Unanticipated Difficult Airway Management in the Prehospital Emergency Setting

Prospective Validation of an Algorithm

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ABSTRACT

Background: Difficult intubation management algorithms have proven efficacy in operating rooms but have rarely been assessed in a prehospital emergency setting. We undertook a prospective evaluation of a simple prehospital difficult intubation algorithm.

Methods: All of our prehospital emergency physicians and nurse anesthetists were asked to adhere to a simple algorithm in all cases of impossible laryngoscope-assisted tracheal intubation. They received a short refresher course and training in the use of the gum elastic bougie (GEB) and the intubating laryngeal mask airway (ILMA), which were techniques to be used as a first and a second step, respectively. In cases of difficult ventilation with arterial desaturation, IMLA was to be used first. Cricothyroidotomy was the ultimate rescue technique when ventilation through ILMA failed. Patient characteristics, adherence to the algorithm, management efficacy, and early complications were recorded (August 2005–December 2009).

Results: An alternative technique to secure the airway was needed in 160 of 2,674 (6%) patients undergoing intubation. Three instances of nonadherence to the algorithm were recorded. GEB was used first in 152 patients and was successful in 115. ILMA was used first in 8 patients and second in the 37 GEB-assisted intubation failures. Forty-five patients were successfully mask-ventilated, and 42 were blindly intubated before reaching the hospital. Cricothyroidotomy was used successfully in a patient with severe upper airway obstruction as a result of pharyngeal neoplasia. Early intubation-related complications occurred in 52% difficult cases.

Conclusion: Adherence to a simple algorithm using GEB, ILMA, and cricothyroidotomy solved all difficult intubation cases occurring in a prehospital emergency setting.

What We Already Know about This Topic

- Airway management in the emergency prehospital setting is often more difficult than that in the operating room

What This Article Tells Us That Is New

- In more than 2,500 patients in a single emergency unit, a simple airway algorithm using gum elastic bougie, intubating laryngeal mask airway, and cricothyroidotomy was uniformly adopted (adherence 98%) and successfully managed 160 difficulty airway situations encountered

UNANTICIPATED difficult intubation is a common, potentially life-threatening problem in several settings (operating room, intensive care unit, and prehospital). Several experts and national anesthesiology societies have proposed algorithms using different techniques

◆ This article is accompanied by two Editorial Views. Please see: Schmidt U, Eikermann M: Organizational aspects of difficult airway management: Think globally, act locally. ANESTHESIOLOGY 2011; 114:3–6; Isono S, Ishikawa T: Oxygenation, not intubation, does matter. ANESTHESIOLOGY 2011; 114:7–9.

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Received from Hôpital Henri Mondor, Créteil cedex, France. Submitted for publication April 1, 2010. Accepted for publication September 1, 2010. Support was provided solely from institutional and/or departmental sources. This work was carried out in the Services de Médecine d'Urgence et de Réanimation (SMUR) of Henri-Mondor University Hospital, Créteil, France.

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 Anesthesiology 2011; 114: 105–10

for difficult airway management.[1–7] Some of these algorithms have been assessed in prospective studies but only within the operating room. Reported adherence and success rates are very high.[1,4,8]

We have validated a simple, efficient algorithm for the use of two alternative devices—the gum elastic Bougie (GEB) and the intubating laryngeal mask airway (ILMA)—in anesthetized patients in the operating room.[1] However, an algorithm developed for use in the operating room is not necessarily directly transposable to a prehospital emergency setting for several reasons: (1) operators in a prehospital setting are emergency physicians or paramedics and do not have the skills of an anesthesiologist in airway management,[9–11] (2) operators cannot call for assistance, (3) a return to the awake state is unlikely in an emergency setting, and (4) emergency intubation always carries a high risk of arterial oxygen desaturation and pulmonary aspiration.[12] A 3-fold higher rate of difficult intubations has been reported by Adnet *et al.* in a prehospital setting than in the operating room.[13]

Our aim was to assess prospectively, in an emergency prehospital setting, a simple difficult intubation management algorithm based on the use of three techniques: GEB, ILMA, and Seldinger cricothyroidotomy.

