

# Sevoflurane for fiberoptic intubation in patients with pharyngeal or laryngeal tumor and severe comorbidities: A retrospective analysis

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## Research Article

**Keywords:** Difficult Airway, Fiberoptic intubation, Sevoflurane, Sedation, Pharyngeal Cancer, Laryngeal Cancer

**Posted Date:** April 28th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-459793/v1>

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# Abstract

**Background:** Current guidelines recommend fiberoptic intubation as the gold standard for intubating patients with “difficult airways.” An awake, spontaneously breathing patient provides some degree of safety; however, many patients require sedation. Sedation may impair spontaneous breathing and counteract the benefits of an “awake fiberoptic intubation.” Sevoflurane might be an alternative to intravenous sedative drugs as it preserves spontaneous breathing and provides patient comfort. For this, we implemented a sevoflurane-based protocol to improve the safety of fiberoptic intubation in high-risk patients with severe comorbidities.

**Methods:** We enrolled 29 patients with pharyngeal or laryngeal carcinoma who had undergone fiberoptic intubation with sevoflurane due to a “difficult airway.” The primary endpoint was the preservation of spontaneous breathing during airway management. Secondary endpoints were drop in oxygen saturation to < 90%, the success rate and duration of intubation, the use of intravenous sedative drugs, changes in vital parameters, complications, and awareness.

**Results:** Preservation of spontaneous breathing was possible in all procedures. Fiberoptic intubation was successful in 25 procedures. In three cases, a video laryngoscope was used. One patient suffering from an unidentified trans-cricoid fistula exhaled sevoflurane before an adequate depth of sedation was achieved. In this patient, oxygen saturation dropped to 71%. In the other 28 patients, oxygen saturation did not drop below 90%. The vital parameters did not change significantly. One fiberoptic intubation was complicated by epistaxis, and four patients had moderate bronchial spasm. None of the patients were able to recall the procedure.

**Conclusions:** We concluded that a sevoflurane-based fiberoptic intubation in patients with “difficult airways” and relevant comorbidities is technically feasible. A trans-cricoid fistula is probably a contraindication for this approach.

## Background

Current guidelines recommend fiberoptic intubation (FOI) as the gold standard for tracheal intubation in patients with a “difficult airway.”<sup>[1-4]</sup> “Awake FOI” is mentioned as a possible option, as a cooperative and spontaneously breathing patient ensures a high degree of safety for the whole procedure.<sup>[1, 4]</sup> Although studies have reported high success rates of up to 99%, most patients require at least some systemic sedation for “awake FOI.”<sup>[5, 6]</sup> Opioids, benzodiazepines, ketamine, propofol, and alpha-2-agonists are often seen as appropriate agents; however, sedation may impair spontaneous breathing and counteract the benefits of an “awake FOI.”<sup>[7, 8]</sup>

Inhalational anesthetic sevoflurane (SEVO) might be an alternative to intravenous sedatives for FOI, as it preserves spontaneous breathing and improves patient comfort.<sup>[9]</sup> Its low blood-gas solubility enables a quick induction of anesthesia, as well as a quick return of airway reflexes once its uptake has stopped.

The latter is the main advantage compared to intravenous drugs, since no “over-sedation” occurs once the patient has stopped breathing.<sup>[10]</sup>

A pharyngeal or laryngeal tumor can cause specific problems throughout FOI due to the destruction of anatomical structures and the vulnerability of the soft tissue with an increased risk of bleeding.<sup>[11]</sup> Older age and alcohol abuse, which are characteristic risk factors for throat tumors, may further reduce the patient’s cooperation during FOI.<sup>[12]</sup> Furthermore, comorbidities such as severe cardiovascular diseases, sleep apnea syndrome, and morbid obesity are disadvantageous.<sup>[13]</sup> Unfortunately, most studies focusing on sedation strategies during FOI exclude these particular patients, resulting in a significant lack of evidence for FOI in patients at high risk of a “cannot intubate cannot ventilate” (CICV) situation and reduced compliance and those with severe comorbidities.<sup>[8, 14, 15]</sup>

This retrospective study was designed to analyze the practicability and safety of a SEVO-based FOI in a high-risk cohort of patients with a relevant risk for a CICV-situation, severe comorbidities, and sedation challenges. The primary endpoint was the preservation of spontaneous breathing during FOI. Secondary endpoints were the drop in oxygen saturation to < 90%, the success and duration of FOI, the need to use additional intravenous sedative drugs, changes in vital parameters, complications, and patient comfort (awareness).

