The Bougie and First-Pass Success in the Emergency Department

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Study objective: The bougie may improve first-pass intubation success in operating room patients. We seek to determine whether bougie use is associated with emergency department (ED) first-pass intubation success.

Methods: We studied consecutive adult ED intubations at an urban, academic medical center during 2013. Intubation events were identified by motion-activated video recording. We determined the association between bougie use and first-pass intubation success, adjusting for neuromuscular blockade, video laryngoscopy, abnormal airway anatomy, and whether the patient was placed in the sniffing position or the head was lifted off the bed during intubation.

Results: Intubation with a Macintosh blade was attempted in 543 cases; a bougie was used on the majority of initial attempts (80%; n=435). First-pass success was greater with than without bougie use (95% versus 86%; absolute difference 9% [95% confidence interval {CI} 2% to 16%]). The median first-attempt duration was higher with than without bougie (40 versus 27 seconds; difference 14 seconds [95% CI 11 to 16 seconds]). Bougie use was independently associated with greater first-pass success (adjusted odds ratio 2.83 [95% CI 1.35 to 5.92]).

Conclusion: Bougie was associated with increased first-pass intubation success. Bougie use may be helpful in ED intubation. [Ann Emerg Med. 2017;70:473-478.]

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INTRODUCTION

Background and Importance

Intubation is routinely performed in the emergency department (ED). Successful intubation on the initial attempt (ie, first-pass success) is highly desirable to avoid complications associated with intubation such as hypoxemia, aspiration, and esophageal intubation.[1] The use of a bougie, a simple and inexpensive device first described by Macintosh[2] in 1949, may increase first-pass success, especially if intubation is difficult or the laryngeal view is poor.[3-6]

However, most physicians who advocate using the bougie use it as a rescue device after a failed initial intubation attempt.[7-10] Only 3.5% of initial intubation attempts in the ED used a bougie, according to data from the National Emergency Airway Registry.[11] With first-pass success averaging 85% among a representative sample of EDs,[11] there is an opportunity to improve the safety and efficiency of emergency intubation. To our knowledge, there are no previous reports of how the bougie performs when used as a primary intubation device in the ED rather than as a backup or adjunct for difficult airways.

Goals of This Investigation

We sought to determine whether bougie use is associated with increased first-pass success in ED patients undergoing emergency intubation.

MATERIALS AND METHODS

Study Design

We performed a retrospective, observational study using video review as our primary method of data collection. This study was approved by the institutional review board at Hennepin County Medical Center.

Setting

We studied consecutive intubations at an urban, Level I trauma center with approximately 100,000 annual ED visits. Emergency physicians manage all airways in our ED. Senior emergency medicine residents (postgraduate year 3 or higher) perform the majority of intubations under the supervision of the attending emergency physician. All residents receive extensive training in intubation, including didactics and

Editor's Capsule Summary

What is already known on this topic

The bougie is a popular adjunct for emergency department (ED) intubation.

What question this study addressed

Is bougie use associated with increased first-pass intubation success?

What this study adds to our knowledge

In this retrospective series of 543 ED intubations, the bougie was used 80% of the time and was associated with higher first-pass success than conventional intubation (95% versus 86%; Δ=9%, 95% CI 2% to 16%; adjusted odds ratio 2.83, 95% CI 1.35 to 5.92).

How this is relevant to clinical practice

Although clinicians may find bougie use helpful in ED intubations, a clinical trial is needed to prove its effectiveness as a routine part of intubation.

hands-on sessions with all direct laryngoscopy and video laryngoscopy devices on airway manikins. Further training occurs in simulation and animal laboratories, and in community hospital ED rotations earlier in training. The C-MAC (Karl Storz Endoscopy, El Segundo, CA) was the only video laryngoscope available in our ED with a Macintosh-shaped blade during the study period. In our ED, the C-MAC is often used as a teaching device for direct laryngoscopy, allowing the resident to intubate with direct visualization while the faculty uses the video monitor to supervise the procedure. The bougie has been used to aid ED intubation since 1996. Emergency physicians used the bougie with standard technique, with insertion of the bougie through the glottis and advancement of the endotracheal tube over the bougie into the trachea.

