An Algorithm for Difficult Airway Management, Modified for Modern Optical Devices (Airtraq Laryngoscope; *LMA CTrach*™)

A 2-Year Prospective Validation in Patients for Elective Abdominal, Gynecologic, and Thyroid Surgery

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ABSTRACT

Background: Because algorithms for difficult airway management, including the use of new optical tracheal intubation devices, require prospective evaluation in routine practice, we prospectively assessed an algorithm for difficult airway management that included two new airway devices.

Methods: After 6 months of instruction, training, and clinical testing, 15 senior anesthesiologists were asked to use an established algorithm for difficult airway management in anesthetized and paralyzed patients. Abdominal, gynecologic, and thyroid surgery patients were enrolled. Emergency, obstetric, and patients considered at risk of aspiration were excluded. If tracheal intubation using a Macintosh laryngoscope was impossible, the Airtraq laryngoscope (VYGON, Ecouen, France) was recommended as a first step and the *LMA CTrach*™ (SEBAC, Pantin, France) as a second. A gum elastic bougie was advocated to facilitate tracheal access with the Macintosh and Airtraq laryngoscopes. If ventilation with a facemask was impossible, the *LMA CTrach*™ was to be used, followed, if necessary, by transtracheal oxygenation. Patient characteristics, adherence to the algorithm, efficacy, and early complications were recorded.

Results: Overall, 12,225 patients were included during 2 yr. Intubation was achieved using the Macintosh laryngoscope in 98% cases. In the remainder of the cases (236), a gum elastic bougie was used with the Macintosh laryngoscope in 207 (84%). The Airtraq laryngoscope success rate was 97% (27 of 28). The *LMA CTrach*™ allowed rescue ventilation (n = 2) and visually directed tracheal intubation (n = 3). In one patient, ventilation by facemask was impossible, and the *LMA CTrach*™ was used successfully.

What We Already Know about This Topic

- Uniform application of a difficult airway algorithm might decrease the incidence of hypoxic brain damage during anesthesia induction

What this Article Tells Us that is New

- In a large prospective study, application of a simple airway algorithm, including use of new visual intubation devices, achieved high adherence rate and successful tracheal intubation in all patients with difficult airways

◆ 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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Conclusions: Tracheal intubation can be achieved successfully in a large cohort of patients with a new management algorithm incorporating the use of gum elastic bougie, Airtraq, and *LMA CTrach*™ devices.

STRICT adherence to defined strategies and algorithms can resolve most problems in airway management.[1,2] The French National Society of Anesthesiology recently proposed strategies for managing "cannot intubate, cannot ventilate" events based on American Society of Anesthesiology guidelines, expert opinion, consensus conferences, and prospectively validated algorithms.[3,4] These strategies allow successful intubation of most patients with difficult airways. The endotracheal tube is introduced without requiring direct vision, using either gum elastic bougie (GEB) or intubating laryngeal mask airway. However, new devices that provide a viewing system, such as the Airtraq laryngoscope (AQ-L; VYGON, Ecouen, France) and the *LMA CTrach*™ (LMA-CT; SEBAC, Pantin, France), have recently been developed and validated for difficult tracheal intubation.[5–7] The current algorithms for difficult airway management do not incorporate these new devices or consider their appropriate role. Because these devices often can allow tracheal intubation under direct vision when conventional airway management fails, we included these new devices in an updated difficult airway management algorithm.

We prospectively assessed an algorithm for difficult airway management that included video assistance using these two new airway devices. We intended that the trachea of all patients with difficult airways would be intubated using visual guidance.

Materials and Methods

Study Design

This prospective validation study was conducted at the Jean Verdier University Hospital of Paris (Bondy, France) from January 2008 to December 2009. The hospital Ethics Committee waived the need for informed consent because randomization was not used and the algorithm was part of routine practice.

