



Updates in emergency airway management

Jestin N. Carlson^a and Henry E. Wang^b

Purpose of review

Historically, most evidence supporting emergency airway management strategies have been limited to small series, retrospective analyses and extrapolation from other settings (i.e. the operating room). Over the past year, several large, randomized clinical trials have offered new findings to inform emergency airway management techniques.

Recent findings

One large, randomized clinical trial, found improved first attempt success rates with bougie facilitated intubation compared with traditional intubation. Two randomized clinical trials suggested better outcomes in adult out-of-hospital cardiac arrest (OHCA) with supraglottic airways (SGA) than intubation. A randomized clinical trial in OHCA patients could not identify outcome differences between endotracheal intubation (ETI) and bag-valve mask (BVM) ventilation but suggested higher rates of aspiration with BVM.

Summary

These studies offer new findings to inform the practice of emergency airway management. Bougie use should be considered as a first-line approach in emergency intubation. SGA-based strategies should be considered as a first-line approach in the management of OHCA.

Keywords

cardiopulmonary resuscitation, emergency medical service, endotracheal intubation, out-of-hospital, tracheal intubation, airway management, bag-mask ventilation, gum-elastic bougie, supraglottic airway

INTRODUCTION

Airway management is a cornerstone of resuscitation of critically ill patients. The most common technique used for advanced airway management is endotracheal intubation (ETI). Whether in the ICU, emergency department, or the prehospital setting, unique challenges arise when managing the airway of acutely ill and injured patients, including the acutely decompensated nature of the patient, the limited available resources, and the skill set of the provider. Several strategies have advocated emergency airway management using novel techniques such as the bougie, video laryngoscopy and supraglottic airways [1[•],2[•],3,4]. These strategies were based on retrospective reviews, case-series or small studies; there have been few randomized clinical trials [1[•],2[•],4]. The past year has seen the completion and report of large randomized clinical trials informing key aspects of emergency airway management (Table 1) [5^{••}–8^{••}].

THE BOUGIE IN EMERGENCY AIRWAY MANAGEMENT

The tracheal tube introducer (also known as the 'bougie' or gum-elastic bougie) is a long flexible

device with an angled tip that can be placed through the vocal cords during intubation, facilitating advancement of an endotracheal tube. The bougie can facilitate intubation even if the glottis cannot be completely visualized, offering advantages in cases of anticipated difficult laryngoscopy or difficult intubation. Simulation studies and retrospective analyses have shown improved rates of successful intubation on the first attempt with the bougie compared with traditional techniques consisting of endotracheal tube insertion without a bougie. However, limited prospective data have examined the utility of the bougie outside the operating room [1[•],9].

Driver *et al.* [5^{••}] conducted the Bougie use in Emergency Airway Management (BEAM) trial, a randomized clinical trial comparing first-pass intubation

^aDepartment of Emergency Medicine, Allegheny Health Network, Erie, Pennsylvania and ^bDepartment of Emergency Medicine, University of Texas Health Science Center at Houston, Houston, Texas, USA

Correspondence to Jestin N. Carlson, MD, MSc, Department of Emergency Medicine, Allegheny Health Network, 232 West 25th St, Erie, PA 16544, USA. E-mail: jestin.carlson@ahn.org

Curr Opin Crit Care 2018, 24:525–530

DOI:10.1097/MCC.0000000000000552

KEY POINTS

- In a single-center randomized trial, bougie use resulted in greater first attempt success for endotracheal intubation in emergency department patients compared with the use of a traditional endotracheal tube with stylet both in the overall emergency department patient population and those with difficult airway characteristics.
- Bag-valve-mask ventilation results in higher rates of airway-related complications compared with intubation in out-of-hospital cardiac arrest.
- On the basis of results of two large randomized clinical trials, an SGA first strategy may result in improved outcomes in out-of-hospital cardiac arrest.

success between bougie-facilitated intubation and conventional intubation with a styletted endotracheal tube. The trial took place at a large urban emergency department and level 1-trauma center. Patients were included if they were at least 18 years old and undergoing ETI in the emergency department. Patients with upper airway obstruction (e.g. angioedema), prisoners and pregnant patients were excluded. Intubations were completed by either an upper level emergency medicine resident or

attending emergency physician. Providers reported difficult airway characteristics (e.g. large tongue, obesity, facial trauma, etc.). The primary outcome was first-attempt intubation success. The patients were assessed in two groups; those with at least one difficult airway characteristic and all patients.

