Managing and securing the bleeding upper airway: a narrative review

La prise en charge et la protection des voies aériennes supérieures lors de saignements: un compte rendu narratif

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Abstract *Failure to manage bleeding in the airway is an important cause of airway-related death. The purpose of this narrative review is to identify techniques and strategies that can be employed when severe bleeding in the upper airway may render traditional airway management (e.g., facemask ventilation, intubation via direct/video laryngoscopy, flexible bronchoscopy) impossible because of impeded vision. An extensive literature search was conducted of bibliographic databases, guidelines, and textbooks using search terms related to airway management and bleeding. We identified techniques that establish a definitive airway, even in cases of impeded visibility resulting from severe bleeding in the airway. These include flexible video-/optical- scope-guided intubation via a supraglottic airway device; cricothyroidotomy or tracheotomy; and retrograde-, blind nasal-, oral-digital-, light-, and ultrasound-guided intubation. We provide a structured approach to managing bleeding in the airway that accounts for the source of bleeding and the estimated risk of failure to intubate using direct laryngoscopy or to achieve a front-of-neck access for surgical airway rescue. In situations where these techniques are predicted to be successful, the recommended approach is to identify the cricothyroid membrane (in preparation for rescue cricothyroidotomy), followed by rapid sequence induction. In situations where traditional management of the airway is likely to fail, we* recommend an awake approach with one of the aforementioned techniques.

Résumé *L'échec de la prise en charge des voies aériennes lors de saignements constitue une cause importante de décès lié aux voies aériennes. L'objectif de ce compte rendu narratif était d'identifier les techniques et stratégies qui peuvent être utilisées lorsque des saignements importants localisés dans les voies aériennes supérieures qui rendent la prise en charge des voies aériennes (par ex., ventilation au masque, intubation par laryngoscopie directe ou vidéolaryngoscopie, bronchoscopie) impossible en raison d'une vision obstruée. Une recherche approfondie de la littérature a été effectuée dans les bases de données bibliographiques, les guides d'exercice et les manuels à l'aide de termes de recherche liés à la prise en charge des voies aériennes et au saignement. Nous avons identifié des techniques permettant d'établir des voies aériennes de façon définitive et ce, même en cas de vision obstruée causée par un saignement important dans les voies aériennes. Ces techniques comprennent une intubation guidée par vidéo / optique via un dispositif supraglottique; une cricothyroïdotomie ou une trachéotomie; et une intubation rétrograde, nasale en aveugle, orale digitale, échoguidée ou guidée par luminosité. Nous proposons une approche structurée à la prise en charge des voies aériennes lors de saignements qui tient compte de la source du saignement et du risque estimé d'un échec d'intubation par laryngoscopie directe ou pour obtenir un accès via le cou antérieur pour un sauvetage chirurgical des voies aériennes. Dans les situations dans lesquelles on prévoit la réussite de ces techniques, l'approche recommandée est l'identification de la membrane cricothyroïdienne (en préparation d'une cricothyroïdotomie de sauvetage), suivie d'une induction en séquence rapide. Dans les situations dans lesquelles une*

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prise en charge traditionnelle des voies aériennes va probablement échouer, nous recommandons de tenter une approche éveillée avec une des techniques susmentionnées.

Bleeding in the upper airway is potentially catastrophic, and is an important cause of airway-related death[1] even in young and otherwise healthy individuals.[2] The estimated lifetime incidence of epistaxis is approximately 60%[3]; post-tonsillectomy hemorrhage occurs in 6–15% of tonsillectomy cases[4] and bleeding following surgery for malignancy in the upper airway is one of the leading reasons for an emergency surgical airway.[5] Management of such patients may be extremely challenging because cornerstone techniques commonly employed to secure the airway, such as direct/video laryngoscopy[6–8] and flexible video/fibreoptic laryngoscopy,[9] may be ineffective because the hypopharynx—and the equipment—get soiled with blood. Supraglottic airway devices (laryngeal mask type airways) may be employed but are typically of limited efficacy because of the increased risk of aspiration and their potential interference with surgical access to the bleeding site in the hypopharynx, glottis, or trachea. Effective preoxygenation/denitrogenation may not be possible because of poor tolerance to, or function of, a facemask,[10] or high flow nasal oxygenation cannula.[11,12] The clinician is thus forced to use other techniques and modify the approach to airway management especially if the pre-induction airway examination reveals that direct laryngoscopy (DL) and/or rescue cricothyroidotomy are likely to fail. We have been faced with managing the difficult bleeding airway on numerous occasions, but have so far not come across a comprehensive review of the options for safe management of these cases. Hence, we have attempted to fill the gap with this narrative review.