Anesthesia Settings and Participants

Jean Verdier Hospital is a tertiary, 350-bed surgical teaching hospital that includes a central surgical unit made of five operating rooms (ORs) encircling a 10-bed postanesthesia care unit and two externalized ORs dedicated to emergent and obstetric cases. Fifteen senior anesthesiologists with more than 5 yr of clinical experience covering the central surgical unit (gynecology, visceral, bariatric, and endocrine surgery departments) participated in the study. On a daily basis, three anesthesiologists managed patients in the central surgery unit. An anesthesiologist supervised one of the ORs and the postanesthesia care unit. The two remaining anesthesiologists managed two ORs each. A specialized anesthetist nurse cared for the patients in each OR. Four-hands induction of anesthesia was systematically performed. The anesthetic nurse usually initiated standard airway management. In case of failure of the first tracheal intubation attempt with the Macintosh laryngoscope (Macintosh-L) assisted with GEB, the anesthesiologist was requested to manage the airway.

Over a 6-month period, all participants were instructed in the use of the AQ-L and LMA-CT devices and then given practical training using a standard intubation mannequin and a difficult airway management simulator. After training, the physicians had a period of clinical experience where the devices (AQ-L and LMA-CT) were used as primary airway devices in morbidly obese patients admitted for elective bariatric surgery. We considered that clinical proficiency was acquired after each airway device, and the video-viewing system had been used successfully 10 times. After training, the study period started.

Patients

All patients admitted for elective surgery given general anesthesia requiring tracheal intubation were enrolled in the study. We included patients receiving therapy for gastric reflux or patients who were known to have a hiatus hernia but were currently asymptomatic. Pregnant women, emergency cases, and patients at risk for aspiration were excluded.

Preoperative Work-up

Anesthesia care, including monitoring, complied with French Society of Anesthesiology and Intensive Care Medicine clinical practice guidelines. Special attention was given to preoperative airway assessment. The participating anesthesiologists routinely assessed the patients before anesthesia using defined measures of airway difficulty (table 1).[8–11] Patients in whom airway management was expected to be difficult were systematically identified and listed on a Difficult Airway Board set up in the anesthesia department and discussed at a weekly meeting. For patients with three or more features of a difficult airway, the anesthesiologist decided before anesthesia started whether to use succinylcholine to aid intubation, and how to proceed with subsequent intubation.

Patient Exclusions

Patients with a mouth opening (or interincisor distance) of less than 25 mm, with severe fixed flexion deformity of the cervical spine, or a history of previous impossible tracheal intubation, were intubated while awake by use of fiberscope-guided nasotracheal intubation. All other patients underwent tracheal intubation given general anesthesia with muscle relaxant.

Airway Management

A standard method for preoxygenation was used, aiming to achieve an end-tidal oxygen concentration more than 90%. Patient position was adjusted according to body mass index

Table 1. Risk Factors for Airway Management Difficulty Systematically Assessed at the Preoperative Visit

Feature	Details
Men > 50 yr	
Obesity with BMI > 30 kg/m^{-2}	
Sleep apnea syndrome	Diagnosed, treated, or highly suspected on the base of the daytime sleepiness[23] scale > 9 and a preoperative sleep apnea screening tool[24] > 15
Mallampati classes III and IV	Patient sitting, head in neutral flexion/extension position, tongue out, without phonation
Mouth opening or intergingival distance < 35 mm	
Thyroid to mentum distance < 65 mm	
Severely limited jaw protrusion	Lower incisors cannot advance to meet upper incisors [9,25]
Neck circumference: > 40 cm in women and 45 cm in men	Measured at the level of the thyroid cartilage[26]

BMI = body mass index.

(BMI). If BMI was more than 35 kg/m^2, the head and neck position was raised for preoxygenation and tracheal intubation. In patients with fewer than three adverse predictors, the anesthesia provider assessed the ease of facemask ventilation before giving muscle relaxant (atracurium or vecuronium). The ease or difficulty of facemask ventilation was graded, using a simple score, as follows:

- Grade I: ventilation without the need for an oral airway;
- Grade II: ventilation requiring an oropharyngeal airway;
- Grade III: difficult and variable ventilation requiring an oral airway and two providers, or an oral airway and one provider using pressure-controlled mechanical ventilation requiring more than 25 cm H_2O; and
- Grade IV: ventilation inadequate with no end-tidal carbon dioxide measurement and no perceptible chest wall movement during attempts at positive pressure ventilation.

To reduce the duration of apnea, succinylcholine (1 mg/kg) was given when ventilation difficulty was graded III or IV. In patients with grade I and II facemask ventilation, intubation was planned 3 min after relaxant administration.

