Techniques, Success, and Adverse Events of Emergency Department Adult Intubations

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Study objective: We describe the operators, techniques, success, and adverse event rates of adult emergency department (ED) intubation through multicenter prospective surveillance.

Methods: Eighteen EDs in the United States, Canada, and Australia recorded intubation data onto a Web-based data collection tool, with a greater than or equal to 90% reporting compliance requirement. We report proportions with binomial 95% confidence intervals (CIs) and regression, with year as the dependent variable, to model change over time.

Results: Of 18 participating centers, 5 were excluded for failing to meet compliance standards. From the remaining 13 centers, we report data on 17,583 emergency intubations of patients aged 15 years or older from 2002 to 2012. Indications were medical in 65% of patients and trauma in 31%. Rapid sequence intubation was the first method attempted in 85% of encounters. Emergency physicians managed 95% of intubations and most (79%) were physician trainees. Direct laryngoscopy was used in 84% of first attempts. Video laryngoscopy use increased from less than 1% in the first 3 years to 27% in the last 3 years (risk difference 27%; 95% CI 25% to 28%; mean odds ratio increase per year [ie, slope] 1.7; 95% CI 1.6 to 1.8). Etomidate was used in 91% and succinylcholine in 75% of rapid sequence intubations. Among rapid sequence intubations, rocuronium use increased from 8.2% in the first 3 years to 42% in the last 3 years (mean odds ratio increase per year 1.3; 95% CI 1.3 to 1.3). The first-attempt intubation success rate was 83% (95% CI 83% to 84%) and was higher in the last 3 years than in the first 3 (86% versus 80%; risk difference 6.2%; 95% CI 4.2% to 7.8%). The airway was successfully secured in 99.4% of encounters (95% CI 99.3% to 99.6%).

Conclusion: In the EDs we studied, emergency intubation has a high and increasing success rate. Both drug and device selection evolved significantly during the study period. [Ann Emerg Med. 2014;■:1-9.]

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INTRODUCTION

Background

By 2002, the majority of emergency department (ED) intubations were performed by emergency physicians, predominantly using rapid sequence intubation.[1-3] Reports of intubation success and events are sparse, and only one previous study reported results from intubations occurring across multiple centers through 2002.[1] Since then, the practice of emergency intubation has been influenced by an array of new devices and techniques. Rates of adoption of these new approaches and related outcomes are relevant to quality of care and patient safety. Debate has ensued about the merits of new devices, principally video laryngoscopes, and the safety and desirability of various induction and neuromuscular-blocking agents.[4-12] There are very few ED-based, multicenter studies that can provide insight about techniques used, expected success and adverse event rates, and the evolution of airway management over time.[1,3,13]

Importance

For a high-risk medical procedure that is known to be evolving so rapidly, ongoing surveillance is essential to define current practice and identify trends in intubation techniques and outcomes. Such surveillance can provide benchmarks for quality outcomes, including success and adverse event rates. Although single-center reports are helpful, generalizability is limited. Intubation is a lifesaving procedure with little room for error, and recent studies have shown that adverse events are more likely with increased numbers of intubation attempts.[11,14,15] Therefore, monitoring trends in clinical practice and intubation

Editor's Capsule Summary

What is already known on this topic

Airway management is an important component of emergency medicine practice. Changes in this practice over time have not been systematically evaluated on a large scale.

What question this study addressed

This prospective, multicenter, international registry of 17,583 emergency department (ED) airways managed in 13 mostly academic EDs tracked indications, techniques, pharmacologic adjuncts, and adverse events from 2002 to 2012.

What this study adds to our knowledge

Most airways were managed with direct laryngoscopy and succinylcholine, though the use of video laryngoscopy and rocuronium has increased recently. Despite this, first-pass success remained below 88% in all years.

How this is relevant to clinical practice

This study captures trends in airway management in a large group of patients at 13 sites and helps practitioners identify opportunities to modify their own practice.

performance is important for patient safety and allows centers to compare their own practices and performance with those of a large, multicenter population.

Goals of This Investigation

We sought to characterize ED intubation practices spanning a decade of experience to analyze performance attributes and identify evolving trends.

