



Current Considerations in Emergency Airway Management

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Abstract

Purpose of Review Emergency airway management is populated by many new concepts, evolving equipment, and contemporary strategies for optimal procedural success. This review aims to discuss various topics within these realms and to continue the ongoing conversation regarding improvement of emergency airway management.

Recent Findings Various literature, opinion pieces, podcasts, and trials have prompted renewed interest in the field of emergency airway management. Though common threads can be found, there is significant debate on optimal practice. Accompanying these conversations is continuous production of new equipment which can be beneficial to providers. However, this ongoing accumulation of material, data, and pathways can create challenges in remaining up to date. Rather than a comprehensive review of current literature and discussion of research findings, this article aims to discuss selected and impactful concepts in real time context and provide potentially immediate additions to emergency airway manager practice.

Summary As emergency airway management evolves, it remains a significant task to maintain up to date on current trends, data, and new equipment. This article aims to discuss several of these items in a digestible fashion and provide immediate impact for emergency airway providers.

Keywords Airway · Intubation · Respiratory failure · Emergency medicine

Introduction

Emergency airway management has evolved dramatically in recent years. This brief article aims to highlight contemporary topics in the realm of emergency airway management, offer insight into advancing technologies, and discuss potential future steps. This is not intended as a comprehensive airway review, but rather as commentary on assorted airway management techniques, technology, and strategies of current interest. There are a myriad of pathways for successful

emergency airway management and equally diverse opinions on optimizing this intervention. We hope to stimulate further consideration of these topics, continue dialogue on emergency airway management, and contribute our enthusiasm to this ever-evolving and advancing practice.

Section 1: Oxygenation

Apneic Oxygenation

Apneic oxygenation has impacted emergency airway management profoundly [1••]. This strategy employs use of nasal cannula (NC) or high-flow nasal cannula (HFNC)

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during the preoxygenation phase and throughout the apneic phase of rapid sequence intubation (RSI). In contrast to previous practice in which the apneic phase did not include active oxygenation, this pathway leaves the nasal cannula in place and flowing throughout apnea. The passive flow of oxygen into the nose, across the turbinates (if present), creates laminar flow and passive flow down into the larynx, trachea, and lungs, and provides ongoing oxygenation. In addition, as oxygen is consumed in the bloodstream, a chemical gradient is created that actively draws oxygen from the relatively oxygen rich environment of the lungs to the relatively oxygen poor environment of the blood [1••, 2]. This is to say, a chemical vacuum forms, actively pulling oxygen into the bloodstream. With apneic oxygenation employed, much longer safe apnea times become present during laryngoscopy, often with minimal or no desaturation.

Very high flow rates can be achieved with simple nasal cannula and high-flow nasal cannula. Interestingly, despite the oxygen flowmeters prompting many providers to view 15 L/min as maximum flow, these devices can deliver much higher flow rates. Some reviews suggest flow rates as high as 60 L/min [2]. The 15 L/min maximum is likely related to many oxygen flowmeters measuring only that volume. To achieve higher flow rates, the provider can simply continue to open the oxygen flowmeter control valve. The maximum flow rate is achieved when the valve is maximally opened mechanically (i.e., turn the valve until it stops turning). This has been labeled “flush rate.” Of note, this creates very high flow rates; each airway manager should be aware of two issues that accompany this strategy: (1) The flow rates are high enough to blow the oxygen tubing off of the flowmeter; the tubing must be pushed onto the flowmeter adaptor (“Christmas tree”) sufficiently to prevent this occurrence. (2) The high flow rates create significant noise in the room and are often uncomfortable for patients. Our experience suggests flush rate is best initiated once sedation medication has been delivered during rapid sequence intubation (RSI). Use of flush rate is likely more optimal with HFNC rather than NC, though more investigation would be of value.

Of note, this strategy does not replace bagging during the initial paralysis phase or between laryngoscopy attempts. The nasal cannula can remain in place during bagging, which may augment oxygenation, but ventilation provided by BVM is critical.

High-Flow Nasal Cannula (HFNC)

Similar to standard nasal cannula, the high-flow nasal cannula (HFNC) can deliver very high flow rates (~50 LPM). The devices typically have moderately larger nasal ports than standard NC. Ease of use, quick placement, and

relative availability make these devices excellent resources in emergent settings. Beyond airway alone, HFNC offers several impactful characteristics for the care of critically ill patients:

These devices can reduce anatomical dead space which improves carbon dioxide (CO₂) removal [3]. This is due to HFNC decreasing minute ventilation and improving respiratory efficiency aiding in clearance of CO₂ in anatomical dead space [4].

HFNC is also an impactful tool for management of respiratory failure. Regarding hypercapnic respiratory failure, a systematic meta-analysis of five randomized trials (198 patients with acute COPD exacerbations) showed HFNC reduced partial pressure of carbon dioxide (PaCO₂) levels when compared to noninvasive ventilation (NIV) or conventional oxygen therapy (COT) [5–8].

For patients in severe respiratory distress, HFNC can reduce respiratory rate and work of breathing (WOB) [9, 10]. Additionally, for patients with mild-to-moderate respiratory depression, HFNC can provide better thoracoabdominal synchrony, when compared to techniques utilizing low-flow oxygen. Considering these effects on anatomical dead space, HFNC is a great resource to reduce the work of breathing (WOB). This was also shown to be beneficial in infants with respiratory distress, as HFNC can reduce respiratory rate and improve thoracoabdominal movement [11].

