

# AANA JOURNAL COURSE

Update for nurse anesthetists

5

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## The SLAM Emergency Airway Flowchart: A new guide for advanced airway practitioners\*

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*Advanced airway practitioners in anesthesiology, emergency medicine, and prehospital care can suddenly and unexpectedly face difficult airway situations that can surface without warning during mask ventilation or tracheal intubation. Although tracheal intubation remains the “gold standard” in airway management, it is not always achievable, and, when it proves impossible, appropriate alternative interventions must be used rapidly to avoid serious morbidity or mortality.*

*The SLAM Emergency Airway Flowchart (SEAF) is intended to prevent the 3 reported primary causes of adverse respiratory events (ie, inadequate ventilation, undetected esophageal intubation, and difficult intubation). The 5 pathways of the SEAF include primary ventilation, rapid-sequence intubation,*

*difficult intubation, rescue ventilation, and cricothyrotomy. It is intended for use with adult patients by advanced airway practitioners competent in direct laryngoscopy, tracheal intubation, administration of airway drugs, rescue ventilation, and cricothyrotomy.*

*The SEAF has limitations (eg, suitable only for use with adult patients, cannot be used by certain categories of rescue personnel, and depends heavily on assessment of  $SpO_2$ ). A unique benefit is provision of simple alternative techniques that can be used when another technique fails.*

**Key words:** Combitube, emergency airway algorithm, failed intubation, laryngeal mask airway, rescue ventilation.

### Objectives

At the completion of this course, the reader should be able to:

1. Understand the relationship between the AVPU system (A, Alert; V, responds to Voice; P, responds only to Pain; U, Unresponsive) and the Glasgow Coma Scale and why the PU-92 Concept adopts an  $SpO_2$  level of 92% as its threshold for hypoxemia.
2. Be familiar with the important elements of the SLAM Emergency Airway Flowchart (SEAF).
3. List the major causes of morbidity and mortality in airway management, and discuss strategies to prevent them.
4. Discuss the benefits and limitations of rescue ventilation.

5. Describe the application of airway assessment and selection of a rational technique for management of the emergency airway.