Materials and Methods

Ethics

The study was approved by the Ethics Committee (*Comité de protection des personnes SE prêtant à la recherche biomédicale*) of Henri Mondor University Hospital, Créteil, France. The committee waived the need for informed consent because the study was unrandomized and assessed an algorithm for use in routine practice.

Study Design and Setting

This was a prospective observational study conducted by the prehospital emergency medical unit of Henri Mondor University Hospital (August 2005–December 2009), which caters to a population of 1,300,000 inhabitants. The prehospital emergency medical unit carries out approximately 11,000 medical emergency out-of-hospital interventions each year. It runs several mobile intensive care units that have a minimum onboard team of a trained ambulance driver, a nurse anesthetist, a senior physician specializing in either emergency medicine (more than 90%) or anesthesiology, or a senior resident. Senior residents have more than 3 yr of emergency medical practice and are allowed to manage patients alone. Prehospital emergency medical unit nurse anesthetists must have 4 yr of experience in the operating room, and prehospital emergency medical unit physicians must have completed more than 90 successful tracheal intubations in a 3-yr period.

Patients

The study included all consecutive adult patients (18 yr or older) needing emergency intubation in the prehospital setting. Airway management was standardized in our prehospital emergency medical unit. The pharmacological procedure firmly recommended rapid sequence intubation for patients with current cardiac activity without evident contraindications for succinylcholine use. Orotracheal intubation was attempted after facemask oxygenation optimization 1 min after succinylcholine (1 mg/kg) bolus injection. Etomidate (0.2–0.3 mg/kg) or ketamine (2 mg/kg) was suggested in case of cardiac or vascular distress, but other hypnotic drugs administered at the appropriate dosage were accepted. Sedation was never considered in patients without cardiac activity.[14]

Operator Training

GEB has been available for many years in our mobile intensive care units, whereas ILMA became available in 2004. Although most of our emergency physicians and nurses have been trained in both techniques, they were all given a 2-h refresher course and practical training on a manikin. They used the manikin during a 3-h session to perform five GEB-assisted intubations (Airway Management Trainer; Laerdal medical France, Limonest, France) and 10 consecutive ILMA intubations (Simulateur d'intubation Ambu®; Ambu, Le Hailan, France). They also performed 10 consecutive cricothyrotomies using the Seldinger method on a simulator (Life Form® cricothyrotomy simulator; Nasco, Fort Atkinson, WI).

At the end of the training, they attended a presentation on an algorithm to be used in all cases of unanticipated difficult intubation with a Macintosh laryngoscope in a prehospital setting. A paper version of the algorithm was handed out, and the issue of the algorithm was regularly brought up at daily staff meetings.

Algorithm Description

Difficult tracheal intubation was defined as a failure to intubate the trachea after either two tracheal intubation attempts with a Cormack and Lehane class less than IV or a single tracheal intubation attempt with a Cormack and Lehane class IV, along with optimal upper airway and head manipulations (head extension, external laryngeal manipulation and backward, upward and right pressure maneuver). In both difficult intubation situations, the participants were requested to move to the next step of the algorithm. The alternative was GEB first (Portex Sims, Hythe, United Kingdom) and ILMA second (Laryngeal Mask Company, Henley-on-Thames, United Kingdom). When ventilation was impossible or difficult and associated with life-threatening hypoxemia (defined as an oxygen saturation less than 85% more than 1 min when using 100% oxygen and positive-pressure mask ventilation), the algorithm recommended IMLA for rescue oxygenation and, if this failed, cricothyrotomy (Melker Emergency Cricothyrotomy Catheter Sets; Cook Inc., Bloomington, IN). When ILMA was contraindicated because of obstructive lesions of the up-

per airways (*i.e.*, "cannot intubate, cannot ventilate"), the only option was cricothyroidotomy.

Outcome Variables

The main outcome variable was overall adherence to the difficult airway algorithm. Other endpoints were impossible or difficult facemask ventilation, hypoxia (oxygen saturation less than 90%), pulmonary aspiration, arterial hypotension, cardiac arrest, and dental trauma during intubation.

