Video Laryngoscopy Is Associated With First-Pass Success in Emergency Department Intubations for Trauma Patients: A Propensity Score Matched Analysis of the National Emergency Airway Registry

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Study objective: We sought to (1) characterize emergency department (ED) intubations in trauma patients and estimate (2) first-pass success and (3) the association between patient and intubation characteristics and first-pass success.

Methods: We performed a secondary analysis of a multicenter prospective observational cohort of ED intubations from the National Emergency Airway Registry (NEAR). Descriptive statistics were calculated for all patients who were intubated for trauma at 23 NEAR EDs between 2016 and 2018. We evaluated first-pass success in patients intubated by (1) emergency or pediatric emergency physicians, (2) using rapid sequence intubation or no medications, and (3) either direct laryngoscopy or video laryngoscopy. We used propensity score matching with a generalized linear mixed-effects model to estimate the associations between patient and intubation characteristics and first-pass success.

Results: Of the 19,071 intubations in NEAR, 4,449 (23%) were for trauma, and nearly all (88%) had at least one difficult airway characteristic. Prevalence of first-pass success was 86.8% (95% confidence interval [CI]: 83.3% to 90.3%). Most patients were intubated with video laryngoscopy, and patients were more likely to be intubated on first-pass with video laryngoscopy as compared to direct laryngoscopy (90% versus 79%). After propensity score matching, video laryngoscopy remained associated with first-pass success (adjusted risk difference 11%, 95% CI: 8% to 14%; and OR 2.2, 95% CI: 1.6 to 2.9). Additionally, an initial impression of difficult airway, blood/vomit in the airway, and use of external laryngeal manipulation were all associated with decreased odds of first-pass success.

Conclusion: Emergency physicians are successful at intubating patients in the setting of trauma, and video laryngoscopy is associated with twice the odds of first-pass success when compared to direct laryngoscopy. [Ann Emerg Med. 2021;78:708-719.]

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INTRODUCTION

Background

Advanced airway management is a critical skill in emergency medicine that is often time-sensitive and fraught with limitations due to patient instability and anatomic distortion. This is especially true among emergency department (ED) patients requiring intubation in the setting of trauma, where they are frequently agitated or intoxicated, hemodynamically unstable, or bound by cervical spine collars and often have soiled airways from vomit or blood.[1] These factors collude to create a high-risk clinical situation that can confound attempts to prepare, preoxygenate, and adequately position the patient for a successful intubation. Despite these suboptimal conditions, first-pass success in ED intubations for trauma is critical to patient safety and the prevention of adverse events such as hypoxemia, hypotension, and cardiac arrest.

Importance

While multiple observational studies have reported unadjusted first-pass success in ED patients intubated for trauma, these studies were published prior to video

Editor's Capsule Summary

What is already known on this topic

Video laryngoscopy is increasingly popular for emergency department intubation.

What question this study addressed

Which has greater first-pass success for trauma intubation—video versus direct laryngoscopy?

What this study adds to our knowledge

In this registry study of 4,449 adult trauma intubations there was greater first-pass success with video versus direct laryngoscopy (90% versus 79%), a difference also found in a propensity score matched analysis of 2,160 of these patients.

How this is relevant to clinical practice

For adult trauma intubation video laryngoscopy appears to exhibit greater first-pass success than direct laryngoscopy.

laryngoscopy becoming the preferred type of laryngoscopy used in EDs.[2-8] Two contemporary studies evaluating first-pass success using the National Emergency Airway Registry (NEAR) have included trauma patients in their analyses and adjusted for trauma as a confounder, but neither have specifically reported on first-pass success in ED intubations for trauma.[9,10] Additionally, patients intubated for trauma in the ED comprise less than 30% of ED intubations and have a higher proportion of anticipated and confirmed difficult airway characteristics.[9,10] Thus, first-pass success in ED trauma intubations is unlikely to be equivalent to first-pass success among all ED intubations. Moreover, as noted by Driver et al,[9] choice of video laryngoscopy blade differs among patients intubated for a medical as compared to a trauma indication. As such, it is critical to examine airway management of this specific subpopulation to inform what techniques are currently used and how they are associated with first-pass success.

Goals of This Investigation

We sought to (1) characterize endotracheal intubations in trauma patients in US EDs and estimate (2) first-pass success and (3) the associations between patient and intubation characteristics and first-pass success.

METHODS

Study Design

We performed an observational study using data from the NEAR, a prospective registry of ED intubations performed at a network of 25 academic hospitals. Institutional review board approval was obtained from each site prior to data collection. All data were reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology statement.[11]

Study Setting and Population

All patients, regardless of age, who were intubated for trauma at a participating NEAR ED from January 1, 2016 through December 31, 2018 were included in the analysis. Patients intubated for trauma at children's hospitals were excluded (2 sites with 13 trauma intubations). When analyzing first-pass success, we only included patients intubated by (1) emergency physicians or pediatric emergency physicians, (2) using rapid sequence intubation or no medications, and (3) either direct laryngoscopy or video laryngoscopy.

