

# Unanticipated Difficult Airway in Anesthetized Patients

## Prospective Validation of a Management Algorithm

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**Background:** Management strategies conceived to improve patient safety in anesthesia have rarely been assessed prospectively. The authors undertook a prospective evaluation of a predefined algorithm for unanticipated difficult airway management.

**Methods:** After a 2-month period of training in airway management, 41 anesthesiologists were asked to follow a predefined algorithm for management in the case of an unanticipated difficult airway. Two different scenarios were distinguished: "cannot intubate" and "cannot ventilate." The gum elastic bougie and the *Intubating Laryngeal Mask Airway*<sup>TM</sup> (*ILMA*<sup>TM</sup>) were proposed as the first and second steps in the case of impossible laryngoscope-assisted tracheal intubation, respectively. In the case of impossible ventilation or difficult ventilation, the IMLA was recommended, followed by percutaneous transtracheal jet ventilation. The patient's details, adherence rate to the algorithm, efficacy, and complications of airway management processes were recorded.

**Results:** Impossible ventilation never occurred during the 18-month study. One hundred cases of unexpected difficult airway were recorded (0.9%) among 11,257 intubations. Deviation from the algorithm was recorded in three cases, and two patients were awakened before any alternative intubation technique attempt. All remaining patients were successfully ventilated with either the facemask (89 of 95) or the *ILMA*<sup>TM</sup> (6 of 95). Six difficult-ventilation patients required the *ILMA*<sup>TM</sup> before completion of the first intubation step. Eighty patients were intubated with the gum elastic bougie, and 13 required a blind intubation through the *ILMA*<sup>TM</sup>. Two patients ventilated with the *ILMA*<sup>TM</sup> were never intubated.

**Conclusion:** When applied in accordance with a predefined algorithm, the gum elastic bougie and the *ILMA*<sup>TM</sup> are effective to solve most problems occurring during unexpected difficult airway management.

THE unanticipated difficult airway, a common clinical problem encountered by all anesthesiologists, is probably the most important cause of major anesthesia-related morbidity.<sup>1</sup> For several years, it has been emphasized that strict adherence to a predefined strategy could decrease respiratory catastrophes and specific anesthesia-

related morbidity and mortality.<sup>2</sup> A decade ago, the American Society of Anesthesiologists published a difficult airway management algorithm.<sup>3</sup> Based on expert opinion and consensus conferences, strategies for difficult airway management makes sense clinically but has rarely been validated prospectively. Schematically, after induction of anesthesia, two concerning respiratory scenarios are distinguished: "cannot intubate" and "cannot ventilate." In these circumstances, most recommended strategies for airway management require the use of airway devices conceived to facilitate tracheal intubation, to create a patent airway, or both. We chose the gum elastic bougie (GEB) to facilitate laryngoscope-assisted tracheal intubation and the *Intubating Laryngeal Mask Airway*<sup>TM</sup> (*ILMA*<sup>TM</sup>) to solve ventilation problems. During 18 months, we evaluated the efficacy of a simple management algorithm, using both devices, in the case of an unpredicted difficult airway occurring in the operating room.

## Materials and Methods

After local ethics committee approval, this study was performed prospectively at the Henri Mondor University Hospital of Créteil (France) between September 2000 and February 2002. All staff senior anesthesiologists (n = 41) working in the operating area agreed to participate in this study.

