Can J Anesth/J Can Anesth (2010) 57:1014–1020
DOI 10.1007/s12630-010-9378-1

REVIEW ARTICLE/BRIEF REVIEW

Brief review: Airway rescue with insertion of laryngeal mask airway devices with patients in the prone position

Article de synthèse court: Sauvetage des voies aériennes en insérant un masque laryngé chez le patient en procubitus

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Received: 19 January 2010 / Accepted: 13 August 2010 / Published online: 2 September 2010

Abstract

Purpose *Unintentional extubation of the trachea while the anesthetized patient is in the prone position is a potentially life-threatening situation that is usually managed by turning the patient supine for emergent re-intubation. However, this approach may delay definitive airway management and lead to irreversible complications. This review evaluates the efficacy of insertion of a laryngeal mask airway device (LMAD) with the patient in the prone position as a rescue method in airway management for unintentional tracheal extubation.*

Principal findings *We searched MEDLINE and EMBASE databases in the English language for the period 1980 to October 2009 in order to identify observational studies and case reports describing insertion of the LMAD with the patient in the prone position. We found 12 such articles (n = 526 patients) consisting of four retrospective studies, one prospective cohort with a control group, one non-controlled prospective study, and six case reports. On the first attempt, the LMAD was inserted successfully in 87.5-100% of the patients involved in the included reports. On the second attempt, the LMAD was inserted successfully in all patients, with or without laryngoscopy. Ventilation was maintained successfully in the lungs of 83.3-100% of the patients involved in the reported articles. Following insertion of the LMAD with patients in the prone position, the most common complications reported were sore throat, bleeding, bradycardia, and laryngospasm.*

Conclusions *Cumulative experience from published reports suggests the feasibility of placing the LMAD with the patient in the prone position in the elective setting; however, the evidence is lacking regarding the use of this method for emergency management of unintended tracheal extubation with the patient in the prone position.*

Résumé

Objectif *L'extubation involontaire de la trachée alors que le patient est en procubitus est une situation potentiellement fatale qu'on corrige en général en couchant le patient afin de réaliser une réintubation urgente. Cette approche pourrait cependant retarder la prise en charge des voies aériennes définitive et entraîner des complications irréversibles. Cet article de synthèse évalue l'efficacité de l'insertion d'un masque laryngé (LMAD) chez un patient en procubitus en tant que méthode de sauvetage pour la prise en charge des voies aériennes lors d'une extubation trachéale involontaire.*

Constatations principales *Nous avons passé en revue les bases de données MEDLINE et EMBASE en anglais pour la période allant de 1980 à octobre 2009 afin de retrouver les études observationnelles et les présentations de cas décrivant l'insertion d'un LMAD chez des patients en procubitus. Nous avons récupéré 12 articles (n = 526 patients), soit quatre études rétrospectives, une étude prospective de cohorte avec groupe témoin, une étude prospective sans groupe témoin et six présentations de cas. L'insertion du LMAD a réussi au premier essai dans 87,5-100 % des patients décrits dans les présentations de cas examinées. L'insertion du LMAD a réussi à la deuxième tentative dans tous les patients, avec ou sans laryngoscopie. La ventilation a été bien maintenue dans les poumons de 83,3-100 % des patients recrutés dans les articles rapportés. À la suite d'une insertion du LMAD*

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chez les patients en procubitus, les complications les plus fréquemment rapportées étaient les maux de gorge, les saignements, la bradycardie et le laryngospasme.

Conclusion *L'expérience cumulée des articles publiés laisse à penser qu'il est faisable d'insérer un LMAD chez un patient en procubitus dans un cadre non urgent; toutefois, nous manquons de données probantes quant à l'utilisation de cette méthode pour la prise en charge d'urgence d'une extubation trachéale involontaire lorsque le patient est en procubitus.*

Prone positioning of patients is required for various surgical procedures, such as spinal surgery, pilonidal sinus excision, and repair of Achilles tendon.[1,2] Prone positioning may pose considerable challenges to the anesthesiologist because the airway is relatively inaccessible while the patient is lying prone. Unintentional extubation of the trachea while the patient is in the prone position is a potentially life-threatening situation that is usually managed by turning the patient supine for emergent tracheal re-intubation. However, this method has several potential limitations.[3] First, it is time-consuming and may delay emergency airway management. Second, it requires additional personnel who may not be immediately available in the operating room at the time of tracheal extubation. Furthermore, depending on the type of surgery, this approach may lead to possible additional postoperative complications.