Data Collection

Physicians at each institution utilized a secure, web-based data collection form (Study-TRAX, version 3.47.0011; ScienceTRAX) to enter all data. Intubating physicians entered data on patient age, sex, estimated weight, and body habitus (ie, very thin, thin, normal, obese, morbidly obese). Data was also collected on whether the intubation was for medical or trauma indications. For traumatic indications, the primary mechanism of trauma was recorded (ie, blunt, penetrating, or burn) as well as the primary injury necessitating intubation (ie, head, face, neck, chest, abdomen, agitation, shock, traumatic arrest, polytrauma, or burn). Categories of preintubation blood pressure were collected: hypertensive (>139), normal (100 to 139), hypotensive (<100), and in arrest. Oxygen saturation at the start of intubation was recorded as well as use and method of preoxygenation. Intubating physicians recorded whether their initial impression suggested a difficult airway (ie, yes/no). Additionally, physicians recorded whether a preintubation airway assessment was completed (eg, Mallampati, mouth opening, thyromental distance), whether additional difficult airway characteristics were present or absent (eg, cervical collar, blood or vomit in airway, facial trauma, airway obstruction), and whether sepsis or an elevated intracranial pressure was presumed prior to intubation. For each intubation attempt, the following data were collected: pharmacologic method, route and position during intubation, device used, bougie use, use of pretreatment medications and doses, induction and paralytic medication and dose (if applicable), grade of glottis view, use of external laryngeal manipulation, and outcome of attempt. In NEAR, device refers to the type of laryngoscope (direct laryngoscopy or video laryngoscopy) used rather than the technique (direct versus indirect) used to obtain a view. Additionally, the specialty and level of training of each intubator and supervising physician were collected. Peri-intubation adverse events were collected, including hypoxia (<90% or >10% drop if <90% to start), hypotension (systolic blood pressure <100), arrhythmias (brady/tachydysrhythmia), cardiac arrest (after induction), oropharyngeal injury, endotracheal tube misplacement, and vomiting. Other than hypoxia, hypotension, and cardiac arrest, the other adverse events were stated and not further defined by NEAR.

After data entry, study investigators reviewed all data using quality assurance algorithms to identify data entry errors and correct where possible. All sites included in NEAR were required to enter a minimum of 90% of all intubations in order to maintain compliance. The study coordinators performed active compliance monitoring to ensure the 90% threshold was maintained. If sites did not maintain compliance, they were dropped from the registry to minimize selection bias.

Outcomes

The primary outcome was successful endotracheal intubation on first attempt, which was self-reported by the intubator. An intubation attempt was defined as any insertion of a laryngoscope beyond the alveolar ridge, whether or not an endotracheal tube was inserted. A successful intubation was defined as a properly placed endotracheal tube during an attempt, which was confirmed by colorimetric or quantitative end-tidal CO_2.

Statistical Analysis

All data management and statistical analyses were performed using SAS Enterprise Guide Version 7.1 (SAS Institute, Inc., Cary, NC). Descriptive statistics were calculated for all variables and adjusted for clustering by site. Continuous data were reported as means with standard deviations or medians with interquartile ranges, as appropriate. Nominal and ordinal data were reported as proportions with 95% confidence intervals (CIs).

To estimate all associations between patient and intubation characteristics and first-pass success, we used a generalized linear mixed-effects model (GLIMMIX in SAS) with a binary distribution and a logit link. Site was included as a random effect. We first estimated bivariate associations of patient characteristics, mechanism of trauma, preintubation vital signs and ventilation status, difficult airway characters, intubation device and positioning, intubator level of training, and site volume of trauma intubations with first-pass success. Next, we developed a full model to estimate the independent associations between all peri-intubation variables and first-pass success. Effect modification was assessed between intubating device and use of augmentation (ie, bougie or external laryngeal manipulation) using interaction terms and included if significant. As this study was a secondary analysis of a national dataset, we did not derive hypotheses a priori and therefore did not perform sample size calculations.

Due to the potential for confounding by indication, we performed a subsequent analysis using propensity score matching. Prior to propensity score matching, we used multiple imputation to account for missing data. Twenty percent of patients in our dataset (808 of 3,999) had at least one missing value (Table 1), with preintubation oxygen saturation being the most frequent (15%). We used PROC MI in SAS using fully conditional specification (ie, chained equations) to create 10 imputed datasets using all available variables in the NEAR dataset. The following categorical variables were imputed when missing: patient sex and body habitus, mechanism of trauma, preintubation vital signs and ventilation status, difficult airway characteristics, pharmacologic method of intubation, and use of bougie and external laryngeal manipulation.

Next, we performed propensity score matching with each imputed dataset. We first used logistic regression to model and calculate the propensity to use video laryngoscopy. Our propensity score model accounted for all variables known prior to intubation that may have influenced the decision to use video laryngoscopy, including site, patient age, body habitus, mechanism of trauma, trauma indication, preintubation blood pressure, oxygen saturation, ventilation status, airway assessment (if completed), all difficult airway characteristics, cervical spine manipulation at time of intubation, pharmacologic method of intubation, use of a bougie or external laryngeal manipulation, and training level of the intubator. We then matched patients intubated with video laryngoscopy with patients intubated with direct laryngoscopy using 1:1 greedy matching without replacement and a 0.1 caliper around the propensity score. Consequently, the propensity score matched dataset was limited to all patients intubated with direct laryngoscopy and their matched patients intubated with video laryngoscopy. Matched patients were compared to assess balance in covariates using standardized mean differences, with <10% reflecting excellent balance (Figure E1, available at http://www.annemergmed.com).[12] The association between type of laryngoscopy and first-pass success was then estimated using a multivariable generalized linear mixed-effects model. Finally, model parameter estimates for each imputed dataset were combined using Rubin's rules (MIANALYZE in SAS) to generate valid

Table 1. Patient and institutional characteristics.