Methods

This narrative review is based on the following sources for the management of the bleeding upper airway: a search of the literature databases including PubMed, Embase, Scopus, CINAHL, Cochrane Central Register of controlled trials, and Cochrane database of systematic reviews, using search terms combining *airway*, *airway management*, *bleeding, and hemorrhage,* and guidelines for management of the difficult airway[13–16] and relevant textbooks.[17–23] Additionally, references cited in the retrieved literature were scrutinized for relevance. The titles/abstracts were evaluated and the full text retrieved from relevant articles (Fig. 1). All searches were limited to

humans and only references from peer-reviewed journals were included in the database search. The literature search concluded February 2019.

Results

The literature search (Fig. 1) retrieved 97 references (15 case series, 23 cases, nine prospective observational studies, eight randomized studies, three controlled non-randomized studies, three systematic and 11 non-systematic reviews, 13 text books/book chapters, four editorials, four guidelines, two letters, one technical paper, and one webpage) that were included in this narrative review.

Etiology and characteristics of a bleeding airway

Airway bleeding is an actual or potential emergency, depending on the site and severity of the bleeding and the physiological compromise of the patient; these factors will influence the subsequent medical management. Airway assessment is focused on how to safely secure the airway and control (or stop) the bleeding. An emphasis on oxygenation, organization of personnel, and preparation of the equipment and environment, as stressed in airway guidelines, is essential. The potential causes of bleeding in the upper airway are summarized in Table 1 and the characteristics that make management so challenging are listed in Table 2.

Initial management

Key points include limiting the bleeding[24]; giving oxygen[10]; initiating fluid/blood resuscitation[25]; and correcting any underlying coagulopathy.[26] It is wise to assume that the amount of blood visible externally represents only a fraction of what may be encountered on initiation of airway management. Simple measures are crucial—including reassurance of the patient and maintenance of an upright posture.

Limiting the bleeding

If possible, it is always preferable to reduce or stop the bleeding before securing the airway. This may make subsequent airway management easier or even unnecessary. In post-tonsillectomy/adenoidectomy[24] or other oral/pharyngeal bleeding scenarios, trans-oral compression of the bleeding vessel can be performed with a clamped swab or an index finger. Timely embolization of the sublingual artery to treat bleeding associated with dental surgery has been described[27] and
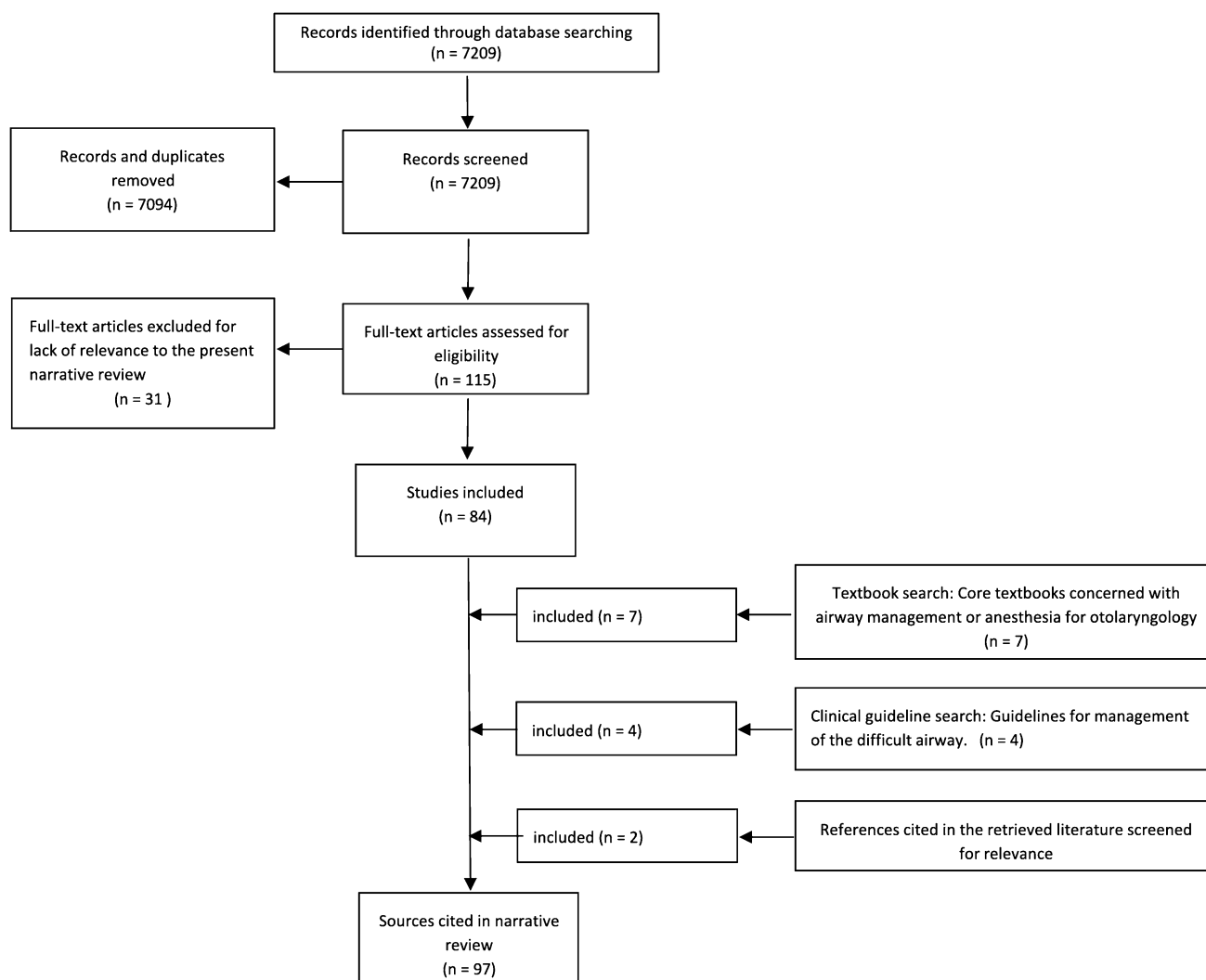
Fig. 1 Flow diagram showing the sources that were searched for literature about the management of bleeding in the upper airway