Several laryngeal mask airway devices (LMAD) have been used for elective surgical procedures with the patient in the prone position. Prior to turning the patient prone, the LMAD is usually inserted following induction of anesthesia with the patient supine,[4,5] or when the patient is already in the prone position, as described in several case reports.[1,6] It has been suggested that insertion of a LMAD with the patient prone may be as easy as insertion in the supine position. In the prone position, the tongue falls anteriorly by gravity and creates an open space for LMAD insertion.[3,7,8]

We undertook a literature review to determine the cumulative clinical experience of LMAD insertion with patients in the prone position as a form of rescue airway management in patients whose tracheas were unintentionally extubated during the course of general anesthesia. In cases of unintentional extubation with the patient in the prone position, we specifically sought to assess the feasibility of LMAD insertion and to document complications related to this method of rescue airway management. In this regard, we first considered the existing evidence of LMAD use in the emergency situation with the patient in the prone position. We also considered the evidence from elective airway management with patients lying prone as a framework from which to assess the cumulative experience from supraglottic airway management in the emergency setting for anesthetized patients in the prone position.

Literature search strategy

We searched The Cochrane Library (Issue 4, 2009), MEDLINE (1980 to October 2009), EMBASE (1980 to October 2009), and Science Citation Index Expanded (1980 to October 2009) by using the following keywords: "laryngeal mask airway", "LMA", and "prone". We hand searched the online format of the meeting abstracts presented by the American Society of Anesthesiologists (ASA), Canadian Anesthesiologists' Society (CAS), and European Society of Anesthesiologists (ESA) from 1990 to 2009. We also undertook a hand search of reference lists from retrieved articles to identify further articles.

We considered all types of study, including controlled or non-controlled clinical trials, retrospective chart reviews, case series, and case reports in which an LMAD was inserted with the patient in the prone position for either rescue or routine airway management. Rescue LMAD insertion was defined as placement of the LMAD with the patient in the prone position following unintentional extubation. As outcomes we considered "*successful placement of the LMAD*", defined as insertion of an LMAD without any failure (e.g., failed passage into pharynx, malpositioning, ineffective ventilation), and *"successful maintenance of ventilation"*, defined as uneventful ventilation with end-tidal carbon dioxide ($ETCO_2$) < 45 mmHg. Also, any reported complications following LMAD insertion were extracted.

The search identified 140 citations, 128 of which were excluded as being not relevant or ineligible for inclusion. A total of 12 articles ($n = 526$ patients) were deemed eligible for inclusion in this review. There were four retrospective studies, one prospective cohort with a control group,[2] one non-controlled prospective study,[1] and six case reports (Table 1). After excluding those patients in the control groups, the LMAD was inserted into the pharynges of 466 patients in the prone position. Of these, 463 patients were cases of elective airway management and three cases involved patients with unintentional extubation requiring LMAD insertion in an emergency situation. Patients in the majority of studies were undergoing orthopedic or minor surgeries in the prone position (Table 1).

The studies by Weksler *et al*. and Osborn *et al*. are the only studies with a control group.[2,8] Weksler *et al.* reported a prospective study comparing insertion of the LMAD with patients in the prone position ($n = 25$) with insertion of the LMAD with patients in the supine position ($n = 25$).[2]

Table 1 Observational studies and case reports on insertion of LMADs with patients in the prone position