	All Patients		Blunt		Penetrating		Burn	
	%	(N)	%	(n)	%	(n)	%	(n)
Mechanism of Trauma*		(4,449)	75	(3,328)	21	(915)	5	(203)
Patient Age (median yrs [IQR])	37	(25-54)	40	(26-57)	30	(24-40)	44	(29-60)
Patient Age (years)								
0–14	4	(173)	4	(144)	2	(18)	0	(11)
15–39	48	(2,124)	42	(1,410)	70	(639)	36	(74)
40–64	33	(1,458)	35	(1,159)	24	(218)	40	(81)
≥65	14	(607)	16	(539)	3	(32)	18	(36)
Missing	2	(87)	2	(76)	1	(8)	0	(1)
Patient Sex								
Male	77	(3,419)	75	(2,494)	86	(791)	65	(132)
Female	23	(1,027)	25	(832)	13	(123)	35	(71)
Missing	0	(3)	0	(2)	0	(1)	0	(0)
Patient Habitus†								
Thin	17	(761)	17	(552)	19	(170)	19	(38)
Normal	58	(2,585)	58	(1,942)	59	(541)	50	(101)
Obese	24	(1,066)	25	(816)	20	(187)	31	(63)
Missing	1	(37)	1	(18)	2	(17)	0	(1)
Indication for Intubation								
Head injury	33	(1,480)	40	(1,330)	16	(148)	0	(1)
Multisystem trauma	22	(977)	26	(864)	12	(107)	2	(4)
Face/neck trauma	10	(425)	8	(272)	17	(151)	1	(2)
Combative/agitated	9	(416)	11	(362)	5	(48)	3	(6)
Arrest	9	(394)	6	(207)	20	(184)	1	(3)
Torso trauma	8	(337)	4	(139)	22	(197)	1	(1)
Burn	5	(223)	1	(34)	0	(4)	91	(185)
Shock	4	(197)	4	(120)	8	(76)	1	(1)
Preintubation Blood Pressure								
Hypertensive (≥140)	27	(1,218)	29	(976)	17	(158)	41	(84)
Normal (100–139)	45	(1,996)	49	(1,620)	30	(274)	50	(101)
Hypotensive (<100)	15	(678)	14	(465)	22	(202)	5	(11)
Coding	12	(525)	7	(249)	30	(270)	2	(5)
Missing	1	(32)	1	(18)	1	(11)	1	(2)
Preintubation O_2 Saturation								
90–100%	75	(3,355)	79	(2,639)	59	(541)	86	(174)
80–89%	3	(124)	3	(101)	2	(17)	3	(6)
<80%	4	(189)	3	(107)	8	(77)	2	(5)
Missing	18	(781)	14	(481)	31	(280)	9	(18)
Difficult Airway Characteristics								
Difficult 1st impression	44	(1,944)	45	(1,495)	37	(339)	54	(109)
Reduced neck mobility	72	(3,224)	89	(2,964)	24	(220)	19	(39)
Facial trauma	38	(1,700)	42	(1,389)	29	(266)	22	(45)
Blood/vomit in airway	38	(1,679)	40	(1,323)	37	(342)	6	(13)
Obese	24	(1,066)	25	(816)	20	(187)	31	(63)
Airway obstruction	6	(248)	5	(162)	7	(63)	11	(23)

Table 1. Continued.

	All Patients		Blunt		Penetrating		Burn	
	%	(N)	%	(n)	%	(n)	%	(n)
Volume of Trauma Intubations‡								
High (≥10)	53	(2,371)	52	(1,727)	59	(537)	53	(107)
Medium (5–9)	22	(981)	22	(735)	21	(191)	26	(52)
Low (2–4)	22	(963)	23	(758)	18	(167)	19	(38)
Very low (<2)	3	(134)	3	(108)	2	(20)	3	(6)

*3 patients without recorded mechanism of trauma.
†Categorized by the intubator based on subjective assessment.
‡Sites categorized by average # trauma intubations per month (High=5 sites; Medium=4 sites; Low=8 sites; Very Low=6 sites).

statistical inferences. Four additional sensitivity analyses were completed, including (1) complete case analysis, (2) analysis dropping the ED with the highest number of intubations that also only used video laryngoscopy, (3) analysis including only 4 high-volume EDs that used a mix of direct laryngoscopy (minimum of 40%) and video laryngoscopy, and (4) analysis excluding patients <15 years of age.

RESULTS

Characteristics of Study Subjects

From January 1, 2016 through December 31, 2018, the National Emergency Airway Registry included 19,071 ED intubations, of which 23% (n=4,449) were for traumatic indications at 23 EDs that treated adults or adults and children. Blunt trauma was the primary mechanism of trauma, followed by penetrating trauma and burns (Table 1). Head injury and multisystem trauma constituted the majority of traumatic injuries necessitating intubation. A notable proportion of patients were hypotensive, in cardiac arrest, or hypoxemic prior to intubation. The majority of patients had reduced neck mobility secondary to a cervical collar and at least one difficult airway characteristic.