After a 2-month period of theoretical education and practical training (dummy) in airway management, anesthesiologists were asked to adhere to a predefined algorithm management in the case of an unanticipated difficult airway occurring in the operating room. The GEB (Portex Sims, Hythe, United Kingdom) and the *ILMA*<sup>TM</sup> (Laryngeal Mask Company, Henley on Thames, United Kingdom) were proposed as the first and second steps in the case of an impossible standard tracheal intubation, respectively. Difficult laryngoscope-assisted tracheal intubation was defined by two failed attempts (two successive removals of the laryngoscope blade from the mouth of the patient) performed by a senior physician under optimal upper airway manipulations. In the case of impossible ventilation or difficult ventilation associated with life-threatening hypoxemia, the *ILMA*<sup>TM</sup> was recommended for rescue oxygenation, followed (in the case of failure) by percutaneous transtracheal jet ventilation. Difficult facemask ventilation was defined by one of the following criteria: inability for a unassisted anes-

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**Table 1. Morphometric Findings in the 100 Unexpected Difficult Intubation Patients**

	Mallampati Class (I/II/III/IV)	Thyromental Distance, mm	Opening Mouth, mm
Six patients with initial difficult facemask ventilation	1/5/0/0	70 (62–80)	34 (28–40)
Three patients considered as deviations from the algorithm	1/2/0/0	66 (63–93)	38 (27–39)
Two patients awoken	0/2/0/0	(63–85)	(36–42)
80 patients intubated with the GEB	22/58/0/0	72 (65–110)	37 (28–50)
Nine failures of GEB use	1/8/0/0	75 (64–105)	38 (32–48)

Results are expressed as median and extremes for thyromental distance and opening mouth.

GEB = gum elastic bougie.

thesiologist to maintain oxygen saturation ( $SpO_2$ ) greater than 90% using 100% oxygen and positive-pressure mask ventilation, necessity to perform a two-handed mask ventilation technique, important gas flow leak from the facemask, and no perception of chest movements.<sup>4</sup> Resorting to the *ILMA*<sup>TM</sup> was mandatory after two failed attempts using the GEB (two successive removals of the bougie from the esophagus of the patient). Facemask ventilation was recommended between intubation attempts, and at any moment, the anesthesiologist could consider the opportunity for the patient to return to the awake state.

With systematic preoperative written information of all anesthetized patients admitted for elective surgery, the study started when all participating staff anesthesiologists had completed the formation, achieved significant expertise in airway devices (GEB, *ILMA*<sup>TM</sup>, percutaneous transtracheal jet ventilation) and manipulation, and sustained a practical evaluation. Standard anesthesia care, including monitoring, was in accord with our national society of anesthesiology practice recommendations.

In all cases of an unexpected difficult airway, the intubation difficulty scale score (number of tracheal intubation attempts; number of operators who attempted to intubate the patient; number of alternative techniques used; glottis exposure, as defined by the Cormack grade; intensity [normal or increased] lifting force applied during laryngoscopy; necessity or lack of necessity to apply external laryngeal pressure for optimized glottic exposure; and position of the vocal cords) was calculated.<sup>5</sup> Morphometric characteristics of the patients (Mallampati score, thyromental distance, and interincisor distance) and the time to efficient ventilation, defined as the time elapsing the last standard laryngoscopy to adequate ventilation (end-tidal carbon dioxide) through either the *ILMA*<sup>TM</sup> (impossible or difficult ventilation) or the endotracheal tube (impossible standard intubation), were measured. The overall adherence to the difficult airway algorithm was assessed. The occurrences of impossible or difficult facemask ventilation, hypoxia episodes (oxygen saturation < 90%), pulmonary inhalation, and dental traumatism during the intubation procedure were recorded.