Study ID	Ref #	Article type	Sample size	Age (range)	Sex	ASA	Airway management	Surgery type	Ventilation	LMA® type	LMA® size	Successful Insertion (rate)	Successful Ventilation (rate)
Stevens 2008	12	Retrospective	103	–	–	–	Elective	Prone surgical procedures	PPV	Classic™ LMA	–	94.2 %† 100 %‡	99.1 %
Brimacombe 2007	6	Retrospective	245	42 (17-88)	M:129 F:116	I:171 II:74	Elective	Orthopedic Pilonidal cyst Skin lesions Varicose veins Liposuction	PPV	Pro Seal ™	–	96.7 %† 100 %‡	100 %
Weksler 2007§	2	Prospective cohort	50 (25)*	36 (18-68)	M:19 F:31	I, II	Elective	Proctologic Vascular Plastic Orthopedic	PPV	Classic™ LMA	3,4	100 %	100%
Ng 2002	1	Prospective	73	—	M:59 F:14	I:53 II:20	Elective	Orthopedic Pilonidal cyst	SB	Classic™ LMA	–	94.6%† 100 %‡	97.3%
Osborn 2002‖	8	Retrospective case-control	41 (6)*	70 (?)	M:5 F:1	II,III	Elective	ERCP	SB	Classic™ LMA	–	100%	83.3%
McCaughey 1993	9	Retrospective	8	—	—	—	Elective	Pilonidal cysts	SB	Classic™ LMA	–	87.5%† 100%‡	100%
Raphael 2004	3	Case report	1	12	F	–	Rescue	Spine	PPV	Classic™ LMA	–	✔	✔
Agrawal 2007	11	Case report	1	25	F	–	Elective	Skin graft (back)	PPV	ILMA™	4	✔	✔
Brimacombe 2005	10	Case report	1	58	M	–	Rescue	Spine	PPV	Pro Seal™	3	✔	✔
Dingeman 2005	13	Case report	1	5	F	–	Rescue	Decompressive craniotomy	PPV	Classic™ LMA	3	✔	✔
Valero 2004	20	Case report	1	19	M	–	Elective	Penetrating trauma to neck	PPV	Classic™ LMA	4	✔	✔
Milligan 1994	19	Case report	1	10	M	–	Elective	Dislocated lens	SB	Classic™ LMA	–	✔	✔

M = male, F = female, ASA = American Society of Anesthesiologist classification; ERCP = endoscopic retrograde cholangiopancreatography; PPV = positive pressure ventilation; SB = spontaneous breathing; LMADs = laryngeal mask airway devices; LMA = laryngeal mask airway; ETT = endotracheal intubation; ILMA = intubating LMA. †First insertion attempt, ‡ Second insertion attempt, §This study compares insertion of LMA with patients in the prone position *vs* insertion of LMADs with patients in the supine position. ‖This study compares insertion of LMA with patients in the prone position *vs* insertion of LMA with patients in the supine position and endotracheal intubation. *Numbers in brackets indicate number of the patients in whom the LMA was inserted in the prone position

Osborn *et al.* reported a retrospective cohort study evaluating the feasibility of using the LMAD during endoscopic retrograde cholangiopancreatography (ERCP) in 41 patients.[8] Four comparison groups were included in the study: LMAD prone insertion, LMAD supine insertion, endotracheal intubation, or monitored anesthesia care. None of the above-mentioned controlled studies was a randomized controlled trial.

Laryngeal mask airway device insertion with patients in the prone position - elective airway management

The method of LMAD insertion with the patient in the prone position was described initially by McCaughey *et al.*[9] in 1993. Later on, this method was adopted and developed further by other authors. With this method, patients were asked to position themselves prone with chest and legs resting on pillows[1] in such a manner as to reduce intra-abdominal pressure.[1] The patient's head was placed on a head ring and inclined to either the right or the left side. In the study by Brimacombe *et al*., the operating table was tilted laterally by 15° to enable further access to the patient's face during LMAD insertion.[6]

After securing venous access, the patient was preoxygenated with 100% oxygen for three minutes[8] or until the end-tidal oxygen was $> 90\%$.[6] This procedure was followed by induction of anesthesia using intravenous fentanyl and propofol. Ng *et al*. and Brimacombe *et al*. reported that they performed manual ventilation, which was easily performed through the face mask following loss of consciousness and prior to LMAD insertion.[1,6] Weksler *et al*. used a standard dose of rocuronium 0.6 $mg \cdot kg^{-1}$ to facilitate the introduction of the LMAD and mechanical ventilation throughout the surgery.[2] However, it was not mentioned whether patients received manual ventilation prior to LMAD insertion.

After loss of consciousness, the head ring was removed and the LMAD was inserted with the patient in the prone position with two staff involved in the procedure. The patient's head was extended and turned slightly to the side by the anesthesiologist placing his/her hand on the patient's forehead. The LMA® Classic™ was used in nine studies (Table 1); the ProSeal™ LMA was used in two studies,[6,10] and only one study used intubating LMA.[11] The size of the LMAD was reported in only six papers and ranged in size from 3 to 5 (Table 1).