Algorithm Description

GEB and AQ-L were available in each OR. In the central postanesthesia care unit, 10 meters from each OR, additional equipment was permanently available, consisting of two sets of three LMA-CT chassis (sizes: 3, 4, and 5), two LMA-CT viewers placed in their charger, and the WIFI viewer for AQ-L. We considered gum elastic bougie (Boussignac Bougie; VYGON) as an adjunct to facilitate tracheal access when Macintosh-L and AQ-L were used. Once the muscle relaxant had been given, the anesthesia providers followed a set algorithm (fig. 1).

If tracheal intubation was not possible using a Macintosh-L fitted with a size 3 blade, then the AQ-L device was used, followed, if necessary, by the LMA-CT device. Impossible direct tracheal access was considered to be current if tracheal access was not possible after two attempts, using either Macintosh-L or AQ-L, aided by use of the GEB and changes in head position and external laryngeal manipulation as necessary. The AQ-L and LMA-CT devices were used exactly according to the manufacturer's instructions and departmental recommendations. For AQ-L, video-controlled tracheal intubation was first attempted using the standard technique of insertion of the device or the rotation maneuver.[8] Once a good view of the glottis was obtained, the endotracheal tube was passed through the vocal cords and held in place as the device was removed.

We used a size 5 LMA-CT for male patients and a size 4 for female patients, inserted as described.[9] Ventilation was maintained during both sealing and viewing procedures. Once a good view of the glottis was obtained, ventilation was discontinued and a reinforced flexible endotracheal tube was inserted through the metallic chassis of the LMA-CT and pushed through the vocal cords into the trachea under visual control. Facemask ventilation was recommended between intubation attempts, if pulsed arterial oxygen saturation (Spo_2) decreased to less than 90%. The anesthesiologist could decide at any time to discontinue intubation attempts and allow the patient to recover.

If mask ventilation was impossible, despite changes in head position or mask size, the LMA-CT device was used immediately. If LMA-CT ventilation failed, indicated by no end-tidal carbon dioxide curve and chest wall movement within 30 s after laryngeal mask placement, percutaneous transtracheal jet rescue oxygenation (ManuJet; VBM, Alleins, France) was to be used.

A proven difficult airway was defined as grade III and IV ventilation difficulty or failed conventional Macintosh-L tracheal intubation despite GEB use.

Study Data Collection

If the first step of the difficult airway management process was taken, the attending senior anesthesiologist managed the airway, and the anesthetic nurse collected airway management details and outcome variables. The physical character-

