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Research Article

Comparison of Airtraq® Laryngoscope, Bonfils Endoscope and Fiberoptic Bronchoscope for Awake Tracheal Intubation: A Randomized, Controlled Trial

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Abstract

Over the last decades several indirect laryngoscopes have been developed to provide a significant better glottic view and improved the success rate in difficult intubations. Some case reports describe the use of indirect laryngoscopes for awake tracheal intubations under preserved spontaneous breathing. However, randomized clinical studies comparing indirect laryngoscopy to the standard of fiberoptic intubation under spontaneous breathing are rare. Therefore, we compared the intubation with the Airtraq® laryngoscope and the Bonfils endoscope, to the standard fiberoptic intubation in patients with an expected difficult intubation under local anesthesia and sedation.

150 patients with an expected difficult intubation were randomized to one of the three devices. All intubation attempts were performed under local anesthesia and sedation. We evaluated success rate, time for intubation and the satisfaction of anesthesiologists and patients.

Fiberoptic intubation was significantly more successful (100%) than intubation with an Airtraq® laryngoscope (88%) or the Bonfils endoscope (88%). Time for intubation was quickest with the Airtraq® laryngoscope and significantly shorter than fiberoptic intubation (p=0.044). There was no difference in satisfaction of the anesthesiologists and none of the patients had a negative recall to one of the techniques.

An expected difficult intubation can be managed using the Airtraq® laryngoscope or the Bonfils endoscope in 88% and shows the same satisfaction of anesthesiologists and patient. We conclude that these techniques represent an acceptable alternative for an awake tracheal intubation under sedation and preserved spontaneous breathing.

Keywords: Airtraq® laryngoscope; Awake tracheal intubation; Bonfils endoscope; Fiberoptic bronchoscope; Predicted difficult intubation

Introduction

Airway management is a key element of a safe anesthetic practice and difficulties or failures of tracheal intubation can lead to severe hypoxia, brain injury or even death [1,2]. Therefore, in patients with an anticipated difficult airway, the awake tracheal intubation under preserved spontaneous breathing and local anesthesia is the recommended technique [3]. To date the flexible fiberoptic bronchoscope is the preferred device for this purpose [4]. However, the successful use of a fiberoptic bronchoscope requires training and regular practice and may in some cases, for example during excessive secretion or bleeding of the pharynx, be difficult or even impossible [5].

In recent years several indirect laryngoscopes have been developed to improve tracheal intubation and have been shown to provide a significant better glottic view than direct laryngoscopy. By now they are widely used in clinical practice, primarily for difficult intubations under general anesthesia. There are also some case reports describing the effective use of indirect laryngoscopes for awake tracheal intubations [6-10]. However, randomized clinical studies comparing the effectiveness of indirect laryngoscopy to the standard of fiberoptic intubation under spontaneous breathing are still rare [11-17]. Most recently two meta-analysis summarized this few studies. The authors concluded that there is no difference between success rate, patient satisfaction or complications between the techniques and that videolaryngoscopy is probably associated with a shorter time for intubation [18,19].

Two indirect laryngoscopes are the Airtraq® laryngoscope and the Bonfils endoscope. The Airtraq® laryngoscope is designed for single use. It has a 90° shape and contains a guiding channel for tracheal tube placement to simplify tracheal intubation. The Airtraq®-guided intubation is easy to handle, shows a steep learning curve and learned skills are easy to maintain [20-22]. The Bonfils endoscope is an optical stylet which is designed for a retromolar oral insertion technique and allows intubation even in patients with a very small mouth opening. Both techniques have been shown to improve success rate of intubations in situations with difficult airways [23,24].

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However, to the best of our knowledge, there are no studies comparing these indirect laryngoscopes to the standard of fiberoptic intubation for awake tracheal intubations.

Therefore, we compared the intubation with an Airtraq® laryngoscope and the Bonfils endoscope to the intubation with a fiberoptic bronchoscope in patients with an expected difficult intubation under sedation and preserved spontaneous breathing.

Methods

Patients

After approval by the local ethics committee (Chamber of Physicians of Northrhein, Düsseldorf, Germany; Registration-Number: 2010090, June 22, 2010), 150 patients scheduled for oral tracheal intubation and general anesthesia, gave their informed written consent to participate in this study.

Only patients, who required oral tracheal intubation and showed at least one criterion for an anticipated difficult intubation, were included. The patients were older than 18 years and presented to the preoperative evaluation center with a mouth opening of 1.8cm or more. Patients with dental abscesses or an ASA physical status of 4 or higher were excluded.