## Methods

Ethical approval for this study (registration number: 16-5648) was provided by the Ethical Committee of the Ruhr-University Bochum, Bochum, Germany (Chairperson Prof. P. Zahn) on 18 March 2016. The need for written informed consent was waived by the Ethical Committee.

### Patient population

We retrospectively included all patients with pharyngeal or laryngeal carcinoma who had received a primary FOI because of expected difficult mask ventilation and difficult laryngoscopy with SEVO sedation between August 2015 and August 2016. An “awake FOI” or tracheotomy was refused by these patients. There were no exclusion criteria.

### Patient preparation

Patients undergoing elective surgery were visited the day before surgery by an experienced anesthesiologist. Patients scheduled for urgent surgery were examined immediately before the procedure. Detailed anamnesis and upper airway examination, including determination of the modified Mallampati classification and the Patil test, were performed in all patients.<sup>[16]</sup> In some cases, ultrasonography or CT scans were used to evaluate the airway and to identify the median cricothyroid ligament.

Each patient was admitted to the preoperative holding area 30 min prior to FOI and underwent standard monitoring (e.g., pulse oximetry, non-invasive blood pressure measurements every 2 min; IntelliVue MX-System, Philips, Amsterdam, The Netherlands). Ten milliliters of lidocaine 2% (Lidocain HCL, B. Braun,

Melsungen, Germany) in oxygen (flow 6 l/min) was administered via an inhalational mask for at least 25 min. Patients suffering from bleeding, increasing stridor, or decreasing oxygen levels were directly transferred to the operating room. The attending anesthesiologist performed a protocol-guided examination, which focused on assessing anatomical landmarks such as the median cricothyroid ligament, recent medical imaging, and current vital signs. The attending ear, nose, and throat surgeon was always present in the operating room, and an alternative approach was planned pre-emptively in case the FOI failed (e.g., front-of-neck access).

The patients were placed in a supine position with their upper body elevated. For local anesthesia of the airway, 2 ml lidocaine 2% was applied in both nostrils and in the oral cavity via a mucosal atomization device (MAD 300, Teleflex Medical, Dublin, Ireland). An additional 2 ml of lidocaine 2% was administered by a trans-cricoid injection.

### **Sevoflurane-based fiberoptic intubation**

The FOIs were performed by consultants or residents with at least 3 years of work experience and additional training in handling a fiberoptic bronchoscope. The residents were always supervised by consultants.

We used the Draeger Primus anesthetic machine (Draeger, Lübeck, Germany) for all FOIs. After the patient was preoxygenated to an expiratory oxygen fraction  $\geq 0.80$ , induction of anesthesia was performed via a non-cushioned facemask (EcoMask, Intersurgical, Sankt Augustin, Germany) with an inspiratory SEVO concentration of 8 vol.% in oxygen (flow 18 l/min). A Guedel airway was inserted when the tongue relapsed. The depth of anesthesia was considered adequate if the patient was not able to hold an arm up against gravity (Guedel stadium III: unconsciousness, loss of lid lash reflex, and maintained spontaneous breathing).

The facemask was removed. In the nostril that had been identified as the bigger one in the pre-procedural airway assessment, a flexible bronchoscope with an external diameter of 5.2 mm was inserted (Storz, Tuttlingen, Germany). The bronchoscope was slowly moved forward until the vocal cords could be observed. After entering the trachea and identification of the carina, the tube (RAE 6.5, Rüschi, Teleflex, Dublin, Ireland) was further pushed forward into the trachea. The correct position of the tube was visually confirmed, the bronchoscope was removed, and a capnometer was connected to the tube.