Table 1 Etiology of upper airway bleeding that can make airway management challenging

Condition	Examples
Spontaneous/idiopathic	Nasal bleeding[70]
Bleeding tumour/malignancy[5]/vascular malformation[71]	Oral, nasal, pharyngeal, laryngeal locations
Coagulopathy,[26,72] anticoagulation treatment or thrombolytic therapy[73]	Pharyngeal bleeding following thrombolytic therapy[73]
Trauma to the face or neck[10,44]	Maxillofacial, neck, and laryngeal injury[10]
Post-surgery[5,24,74]	E.g., post-tonsillectomy, post cancer surgery,[5] and following dental implant insertion[74]
Iatrogenic—often due to airway management	Oral[75] or nasal[76] intubation, application of facemask (facial trauma)[77]
Cocaine abuse	Nasal or alveolar bleeding[78]

epistaxis can be treated with intranasal packs.[28] Soaking the swab with a topical haemostatic agent, such as epinephrine or thrombin may help control bleeding. Anti-fibrinolytics, such as tranexamic acid,[29] should also be considered and, in addition to intravenous injection, may be administered via nebulization[30] or applied directly with

Table 2 Summary of challenges posed by upper airway bleeding

Reason	Comment
All techniques used to manage these scenarios are likely to be difficult and may fail	Effective multidisciplinary strategy planning involving mobilization of available resources[79] and experienced staff is essential.
Altered functionality of airway management devices	Video laryngoscopes[6–8] and flexible optical-/video-scopes ("fibrescopes")[9] may be ineffective in the bleeding airway, even in experienced hands.[80]
Supraglottic airway devices are not suitable as definitive airways	Risk of aspiration of blood from the stomach[1]; interference with surgical access.
Preoxygenation and denitrogenation are less efficient	Patient may already be hypoxic and agitated.[32] Often difficult to apply a tight-fitting facemask with a good seal; worsening airway obstruction, may contribute to subcutaneous emphysema.[10]
High flow nasal oxygenation (HFNO) may fail;[11] transnasal humidified insufflation ventilatory exchange (THRIVE) is not recommended[12]	Blood in the airway is a potential cause of interrupted gas flow and blood may be forced into the distal airway.[11]
Requires urgent or emergent hemostasis[81]	Bleeding management can rarely be postponed to the following day.
Obstructed vision[82]	Blood can render any device that relies on visualization (including direct laryngoscopy) impossible.[81]
Concomitant suctioning[81]	Suctioning of upper airway with two suctioning systems enhances view[46] but limits working space and adds complexity to medical care.
A blood clot can mimic tissue/pathology[83]	
A blood clot can obstruct or displace[82] the airway	
The patient often cannot lie flat[43]	Airways flooded; feeling of suffocation. Patients should be allowed to adopt their most comfortable position. Sitting position may be ideal.[43]
Hypovolemia with impending or established circulatory collapse[29]	Complicates scenario, decreases patient cooperation, and increases impact of hypoxia.
Aspiration risk due to blood in the upper airway or stomach[68]	Swallowed blood is emetogenic. Preferable to empty stomach after securing the airway.
May require emergency front-of-neck-access[5,82,84]	Cricothyroidotomy or tracheotomy.[85]
'Waking up the patient' following failed airway management is rarely an option	
The patient may re-bleed upon extubation[62]	Re-bleeding can occur between seconds[62] and weeks[86] after extubation.
Clinical care team overwhelmed by stress	Training to manage these cases requires non-technical skills education.[79]

drug-soaked cotton pledgets[31] for uncontrolled airway bleeding.