Methods

Patients were scheduled for elective gynecologic, senologic, abdominal, urologic or oral and maxillofacial surgery under general anesthesia.

In all patients a difficult intubation was anticipated, defined by at least one of the following criteria: Mouth opening less than 3.5cm, Mallampati score of IV, documented history of a difficult intubation or Body Mass Index (BMI) greater than $40 kg \cdot m^{-2}$. The modified Mallampati score was assessed with the patient in sitting position. The patients opened their mouth as wide as possible and protruded their tongue [25].

All intubation attempts were performed under local anesthesia and sedation. During the procedure patients were placed supine with their head on a head rest. All patients received oxygen ($2\text{-}4\ l \cdot min^{-1}$) through a nasal catheter and were monitored by pulse oximetry, non-invasive blood pressure measurement and ECG. After placement of a peripheral venous catheter 1mg midazolam was administered and a continuous remifentanil infusion of $0.03\text{-}0.05\ \mu g \cdot kg^{-1} \cdot h^{-1}$ was started. According to the discretion of the anesthesiologists additional doses of midazolam could be added (Figure 1). Depth of sedation was measured by the Ramsay Sedation score with the aim to reach a sedation score of 2 or 3 (0=Awake, orientated; 1=Anxious, agitated or restless; 2=Cooperative, orientated and tranquil; 3=Responding to commands only; 4=Asleep but brisk response to stimulus; 5=Sluggish response to stimulus; 6=No response to stimulus) [26].

Topical anesthesia was achieved by lidocaine spray 10% (five doses; delivering 10mg per dose), which was applied directly at the base of the tongue, followed by administration of lidocaine 4%, to the posterior pharynx and larynx. We used a bendable catheter with a tip that disperses the lidocaine solution (LMA® MADgic® Laryngo-Tracheal Mucosal Atomization Device; Wolfe Tory Medical Inc., Salt Lake City, UT, USA). It was bent to reach the epiglottis and thus allowed the delivery of lidocaine towards the glottis during inspiration. A maximum dose of 10-15 ml lidocaine 4% was administered (maximal $8.0 mg \cdot kg^{-1}$), which is according to the guidelines of diagnostic flexible bronchoscopy of the British Thoracic Society [27]. Within the limits, 5 to 10 ml of lidocaine could be added for topical anesthesia under direct sight if necessary.

Eight anesthesiologists, with at least one year of experience in the management of difficult intubations including the use of all three devices, performed all of the intubations. Anesthesiologists were blinded to the randomization and were informed about the used technique not until the local anesthesia was declared as completed and the tracheal tube size was chosen. Patients were randomized for the intubation with an oral Airtraq® laryngoscope, a Bonfils endoscope (Karl Storz, Germany) or a fiberoptic bronchoscope (11301BN1, outer diameter 5.2mm; Karl Storz, Germany) (Figure 2).

To optimize tracheal intubation the anesthesiologists were allowed to use either alone or in combination external manipulation of the larynx, change in head positioning, an Eschmann stylet (Portex,

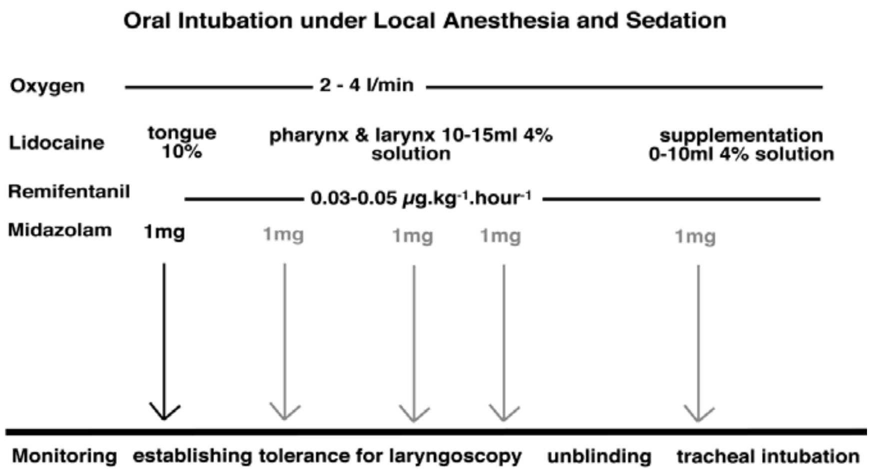

Figure 1: Flow sheet of the administration of sedation, local anesthesia and oxygen, combined with the respective manipulations. Midazolam was given in a standard dose (1mg) and supplemented according to the discretion of the anesthetist (in 1mg steps, grey arrows). The randomization was revealed upon completion of the local anesthesia.