MATERIALS AND METHODS

Study Design

This is an analysis of a prospective multicenter registry of ED intubations, approved by the institutional review boards of all participating centers.

Setting

The National Emergency Airway Registry is an international network of academic and community hospitals. Each center had a site investigator who was responsible for ensuring compliance, defined as data entry on 90% or more of ED intubations, confirmed by comparison of captured patient data with institutional coding for intubation procedures. Center characteristics are listed in Table E1, available online at http://www.annemergmed.com.

After intubation, the operator recorded intubation details on a standardized intubation form accessed at www.near.edu, using a center-specific log-in and password. Data were entered with a custom-designed Web-based data entry tool and imported directly into a relational data base (Microsoft Access version 11.0; Microsoft, Redmond, WA) at the coordinating center. Each site investigator submitted a compliance plan that outlined the process for detecting and recording ED intubations. Compliance plans were required to include a criterion standard detection method of computer-generated professional or procedural codes indicating intubation. The compliance officer at the coordinating center at Brigham and Women's Hospital (Boston, MA) reviewed and approved each plan. Each site was required to undertake a 4-week trial period of recording intubations and could enter live data if the 90% compliance threshold was met. The site investigator cross-referenced institution-derived intubation lists with the online registry routinely to identify intubations that occurred but were not entered into the database. The site investigator also ensured, through direct provider contact, that a minimum of 90% of all intubations were entered in the registry. Each site submitted regular compliance reports to the coordinating center for review. Centers that did not maintain a 90% capture rate had their data removed from the final data set.

Selection of Participants

This report represents intubation data collected from July 1, 2002, through December 31, 2012. All adult ED patients with an attempt at intubation were eligible for analysis. Pediatric patients (<15 years) and intubations with an attempt by a nonphysician were excluded (Figure 1).

Methods of Measurement

All data were imported into Access (Microsoft). Variables included demographic patient information, indication for intubation, methods, devices and drugs used, number of attempts, intubation success or failure, operator characteristics, intubation events, and patient disposition. We used operational definitions in regard to attempts, methods, and adverse events that have been published previously.[1] We defined an intubation attempt as any single effort to place a tracheal tube, which occurred when the leading edge of the laryngoscope blade entered the oral cavity past the alveolar ridge. We defined a method as any single approach to securing the airway, using specific technique and

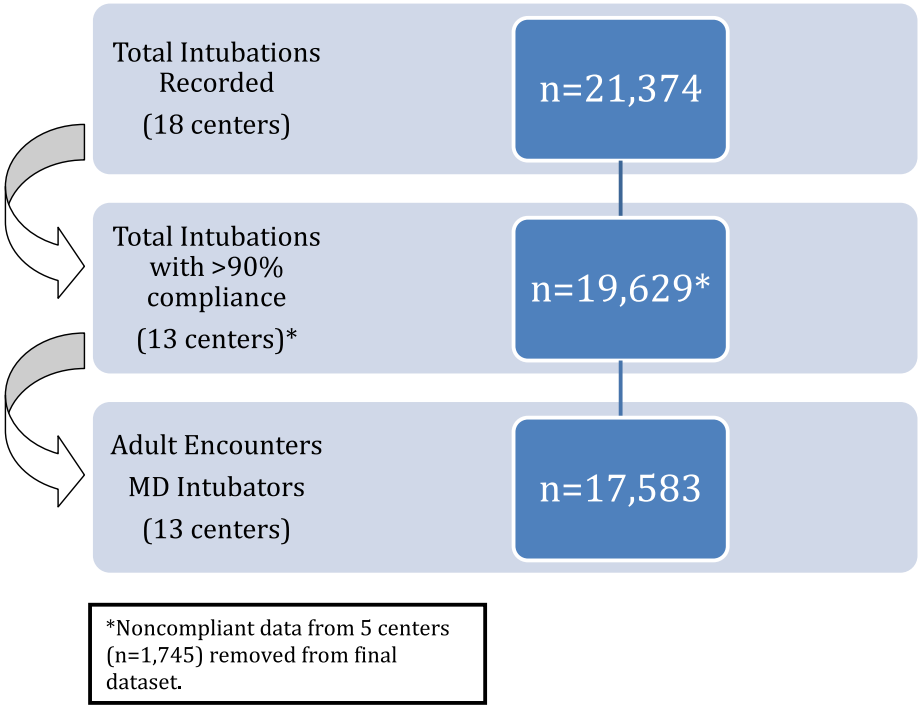

Figure 1. Inclusion criteria and enrollment strategy.

drugs, such as orotracheal rapid sequence intubation. When describing adverse events associated with intubation, we avoided the term *complication* because we endeavored to record all possible associated adverse events, whether or not they might be interpreted as true complications. Additionally, not all intubation-associated events are complications, and the definition of *complication* varies among studies.

