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Evaluation of rescue techniques following failed laryngoscopy: A multicenter prospective observational study

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ABSTRACT

OBJECTIVE: The Fourth National Audit Project revealed that severe airway complications occur in the frequency of 1/22,000. Various rescue techniques were recommended in difficult airway guidelines. This study aims to evaluate the rescue techniques following failed direct laryngoscopy and analyze the success rates and potential complications during difficult airway management.

METHODS: This was a multicenter and prospective observational study carried out in four referral centers. Four academic university hospitals using fiberoptic bronchoscopy and videolaryngoscopy in their daily practice were included in the study. Patients undergoing general anesthesia with anticipated or unanticipated difficult intubation were enrolled. The preferred rescue technique and the attempts for both direct and indirect laryngoscopies were recorded.

RESULTS: At the mean age of 46.58±21.19 years, 92 patients were analyzed. The most common rescue technique was videolaryngoscopy following failed direct laryngoscopy. Glidescope was the most preferred videolaryngoscope. Anesthesia residents performed most of the first tracheal intubation attempts, whereas anesthesia specialists performed the second attempts at all centers. The experience of the first performer as a resident was significantly higher in the anticipated difficult airway group (4.0±5.5 years) (p=0.045). The number of attempts with the first rescue technique was 2.0±2.0 and 1.0±1.0 in the unanticipated difficult airway and anticipated difficult airway groups, respectively (p=0.004).

CONCLUSION: Videolaryngoscopy was a more commonly preferred technique for both anticipated and unanticipated difficult intubations. Glidescope was the most used rescue device in difficult intubations after failed direct laryngoscopy, with a high success rate.

Keywords: Airway management; anesthesia; rescue technique; tracheal intubation.

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Tracheal intubation can be defined as difficult if multiple attempts or operators are required; an auxiliary introducer-type device such as a bougie is needed to facilitate tracheal intubation; and an alternative device following the failure of tracheal intubation is a necessity [1]. The rate of difficult intubation varies widely from 0.5% to 10% in patients under general anesthesia [2]. In the NAP4 study, the most frequently recorded primary airway problems were related to tracheal intubation [3]. The rate of failed intubation, difficult, or delayed intubation, and "can't intubate can't ventilate" was approximately 39% of all events under anesthesia.

The American Society of Anesthesiologists practice guideline recommends awake tracheal intubation for anticipated difficult airway [4]. The Difficult Airway Society guidelines recommend using supraglottic airway devices for unanticipated failed tracheal intubation [5]. However, there is no high-grade evidence for the use of a particular device or technique in difficult tracheal intubation. For this reason, recommendations are usually based on expert consensus [6, 7].

Direct laryngoscopy is presumably the technique used in most tracheal intubations during airway management. Possible alternative devices used after failed conventional direct laryngoscopy include supraglottic airway devices, modified laryngoscope blades, and rigid and flexible intubation endoscopes [8]. Today, a convenient alternative to awake fiberoptic intubation is awake videolaryngoscopy [9]. Videolaryngoscopes enable an optimized view of the glottis and, thus, provide a higher first-pass success rate. Moreover, they reduce the airway complications [10]. The experience of the physician is a factor that should be taken into consideration. The primary aim of this study was to evaluate the operators' preferences as a rescue technique following failed tracheal intubation. The secondary aim was to determine the success rate of rescue devices.

Highlight key points

- Most frequently recorded airway problems occur during tracheal intubation.
- There is no high-grade evidence for a particular rescue device in difficult airway.
- The recommendations in difficult airway are usually based on expert consensus.
- There is a growing evidence on awake intubation using the videolaryngoscopes.

MATERIALS AND METHODS

The Ethics Committee from Kocaeli University has approved the current study under the protocol number 2017/317. The study was registered before patient enrollment at www.clinicaltrials.gov with the registration number NCT03545620. This was a multicenter and prospective observational study carried out in four referral centers for advanced airway management. The study was held between December 2017 and June 2018, with the participation of academic university hospitals where videolaryngoscopes and fiberoptic scopes were used in their daily practice. The patients with unanticipated difficult tracheal intubation were informed about the study in the post-operative recovery room. Written informed consent was obtained from all patients who agreed to participate in the study.