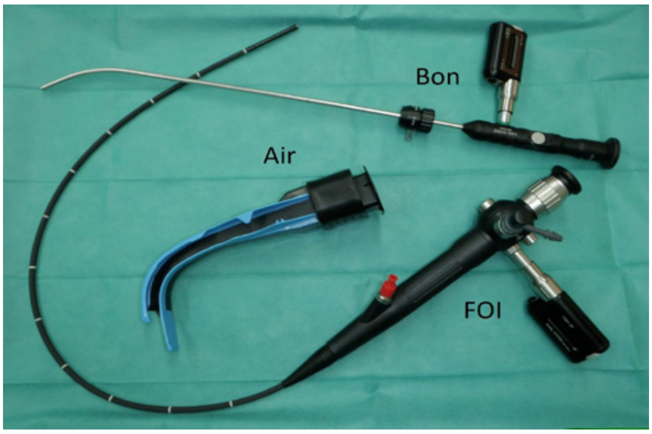

Figure 2: Presentation of the equipment for tracheal intubation under local anesthesia and sedation. (Air: Airtraq® laryngoscope; Bon: Bonfils Endoscope; FOI: Fiberoptic Bronchoscope).

Smiths Medical, Hythe, Kent, UK) and/or a Magill forceps. The number of optimizing maneuvers was analyzed in four categories: category 1=none; category 2=1; category 3=2 and category 4=3 maneuvers. The sequence of the maneuvers laryngeal manipulation, Eschmann stylet and Magill forceps was left to the discretion of the anesthesiologists.

In case of an unsuccessful initial intubation the anesthesiologists could choose one of the remaining alternative devices.

Visualization of the laryngeal entrance was assessed according to the classification of Cormack and Lehane: I = vocal cords visible; II = less than half of the glottis or only the posterior commissure is visible; III = only the epiglottis is visible; IV = none of the foregoing is visible [28].

Time for intubation was measured from mouth opening until inflation of the cuff. In addition the satisfaction score of patients and anesthesiologists were assessed using a scale from 1 (most satisfied) to 6 (not at all satisfied).

Furthermore, the doses of local anesthesia and medication for sedation as well as the resulting depth of sedation were recorded.

Data analysis

Data are presented as median, IQR and range. The priori null hypothesis to test was defined as: There is a significant difference in the time for oral intubation using the Airtraq® laryngoscope, the Bonfils endoscope or a fiberoptic bronchoscope for tracheal intubation. Sample size calculation was based on a difference to detect of 60 seconds, an alpha error of 0.05, a beta error of 0.8 and an expected standard deviation of 90 seconds. The result was a minimal number of patients of 36 for each group. We rounded the number to 50 for each group.

We also tested the secondary hypotheses, that there was a difference in the success rate for intubation between the two groups and that there was a difference in the satisfaction rate of the intubating anesthesiologists.

Hypotheses were tested using ANOVA (time for intubation) or chi-square test (success rate of tracheal intubation, satisfaction rate). Differences were considered significant for $p<0.05$.

Results

A flow diagram of the study is shown in Figure 3.

Table 1 shows the characteristics of 150 patients randomized to the intubation with the Airtraq® laryngoscope, the Bonfils endoscope or the fiberoptic bronchoscope. The overall distribution in age, height, weight, BMI, mouth opening, thyreomental distance, Mallampati score and history of a difficult intubation did not differ between the three groups (Table 1). 59% of the patients fulfilled more than 1 criterion for enrollment into the study.

There was neither a significant difference in the dose of local anesthesia nor in the dose of medication used for sedation. The resulting depth of sedation showed no significant differences in the Ramsay Sedation score between the three groups. Drug dosages and Ramsay Sedation score are presented in Table 2.

All patients were successfully intubated with one of the devices. Tracheal intubation with the fiberoptic bronchoscope showed a significant higher success rate (100%), while intubations with the Airtraq® laryngoscope and the Bonfils endoscope were less successful ($p=0.037$). In both groups 6 intubations could not be managed with the initially allocated device (88% success rate). If an intubation failed it was performed with one of the other techniques.

