A small proportion of patients (4.08%) reached a deeper sedation level (Score 3) at T2, with no significant differences between the first-attempt and multiple-attempt success groups (P = 0.534). Sedation levels fluctuated slightly during the procedure, with most patients maintaining a tranquil state (Score 2) at later time points (T3–T6). At T5 and T6, a small proportion of patients in the

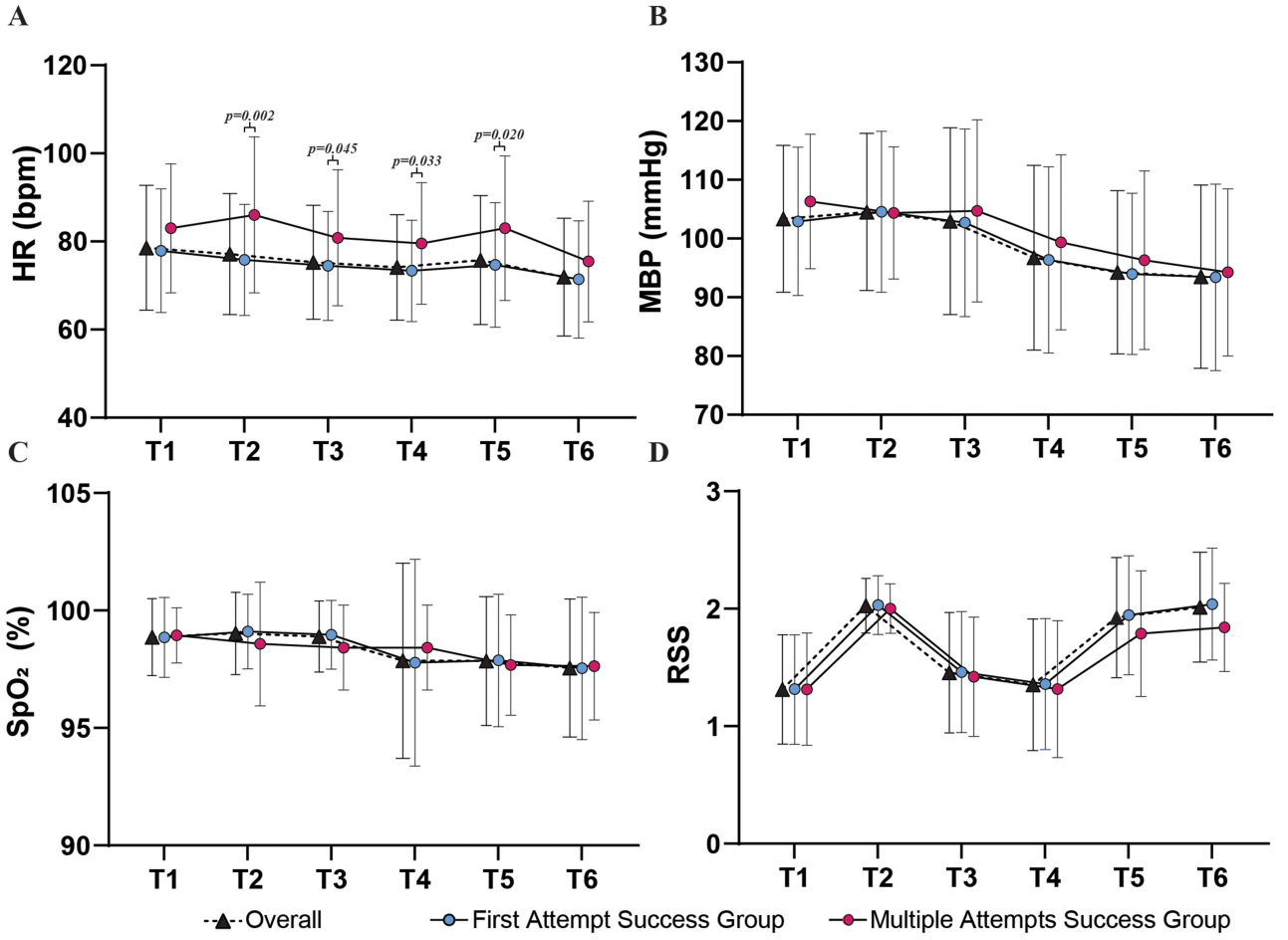

Figure 1 Changes over time in heart rate (HR), mean non-invasive blood pressure (MBP), oxygen saturation (SpO2), and Ramsay sedation scale (RSS). (**A**) Statistically significant differences in HR between the first and multiple attempt success groups were observed at T2 (P = 0.002), T3 (P = 0.045), T4 (P = 0.033), and T5 (P = 0.020). No statistically significant differences were noted between the first and multiple attempt success groups in MBP (**B**), SpO_2 (**C**), or RSS (**D**) between the groups at any time point. Filled circles represent means / proportion of the groups.

multiple-attempt success group had a sedation score of 1, indicating they were more anxious or restless compared to the first-attempt success group, though the differences were not statistically significant.

In summary, hemodynamic parameters remained stable during the procedure, with HR being slightly higher in the multiple-attempt success group at specific time points. Sedation levels were adequate and consistent across groups, with most patients achieving a tranquil state during the procedure.

Discussion

Our study comprehensively evaluated 147 AFBI cases using video recordings and electronic medical records. The integration of video recordings and a detailed review of procedural data represented a novel approach to studying AFBI. This methodology allowed for an objective assessment of operator performance, patient responses, and procedural outcomes, offering a unique contribution to the field of airway management. Among the 147 AFBI cases, the success rate was 100%, with a first-attempt intubation success rate of 87.7%. Hence, patients with pre-operative laryngeal obstruction, severe coughing, or a strong gag reflex were more likely to require multiple intubation attempts to achieve success and the implementation of an AFBI protocol revised according to the ATI guidelines[9] significantly contributed to improving the quality and safety of clinical practice.