For patients in an immunocompromised state, when compared to NIV or COT, HFNC was a better tool to reduce intubation rate, mortality at 90 days, and the amount of ventilator-free days at day 28 [12].

A simple and easily accessible device, requiring low-cost material and standard oxygen flowmeters, HFNC can add significant value to emergency providers' care of respiratory patients in prevention of intubation, oxygenation during the peri-intubation phase, and safe apnea during RSI.

The use of heated-high flow nasal cannulas (HHFNC) should be considered here as well. Though these devices have profoundly impacted respiratory patient care globally (particularly during the COVID-19 pandemic), the additional benefit for airway management may not be quite as profound. The use of apneic oxygenation discussed above is most commonly employed with nasal cannula or high-flow nasal cannula. This pathway can also be employed using the heated-high flow nasal cannula, though the additional benefit may not be pronounced [13]. HHFNC can deliver very high flow rates (e.g., 60L/min) and even likely provide a small amount of positive end expiratory pressure (PEEP), which may further enhance oxygenation. The additional benefit is likely in care of respiratory distress and severely hypoxic patients. Use of these devices for preoxygenation and apneic oxygenation in the peri-intubation phase (in comparison to HFNC) may be limited, though more data is needed.

Bifurcated Oxygen Flowmeters

A common barrier to optimal preparation for airway management is access to oxygen sources. Use of bifurcated oxygen trees helps circumvent this challenge by doubling the available oxygen sources. In a typical emergency department room, there may be one or two oxygen ports in the wall or resuscitation box. The bifurcation devices double access for oxygen. Each port can then hold two oxygen flowmeters, enhancing access to two to four ports. This is exemplified in Fig. 1. This enhances and simplifies oxygen delivery. With increased ports, more oxygen can be delivered, and the need to switch ports during the airway is minimized.

A setup utilized by the authors of this paper is thus:

- 1 Flowmeter port #1: High-flow nasal cannula (HFNC)
- 2 Flowmeter port #2: Non-rebreather (NRB)
- 3 Flowmeter port #3: Bag-valve mask (BVM)
- 4 Flowmeter port #4: Ventilator

The use of this setup gives direct access to multiple oxygenation devices and forgoes the need to switch out tubing during the intubation process. For example: During the pre-intubation phase, the HFNC and NRB are placed on the patient and initiated at flow tolerable to the patient. During the apneic oxygenation phase, the HFNC remains in place, and flow is increased to flush rate, the NRB is removed, and the patient is bagged with the BVM. During intubation the HFNC remains in place at flush rate. Following intubation

the ventilator is connected to the endotracheal tube. At no point during the intubation process does the provider need to change oxygen ports. This removes not only a cognitive challenge, but also a physical action during the intubation process, augmenting oxygenation while simplifying the overarching task.

Section 2: Laryngoscopy

Video Laryngoscopy

Video laryngoscopy (VL) is one of the most innovative contemporary advances in emergency airway management. Macintosh, Miller, and angulated blades are all now available as video laryngoscopy devices, and new additional devices with unique orientation are also becoming more widespread. With appropriate use, video laryngoscopy increases first pass success and helps navigate expected and unexpected difficulties during laryngoscopy [14•, 15]. Video laryngoscopy is also a powerful tool in teaching and instruction for airway learners. Most notably, in contrast to direct laryngoscopy (DL), as each airway evolves, all providers present can view the anatomy and procedural progression. While only one provider has hands-on experience during an intubation attempt, each viewing provider can have an impactful and beneficial procedural experience. Moreover, supervising providers can provide real-time feedback of airway management techniques.

Fig. 1 Bifurcated oxygen port. This allows two oxygen flowmeters to connect to a single wall port



Direct laryngoscopy and video laryngoscopy overlap significantly, but are distinct pathways. With traditional geometry blades (Macintosh, Miller), the pathway of laryngoscopy can be similar (sweep tongue right to left, move midline, expose larynx). There is some discussion when using VL, that sweeping the tongue is not necessary, but rather a direct midline approach can be taken [15, 16]. Though this does result in adequate glottic exposure, it can lead to difficulty passing the endotracheal tube (ETT). These authors theorize that this is due to the tongue acting as a fulcrum, causing pressure in the midshaft of the stylet or bougie, thereby causing the devices to miss posteriorly. Sweeping of the tongue helps take the tongue out of anatomic position and allow easier passage of the stylet or endotracheal tube. An additional benefit of sweeping the tongue while using video laryngoscopy: As the geometry of the VL blade matches traditional direct laryngoscopy blades, a VL blade can be used as a direct blade in the instance that the camera is obscured, though the technique mentioned below can help reduce this possibility.

Angulated blades, however, are the exception to this rule. A midline approach is appropriate as the hyperangulated rigid stylets can simply maneuver around the tongue, and the tongue-as-a-fulcrum issue is bypassed. Recall as well that utilization of angulated blades negates the possibility of direct laryngoscopy; that is to say, there is no direct view available with use of angulated blades.

Regarding limitations of VL, the often-cited concern regarding occlusion or obstruction of the video laryngoscope cameras can be often prevented or bypassed [16]. One such maneuver to accomplish this task is to stay “high” in the airway and to incrementally lead with the suction catheter while keeping the laryngoscope blade as anterior as possible. Rather than “scoop and lift,” the blade is intentionally slid along the surface of the tongue, along the posterior oropharynx and into the vallecula (or over the epiglottis when using Miller blade) with constant upward and anterior pressure of the blade, following a leading suction catheter. Avoidance of a posteriorly placed blade and “scooping” helps keep the video laryngoscope screen clear of the secretions. In

addition, by using suction catheter techniques that will be discussed later, a provider can clear the airway of blood and secretions prior to advancing the laryngoscope blade, keeping the screen free of debris.