Time for intubation (mouth opening until inflation of the cuff) was quickest with the Airtraq® laryngoscope, followed by the Bonfils endoscope and the fiberoptic bronchoscope (Figure 4). Compared to the fiberoptic intubation, Airtraq®-guided intubation was significantly

Table 1: Characteristics of 150 patients, randomized for intubation with Airtraq (n=50), Bonfils (n=50) or a fiberoptic bronchoscope (FOI; n=50) (mean ± SD).

	Airtraq	Bonfils	FOI
Age (y)	57 ± 14	58 ± 15	53 ± 15
Height (cm)	173 ± 10	169 ± 9	171 ± 10
Weight (kg)	98 ± 34	108 ± 38	104 ± 31
MO (cm)	3.2 ± 0.7	3.3 ± 0.6	3.2 ± 0.7
TMD (cm)	6.6 ± 0.9	6.4 ± 1.1	6.4 ± 0.9
Mal (score, 1-4)	0/11/30/9	0/20/21/8	2/10/27/11

MO: Mouth Opening; TMD: Thyreomental Distance; Mal: Mallampati Score.

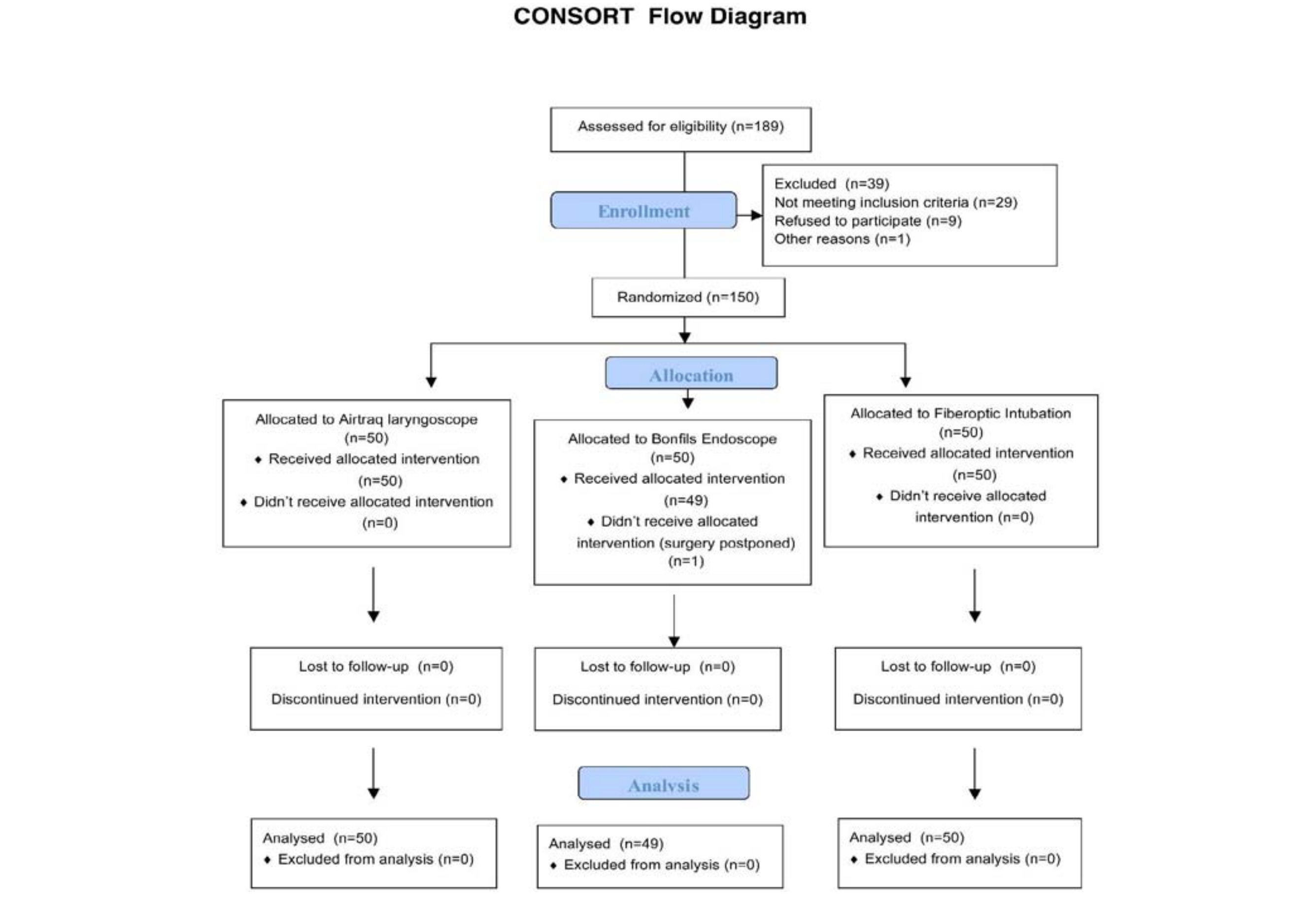

Figure 3: CONSORT diagram for the enrolment, randomization, and analysis of the study population.