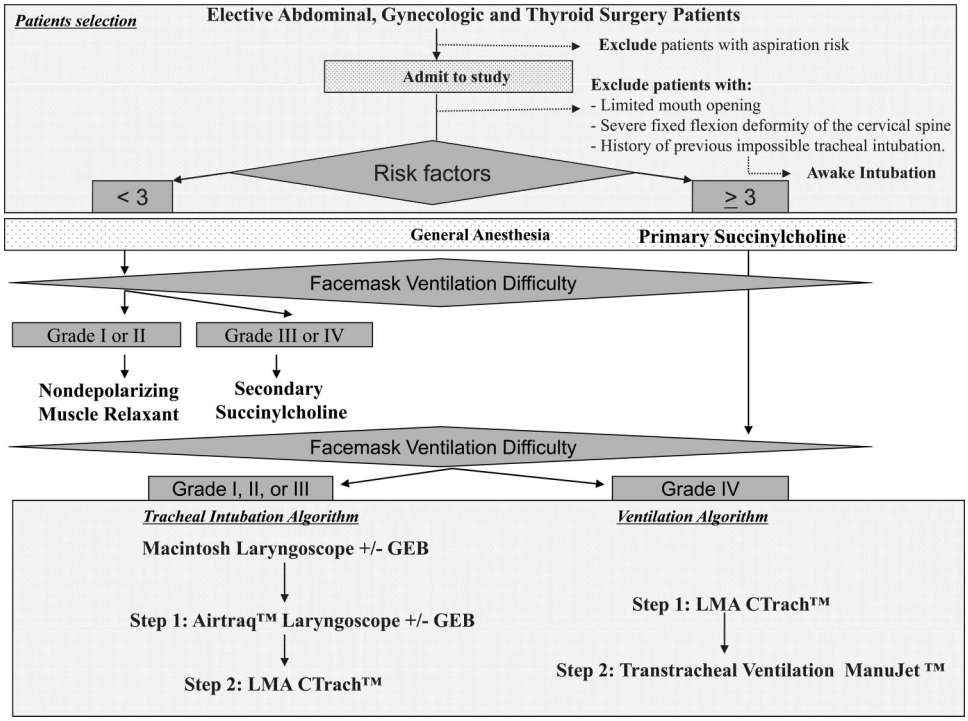

Fig. 1. Decision tree for muscle relaxant choice and airway management. The difficult ventilation grading scale is the following: Grade I, ventilation without the need for an oral airway; grade II, ventilation requiring an oral airway; grade III, difficult and unstable ventilation requiring an oral airway and two providers, or an oral airway and one provider, using mechanical ventilation (pressure-controlled mode); and grade IV, impossible ventilation. GEB = gum elastic bougie.

istics of all patients with difficult airways were recorded from the anesthesia record.

Outcome Variables

The main outcome variables were the success rate for tracheal intubation using visual guidance and adherence to the management algorithm. Other endpoints were the incidence of complications (hypoxemia, noted as the lowest Spo_2 during airway management, pulmonary aspiration, and evidence of airway trauma).

Statistical Analyses

Descriptive statistics, including frequency counts, proportion, mean, and SD calculation, were computed using XLSTAT 2008 (Addinsoft, Paris, France).

Results

Patients and Anesthesia

In the 2-yr study period, 12,225 patients were admitted for planned elective surgery given general anesthesia. Their mean (SD) age was 51 (14) yr and gender ratio (M/F) was 66/44. A difficult airway was encountered in 125 patients (1%). Physical characteristics and risk factors for airway management of all participants (n = 12,225) and details of patients with airway management difficulties (n = 125) are listed in table 2. General anesthesia and paralysis were induced in 12,221 of these patients. The four other patients underwent awake fiberscope-guided nasotracheal intubation. Of these four patients, one had a history of previous difficult intubation (35 kg/m BMI, 22 mm interincisor distance, and Mallampati class IV), one had a large thyroid tumor distorting the upper airway and severely narrowing the trachea, and two had a fixed flexion deformity of the cervical spine and a limited mouth aperture (20 mm) preventing airway insertion and manipulation.

Airway Management Outcomes

The pattern of management of the patients is shown in figure 2. Outcome of airway management of all anesthetized participants (n = 12,221) and of patients with airway management difficulties (n = 125) are listed in table 3. Grade III or IV ventilation difficulty occurred in 104 patients (0.8%). Two patients (0.01%) could not be ventilated by facemask (grade IV), and 102 patients (0.8%) had grade III ventilation difficulty. Among these patients, 12 received primary succinylcholine because they showed at least three predictors of difficult airway management and 90 received secondary succinylcholine because of grade III ventilation difficulty just after induction before muscle relaxant injection. Difficult ventilation (grade III) was encountered in 67 (7%) obese patients (BMI more than 30 kg/m). Combined grade III ventilation difficulty and impossible Macintosh-L intubation despite GEB use occurred in 7 (0.05%) patients. Ventilation difficulty (grade IV) was encountered twice in this series: just after induction of anesthesia and during AQ-L intubation at-

Table 2. Physical Characteristics and Risk Factors for Airway management of All Participants (n = 12,225) and Details of Patients with Airway Management Difficulties (n = 125)

	Patients, n (%) or Mean ± SD
All participants (n = 12,225)	
Planned awake fiberscope-guided nasotracheal intubation	4 -
Surgery	
Abdominal	6,969 (57)
Gynecological	4,768 (39)
Thyroid	488 (4)
Obese patients with BMI > 30 kg/m (n = 789)	
Abdominal surgery	579 (74)
Gynecological surgery	151 (19)
Thyroid surgery	59 (7)
Morbidly obese patients with BMI > 50 kg/m (n = 104)	
Abdominal surgery	88 (85)
Gynecological surgery	15 (14)
Thyroid surgery	1 (1)
Patients showing > 3 difficult airway management factors at the preoperative anesthesia visit (n = 188)	
Abdominal surgery	147 (78)
Gynecologic surgery	35 (18)
Thyroid surgery	6 (4)
Patients with airway management difficulties* (n = 125)	
Gender (M/F) ratio	66/34
Mean age, yr	50 ± 13
Mean body mass index, kg/m	43 ± 14
Mean interincisor distance, mm	33 ± 4
Mean thyromental distance, mm	64 ± 5
Retrognathia	16 (13)
Severely limited jaw protrusion	10 (8)
Obstructive sleep apnea	82 (66)
Mallampati class (n per class)	I/5 - II/32 - III/75 - IV/12
Mean cervical neck circumference, cm	44 ± 5
Cricothyroid membrane access difficulty score† (n per score)	0/32 - 1/82 - 2/10 - 3/2