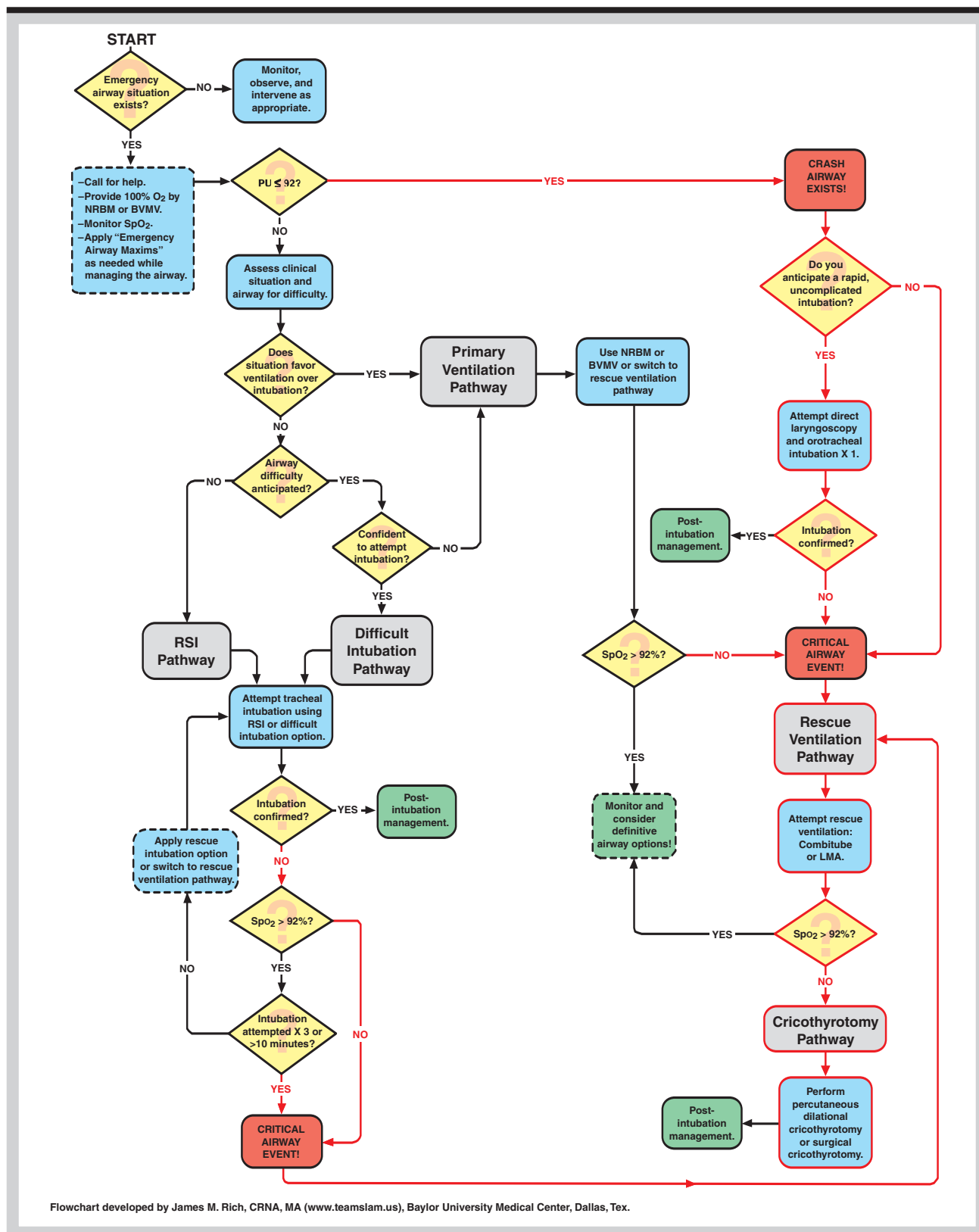
### Introduction

The SLAM Emergency Airway Flowchart (SEAF) (Figure 1) was created by one of us (J.M.R.) for the following reasons: (1) to create a comprehensive flowchart with clear and effective strategies for dealing with any emergency airway situation, especially those occurring in the prehospital and non-operating room hospital environments; (2) to teach prevention, rapid recognition, and treatment of critical airway events; (3) to assist practitioners in developing critical decision-making skills for emergency airway management; and (4) to improve patient safety with regard to

\* SLAM refers to Street Level Airway Management, which is an instructional method for teaching emergency airway management to advanced airway practitioners.

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**Figure 1. SLAM Emergency Airway Flowchart\***



The SLAM Emergency Airway Flowchart is based on the SLAM instructional system that teaches emergency airway management to advanced airway practitioners.

\*SLAM indicates Street Level Airway Management.

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Figure 1 (continued)

### Color and Line Key

- Pathway headings are gray.
- Decision points are yellow with a question mark.
- Action blocks are aqua.
- Critical blocks, borders, and lines are red: Treatment delays can lead to serious morbidity or mortality.
- Safe blocks are green: Definitive airway is established or oxygenation is attained and maintained using a ventilation technique.
- Consideration borders are dashed: Factors to consider include airway difficulty, clinical setting, clinical situation, provider skill, equipment/device availability, provider privileges, medical direction, and protocols/standing orders.

### Abbreviations/Definitions

- **BAAM:** Beck Airway-Airflow Monitor, Great Plains Ballistics, Lubbock, Tex (a.k.a. Beck whistle)
- **BURP:** Backward upward rightward pressure on the thyroid cartilage to improve the laryngoscopic view
- **BVMV:** Bag-valve-mask ventilation
- **Class IIa device:** A therapeutic option for which the weight of evidence is in favor of its usefulness and efficacy
- **Crash airway** patients have severe acute respiratory failure and typically 1) exhibit reduced responsiveness or are unresponsive; 2) have a respiratory rate of <10 or >30 breaths per minute; and 3) have severely depleted oxygen levels. Such patients are usually close to death and require either rapid tracheal intubation or immediate rescue ventilation.
- **Critical airway event:** Indicated by 1) any CVCI situation; 2) three or more failed intubation attempts or attempting intubation for >10 minutes (by the most experienced laryngoscopist); or 3) sustained hypoxemia that is refractory to positive pressure ventilation with 100% O<sub>2</sub>
- **CVCI:** Cannot ventilate—cannot intubate
- **Definitive airway:** Orotracheal tube, nasotracheal tube, or surgical airway
- **Difficult intubation:** When multiple laryngoscopies, maneuvers, and/or blades are needed by the most experienced practitioner
- **Difficult/inadequate mask ventilation:** Inability of the most experienced practitioner to prevent or reverse signs of inadequate ventilation with one- or two-person positive pressure BVMV, using an oropharyngeal or nasopharyngeal airway (or both) and 100% O<sub>2</sub>
- **ELM:** External laryngeal manipulation to improve the laryngoscopic view
- **Failed intubation:** Failure to intubate the trachea after multiple attempts, with or without hypoxemia
- **ILMA:** Intubating laryngeal mask airway or LMA-Fastrach
- **Lehane & Cormack laryngoscopic views of the airway:** Grade I—full view of the glottis from anterior to posterior commissure; Grade II—partial view of the glottis; Grade III—epiglottis only; Grade IV—soft tissue only—no visible laryngeal anatomy
- **LMA:** Laryngeal mask airway (LMA-Classical, LMA-Unique, LMA-Flexible, LMA-ProSeal)
- **MIAS:** Manual in-line axial stabilization
- **NRBM:** Nonbreathing mask
- **PU # 92:** (From Mason's PU-92 Concept.) With the AVPU system (A = alert; V = responds to voice; P = responds only to pain; U = unresponsive), patients with "P" or "U" assessments have Glasgow Coma Scale (GCS) scores of 9 or less. Hypoxemia exists with SpO<sub>2</sub> levels of 92% or less (allowing for ±2% accuracy of pulse oximeters). If a "P" or "U" assessment and hypoxemia occur simultaneously (i.e., PU # 92) despite optimal attempts at oxygenation using positive pressure BVMV and 100% O<sub>2</sub>, then a crash airway exists.
- **Rescue ventilation:** Administration of 100% O<sub>2</sub> and positive pressure ventilation (preferably via a Class IIa alternative airway device (i.e., Combitube or LMA) to treat a critical airway event
- **RSI:** Rapid sequence intubation. Relative indications are 1) head trauma with need for airway control and ventilation (e.g., Glasgow Coma Scale " 9); 2) uncooperative or combative patient with compromised airway; 3) uncontrolled seizure activity requiring airway control; 4) depressed level of consciousness in trauma patient; 5) risk of pulmonary aspiration (e.g., full stomach).
- **SLAM:** Street Level Airway Management is an instructional system for teaching emergency airway management ([www.teamslam.us](http://www.teamslam.us)).
- **SpO<sub>2</sub>:** Oxygen saturation as measured by a pulse oximeter
- **Tracheal intubation:** Indications include 1) airway protection and risk of aspiration; 2) definitive maintenance of airway patency; 3) head injury and Glasgow Coma Scale " 9; 4) mechanical ventilation and respiratory failure; 5) emergency surgery and requirement for general anesthesia; 6) application of advanced cardiac life support and drug administration; 7) maintenance of oxygenation or positive end-expiratory pressure; 8) pulmonary toilet.
- **Troop Elevation Pillow (Mercury Medical, Clearwater, Fla):** Airway management pillow that positions the patient in the head-elevated laryngoscopy position