Selection of Participants

Using the electronic medical record, we identified all adults (>17 years) who underwent intubation in the ED during calendar year 2013. Eligible patients were identified if an intubation procedure note, a professional fee for intubation, or ventilator settings were present in the ED chart of a patient. Patients with missing videos and those found on video review to be intubated before arrival to the ED were excluded. Patients undergoing intubation with a Macintosh laryngoscope (either direct laryngoscopy or a video laryngoscopy device with a Macintosh-shaped blade) were included in the analysis. We did not include cases in which a bougie was used with a hyperangulated video laryngoscope blade, such as the GlideScope (Verathon Medical, Bothell, WA) or the Storz D-BLADE, because it can be difficult to pass the bougie in these cases[12,13]; it is more common to use the GlideRite stylet with these devices.[14]

Methods of Measurement

We performed a structured review of resuscitation room videos recorded for each patient case. Critically ill or injured patients receive care in a 4-bay stabilization room. Each bay has 3 ceiling-mounted video cameras activated by motion sensors. Automated software combines the video streams with output from the patient cardiac and vital sign monitor, as well as audio recording of the room. The videos are stored on a secure database and are primarily used for peer review and quality assurance purposes.

Three trained investigators independently viewed all videos and recorded observations on a structured data collection form, using Research Electronic Data Capture tools.[15] Preintubation characteristics of interest included obesity, cervical immobilization (cervical collar in place before intubation; manual inline stabilization performed during intubation), the presence of abnormal airway anatomy (defined as facial trauma, anterior neck trauma, angioedema, airway mass of any type, or other obvious abnormality visible on camera or captured through the verbal discussions of the treating physicians), and body fluids visible from the mouth. Intubation characteristics included the device used, whether the video screen was viewed by the intubating physician, intubation route, duration of each intubation attempt, bougie use, the level of training of the intubating physician, and whether the sniffing position (defined as the tragus aligned with the sternal notch) was achieved or the head was lifted off the bed during the intubation attempt. We also screened for the presence of hypoxemia (defined as oxygen saturation <90%) or esophageal intubation during the intubation attempts. An intubation attempt was defined as a single insertion of the laryngoscope blade; attempt duration was defined as the time elapsed between inserting and removing the laryngoscope blade, regardless of status or position of the endotracheal tube. Missing data or data points unable to be determined by video review were left blank with no assumed value. First-pass success and key variables that could influence it were documented by a second video reviewer for 10% of the videos to evaluate interobserver agreement.

Video reviewers were aware of the general nature of the study but were blinded to specific study aims. The age, sex,

medications administered, and primary diagnosis for each patient were extracted from the electronic medical record.

Outcome Measures

The primary outcome was first-pass success, which was defined as successful intubation with a single laryngoscope blade insertion. Successful intubation was defined as confirmed intratracheal placement by the treating physicians, usually by waveform capnography, without any subsequent intubation attempts. Insertion of a laryngoscope was considered an attempt, regardless of whether an attempt to pass an endotracheal tube or bougie was performed.

Primary Data Analysis

We compared baseline and intubation characteristics between bougie and nonbougie cases. We used multivariable logistic regression to determine whether bougie use was independently associated with first-pass success. We adjusted for variables that could confound the relationship between bougie use and intubation success, including neuromuscular blockade,[16,17] video laryngoscopy use,[18] abnormal airway anatomy, and whether the patient was placed in the sniffing position or the head was lifted off the bed during intubation.[19] We fit a second model replacing video laryngoscopy use with whether the video laryngoscopy screen was viewed by the intubator during the intubation attempt, with all other variables remaining unchanged. In this model, patients intubated with a traditional Macintosh laryngoscope were coded as screen not viewed, as were patients for whom video laryngoscopy was used without the screen's being viewed by the intubating physician. Because the video laryngoscopy device used during the study period can facilitate both direct laryngoscopy and video laryngoscopy, we sought to use this secondary model to isolate the effect of video laryngoscopy on any association between bougie use and first-pass success. To maintain adequate statistical power, we limited adjustment to the variables most closely associated with first-pass success, adhering to the "rule of tens" for logistic regression.[20] We used Stata (version 12.1; StataCorp, College Station, TX) for all data analyses.

