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Airway Safety in the OR and Beyond: Balancing Innovation, Safety, and Core Skills

by Avery Tung, MD, FCCM, and P. Allan Klock, Jr., MD

INTRODUCTION

Over the past three decades, few aspects of anesthesia practice have evolved as much as airway management. Amidst an explosion of new devices, medications, and techniques, an anesthesia professional practicing in 1990 would have considerable difficulty recognizing airway management as it is currently practiced in 2025. Among the innovations likely to amaze the clinician of yesteryear would be the use of the Supraglottic Airway (SGA) as a rescue device or intubating tool,[1] and that video laryngoscopy (VL) is now commonly used for even routine airway management.[2] They would be surprised that airway management guidelines now recognize the physiologically difficult airway and the value of limiting the number of intubating attempts,[3] astonished that nondepolarizing muscle relaxants can be quickly and completely reversed,[4] and impressed that extracorporeal membrane oxygenation (ECMO) is increasingly used for extremely high-risk airways.[5]

After their initial surprise, our anesthesia professional of yesteryear would realize that high-success approaches are now available for many airways previously considered difficult and wonder whether the difficult airway is mostly solved or whether safety issues still remain for today's practitioner. They might then be intrigued to learn that while the number of publications per year with the keyword "difficult airway" has increased from 79 in 1990 to over 450 per year in 2024, the number of closed claims for difficult tracheal intubation as the damaging event has not decreased over time and, in fact, more recent claims generally involved sicker patients and nonoperative locations.[6]

This review will identify existing safety considerations, discuss current approaches to improving and maintaining safety, and suggest future strategies for addressing ongoing issues in modern airway management.

EPIDEMIOLOGY

The characteristics of adverse events during difficult airway management (DAM) are tough to describe because such events occur infrequently. Nevertheless, a 2019 review of closed malpractice claims due to airway management suggests a shift in the clinical features of such adverse events.[6] When compared to claims from 1993–1999, those from 2000–2012 more often involved sicker patients undergoing emergency procedures in nonoperating room (OR) locations. A 2017 review of Norwegian malpractice claims for injuries related to airway management noted that 37% of claims occurred during emergency procedures and that more than half of cases resulting in death were due to failed intubation or a misplaced endotracheal tube.[7] The 2015 United Kingdom National Audit Program 4 collected reports of airway management complications from 2008 to 2009 and similarly found that of the 33 events resulting in death, 16 occurred in the intensive care unit (ICU) and 3 in the Emergency Department.[8] Together, these observations suggest that today, airway events that lead to severe injury occur less often in elective OR situations and have shifted to occur more often during emergencies and in the ICU or other non-OR locations.

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CURRENT SAFETY IMPLICATIONS

This shift in the types of clinical encounters likely to lead to severe complications of DAM has two implications for improving safety. Because airway encounters associated with severe outcomes are more likely to be emergent and occur outside the OR, a focus of safe airway management should be to verify that equipment needed to handle likely DAM scenarios is readily accessible to airway managers outside the OR. In addition, the emergent nature of many DAM situations introduces time pressure, which increases stress and the risk for cognitive errors.

Whether originating in a call for urgent or emergent airway management in ICU or during a sequence of failed airway attempts in the OR, cognitive training is an increasingly important element of DAM. Evidence is increasing that "judgment errors" play a large role in adverse airway management events. Such errors include a lack of backup plans for airway management, failure to call for help early, failure to use a SGA as a bridge to oxygenation, and failure (or reluctance) to awaken the patient or progress to a surgical airway when it is clear that all available noninvasive options have failed.

Addressing the cause of "judgment" or decisional errors during DAM likely requires a multipronged approach. In the 2019 American Society of Anesthesiologists (ASA) closed claims study, judgment errors were more common during elective than urgent airway management. This observation suggests that prior to airway management, airway managers may have failed to recognize predictors of DAM during screening evaluations, or that screening exams may not always predict airway difficulty.[6] Both possibilities identify potential avenues for improvement. During airway management, several "cognitive traps" have been described including failure to promptly move to a surgical airway when indicated, repeatedly attempting intubation when previous efforts have failed, a reluctance to admit defeat, or not clearly declaring failure of conventional airway management techniques. These "human factor" issues may be amenable to metacognitive reflection[9] or simulation training.[10] Debriefing after events occur and participating in focused case conferences may also "move the needle" with respect to improving performance.[11]

Cognitive errors can meaningfully affect the course of airway management. Considerable data now suggest that repeated airway instrumentation both decrease the likelihood of subsequent success[12] and worsen eventual outcomes.[13] The 2022 ASA guidelines advise limiting intubation or supraglottic airway attempts to 3 or fewer if possible.[3] Repeatedly attempting to intubate or an unwillingness to admit failure can thus not only delay successful intubation but lead to adverse events.

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Cognitive Errors Can Contribute to Adverse Events in Airway Management

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Existing data show that airway managers must also make difficult decisions in the context of cardiorespiratory instability. The 2024 INTUBE study reviewed 2964 patients requiring intubation in the ICU and found that 45% experienced either cardiovascular instability, severe hypoxemia, or cardiac arrest during emergency intubation.[14] Even during elective anticipated DAM, the incidence of cardiorespiratory destabilization can be high, as observed in a 2025 descriptive study of 1295 episodes of elective DAM.[15] Although no cases from that series were cancelled for failure to intubate, the incidence of hypoxemia was 50%, the frequency of cardiovascular destabilization was 20%, and 30% of patients required 3 or more intubation attempts.[15]

Taken together, these large studies of airway management and clinician behavior suggest that airway managers should expect DAM to be both cognitively and technically difficult. Increasingly in 2025, important elements of safe airway management include developing an airway strategy with sequences of backup plans and training to avoid cognitive pitfalls such as perseveration, failure to call for help, losing track of time during a crisis, and reluctance to proceed to surgical airway access.