In addition to the clinical impact and real-time teaching, video laryngoscopy allows recording of airway management. These videos can then be examined after the procedure and saved for future review and teaching. The University of Kansas Medical Center and the University of Kansas Health System, with our first author’s guidance, have developed an Airway Video Database in which hundreds of these videos are captured. To maintain patient and practitioner anonymity, all patient information has been removed, the videos begin and end at the teeth and lips, and there is no link to the providers or chart. With these contingencies and precautions in place, the videos are uploaded to the database and are reviewable asynchronously by learners of all levels. This provides an excellent opportunity to review anatomy, understand and discuss troubleshooting techniques, evaluate a series of cases (e.g., burn, trauma, pediatrics), and to enhance overall understanding of the dynamics of emergency airway management. If interested in reviewing the database, please email Dr. Andrew Pirotte (apirotte@kumc.edu).

Section 3: Suction

Large-Bore Suction Catheters

Pictured below is the “DuCanto” suction catheter in Fig. 2a, b. This is not intended to specifically endorse a product, but rather to illustrate the impact a large bore suction catheter can have in successful airway management. The traditional suction catheter (typically a Yankauer) is not an optimal device for airway management, especially in an emergency scenario. Given the dynamics of any difficult airway, including the character of secretions encountered (blood, saliva, vomitus, pulmonary edema, etc.), the traditional catheter does not provide optimal suction [17, 18]. Prior to the introduction of large-bore suction catheters, occlusion

Fig. 2 **a** and **b** Large bore (“DuCanto”) suction catheters



of traditional catheters was a common experience. In such circumstances, not uncommonly these catheters would be removed, and the suction tubing itself would be used in an improvised attempt to clear the airway of secretions. Though this increased the diameter of the suction device and improved efficiency of suction, the tubing did not allow optimal navigation of the airway, often kinking when encountering resistance. The large bore suction catheter provides powerful suction, cannot kink, and rarely occludes.

Suction-Assisted Laryngoscopy for Airway Decontamination (SALAD)

First described by Dr. James DuCanto, suction-assisted laryngoscopy for airway decontamination (SALAD) is a novel concept of dynamic suctioning during intubation [19•]. This allows management of high-volume secretions throughout laryngoscopy and during intubation, rather than two separate phases of the procedure. High-volume bleeding in the setting of hematemesis, hemoptysis, trauma, or high-volume pulmonary edema can diminish optimal intubation environments. SALAD helps navigate this barrier, keeping the view of the airway more available during intubation.

The SALAD technique involves placing and leaving a suction catheter in the posterior oropharynx. The suction catheter can be placed behind the intubating provider's left hand and left in the airway ("parked") to provide constant suction (demonstrated in Fig. 6a) [19•]. By placing the suction catheter out of the way, the constant suction can continuously clear blood, pulmonary edema, or other secretions while the intubating provider lets go of the catheter, leaving it in the airway, to continue the intubation attempt with a bougie or stylet. This technique allows the user to place and leave the suction catheter in the posterior oropharynx to provide constant suction, even while the endotracheal tube or bougie is inserted and advanced. SALAD is shown in the following Figs. 3, 4, and 5, provided by Dr. James DuCanto with permission for use in this manuscript:

Figures 3–5: Mannequin demonstration of SALAD ("parking"). Photos compliments of Dr. James DuCanto, Staff Anesthesiologist, Advocate Aurora Health Care, Milwaukee, Wisconsin.

Moreover, large bore suction catheters can be utilized to facilitate intubation of the airway itself (for example in high-volume pulmonary edema). This technique requires the suction catheter to be placed in the glottic opening, removal of suction tubing followed by introduction of the bougie through the catheter and into the trachea. The suction catheter can then be removed over the bougie and exchanged with an endotracheal tube, which can then be passed down into the trachea. This is possible as a bougie fits through the lumen of the catheter (see Fig. 6b below).



Fig. 3 Laryngoscopy with large volume secretions and large bore suction catheter

Section 4: Airway Adjuncts

Bougie

The bougie is far from new, but continues to significantly impact airway management. Recent literature has shown conflicting results, though from an observational experience by these authors, the bougie provides a profoundly positive impact on airway management [20, 21]. The combination of video laryngoscopy and bougie is a powerful pathway for optimal airway management, though provider technique impacts this greatly. The following are several pearls for optimal use of the bougie:

1. Hold the bougie in a "pencil grip," rather than the shaft of the bougie running along the palm with the thumb facing cranially.



Fig. 4 Transitioning suction catheter from traditional right side to left side ("parking")



Fig. 5 Suction catheter in right side position (“parked”). This position allows continuous suction while providing adequate space on the right side of the oropharynx for passage of intubating devices

2. Adduction of the shoulder improves position and alignment. Avoid abduction of the shoulder (“chicken wing” position), which malpositions the bougie and causes the device to frequently miss left posterolateral to the larynx. This technique primarily works by keeping the bougie in line with the airway axis and parallel to the trachea. See Figs. 7 and 8 below.
3. If possible, avoid direct contact of the bougie with the tongue, as this can cause the midshaft of the bougie to bend (tongue acts as a fulcrum) and miss posteriorly (see Fig. 9 below). This barrier can be avoided by sweeping the tongue to the left, as is used in direct laryngoscopy, or displacing the tongue anteriorly with the blade of the laryngoscope (particularly with DL). If during use of bougie the device continues to miss posteriorly, we rec-

ommend removal of blade, intentional displacement of tongue anteriorly or left, and again advancing bougie. Bimanual laryngoscopy (either right hand under occiput or manipulating larynx anteriorly) can also be of great aid.