### SLAM (Street Level Airway Management) Emergency Airway Maxims

1. **Call for help early. Maintain a portable emergency airway kit** with adjuncts that help to remedy difficult intubation, provide rescue ventilation, facilitate cricothyrotomy, and confirm tracheal intubation. **Patients suffer death and disability from failure to oxygenate and failure to ventilate**, not failure to intubate.
2. **General: The simple recognition that a patient needs a definitive airway** does not mean that the patient should receive a definitive airway if the provider is not skilled in establishing one. **Never exceed your ability**, experience, or scope of practice. **Consider naloxone or dextrose** to treat drug-induced coma. **Patients with a clenched jaw** will require paralysis and/or sedation in order to facilitate access to the oropharynx. In the absence of RSI drugs, insert 1 or 2 soft nasopharyngeal airways to optimize oxygenation.
3. **Primary Ventilation: Provide 100% O<sub>2</sub>** by NRBM or BVMV (± chin lift/head tilt or jaw thrust with oral/nasal airway as tolerated). **If tension pneumothorax exists**, decompress immediately. **Monitor SpO<sub>2</sub>** (carbon monoxide toxicity will falsely elevate SpO<sub>2</sub>). When a standard pulse oximeter probe fails to register a reading due to low perfusion, apply a probe to a different site or use Masimo SET technology (Masimo Corp, Irvine, Calif). Hypoxemia is difficult to diagnose clinically, so make every attempt to use pulse oximetry or obtain a blood gas reading.
4. **Assessment: Assess the clinical situation and airway** for potential signs of difficulty (e.g., disproportion, distortion, decreased range of motion, and dental overbite). When no airway difficulty is predicted, unexpected difficulty managing the airway may still arise.
5. **C-Spine Protection: Protect the c-spine** in suspected or evident c-spine injury by using MIAS during all airway maneuvers and when c-spine collar is not in place. Any intubation technique is acceptable as long as MIAS is employed.
6. **Aspiration Prophylaxis: Provide available aspiration prophylaxis** to help prevent silent aspiration or passive regurgitation, e.g., cricoid pressure, particulate-free antacid, and metoclopramide. The aspiration prophylaxis afforded by the Combitube is comparable to that of a tracheal tube. The LMA protects against aspiration substantially better than BVMV. Direct laryngoscopy and tracheal intubation without neuromuscular blockers (NMBs) has a higher documented incidence of aspiration than RSI with neuromuscular blockers.
7. **Tracheal Intubation:** Use only methods with which you are trained and skilled. **Intubation attempts should be limited** to <10 minutes or " 3 times by the most experienced practitioner. Employ intubation-rescue techniques between attempts (to decrease the occurrence of trauma, bleeding, and edema in the airway, which can impair mask ventilation or subsequent intubation attempts and possibly cause a CVCI situation). **Intubation-rescue techniques include** bougie-assisted intubation (e.g., gum elastic bougie, Eschman Introducer, SunMed Bougie Introducer, etc); ELM or BURP; head-elevated laryngoscopy position; assessing and/or improving neuromuscular blockade; changing blade type (straight vs. curved) or blade length. **Along with the previously mentioned intubation-rescue techniques, difficult intubation options include but are not limited to** use of the McCoy laryngoscope, blind nasotracheal intubation (± BAAM (+ Endotrol tube where mouth opening is inadequate)), and ILMA (± spontaneous ventilation; ± BAAM). Combined use of the Troop Elevation Pillow, ELM or McCoy articulating laryngoscope, and bougie introducer can synergistically facilitate intubation in patients with c-spine precautions (MIAS), morbid obesity, and other causes of Lehane & Cormack grade III or IV laryngoscopic views. **A definitive airway is always best**; however, rescue ventilation can provide interim improvement in oxygenation and ventilation until a definitive airway is established.
8. **Confirmation of Tracheal Intubation: Always confirm and document intubation** using an evidence-based device (CO<sub>2</sub> detector or self-inflating bulb) in conjunction with auscultation over the mid-axillary lines and abdomen. Use a quantitative or qualitative CO<sub>2</sub> detector in patients with a perfusing heart rhythm. Use a self-inflating bulb in patients with a nonperfusing heart rhythm.
9. **Rescue Ventilation: Provide rescue ventilation using a Combitube or LMA** in the presence of a critical airway event. The Combitube and LMA are supraglottic airway devices and thus can only assist with a supraglottic obstruction. If rescue ventilation fails, the final option is cricothyrotomy. Glottic or subglottic obstructions require intervention using either a tracheal tube or cricothyrotomy.
10. **Traumatized or Burn Airway: Avoid blind intubation techniques** in the presence of laryngotracheal trauma. Avoid neuromuscular blockers in blunt neck trauma to prevent potential airway collapse. Up to 6% of patients with blunt airway trauma may have coexisting c-spine injuries. Use only a tracheal tube to maintain patency of a surgical airway for acute burn and inhalation injuries and thus prevent subsequent edema of the anterior neck tissues from engulfing the surgical airway.