Sensitivity Analyses

The charts of the patients with missing videos were reviewed to attempt to determine the first attempt approach, neuromuscular blockade, video laryngoscopy use, abnormal anatomy, and success. Bougie use and positioning were not routinely documented in the electronic medical record during the study period. Cases with missing videos and involving attempted intubation with a Macintosh laryngoscope (direct laryngoscopy or video laryngoscopy with a Macintosh blade) were used for 2 sensitivity analyses: assuming the bougie was used in all cases, and assuming the bougie was used in none of the cases. After replacing the relevant missing data as above, we repeated the multivariable analysis, assuming first-pass success rates between 0 of 70 (0%) and 70 of 70 (100%) under assumption 1 and assumption 2. We determined the threshold success rate at which bougie use was no longer associated with first-pass success (defined as the lower bound of the 95% confidence interval [CI] of the odds ratio being less than 1).

We also fit an additional multivariable logistic regression model including all baseline characteristics listed in Table 1.

RESULTS

Characteristics of Study Subjects and Main Results

During the study period, there were 676 adult ED intubations, of which videos were available for 593 (88%). Of the 593 videos reviewed, 543 (92%) had a first attempt with a Macintosh blade; of these, a bougie was used for the first attempt in 435 cases (80%) (Table 1). Interobserver agreement for variables included in the multivariable model ranged from fair to almost perfect agreement (Table E1, available online at http://www.annemergmed.com).

First-pass success was higher with bougie use (414/435; 95%) than without it (93/108; 86%) (difference 9%; 95% CI 2% to 16%). Complications of hypoxemia and intubation, as well as attempt duration, are presented in

Table 1. Baseline characteristics.

Parameter	Bougie (n=435)	No Bougie (n=108)
Age, median (IQR), y	50 (32–61)	46 (27–61)
Male sex	305 (70)	73 (68)
Indication		
Neurologic	165 (38)	47 (44)
Medical	120 (28)	33 (31)
Trauma	100 (23)	17 (16)
Cervical immobilization	97 (22)	17 (16)
Obesity	234 (54)	54 (50)
Abnormal airway anatomy*	51/419 (12)	9/99 (9)
Body fluids in mouth*	63/429 (15)	12/107 (11)
Neuromuscular blockade	393 (90)	100 (93)
Sniffing position or head elevated*	210/424 (50)	47/106 (44)
Senior resident (PGY3 or higher) performed intubation	420 (97)	100 (93)
C-MAC used	416 (96)	98 (91)
C-MAC screen viewed*	189/411 (46)	18/97 (19)

IQR, Interquartile range; *PGY*, postgraduate year.
Data are presented as No. (%) unless otherwise indicated.
*For these variables, in a portion of the cases a value was not able to be determined by video review.

Table 2. Intubation success and complications.

Parameter	Bougie (n=435)	No Bougie (n=108)
First-pass success (95% CI), %	414 (95; 93–97)	93 (86; 79–93)
Median attempt duration (95% CI), s	40 (39–42)	27 (25–29)
Hypoxemia (%)*	49/283 (17)	10/79 (13)
Esophageal intubation (%)	1 (0)	1 (1)

*Hypoxemia data could not be obtained from the remaining 181 videos (in 114, the vital sign monitor feed failed to be captured with the video stream; in 56, no valid oximetry waveform or value was present at any point during intubation; in 11, a valid oximetry waveform was present only before intubation but not during the attempt).

Table 2. The duration of a first attempt with a bougie was modestly higher (median difference 14 seconds [95% CI 11 to 16 seconds]).

On multivariable analysis, bougie use remained associated with increased first-pass intubation success (adjusted odds ratio 2.83 [95% CI 1.35 to 5.92]) (Table 3). Bougie use remained associated with first-pass success when adjusting for video laryngoscopy screen use (Table 3).