4. Additionally, there is a strategy for bougie use in which the endotracheal tube is placed on the bougie prior to intubation. The “Kiwi grip” and the “D grip” are well described [22]. These pathways can be of great value but should be pursued individually and mindfully as the presence of the endotracheal tube (ETT) can reduce the typical flexibility of the bougie and essentially transition the bougie into a stylet.

Articulating Bougie

Several proprietary devices are now available that utilize the technology of the bougie, but advance the pathway with an articulating tip. The articulating end of the device can help navigate laryngoscopy and endotracheal tube placement. The articulating bougie can reduce challenging intubation in settings of anterior airways, or in the setting of prominent soft tissue and tongue. The most common difficulty with this adjunct, as observed by these authors, is the inability for a typical bougie to advance into the airway when the tongue acts as a fulcrum on the midshaft of this device. This fulcrum subsequently manipulates the angle of the bougie and forces it more posterior than is optimal (discussed above). The articulating bougies can often bypass this either through increased rigor of the material (e.g., hard rather than flexible plastic), a greater anterior angle of the device tip, and the ability to manipulate the distal device end dynamically. This final characteristic is the hallmark of these devices. Active manipulation of the distal end can aid providers in

Fig. 6 a “Parked” suction catheter while intubating with a bougie (left) and **b** large bore suction catheter and an intubating bougie (right). If needed, the suction catheter can be placed directly into the glottis and the bougie can be inserted through the suction catheter into the airway

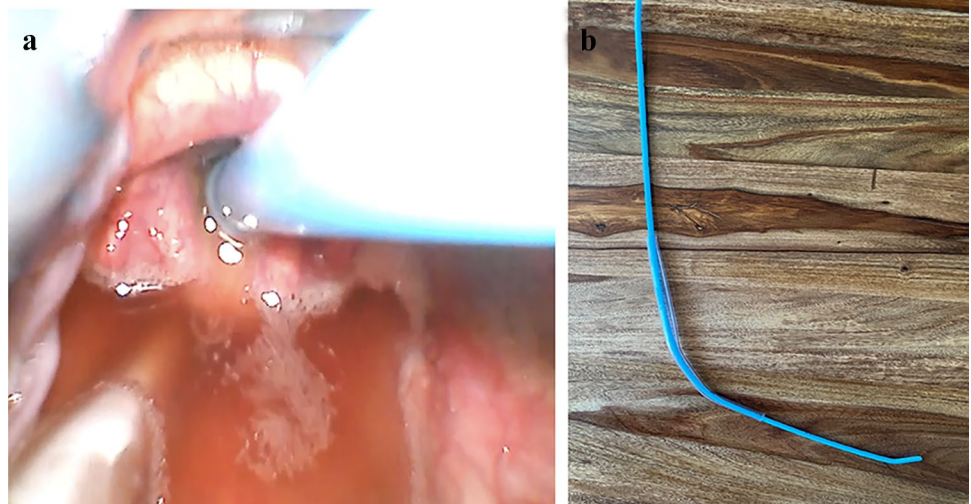
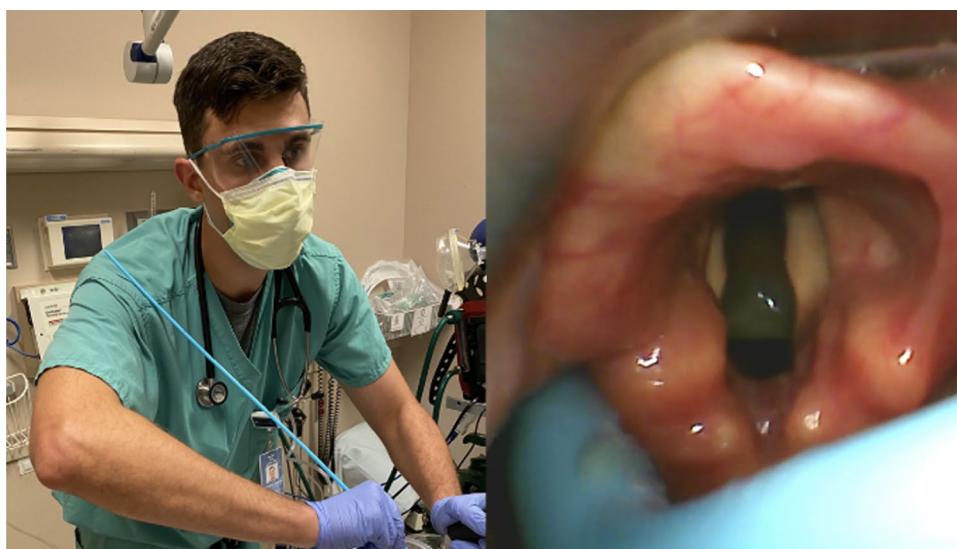


Fig. 7 Adduction of shoulder (“chicken wing”) causes suboptimal bougie entrance angle and left posterolateral malposition in relation to airway



navigating a challenging airway. This mobility is accomplished in a variety of ways, but primarily seeks the same result of dynamic motion of the device tip. Though more expensive, these devices are excellent backups should the initial pass(es) with stylet or bougie fail.