Oxygenation

Proactive oxygenation[10] throughout airway management is a cornerstone of safe patient care. Whenever possible, binasal oxygen delivery prior to, and during, intubation is beneficial. This should be supplemented by facemask-delivered oxygen if possible, although this may not be tolerated by patients with active airway bleeding, and is relatively contraindicated in facial trauma, particularly skull base fractures where it increases the risk of intracranial infection.[10] High Flow Nasal Oxygen (HFNO)/Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE) should be used with extreme caution when there is bleeding[12] and is relatively contraindicated[12] as blood may be forced distally into the trachea. Moderate flow rates (8–20 L·min^{-1}) may be better than high flow rates. Cautious sedation with ketamine may be necessary to facilitate effective preoxygenation/denitrogenation in the uncooperative patient.[32]

Fluid/blood resuscitation and correction of coagulopathy

With severe bleeding, the patient may be hypovolemic[30] and in such cases large-bore intravenous access and crystalloid/colloid/blood resuscitation should be initiated. Blood samples should be sent expeditiously for cross match. Volume replacement is the cornerstone of resuscitation for profuse bleeding, but non-targeted aggressive fluid resuscitation must be avoided to allow clot formation and to prevent increased bleeding.[25] If faced with a coagulopathy, this needs to be actively managed[26] and expert hematology input may be sought if time permits. Maintenance of normothermia (including warming of administered fluids) and correction of

metabolic acidosis are important considerations, as with any massive transfusion scenario.

Airway management

Bleeding in the upper airway (above the vocal cords) is a relatively common scenario.[3,4] Of the many possible ways of managing the airway, only placement of a cuffed tube in the trachea fulfils the desired goals of a) securing a conduit for patient ventilation, b) protecting against further aspiration of blood into the lungs, and c) allowing sufficient access to surgically address the source of bleeding.

A cuffed endotracheal tube can be inserted via the oral or nasal route, cricothyroid membrane (CTM), or tracheal stoma. The choice will be influenced by the site of bleeding and the approach required for safe airway management. Supraglottic airway devices, such as the laryngeal mask airway or the Combitube (Tyco Healthcare Group LP, Boulder, CO, USA), should only be considered as a temporary means of securing the airway, as they do not definitively isolate the lungs from blood in the upper airway. To guard against aspiration, it is preferable to insert a cuffed endotracheal tube either following rapid sequence induction (RSI) or while the patient is awake. An RSI should only be performed if the pre-anesthetic airway evaluation does not suggest difficulty with DL and confirms that the CTM is identifiable, and thus accessible should DL fail. A stepwise approach to managing the bleeding upper airway is summarized in Fig. 2.

Airway evaluation

Despite the limitations in predicting difficult/failed DL, a thorough preoperative airway evaluation is essential to help inform whether an awake technique, rather than an RSI, would be a safer approach. The evaluation can be done at the bedside. Features suggestive of a potentially difficult DL include limited mouth opening, mandibular protrusion, thyromental distance, submandibular compliance, sternomental distance or head and upper neck extension, Mallampati class 3 or 4, narrow dental arch, increased neck circumference, and history of previous difficult airway management.[14,33–35] Nevertheless, even with a reassuring airway assessment that suggests easy DL, this evaluation will occasionally mislead and therefore preparation must also include provision for a front-of-neck access (FONA) like a cricothyroidotomy or tracheotomy.

A difficult FONA is more likely in cases of female sex, age < eight years, thick/obese neck, overlying pathology (inflammation, induration, radiation, tumour), a displaced airway, or a fixed cervical spine flexion deformity.[14]

Identification of the CTM

The potential need for a FONA, either pre-emptively or as part of airway rescue, is substantial when managing the bleeding airway. In small children (< ten years old) tracheotomy may be the preferred FONA approach[36] but the ideal approach depends on skill and experience.[37] In adults, a scalpel cricothyroidotomy is the FONA technique of choice to rescue a "can't intubate, can't oxygenate" scenario according to recent guidelines.[15] For elective FONA in the awake patient there is less time pressure than in the emergent situation, and thus either a cricothyroidotomy or a tracheotomy may be performed. While the patient is being stabilized and prepared for definitive airway management, (ideally prior to induction of general anesthesia, circumstances permitting) the CTM and trachea should be identified and marked.[38] Ideally, this should be done in conjunction with a surgical colleague skilled in upper airway surgery. In slim individuals, inspection and palpation will usually identify the CTM and trachea.[39] However, both conventional palpation and the "laryngeal handshake"[40] technique have a high failure rate of identification in obese patients and in patients with neck pathology. In such cases, the CTM and trachea may be identified quickly and reliably using ultrasonography.[39,41] Accurate identification of the CTM and trachea facilitates both pre-emptive and rescue cricothyroidotomy, tracheotomy, and awake retrograde intubation.[42] The CTM should ideally be marked with the patient's head in the same position that the clinician would potentially use for surgical access via the CTM. If the CTM is identified and marked in the sitting position, its location might change when the patient is placed supine. We emphasize that ultrasonography for correct identification of the CTM and trachea may be life-saving.[42]