## Results

During the study period, 100 cases of unexpected difficult airways occurred in anesthetized patients among 11,257 intubations (0.9%). Eighty-five patients received a nondepolarizing neuromuscular blocking agent, and 15 were given succinylcholine before the first intubation attempt. The median (extremes) time elapsing the last standard laryngoscopy and adequate ventilation through either the *ILMA*<sup>TM</sup> or the endotracheal tube was 4.5 min (1.6–21.0 min). Although a difficult ventilation scenario was encountered in 6 patients, impossible ventilation never occurred nor was percutaneous transtracheal ventilation requested during the 18-month study. The mean age and body mass index of difficult-airway patients were 61 yr (range, 32–87 yr) and 26 kg/m<sup>2</sup> (range, 17–35 kg/m<sup>2</sup>), respectively. The male:female ratio was 62:38. The median intubation difficulty scale score (25th–75th percentiles) was 9 (range, 5–18). Morphometric characteristics of the patients (Mallampati score, interincisor distance, thyromental distance) are reported in table 1. Morphometric data collection revealed that three patients had an interincisor distance less than 3 cm. Deviation from the algorithm was recorded in three cases (fig. 1). A fiberscope was used as first step for one patient, the second patient was intubated with a stylet, and the last patient underwent six laryngoscopies before being intubated by a rescue senior anesthesiologist. Two patients were awakened without any alternative intubation technique trial. Six patients who experienced difficult facemask ventilation were successfully ventilated through the *ILMA*<sup>TM</sup> before the first intubation step was completed (fig. 1). Among the remaining 89 patients who sustained the first intubating step, 80 were intubated with the GEB: 41 at the first attempt, and 39 at the second attempt. A total of 15 patients (six difficult facemask ventilations and nine GEB failures) were successfully ventilated with *ILMA*<sup>TM</sup> (fig. 1). Regarding these 15 *ILMA*<sup>TM</sup> patients, intubation through the *ILMA*<sup>TM</sup> was achieved at the first attempt in nine patients, at the second attempt in three cases, and at the third attempt once but failed twice. One of these two nonintubated patients was awakened for delayed intervention, and the remaining patient completed peripheral surgery under