Intubation Attempts and Outcomes

Prevalence of first-pass success was 86.8% (95% CI: 83.3% to 90.3%), and 97.1% (95% CI: 96.0% to 98.1%) of patients were intubated by second attempt (Table 2). Emergency medicine- or pediatric emergency medicine-trained physicians performed almost all first and second ED intubation attempts. Similarly, resident emergency physicians performed almost all first intubation attempts, with post-graduate year 3 residents performing the most, followed by post-graduate year 2 residents. The majority of patients were intubated with video laryngoscopy. Of those intubated with video laryngoscopy, identical proportions of patients were intubated with standard geometry (ie, Macintosh) and hyperangulated blades. A bougie was additionally used in a minority of first attempts. Only 31 of 4,499 patients necessitated a surgical airway (0.7%, 95% CI: 0.5% to 1.0%), and 7 of 31 surgical airways (23%) were done on first attempt. Most patients were intubated with rapid sequence intubation or no medications. When used, etomidate was the primary sedative, followed by ketamine. Succinylcholine was the primary paralytic, followed by rocuronium. Twelve percent (529 of 4,449) of all ED intubations for trauma had an associated adverse event, and the incidence of adverse events increased with subsequent attempts (Table 3). Hypoxemia was the primary adverse event, followed by hypotension. Prevalence of any adverse event was identical for patients intubated with video laryngoscopy as compared to direct laryngoscopy on first attempt (Table E1, available at http://www.annemergmed.com). However, esophageal intubations were more common in patients intubated with direct laryngoscopy as compared to video laryngoscopy (1.5% versus 0.4%, difference=1.1%, 95% CI: 0.4% to 2.0%).

Unadjusted First-Pass Success by Emergency or Pediatric Emergency Physicians

Figure 1 shows first-pass success by intubating device (video laryngoscopy versus direct laryngoscopy) with or without augmentation (ie, bougie or external laryngeal manipulation). Video laryngoscopy was associated with first-pass success as compared to direct laryngoscopy (90% versus 79%, difference=11%, 95% CI: 8% to 13%). Three approaches were most successful, including Macintosh video laryngoscopy with a bougie (96%, 95% CI: 91% to 100%), hyperangulated video laryngoscopy (92%, 95% CI: 90% to 94%), and Macintosh video laryngoscopy without augmentation (90%, 95% CI: 86% to 94%). Direct laryngoscopy without augmentation (87%, 95% CI: 85% to 89%) performed similarly to Macintosh video laryngoscopy without augmentation. Figure 2 shows the proportions of intubating device used on first attempt by site along with the variation in first-pass success by site.

Table 2. ED trauma intubation attempts by intubator specialty, training, and techniques used.

	1st Attempt		2nd Attempt		3rd Attempt		4th Attempt		5th Attempt	
	n=4,449		n=591		n=129		n=23		n=8	
Intubation Attempts (N=5,199)	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
Intubation Success (%, n)										
Yes	87	(3,856)	78	(460)	82	(104)	65	(14)	75	(6)
No	13	(591)	22	(129)	18	(23)	35	(8)	25	(2)*
Missing†	0	(2)*	0	(2)*	0	(2)*	0	(1)*	–	(0)
Intubator Specialty										
Emergency/Pediatric Emergency Medicine	94	(4,187)	84	(498)	66	(85)	43	(10)	13	(1)
Anesthesia	4	(181)	12	(70)	24	(31)	30	(7)	75	(6)
Other Physician	1	(37)	2	(12)	10	(13)	22	(5)	13	(1)
Non-Physician	1	(44)	2	(11)	–	(0)	4	(1)	–	(0)
Missing	–	(0)	–	(0)	–	(0)	–	(0)	–	(0)
Intubator Level Training										
PGY 1	6	(289)	3	(20)	2	(2)	–	(0)	–	(0)
PGY 2	30	(1,332)	26	(151)	13	(17)	4	(1)	–	(0)
PGY 3	46	(2,029)	35	(205)	21	(27)	4	(1)	–	(0)
PGY 4 or Fellow	13	(590)	14	(83)	16	(21)	30	(7)	13	(1)
Attending	4	(160)	20	(116)	45	(58)	52	(12)	88	(7)
Missing	1	(49)	3	(16)	3	(4)	9	(2)	–	(0)
Devices Used										
Direct laryngoscopy	28	(1,227)	33	(194)	36	(47)	22	(5)	38	(3)
Video laryngoscopy	71	(3,173)	64	(376)	50	(65)	48	(11)	50	(4)
Bronchoscope	0	(19)	0	(2)	2	(2)	–	(0)	–	(0)
Cricothyrotomy	0	(7)	1	(6)	9	(11)	26	(6)	13	(1)
Finger/digital	0	(5)	0	(1)	–	(0)	–	(0)	–	(0)
Intubating laryngeal mask airway	0	(3)	1	(4)	–	(0)	–	(0)	–	(0)
Missing	0	(15)	1	(8)	3	(4)	4	(1)	–	(0)
Bougie Assisted	15	(645)	22	(129)	33	(43)	30	(7)	13	(1)
Medications Used‡										
Sedation + paralysis	83	(3,676)	4	(26)	12	(16)	4	(1)	–	(0)
Sedation only	1	(39)	1	(3)	1	(1)	–	(0)	–	(0)
Paralysis only	3	(131)	2	(15)	4	(5)	4	(1)	–	(0)
Topical +/- Sedation	0	(6)	–	(0)	–	(0)	–	(0)	–	(0)
No medications	12	(594)	92	(547)	73	(107)	92	(11)	100	(8)
Missing	0	(2)	–	(0)	–	(0)	–	(0)	–	(0)