Disposable Endoscopes

Disposable endoscopes are a recent impactful advance in airway management. Though endoscopes are well-established technology, in previous iterations, the reusable version of these devices was costly to purchase, required special cleaning and handling, and frequently broke or necessitated repair servicing. The disposable version of these devices has increased access to complementary metal-oxide

semiconductor (CMOS) and fiberoptic technology and may represent another profoundly positive phase of airway management [23].

Diagnostically, use of disposable endoscopes via flexible laryngoscopy is a critical tool for evaluating the airway. Angioedema is a common case example in which this modality is utilized. In the setting of angioedema, flexible laryngoscopy helps inform the airway manager if the airway is emergent, or is stable (e.g., tongue swelling but no involvement of airway structures). This pathway can help prevent unnecessary intubation, allowing observation rather than prompting airway securement as a preventive measure. In addition to angioedema, flexible laryngoscopy can be useful in a myriad of clinical scenarios: Burn and inhalation injury, head and neck trauma, allergic reaction and anaphylaxis, foreign body aspiration, and evaluation of

Fig. 8 Abduction of shoulder (“tucking the elbow”) produces optimal entrance angle for bougie and alignment with airway

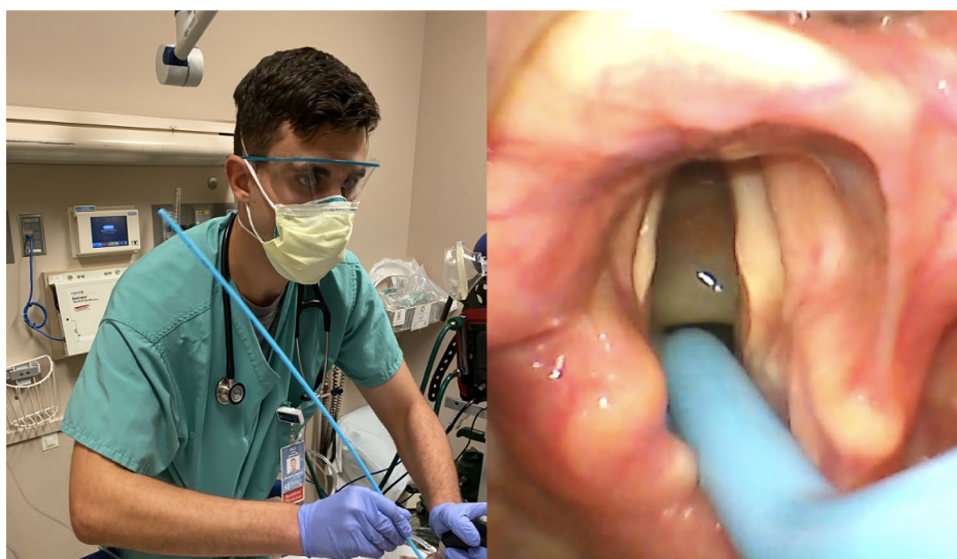




Fig. 9 Note the tongue spilling over the right side of the laryngoscope blade with this midline approach. In this position the tongue acts as a fulcrum for the bougie and bends the distal end posteriorly. A practitioner could re-sweep the tongue left to right prior to advancing the blade on this intubation attempt to reduce the possibility of a tongue fulcrum

stridor. Previously, the devices required for this procedure were often prohibitively expensive or not readily available in the emergency department. Arrival of the disposable version of these devices increases access to this critical pathway.

Beyond flexible laryngoscopy, disposable endoscopes advance providers' access to technology that allows troubleshooting of challenging airways (Fig. 10). Most notably, the disposable endoscopes may be used as an articulating bougie (with the addition of a camera view). In this pathway, two providers pursue the airway simultaneously, as demonstrated in Figs. 11 and 12. The first provider advances the laryngoscope and exposes what structures are visible. The second provider then advances the endoscope with the pre-loaded endotracheal tube. The articulating end of the endoscope then navigates the airway, advances into the larynx, with the endotracheal tube then advanced.

Section 5: Additional Considerations

Airway Checklist

Use of checklists enhances airway care dramatically. Particularly in emergency airway management, it is easy to overlook simple tasks that significantly impact optimal care. Checklists help prevent unforced errors in airway management. An example of an airway checklist is shown in Fig. 13, and it is the current version utilized at the University of Kansas Medical Center Emergency Department, created by Dr. Andrew Pirotte of University of Kansas Medical Center.

Many medical institutions supplement these checklists to ensure communication among providers and patient



Fig. 10 Flexible laryngoscopy as a method to view the vocal cords and epiglottis if indicated

safety. In the context of COVID19, an Airway Response Team (ART) at Massachusetts General Hospital employed the following practices. When identifying signs of respiratory insufficiency the following strategy in Fig. 14 was utilized:

After identifying a critical situation, the airway team can obtain relevant medical information from the primary team about the patient. Some examples are listed in Fig. 15.

These checklists and communication aids allow the team to monitor respiratory distress in patients, create a plan for early intubation, and provide awareness of patient comorbidities [25]. Checklists provide impactful structure for intubation. Additionally, airway checklists can provide helpful feedback to improve knowledge gaps for learners [26].