The trial enrolled 757 patients, including 381 facilitated by bougie and 376 with endotracheal tube and stylet. The primary analysis compared first-attempt success in patients with at least one difficult airway characteristic. In these patients, first-attempt success at intubation was higher in the bougie than the standard endotracheal intubation group [96 vs. 82%, absolute between-group difference, 14% (95% CI 8–20%)]. When including all patients, first-attempt success at intubation was also higher in the bougie (98%) than standard endotracheal intubation group (87%) [absolute difference, 11% (95% CI 7–14%)]. Secondary outcomes such as duration of first intubation attempt and hypoxemia were similar between the groups.

Although the results of the BEAM study are intriguing, there are important limitations. The operators in the Driver study had regular experience with first-line bougie use in emergency airway management [5^{***}]. The results may have differed in settings with practitioners lacking bougie experience. The trial took place at a single center, and it

Table 1. Summary of recent randomized clinical trials in emergency airway management

Study	Setting	Population (n)	Comparison (n; n)	Primary outcome	Primary results	Comments
Driver <i>et al.</i> [5 ^{***}]	ED	All patients undergoing ETI (n=757)	Bougie-facilitated (n=381) and endotracheal tube with stylet (n=376)	First-attempt success rate for endotracheal intubation in patients with at least one difficult airway characteristic	Bougie, 96% Endotracheal tube with stylet, 82% Absolute between-group difference, 14% (95% CI 8–20%)	Operators had significant prior experience with the bougie
Jabre <i>et al.</i> [6 ^{***}]	Prehospital	OHCA (n=2043)	BVM (n=1020) and ETI (n=1023)	Good neurologic outcome at 28 days	BVM, 4.3% ETI, 4.2% Difference, 0.11% (one sided 97.5% CI –1.64 to infinity)	Airways were managed by prehospital physicians. Unable to demonstrate either inferiority or noninferiority of BVM to ETI
Wang <i>et al.</i> [7 ^{***}]	Prehospital	OHCA (n=3004)	SGA (n=1505) and ETI (n=1499)	Survival at 72 h	SGA, 18.3% ETI, 15.4% Adjusted difference, 3.6% (95% CI 0.3–6.8%)	Examined the King LT Not powered for longer-term outcomes ETI success rate 51.3%
Benger <i>et al.</i> [8 ^{***}]	Prehospital	OHCA (n=9296)	SGA (n=4886) and ETI (n=4410)	Neurologically intact survival at hospital discharge or 30 days	SGA, 6.4% ETI, 6.8% Adjusted risk difference –0.6% (95% CI 1.6–0.4%)	Examined the iGel Randomization occurred at the paramedic level Over 20% of the patients in the ETI group did not receive ETI or SGA

BVM, bag-valve-mask ventilation; CI, confidence interval; ED, emergency department; ETI, endotracheal intubation; LT, laryngeal tube; SGA, supraglottic airway.

is uncertain how these results would generalize to other emergency departments or practice settings (i.e. ICU or prehospital). Operators used a single type of laryngoscope blade (standard Macintosh blade). The operators were not blinded to the allocation group. Protocol deviations occurred in 7% of cases where providers elected to use the bougie instead of standard intubation.

Despite its potential advantages, the bougie is utilized in less than 5% of emergency department intubations, customarily reserved for cases of intubation difficulty [10]. The Driver study highlights the potential benefit of primary bougie use in emergency intubations. The bougie is inexpensive and can be used in a broad range of clinical scenarios. If confirmed in larger studies, the findings of BEAM could influence emergency intubation practices. Given the findings of this prospective RCT, it is reasonable to consider the bougie as a first-line intervention for emergency intubation; however, successful use requires training and skill maintenance for proficiency.