The inclusion criteria included adult patients with a defined difficult airway, undergoing elective surgery under general anesthesia. We excluded pediatric patients, emergency surgical procedures, and surgeries under regional anesthesia. We applied the unanticipated difficult intubation criteria when we found one or more of the following criteria: Multiple attempts or operators required for tracheal intubation; the need for an auxiliary device such as a bougie to facilitate tracheal intubation; and the necessity of an alternative device following the failure of tracheal intubation. For the diagnosis of an anticipated difficult airway, eight parameters were evaluated by considering the patients' physical examination and medical history. History of difficult tracheal intubation, Mallampati score 3–4, interincisal distance <4 cm, thyromental distance <6 cm, sternomental distance <12 cm, head and neck extension <30°, neck circumference >40 cm, and protrusion of the mandible were determined and recorded. Failed tracheal intubation was defined as the failure following multiple attempts during placement of the tracheal tube [4].

We divided the study's patients into two groups: The unanticipated difficult airway and anticipated difficult airway groups. Patients' demographics, comorbidities, and the history of surgical procedures, and difficult intubation were recorded. Patients' ventilation scale, Cormack Lehane score, blade size and type, the number of tracheal intubation attempts, and the rescue method following failed direct laryngoscopy were documented [11]. Mask ventilation was

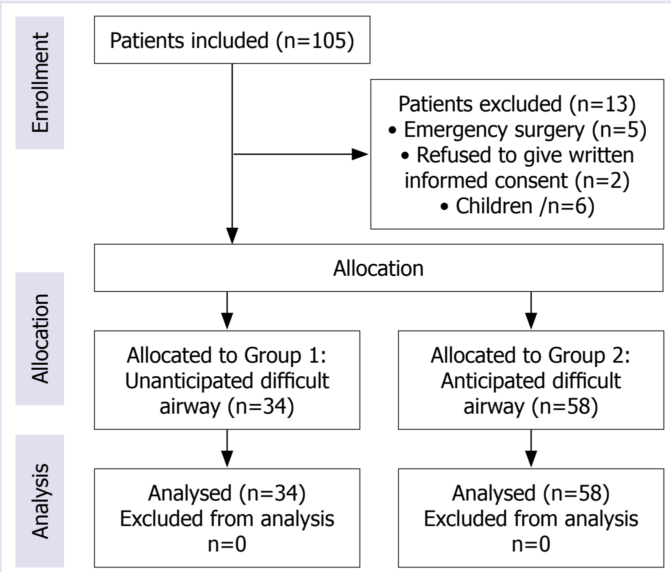

FIGURE 1. Flow diagram of the study.

classified as easy (Grade 1), difficult requiring an oral airway or other adjuvant (Grade 2), very difficult requiring two practitioners (Grade 3), and unable to mask ventilate (Grade 4).

The operators' title and experience level were recorded. All operators were experienced anesthesiologists. Anesthesiologists who had performed at least 500 intubations with direct laryngoscopes, and 50 intubations with videolaryngoscopes were considered "experienced" [12]. The anesthesiologists performed tracheal intubation using either direct or indirect laryngoscopes according to their preference. The operators were also free to use any kind of airway devices when they came across with failed tracheal intubation. A stylet was used for all tracheal intubation attempts. Peripheral SpO_2 ≤93% was considered as hypoxia and the duration of hypoxia was recorded. Complications were recorded as: No trauma; dental injury; pharyngeal trauma; tracheal injury; and death. The patients were questioned for sore throat in the postoperative period. A researcher was responsible for data collection to prevent potential sources of bias.

Statistical Methods

IBM SPSS Statistics for Windows, Version 25.0 (Armonk, NY, USA) was used for the statistical analysis. Independent samples t-test was used for the comparison of patients with anticipated difficult airway (Group 1) and those with unanticipated difficult airway (Group 2).

TABLE 1. The comparison of operators' experience, number of attempts and techniques

	Group 1 (n=34)	Group 2 (n=58)	p
1st operator			
Experience (year)	**3.0±3.0**	**4.0±5.5**	**0.045***m
No. of attempts	2.0±1.0	1.0±1.0	0.155m
2nd operator			
Experience (year)	4.5±6.0	5.0±10.75	0.720m
No. of attempts	2.0±1.0	2.0±1.25	0.653m
3rd Operator			
Experience (year)	10.0±6.0	4.0±7.0	0.069m
No. of attempts	1.5±2.0	1.0±1.0	0.381m
No. of attempts with first tracheal intubation technique	**2.0±2.0**	**1.0±1.0**	**0.004***m
No. of attempts with first rescue technique	1.0±1.0	1.0±0.75	0.160m

m: Mann–Whitney U-test: values are given as mean±standard deviation (95% CI of mean).