* A patient with airway management difficulties was arbitrarily defined as facemask ventilation difficulty grade III–IV or failed Macintosh-laryngoscope tracheal intubation, despite gum elastic bougie use. Difficult ventilation grading scale: Grade I, ventilation without the need for an oral airway; grade II, ventilation requiring an oral airway; grade III, difficult and unstable ventilation requiring an oral airway and two providers, or an oral airway and one provider, using mechanical ventilation (pressure-controlled mode); and grade IV, impossible. † Difficulty of cricothyroid membrane access was evaluated by anterior neck palpation using a 4-point score (0 = easy, 1 = moderately difficult, 2 = difficult, 3 = very difficult).

BMI = body mass index.

tempts in another patient. These two patients who benefited from rescue ventilation with the LMA-CT device were intubated using visual guidance through the laryngeal mask.

There were two deviations from the algorithm after failed Macintosh-L intubation. In a case of Macintosh-L failure, the McGrath (SEBAC) was used successfully instead of the AQ-L device. In a patient in whom there was a grade III view of the larynx (Cormack and Lehane), the AQ-L device was used after Macintosh-L direct laryngoscopy without attempting GEB assistance. For all other patients, GEB was used to assist Macintosh laryngoscopy in 236 patients (1.9%), and of these patients, successful tracheal access was achieved in 207 (84%). GEB-assisted Macintosh-L Tracheal intubation was not possible in 29 patients (0.02%). In these patients, AQ-L intubation was then attempted. The AQ-L device allowed successful tracheal intubation under visual guidance in 27 of the 29 remaining patients, with the GEB used as an adjunct to the AQ-L device in 3 of these 27 cases. In one of these patients, ventilation could not be achieved after the first AQ-L intubation attempt, and rescue LMA-CT oxygenation was required followed by tracheal intubation under visual control through the laryngeal mask. The trachea of the patient with AQ-L failure, despite GEB assistance, was intubated under visual control using LMA-CT. He was a tall (1.9 m) morbidly obese man (40 kg/m BMI). Standard insertion and manipulation of AQ-L gave a poor, distant view of laryngeal structures that included a long, floppy epiglottis that could not be lifted.

Episodes of hypoxemia (Spo_2 < 90%) occurred in 87 patients (0.7%); in 17 patients (0.1%), Spo_2 became less than 80%. The features of these 17 patients are presented in table 4. The lowest Spo_2 was 68% and occurred in the patient in whom primary facemask ventilation was not possible. This patient had a bushy beard and had five predictive features of a difficult airway.