AIRWAY MANAGEMENT IN OUT-OF-HOSPITAL CARDIAC ARREST

Airway management is a cornerstone in the resuscitation of out-of-hospital cardiac arrest (OHCA). However, how and when to perform advanced airway management are unclear [11,12]. Although widely used in United States paramedic practice, numerous studies highlight the pitfalls of out-of-hospital endotracheal intubation, including unrecognized tube misplacement, multiple attempts, and interruptions in CPR chest compressions [13]. To minimize chest compression interruptions, some EMS practitioners utilize supraglottic airways [e.g., laryngeal tube, igel, and laryngeal mask airway (LMA)]. However, observational studies suggest higher survival with intubation than the simpler supraglottic airway devices [14,15]. Similar retrospective analyses have suggested greater survival with BVM ventilation over either SGA or ETI [16,17]. These observational studies had significant limitations, including confounding by indication where by the decision to select a specification treatment (i.e. ETI) may confound the outcome of interest. These limitations can only be overcome by performing a randomized controlled trial. Three new clinical trials shed new light on BVM, SGAs and ETI in OHCA.

THE ROLE OF BAG-VALVE MASK VENTILATION IN CARDIAC ARREST

Bag-valve-mask (BVM) is the fundamental technique for ventilating critically ill patients. A growing

body of observational data suggests that BVM may result in better OHCA compared with advanced airways [16,17]. Almost 20 years ago, Gausche *et al.* [18] performed the only randomized controlled trial comparing out-of-hospital BVM and ETI in critically ill children, finding no difference in outcomes. Given the limitations of the current literature, a clinical trial comparing BVM to ETI could help to provide insight into these airway management techniques in this population.

Jabre *et al.* [6^{***}] performed a multicenter non-inferiority RCT in Belgium and France comparing BVM with ETI in adult OHCA. All airways were managed by prehospital physicians who attended the patient by specialized mobile prehospital intensive care units. The primary outcome was 28-day survival with good neurologic outcome. Good neurologic outcome was defined as a Glasgow-Pittsburgh Cerebral Performance Category of 2 or less. The authors enrolled 2043 patients; 1020 BVM and 1023 ETI. Good neurologic outcome at 28 days was similar between BVM (4.3%) and ETI (4.2%) [difference 0.11%; one-sided 97.5% CI (−1.64% to infinity)] in the intention-to-treat analysis. Other studied outcomes (survival to hospital admission and survival at 28 days) were similar between groups. Results were similar in the per-protocol analysis. However, the authors were unable to conclude the noninferiority or inferiority of BVM. The authors did find that complications occurred more frequently in the BVM group (18.1%) than the ETI group (13.4%) (difference 4.7%; 95% CI 1.5–7.9%), including ventilation failure (BVM 6.7%; ETI 2.1%) and regurgitation of gastric contents (BVM 15.2%; ETI 7.5%).

The Jabre *et al.* study has several limitations. The authors used a noninferiority design but did not attain parameters to reach a definitive conclusion, and thus the study could neither conclude the inferiority or noninferiority of either airway technique. Revision of the design to entail a larger number of subjects may have allowed the authors to make a definitive conclusion. All airways were managed by prehospital physicians, limiting its generalizability, as few EMS systems in the world have physician-staffed response units. All patients underwent intubation after return of spontaneous circulation. Limited data were available on the quality of chest compressions between the study arms.

However, the Jabre *et al.* results do shed light on the difficulty of BVM ventilation in adult OHCA. Some experts suggest that BVM should be the default ventilation approach in OHCA. However, Jabre *et al.*'s observations of higher rates of ventilation failure and gastric regurgitation undermine this recommendation. BVM is a difficult technique,

especially under the conditions of the out-of-hospital environment. These findings suggest that EMS providers may use BVM as a bridge until a more definitive SGA or ETI tube can be placed.