Rapid sequence induction

If the airway evaluation reassures that intubation under DL is likely to be successful, and that the CTM and the trachea are identifiable, then an RSI is indicated. The patient may be hypovolemic[29] and in such cases large-bore intravenous access and fluid/blood resuscitation should be initiated. A continuously cycling non-invasive blood pressure cuff, or invasive blood pressure monitoring (time and circumstances permitting) will help to monitor and treat hypotension that typically accompanies induction of general anesthesia. Ready access to vasopressors such as ephedrine and phenylephrine must be ensured, and judicious use of appropriate (small) doses of hypnotics and opioids may be necessary to avoid catastrophic cardiovascular collapse. Induction with ketamine or etomidate should be considered. The patient often needs
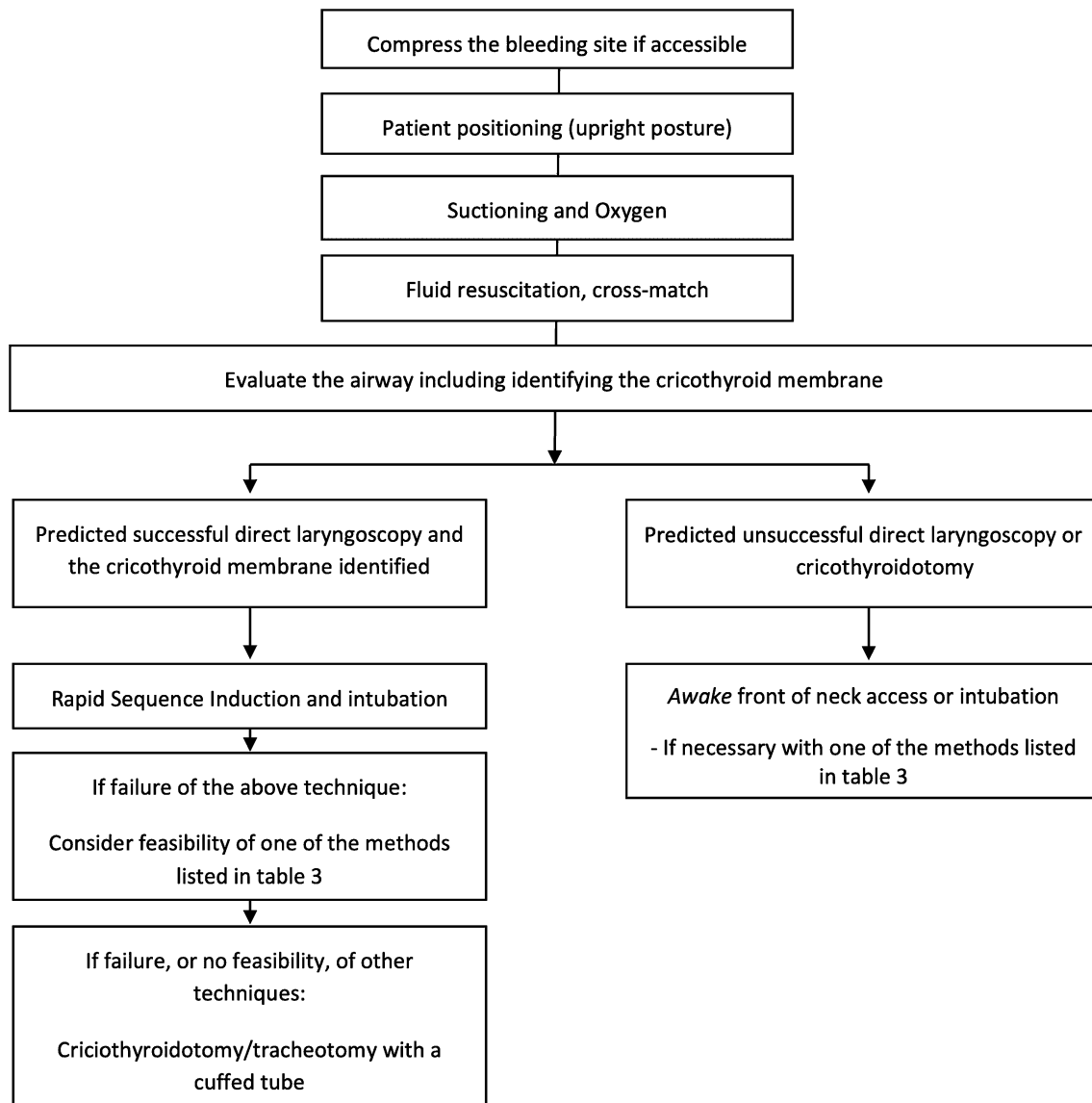
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┌─────────────────────────────────────────────┐
│    Compress the bleeding site if accessible   │
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┌─────────────────────────────────────────────┐
│      Patient positioning (upright posture)    │
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┌─────────────────────────────────────────────┐
│            Suctioning and Oxygen              │
└─────────────────────────────────────────────┘
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┌─────────────────────────────────────────────┐
│        Fluid resuscitation, cross-match       │
└─────────────────────────────────────────────┘
                       │
┌────────────────────────────────────────────────────────────────────┐
│  Evaluate the airway including identifying the cricothyroid membrane   │
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Predicted successful direct laryngoscopy and the cricothyroid membrane identified