Before analysis, data were reviewed for completeness. Solitary incomplete entries were rectified by manual chart review. Duplicate incomplete entries (an incomplete entry followed by an identical completed entry) were removed. Any incomplete entries that could not be completed by referencing original data were kept in the database.

We report information about indications for intubation, intubator discipline and experience, methods and devices used to intubate, medication regimens and intubation success, failure, and adverse events.

We present univariate descriptive data as proportions with 95% confidence intervals (CIs) and compare proportions with risk differences. Trends over time were analyzed with linear or logistic regression, with year as the dependent variable. In reporting such data, we report beginning-of-period figures as pooled data from the first 3 years, and we do likewise for the end-of-period data, but the statistical tests are regressions on year, including all unpooled years. We performed all analyses with SAS (version 9.12; SAS Institute, Inc., Cary, NC).

RESULTS

Of 18 reporting sites, 5 were excluded for failing to maintain consistant compliance standards. In the 13 compliant sites, 19,629 unique encounters were recorded from July 2002 through December 2012; 17,583 adult airway encounters met inclusion criteria for analysis. There were 11,488 (65%) medical and 5,451 (31%) trauma encounters. There were 644 (3.7%) free-text entries classified as "other." The indications for intubation are reported in Table 1.

Emergency physicians were the primary operators for 16,692 encounters (95%; 95% CI 93.5% to 97%), most of those were physician trainees (79%). Anesthesiologists were the primary operators for 2.9% of cases. Orotracheal rapid sequence intubation (induction agent and paralytic) was the most common initial method, used in 85% of all encounters, and had an overall first-pass success rate of 85%. Table 2 shows intubation characteristics of all encounters, rates of first-pass success, and 95% confidence limits.

A direct laryngoscope was the most common initial device, used in 84% of cases. The C-MAC or video Macintosh laryngoscope was chosen as the first device in 1,077 cases (6.1%; 95% CI 5.8 to 6.5) and the GlideScope video laryngoscope was used in 560 cases (3.2%; 95% CI 3.0 to 3.5). Video laryngoscopes were chosen as the first device in 0.74% of intubations in the first 3 years versus

Table 1. Indications for intubation.

Indication	Frequency	Percentage	95% CI
Traumatic head injury	2,030	12	11-12
Altered mental status, not overdose	1,759	10	10-11
Overdose	1,343	7.7	7.3-8.1
Cardiac arrest	1,234	7.1	6.7-7.5
Pneumonia	1,007	5.8	5.5-6.2
Polytrauma	1,000	5.8	5.4-6.1
Coma	889	5.1	4.8-5.5
CHF	885	5.1	4.8-5.4
Medical shock	827	4.8	4.5-5.1
Stroke	798	4.6	4.3-4.9
COPD	757	4.4	4.1-4.7
Gunshot/knife stab wound	708	4.1	3.8-4.4
Seizure	667	3.8	3.6-4.1
Other	644	3.7	3.4-3.9
Combative trauma	637	3.7	3.4-4.0
Face/neck trauma	389	2.2	2.0-2.5
GI bleed	334	1.9	1.7-2.1
Asthma	315	1.8	1.6-2.0
Airway obstruction	296	1.7	1.5-1.9
Burn/inhalation injury	279	1.6	1.4-1.8
Traumatic arrest	230	1.3	1.2-1.5
Acute MI	216	1.2	1.1-1.4
Traumatic shock	178	1.0	0.9-1.2
Pulmonary embolism	85	0.5	0.4-0.6
Anaphylaxis	59	0.3	0.3-0.4
Intracranial hemorrhage	17	0.1	0.1-0.1
Total	17,583	100	

CI, Confidence interval; *CHF*, congestive heart failure; *COPD*, chronic obstructive pulmonary disease; *MI*, myocardial infarction.