#### SLAM (Street Level Airway Management) Emergency Airway Flowchart

- The advice featured in this flowchart should be overridden when medical direction, clinical experience, the clinical situation, and/or local protocols dictate.
- This flowchart is intended for use in adult patients and should only be used by advanced airway practitioners who at a minimum are competent in the use of airway management drugs, direct laryngoscopy, tracheal intubation, rescue ventilation techniques, and cricothyrotomy.

emergency airway management.<sup>1-3</sup> It is intended for use by advanced airway practitioners trained in direct laryngoscopy, tracheal intubation, the administration of drugs for airway management,<sup>4</sup> rescue ventilation techniques,<sup>2</sup> and cricothyrotomy.<sup>5</sup>

Tracheal intubation (ie, the “gold standard”) is not always achievable, and airway difficulty cannot always be predicted.<sup>6</sup> Difficulty with intubation usually results from a complex clinical situation. The degree of difficulty can vary from case to case and problems can occur rapidly during mask ventilation or tracheal intubation.<sup>7</sup> Difficult laryngoscopy<sup>6</sup> (eg, inability to view any portion of the glottic inlet using an optimal laryngoscopic technique) is reported to be around 6% in anesthesia,<sup>6</sup> whereas difficult laryngoscopy created by the need for the neutral head position (eg, cervical spine precautions) runs as high as 42%.<sup>8</sup> The increase in morbid obesity also is resulting in an increased incidence of difficult laryngoscopy from prehospital through operating room settings.<sup>9</sup> Regardless of why laryngoscopy is difficult or failed intubation occurs, the situation usually can be resolved with rescue ventilation.<sup>2,10</sup> Rescue ventilation using a laryngeal mask airway (LMA) (LMA North America, San Diego, Calif) or esophageal-tracheal Combitube (Tyco-Healthcare-

Nellcor, Pleasanton, Calif) can provide a crucial life-line.<sup>2</sup> Since a difficult airway situation can occur without warning and regardless of the experience or scope of practice of the practitioner,<sup>6,11-18</sup> the SEAF does not differentiate between physician and nonphysician (Table 1).

## Methods

Wherever possible, recommendations and methods used<sup>6,19-23</sup> for the development of previous airway management algorithms were applied. However, particular emphasis was placed on the development of evidence-based universal guidelines suitable for use by any advanced airway practitioner.

Connis et al<sup>24</sup> reported that evidence-based practice guidelines are becoming the preferred resource for decision making in patient care. Previous airway flowcharts and guidelines were developed by using scientific linkages, the weight of medical evidence from peer-reviewed literature, and the consensus of expert opinion.<sup>6,20,21,23</sup> However, practice guidelines and evidence-based recommendations for airway management remain limited.