Laryngeal pathologies contributing to difficult intubation were often the result of structural changes, which can complicate both ventilation and intubation. Older individuals with laryngeal malignancies were reported to be much vulnerable to difficult intubation due to age-related airway pathologies. Previous studies have reported that those patients have a higher likelihood of complications, including arrhythmias, cardiac arrest during intubation, post-intubation hypotension, and other adverse events.[1,18] Notably, awake tracheal intubation has been associated with a lower incidence of severe adverse events compared to intubation under general anesthesia, highlighting its potential advantage in high-risk populations.[19]

Compared with the incidence of ATI (1%–1.7%) reported by general hospitals.[8,10,11] The incidence of ATI in otolaryngology-focused institutions was reported to be higher and is attributed to the complexity of cases with head and neck tumors.[20,21] Our study focused specifically on AFBI in otorhinolaryngology patients, a population that is underrepresented in previous research. By addressing this gap, our findings provided valuable insights into the challenges and solutions associated with managing difficult airways in this high-risk group. Supporting this observation, a related study involving 600 AFBI cases found that 86.2% of cases were associated with specialized head and neck care, with otorhinolaryngology procedures accounting for the highest proportion of awake intubations.[8]

The success rate of AFBI (100%) was higher than the previously reported 98% to 99%.[8,10–12,22–24] The main reasons were that our study has a small sample size, and more importantly, it was attributed to the comprehensive training provided to operators at our center, which included a structured airway management program. Additionally, the use of a standardized AFBI protocol, developed in accordance with ATI guidelines, ensured consistency and reproducibility in clinical practice. This combination of advanced training[25] and protocol-driven care represented a significant innovation in improving outcomes for patients with complex airways.