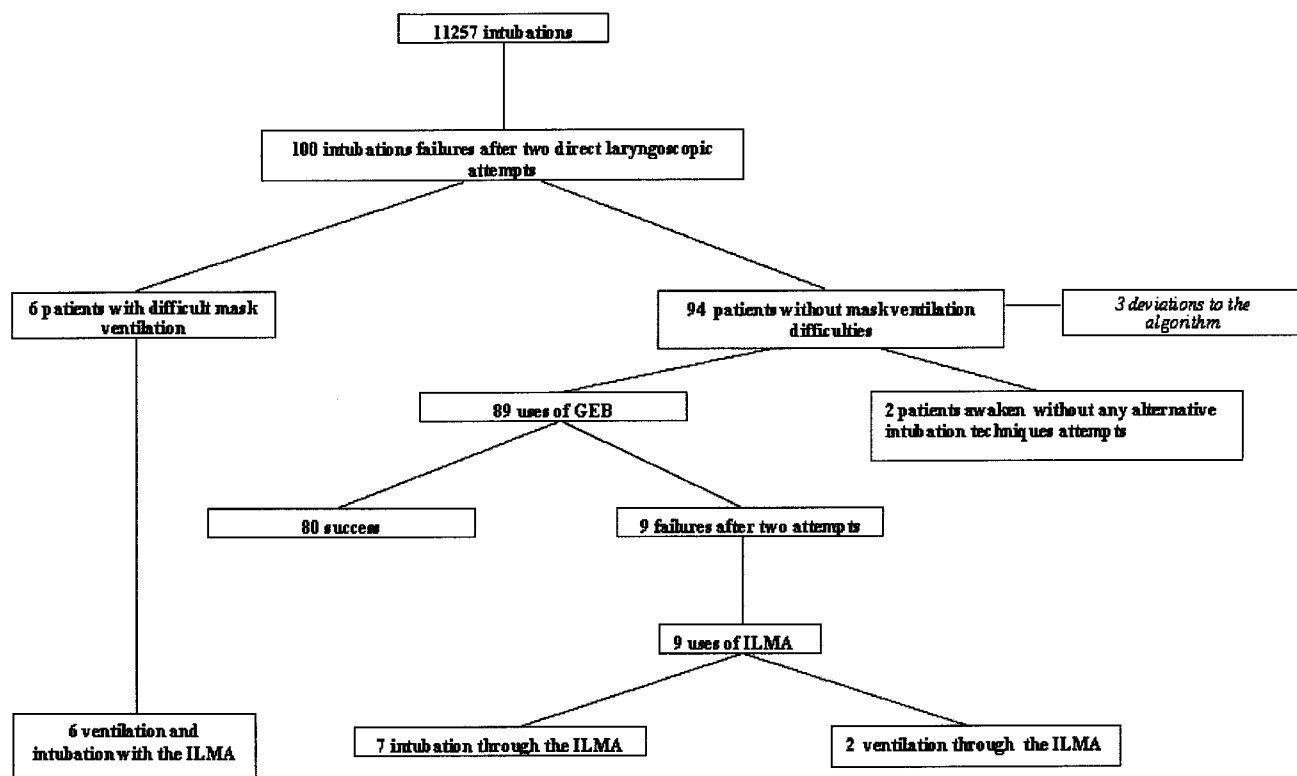


Fig. 1. Algorithm for the management of an unanticipated difficult airway recommended two airway devices: the gum elastic bougie (GEB) and the *Intubating Laryngeal Mask Airway*<sup>TM</sup> (ILMA<sup>TM</sup>). GEB was proposed as the first step in the case of difficult standard tracheal intubation. ILMA<sup>TM</sup> was used as the second step in the case of GEB failure or as the first step in the case of a difficult facemask ventilation scenario.

spontaneous ventilation with the ILMA<sup>TM</sup>. A total of 16 patients experienced transient hypoxemia episodes during the difficult airway management process, with a lowest SpO<sub>2</sub> ranging between 48% and 89%. Findings regarding the 16 patients who experienced hypoxemia are reported in table 2. One patient experienced gastric regurgitation and was suspected to have pulmonary inhalation, and a single dental trauma was reported.

## Discussion

In the current study, we have observed a strong adherence to a simple difficult airway management algorithm that demonstrates its efficiency to solve most unexpected airway problems occurring in anesthetized patients.

Our study has limitations. It was performed in a university hospital that covers most adult surgical disci-

Table 2. Characteristics of the Patients Who Experienced Hypoxemia during Airway Management

Sex	Age, yr	SpO <sub>2</sub> LOW, %	Time of Hypoxemia Occurrence	Intubation Technique
M	44	88	During 2nd GEB attempt	GEB 2nd attempt
M	36	49	During 2nd GEB attempt	ILMA <sup>TM</sup> after two unsuccessful GEB attempts
M	66	84	During 1st GEB attempt	GEB 2nd attempt
F	55	85	During 1st GEB attempt	GEB 1st attempt
F	72	88	During facemask ventilation	ILMA
F	61	80	During facemask ventilation	None
M	45	89	During 2nd GEB attempt	GEB
M	76	88	During 2nd GEB attempt	GEB
M	52	82	During facemask ventilation	ILMA
M	71	76	During facemask ventilation	ILMA
F	50	75	During 2nd GEB attempt	ILMA <sup>TM</sup> after two unsuccessful GEB attempts
M	59	85	During 1st GEB attempt	GEB 1st attempt
M	66	86	During 2nd GEB attempt	GEB 2nd attempt
M	66	88	During 2nd GEB attempt	GEB 2nd attempt
M	52	87	During 2nd GEB attempt	ILMA <sup>TM</sup> after two unsuccessful GEB attempts
F	54	86	During multiple direct laryngoscopic attempts	Direct laryngoscopy at 6th attempt

GEB = gum elastic bougie; ILMA<sup>TM</sup> = *Intubating Laryngeal Mask Airway*<sup>TM</sup>; SpO<sub>2</sub> LOW = lower arterial oxygen saturation during airway management.

plines except obstetric and pediatric surgery. Therefore, our results may not be applicable to parturient anesthesia, a well-known situation of frequent difficulties of both ventilation and tracheal intubation. Moreover, our algorithm was conceived for unpredicted difficult-intubation patients, and our high success rate is not transposable to anticipated difficult-intubation patients. Nevertheless, there are several reports of great efficacy of both the GEB and the *ILMA*<sup>TM</sup> when difficult intubation is anticipated.<sup>6-8</sup>