*Disposition for missing: 1st attempt—both unknown; 2nd attempt—1 unknown and 1 survived to ICU admission; 3rd attempt—both died in ED from nonairway cause; 4th attempt—survived to admission; 5th attempt—both survived to admission.
†Missing denotes no documentation of attempt success, no documentation of subsequent attempts, and no documentation of endotracheal tube confirmation (ie, qual/quant end-tidal CO2, auscultation of lungs, condensation in tube).
‡When multiple attempts, denotes additional medications given with each attempt.

Patient and Intubating Characteristics Associated With First-Pass Success

Nearly all preintubation characteristics differed between patients intubated with video laryngoscopy versus direct laryngoscopy, supporting our strategy to use propensity score matching to account for confounding by indication (Table E2, available at http://www.annemergmed.com). The following 4 patient and intubating characteristics

Table 3. Adverse events peri-intubation.

Intubation Attempts (N=5,199)	1st Attempt n=4,449 %	(n)	2nd Attempt n=591 %	(n)	3rd Attempt n=129 %	(n)	4th Attempt* n=23 %	(n)
Adverse Events‡								
None	88	(3899)	87	(509)	80	(100)	77	(17)
Any AE	12	(529)	13	(75)	20	(25)	23	(5)
Missing	0	(21)	0	(7)	0	(4)	0	(1)
Cardiorespiratory AE								
Hypoxia	7	(333)	9	(52)	14	(19)	17	(5)
Hypotension	3	(136)	3	(17)	5	(6)	3	(1)
Cardiac arrest	1	(43)	1	(4)	1	(1)	–	(0)
Bradydysrhythmia	1	(42)	1	(4)	2	(2)	–	(0)
Tachydysrhythmia	0	(5)	–	(0)	–	(0)	–	(0)
Laryngospasm	0	(3)	–	(0)	–	(0)	–	(0)
Iatrogenic Trauma AE								
Dental trauma	0	(2)	–	(0)	–	(0)	–	(0)
Epistaxis	0	(2)	–	(0)	–	(0)	–	(0)
Nonspecific OP bleeding	0	(2)	0	(1)	1	(1)	–	(0)
Pneumothorax	0	(1)	0	(1)	–	(0)	–	(0)
Pharyngeal laceration	–	(0)	–	(0)	–	(0)	–	(0)
Lip laceration	–	(0)	–	(0)	–	(0)	–	(0)
Endotracheal Tube Malposition								
Esophageal intubation	1	(32)	1	(3)	1	(2)	1	(4)
Mainstem intubation	0	(19)	1	(3)	–	(0)	–	(0)
ETT cuff failure	0	(8)	1	(3)	1	(1)	–	(0)

AE, adverse event; OP, oropharyngeal; ETT, endotracheal tube.
*No AEs in 5th attempt.
‡Multiple AEs may occur on same patient.

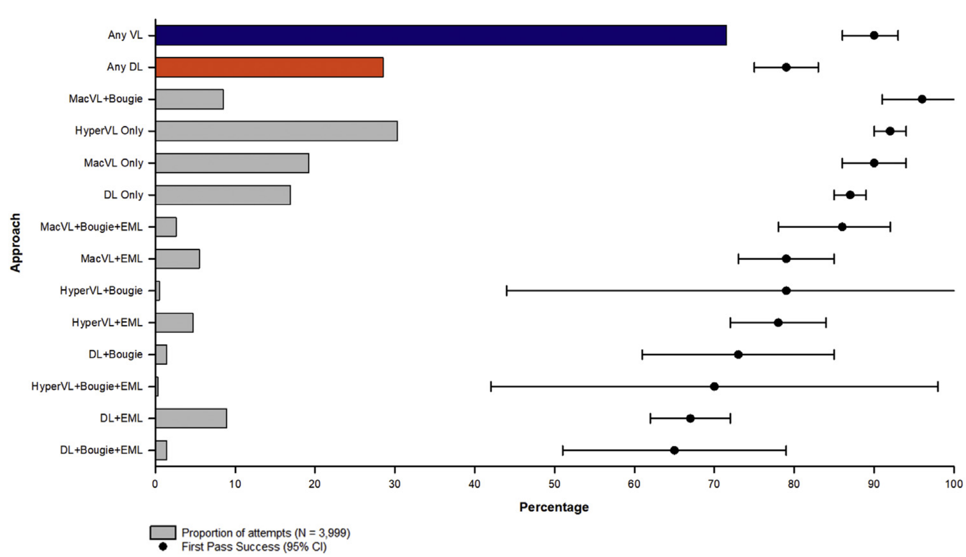

Figure 1. First-pass success by first approach, adjusted for clustering by site. *EML,* external laryngeal manipulation; *Hyper*, hyperangulated; *Mac*, Macintosh.