27% in the last 3 years (risk difference 27%; 95% CI 25% to 28%; mean odds ratio increase per year [ie, slope] 1.7; 95% CI 1.6 to 1.8). By the final year, use of video laryngoscopes as the first device had increased to 39%, whereas direct laryngoscopes had declined to 55%. Figure 2 shows laryngoscope selection over time.

For encounters in which an induction agent and a neuromuscular-blocking agent were used on the first attempt (ie, rapid sequence intubation), etomidate was the most common induction agent (91%) and succinylcholine was the most common neuromuscular-blocking agent (75%). The types and frequency of use of drugs for rapid sequence intubation are shown in Table 2. Ketamine and propofol were rarely used. Pentothal use has not been recorded in the registry since 2007. Among neuromuscular-blocking agents for rapid sequence intubation, rocuronium use increased from 8.2% in the first 3 years to 42% in the last 3 years (mean odds ratio increase per year [ie, slope] 1.3; 95% CI 1.3 to 1.3). Figure 3*A* and *B* displays trends in induction agent and neuromuscular-blocking agent use.

Overall, first-pass success was achieved in 83% of encounters, and 99% of patients were intubated in 3 or fewer attempts. First-attempt success was higher in the last 3 years of the study than in the first 3 (86% versus 80%; risk difference 6.2%; 95% CI 4.2% to 7.8%). Figure 4 shows rates of first-attempt success by year. We also observed a decrement in the proportion of intubations requiring greater than 3 attempts, 1.8% in the first 3 years and 1.5% in the last 3 years (mean odds ratio decrease per year 0.95; 95% CI 0.910 to 0.996). Emergency medicine trainees (post-graduate year 1-4) had a first-pass success of 87%, whereas attending physicians were successful on first attempt 72% of the time. Medical and trauma intubations had similar first-pass success rates, 83% and 84%, respectively. First-attempt success was highest with the C-MAC or video Macintosh (91%), followed by a direct laryngoscope (84%) and GlideScope (80%). When chosen as the first device, a direct laryngoscope was ultimately successful (without a need to change devices) 98% of the time (95% CI 97% to 98%). When the C-MAC or V-MAC and GlideScope were chosen as the first device, ultimate success was 98% (95% CI 97% to 99%) and 92% (95% CI 90% to 94%), respectively.

The initial attempt was by needle or surgical cricothyrotomy in 25 cases (0.14%; 95% CI 0.086 to 0.20). Rescue cricothyrotomy (ie, initiated after an unsuccessful nonsurgical attempt) occurred in 54 cases (0.31%; 95% CI 0.22 to 0.39). Summing these, a surgical airway was used at any point in 79 of the encounters (0.45%; 95% CI 0.35 to 0.55). Trauma intubations were more likely to require a rescue cricothyrotomy, 0.2% versus 0.4%, risk difference 0.19% (95% CI 0% to 0.37%). Intubation success was not documented or the intubation was abandoned in 0.6%.

Adverse intubation-related events were reported in 12% of all encounters, of which 98% reported a single adverse event and 2% reported more than 1 event. The most common was esophageal intubation with immediate recognition that occurred in 3.3% of intubations, followed by hypotension (1.6%) and cardiac arrest (1.5%). Table 3 lists all reported adverse events.

LIMITATIONS

Our study has several important limitations. First, self-reporting is subject to the possibility of bias, including selective reporting of intubation attempts, failures, and adverse events. Our rate of adverse events is low compared with that of previous literature and may represent underreporting.[11,14] This may bias our results toward better overall airway management performance. Active compliance reporting and monitoring limit this possibility, and we have no indication that intentional underreporting occurred. Although we promoted and expected real-time data entry, we know this did not happen for all encounters. The extent to which records were not entered in real time is unknown, as is the potential for recall bias. Additionally, the number of intracranial

Table 2. First-attempt intubation characteristics and first-pass success.