THE ROLE OF SUPRAGLOTTIC AIRWAYS IN OUT-OF-HOSPITAL CARDIAC ARREST

SGAs are blindly inserted airway devices that set in the posterior pharynx. Their design allows for rapid placement by providers with a range of skills and does not require the intensive training required of ETI. Supraglottic airways have been advocated as the primary airway management strategy in OHCA given their rapid, easy placement and lower likelihood of interrupting chest compressions [3,19]. Despite these potential benefits, retrospective analyses have suggested worse outcomes with SGAs compared with ETI in OHCA [14,15]. This year, two large RCTs were published comparing SGAs to ETI in OHCA.

PRAGMATIC AIRWAY RESUSCITATION TRIAL

Wang *et al.* performed a multicenter, cluster-randomized, cross-over trial in the United States comparing 72-h survival between patients treated with either laryngeal tube (King LT, Ambu, Copenhagen, Denmark) or ETI [7²²,20]. Inclusion and exclusion criteria were similar to other OHCA trials including enrolling those aged at least 18 years of age and excluding prisoners and patients with do-not-resuscitate orders [6²²,8²²,20]. Emergency medical services (EMS) agencies were cluster-randomized to laryngeal tube or ETI, with cross-over to the alternate intervention every 3–5 months.

A total of 27 EMS agencies from five cities enrolled 3004 patients; 1505 received laryngeal tube, and 1499 received ETI. Survival at 72 h was higher in the laryngeal tube (18.3%) than ETI (15.4%) group (adjusted difference 3.6%; 95% CI 0.3–6.8%). The superiority of laryngeal tube was also seen across other secondary outcomes, including return of spontaneous circulation, survival to hospital discharge and favorable neurologic status at discharge. Complications including oropharyngeal injury and pneumonia, were similar between the groups. Of note, laryngeal tube insertion was almost 2.5 min faster than ETI.

An important observation of Pragmatic Airway Resuscitation Trial (PART) was the 51% insertion success rate in the ETI arm, compared with 90.6% for the laryngeal tube arm. The vast majority of unsuccessful intubations were successfully rescued by laryngeal tube insertion. Many EMS medical

directors advocate early laryngeal tube rescue in the face of failed intubation efforts, and hence the observations of the trial may reflect common clinical practice. The pragmatic focus of the study limited the ability to modify other aspects of care outside of the allocation arms; for example, mandating additional ETI training or modifying existing ETI techniques. However, specialized training would have limited the generalizability of the trial, as most EMS agencies do not have access to specialized ETI training.

PART has several limitations. The pragmatic design limited the ability to modify other aspects of care outside of the allocation arms (e.g. additional educational education on airway techniques or modify existing EMS protocols). The sample size was not powered to examine other longer term outcomes (e.g. neurologically intact survival at 30 days). There were subtle differences in the groups based on the cluster-randomization methodology. There were no data on the quality of the chest compression. Providers were not blinded to the allocation arm. First attempt success with ETI was 51.3% compared with 90.6% for SGA. How these results generalize to agencies with higher rates of ETI placement is unknown.

AIRWAYS-2

Benger *et al.* [8²²] performed a multicenter RCT in England comparing favorable functional outcome at either hospital discharge or 30 days between OHCA patients treated with either i-gel supraglottic airways (Intersurgical, Workingham, Berkshire, UK) or ETI. Randomization occurred at the paramedic level (ETI $n = 764$ vs. SGA $n = 759$). Inclusion and exclusion criteria were similar to those in PART. Only patients receiving care by a study paramedic were enrolled in the trial.

The trial enrolled 9296 patients; 4886 i-gel and 4410 ETI. Favorable functional outcome at either hospital discharge or 30 days was similar between the i-gel (6.4%) and ETI (6.8%) (adjusted risk difference -0.6% ; 95% CI -1.6 to 0.4%). Other outcomes including regurgitation and aspiration were also similar between the groups. In both groups, a portion of patients received BVM-ventilation only (22.4% in ETI group, and 14.8% in the i-gel group). However, when including only those cases where either ETI or i-gel was placed (a 'per protocol' analysis), patients treated with i-gel had better neurologically intact survival (i-gel 3.9%; ETI 2.6%; RD 1.4%; 95% CI 0.5–2.2%).