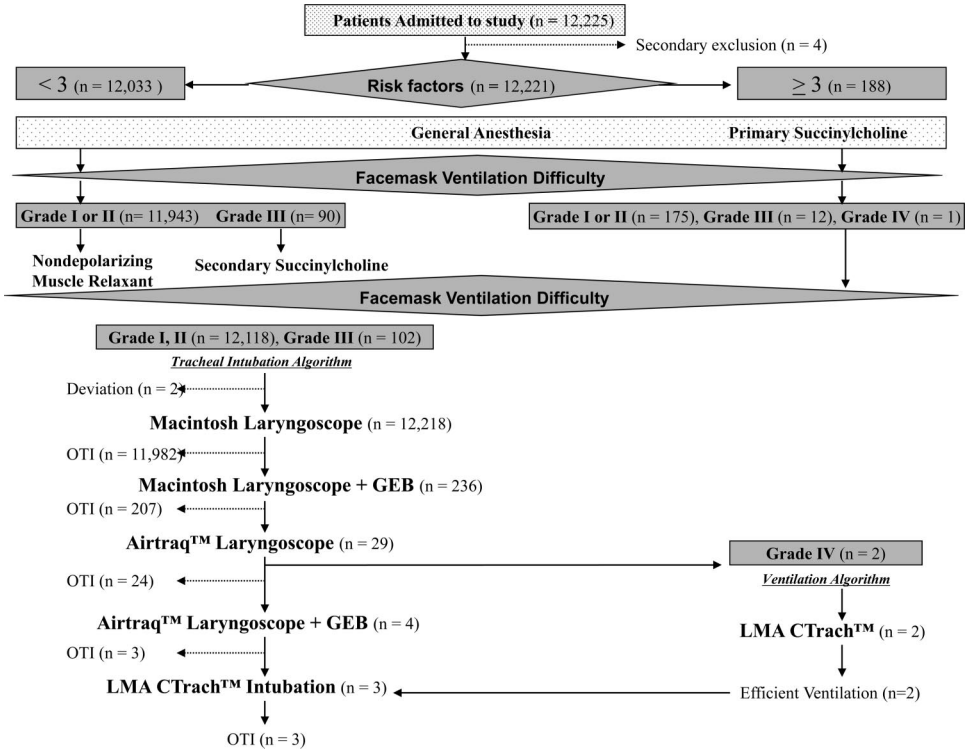

Fig. 2. Outcome of the management of patients, using the new algorithm. GEB = gum elastic bougie; OTI = orotracheal intubation.

No patient suffered aspiration of gastric contents. Trauma to the teeth by the Macintosh-L occurred in two patients.

Discussion

In this prospective study of 12,221 patients given general anesthesia for elective surgery, we have shown that an algorithm incorporating the GEB and two visual systems for tracheal intubation (AQ-L and LMA-CT) allowed tracheal intubation under visual guidance in all patients in whom airway management was difficult.

Limitations of the Study

Our study has three limitations. The first is that the patient population is limited to abdominal, gynecologic, and thyroid surgery. Although many of the patients were morbidly obese, we did not include other patients with potential problems, such as patients with tumors in the upper airway, patients with cervical trauma and immobilization, or obstetric patients. Application of our algorithm to such patients may not be justifiable. However, physicians in our obstetrics unit have also received instruction in the use of new optical airway devices, and we now incorporate use of AQ-L as the second step after failed Macintosh-L tracheal intubation in our algorithm for difficult tracheal intubation during anesthesia for emergency cesarean section.[12] The second limitation is that successful use of the algorithm was based on thorough training and practical experience with these new devices. The physicians involved in this study completed training with AQ-L and LMA-CT and were accustomed to using the devices clinically. Because a short time is needed to acquire proficiency with AQ-L[13] and all participants were already familiar with the intubating laryngeal mask airway, we estimated that proficiency was acquired after 10 successful uses of both devices. On the basis of our study, we cannot recommend the current algorithm for anesthesia providers who are not experienced with both new airway devices. The third weakness is the size of our institution: an environment limited to five operating rooms and a staff of 15 anesthesiologists. In a larger hospital, provision of these airway management devices at all anesthetizing locations and training a larger staff of physicians could be a significant financial and organizational task.

Conception of the Difficult Airway Management Algorithm

We included AQ-L and LMA-CT devices in a previous algorithm for managing unanticipated difficult airways, in the operating room[1] or the prehospital setting,[14] because of their proven efficacy, especially in patients with risk factors.[15] We did not consider GEB as an airway, but rather as a tool to promote or facilitate tracheal access in case of Cormack and Lehane III and IV and when the arytenoids were visible with laryngoscopes (direct or indirect), respectively. Adherence to the algorithm was very good (there were only two deviations), no doubt because of its simplicity, device efficacy, appropriate staff training, and the fact that most participants already had taken part in validation studies on AQ-L and

Table 3. Outcome of Airway Management of All Anesthetized Participants (n = 12,221) and of Patients with Airway Management Difficulties (n = 125)