- *SEAF developmental process.* The SEAF was developed in response to requests for information on decision-making strategies for emergency airway situa-

**Table 1. Comparisons between airway management flowcharts**

	<b>For use by</b>	<b>Target location</b>	<b>Advocates airway evaluation?</b>	<b>Offers intubation-rescue techniques?</b>	<b>Presents rescue ventilation techniques?</b>	<b>Presents information on aspiration prophylaxis?</b>	<b>Advocates evidence-based techniques for confirmation of TI?</b>
Algorithms of R.M. Walls <sup>19</sup>	Emergency medicine physicians	Emergency department	Yes	Yes	Yes	Yes: cricoid pressure	No
ASADAA <sup>20</sup>	Anesthesiologists and those supervised by them* <sup>20</sup>	Anesthetizing locations	Yes: 11-step pre-operative assessment plan	No	Yes	No	Yes: capnography or EDD
ERC flowchart for advanced management of the airway and ventilation <sup>21</sup>	Physicians	Prehospital and hospital locations	No	No	Yes	No	No
SLAM Emergency Airway Flowchart <sup>9</sup>	Advanced airway practitioners: room hospital nurses, physicians, paramedics, and others	Prehospital, non-operating room hospital locations, and operating room as indicated	Yes: quick 4-step assessment	Yes	Yes	Yes: cricoid pressure, nonparticulate antacid, and metoclopramide	Yes: capnography or EDD

SLAM indicates street level airway management; ASADAA, ASA Difficult Airway Algorithm; ERC, European Resuscitation Council; TI, tracheal intubation; EDD, esophageal detector device.

\*ASADAA application statement: “The guidelines are intended for use by anesthesiologists and by individuals who deliver anesthetic care and airway management under the direct supervision of an anesthesiologist.”<sup>20</sup>

tions from participants at multidisciplinary advanced airway programs.<sup>25</sup> This was accomplished by performing a default electronic PubMed literature search and reviewing other peer-reviewed literature not indexed in PubMed. The literature search included criteria and recommendations from previous algorithms<sup>6,20,22,23,26</sup> and additional aspects not addressed in previous airway algorithms.

Care was taken to ensure the suitability of the SEAF for advanced airway practitioners working in prehospital through non-operating room hospital settings. This was accomplished through review by acknowledged international experts in airway management and by soliciting comments from advanced airway practitioners at multidisciplinary professional meetings. At these meetings, the SEAF was presented in various formats, including oral presentation,<sup>27,28</sup> poster session,<sup>29</sup> abstract,<sup>9,30</sup> and educational/scientific exhibit.<sup>31,32</sup> Rich et al<sup>32</sup> received the award for the best scientific exhibit for clinical application at the 57th Postgraduate Assembly of Anesthesiologists.<sup>33</sup>

• **Definition of terms.** “Airway event” definitions that are in current use are largely directed at situations encountered by physicians or those supervised by them (see Table 1).<sup>6,19,20</sup> However, not all come under direct medical supervision (eg, many Certified Registered Nurse Anesthetists, paramedics, nurses). The definitions used in the SEAF (eg, difficult or inadequate mask ventilation, difficult intubation, failed intubation, and rescue ventilation) are consistent with those used in current standard guidelines (see Figure 1).<sup>6,19-21,26</sup> However, a new term, *critical airway event*, is used in lieu of the anecdotal term *failed airway* to encapsulate the critical airway conditions that generally are reversible using rescue ventilation but may lead to death or disability if they are allowed to continue unchecked.<sup>2,14,15</sup> Therefore, a critical airway event consists of any one of the following: (1) any “cannot ventilate–cannot intubate” situation, (2) 3 or more failed intubation attempts or attempting intubation for more than 10 minutes (by the most experienced laryngoscopist), or (3) sustained hypoxemia (ie, SpO<sub>2</sub> < 92%) that is refractory to positive-pressure ventilation with 100% oxygen.<sup>2</sup>

## Results

The SEAF (see Figure 1) consists of the following: (1) 5 distinct treatment pathways; (2) color-coded blocks and lines to differentiate between treatment pathways (gray), safe zones (green), critical airway events (red), decision points (yellow), required actions (blue), and clinical considerations (dashed border); (3) emergency airway definitions; and (4) emergency airway maxims. It allows for the fact that airway management is performed in various locations (eg, prehospital

locations, non-operating room hospital locations, operating rooms) by different types of practitioners (eg, paramedics, nurses, and physicians) with different levels of training and experience who face a variety of clinical situations.<sup>2-4,12,13,17,34,35</sup> The location of care can affect the clinical situation by creating difficulty in what might otherwise be a fairly routine airway management encounter (eg, prehospital confined-space rescue).<sup>16,17,36</sup> Additional beneficial features are listed in Table 2.

## Discussion

The American Society of Anesthesiologists Closed Claims Study of 1990 demonstrated that death or brain damage occurred in more than 85% of 522 airway claims that were analyzed through 1985.<sup>14</sup> Inadequate ventilation, unrecognized esophageal intubation, and difficult intubation accounted for approximately 75% of the adverse respiratory events.<sup>14</sup> Improvements in monitoring within the operating room have greatly decreased the first 2 mechanisms of injury in anesthesiology.<sup>2</sup> However, reports of airway injury, inadequate ventilation, unrecognized esophageal intubation, and other complications of airway management continue to be reported across the spectrum of airway management.<sup>12,15,35</sup> The SEAF is intended, at a minimum, to assist in preventing these types of airway complications.