Predicted unsuccessful direct laryngoscopy or cricothyroidotomy

Rapid Sequence Induction and intubation

Awake front of neck access or intubation

- If necessary with one of the methods listed in table 3

If failure of the above technique:

Consider feasibility of one of the methods listed in table 3

If failure, or no feasibility, of other techniques:

Criciothyroidotomy/tracheotomy with a cuffed tube

Fig. 2 Flow chart summarizing approach to managing the bleeding upper airway. Please refer to the main text for detailed explanation

to be sitting,[43] or even leaning forward, until unconsciousness is achieved and can subsequently be placed in a sniffing, semi-lateral, or head down position depending on preference and circumstances. An assistant solely dedicated to managing hemodynamic changes and fluid resuscitation may be necessary.

Two direct laryngoscopes should be available in case one fails and ideally one of these should be a video laryngoscope with a Macintosh-shaped blade; it can be used as a direct laryngoscope if blood obscures the video function of the device or as a video laryngoscope if blood soiling is less than expected and the direct view is more restricted than predicted.

Two rigid, large-bore Yankauer-type suction catheters[44] attached to separate suction sources should be available, as well as Magill forceps to retrieve clots in the oropharynx.[45] An assistant dedicated to suctioning of the airway may be required. When optimal glottic visualization is obtained, the suction catheter can be wedged to the left side of the laryngoscope,[44] in the upper oesophagus,[46] or in the hypopharynx below the glottis to prevent re-flooding of the airway during intubation. A malleable intubation guide/bougie/introducer may be useful if the larynx is partially covered with blood, as visibility of the epiglottis, not the larynx, may be sufficient to effectively insert these devices. Some authors even categorise the use of such guides as a "nonvisual" techniques,[47] despite some visualization being required to identify the epiglottis.

Following intubation, it is advisable to suction down the tracheal tube prior to commencing assisted ventilation.

This will limit blood contamination of the distal airways; otherwise, distal airway obstruction may occur because of blood and/or clot.

Approach if the airway examination suggests DL may fail

The approaches recommended in airway management algorithms[7–10] almost exclusively depend on visualization of the glottis (directly or indirect, Table 2) and so are inadequate when employed in the bleeding airway, particularly when the bleeding is profuse. Table 3 summarizes methods for securing the airway that are less affected by the presence of blood. These include flexible video/optical endoscope-guided intubation via a supraglottic airway device, retrograde intubation, blind oral and blind nasal intubation, light-guided intubation, ultrasound-guided intubation, cricothyroidotomy, and

tracheotomy. Finally, cardiopulmonary bypass or extracorporeal membrane oxygenation may be employed for bridging in desperate situations.

These methods may be employed in an *awake* patient when techniques to visualize the glottis (typically flexible or rigid video laryngoscopy) have failed or are anticipated to fail. These methods may also be considered in the *unconscious/anesthetized* patient, if clinically appropriate, when visualization-dependent techniques have failed because of excessive bleeding. Otherwise, FONA will be the technique of choice.

Awake approach

An awake approach to securing the airway is prudent especially if the airway assessment suggests that intubation after induction of general anesthesia may fail and/or that the "rescue technique", usually cricothyrotomy, may be

Table 3 Airway techniques that do not rely on visualization of the glottis, and may be considered when the upper airway is soiled with blood

Technique	Indication	Comments
Supraglottic airway devices[52,53]	For failed ventilation and/or as a conduit for intubation,[53] in the awake[52] or unconscious patient.	Only suitable for bleeding above the larynx. Requires adequate mouth opening. Poor protection against aspiration. Mainly temporizing technique until intubation is achieved.
Retrograde intubation[42,50,66,87,88]	An awake approach is recommended, but can be applied in the unconscious patient.[89]	May be used in patients with critical cervical spine lesions.[65] Can be applied with a supraglottic airway device in place.[59] Can be combined with light-guided intubation.[67]
Light-guided intubation, using either a lightwand,[49] or a flexible endo scope[48] as light-guide	Awake, following induction, or unconscious.	High success rate in predicted difficult intubation in spontaneous breathing,[90,91] or anesthetized,[91] patients. Can be combined with retrograde intubation.[67]
Blind nasal intubation[90,92]	Must be guided by breath sounds. Awake or with preserved spontaneous bleeding.	High success rate in spontaneous breathing patients with neck trauma.[92]
Cricothyroidotomy[60]	Pre-emptive[60] or rescue.[5] Awake, following induction, or unconscious.	Patient may be unable to lie flat (but semi-recumbent position may be an option).
Tracheotomy	Pre-emptive[63] or rescue.[5] Awake,[63] following induction,[5] or unconscious.	
Ultrasound-guided intubation[93,94]	Visualization obscured by blood.[93] Awake, following induction, or unconscious	Requires separate operator. Recommended for the bleeding airway, but only limited clinical use reported in the literature
Oral-digital intubation[47]	Difficult technique; demands adequate mouth opening.	Rarely tolerable for the awake patient.[47]
Esophageal Combitube,[73,95] Laryngeal tube, or similar device	Mainly as rescue technique.	Bulky; may be traumatic to insert; may interfere with surgical access.
Cardiopulmonary bypass/extra corporeal membrane oxygenation[96,97]	Has been used for massive hemoptysis[96] and tracheal granuloma.[97]	Does not protect from aspiration; may not be available for emergency use; anticoagulation requirement may complicate hemostasis.