Data Collection and Processing

Immediately after airway management, the mobile intensive care unit physician recorded the following data for each case of difficult intubation encountered: patient age, gender, known or estimated weight and height, Glasgow coma score, history of ear-nose-throat neoplasia or surgery, facial trauma, cervical immobilization, circumstances of intubation (*e.g.*, cardiac arrest, coma because of self-poisoning or neurologic disease, respiratory distress, trauma, shock, or analgesia), and the variables making up the Intubation Difficulty Scale score (number of operators, number of attempts, number of techniques, Cormack view, intensity [normal or increased] of lifting force, the need or not to apply external laryngeal pressure, and vocal cord position).[13] All data were entered and managed on a personal computer database (Microsoft Office Excel 2003, Redmond, WA).

Statistical Analysis

Categorical data are reported as numbers (%) and quantitative data as medians with 25th–75th percentiles (Microsoft Office Excel 2003).

Results

Fifty-three emergency care staff (23 senior emergency physicians, 6 senior residents, 3 senior anesthesiologists, and 21 nurse anesthetists) performed tracheal intubations during the 4.5 yr of the study. A total of 2,674 patients were included in the study. Difficult intubation was observed in 160 patients (6%). For these 160 patients, intubation by direct laryngoscopy proved impossible, and an alternative technique was required. The overall adherence rate to the predefined algorithm was 157 of 160 (98%).

Patient characteristics and the indications for intubation are given in table 1. The main indication was cardiac arrest (38%). Management of the 160 difficult intubation patients is shown in the flowchart of figure 1. The algorithm was not applied in three patients who each underwent more than two intubation attempts by direct laryngoscopy before successful use of GEB as an alternative. An alternative technique was used after only one intubation attempt by direct laryngoscopy in 26 patients. GEB was used as the first alternative in 151 patients and was successful in 114 patients after one or two attempts. All 37 GEB-assisted intubation failures were managed using ILMA. These 37 patients were adequately mask-ventilated through the ILMA: 34 were intubated blindly through the mask out of the hospital and 3 were mask-ventilated through the ILMA during transport and underwent intubation by fiberoptic intubation in the hospital triage area. Primary or early impossible or difficult facemask ventilation situations, associated with life-threatening hypoxemia, were encountered in nine patients. The ILMA was used as a rescue oxygenation technique in eight of these patients because of combined facemask ventilation difficulties associated with severe arterial oxygen desaturation and direct laryngoscopy intubation failure.

Cricothyroidotomy was used successfully in a patient who presented with severe upper airway obstruction as a result of pharyngeal neoplasia and in whom ILMA was contraindicated because of major upper airway distortion. The number of intubations, according to the Intubation Difficulty Scale, is shown in figure 2, and the results of the variables making up the Intubation Difficulty Scale are reported in table 2. Intubation-related complications occurred in 52% of patients and are detailed in table 3.

Table 1. Patient Demographics and Intubation Circumstances

Patients (n)	160
Sex, n (%)	
Female	54 (34)
Male	106 (66)
Median body mass index (kg/m^2)	26 (24–29)*
Body mass index >35 kg/m^2 (n)	21
Median age (yr)	55 (44–71)*
Circumstances of intubation, n (%)	
Cardiac arrest	61 (38)
Respiratory distress	15 (9)
Trauma	13 (8)
Coma as a result of self-poisoning	16 (10)
Coma as a result of neurological disease	32 (20)
Shock	19 (12)
Other	4 (3)
History of eyes-nose-throat disease, n (%)	13 (8)
Cervical immobilization, n (%)	28 (18)
Facial trauma, n (%)	14 (8)
Medications used, n (% patients with spontaneous cardiac activity)	
Succinylcholine	88 (89)
Etomidate	73 (74)
Thiopental	4 (4)
Ketamine	5 (5)

* 25th–75th percentiles.

Discussion

Adherence to our simple algorithm for difficult airway management in the prehospital emergency setting was high (98%). The algorithm was effective in solving all unanticipated airway problems.