	Patients, n (%) or Mean ± SD
Anesthetized patients (n = 12,221)	
Primary indication for succinylcholine (> 3 risk factors)	188 (1.5)
Difficult ventilation, grade IV*	2 -
Difficult ventilation, grade III*	102 (0.8)
Secondary indication for succinylcholine (difficult ventilation, grade III* before muscle relaxant administration)	90 (0.7)
Nondepolarizing neuromuscular blockade (72% atracurium; 28% vecuronium)	11,852 (97)
Cormack and Lehane grade III	167 (1.3)
Cormack and Lehane grade IV	3 (0.025)
Failure using Macintosh laryngoscope	236 (2.0)
Failure using Macintosh laryngoscope + GEB	29 (0.2)
Hypoxemia episodes, Spo_2 < 90%	87 (0.7)
Hypoxemia episodes, Spo_2 < 80%	17 (0.1)
GEB use with Macintosh laryngoscope (n = 236)	
GEB success	207 (84)
Airtraq laryngoscope use (n = 29)	
Successful Airtraq laryngoscope plus GEB for viewed tracheal intubation	27 (97)
LMA CTrach™ success for ventilation	2 (100)
LMA CTrach™ success for tracheal intubation under visual control	3 (100)
Patients with airway management difficulties† (n = 125)	
Cormack and Lehane grade for direct laryngoscopy (n per grade)	I/5 - II/27 - III/91 - IV/2
Facemask ventilation difficulty (n per grade)	I/21 - II/37 - III/64 - IV/2
Combined Grade III ventilation difficulty and impossible Macintosh laryngoscope GEB-assisted tracheal intubation	7 (5)
Minimum Spo_2 during airway management, %	91 ± 7

* Difficult ventilation grading scale: Grade I, ventilation without the need for an oral airway; grade II, ventilation requiring an oral airway; grade III, difficult and unstable ventilation requiring an oral airway and two providers, or an oral airway and one provider, using mechanical ventilation (pressure-controlled mode); and grade IV,impossible ventilation. † A patient with airway management difficulties was arbitrarily defined as facemask ventilation difficulty Grade III–IV or failed Macintosh-laryngoscope trachéal intubation despite gum elastic bougie (GEB) use.

BMI = body mass index; Spo_2 = pulse oxygen saturation.

LMA-CT devices.[15–20] We could have chosen another video laryngoscope, such as the GlideScope or the McGrath, to replace AQ-L in the algorithm, and the wide use of these devices is undisputable. However, these devices provide a very different mechanical approach to the larynx, and we cannot predict that the results of the current study would be the same if we had chosen to use them in our algorithm. Moreover, during difficult airway management, the superiority of AQ-L tracheal intubation efficiency in other optical devices and video laryngoscopes has been systematically demonstrated. We confirmed the efficacy of the AQ-L device after Macintosh-L failure for tracheal intubation. However, we encountered one case of AQ-L device failure in a tall morbidly obese patient. Although AQ-L device failure has already been reported,[5] we could not determine the exact reason for failure to intubate on this occasion, despite GEB assistance. The clinician managing the patient considered it possible that the standard size AQ-L blade was too short in this large patient.

The use of a muscle relaxant in the current trial is arguable. We have decided to use succinylcholine in patients with anticipated difficult airway management and patients with grade III and IV difficult mask ventilation before injection of muscle relaxants because this strategy was currently applied during our daily clinical practice. Of interest, this short duration depolarizing muscle relaxant never worsened facemask ventilation quality, but rather improved it in most cases. Indeed, of the 90 patients that received secondary succinylcholine injection, 56 improved by one grade their ventilation quality. Moreover, none of the 11,943 grade I and II difficult mask ventilation patients who were injected with nondepolarizing muscle relaxant altered ventilation quality.

Outcomes of the Airway Management

With the current algorithm, we have successfully managed the airway of many obese patients who could have had difficult intubation or ventilation. Interestingly, only a few of them (2%; 16 of 789) experienced transient Spo_2 episodes less than 80%. These encouraging safety data may result from both the French Society of Anesthesia Clinical Practice Guidelines that advise a 90% end-tidal oxygen concentration before induction of anesthesia, particularly if risk factors for a difficult airway are present, and also from the efficacy of the devices used in the algorithm. Compared with the previous algorithm, which we validated for the management of unanticipated difficult airway,[1] our current trial included many

Table 4. Features of the 17 Patients that Experienced Spo_2 less than 80% during Airway Management