Intubation Variable	Initial Attempt	Percent of All Encounters, % (95% CI)	First Attempt Successful	First Attempt Successful, % (95% CI)
Indication (total=17,583)				
Medical	11,488	65 (65–66)	9,556	83 (82–84)
Trauma	5,451	31 (30–32)	4,606	84 (84–85)
Other	644	3.7 (3.4–3.9)	508	79 (76–82)
Operator (total=17,583)				
EM PGY1	1,256	7.1 (6.8–7.5)	1,103	88 (86–90)
EM PGY2	4,763	27 (26–28)	4,215	88 (88–89)
EM PGY3 or 4	7,122	41 (40–41)	6,110	85 (85–87)
EM PGY5+	63	0.36 (0.27–0.45)	57	90 (83–98)
Attending	3,488	20 (19–20)	2,498	72 (70–73)
Anesthesia	510	2.9 (2.7–3.1)	376	74 (70–78)
Other	381	2.2 (2.0–2.4)	311	82 (78–86)
Device (total=17,583)				
Direct laryngoscope	14,825	84 (84–85)	12,484	84 (84–85)
Direct laryngoscope and bougie	620	3.5 (3.3–3.8)	427	69 (65–73)
C-MAC or V-MAC	1,077	6.1 (5.8–6.5)	979	91 (89–93)
GlideScope	567	3.2 (3.0–3.5)	452	80 (76–83)
Flexible fiberoptics	177	1.0 (0.86–1.2)	93	52 (45–60)
I-LMA with intubation	38	0.22 (0.20–0.28)	27	71 (56–85)
Lighted stylet	47	0.27 (0.19–0.34)	32	68 (55–81)
Surgical cricothyrotomy	20	0.11 (0.06–0.16)	14	70 (49–90)
Method (total=17,583)				
Oral rapid sequence intubation	14,881	85 (84–85)	12,575	85 (84–85)
Oral sedation only	628	3.6 (3.3–3.8)	478	76 (73–80)
Oral, no meds	1,758	10 (9.6–10)	1,410	80 (78–82)
Nasal, topical or sedation	88	0.50 (0.39–0.60)	48	60 (49–69)
Nasal, no meds	74	0.42 (0.33–0.52)	52	65 (54–76)
Induction (total=14,915)				
Etomidate	13,516	91 (90–91)	11,411	84 (84–85)
Ketamine	284	1.0 (1.7–2.1)	226	80 (75–84)
Propofol	206	1.4 (1.2–1.6)	167	81 (76–86)
Midazolam	475	3.2 (2.9–3.5)	379	80 (76–83)
Pentothal	360	2.4 (2.2–2.7)	305	85 (81–88)
Paralytic (total=14,691)				
Succinylcholine	10,983	75 (74–75)	9,180	84 (83–84)
Rocuronium	3,306	23 (22–23)	2,920	88 (87–89)
Other neuromuscular-blocking agent	402	2.7 (2.4–3.1)	322	80 (74–86)

V-MAC, Video Macintosh; *I-LMA*, intubating laryngeal mask airway.

hemorrhages written in as the indication for intubation is low and likely does not represent the true number in the registry. Because the diagnosis is not often known at intubation, these would be mixed in with both medical cases of mental status change and traumatic head injuries.

Furthermore, high compliance standards for self-reported registries must be balanced with usability. A more onerous data form would result in lower compliance. Historically, passive surveillance has been incapable of recording high-quality serial vital sign measurements both pre- and postintubation.[1] Because of this, we did not record these variables in our study and cannot make any statement about vital sign stability during intubation. We did not distinguish between curved- and straight-blade direct laryngoscopes or the various versions of GlideScope blades and are unable to make comparisons between these devices.

Although this is a multicenter registry with community and university-based hospitals, most centers that contributed data to the final data set are affiliated with academic institutions and residency training programs. Our findings predominantly represent practices and trends in these academic centers with interest in airway management research. Additionally, the distribution of intubations by center was uneven because of variability in both patient acuity and duration of center involvement. Observed trends may reflect practices more in the higher-volume and higher-acuity centers. Therefore, our findings may not be applicable to all practice settings.