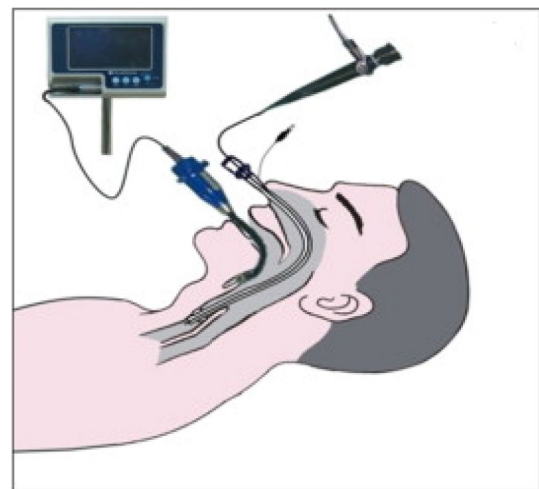
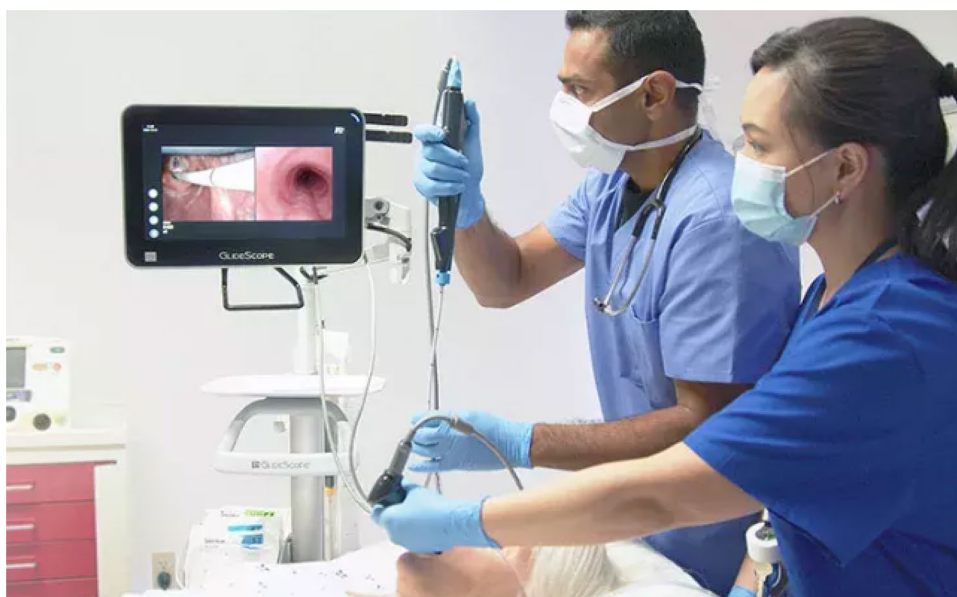


Fig. 11 Depiction of two device intubation technique with video laryngoscopy and endoscope employed simultaneously

Fig. 12 Demonstration of two provider intubation techniques with video laryngoscope and disposable endoscope used to assist intubation [24]



Difficult Airway Response Team (DART)

A new phase of airway management includes development and implementation of difficult airway response teams. The John Hopkins Hospital initially described the formation and implementation of such a team [27]. Our institution has implemented a similar pathway at the University of Kansas Health System. This team coalesces providers and equipment rapidly and efficiently, positively impacting patient care. When initiating the DART response team, it was important to identify the types of critical airway encountered. Types of difficult airways include: (1) anatomical, (2) physiological, (3) environmental, and (4) circumstantial. Anatomically difficult airways consist of specific structural abnormalities that create physical challenges to intubation. Physiologically difficult airways are those burdened by chronic disease such as pulmonary hypertension that compromise cardiopulmonary function [28]. Environmentally difficult airways occur when clinical management is affected by the physical working environment (e.g., outside of clinical care areas, such as a patient collapsing in the hospital cafeteria) [29]. Circumstantially difficult airways refer to situations in which there are deficiencies in available staff, equipment, or education.

The DART pathway for mobilization of providers, resources, equipment, and information allows for swift, comprehensive care for patients with any of the aforementioned difficult airway scenarios.

While DART protocols may differ between institutions, the following Fig. 16 is an example checklist for use during a typical DART response at the authors' home institution.

This pathway is complex and requires endorsement across a multidisciplinary team. Though more study

needs to be pursued regarding optimal practice, the benefit of rapid resource activation certainly seems sound. Acknowledging the significant resource use and the substantial institutional support required, the service provided to patients is impactful and can positively influence patient safety and outcomes [27].

Ketamine

Ketamine was previously used rarely and often thought to be unsafe for many patients (e.g., intracranial hemorrhage) [30]. However, time disproved the previous tacit about the harms of Ketamine, and now it is a commonly utilized agent for procedural sedation and sedation during RSI [31]. The increased use of ketamine has dramatically impacted patient care and RSI.

In addition to routine use, ketamine can be of great value in high risk airways. Particularly during emergent airway scenarios when a patient will not tolerate apnea, ketamine can be used as a dissociative anesthetic that allows the patient to maintain their airway. This characteristic can be profoundly impactful for safe airway management. For example, in a patient with severe asthma, a patient with structural airway compromise (e.g., angioedema/anaphylaxis), or a patient suffering from severe agitation or anxiety (e.g., not participating in care) ketamine can be utilized without immediate subsequent paralysis [32]. In these scenarios, the patient experiences dissociation and anxiolysis, thereby providing an opportunity for the provider to enhance airway preparations, improve oxygenation, and (in some case scenarios) visualize the glottis without paralysis. These effects of