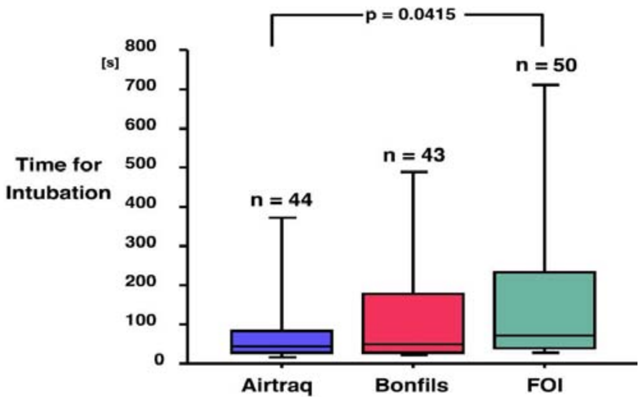

Figure 4: Box plot of the time for intubation with an Airtraq® laryngoscope (blue, n=44), a Bonfils endoscope (red, n=43) or a fiberoptic bronchoscope (green, n=50) in patients with an anticipated difficult intubation. Intubations with the Airtraq® laryngoscope were significantly shorter compared to fiberoptic intubation (ANOVA).

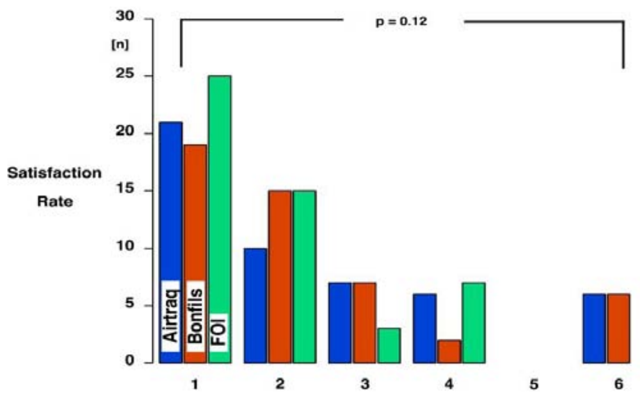

Figure 5: Satisfaction rate of the anesthesiologists using the Airtraq® laryngoscope (blue bars), the Bonfils endoscope (red bars) or the fiberoptic bronchoscope (FOI, green bars). Satisfaction was rated to German school marks with 1 as the best and 6 as the worst mark. There was no significant difference in satisfaction between the three devices (chi-square test).

shorter (p=0.0444).

There was no significant difference in the satisfaction of the anesthesiologists using the Airtraq® laryngoscope, the Bonfils endoscope or the fiberoptic bronchoscope (Figure 5).

None of the patient had a negative recall with one of the techniques and they all agreed to undergo another tracheal intubation with the same technique if necessary.

Discussion

In patients with an expected difficult airway, the use of an Airtraq® laryngoscope or a Bonfils endoscope is an alternative to the fiberoptic

Table 2: Sedation and local anesthesia for 150 patients randomized for tracheal intubation with an Airtraq laryngoscope (n=50), Bonfils endoscope (n=49) or a fiberoptic bronchoscope (FOI; n=50) (mean ± SD).

	Airtraq	Bonfils	FOI
Midazolam (mg)	4.8 ± 1.3	4.9 ± 1.6	4.7 ± 1.5
Remifentanil (µg)	28 ± 12	27 ± 8	34 ± 18
Lidocaine (mg/kg)	4.2 ± 1.7	4.0 ± 1.7	4.1 ± 1.6
Ramsay Score (0/1/2/3/4/5/6)	0/0/26/24/0/0/0	0/0/26/23/0/0/0	0/0/32/18/0/0/0

intubation for an awake tracheal intubation under sedation and preserved spontaneous breathing. However the intubation with the Airtraq® laryngoscope and the Bonfils endoscope was less successful (88% *vs.* 100%), but it succeeded in shorter time and showed equal physician satisfaction and patients' acceptance compared to the fiberoptic intubation (Figure 4 and 5).