We observed significant trends in both technique and outcomes over time. Our intent with this article is to report what has been recorded through passive observation, and because we did not control for confounders that may

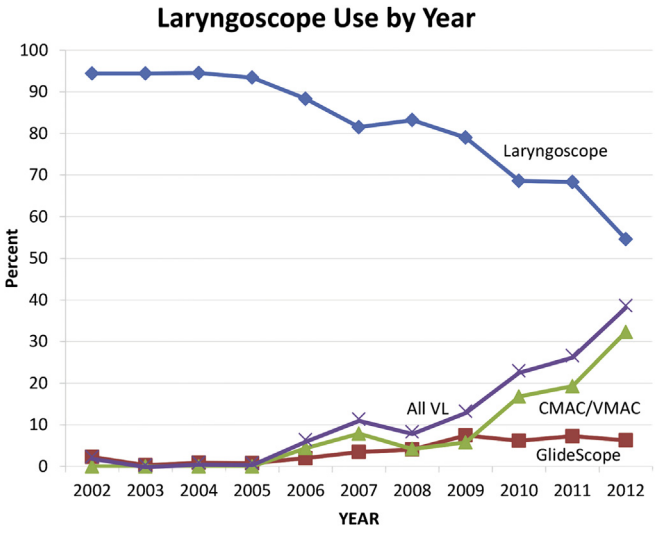

Figure 2. Laryngoscope use by year. *VL*, video laryngoscope.

have influenced outcomes over time (operator experience, specialty, airway difficulty, etc) and cannot account for unmeasured confounders, it is not possible to infer causal relationships between these trends. Even with these inherent limitations, we believe our sample accurately represents airway management practices at these centers.

DISCUSSION

We report on practices and trends among 17,583 adult ED intubations from 13 centers. Emergency physicians managed 95% of all encounters, higher than what has historically been reported.[1,2] This provides continued evidence that emergency physicians are the principal point of contact for critically ill and injured patients requiring airway management and highlights the importance of airway management education and research to modern emergency care. That most operators were emergency medicine trainees at various levels speaks to the education role of the participating sites.

Compared with previous registry data, trainee intubation success has improved during the past several years. In previous reports, post-graduate year 1 and 2 intubators had a 72% and 82% first-pass success rate, respectively.[3,16] In our study, they had a first-attempt success rate that was higher (88%). Attending physicians had a lower one, at 71.6%, compared with 90% in the study by Sagarin et al.[3] This discrepancy is hard to explain, but increased oversight and patient selection (systematic removal of difficult intubations for junior-level residents) may explain higher first-pass success for interns and lower success for attending physicians who, presumably, were managing much more challenging intubations. Anesthesiologists managed fewer than 3% of all encounters, a finding similar to what we reported in phase two of the national emergency airway registry.[1] Their first-attempt success was also lower (74%), similarly suggesting that they were called on to manage more difficult intubations. The most common method of intubation was orotracheal intubation facilitated by rapid sequence intubation in 85% of cases. This is higher than what was reported in previous NEAR studies (69%) but is similar to what has been observed in a recent single-center report.[12] This may be due to increased familiarity with rapid sequence intubation, ongoing emergency airway management education, and higher penetration of residency-trained emergency physicians.

Ultimate success rates were 99% and first-pass success varied by operator and device selected. When rapid sequence orotracheal intubation was used, intubation success occurred on first attempt 85% of the time. Airway failure requiring rescue cricothyrotomy occurred in only 0.3% of cases and was lower than what we reported with previous registry data.[1,17] Our finding that twice as many failed airways occur in trauma versus medical patients has been reported previously and highlights the high-risk nature and continued challenges of trauma intubations.