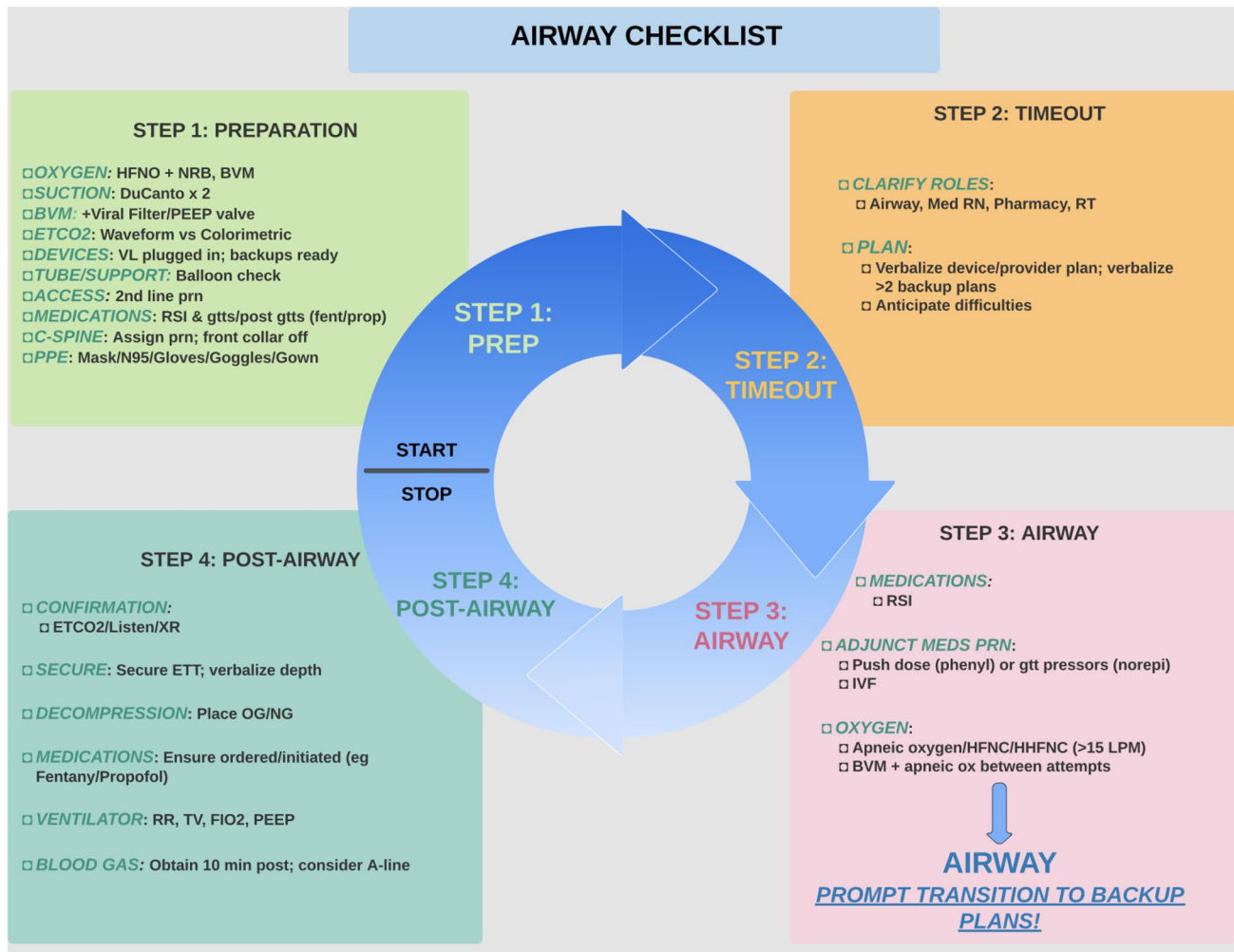


Fig. 13 Airway checklist

ketamine impact a provider's ability to safely proceed with airway management. If a structural issue that would preclude intubation is encountered, the attempt can be aborted and a new airway plan pursued (e.g., surgical airway). This strategy has been described as "delayed sequence intubation" (DSI) and is informed significantly by agents such as ketamine [33].

Of note, delayed sequence intubation was described in use during the initial phases of the COVID-19 pandemic. During this data collection period, patients were commonly hypoxic and agitated, creating oxygenation and intubation barriers. Utilizing DSI, these patients were successfully oxygenated and intubated [34]. Further, a DSI prospective observational study found oxygen saturations increased from a mean of 89.9% before DSI to a mean of 98.8% after DSI, an increase of 8.9% (95% confidence interval 6.4% to 10.9%). Additionally, some patients in this final study were identified as having a high potential for critical desaturation, defined at pre-DSI saturation $\leq 93\%$. When DSI was administered to

these critical patients, 91% of these patients increased their saturation post-DSI to $> 93\%$ [35].

Ongoing Vasopressors for Rapid Sequence Intubation (RSI)

Push dose vasopressors have long been used in the peri-intubation phase to hemodynamically support patients and help prevent post-intubation hypotension and cardiovascular collapse. There is ongoing consideration of expanding this practice to include vasopressor drips during the peri-intubation phase. This is to say, rather than push-dose vasopressor only, the patient receives continuous vasopressor (even low dose) during intubation. If the hemodynamics are stable following intubation, the vasopressor is subsequently stopped. This is not intended for hypertensive patients or patients at risk of hypertensive complications (e.g., hemorrhagic stroke patients requiring intubation). Further study would be of value, though the concept appears sound.