For the comparison of differences when the dependent variable is either ordinal or continuous, but not normally distributed, Mann–Whitney U-test was used. For the comparison of multiple groups from numerical data, Kruskal–Wallis H and one-way analysis of variance tests were used, and non-parametric and Chi-square tests were used to analyze the repeated variables. The results were evaluated in the 95% confidence interval and $p<0.05$ was considered as statistically significant.

RESULTS

A total of 99 patients were included in the study. Rapid sequence induction was performed for five patients undergoing emergency surgery, two patients refused to give written informed consent, and six children were excluded from the study (Fig. 1). There were no missing data.

Data analysis of 92 patients aged between 18 and 85 years (46.58±21.19 years) was performed. Failed tracheal intubation was detected in 56 of these patients and a rescue technique was applied. In 36 patients, successful tracheal intubation was performed with the first method. There were 34 patients in the unanticipated difficult intubation group (Group 1) and 58 patients in the anticipated difficult intubation group (Group 2). There was no statistically significant difference between

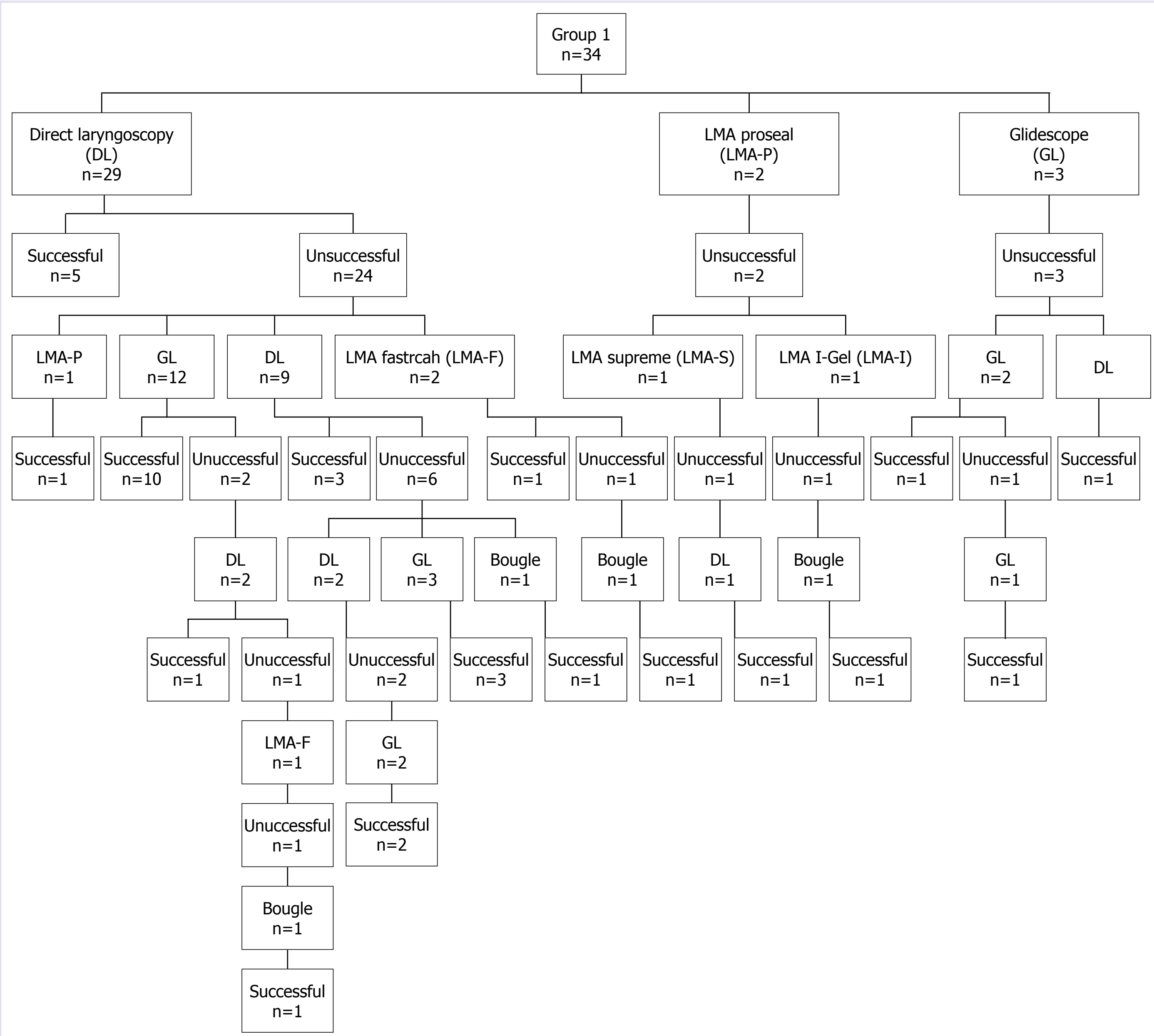

FIGURE 2. The distribution of patients with unanticipated difficult tracheal intubation using the rescue techniques.

the two groups in terms of patient demographics. Mean age was 47.5±27.75 years in Group 1 and 52.0±22.5 years in Group 2 (p=0.718). The body mass index was 33.0±7.5 and 31.05±10.0 in Groups 1 and 2, respectively (p=0.548). The female-to-male ratio was also similar between groups (p=0.671).

The first operator's experience was significantly higher in the anticipated difficult airway group (5.8±4.9 years) than in the unanticipated difficult airway group (4.1±3.8 years) (p=0.045). The operators' experience and the number of attempts for the rescue techniques are shown in Table 1. The number of attempts with the first rescue technique was 2.0±2.0 times in the unanticipated difficult airway group and 1.0±1.0 in the anticipated difficult airway group (p=0.004).

In both anticipated and unanticipated difficult intubation groups, direct laryngoscopy was the first tracheal intubation method used. When direct laryngoscopy again failed, all cases could be intubated with Glidescope (Fig. 2). In the anticipated difficult airway group, direct laryngoscopy was the most common airway management method (36 of 58 patients, 62.0%, Fig. 3). Direct