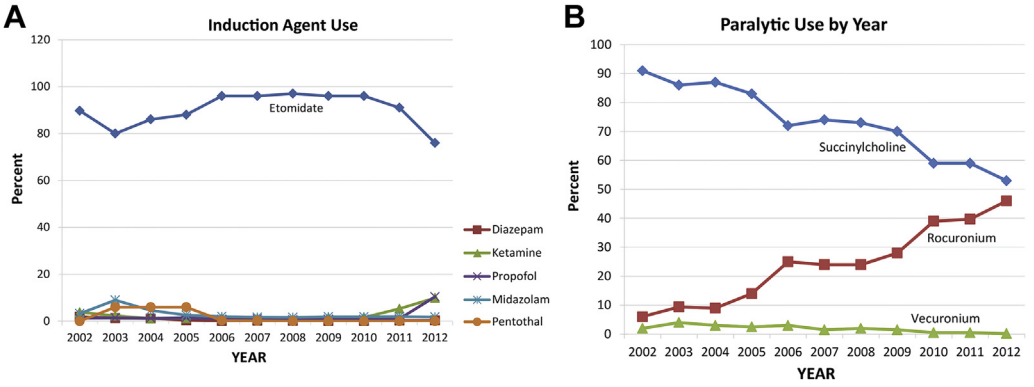

Figure 3. Induction agent and neuromuscular-blocking agent use by year.

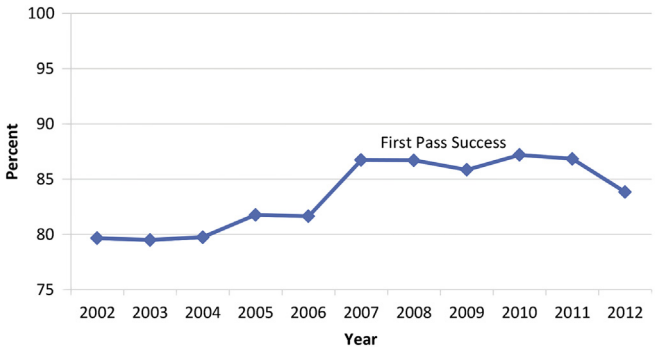

Figure 4. Time-trended first-attempt success by year.

First-pass success improved significantly during the registry period. Multiple studies have described the relationship between increasing intubation attempts and adverse peri-intubation events.[14,15] Given this, as well as a lower surgical airway rate, it is reasonable to assert that emergency airway management has become safer for patients. During this same period, VL use increased. During the first 3 years of data collection, VL was rarely used, yet nearly a third of all intubations were managed with a video laryngoscope during the last 3 years of the registry. In 2012 alone, video laryngoscopy use was 39%. Factors influencing VL use likely include familiarity with the technology, increased availability, and the desire in academic institutions to augment airway management education and attending comfort because observers can view the airway throughout the procedure. During the same amount of time, direct laryngoscopy decreased from a registry high of 94% to a registry low of 55% in 2012.

Table 3. Peri-intubation adverse events.

Adverse Event	Frequency	Total Adverse Events, %	Total Encounters, %
Esophageal intubation, immediate recognition	576	26.5	3.3
Hypotension-required IV fluid	279	12.8	1.6
Cardiac arrest	257	11.8	1.5
Main stem intubation	214	9.8	1.2
Other	136	6.3	0.77
Dysrhythmia	124	5.7	0.71
Vomit, aspiration	105	4.8	0.60
Vomit, no aspiration	98	4.5	0.56
Hypoxia	86	4.0	0.49
Dental trauma	76	3.5	0.43
Laryngospasm	74	3.4	0.43
Direct airway injury	32	1.5	0.18
Esophageal intubation, delayed recognition	23	1.1	0.13
Epistaxis	22	1.0	0.13
Pneumothorax	27	1.2	0.15
ETT cuff failure	21	1.0	0.12
Lip laceration	14	0.6	0.079
IV infiltrated	12	0.6	0.068
Total	2,176	100.0	

ETT, Endotracheal tube.

Both the GlideScope and C-MAC or V-MAC have been shown to improve glottic visualization and intubation success in emergency populations.[12,18-20] For cases that used video laryngoscope in our registry, approximately two thirds used the C-MAC or V-MAC, whereas one third used the GlideScope. First-pass success for the C-MAC or V-MAC was 91% significantly higher than that of both DL and GlideScope. Although findings for the C-MAC are congruent with those from other ED-based video laryngoscopy studies, GlideScope success is lower.[11,12] One explanation would be patient selection and operator experience. The GlideScope is often described as a difficult airway tool and may have been used preferentially in patients with more difficult airway attributes such as reduced mouth opening and reduced neck mobility, the same characteristics that might make overall airway management more challenging. In addition, GlideScope mechanics are different from DL, and although the C-MAC and V-MAC are true indirect video laryngoscopes, they also maintain standard Macintosh geometry and therefore may seem more familiar for clinicians comfortable with conventional laryngoscopic mechanics. This finding requires more investigation. Our results suggest, however, that modern emergency airway managers are migrating away from conventional laryngoscopy and toward video devices.