Sensitivity Analyses

On chart review of the 83 cases with no video available, 70 had an orotracheal approach with a video laryngoscopy device or Macintosh blade for the first attempt. If a bougie was used in all 70 cases, at a success rate of 40 of 70 (57%) or lower for the bougie (overall bougie success rate 454/505 [90%]), bougie use would no longer be independently associated with first-pass success. If an endotracheal tube with stylet was used in all 70 cases, at a success rate of 68 of 70 (97%) or higher for the endotracheal tube (overall success rate without a bougie 161/178 [90%]), bougie use would no longer be associated with first-pass success. The documented first-pass success rate for these 70 cases, by chart review, was 64 of 69 (93%); in one case it was not possible to determine first-pass success. Therefore, neither the worst case for bougie use nor best case for endotracheal tube alone presented above would have been possible, given the documented success rate for the missing cases.

When including all baseline characteristics in the multivariable logistic regression model, the bougie remained associated with first-pass success (adjusted odds ratio of 3.40 [95% CI 1.52 to 7.60]) (Table E2, available online at http://www.annemergmed.com).

LIMITATIONS

This investigation has several important limitations. These data are from a single institution with frequent bougie use and familiarity with the device, and hence the results may not be generalizable to physicians less familiar with its use. The retrospective design is subject to bias. We attempted to mitigate this limitation by using rigorous video review technique and repeated examination by multiple reviewers.[21] Although many videos were missing, the sensitivity analyses demonstrate that bougie use would have remained associated with first-pass success even if the videos were available for review. We did not collect data on the preintubation assessments (eg, Mallampati, mouth opening, thyromental distance, neck circumference) that may have influenced first-pass success.

The reason for bougie use in each case is unknown, and it is possible that the bougie was used for easier airways or for better laryngeal views. However, baseline characteristics do not support this assertion. In our practice, both the endotracheal tube and bougie are available when the laryngeal view is obtained, and the endotracheal tube is generally reserved for when a good

Table 3. Multivariable logistic regression models for first-pass success.

	With C-MAC Device Used (n=507)		With C-MAC Screen Viewed (n=501)	
Variable	**Odds Ratio**	**95% CI**	**Odds Ratio**	**95% CI**
Bougie used	2.83	1.35–5.92	3.16	1.49–6.73
Abnormal anatomy	0.77	0.25–2.34	0.90	0.30–2.69
Sniffing position or head lifted off of bed	1.08	0.53–2.23	1.13	0.56–2.30
Neuromuscular blockade	0.75	0.17–3.36	0.71	0.16–3.16
Video laryngoscopy device used	5.04	1.91–13.35	N/A	N/A
Video laryngoscopy device viewed	N/A	N/A	0.92	0.43–1.97
Hosmer-Lemeshow test	*P*=.80		*P*=.57	

Two models are presented: the first includes the use of the video laryngoscope as a covariate; the second includes whether the screen of the video laryngoscope device was viewed. In the C-MAC screen-viewed model, patients intubated with a direct Macintosh laryngoscope were coded as screen not viewed even though the C-MAC was not used. These models examine subjects who did not have missing values for C-MAC screen use, abnormal anatomy, or head/neck positioning. In models including all subjects (assuming missing values to be zero), the results of the model were not significantly different.
NA, Not applicable.

view of the laryngeal inlet is obtained, although some physicians use the bougie for every intubation attempt regardless of the view obtained. With this study method, however, we were unable to record the laryngeal views and cannot know whether they differ between the groups.

Data for hypoxemia were limited because of failure to capture the monitor in the video feed in 114 videos (21%), and because of a poor or absent waveform in 67 cases. It is possible that extended laryngoscopy with bougie use was associated with increased hypoxemia. We did not record potential complications related to direct airway trauma for either device, such as upper airway trauma, tracheobronchial injury, or pneumothorax. However, there have been few bougie complications reported in the medical literature despite more common use in other countries.[6,22-24]

DISCUSSION

Bougie use increases first-pass success in multiple randomized trials in anesthetized patients in the operating room who have simulated difficult airways.[3,5,25] Furthermore, the bougie is known to be an effective backup device after failed attempts or when the laryngeal view is poor.[4,7-10] To our knowledge, there is no high-quality evidence supporting routine bougie use in the ED. Case reports and studies on manikins and cadavers are generally supportive, yet 2 small, single-center reports of bougie use among emergency physicians unfamiliar with its use reported limited success.[26,27]

To our knowledge, this is the largest description of bougie use in any setting. In our institution with frequent use, bougie application was associated with increased first-pass intubation success. Because of the limitations of our study design, we cannot conclude that the bougie should be used in all first attempts. Rather, our study highlights the utility of the bougie in emergency intubation. Prospective clinical trials are needed to definitively determine whether the bougie can improve first-pass success in a subset of ED patients or all ED patients.