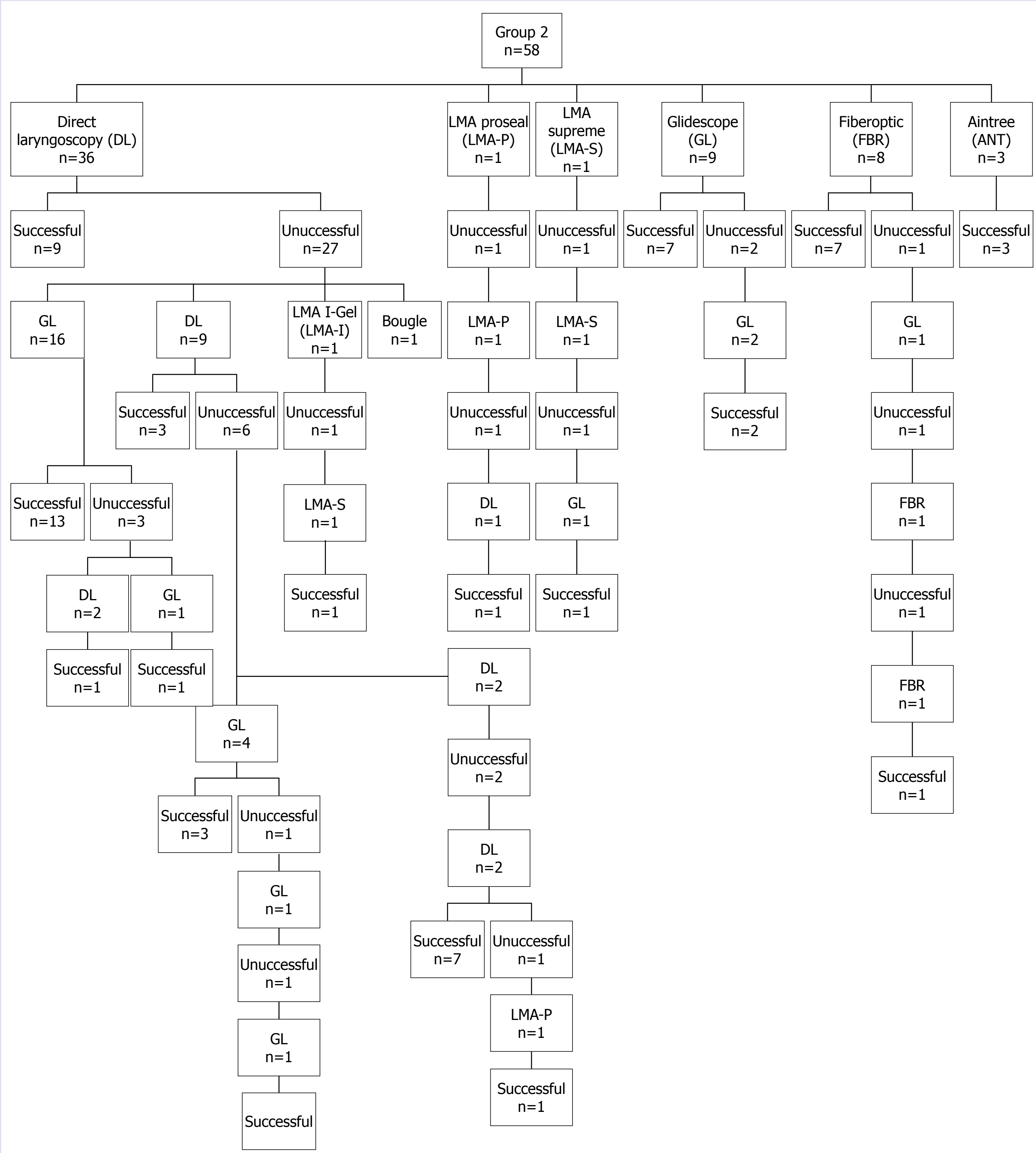

FIGURE 3. The distribution of patients with anticipated difficult tracheal intubation using the rescue techniques.

laryngoscopy failed in 27 of 36 patients. The first-choice rescue method was Glidescope in these patients, and 81.25% success rate was achieved.

Awake intubation using Glidescope was performed in nine patients, seven of them were successful. In the other two cases, Glidescope use failed but achieved by a more

Table 2. The comparison of preferred rescue techniques in anticipated and unanticipated difficult airway groups

	Group 1 (n=34)	Group 2 (n=58)	p
First airway management technique			0.050[c]
Direct laryngoscopy	29	36	
LMA proseal	2	1	
LMA supreme	0	1	
Glidescope	3	9	
Aintree-guided fiberoptic intubation	0	1	
Direct fiberoptic intubation	0	8	
Bougie	0	2	
First rescue technique			0.909[c]
Direct laryngoscopy	10	11	
LMA proseal	1	1	
LMA supreme	1	1	
Glidescope	14	12	
LMA fastrach	2	0	
Bougie	0	1	
I gel	1	1	

c: Chi-square test: Values are given as frequency (percentage). LMA: Laryngeal mask airway.

Table 3. The comparison of difficult airway predictors between groups

	Group 1 (n=34)	Group 2 (n=58)	p
History of difficult intubation			**0.049***[c]