Airways-2 has important limitations. The trial randomized paramedics to ETI or SGA during the study period. This design led to an imbalance of

treatment allocation among patients. Paramedics did not cross-over to the other arm for the entire 2-year study; some believe that paramedic ETI and i-gel skill may have decayed as a result of this strategy. A large portion of patients in both arms received BVM ventilation only. Only limited data were available on the quality of chest compressions between the study arms. However, Airways-2 is the largest out-of-hospital airway trial to date, and the results suggest that – at best – intubation is not superior to i-gel insertion in this population.

PART and Airways-2 collectively provide important evidence to influence the field of out-of-hospital airway management. Although the trials have key design differences, many of the findings are consistent. Both the primary analysis of PART and the per-protocol analysis of Airways-2 suggest the superiority of a SGA strategy over ETI as the initial advanced airway technique in adult OHCA. Although many studies have questioned the benefit of advanced life support, Airways-2 and PART suggest effectiveness of an advanced technique in OHCA – SGAs. The implementation of the findings into international EMS practices poses important challenges and considerations. Drawing upon the findings of PART and Airways-2, EMS agencies with limited training resources and clinical experience with ETI may elect SGA insertion and should consider this approach in OHCA. EMS agencies with advanced intubation training resources may elect to maintain ETI as the current practice as this approach resulted in similar outcomes compared with SGA in providers with regular exposure to ETI. Regardless of their choices, the trials highlight the important role of advanced airway management in OHCA and the need for comprehensive training and quality assurance in all EMS airway management practices.

CONCLUSION

Emergency airway management is complicated by several factors and many techniques have been proposed to help improve success at airway management and improve patient outcomes. The recent completion of several well conducted clinical trails has helped to better clarify the role of the bougie in facilitating ETI and understand various airway management techniques in OHCA.

Acknowledgements

None.

Financial support and sponsorship

J.N.C. and H.E.W. are supported by UH2-HL125163 from the National Heart, Lung and Blood Institute (NHLBI) for the Pragmatic Airway Resuscitation Trial.

Conflicts of interest

J.N.C. and H.E.W. are investigators of the Pragmatic Airway Resuscitation Trial.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