Signs of emergence from anesthesia or defensive movements during FOI were treated either by SEVO supplementation via a bronchoscopy mask (VBM Medizintechnik, Sulz, Germany) or by application of an intravenous bolus of  $0.3 \text{ mg} \cdot \text{kg}^{-1}$  s-ketamine. Coughing was treated with 2 ml of lidocaine 2% administered through the working channel of the bronchoscope.

Excessive bleeding with sight obstruction, loss of spontaneous breathing for  $> 30$  s, and a drop in oxygen saturation to  $\leq 90\%$  were the stopping criteria for the FOI. An alternative approach was then performed (e.g., front-of-neck access).

Vital signs were recorded from the patient monitoring system, and the procedure was documented on an anesthesia record form with a specific appendix for sevoflurane-based FOI.

All patients were visited the day after the FOI, and a structured interview was conducted. Patients were asked about awareness, their last memories before and after the procedure, and their overall satisfaction.

### **Statistical analysis**

Excel 2007 (Microsoft Corp., Redmond, WA, USA) and SPSS statistics 22 (IBM, Ehningen, Germany) were used for statistical analysis. After testing data for normal distribution using a Kolmogorov-Smirnov test, two-sided significance with an error probability of < 5% (p-value < 0.05) was calculated using a Student's t-test. Descriptive statistics were provided to describe the baseline characteristics. Continuous and categorical data were described as mean  $\pm$  standard deviation values and numbers (percentages), respectively.

## **Results**

A total of 29 procedures were performed. The patient characteristics are shown in Table 1.

Table 1  
Patient characteristics

<b>Demographic data (n = 29)</b>	
Sex (male/female) [%]	55.2/44.8
Age [years]	63.9 ± 10.3
Height [cm]	168.8 ± 9.9
Weight [kg]	72.9 ± 23.5
BMI [kg.m <sup>-2</sup> ]	26.0 ± 9.8
<b>Comorbidities [%]</b>	
COPD	59
Nicotine abuse	69
Alcohol or drug abuse	24
Impaired coagulation status	28
Stroke or myocardial infarction	21
Adiposity (BMI > 30 kg.m <sup>-2</sup> )	24
Radiotherapy of the airway	45
Previous surgery of the tumor	31
<b>ASA status [n]</b>	
I / II / III / IV / V	0 / 4 / 17 / 6 / 2
<b>Kind of surgery [n]</b>	
Tracheotomy	10
Urgent surgery (emergency intervention)	4
Data are given as mean ± standard deviation, proportion, or number.	
BMI, body mass index; COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiologists	

The results of the preprocedural airway examinations and risk evaluations are shown in Table 2.

Table 2  
Results of the pre-procedural risk evaluation and airway examination

<b>Medical history [n]</b>	
History of difficult laryngoscopy	14
History of difficult mask ventilation	10
History of FOI	5
<b>Physical examination before procedure [n]</b>	
Mouth opening $\geq 2$ cm and $\leq 4$ cm	9
Mouth opening $< 2$ cm	4
Mallampati classification III or IV	21
Patil test $< 6$ cm	12
Median cricothyroid ligament not palpable	4
Stridor	7
Oxygen saturation $< 90\%$	2
Swelling of the airway in endoscopy	27
<b>Additional diagnostic tests [n]</b>	
Airway obstruction in CT-scan	23
Airway obstruction in ultrasound	16
Data are given as number.	
FOI, fiberoptic intubation; CT, computed tomography	

### Sevoflurane-based fiberoptic intubation

In all 29 procedures, the patients breathed spontaneously during FOI. Tracheal intubation was successful in 18 patients in the first attempt, in five patients in the second attempt, and in two patients in the third attempt. The mean duration  $\pm$  SD from the first SEVO administration until successful tracheal intubation was  $9.04 \pm 6.02$  min.

In three patients, it was not possible to pass the nostril with the bronchoscope due to huge laryngeal cysts or large tumor masses. The FOI was stopped, and a video laryngoscope (GlideScope®, Verathon Medical Europe B. V., Rennerod, Germany) was successfully used.

In one patient, the SEVO-based sedation technique failed. This patient had a preprocedural undetected trans-cricoid fistula and exhaled SEVO through the fistula before an adequate depth of sedation was achieved. The oxygen saturation dropped below 90% for 30 s to a minimum of 71%. The FOI was stopped, and the patient had front-of-neck access under preserved spontaneous breathing.