Significant bleeding airway scenarios are challenging to manage and may necessitate the use of techniques less familiar to the treating physician. Patient management should be performed by individuals who have experience with these techniques and have rehearsed the bleeding airway scenario

difficult or impossible.[14] The awake approach can be either via tracheal intubation or FONA. A sitting position and applying pressure to the bleeding site with gauze-loaded forceps may be helpful. If the bleeding is limited, then awake flexible endoscopy or awake videolaryngoscopy can be attempted, but the operator must be prepared for failure.

If airway visualization with the flexible endoscope or video laryngoscope is unsuccessful, an alternative awake technique is required (Table 3). Occasionally, unsuccessful awake intubation can be salvaged using a flexible endoscope as a "lighted stylet". The tip of the endoscope is advanced posteriorly past the epiglottis and caudal towards the estimated position of the glottic opening and then the tip of the scope is manipulated anteriorly to wedge it against the anterior luminal surface of the trachea. The light from the scope can then be seen through the anterior neck, thus verifying the position of the tip of the scope in the trachea.[48] If clinicians wish to include such a technique in their airway management armamentarium, then it should be practiced in the non-bleeding airway to optimize its familiarity.

Airway topicalization and sedation

Airway topicalization (e.g., nebulized, atomized, gauze/pledget soaked with local anesthetic) is largely ineffective in the presence of blood and alternative methods may be required. Bilateral superior laryngeal nerve blocks combined with trans-tracheal injection of local anesthetic may produce a superior result.[49] Nevertheless, it may be preferable to refrain from anesthetizing the trachea so that the patient can still react (cough) if blood enters the trachea; the trade-off is that the patient may also react when the endotracheal tube enters the trachea, but this does not seem to limit the success of intubation. In fact, the presence of blood lubricates the airway so that intubation may be possible without local anesthetic and with only limited patient discomfort.[50] In patients presenting with severe respiratory distress or with hypercarbia-induced somnolence, and a likely difficult DL, awake intubation with an appropriate technique is indicated and is often well tolerated without topicalization or sedation.[51] Nevertheless, in some patients, cautious sedation may be required; ketamine may be particularly helpful as there is little associated respiratory depression.[32]

Ventilation and intubation via a supraglottic airway device

A supraglottic airway device can protect the trachea to some degree from blood soiling, provided that the origin of the bleeding is above the glottis. This can permit life-saving ventilation. The insertion of a supraglottic airway device and using it as a conduit for intubation can be applied in the awake patient,[52] or used as a rescue technique in the unconscious (or anesthetized) patient after failed intubation[53] or facemask ventilation.[54] A supraglottic airway device (without subsequent intubation) should be used with caution and should be considered only as a temporary solution as it offers limited protection from aspiration. Of note, a supraglottic airway may not provide sufficient space for surgical access to the bleeding site.

A supraglottic airway device specifically designed to accommodate an endotracheal tube should be used, and the intubation should be performed under visual guidance of a flexible endoscope. If a standard supraglottic airway device (i.e., not designed to facilitate intubation) is used, successful intubation can be facilitated using an Aintree Intubation Catheter (Cook Medical, Bloomington, IN, USA) with an appropriately sized fibrescope and endotracheal tube.[13] A second-generation supraglottic airway device with large-bore gastric access may allow egress or suctioning of blood from the stomach, but may not provide effective protection against aspiration. "Blind" (i.e., without guidance of a flexible, optical endoscope) intubation via a supraglottic airway device in a bleeding airway has been described,[53] and may be considered as a last resort prior to emergency FONA.[55] Nevertheless, we would caution that blind techniques have an unacceptably low success rate,[56] especially in children[57]; flexible, optical endoscope-guided intubation has a higher success rate[58] and should be used whenever possible. Finally, supraglottic airway device ventilation can be converted to endotracheal tube ventilation using a retrograde technique; a guidewire is passed via the CTM, directed cranially via the supraglottic airway device, and then used to guide an obturator anterogradely via the proximal end of the device and then out through the distal end, which in turn can be used to guide insertion of an endotracheal tube.[59]

Cricothyroidotomy

Cricothyroidotomy can be performed in the awake patient as a primary or "pre-emptive" airway,[60] or after induction as an airway rescue for failed intubation.[5] In adults, it should be performed using a technique that permits the placement of a cuffed endotracheal tube of at least a 5-mm internal diameter. This will provide effective ventilation while protecting against further aspiration,[61] yet allow sufficient space for surgical treatment of bleeding. A narrow-bore cannula ("needle") cricothyroidotomy is not suitable other than as a temporary oxygenation technique.[62]