The incidence of unanticipated difficult intubations in the prehospital setting was higher than in the operating room, as already reported by Adnet *et al.*[13,15] We had to

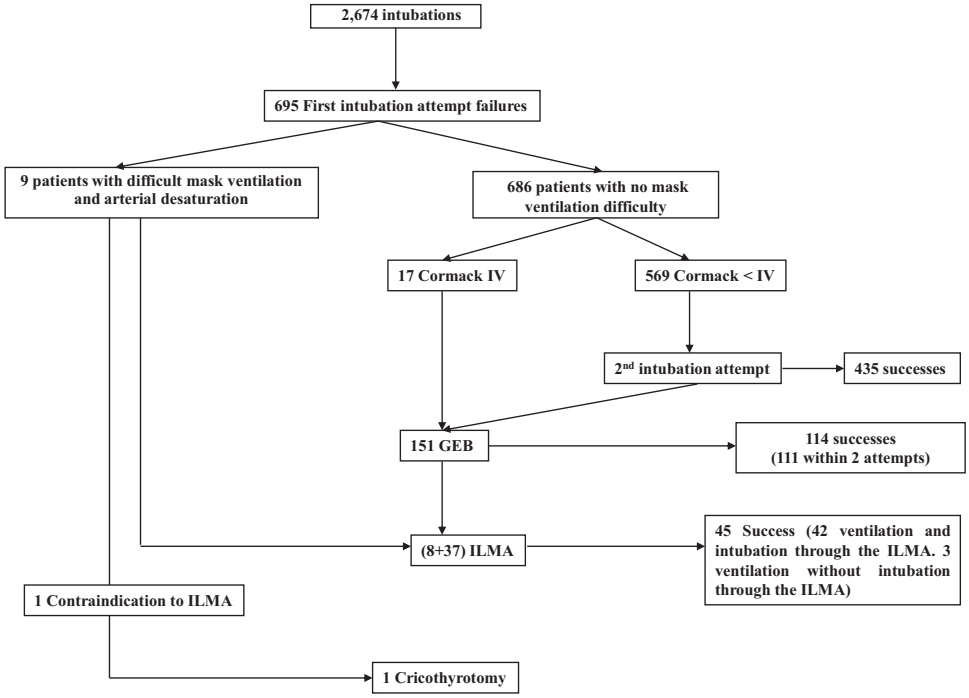

Fig. 1. Flowchart of the patients intubated during the study period. GEB = gum elastic bougie; ILMA = intubating laryngeal mask airway.

resort to an alternative intubation technique in 6% of patients, whereas in the operating room, this was the 1% in our previous study.[1] There are several reasons for this higher incidence: operators are not anesthesiologists with specific skills in airway management, patients may be in vital distress, overall circumstances are more hostile (*e.g.*, patient lying on the ground, cramped space, frequent presence of blood or gastric fluid in the pharynx, or uncooperative patient), and arterial oxygen desaturation occurs more often.[12]

For all of these reasons, we had to adapt our operating room algorithm to the prehospital setting. We recommended GEB after just one intubation attempt under direct laryngoscopy for a class IV laryngeal view, according to the Cormack and Lehane classification. In addition, we recommended cricothyroidotomy rather than percutaneous transtracheal jet ventilation in cannot intubate, cannot ventilate situations. Although transtracheal jet ventilation is a highly effective rescue technique when prompt surgical tracheotomy is possible, it is unrealistic in a prehospital setting. We thought that a technique such as cricothyroidotomy, allowing inspiration and expiration through the same tube, was more appropriate because of the time that may elapse between tracheal access and arrival at the hospital. In fact, we used cricothyroidotomy only once in a patient with severe respiratory distress as a result of a malignancy obstructing the upper airway and in whom direct tracheal access was mandatory for rescue oxygenation.

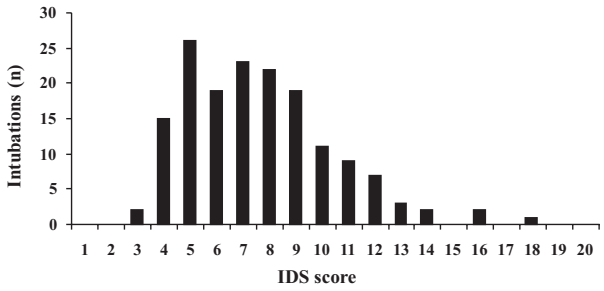

Fig. 2. Distribution of the IDS values of the 160 difficult intubations recorded during the study period. IDS = intubation difficulty scale.