Fig. 14 Suggested criteria for notification of a COVID-19 airway response team (ART) [25]

Criteria for non-urgent ART notification	Criteria for urgent ART notification
Any ED or inpatient patient with:	Any ED or inpatient patient with:
1. Confirmed or suspected infection with COVID-19	1. Confirmed or suspected infection with COVID-19
AND	AND
2. Respiratory symptoms, including:	2. Signs of respiratory insufficiency, including any of the following:
- Dyspnea	- Tachypnea (> 30 breaths/min)
- Wheezing	- Hypoxemia (< 93% on room air)
or	- Increased work of breathing
2. Significant co-morbidities, including:	- Stridor or airway obstruction
- Asthma	- Radiographic evidence of worsening disease on chest imaging
- COPD or smoking history	- Cardiopulmonary arrest
- Heart failure	
- Renal disease	
- Cerebrovascular disease	
- Immunosuppressed	

End-Tidal Oxygen Monitoring

Though not currently widely available, end-tidal oxygen (ETO2M) monitoring has the potential to improve emergency airway care dramatically. Though use in the Emergency Department remains relatively uncommon, ETO2M is a tool considered feasible and has potentially significant

benefits to preoxygenation [36]. These devices continuously monitor partial pressure of oxygen (PaO₂), rather than pulse oximetry (SpO₂). The quantification of oxygen content in the bloodstream could profoundly impact safe airway management. While pulse oximetry measures a maximal O₂ of 100%, without an arterial blood gas, the provider cannot confidently discern if the PaO₂ is 120 mm Hg or 350 mm

Fig. 15 Relevant information to communicate during airway response team (ART) consultation [25]

Relevant information to communication during ART consultation	
<i>Medical history</i>	• Age • Major co-morbidities, including: - Asthma - COPD or smoking history - Cardiovascular disease - Renal disease - Cerebrovascular disease • Previously documented intubations • Results of any recent cardiac or pulmonary studies, including: - Echocardiogram - Cardiac catheterization - Lung imaging - Pulmonary function tests
<i>Hospital course</i>	• Unit/location • Reason for admission • Current respiratory status, including: - Oxygen requirement - Objective work of breathing • Current hemodynamic status • Relevant labs and/or imaging

Difficult Airway Response Team Intubation Checklist



- 1.) Call Out
- 2.) Check Back
- 3.) Close the Loop

Coordinated Discussion with DART and Activating Providers
STEP 1: Airway Assessment & Plan

- ☐ When? *Stable or Unstable?*
- ☐ Where?
- ☐ Who? *Provider plan (eg ED → Anesthesia → ENT)*
- ☐ What? *Devices/equipment (eg CMAC Mac 3 VL → CMAC D blade VL → Trach)*
- ☐ How?

STEP 2: Preparation/Adjuncts
Pre-Intubation Plan

- ☐ Team PPE
 - ☐ *Airborne precautions?*
- ☐ Access
- ☐ Equipment
 - ☐ *VL, Fiberoptics, ETT, ETT securement device, viral filter, ventilator, etc*
- ☐ Suction
- ☐ Oxygenation plan
- ☐ Medications for Intubation
 - ☐ *RSI?*
 - ☐ *Awake?*
 - ☐ *Pretreatment (eg phenylephrine, bicarb)?*
 - ☐ *Who is managing medications (eg Anesthesia? ED pharmacy)?*

Post-Intubation Plan

- ☐ Securement device/depth
- ☐ Confirmation (*Colorimetric vs waveform ETCO2*)
- ☐ OG vs NG
- ☐ Post-intubation Medications
 - ☐ *Analgesia*
 - ☐ *Sedation*
- ☐ Ventilator Settings
 - ☐ *Rate, Tidal volume, FiO2, PEEP*
- ☐ ABG
- ☐ CXR

STEP 3: Disposition, Plan following airway
STEP 4: Debrief

- What went well?
- What needs to be improved?

Fig. 16 Difficult airway response team intubation checklist

Hg. With this example in mind, these two values have a significantly different safe apnea time during intubation. With use of end-tidal oxygen monitoring, the provider could theoretically monitor (in real time) the evolution of the PaO₂, rather than relying on the SpO₂ alone. In the above example, the transition from hyperoxia to hypoxia could be anticipated earlier and more reproducibly [36].

In a single study regarding use of ETO₂M in the peri-intubation phase, 67% ($n=67$, CI: 57 to 76%) of study participants with use of ETO₂M achieved an ETO₂ level > 85%, while 26% ($n=26$, CI: 18 to 36%) of control participants achieved the same ETO₂ level. This study additionally found ETO₂M particularly useful in the induction phase of intubation. With the use of only bag-valve-masks (BVM), induction was 80% successful in control patients, while the study group used BVM plus ETO₂M and achieved 90% successful inductions. Additionally, the prevalence of hypoxemia

(SpO₂ < 90%) was 18% ($n=18$, 95% CI: 11 to 27%) in the control group, while only 8% in the study group ($n=8$, 95% CI: 4 to 15%) [33]. Another study found the use of ETO₂M during rapid sequence intubation in the ED allowed for maximal preoxygenation in 44% (95% CI 29.6 to 55.8) more patients [37]. Future investigation should be completed with larger participant groups to further understand the benefits and limitations of ETO₂M on preoxygenation and hypoxia, though use of ETO₂M may be of great benefit for enhancing airway management safety.

Conclusion

Emergency airway management is an ever-evolving field that will continue to expand as new techniques and technologies become available. Advancing technologies,

strategies, and methods enhance provider ability to provide safe respiratory failure management and intubation care for patients. Continued effort in the airway community to equitably share information and innovations, continue conversations on best practice, and pursue an optimized and comprehensive care pathway will positively impact care locally, regionally, nationally, and globally.

Declarations

Conflict of Interest The authors declare no competing interests.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- Of importance
- Of major importance

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