**Table 2. Additional beneficial features of the SLAM emergency airway flowchart**

1. Assessing\* the airway for difficulty<sup>4,6,19,20,37</sup>
2. Use of a primary ventilation option instead of tracheal intubation if assessment of the airway or clinical situation favors ventilation over intubation<sup>2,3,34</sup>
3. Use of technique modification between laryngoscopy attempts in an effort to rescue an unsuccessful intubation<sup>38</sup>
4. Always proceeding with rescue ventilation in the presence of a critical airway event (eg, sustained hypoxemia or attempting intubation ≥ 3 times or > 10 minutes without success)<sup>6,13,19,38</sup>
5. Inclusion of Mason’s PU-92 Concept for rapid recognition of the crash airway<sup>30</sup>
6. Use of a class IIa adjunctive airway device (ie, esophageal-tracheal Combitube or laryngeal mask airway) to provide rescue ventilation<sup>4,6,13,19,23,38</sup>
7. Selecting an evidence-based adjunctive device to confirm tracheal intubation according to the presence or absence of a perfusing cardiac rhythm<sup>4,6,12,13,15,26,38</sup>

SLAM indicates street level airway management.

\*Airway assessment should be undertaken rapidly as the situation permits, using the 4-D method described by Mallampati (ie, disproportion, distortion, decreased range of motion, and dental overbite).<sup>37</sup>

One aspect of the SEAF is the primary ventilation pathway, which can be chosen in lieu of either of the tracheal intubation pathways if the clinical situation favors ventilation over intubation.<sup>3,16,17,36</sup> In addition, the SEAF offers a choice of 2 tracheal intubation pathways—the difficult intubation and the rapid-sequence intubation pathways. By design, both tracheal intubation pathways use a common format to do the following: (1) confirm intubation, (2) attempt to maintain an SpO<sub>2</sub> of more than 92% (see later discussion of Mason's PU-92 Concept), (3) limit intubation attempts to 3 or fewer (by the most experienced laryngoscopist), and (4) attempt intubation-rescue techniques<sup>9,39</sup> between intubation attempts. This is accomplished by using simple techniques intended to improve a subsequent intubation attempt (eg, external laryngeal manipulation, head-elevated laryngoscopy position, use of bougie-assisted intubation, change in blade length or type, assessment of the degree of muscle paralysis, and combined use of a lever-tip laryngoscope (eg, McCoy) and bougie for cervical spine-injured patients).<sup>8,19,38,39</sup> As an alternative, the rescuer may switch to the rescue ventilation pathway if intubation is found to be unfeasible after 1 or 2 attempts. However, if intubation has been attempted 3 times or more or for 10 minutes or longer<sup>6,38</sup> or the SpO<sub>2</sub> is 92% or less even with the use of 100% oxygen and optimal positive-pressure ventilation,<sup>38</sup> it is essential to acknowledge that a critical airway event is present and to immediately use rescue ventilation.<sup>2</sup> If rescue ventilation fails, the final option is performance of a cricothyrotomy.<sup>9</sup>

Difficult intubation continues to be a source of disability and death during emergency airway management.<sup>6,14,15,35</sup> Therefore, the SEAF goes beyond some algorithms<sup>20,21</sup> through the additional techniques it recommends for rescuing failed intubation<sup>9,17,38,39,40-43</sup> and overcoming a predicted difficult intubation.<sup>39</sup> Use of these techniques can attenuate difficult intubation and prevent the airway trauma that has been reported to cause death or disability.<sup>14,15,38</sup> A recent report indicates that regular practice along with the use of a practical algorithm is the key to success in overcoming difficult airway situations.<sup>44</sup>

The rapid-sequence intubation pathway is recommended for use only in patients meeting the criteria for it.<sup>45</sup> As an algorithm, the SEAF is unique in recommending acknowledged techniques that promote aspiration prophylaxis.<sup>38,45,46</sup> In addition, in accordance with International Guidelines 2000, only an evidence-based method (eg, use of an esophageal detector device and/or a carbon dioxide detector) is recommended for confirmation of tracheal intubation or monitoring of lung ventilation, regardless of the location of care (see Figure 1).<sup>2,26,47</sup>

Walls<sup>19</sup> originally described the “crash air-

way”<sup>13,21,26,38,48</sup> to categorize patients with acute respiratory failure who (1) were unconscious, (2) were apneic or having agonal respirations, (3) had arrested or were near death, and (4) were anticipated to be unresponsive to (ie, tolerant of) laryngoscopy. The rescue ventilation pathway is recommended in the presence of a crash airway or other critical airway event.<sup>23,26</sup> Even though such patients are clearly in extremis and possibly beyond help, the concept of a crash airway is of great value because it conveys an unmistakable sense of urgency to the rescuer. For this reason, we revised the definition of the crash airway and broadened its scope to include other victims who might benefit from immediate intervention to secure the airway (Table 3).<sup>1</sup>

On recognition, rapid treatment of the crash airway is required to prevent disability and, in the worst case, death. At a minimum, patients require immediate ventilation and oxygenation to survive. By using the SEAF, the provider has 2 treatment options to improve the oxygenation when a crash airway is identified. Should the rescuer initially determine that the clinical situation does not favor a rapid, uncomplicated intubation, rescue ventilation should be used immediately (see Figure 1).<sup>2</sup> However, if the rescuer determines that the clinical situation favors provision of a rapid, uncomplicated intubation, 1 attempt at direct laryngoscopy and tracheal intubation may be made.<sup>19</sup> However, if tracheal intubation is not confirmed immediately, the rescuer should proceed directly with rescue ventilation (see Figure 1).