The techniques used in steps 1 and 2 of our algorithm (GEB and ILMA) do not take long to learn.[16,17] A short learning curve is essential when operators perform few intubations. Our emergency physicians intubate, on average, 14 patients per year, whereas anesthesiologists intubate several hundreds. Despite their lesser experience, their success rates for GEB and ILMA use were similar to those reported in operating room studies. Minimal initial skill was required for nonanesthesiologist training to apply these alternative techniques within the framework of our algorithm. We have to point out that our algorithm was applied by senior operators and was regularly brought up at daily staff meetings to all the staff. We believe that these two keys points enhanced the adherence to the program and resulted in the success rate we observed with our algorithm.

Our intubation-related complications rate was high (52%). Most of our patients underwent more than two intubation attempts, and thus were exposed to a high risk of arterial oxygen desaturation. The most common complications we encountered were esophageal intubation (36%) and arterial oxygen desaturation (26%). Mort[18,19] reported up to

Table 2. Distribution of the Intubation Difficulty Scale Subcomponents in the 160 Patients

Parameter	N = 160
N1: Number of attempt >1 (n)	
1	26
2	47
3	50
4	21
5	10
6	6
Number of operators >1 (n)	
0	73
1	74
2	13
Number of alternative techniques (n)	
1	115
2	45
Cormack and Lehanne grade (n)	
I	2
II	13
III	128
IV	17
Lifting force required (n)	
Normal	33
Increased	127
Laryngeal pressure (n)	
Not applied	54
Applied	106
Vocal cord mobility (n)	
Abduction	15
Adduction	0
Not seen	145

70% complications rate in case of multiple tracheal intubation attempts. Prolongation of the airway management process was shown to increase the incidence of complications.[19] The two main reasons for such high complications rate are obvious. First, airway management in the emergency context exposes the patient to a higher risk for airway management–related complications.[12] Second, most medical or surgical conditions (coma, severe trauma, shock, or respiratory distress) necessitating emergency tracheal intubation prevent preoxygenation efficiency at increasing oxygen lung reserve because of decreased residual functional capacity. Thus, the occurrence of hypoxemia episodes is not surprising during the airway management of critically ill patients.[18,20]

Table 3. Early Complications during and within 15 Min of Intubation

Complications	N* (%)
Patients with complications	83 (52)
Oesophageal intubation	58 (36)
Vomiting	11 (7)
Pulmonary aspiration	23 (14)
Dental trauma	3 (2)
Bronchospasm or laryngospasm	3 (2)
Arterial desaturation during intubation	42 (26)
Cardiac arrest during intubation	10 (6)

* Total exceeds 83 because some patients had more than one complication.

Our study has limitations, particularly with regard to the generalization of conclusions. It concerned mobile emergency units staffed by emergency physicians from a single emergency unit. Thus, our conclusions may not apply to all emergency units and to ambulances manned by paramedics only. We recorded only early complications related to the intubation procedure. There was no long-term follow up of patients.

In conclusion, we have prospectively validated the efficiency of a simple algorithm for managing unanticipated difficult airway intubation in a prehospital emergency setting. This algorithm using simple techniques helped emergency physicians solve all the difficult airway management cases encountered in a 4.5-yr period.

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ANESTHESIOLOGY REFLECTIONS

S. S. White's Poster for the Centennial Exhibition of 1876

As the United States celebrated the 100th anniversary of its "Declaration of Independence," Philadelphia hosted the "Centennial Exhibition of 1876." Among the scores of competing dental manufacturers was the hometown one co-founded by Samuel S. White, D.D.S. (1822–1879). Three years earlier, for its "peculiar distinction of eminent merits," White's firm had received the Grand Diploma of Honor (*upper right*) at the 1873 exposition in Vienna—a lofty distinction, since all runner-up dental firms had received bronze, rather than gold or silver medals. After featuring an etching of the Horticultural Hall (*lower right*) on his firm's two-toned Centennial poster (*left*), founder Samuel Stockton White, D.D.S. (1822–1879), was delighted to learn that the U.S. Centennial Commission Examiners' had cited his products as "decidedly superior" and "excelling [beyond] any other exhibit." By the end of the 19th Century, his legacy firm, S.S. White Dental Manufacturing Company would become the world's leading purveyor of dental supplies, anesthesia machines, and nitrous oxide. (Copyright © the American Society of Anesthesiologists, Inc. This image also appears in the *Anesthesiology Reflections* online collection available at www.anesthesiology.org.)

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