Ng *et al.* reported that the LMA® was inserted by the anesthesiologist while the assistant opened the patient's mouth by holding the tip of the patient's chin.[1] Stevens *et al*. used a slightly different method of LMA® insertion, i.e., the anesthesiologist used his/her non-dominant hand to open the patient's jaw and placed the LMA® with the dominant hand with the assistant extending and turning the patient's head to the side.[12] Osborn *et al*. adopted the thumb insertion technique to place the LMA® with the patient in the prone position. In this technique, the proximal end of the deflated LMA® is pushed across the palate with the thumb and then pushed downward in an arching motion into the pharynx.[8]

In the study by Brimacombe *et al*., 3.3% (8/245) of patients required a second attempt with laryngoscope-guided insertion while in the prone position.[6] This attempt involved 1) obtaining the best view of the oropharynx with a Macintosh laryngoscope blade; 2) inserting a gum elastic bougie—straight end first—through the hypopharynx into the proximal 5 cm of the esophagus; and 3) guiding the ProSeal™ LMA along its drain tube into the pharynx.

After LMAD insertion, maintenance of ventilation was achieved by either spontaneous breathing or controlled ventilation (Table 1). The position of the patients at removal of the LMAD was not specified clearly among the majority of the papers. In the study by Brimacombe *et al*., patients were rotated back onto the bed at the end of surgery and then the anesthesia was discontinued.[6] The LMAD was removed in the postanesthesia care unit. Stevens *et al*. ($n = 103$ patients) reported the removal of the LMAD while the patient was still in the prone position.[12]

Laryngeal mask airway device insertion with patients in the prone position -for rescue in airway management

In three case reports, the LMAD was inserted with the patient in the prone position following unintentional tracheal extubation (Table 1). Raphael *et al.* reported unintentional extubation in a 12-yr-old female patient once a wake-up test was performed during a posterior spine fusion surgery.[3] Dingeman *et al.* reported displacement of the nasotracheal tube in a five-year-old girl undergoing decompressive craniotomy while in the prone position.[13] Brimacombe *et al.* reported difficult ventilation in an obese 58-yr-old male during surgery. The difficulty was due to displacement of the endotracheal tube.[10]

For the airway management in these cases, Raphael *et al*. and Dingeman *et al*. used the LMA Classic™, but Brimacombe *et al*. used the ProSeal™ LMA. In all cases, the LMAD was inserted successfully as a rescue airway management while preparations were being made to return the patient to the supine position for re-intubation. After the LMAD insertion, the patients were maintained in the prone position with their lungs mechanically ventilated for the remainder of the operation.

Clinical outcomes

On the first attempt, the LMAD was inserted successfully in 87.5-100% of the patients involved in the included studies. The overall success rate was 96% (447/466). On the second attempt, the LMAD was inserted in all patients, with or without a laryngoscope (Table 1). Malpositioning of the LMAD, which was reported in three studies, was the most common reason for failed insertion.[1,6,9] This difficulty was resolved successfully by repositioning[1,9] or re-inserting the LMAD using a laryngoscope.[6] The LMAD was inserted successfully in all the patients reported in the case reports, either as an elective or as rescue airway management (Table 1).

Ventilation was maintained successfully in the lungs of 83.3-100% of the patients involved in the included studies. The overall success rate was 98.7% (460/466). In the study by Ng *et al.* ($n = 73$ patients), the average SpO_2 was 97 ± 1% at induction and remained the same after LMAD insertion.[1] Stevens *et al.* reported that the average intra-operative SpO_2 was 98.9% (94-100%).[12] Impaired ventilation or hypoventilation was reported in four cases (0.9-16.6% of total patients in each study). These cases were managed successfully by either manual ventilation through the LMAD[1] or re-insertion of the LMAD with the patient in the supine[12] or the prone position[8] (Table 1).