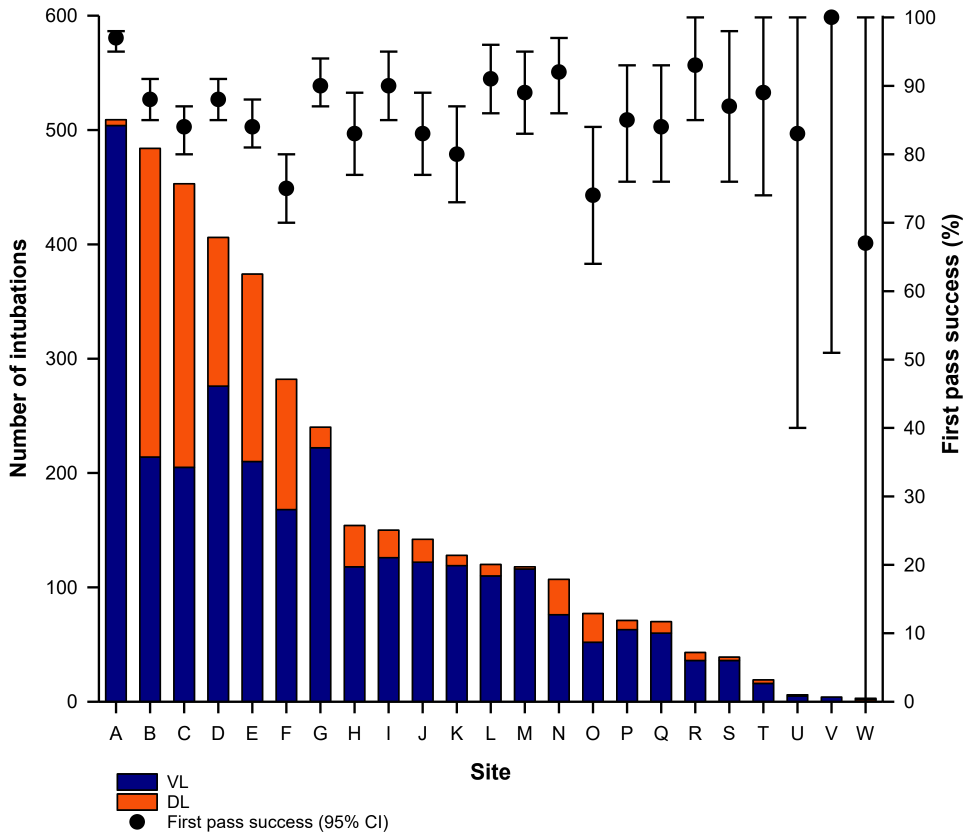

Figure 2. First-pass success by site and device.

remained significant after propensity score matching: intubating device (direct laryngoscopy versus video laryngoscopy), intubator's initial impression of difficult airway, blood or vomit in the airway, and use of external laryngeal manipulation (Table 4). In all sensitivity analyses (Table E3, available at http://www.annemergmed.com), video laryngoscopy remained associated with first-pass success in ED trauma intubations, with only a minimal decrease in odds of first-pass success after excluding the high-volume site that almost always used video laryngoscopy (OR 1.9, 95% CI: 1.5 to 2.6), limiting the dataset to only high-volume sites that utilized a mix of direct laryngoscopy (>40%) and video laryngoscopy (OR 2.0, 95% CI: 1.3 to 5.0), and excluding patients <15 years (OR 2.1, 95% CI: 1.6 to 2.9).

LIMITATIONS

Our study has several potential limitations. First, our data were collected using a web-based data collection platform where intubating physicians directly entered self-reported data. Thus, the integrity of our data relies on honest reporting of intubation success and adverse events. While site investigators actively monitored data entry compliance, each data element was not confirmed; therefore, underreporting may have occurred. However, our adverse event rates and need for multiple attempts were similar to those reported in a systematic review and meta-analysis of ED intubations, suggesting that underreporting in the NEAR registry is likely low.[3] Second, 20% of patients had at least one missing variable in the dataset, with preintubation oxygen saturation representing the majority of missing data. To minimize case exclusion, we used multiple imputation to estimate these missing values and included complete case analysis as a sensitivity analysis. Third, the NEAR database did not capture the technique used to obtain a view of the larynx. While this can be inferred when a direct laryngoscopy or video laryngoscopy with hyperangulated blade is used, a direct and indirect view of the larynx can be achieved with a using a standard geometry blade. Thus, in this study, laryngoscope (ie, device) refers only to the presence (video laryngoscopy) or absence (direct laryngoscopy) of an attached video screen. Fourth, although our study utilized data from 23 institutions, all were academic-affiliated institutions with emergency medicine residency training programs and many were institutions with an interest in airway management research. Additionally, 53% of our data came from 5 high-

Table 4. Patient and intubating characteristics associated with first-pass success.