Application of algorithms, predefined strategies used to optimize patient treatment, is recommended in medical practice. For the anesthesiologists, the most problematic situation remains the impossibility to maintain a patent airway in an anesthetized patient who has lost his or her spontaneous breathing. Then, it is logical that new algorithms for difficult airway management are regularly proposed, most of them being associated with the development of innovative devices for intubation or ventilation. Interestingly, although alternative techniques in the case of an unanticipated difficult ventilation or tracheal intubation are so numerous, only two studies have prospectively assessed the efficiency of a predefined algorithm in the case of an unanticipated difficult airway.<sup>9,10</sup> The first study reported the interest of systematic use of the laryngeal mask airway in the case of a combined unanticipated difficult intubation and ventilation. The authors demonstrated that 94% of the patients treated with the laryngeal mask airway as the first rescue alternative technique were successfully ventilated.<sup>9</sup> More recently, a study reported the high success rate of tracheal intubation using both the *ILMA*<sup>TM</sup> and the light wand in 44 unpredicted failed laryngoscopy-assisted tracheal intubations.<sup>10</sup> In the current study, when treated following a predefined algorithm, 100% of the difficult-airway patients have been correctly ventilated, and 98% (93 of 95) were finally intubated.

We have deliberately conceived a simple algorithm in the case of an unpredicted difficult airway that covers both the "cannot intubate" and the "cannot ventilate" scenarios. We have chosen the GEB as the first step in the case of an impossible intubation because of its efficacy, simplicity of use, and low cost. Several studies have reported the usefulness of the GEB, especially when the direct view of the glottis is difficult. The GEB is a simple tool that was shown to be more efficient than the stylet in the management of simulated difficult intubation.<sup>11</sup> Moreover, a recent report demonstrated a high success rate of tracheal intubation associated with the use of the GEB in a population of predicted and unanticipated difficult intubations.<sup>12</sup> These publications confirm our local experience with the GEB that solves 80% of unpredicted difficult intubations. We demonstrated a high success rate of tracheal intubation using the GEB, with 90% (80 of 89) of difficult-intubation patients intubated at the second attempt.

The *ILMA*<sup>TM</sup> as an intubating device was proposed in second position after the GEB because this device is not as simple to use as the GEB. Indeed, a learning curve was described before acquiring a significant expertise with the *ILMA*<sup>TM</sup>, with most intubating failure occurring during the first 20 attempts.<sup>13</sup> This was the goal of the preliminary training that senior anesthesiologists sustained before this study began. However, placed in experienced anesthetists' hands, the *ILMA*<sup>TM</sup> was shown to be an efficient device for blind intubation in both normal and difficult-airway patients, with a success rate ranging between 95 and 97%.<sup>7,14</sup> Anesthesiologists participating this study were skilled with the laryngeal mask airway but were still learning to use the *ILMA*<sup>TM</sup>. This fact may explain the 13% failure rate (2 of 15) that we observed when blind tracheal intubation was challenged through the *ILMA*<sup>TM</sup>.

Since 1996, the laryngeal mask airway is used in our department in the case of the "cannot ventilate" scenario occurring during difficult airway management. Then, naturally, the *ILMA*<sup>TM</sup> was selected as the first step in the case of an impossible or a difficult ventilation. This airway device was shown to render a patent airway in almost 100% of normal- or difficult-airway adult patients. In the current study, all 15 patients in whom an *ILMA*<sup>TM</sup> was inserted were easily ventilated.

Although not required in the 100 difficult-airway patients we have treated, senior anesthesiologists participating this study were prepared to perform percutaneous transtracheal jet ventilation. Failure of the *ILMA*<sup>TM</sup> to promote ventilation is probably exceptional, but direct tracheal access would have been the final rescue technique in the case of severe hypoxia.