There are some case reports [6-10] but only few randomized studies [11-17] comparing the standard of fiberoptic intubation to alternative devices for airway management in patients with an anticipated difficult airway. Recently two meta-analysis summarized this few studies. The authors reported that there is no difference between success rate, patient satisfaction or complications between the techniques and that videolaryngoscopy is probably associated with a shorter time for intubation [18,19].

To the best of our knowledge, we performed the first study comparing the use of the Airtraq® laryngoscope and the Bonfils endoscope to the fiberoptic bronchoscope for a tracheal intubation under preserved spontaneous breathing.

Studies about difficult intubations are complicated by the fact, that a difficult intubation can only be recognized after it has been attempted. All studies on this topic are hampered by the fact that all predictors of a difficult intubation have only limited meaning. We only used severe predictors of a difficult intubation to define our inclusion criteria (Mallampati score of IV, history of a difficult intubation, BMI >40kg/m^2, mouth opening <3.5cm). Combination of two or more of these criteria increases the risk of a difficult intubation [29-31]. More than half of our patients showed more than one inclusion criterion, so that the predictive value for a difficult intubation became higher. Thereby, we were confident to examine a patient collective that required difficult airway management.

Patients were randomized to the intubation techniques and the groups showed no differences regarding the patients' characteristics and intubation criteria (Table 1).

The second limitation of a study about difficult intubations with different devices is that the participating anesthesiologists cannot be blinded concerning the device. Nevertheless the anesthesiologists were informed about the randomization only after the local anesthesia and sedation were completed. So we avoided an influence of the chosen device on the local anesthesia and the sedation. Drug dosage and Ramsay Sedation score were equal distributed between the groups (Table 2).

Thus, the randomized patient distribution and the similarity in the immediately preceding medical treatment ensure the comparability of the three groups.

The intubation with the Airtraq® laryngoscope and the Bonfils endoscope was less successful than the fiberoptic intubation (88% *vs.* 100%). Even though we had a success rate of 100% for fiberoptic intubations, previous studies showed that this is not necessarily always the case. Heidegger et al. for example reported a failure rate of 1.5% in experienced colleagues [5] and Woodall et al. showed a failure rate of even 10% in anesthesiologists with limited experience [32].

But of course the Airtraq® laryngoscope and the Bonfils endoscope were still less successful. One problem with the Airtraq® laryngoscope was the triggering of a gag reflex, so it was less tolerated than the flexible bronchoscope. This made intubation impossible in some cases. The Airtraq® laryngoscope requires more mouth opening and space in the pharynx than for example the C-Mac system with a D-Blade [15] or the Mac Grath laryngoscope [16] and that might explain the difference in the success rate between our study and these previous studies. Similar to the Aitraq laryngoscope® is the Pentax Airway Scope®, which was tested by Mendonca et al. 2016. It was used for awake intubations in 20 patients and intubation succeeded in every case. But this study showed less severe inclusion criteria like Mallampati 3 or limited neck extension and only patients with a mouth opening greater than 2.5cm were studied, whereas we only excluded patients with a mouth opening less than 1.8cm. So this might explain the difference in the success rate.

The intubation with an Airtraq® laryngoscope is easy to learn and perform [20-22] and our results showed a significant shorter time for intubation compared to the fiberoptic intubation (Figure 4). The Airtraq laryngoscope is inexpensive and it can be easily stored at remote workplaces. Therefore, a successful use for awake intubation could expand the armamentarium for difficult intubation and facilitate logistic advantages in remote places. Its use is limited by its size, i.e. the use of the device needs more mouth opening than the fiberoptic technique or the Bonfils endoscope. The Bonfils endoscope can be used in patients with a small mouth opening and has a fixed angle which does not fit for all patients. Meanwhile a new Bonfils endoscope has been developed with a flexible tip, but was nor used for our study.

However, even if the intubation under preserved spontaneous breathing does not succeed, there is still the option to change to an alternative technique without increasing the risk for the patient.

Our findings support the results of previous studies [11-17] that indirect laryngoscopes can be used in case of an expected difficult airway for intubations under sedation. Here we show that it can be achieved using the Airtraq® laryngoscope or the Bonfils endoscope. However, with these two devices the success rate was significantly lower compared to the fiberoptic technique. We think that these devices cannot replace the fiberoptic intubation in general but they represent an acceptable alternative for an awake tracheal intubation under sedation and preserved spontaneous breathing. Of course any anesthesiologist still has the responsibility to learn, teach and maintain his skills of fiberoptic intubations.

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