Drug selection also changed over time. We found that, for cases in which rapid sequence intubation drugs were administered, etomidate use was nearly universal, administered in more than 90% of all encounters, with the exception of 2012, when its use declined in parallel with an increase in propofol and ketamine use. Continued surveillance is required to determine whether this recent downward trend reflects true "signal" and the beginning of a long-term change in clinician selection or "noise" that will reverse with time. Additionally, a national shortage of etomidate, announced in the early part of 2012, may have affected its use. Our data show that etomidate remains the standard induction agent for emergency airway management. Ketamine has been advocated for intubating patients with critical illness; however, it was rarely used in our registry, which suggests it is not yet a familiar agent for adult emergency airway management.[6] This is an important finding and underscores the importance of rational analysis of the etomidate in sepsis data. Retrospective studies have claimed various adverse effects from etomidate in sepsis patients, including increased mortality, whereas prospective randomized studies have not.[6,21-23] Conflicting results, combined with etomidate's hemodynamic stability and widespread familiarity, would argue in favor of retaining it for use in hemodynamically compromised sepsis patients. Other

historically important induction agents, such as midazolam and thiopental, showed a significant decline in use during the registry period. Our data suggest that current trends have virtually eliminated benzodiazepines and barbiturates from rapid sequence intubation regimens.

Succinylcholine was the most common neuromuscular-blocking agent used, yet rocuronium became more prominent in the later years of data collection. Enthusiasm for succinylcholine may be tempered by concerns for hyperkalemia that can occur in patients with myopathies, subacute neurologic injury, or burns.[24-26] Rocuronium has been shown to be a reasonable alternative to succinylcholine for emergency airway management.[13,27] Our results suggest that comfort and familiarity with rocuronium are increasing.

In summary, our multicenter registry has shown that emergency physicians, predominantly using rapid sequence intubation, successfully manage the majority of ED intubations. Physician trainees have improved their intubation success rates compared with historical controls. First-pass success has improved nearly 6% during the past decade and is highest when a C-MAC video laryngoscope is chosen as the first device. We observed a fundamental change in airway device selection with video laryngoscopes now used in approximately one third of all encounters. Conventional laryngoscope use has undergone a significant decline, although such devices remain the most common ones used. Etomidate is the most common induction agent and ketamine use is rare. Succinylcholine is the most commonly selected neuromuscular-blocking agent, but rocuronium use is increasing rapidly. Reported intubation-associated adverse events occur in 12% of intubations. These findings should be used as a framework from which emergency airway managers and educators can compare their own practices against these national trends.

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APPENDIX

Table E1. NEAR III center characteristics.

Institution	Location	NEAR Intubations	Residency	Trauma Center	Annual Volume	Pediatrics
Summa Health System	Akron, OH	1,560	Y	Level I	70,000	Y
Brigham and Women's	Boston, MA	1,742	Y	Level I	60,000	N
Doctors Medical Center	San Pablo, CA	1,314	N	Level II	80,000	Y
Maricopa Medical Center	Phoenix, AZ	1,542	Y	Level I	60,000	Y
NY Presbyterian	New York City, NY	469	Y	Level I	70,000	Y
Pitt County Hospital	Greenville, NC	326	Y	Level I	120,000	Y
Royal Melbourne	Melbourne, Australia	488	Y	Level I	60,000	Y
University of South Carolina	Charleston, SC	947	Y	Level I	50,000	Y
University of California–Davis	Sacramento, CA	5,073	Y	Level I	70,000	Y
University of Cincinnati	Cincinnati, OH	1,178	Y	Level I	85,000	N
University of Nebraska	Omaha, NE	864	Y	Level I	50,000	Y
University of Southern California	Los Angeles, CA	1,895	Y	Level I	150,000	Y
Vancouver General	Vancouver, Canada	185	Y	Level I	84,000	Y