	Unadjusted[†]		Adjusted		PS-Matched[‡]	
(N=3,999)*	OR	95% CI	OR	95% CI	OR	95% CI
Intubation Device						
Video laryngoscopy	2.2	(1.8-2.8)	2.0	(1.6-2.6)	2.2	(1.6-2.9)
Direct laryngoscopy	Ref		Ref		Ref	
Patient Age (years)	0.99	(0.99-1.0)	0.99	(0.99-1.0)	0.99	(0.99-1.00)
Patient Sex						
Male	Ref		Ref		Ref	
Female	1.0	(0.8-1.3)	1.0	(0.8-1.3)	1.0	(0.7-1.4)
Patient Habitus						
Thin	0.9	(07-1.2)	0.9	(07-1.1)	0.9	(0.6-1.3)
Normal	Ref		Ref		Ref	
Obese	0.8	(0.6-1.0)	0.8	(0.6-1.0)	0.8	(0.5-1.0)
Mechanism of Trauma						
Blunt	Ref		Ref		Ref	
Penetrating	1.0	(0.8-1.4)	0.9	(0.6-1.4)	0.9	(0.6-1.3)
Burn	1.4	(0.8-2.5)	1.0	(0.5-1.8)	1.2	(0.5-3.2)
Preintubation Blood Pressure						
Hypertensive (SBP>139)	1.0	(0.8-1.3)	1.1	(0.9-1.4)	1.0	(0.7-1.5)
Normal (SBP 100–130)	Ref		Ref		Ref	
Hypotensive (SBP<100)	1.0	(0.7-1.3)	1.1	(0.8-1.6)	1.3	(0.8-2.0)
Coding	0.5	(0.4-0.7)	0.6	(0.4-0.8)	0.6	(0.3-1.0)
Missing	0.3	(0.1-1.6)	0.4	(0.0-4.7)		
Preintubation O_2 Sat						
90–100%	Ref		Ref		Ref	
<90%	0.6	(0.4-0.8)	1.0	(0.7-1.5)	0.8	(0.6-1.8)
Missing	0.9	(0.7-1.1)	1.2	(0.9-1.7)		
Ventilation Status						
Breathing	Ref		Ref		Ref	
Apneic	0.6	(0.5-0.8)	0.7	(0.5-1.0)	0.8	(0.5-1.8)
Immediate intub required	0.7	(0.5-0.8)	0.9	(0.7-1.2)	1.0	(0.7-1.5)
Difficult Airway Characteristics						
Difficult initial impression	0.5	(0.4-0.6)	0.7	(0.5-0.9)	0.7	(0.5-0.99)
Blood/vomit in airway	0.4	(0.4-0.5)	0.6	(0.5-0.7)	0.5	(0.4-0.8)
Neck immobilization	0.8	(0.6-0.97)	0.9	(0.6-1.3)	0.8	(0.5-1.3)
Facial trauma	0.7	(0.6-0.9)	1.1	(0.9-1.4)	1.2	(0.8-1.8)
Airway obstruction	0.4	(0.3-0.5)	0.6	(0.4-0.9)	0.6	(0.4-1.1)
Intubation Position/Augmentation						
C-spine manipulation	1.3	(1.01-1.7)	1.5	(1.01-2.2)	1.2	(0.7-2.0)
Ext laryngeal manipulation	0.3	(0.3-0.4)	0.4	(0.3-0.5)	0.4	(0.3-0.5)
Bougie use	0.6	(0.4-0.8)	0.9	(0.6-1.3)	0.9	(0.5-1.4)
Intubator						
PGY 1	0.8	(0.6-1.2)	0.7	(0.5-1.1)	0.7	(0.4-1.3)
PGY 2	0.8	(0.6-0.99)	0.8	(0.6-1.0)	0.8	(0.6-1.1)
PGY 3	Ref		Ref		Ref	
PGY 4 or fellow	1.2	(0.9-1.7)	1.2	(0.9-1.7)	1.3	(0.8-2.0)
Attending	1.1	(0.6-1.9)	1.1	(0.6-2.0)	2.3	(0.7-7.7)

Table 4. Continued.

	Unadjusted†		Adjusted		PS-Matched‡	
(N=3,999)*	OR	95% CI	OR	95% CI	OR	95% CI
Monthly Trauma Intubations						
High (≥10)	Ref		Ref		Ref	
Medium (5–9)	0.7	(0.4-1.3)	0.6	(0.4-0.9)	0.7	(0.4-1.0)
Low (2–4)	0.7	(0.4-1.2)	0.6	(0.4-0.96)	0.8	(0.5-1.3)
Very low (<2)	1.1	(0.5-2.5)	0.8	(0.4-1.7)	0.8	(0.3-2.4)

Ref, reference; *SBP*, systolic blood pressure; *Sat*, saturation; *Intub*, intubation; *Ext*, external; *PGY*, post-graduate year.
*Intubations by emergency medicine/pediatric emergency medicine, using direct laryngoscopy or video laryngoscopy, and rapid sequence intubation or no meds.
†Adjusted for clustering by site only.
‡N=2160 (average number of patients in 10 imputed datasets).

volume level 1 trauma centers in large US cities. Thus, our findings may reflect practices that are more commonly seen in these types of settings and, therefore, may not generalize to all settings. Lastly, while failure to achieve first-pass success is associated with peri-intubation adverse events that can have serious consequences for patients, our study did not include patient-centered outcomes, such as intensive care length of stay, ventilator days, and in-hospital or 28-day mortality.