	Patients, n (%) or Mean ± SD
Gender (M/F) ratio	12/5
Mean age, yr	39 ± 14
Mean body mass index, kg/m^2	49 ± 7
Mallampati class (n per class)	II/7 - III/9 - IV/1
Patients with > 3 predictors of difficult airway management	5 (30)
Cormack and Lehane grade for direct laryngoscopy (n per grade)	II/3 - III/13*
Facemask ventilation difficulty (n per grade)†	II/9 - III/6 - IV/2
Moment of occurrence of Spo_2 < 80%	
During facemask ventilation attempts	3 (18)
During failed Macintosh laryngoscope ± GEB intubation attempts	11 (64)
During failed Airtraq laryngoscope ± GEB intubation attempts	3 (18)

* The Cormack and Lehane grade was not evaluated in one patient who was given *LMA CTrach* (SEBAC, Pantin, France) for rescue ventilation. † Difficult ventilation grading scale: Grade I, ventilation without the need for an oral airway; grade II, ventilation requiring an oral airway; grade III, difficult and unstable ventilation requiring an oral airway and two providers, or an oral airway and one provider, using mechanical ventilation (pressure-controlled mode); and grade IV, impossible ventilation.

GEB = gum elastic bougie; Spo_2 = pulse oxygen saturation.

patients with risk factors for a difficult airway. Most of these patients with several risk factors (at least three) would have been excluded from our previous algorithm and would have been managed using a fiberscope. Only a few episodes of hypoxemia (Spo_2 < 80%) episodes were attributed to difficulty with ventilation (table 4). Most of these were in morbidly obese patients during failed Macintosh-L tracheal intubation attempts, as found in our previous algorithm.[1] Because most episodes of hypoxemia are related to difficult Macintosh-L intubation, we believe that previous movement to the second step of the cannot-intubate branch of the current algorithm is advisable. Reducing the duration of attempts with the Macintosh-L could have prevented some episodes of hypoxemia. In our obstetric unit, we have now set a time limit of 2 min for Macintosh-L attempts at tracheal intubation before using AQ-L.

Difficulty with mask ventilation (grades III and IV) (0.8%) had an incidence similar to that reported in a recent review.[11] Grade III difficulty in obese patients occurred in 6% of patients who had at least three or more risk factors. This contrasts with a rate of 0.3% grade III ventilation difficulty encountered in patients with fewer than three features. Clearly, our set of predictors for difficult airway management aids detection of patients with difficult airways. Seven of our 29 GEB-assisted Macintosh-L intubation failures had grade III mask ventilation difficulty, strengthening the association between difficult ventilation and difficult intubation.

A majority of our cases with difficult airways were morbidly obese men more than 50 yr of age. Sleep apnea syndrome, large neck, and high Mallampati grades III and IV were the most frequent features associated with both difficult ventilation and tracheal intubation with the Macintosh-L. We encountered only one primary instance of cannot-ventilate in a 68-yr-old morbidly obese patient with many adverse factors and with a bushy beard hampering cricothyroid membrane palpation. This patient's arterial oxygenation was restored promptly with LMA-CT. During the study period, we used LMA-CT (two with size 4 and one with size 5) in three patients to effectively restore or establish an open airway. This efficacy has already been recorded.[21,22] If LMA-CT failed to improve oxygenation in this cannot-ventilate scenario we encountered, further management would have been extremely difficult because identification of the trachea surface landmarks was impossible. In this particular case, an attempt at direct laryngoscopy could have been lifesaving. Although not recommended by the French Society of Anesthesia, deviation from the algorithm might have been appropriate here. After our experience with this patient, all morbidly obese patients with a beard are asked to remove it before surgery. Those who have three or more risk factors and refuse to shave are managed with awake nasotracheal intubation. This policy is now systematically applied in case the surgery may require deep neuromuscular blockade.

Over the 2 yr of the study, only four patients had to be excluded from this management algorithm. An important reason is that head and neck cancer surgery is not undertaken in our hospital, although we did include patients with a history of treated pharyngeal or laryngeal tumor. The four exceptions had awake fiberscope-guided nasotracheal intubation performed by two specialized senior anesthesiologists. Before the advent of the new airway devices with a viewing system, we carried out 10–15 fiberscope-guided intubations per year, mostly in super obese patients. This technical advance has clearly changed our practice in airway management in morbidly obese patients and reduced the indications for fiberscope-guided intubation.

Conclusion

In conclusion, we used an algorithm for airway management that incorporates GEB, LMA-CT, and AQ-L devices in a large cohort of anesthetized, paralyzed patients. Successful tracheal intubation under visual control was achieved in all patients with difficult airways.

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