Mason's PU-92 Concept (Figure 2) is central to rapid recognition of the crash airway.<sup>30</sup> The inclusion of this

**Table 3. Revised\* model of the crash airway<sup>19</sup>**

Patients who simultaneously exhibit the following triad of signs should be considered to have a crash airway:

1. Significantly reduced responsiveness (having a Glasgow Coma Scale score of 9 or less)
2. Significantly depleted oxygen levels<sup>†</sup> (having an Sao<sub>2</sub> level of 90% or less)
3. A respiratory rate of <10 or >30 breaths per minute,<sup>2,30</sup> the hypoxemia having been unresponsive to basic methods to improve oxygenation (eg, positioning and clearing of the airway, use of a nonbreathing mask or bag-valve-mask ventilation together with high-flow oxygen therapy)

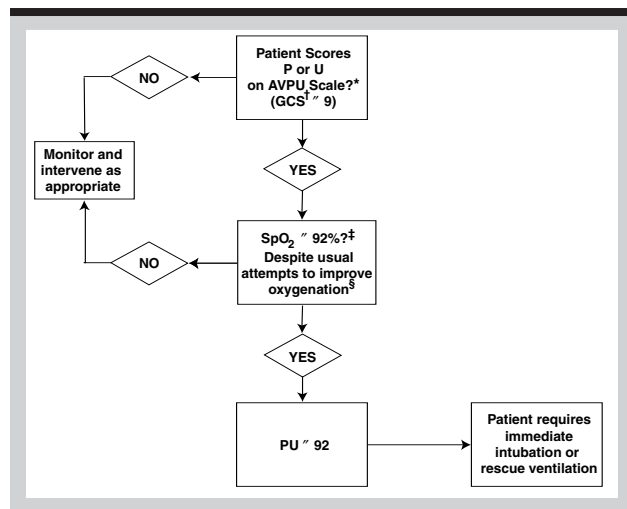
\*Use of this revised model for the crash airway should ensure that trauma patients who might benefit from immediate airway intervention are not overlooked in the prehospital phase of treatment.

† Early oxygenation via a secure airway is of vital importance for patients who have sustained serious brain injuries since the combination of hypoxemia and hypercarbia is potentially lethal in patients who already have a primary cerebral insult.

new concept enhances the functionality of the SEAF. Mason's concept simply combines an assessment of the level of consciousness using the AVPU system (A, Alert; V, responds to Voice; P, responds only to Pain; U, Unresponsive) with the patient's SpO<sub>2</sub> level.<sup>30,49</sup> McKay et al<sup>49</sup> established that an AVPU assessment of P or U corresponds to a Glasgow Coma Scale score of 9 or less. Therefore, using the PU-92 Concept, a "P" or "U" AVPU assessment indicates that the patient already meets one of the criteria for immediate intubation (see Figure 2). The second limb of the PU-92 Concept recognizes that pulse oximeters have an inherent accuracy of  $\pm 2\%$ .<sup>50</sup> Therefore, to ensure that the arterial oxygen saturation level (SaO<sub>2</sub>) is kept above the hypoxemia threshold of 90%, the rescuer is encouraged to make every attempt to maintain the SpO<sub>2</sub> above 92%. By combining these 2 components, a "yes" answer to the "PU  $\leq 92$ " question posed in the SEAF (following maximal efforts with positive-pressure mask ventilation and 100% oxygen) indicates that both criteria for immediate intubation have been met and that a crash airway exists. When an SpO<sub>2</sub> reading cannot be obtained, a respiratory rate of less than 10 or more than 30 breaths per minute in conjunction with a P or U assessment using the AVPU system similarly should alert the rescuer to suspect the existence of a crash airway.

Rescue ventilation involves using 100% oxygen

**Figure 2. Mason's PU-92 Concept is a simple scheme to identify patients requiring either immediate intubation or rescue ventilation.**



\*AVPU Scale: A, alert; V, responds to voice; P, responds only to pain; U, unresponsive to pain. An AVPU assessment of P or U corresponds to a Glasgow Coma Scale score of  $\leq 9$ .<sup>49</sup>

<sup>†</sup>GCS indicates Glasgow Coma Score.