No	**33**	**48**	
Yes	**1**	**10**	
Mallampati	**2.0±1.0**	**3.0±1.0**	**0.000***[m]
Interincisal distance (cm)	3.75±1.13	3.5±1.25	0.635[m]
Tyromental distance (cm)	6.0±2.0	6.75±2.0	0.678[m]
Ventilation scale	1.5±1.0	1.0±1.0	0.851[m]
Cormack Lehane grade	3.0±1.25	3.0±1.0	0.651[m]
Duration of tracheal intubation (sec)	**6.0±10.25**	**4.0±6.0**	**0.002***[m]
First et CO_2 pressure	41.24±8.47	39.98±10.0	0.542[s]
Head and neck extension			0.641[c]
Limited	6	14	
Normal	28	44	
Protrusion of the mandible			0.705[c]
No	32	52	
Yes	2	6a	

m: Mann–Whitney U-test: Values are given as mean±standard deviation. s: Independent Samples T test: Values are given as mean±standard deviation (95% CI of mean). c: Chi-square test: Values are given as frequency (percentage).

experienced practitioner after the first attempt. Awake fiberoptic tracheal intubation was performed in eight patients, and seven of them succeeded on the first attempt. In a patient, Glidescope use failed, but fiberoptic intubation was successfully performed by a more experienced practitioner. In three patients, awake fiberoptic tracheal intubation through supraglottic airway device was performed using the Aintree catheter, and all were successful.