Tracheotomy

Similarly, tracheotomy can be used as a primary, awake approach[63] or as a rescue technique[5] and is the FONA technique of choice in smaller children (< ten years).[36] In a child with a bleeding airway, it is crucial to have a gloved surgeon present during induction of anesthesia as immediate tracheotomy may be necessary because of intubation failure.[24]

Profuse bleeding

If the bleeding is so profuse that flexible or rigid videolaryngoscopy are likely to (or have) fail(ed), then a variety of options may be considered (Table 3). Awake, pre-emptive tracheotomy[63] or cricothyroidotomy[60] should always be considered in such cases. Nevertheless, in certain scenarios, other awake approaches may be preferable depending on clinical experience. Of these, the retrograde "pulling" technique is especially well-suited in the management of an awake, sitting patient with a profusely bleeding airway. Retrograde intubation, where the tube is pulled either through the nose or mouth into the trachea using an epidural catheter inserted through the CTM, or through the crico-tracheal membrane,[64] has the following advantages: it is relatively simple, requires readily available equipment (an epidural catheter),[47] is independent of vision and thus works in bloody airways,[42] allows intubation via the mouth or the nose as appropriate,[65] and allows re-intubation if necessary (as the catheter is left *in situ* following extubation). The technique should preferably be used in the awake patient. One detailed approach to this technique has been described.[50] The CTM or the crico-tracheal membrane is identified and an 18G venous cannula is introduced into the airway through which an epidural catheter is introduced in a cephalad direction until it protrudes via the mouth. Subsequently the epidural catheter is looped around the Murphy eye so the tube can be pulled into the trachea using a "sliding knot".[50] If a nasal intubation is preferable, a second epidural catheter can be inserted through the nares, and "fished" out of the mouth using forceps. This catheter can be tied to the catheter inserted via the CTM (above), and pulled cephalad until there is a single, unknotted length of epidural catheter extending from the nares to CTM. The epidural catheter can then be looped through the Murphy eye of the endotracheal tube, and used to guide it into the trachea.[65]

Alternative retrograde intubation techniques for the bleeding difficult airway include a long guidewire and a tube-exchange catheter,[42] a Tuohy needle and a guidewire,[66] retrograde intubation with a supraglottic airway device in place,[59] or a dedicated kit specifically designed for this purpose.[47]

Finally, lightwand-guided intubation is another useful technique in this setting and can even be used in combination with retrograde intubation.[67] This approach requires dedicated equipment, although a flexible endoscope may be used for this purpose,[48] as briefly described above.

The unconscious patient

In the unconscious patient with an urgent need for a cuffed endotracheal tube, typically a major trauma patient, the choices for airway management are the same as those listed in Fig. 2 and Table 3, without the "awake" options. Nevertheless, if the patient has sufficient spontaneous ventilation these techniques may still be attempted. The initial approach would most often be an attempt at intubation with DL followed by FONA in case of failure, or alternatively with FONA as the primary approach.

Postoperative management

If there is suspicion of aspiration of blood from the upper airway into the tracheobronchial tree, this should be verified and appropriately treated by suctioning via a flexible optical endoscope.[68] Multidisciplinary discussion and planning are needed to manage postoperative care. Consideration should be given to keeping the patient intubated in a high acuity recovery area (e.g., intensive care unit) until the cessation of bleeding is certain, fluid status has been appropriately managed, and any coagulopathy has been addressed. The treating team must formulate an airway rescue plan to deal with the possibility of recurring bleeding or the airway becoming compromised following extubation. Corticosteroid therapy should be initiated in case of expected postoperative stridor.[69]

Caveats

Owing to the limited data that are available, it is not possible to provide a systematic review, making it difficult to provide definitive conclusions on how to best manage various bleeding airway scenarios. It is hard to imagine how to design comparative prospective studies that could account for the complex clinical presentation of these patients, with etiologies ranging from medical (coagulopathy) to trauma to malignancy. The options we review have various advantages and disadvantages, and the choice for any one technique relates to the clinical

circumstances, available equipment and—most importantly—clinical experience. It is crucial to gain familiarity with these techniques in the non-urgent situation, and we would strongly encourage healthcare providers who may handle this type of challenging patient to participate in workshops towards this end.

Conclusion

The bleeding upper airway can be extremely challenging to manage, and requires a structured, multidisciplinary approach to achieve a successful outcome. Optimization of both technical and non-technical (i.e., communication, organization, and teamwork) skills is crucial. Standard airway management algorithms based on being able to visualize the glottis directly or indirectly, may be inadequate in this scenario.

The situation is made all the more challenging by the tremendous pressure to provide expeditious, expert medical care. Presentation, audit, and review of such cases are important so lessons can be learned and future management improved. Undoubtedly, there will be clinicians facing such scenarios for the first time and our hope is that this review will make that experience less daunting.

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