We observed a 12.93% incidence of multiple attempts during AFBI, which falls within the previously reported range of 4.2% to 14.8%.[8,10,23] The study identified pre-operative laryngeal obstruction and vomiting or coughing before intubation as significant factors contributing to multiple attempts. Under a standardised AFBI protocol, repeated attempts were associated with prolonged procedure times, the need for more experienced operators, changes in endotracheal tube size, and elevated heart rates. Previous studies have shown that patients requiring ATI face a higher risk of severe complications during multiple attempts, potentially leading to patient discomfort, operator anxiety, and iatrogenic airway injury.[26,27] These findings highlight the need for refined strategies in managing complex airways, including enhanced pre-operative assessment, improved operator experience, optimized endotracheal tube selection, and individualized AFBI protocols to minimize complications. This study underscores the importance of identifying factors contributing to multiple attempts and developing targeted interventions to reduce their occurrence. By systematically analyzing procedural details, our findings provide a foundation for improving patient safety and reducing the risk of complications.

Adequate airway anesthesia and appropriate sedation depth are critical to ensure the smooth performance of AFBI.[28] Compared to other local anaesthetics, lidocaine offers superior cardiovascular safety and lower risks of systemic

toxicity.[29] Studies indicated that lower concentrations of lidocaine are as effective as higher ones.[30,31] As a result, our centre primarily used 2% lidocaine for airway surface anesthesia.

Our analysis found that a median dose of 3.27 mg/kg of 2% lidocaine was effective for airway surface anesthesia in ear, nose and throat (ENT) procedures. This study also highlights the innovation of optimizing sedation and anesthesia practices,[32–34] including the use of dexmedetomidine (median dose, 0.71 μg/kg) to achieve effective sedation while maintaining spontaneous respiration.[14,35–39] By balancing patient comfort with safety (RSS score of 1 to 2), the evidence-based practices could be tailored to meet the unique demands of AFBI.

It has been reported that as high as 65% of awake intubation failures were caused by the difficulty of the initial tube passing through the glottis.[10,12] Tracheal tubes with a smaller external diameter, particularly in patients with malignant tumours, could significantly reduce the intubation failure rate and the risk of complications.[10,40,41] In our study cohort, the average tracheal tube size was 5.5 mm, usually considered undersized for adult patients. 15.79% of patients who required multiple intubation attempts succeeded after switching to a smaller one. These findings highlighted that selecting appropriate tube sizes is crucial, especially for patients with airway abnormalities. Switching to a smaller tube during difficult intubation could be an effective strategy to improve overall success, offering valuable guidance for managing high-risk populations.

In our study, the majority of patients (94.56%) were provided with low-flow oxygen therapy via nasal cannula, rather than using HFNO as a routine approach. Although HFNO with heated humidification had been associated with a reported desaturation rate of only 0–1.5%,[8,42] we only prioritised nasal cannula oxygen due to the high cost of HFNO. Even though, the results showed a median lowest oxygen saturation of 95% among our patients, with a hypoxemia incidence of 9.52%, lower than the 12–16% reported in studies on low-flow oxygen therapy in the guidelines.[9] This is most likely because we used a relatively small dose of dexmedetomidine to alleviate anxiety and sedate patients, maintaining the RSS score at 1–2, and only administered a single intravenous injection of fentanyl before attempting intubation if being suggested by the operator.

Limitations

This study offers clinical data supporting AFBI procedures, though several limitations must be acknowledged. Firstly, the sample size of the study is relatively small, primarily because the incidence of awake intubation is as low as 1–1.7%. Secondly, since this study was conducted at a single center with a protocol tailored to the unique conditions and practices of that center, the applicability and generalizability of the results to other settings or institutions may be limited. Future studies should aim to incorporate data from multiple centers and further investigate more refined procedural techniques and personalized management strategies to enhance the applicability and robustness of the findings.

Conclusion

This study provides a comprehensive review of the detailed procedures of AFBI in otolaryngological surgeries, achieving a 100% overall success rate and 87.7% first-attempt success. As the first study to systematically evaluate sedation, patient responses, and detailed drug dosages during AFBI, it emphasizes the importance of standardized protocols in enhancing safety and success rates. These findings underscore the clinical significance of optimizing intubation strategies to reduce complications and improve outcomes, particularly for high-risk patients with difficult airways.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The author(s) report no conflicts of interest in this work.

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