In the other 28 patients, oxygen saturation did not drop below 90% during the FOI (Table 3). The “minimum during FOI” refers to the lowest oxygen saturation documented during the FOI. Oxygen saturation before and during the FOI was not statistically different ( $p = 0.820$ ).

Table 3  
Oxygen saturation

	Oxygen saturation [%] (n = 29)
Before FOI [%]	95.2 ± 5.3 (74–100)
Minimum during FOI	95.5 ± 6.2 (71–100)
Data are given as mean ± standard derivation (minimum – maximum).	
FOI, fiberoptic intubation	

### Use of additional drugs

SEVO was used exclusively in 23 patients. Five patients received an additional topical bolus of lidocaine to treat their coughing, and the patient with the trans-cricoid fistula additionally received s-ketamine to perform front-of-neck access.

### Vital parameters and complications

Blood pressure and heart rate did not change essentially during FOI compared to pre-procedural values. Only the minimum systolic blood pressure decreased significantly compared to the pre-procedural value (Table 4).



Table 4  
Hemodynamic parameters before and during FOI

		p-value
<b>Systolic blood pressure [mmHg]</b>		
Before FOI	142 ± 22	
Minimum during FOI	123 ± 22	Before vs. minimum: <b>0.002</b>
Maximum during FOI	151 ± 21	Before vs. maximum: 0.117
<b>Heart rate [bpm]</b>		
Before FOI	83 ± 17	
Minimum during FOI	77 ± 13	Before vs. minimum: 0.137
Maximum during FOI	89 ± 21	Before vs. maximum: 0.237
Data are given as mean ± standard deviation.		
FOI, fiberoptic intubation; bpm, beats per minute		

One FOI was complicated by epistaxis, but tracheal intubation via FOI was still successful. Four patients received anti-obstructive medication after tracheal intubation (salbutamol or terbutaline) due to moderate bronchial spasm.

### Awareness

All patients were visited the day after the surgery. None of the participants could recall the FOI or reported dreams. No postprocedural complications occurred.

## Discussion

Although “awake FOI” seems to be an ideal regime for managing a “difficult airway” in patients with high CICV-risk and severe comorbidities, clinical practice has shown that some sedation is needed by most patients. However, the use of intravenous drugs may lead to over-sedation with airway obstruction, apnea, and a lack of patient cooperation.<sup>[7]</sup> Thus, the ideal sedation regime for FOI in these patients is still controversial. In our study, all patients had a relevant risk for a CVCI-scenario and relevant comorbidities. In all 29 procedures, the patients breathed spontaneously during FOI.

The use of SEVO for inhalational induction of anesthesia in children has been common practice for years, and it has also been used in patients with anticipated “difficult airways”. In 1997, Mostafa and Atherton reported about three patients undergoing head and neck surgery who breathed spontaneously during FOI.<sup>[17]</sup> Studies by Pean et al. and Favier et al. investigated SEVO for FOI in patients with expected “difficult

airway,” but they excluded patients with pathologies of the upper airway, reduced muscular tone, expected “difficult ventilation,” symptomatic gastro-esophageal reflux disease, seizure disorder, coagulopathy, or nasal injury.<sup>[18, 19]</sup> Bonnin et al. compared a target controlled propofol infusion with SEVO for FOIs but excluded all patients with any predictor of a “difficult airway.”<sup>[20]</sup> Wang et al. investigated the effectiveness and safety of a new approach - the “fast difficult airway evaluation - FDAE-approach” – in 150 patients with anticipated potential difficult mask ventilation or tracheal intubation.<sup>[15]</sup> Unfortunately they excluded patients with severe airway obstruction, external tracheal compression, or complicated respiratory diseases including asthma or chronic bronchitis. Consequently, an evaluation of the use of SEVO in patients with a high risk for “CICV” was missing, although the results were encouraging. An explanation might be that anesthesiologists are concerned about dose-dependent upper airway collapsibility and pharyngeal dysfunction.<sup>[21, 22]</sup> However, in this study, all patients breathed spontaneously and adequately throughout FOI (oxygen saturation  $\geq$  90% during 97% of all FOIs), although we used SEVO at a high concentration.