Table 4. The effect of variables on anticipated difficult intubation

Model	df	F	Sig.
	ANOVA[a]		
1			
Regression	7	6.866	0.000b
Residual	82		
Total	89		

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
	Coefficients[a]				
	Beta	Std. error	Beta		
1					
Constant predictors	0.096	0.361		0.266	0.791
Mallampati	0.325	0.048	0.636	6.790	**0.000**
Thyromental distance	0.018	0.037	0.054	0.497	0.621
BMI	-0.014	0.008	-0.162	-1.727	0.088
Interincisal distance	0.032	0.054	0.061	0.583	0.562
Cormack lehane	-0.031	0.055	-0.052	-0.562	0.576
Head and neck extension	-0.052	0.108	-0.045	-0.485	0.629
Protrusion of the mandible	-0.114	0.175	-0.063	-0.651	0.517

a: Dependent variable: Anticipated difficult tracheal intubation; b: Constant predictors: Protrusion of the mandible, Body mass index, Cormack–Lehane grade, Interincisal distance, Head and neck extension, Mallampati, Thyromental distance. ANOVA: Analysis of variance; BMI: Body mass index.

The most commonly preferred rescue device was Glidescope, and there was no statistically significant difference between groups (Table 2). The second most frequently used technique was the use of direct laryngoscopy by a more experienced operator. As a rescue technique, laryngeal mask airway (LMA) ProSeal, I gel, or LMA Supreme was used (p=0.909). LMA ProSeal was the most commonly preferred laryngeal mask.

Mallampati score was found to be significantly higher in patients with difficult intubation (Table 3). The most common complication was a dental injury. Two patients in Group 1 and three patients in Group 2 experienced this complication. In three patients, dental injury occurred with pharyngeal trauma. Bronchospasm occurred in one patient. Pneumothorax was recorded in another patient. There were no statistically significant differences between hypoxia and sore throat rates among groups (p=1.000 and p=0.666, respectively). The effect of variables on anticipated difficult intubation was evaluated. A correlation was found between the Mallampati score and difficult tracheal intubation (Table 4).

DISCUSSION

In this multicenter, prospective, and observational study, the rescue techniques were determined following failed tracheal intubation in patients with anticipated and unanticipated difficult airway. The most commonly used device was Glidescope in both groups following failed direct laryngoscopy. The most frequently observed complication was dental injury at all centers. The most commonly used laryngeal mask was LMA ProSeal.

The Mallampati score, which is one of the difficult intubation predictors, was found to be significantly higher in patients with difficult intubation. The effect of variables on anticipated difficult intubation was evaluated and a correlation was found between the Mallampati score and difficult intubation. A recent Cochrane systematic review reported the specificity and sensitivity of the modified Mallampati score in diagnosing difficult tracheal intubation as 0.87 and 0.51, respectively [13]. A positive likelihood ratio of 4.1 was achieved in another systematic review with the modified Mallampati score ≥3 [14].

In airway management, direct laryngoscopy is the method mostly used for tracheal intubations. However, difficult, delayed, and failed tracheal intubation accounts for 39% of all events under general anesthesia [8]. When direct laryngoscopy fails, the failure rate may increase to approximately 80% in repeated attempts with the same technique [15]. Alternative techniques such as videolaryngoscopy increase the success rate.

In a multicentered prospective trial with 1100 patients, the intubation success rate on the first attempt was 96.2% for Glidescope [16]. A meta-analysis showed that videolaryngoscopy improved the glottic view and the rate of Cormack–Lehane grade 3 or 4 and also showed that the acutely angled blade use such as Glidescope increases the incidence of success rate [8]. In our study, we analyzed the data of four university hospitals, and the most frequently preferred rescue technique was videolaryngoscopy after the failure of direct laryngoscopy in all centers. The most preferred videolaryngoscope was Glidescope. We concluded that the main factor was an acutely angled blade and the widespread availability of the device. The success rate at the first attempt in anticipated difficult airway is high with the use of angulated blades [17]. Glidescope is a rigid indirect videolaryngoscope. The efficacy was proven in difficult airway management [18, 19].

The recommendation of the guidelines in the anticipated difficult airway is awake tracheal intubation. In this context, when awake tracheal intubation is needed, the most commonly used method was awake fiberoptic tracheal intubation. Direct fiberoptic intubation was mostly used. Aintree-guided fiberoptic tracheal intubation through supraglottic airway device was rare. However, an important finding that stands out was that more than half of difficult intubation cases (62%) were expected to be intubated with direct laryngoscopy under general anesthesia. The failure rate in these patients was 75%. This striking result shows us that the rate of adherence to guidelines is low. We should still consider education and experience in this field. Edelman et al. [20], concluded in their directed review that there is a lack of current literature as to whether the application of airway algorithms has an impact on adjustment in clinical practice. There is also no consensus among practitioners as to which airway management approaches are applicable. There are cases in this observational study that the anesthesiologist used direct laryngoscopy several times more than indicated in the guidelines; there are cases where the anesthesiologist used a Glidescope and then used direct laryngoscopy.