1. Driver B, Dodd K, Klein LR, *et al.* The Bougie and first-pass success in the emergency department. *Ann Emerg Med* 2017; 70:473.e1–478.e1. This observational trial suggests improved first-pass success with the bougie in the emergency department patients.
2. Ducharme S, Kramer B, Gelbart D, *et al.* A pilot, prospective, randomized trial of video versus direct laryngoscopy for paramedic endotracheal intubation. *Resuscitation* 2017; 114:121–126. This pilot randomized clinical trial found similar rates of first-pass attempt at intubation between video laryngoscopy and direct laryngoscopy in the prehospital setting.
3. Guyette F, Greenwood MJ, Neubecker D, *et al.* Alternative airway in the prehospital setting (resource document to NAEMSP position statement). *Prehosp Emerg Care* 2007; 11:56–61.
4. Driver BE, Prekker ME, Moore JC, *et al.* Direct versus video laryngoscopy using the C-MAC for tracheal intubation in the emergency department, a randomized controlled trial. *Acad Emerg Med* 2016; 23:433–439.
5. Driver BE, Prekker ME, Klein LR, *et al.* Effect of use of a bougie vs endotracheal tube and stylet on first-attempt intubation success among patients with difficult airways undergoing emergency intubation: a randomized clinical trial. *JAMA* 2018; 319:2179–2189. This randomized clinical trial found improved first-attempt success rates were higher in bougie-facilitated intubations compared with traditional stylet intubation in emergency department patients.
6. Jabre P, Penaloza A, Pinero D, *et al.* Effect of bag-mask ventilation vs endotracheal intubation during cardiopulmonary resuscitation on neurological outcome after out-of-hospital cardiorespiratory arrest: a randomized clinical trial. *JAMA* 2018; 319:779–787. This randomized clinical trial found similar rates of neurologically intact survival between adult out-of-hospital cardiac arrest patients treated with intubation compared with bag-valve-mask ventilation; however, complication rates were higher in the bag-valve-mask group.
7. Wang HE, Schmicker RH, Daya MR, *et al.* Effect of a strategy of initial laryngeal tube insertion vs endotracheal intubation on 72-hour survival in adults with out-of-hospital cardiac arrest: a randomized clinical trial. *JAMA* 2018; 320:769–778. This randomized clinical trial found higher rates of 72-h survival in adult out-of-hospital cardiac arrest patients treated with supraglottic airways compared with intubation. Other outcomes (return of spontaneous circulation, survival to hospital discharge and neurologically intact survival at discharge) also favored supraglottic airways.
8. Benger JR, Kirby K, Black S, *et al.* Effect of a strategy of a supraglottic airway device vs tracheal intubation during out-of-hospital cardiac arrest on functional outcome: the AIRWAYS-2 Randomized Clinical Trial. *JAMA* 2018; 320:779–791. This randomized clinical trial, comparing supraglottic airways to intubation, found similar rates of neurologically favorable outcomes either at hospital discharge or 28 days in adult out-of-hospital cardiac arrest patients.
9. Tandon N, McCarthy M, Forehand B, Carlson JN. Comparison of intubation modalities in a simulated cardiac arrest with uninterrupted chest compressions. *Emerg Med J* 2013; 31:799–802.
10. Brown CA 3rd, Bair AE, Pallin DJ, *et al.* Techniques, success, and adverse events of emergency department adult intubations. *Ann Emerg Med* 2015; 65:363.e1–370.e1.
11. Neumar RW, Otto CW, Link MS, *et al.* Part 8: adult advanced cardiovascular life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation* 2010; 122(18 Suppl 3):S729–S767.
12. Benoit JL, Prince DK, Wang HE. Mechanisms linking advanced airway management and cardiac arrest outcomes. *Resuscitation* 2015; 93: 124–127.
13. Wang HE, Simeone SJ, Weaver MD, Callaway CW. Interruptions in cardiopulmonary resuscitation from paramedic endotracheal intubation. *Ann Emerg Med* 2009; 54; 645.e1–652.e1.
14. Wang HE, Szydlo D, Stouffer JA, *et al.*, ROC Investigators. Endotracheal intubation versus supraglottic airway insertion in out-of-hospital cardiac arrest. *Resuscitation* 2012; 83:1061–1066.

15. Benoit JL, Gerecht RB, Steuerwald MT, McMullan JT. Endotracheal intubation versus supraglottic airway placement in out-of-hospital cardiac arrest: a meta-analysis. *Resuscitation* 2015; 93:20–26.
16. Hasegawa K, Hiraide A, Chang Y, Brown DF. Association of prehospital advanced airway management with neurologic outcome and survival in patients with out-of-hospital cardiac arrest. *JAMA* 2013; 309:257–266.
17. Fouche PF, Simpson PM, Bendall J, *et al*. Airways in out-of-hospital cardiac arrest: systematic review and meta-analysis. *Prehosp Emerg Care* 2013; 18:244–256.
18. Gausche M, Lewis RJ, Stratton SJ, *et al*. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. *JAMA* 2000; 283:783–790.
19. Beauchamp G, Phrampus P, Guyette FX. Simulated rescue airway use by laypersons with scripted telephonic instruction. *Resuscitation* 2009; 80:925–929.
20. Wang HE, Prince DK, Stephens SW, *et al*. Design and implementation of the Resuscitation Outcomes Consortium Pragmatic Airway Resuscitation Trial (PART). *Resuscitation* 2016; 101:57–64.