DISCUSSION

To our knowledge, this is the first multicenter study to characterize contemporary trauma airway management in US EDs, focusing on the techniques used and outcomes associated with these intubations. Previous NEAR studies have reported unadjusted first-pass success in trauma intubations of 83% (data from September 1996 to June 2001) and 84% (data from July 2002 to December 2012).[2,7] Other single-institution studies have reported first-pass success in ED trauma intubations ranging from 73% to 86%.[13-18] Our study using the most recent NEAR data showed an increased first-pass success in trauma intubations to 87% in the context of a dramatic increase in the use of video laryngoscopy on first attempt. In 2012, the last year of the previous NEAR study, 39% of ED intubations occurred using video laryngoscopy.[2] In contrast, in our study, 72% of ED trauma intubations were performed using video laryngoscopy on first attempt.

With increasing use of video laryngoscopy in a variety of clinical settings, multiple studies have sought to determine whether direct laryngoscopy or video laryngoscopy should be the first-line device for airway management. In 2016, a Cochrane review using data from 64 randomized controlled and quasi-experimental studies found no statistically significant difference in first-pass success between direct laryngoscopy and video laryngoscopy (OR 1.3, 95% CI 0.8 to 2.1).[19] The only ED study included in the Cochrane review was a single-center study at an academic trauma center between 2008 and 2010.[18] Trauma patients were randomized to direct laryngoscopy or video laryngoscopy (hyperangulated blade), and emergency physicians performed approximately 50% of intubations in the study. No significant difference in first-pass success was found between direct laryngoscopy and video laryngoscopy (81% versus 80%).[18] Since then, 3 small randomized controlled trials, including 1 single-center ED study, have attempted to answer this question. All showed no statistical difference between first-pass success and intubating device.[20-22]

Our study adds to the literature on whether direct laryngoscopy or video laryngoscopy is associated with first-pass success by examining this association in ED intubations for trauma that were recently performed by emergency physicians. Our study used data from a large, multicenter observational study to examine this association using robust statistical methods to adjust for confounding by indication through propensity score matching. By matching patients with similar preintubation characteristics, propensity score matching attempts to create balanced groups as seen in randomized trials. With these methods, we found the odds of first-pass success in ED trauma intubations were 2 times higher when video laryngoscopy was used as compared to direct laryngoscopy.

One explanation for why our findings may differ from prior studies is that the intubations in our study were performed more recently and overwhelmingly by resident physicians, who all entered residency when video laryngoscopy had become the preferred intubating device. As such, contemporary emergency physicians have likely performed more intubations with video laryngoscopy as compared to direct laryngoscopy. While some high-volume academic EDs still use and teach their residents direct laryngoscopy, most intubations during emergency medicine residency training are now performed with video laryngoscopy. In contrast, attending emergency physicians in our study likely had more training with direct laryngoscopy, which may explain why they were the only group to trend toward improved first-pass success with direct laryngoscopy as compared to video laryngoscopy (91% versus 84%, 7% difference [95% CI: -7% to 18%]). Consequently, our findings may simply reveal that emergency physicians are most successful with the device they have used most.

The transition to video laryngoscopy in a graduate medical education setting is arguably superior from a teaching perspective. Unlike direct laryngoscopy, video laryngoscopy allows the supervising physician to actively participate in airway management by allowing visualization of what the resident is seeing while providing real-time feedback. Yet, each type of laryngoscope and blade combination requires different mechanical techniques to achieve glottic visualization and successfully pass the endotracheal tube into the trachea.[23] While there are similarities between techniques, particularly direct laryngoscopy and video laryngoscopy with a standard geometry blade, there are also differences, some nuanced and others substantive. The steepest part of the learning curve with direct laryngoscopy is the mechanics to obtain glottic visualization.[23] In contrast with video laryngoscopy, glottic visualization is easier to obtain, but passing the endotracheal tube can be more challenging, particularly with indirect visualization.[23,24] These differences may explain why we found that direct laryngoscopy and video laryngoscopy (standard geometry blade) without augmentation performed similarly. However, when direct laryngoscopy required augmentation, first-pass success significantly declined (87% to 68%), which may reflect that augmentation was being used to compensate for a less-than-optimal glottic view. Competency with each device and blade combination requires sufficient training and use in all types of ED intubations, which may be difficult to achieve in all training environments. Consequently, whether a specific device and blade combination significantly improves first-pass success in ED intubations is a critical clinical question in emergency medicine that has implications for patient care and clinical training. Moreover, our study shows variation in use of both direct laryngoscopy and video laryngoscopy in US EDs, suggesting clinical equipoise. While propensity score matching can help mitigate confounding by indication, it cannot control for unmeasured confounding. Thus, a large randomized controlled trial of direct laryngoscopy versus video laryngoscopy is likely required to definitively answer this question.

In conclusion, emergency physicians are successful at intubating patients in the setting of trauma. With the increasing use of video laryngoscopy, first-pass success in ED intubations for trauma performed in the NEAR network has improved, and video laryngoscopy is associated with twice the odds of first-pass success when compared to direct laryngoscopy.

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