A sore throat, reported in two studies, was the most common complication related to LMAD insertion with patients in the prone position (Table 2). Ng *et al.* reported six patients (8.2%) with sore throat, which was resolved by postoperative oral fluid.[1] Weksler *et al.* showed that the rate of sore throat was significantly ($P = 0.009$) less following LMAD insertion with patients in the prone position (20%) *vs* the supine position (56%).[2] Bleeding was the second most common complication reported.[1,2,6] Ng *et al.* noted that some blood appeared in the mouth and nostrils in two of 73 patients (2.7%).[1] The problem was easily managed by suction. In four of 245 patients (1.6%), Brimacombe *et al.* reported visible blood on the surface of the ProSeal™ LMA at removal.[6] Weksler *et al.* found that the incidence of bloody saliva did not differ significantly between the patients with LMAD insertion in the prone position *vs* the supine position (prone, 60% *vs* supine, 44%; $P = 0.198$).[2]

Bradycardia was another common complication reported, with a frequency of 6.8% reported by Ng *et al.* and 0.9% reported by Stevens *et al.*[1,12] Other less common complications included laryngospasm and partial airway obstruction (Table 2). Weksler *et al.* showed that LMAD insertion with patients in the prone position *vs* the supine position resulted in more favourable hemodynamic parameters.[2] In their study, the mean delta systolic blood pressure was 21 ± 8 mmHg (range 10-37) in the prone group *vs* 34 ± 13 mmHg (range 17-67) in the supine group ($P < 0.001$). The mean change in diastolic blood pressure was 12 ± 5 mmHg (range 5-21) in the prone group *vs* 24 ± 7 mmHg (range 8-36) in the supine group ($P < 0.001$). The variation in the heart rate was 15 ± 6 mmHg (range 5-30) in the prone group *vs* 24 ± 11 mmHg (range 8-36) in the supine group ($P < 0.001$).

Translation of cumulative experience of elective cases into emergent situations

Unintentional extubation of a patient's endotracheal tube while placed in the prone position is a potentially life-threatening situation. Insertion of the LMAD with the patient in the prone position can be considered an alternative rescue management technique due to the benefit of not having to turn the patient back to the supine position. This review identified 12 articles, including several prospective cohort and retrospective studies as well as case reports. It is impressive to learn that "experienced hands" placing the LMAD with the patient in the prone position achieved a success rate of 87.5-100% on first attempt and achieved a 100% success rate by the second attempt. However, we caution that these findings are limited to observations from case reports and observational studies.

Table 2 Complications related to insertion of laryngeal mask airway devices with patients in the prone position

Complications	Rate %	Resolution method	Studies
LMAD malpositioning	0.4-12.5%	LMAD repositioning	Ng 2002, Brimacombe 2007, McCaughey 1993
Hypoventilation or O_2 desaturation	0.9-16.6%	Replacement of LMAD or manual ventilation	Osborn 2002, Ng 2002, Stevens 2008
Laryngospasm	1.3%	More propofol	Ng 2002
Partial obstruction of the airway	1.2%	Adjusting the position of the head/neck	Brimacombe 2007
Bleeding	1.6-2.7%	Suction	Brimacombe 2007, Ng 2002
Bradycardia	0.9-6.8%	Atropine	Stevens 2008, Ng 2002
Sore throat	8.2-20%	Postoperative oral fluid	Ng 2002, Weksler 2007

LMAD = laryngeal mask airway device

Also, the majority of the available evidence comes from studies that were not conducted in emergency situations. These findings suggest the feasibility of placing the LMAD with patients in the prone position in the elective setting; however, evidence is lacking regarding use of this rescue method for emergency management of unintended tracheal extubation with patients in the prone position.

After unintentional extubation, there are several possible options to emergently place an airway device in the tracheas of prone patients. First, the patient can be turned to the supine position and the trachea re-intubated. This approach may interfere with the surgical field and lead to subsequent potential infectious or irreversible neurological complications, especially in the case of neurosurgical or spine procedures. Second, re-intubation could be performed with the patient in the lateral decubitus position, which is intuitively faster to accomplish than repositioning the patient supine. However, a study on mannequins showed that tracheal intubation using direct laryngoscopy in the lateral decubitus position could be more difficult, probably because the anatomy of the airway is distorted and most anesthesiologists are unfamiliar with the technique.[14]

Alternatively, fibreoptic tracheal intubation with the patient in the prone position is another option to emergently secure the airway in a patient whose trachea is unintentionally extubated. This approach was adopted by Hung *et al*. in a patient in the prone position with her neck flexed by a head pin holder during a neurosurgical procedure.[15] Also, Kramer *et al*. reported the same technique in a patient with cervical spine surgery.[16] In both cases, the fibreoptic technique was preferred because insertion of the LMAD was not feasible, either due to an edematous upper airway caused by the neck flexion[15] or dental instability of the patient.[16]

However, fibreoptic intubation with patients in the prone position has its own limitations. First, the procedure requires space and open access to the head and neck to perform the procedure. The procedure might seem possible in patients lying on the Jackson table with the Mayfield apparatus but not necessarily possible with other types of operating tables,[15] or the procedure might require reverse Trendelenburg positioning of the table and, thus, take too much time to perform.[16] Second, fibreoptic bronchoscopes may not always be available in the operating room at the time of the emergency. Finally, the technique requires extensive training and likely would be more difficult to perform in the prone position in an emergency situation than in an elective procedure.