FOI failed in four patients (14%). This seems like a high failure rate, as other investigators reported failure rates of approximately 1–5%.<sup>[5, 7, 23]</sup> However, in three patients, the FOI failed because of a blocked nose. An oral FOI would have been possible, but video laryngoscopy was technically feasible and used instead. Front-of-neck access was performed in only one patient (3%). All patients breathed spontaneously until the trachea was intubated. Furthermore, all patients had severe airway pathologies (pharyngeal or laryngeal tumors), and a permanent tracheostomy was performed in 34% of patients. In contrast, Law et al. reported a failure rate of 2%, but only 26% of the patients were scheduled for head and neck surgery, and the reasons for the FOI remained unclear. However, in 22 patients, the FOI failed due to anesthesia-associated problems.<sup>[5]</sup> Kim et al. published experiences of second-year anesthesiology residents learning nasal FOI. Failure rates were 5% in intravenously sedated patients and approximately 14% in awake patients.<sup>[24]</sup> In this study, the FOI lasted 9 min on average. This is consistent with results from Pean et al. who reported a median duration of 8.6 min.<sup>[20]</sup>

Changes in vital parameters during FOI were negligible. One patient suffered from epistaxis which is a typical complication even in healthy probands.<sup>[24, 25]</sup> In four patients, a moderate bronchial spasm occurred although SEVO is a potent bronchodilator. However, approximately 60% of our patients had COPD. Thus, the frequency of this side effect could have even been higher when using intravenous sedatives.<sup>[26]</sup> Awareness did not occur, which is expected due to the high SEVO concentrations; this is an advantage against intravenous sedation strategies.<sup>[27, 28]</sup>

Although not formally assessed, medical staff noticed a smell of SEVO in some cases. This reflects that inhalational inductions are associated with SEVO pollution, and possibly, with anesthetic gas exposure of the medical staff.<sup>[29]</sup>

Major limitations of this study were its retrospective nature and the small number of FOIs. Therefore, the results must be interpreted with caution. However, we tried to provide evidence for the use of SEVO in

high-risk patients.

## Conclusions

Our results indicate that a SEVO-based FOI is technically feasible in most high-risk CV patients with relevant comorbidities. However, a trans-cricoid fistula is a contraindication. Spontaneous breathing during the procedure is advantageous. Randomized controlled trials are necessary to compare different sedation regimes in this high-risk group.

## List Of Abbreviations

FOI Fiberoptic intubation

SEVO Sevoflurane

CICV Cannot intubate, cannot ventilate

BMI Body mass index

COPD Chronic obstructive pulmonary disease

ASA American Society of Anesthesiologists

CT computed tomography

## Declarations

### *Ethics approval and consent to participate*

Ethical approval for this study (registration number: 16-5648) was provided by the Ethical Committee of the Ruhr-University Bochum, Bochum, Germany (Chairperson Prof. P. Zahn) on 18 March 2016. The need for written informed consent was waived by the Ethical Committee of the Ruhr-University Bochum.

The study was performed in accordance with the ethical standards of the Declaration of Helsinki (1964) and its subsequent amendments.

### *Consent for publication*

Not applicable.

### *Availability of data and materials*

The datasets are not publicly available because they contain information that could compromise participants' individual privacy, but are available from the corresponding author upon reasonable request.

## *Funding*

We acknowledge the support from the Open Access Publication Funds of the Ruhr-Universität Bochum.

## *Competing interests*

The authors have no conflicts of interest.

## *Authors' contributions*

AFCBK: study design, data analysis, and writing of the paper; AN: data collection and data analysis; JHN: manuscript revision; MB: data analysis and statistical assistance; HV: writing of the paper; TPW: conceptualization; SD: study design and manuscript revision; SV: data collection and data analysis; and PG: writing of the paper and manuscript revision. All authors read and approved the final manuscript.

## *Acknowledgements*

The authors would like to thank Editage ([www.editage.com](http://www.editage.com)) for editing.

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