<sup>‡</sup> Pulse oximeters have an inherent accuracy of  $\pm 2\%$ .<sup>50</sup>

<sup>§</sup> High-flow oxygen via non-rebreathing mask or bag-valve-mask assisted ventilation with oropharyngeal or nasopharyngeal airway,  $\pm$  decompression of tension pneumothorax

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and positive-pressure ventilation, ideally via a class IIa adjunctive airway device.<sup>2,23</sup> Class IIa status is reserved for a therapeutic option for which the weight of evidence is in favor of its usefulness and efficacy.<sup>47</sup> Although other techniques may prove effective for rescue ventilation,<sup>51</sup> the esophageal-tracheal Combitube and LMA currently are the only alternative airway devices with a class IIa designation<sup>2</sup> and, therefore, are recommended preferentially for treating critical airway events.<sup>2,3,6,9,10,19-21,38</sup> However, since the esophageal-tracheal Combitube and LMA are supraglottic airway devices, they offer no assistance in overcoming a glottic or subglottic obstruction.<sup>38</sup> For these types of obstruction, a tracheal tube or cricothyrotomy should be used.<sup>38</sup>

## Conclusions

The SEAF offers a clear evidence-based approach to facilitate management of a wide range of emergency airway situations encountered by advanced airway practitioners who provide care in various treatment locations. Throughout the SEAF, oxygenation and ventilation are emphasized over intubation, because patients die or are disabled from failure to ventilate and oxygenate, rather than failure to intubate.<sup>14</sup>

The SEAF has similarities and differences with regard to previous algorithms (see Table 1). Like the American Society of Anesthesiologists Taskforce on Difficult Airway Management, the SEAF recommends ready availability of a portable airway kit (Table 4). In addition, it provides a resource for developing management strategies essential to the common practice of emergency airway management (see Figure 1).

The 3 primary limitations of the SEAF are the following: (1) It is suitable for use only with adult patients. (2) It cannot be used by rescue personnel who are not trained in the use of anesthetic drugs and neuromuscular blocking agents to facilitate intubation. (3) It depends heavily on assessment of the SpO<sub>2</sub>. If measurement of SpO<sub>2</sub> is impossible or data are unavailable, rescuers must proceed using their best judgement about the status of the oxygen content. However, since the clinical recognition of hypoxia is unreliable,<sup>52</sup> every effort should be made to obtain a pulse oximeter reading (see Figure 1). Nevertheless, one of the main benefits of the SEAF is provision of effective alternative techniques that can be used when an intubation or ventilation technique fails. This gives the rescuer the advantage of modifying a failed technique or substituting another technique to rectify the crisis. Unpublished anecdotal reports exist showing that application of the SEAF has resulted in the successful rescue of several critical airway situations; however, further field testing is required to confirm its usefulness in the clinical situations for which it has been designed.

**Table 4. Recommended contents for a portable emergency airway kit**

1. Tracheal intubation components
  - a. Beck airway airflow monitor (BAAM whistle, Great Plains Ballistics, Lubbock, Tex)
  - b. Blades: straight (#2, #3, and #4) and curved (#3 and #4)
  - c. Drugs
    - i. Etomidate
    - ii. Lidocaine jelly, 2%
    - iii. Topical lidocaine, 4%
    - iv. Oxymetazoline nasal spray
    - v. Rocuronium
    - vi. Succinylcholine
    - vii. Glycopyrrolate
  - d. Examination gloves
  - e. Flexible bougie introducer/stylet (eg, gum elastic bougie)
  - f. Water soluble lubricant such as K-Y Jelly
  - g. Laryngoscope handle (2)
  - h. LMA-Fastrach (optional)\*
    - i. #3, #4, and #5
    - ii. Stabilizing rod
    - iii. Straight reinforced atraumatic tracheal tubes 7.0, 7.5, 8.0
  - i. Lever-tip laryngoscope (optional)
  - j. Magill forceps
  - k. Malleable stylet
  - l. Syringes and needles
  - m. Tape, tracheostomy tape, or Thomas endotracheal tube holder (Laerdal Medical, Wappingers Falls, NY) to secure tracheal tube or LMA
  - n. Tracheal tubes (sizes 6.0, 7.0, and 8.0)
  - o. Tracheal tube exchange catheter (eg, Cook exchange catheter, Cook Group Inc, Bloomington, Ind)
2. Ventilation devices and adjuncts
  - a. Combitube SA (37F)
  - b. LMA-Classic or LMA-Unique (#3, #4, and #5)
  - c. Oropharyngeal airways, 70 mm through 100 mm
  - d. Nasopharyngeal airways 26F through 34F
  - e. Ventilation bag with face mask
3. Devices to confirm tracheal intubation
  - a. Handheld carbon dioxide detector (electronic or colorimetric)
  - b. Self-inflating bulb
  - c. Stethoscope
4. Cricothyrotomy: percutaneous dilational cricothyrotomy kit (eg, Melker [Cook Group Inc, Bloomington, Ind], Pertrach [Engineered Medical Systems, Indianapolis, Ind])

\* LMA indicates laryngeal mask airway.

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