Laryngeal mask airway device insertion with patients in the prone position is an alternative approach. The LMAD is a major advance in airway management and has been included in the algorithm for the management of the difficult airway.[17] Advantages of LMAD insertion with the patient in the prone position include the following: 1) The jaw and tongue fall anteriorly due to gravity and create a natural opening of the posterior oropharyngeal space, which facilitates LMAD insertion as well as manual ventilation of the lungs[1]; thus, maintenance of the airway and insertion of the LMAD are straightforward. 2) Prone positioning leads to a physiologic increase in functional residual capacity and alterations in the distribution of both ventilation and perfusion throughout the lungs. This may lead to improved ventilation/perfusion matching and, consequently, improved oxygenation in the surgical patient.[18] These advantages could explain the high rate of successful insertion and maintenance of ventilation shown in the included studies and case reports in this review.

Experts considered placement of the LMAD with the patient in the prone position as easy as placement in the supine position,[12] but additional skills are required. Furthermore, the able assistance of another operating room nurse or anesthesia assistant is required to open the patient's mouth. Ng *et al.* suggested that this technique can be easily learned and practised with approximately ten supervised cases.[1] In two studies on elective cases, it was mentioned that another trolley was available to turn the patient supine if LMAD insertion failed.[1,6] In the setting of emergency airway management, it is essential to have alternative options prepared simultaneously. The following major problems have been reported with LMAD insertion with patients prone: a) difficulty in advancing the LMAD into the pharynx; b) malpositioning of the LMA®; c) airway obstruction during insertion; and d) difficulty in ventilation with the LMA®. In these situations, the following solutions should be considered: 1) re-adjustment of the LMAD; 2) adjustment of the position of the patient's head and neck; and 3) re-insertion of the LMAD, with or without laryngoscope guidance. An important finding of this review was that the second attempt of the LMAD insertion was successful in all cases, regardless of whether a laryngoscope was used as a guide.

One of the criticisms against the use of an LMAD in these situations is that the LMAD may not be suitable to maintain anesthesia and ventilation with patients in the prone position due to the possibility of LMAD dislodgment. Subsequent regurgitation may occur following positive pressure ventilation.[6,7] However, it has been suggested the LMAD remains secure with patients in the prone position because the proximal end of the LMAD and the connector are supported by the operating table.[1] In addition, aspiration may be less likely with patients in the prone position as gravity should draw any regurgitated fluid away from the lungs.

The findings of this narrative review should be interpreted in light of the following limitations. All studies were conducted in the elective setting. There are valid reasons to

surmise that the elective and the emergency situations (the three case reports) are different, especially with regard to head positioning and conduct of anesthesia. Therefore, extrapolating these cumulative experiences from the elective to the emergent situation could be misleading. It is important to consider that emergent insertion of the LMADs with the patient prone should be performed only by those who are experienced with this technique in the elective setting. The somewhat limited experience reported regarding LMAD insertion with patients in the prone position is from observational studies and case reports. There are only two reports of clinical studies with control groups, but they were not randomized trials. By design, it is virtually unfeasible to conduct randomized clinical trials for emergency airway management; however, such trials can be planned for elective cases. The strength of currently available evidence is minimal, limiting the recommendations that can be made.

In conclusion, this review suggests that LMAD insertion with patients in the prone position may be considered as a feasible alternative approach for airway management in the elective setting. This recommendation, however, is based on observational and uncontrolled studies. The evidence is lacking with regard to the feasibility of using this technique in emergency situations, i.e., as a rescue airway device following accidental tracheal extubation with the patient in the prone position. Further clinical evaluation is warranted.

Funding disclosure Funding from the Department of Anesthesia, Toronto Western Hospital, University of Toronto. None of the authors has any competing interests in this review; this would include financial interests related to patents and/or share holdings in corporations involved in the development and/or marketing of the medical devices that were evaluated in the review.

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