We have observed a strong adherence to this algorithm. When retrospectively interviewed, physicians who participated in the study proposed three main reasons. The first one is linked to the simplicity of the algorithm, which is made of two distinct scenarios. The second relies on the efficiency and easiness of use of two airway devices familiar to the anesthetists of our institution. Finally, the initial information, theoretical education, and practical training seemed to be determining factors.

In conclusion, we have prospectively validated the efficiency of a simple local algorithm conceived to manage unanticipated difficult airways occurring in anesthetized patients.

## References

1. Cheney FW, Weiskopf RB: The American Society of Anesthesiologists Closed Claims Project: What have we learned, how has it affected practice, and how will it affect practice in the future? *ANESTHESIOLOGY* 1999; 91:552-6
2. Crosby ET, Cooper RM, Douglas MJ, Doyle DJ, Hung OR, Labrecque P, Muir H, Murphy MF, Preston RP, Rose DK, Roy L: The unanticipated difficult airway with recommendations for management. *Can J Anaesth* 1998; 45:757-76
3. American Society of Anesthesiologists Task Force on Management of the

Difficult Airway: Practice guidelines for management of the difficult airway. *ANESTHESIOLOGY* 1993; 78:597-602

4. Langeron O, Masso E, Huriaux C, Guggiari M, Bianchi A, Coriat P, Riou B: Prediction of difficult mask ventilation. *ANESTHESIOLOGY* 2000; 92:1229-36

5. Adnet F, Borron SW, Racine SX, Clemessy JL, Fournier JL, Plaisance P, Lapandry C: The intubation difficulty scale (IDS): Proposal and evaluation of a new score characterizing the complexity of endotracheal intubation. *ANESTHESIOLOGY* 1997; 87:1290-7

6. Cros AM, Maigrot F, Esteben D: Fastrach laryngeal mask and difficult intubation (in French). *Ann Fr Anesth Reanim* 1999; 18:1041-6

7. Ferson DZ, Rosenblatt WH, Johansen MJ, Osborn I, Ovassapian A: Use of the intubating LMA-Fastrach in 254 patients with difficult-to-manage airways. *ANESTHESIOLOGY* 2001; 95:1175-81

8. Dogra S, Falconer R, Latto IP: Successful difficult intubation: Tracheal tube placement over a gum-elastic bougie. *Anaesthesia* 1990; 45:774-6

9. Parmet JL, Colonna-Romano P, Horrow JC, Miller F, Gonzales J, Rosenberg H: The laryngeal mask airway reliably provides rescue ventilation in cases of

unanticipated difficult tracheal intubation along with difficult mask ventilation. *Anesth Analg* 1998; 87:661-5

10. Dimitriou V, Voyagis GS, Brimacombe JR: Flexible lightwand-guided tracheal intubation with the intubating laryngeal mask Fastrach in adults after unpredicted failed laryngoscope-guided tracheal intubation. *ANESTHESIOLOGY* 2002; 96:296-9

11. Gataure PS, Vaughan RS, Latto IP: Simulated difficult intubation: Comparison of the gum elastic bougie and the stylet. *Anaesthesia* 1996; 51:935-8

12. Latto IP, Stacey M, Mecklenburgh J, Vaughan RS: Survey of the use of the gum elastic bougie in clinical practice. *Anaesthesia* 2002; 57:379-84

13. Messant I, Lenfant F, Chomel A, Rapenne T, Freysz M: Evaluation of the learning curve of a new intubation technique: Intubating laryngeal mask (in French). *Ann Fr Anesth Reanim* 2002; 21:622-6

14. Pandit JJ, MacLachlan K, Dravid RM, Popat MT: Comparison of times to achieve tracheal intubation with three techniques using the laryngeal or intubating laryngeal mask airway. *Anaesthesia* 2002; 57:128-32