FUTURE CONSIDERATIONS

With the introduction of VL, SGA, other advanced airway tools, rapidly reversible neuromuscular blockers, and recognition of cognitive pitfalls in DAM, modern airway management is considerably safer than in the 1990s. However, the expanded "menu" of airway options and strategies available today introduces other potential safety challenges.

Among these challenges is the relative role of different intubating devices. Although not introduced into wide clinical practice until 2001, VL has overcome cost and learning curve challenges and supplanted direct laryngoscopy for many DAM applications. A 2023 multicenter randomized trial of intubation in critically ill patients found a higher first pass success rate with video than with direct laryngoscopy[16], leading many to propose that VL should become the standard for intubation. However, it is easy to see that preferential VL use can create a self-reinforcing loop where a "first attempt VL" preference leads to gradual deskilling in the use of direct laryngoscopy, which then tilts comparative trial outcomes towards VL—further reinforcing a "first attempt VL preference." It is likely that future use of direct laryngoscopy will diminish rapidly unless steps are taken to preserve it.

Similarly, because VL and SGA are effective in a wide variety of difficult airways, the role of awake flexible bronchoscopic intubation (AFB) is increasingly unclear. Because AFB requires considerable skill and practice, a preference for alternative techniques can lead to the same "deskilling" cascade as with direct laryngoscopy. Ultimately, further work is needed to determine whether AFB can/should continue to play a role in difficult airway management.

The more rapid learning curve for VL than for direct laryngoscopy or AFB also raises an organizational question as to how best to deploy airway management expertise.[17,18] Because fewer repetitions are needed with VL to achieve basic airway expertise, Emergency Room and Medical ICU clinicians can now provide a wide range of airway management services, freeing up anesthesiology clinicians currently in high demand for OR anesthesiology coverage. However, deciding when and how to bring anesthesiology and surgical expertise to an airway management event initiated by a nonanesthesia clinician remains an unanswered question. Although a first attempt by nonanesthesia airway managers is likely more efficient, potential pitfalls include a failure to recognize the difficult airway, the likelihood of airway damage or worsening conditions with repeated attempts. Multidisciplinary difficult airway response teams have had some success but still need to be called in a timely fashion by the initiating service.[19] How best to collaborate among services with respect to DAM will clearly be a safety challenge going forward.

Another unresolved issue is to determine the optimal approach to airway management in patients at increased risk for aspiration of gastric contents. Although current data suggest that asleep intubation with cricoid pressure does not reduce aspiration risk in high-risk patients and may worsen laryngoscopic views,[20] it is unclear whether an awake, topicalized, or AFB approach is better. No prospective randomized trial comparing the two techniques has been performed, and although a 1989 prospective observational trial found no explicit aspiration in 123 high-risk patients intubated via AFB, 10 patients developed laryngospasm, and severe coughing was present in 32.[21] From a safety perspective, strategies to preserve AFB skills among practitioners and identifying the optimal approach in patients at high risk for aspiration are both relevant future safety questions.

Another potential safety issue is the operational use of ECMO services for extremely difficult airways such as in patients with severe substernal goiter. In addition to being anatomically challenging, a large goiter can often make surgical airway access difficult and such patients may have tracheal compression below the vocal cords potentially impeding passage of an endotracheal tube. By restoring adequate gas exchange and potentially providing hemodynamic support in patients with mediastinal masses, venovenous or venoarterial ECMO can reduce the risk of oxygen desaturation or hypercarbia during airway management.[22]

Providing ECMO support to airway management is complex and requires strong teamwork between the ECMO clinician (usually cardiology or cardiac surgery) and the airway management team.[22] Issues include whether to implement ECMO in the awake patient prior to airway management, provide standby support with sheaths pre-inserted into the femoral vessels, or be ready to cannulate if airway management fails and emergent rescue is needed. If ECMO is needed for urgent rescue, training becomes an important element of successful time-

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Higher First Pass Success Rate With Video Laryngoscopy Than With Direct Laryngoscopy

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dependent execution. Although ECMO services are currently limited mostly to major academic or urban medical centers, accessibility may improve as ECMO technology becomes increasingly widespread. Better understanding how to deploy it effectively for DAM and how to train participants for rescue cannulation will be relevant future safety concerns.

SUMMARY

Although modern airway management is safer than ever, challenges still remain and the task of maintaining safe airway practice has grown increasingly complex. Many previously difficult airways are now easily managed with VL, and use of SGA as rescue devices and intubating tools is now widely recognized. However, the proliferation of intubating devices and techniques raises new safety questions. Among these is how best to preserve direct laryngoscopy skills when VL is increasingly the first choice for routine airways, how best to mitigate aspiration in high-risk patients, developing and teaching behavioral strategies to avoid cognitive traps, and integrating ECMO support into preemptive, standby, or rescue scenarios in patients with particularly high-risk airways. The solutions to these questions are likely to make airway management even safer in the future.

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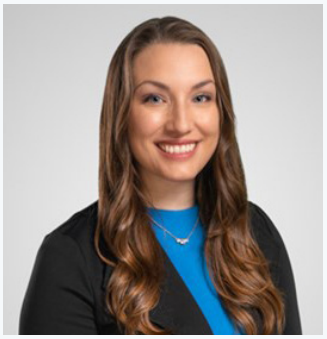

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