Besides, another reason for not implementing the awake intubation guidelines may be the lack of education and experience in this regard. There is evidence that the primary learning curve for fiberoptic intubation is raised, and the skill can be taught within ten intubations in patients with normal laryngeal anatomy [21]. However, ten fiberoptic intubations can be a high number to reach for the residents working in an academic hospital. It has been observed that a relatively large number of anesthesiologists with airway training lack the desire to master fiberoptic intubation [22, 23]. Providing the necessary psychomotor skills, supply and cleaning costs and time pressure in the operating room are related to the steep learning curve. Fiberoptic intubation is a difficult technique to learn and requires regular practice to maintain skills [24]. In a survey study conducted in the USA, it was reported that fiberoptic intubation procedures were taught in 64% of residency programs. However, 65% of residents applied <10 before graduation [25].

Videolaryngoscopy has become more common since the 2000s [26]. Nowadays, the variety of videolaryngoscopes has increased. Besides, it is easy to use. These features have led to their preference. A meta-analysis comparing awake fiberoptic intubation and videolaryngoscopy revealed that videolaryngoscopes provide faster intubation times and similar success rates [8]. In our study, 11 of the patients had awake fiberoptic tracheal intubation, and nine were intubated with videolaryngoscopes. The first attempt success rate for fiberoptic tracheal intubation (90%) was slightly higher compared with that for videolaryngoscopes (77%). However, airway was successfully achieved in all patients in the second trial of awake tracheal intubations using Glidescope. The second practitioner was composed of more experienced operators in both groups.

Hodzovic and Bedreag stated that awake fiberoptic intubation should not be considered as the first-choice method anymore because videolaryngoscopy is more effective for managing an anticipated difficult airway [27]. Awake videolaryngoscopy can be quickly learned, and it is simple to maintain the skills. Moreover, videolaryngoscopes have several design features. Therefore, these devices provide one more step toward improving patient safety.

In the unanticipated difficult airway scenario, videolaryngoscopes offer a useful rescue technique for failed direct laryngoscopy. Aziz et al. [28], reviewed records from 71,570 intubations. Glidescope was used in 2004 cases for difficult airway management with a success rate of 97%. The studies directly comparing fiberscopes and videolaryngoscopes for awake tracheal intubation, declared conspicuous results. According to three studies, the intubation time was significantly longer with the fiberoptic technique than with the videolaryngoscope technique [29–31]. However, in a recent study, videolaryngoscopy resulted in a greater degree of cervical spine movement [32].

In the unanticipated difficult airway, the attempt was repeated with Glidescope in two patients after the failure with direct laryngoscopy; however, it was again unsuccessful. Despite a perfect view of the glottis with Glidescope, tracheal intubation may be difficult to perform. Furthermore, providers should pay attention to improving hand-eye coordination skills. Repeated practices are essential in gaining these coordination skills.

Limitations

In our study, we could not determine the time for tracheal intubation for unanticipated difficult airway group. Therefore, we did not have the opportunity to compare the intubation time of fiberscopes and videolaryngoscopes. The level of device-specific experience of all operators was not uniform. The sample size was small due to the number of included patients during the study period.

Conclusion

Videolaryngoscopes are frequently used as a rescue technique. In this study, it was revealed that Glidescope is a preferred device for both unanticipated cases and patients with an anticipated difficult airway.

Ethics Committee Approval: The Kocaeli University Non-Interventional Research Ethics Committee granted approval for this study (date: 29.11.2017, number: 2017/317).

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Authorship Contributions: Concept – KTS, MY, AS, AK, ZA, OE; Design – KTS, MY, AS, AK, ZA, OE; Supervision – AZT, VA, OD; Fundings – AZT, VA, OD; Materials – AZT, VA, OD; Data collection and/or processing – AZT, AK, AS, OD; Analysis and/or interpretation – AS, VA, OD; Literature review – AS, ZA, AK; Writing – MY, KTS; Critical review – AS, AK, ZA, OE.

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