The results of this study do not indicate the reasons for bougie's influencing first-pass success. However, the bougie may be passed into the trachea when optimal laryngeal views are not present (ie, the vocal cords are not visualized, as in modified Cormack-Lehane grade IIB or worse views caused by patient anatomic factors or excessive emesis or blood in the hypopharynx).[4,10] Furthermore, the bougie can be used when no view of the larynx is available by passing it blindly; the intubating physician receives tactile feedback of correct placement as the angled bougie tip strikes tracheal rings as it moves toward the carina.[28-30]

Some of the difference in first-pass success may be explained by modestly higher video laryngoscopy use in the bougie group[18]; bougie use, however, remained associated with increased first-pass success even after adjusting for video laryngoscopy use. Additionally, the first-pass success rate when a bougie was used in this study (95%) is higher than that with the C-MAC laryngoscope in a large national registry (91%).[11]

There may be downsides to routine bougie use in the ED. In our study, the median attempt duration when a bougie was used was 14 seconds longer than without a bougie. This is consistent with previous operating room data demonstrating modestly longer intubation duration with a bougie.[5,25] Because our ability to report on the complication of hypoxemia was limited, we do not know whether this longer duration is associated with higher rates of hypoxemia. Rapid first-attempt success is of particular importance for patients with a low baseline oxygen saturation (<96%) or the propensity for rapid desaturation.[31] There are reports of difficulty advancing the bougie past the hypopharynx or passing the endotracheal tube over the bougie in the ED.[26,27] Some experts advocate slightly withdrawing the bougie, rotating 90 degrees counterclockwise, and readvancing with the bevel in a more favorable position.[32,33]

In summary, in this study we found that bougie use was associated with increased first-pass intubation success. Bougie use may be helpful in ED intubation efforts.

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Author contributions: BD, LK, JM, RR, and MP conceived and designed the study, created the data collection forms, and trained the video reviewers. KD, RB, and AR performed the video review. BD and MP performed the data analysis. BD drafted the initial manuscript, and all authors contributed substantially to its revision. BD takes responsibility for the study as a whole.

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Table E1. Interobserver agreement for model variables.

Variable	Percentage Agreement	κ
First-pass success	98	0.9
Bougie used	91	0.66
Abnormal anatomy	85	0.32
Sniffing position or head lifted off of bed	71	0.44
Video laryngoscopy device used	100	1
Video laryngoscopy screen viewed	93	0.86
Body fluids in mouth	89	0.4
Cervical immobilization	93	0.78

Ten percent of the videos were reviewed by a second abstractor to determine interobserver agreement for these model variables.

Table E2. Multivariable logistic regression model including additional baseline variables.

Variable	Odds Ratio	95% CI
Bougie used	3.40	1.52–7.60
Age, y	0.98	0.97–1.00
Male sex	0.45	0.18–1.10
Abnormal anatomy	1.27	0.33–4.95
Body fluids in mouth	0.29	0.10–0.82
Cervical immobilization	0.65	0.22–1.93
Obese	0.50	0.22–1.14
Neuromuscular blockade	0.63	0.13–3.01
Sniffing position or head lifted off of bed	1.00	0.43–2.32
Video laryngoscopy device used	7.02	2.42–20.33
Intubator senior resident or higher	4.76	1.28–17.70

This model examined the 503 subjects who did not have missing values for any variable. This model is different from the main model (Table 3) in that it includes all baseline variables in Table 1 except the indication for intubation. The Hosmer-Lemeshow *P* value for this model was .23.