The First Shot Is Often the Best Shot: First-Pass Intubation Success in Emergency Airway Management

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Emergency airway management is often lifesaving but may occasionally result in severe or fatal complications.[1–4] A fatal outcome after airway management may be especially tragic when a patient was spontaneously breathing beforehand, or a rescuer induces anesthesia but fails to effectively manage subsequent apnea.[5–8]

Although alternative airway devices have been described, endotracheal intubation remains the gold standard in emergency airway management.[9] However, even experienced care providers may encounter an unanticipated difficult airway,[9–12] underestimate airway problems, or be called to help a colleague. In these circumstances, multiple intubation attempts may result in bleeding, swelling of soft tissues, and/or oxygen desaturation,[13] all of which can render endotracheal intubation increasingly difficult and stressful. To minimize complications of emergent airway management, we propose that airway managers should prioritize successful intubation during the first attempt.[3]

A doctrine of "first-pass success" does not mean routinely performing a tracheostomy or cricothyroidotomy on every patient, because these invasive techniques are associated with a high rate of complications and are not necessary in most airway management episodes. Rather, we argue that anesthesiologists should develop judgment with respect to their skills, experience, and knowledge regarding the choice of technique and drugs, with the goal of optimizing the first nonsurgical attempt. To evaluate the literature support for our argument, we reviewed the evidence with respect to (1) the concept of first-pass intubation success, (2) intubation success rates for physicians and nonphysician providers, and (3) the impact of training on first-pass and overall pass success rates.

METHODS

By using the key words "multiple intubation attempts," "first-pass success," "intubation," "learning curve," we searched MEDLINE, EMBASE, and PubMed to identify relevant studies and expanded our search to include references from those articles. Citations from the past 5 years in which paramedics, in-hospital physicians, and prehospital physicians performed emergency airway management were also reviewed (n = 153). Articles judged relevant by 2 authors were included for full review (n = 35).

RESULTS

The Effects of Multiple Intubations Attempts on Complication Rate

We found 8 studies demonstrating an association between multiple intubation attempts and complications (Table 1). Three studies evaluated the magnitude of the increase in complication rate (with ≥3 intubation attempts) with odds ratios of 6.7 (n = 2284),[14] 4.7 (n = 1903),[15] and 4.5 (n = 2616).[16] A fourth study found a similar association with the largest increase occurring during the second attempt, and an odds ratio of 7.5 for multiple attempts (n = 1828).[3]

A 2004 analysis of 2833 airway management episodes further supports the increase in risk with multiple laryngoscopies.[17] Multiple attempts were associated with an almost 10-fold increase in the risk of hypoxemia, esophageal intubation, aspiration, and cardiac arrest. In another 2014 abstract, >1 intubation attempt was associated with a 4-fold increase in severe complication rate and a 5-fold increase in total complication rate.[18] A contemporaneous study of prehospital critical care teams found a similar result.[19]

A 2014 emergency room registry review found that patients with a first-pass intubation failure were less likely to achieve return of spontaneous circulation.[20] Data from paramedics,[21–24] prehospital physicians,[19,22,25,26] and in-hospital physicians[3,27–32] also indicate that first-pass success rates differ by provider type (Table 2 and Figs. 1 and 2). First-pass success rates ranged from 46.4% to 77.2% for paramedics, 71.2% to 87.5% for prehospital physicians, and 60.7% to 97.3% for in-hospital physicians.

If multiple attempts increase the risk of adverse airway events, then one strategy to improve airway management outcomes is to focus on training in airway management. Evidence suggests that training indeed improves first-pass success rates. One 2011 study of prehospital intubation[25] found a higher first-pass success rate with experience of >6 months. Another study of paramedics with a median of 10 previous intubations found an odds ratio of 1.09 for success with each increase in the number of previous intubations.[24] A 2012 study in anesthesia residents found that first-pass success rates did not stabilize until >150 intubations had been

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Table 1. Effects of Multiple Intubation Attempts on Complication Rate

Study	Study design	Setting	Patients	Findings
Martin et al.[14]	Prospective observational study	In-hospital physicians	n = 3423	≥3 intubation attempts were an independent predictor of the composite complication outcome (aOR = 6.7, 95% CI = 3.2–14.2, P = 0.001)
Mort[17]	Prospective observational study	In-hospital physicians	n = 2833	In 10% ≥3 intubation attempts, comparison ≤2 intubation versus ≥3 intubation attempts: hypoxemia, 10.5% vs 70%; severe hypoxemia (Spo_2 < 70%), 1.9% vs 28%; esophageal intubation, 4.8% vs 51.4%; regurgitation, 1.9% vs 22%; aspiration, 0.8% vs 13%; bradycardia, 1.6% vs 18.5%; and cardiac arrest, 0.7% vs 11% (all P < 0.001)
Hasegawa et al.[16]	Multicenter prospective JEAN registry	In-hospital physicians	n = 2616	11% ≥3 intubation attempts, comparison ≤2 intubation versus ≥3 intubation: all adverse events, 9% vs 35%; major adverse events, 5% vs 23%; esophageal intubation, 3% vs 17%; minor adverse events (e.g., dental/lip trauma, mainstem bronchus intubation), 4% vs 14%; ≥3 multiple intubations were independently associated with adverse events (aOR = 4.5; 95% CI = 3.4–6.1)
Hasegawa et al.[15]	Multicenter prospective JEAN	In-hospital physicians	n = 1903	Multiple intubation attempts (≥3) were independently associated with overall adverse events (aOR = 4.7; 95% CI = 3.4–6.4; P < 0.001)
Sakles et al.[3]	Retrospective observational study	In-hospital physicians	n = 1828	Increased incidence of adverse events because of the number of intubation attempts: FPS, 14.2%; SPS, 47.2%; TPS, 63.6%; >3 intubation attempts: 70.6%, comparison FPS and ≥2 multiple intubation attempts: desaturation (9.2% vs 37.8%), aspiration (0.8% vs. 5.9%), and oesophageal intubation (0.0% vs. 15.8%), multiple intubation attempts were a predictor of the occurrence of ≥1 adverse events (aOR = 7.52, 95% CI = 5.86–9.63)
Duggan et al.[18]	Prospective observational study	In-hospital physicians	n = 271	≥2 intubation attempts were associated with a 4-fold increase in severe complication rate, and a 5-fold increase in total complication rate
Rognås et al.[19]	Prospective observational study	Prehospital physicians	n = 683	22.4% ≥2 intubation attempt, complication rate: FPS, 7.4%; SPS, 23.3%; ≥2 intubation attempts, 32.2%; ≥2 multiple intubation attempts were associated with an increased overall incidence of complications
Kim et al.[20]	Retrospective, registry data	In-hospital physicians	n = 512	FPS, 85%; patients without FPS had a significant lower rate of ROSC (42.9% vs 59.8%, P = 0.0006), patients without FPS had a decreased chance of a ROSC (OR = 0.40; 95% CI = 0.23–0.71; P = 0.002)

aOR = adjusted odd ratio; CI = confidence interval; FPS = first-pass success; JEAN = Japanese Emergency Airway Network; OR = odds ratio; SPS = second-pass success; TPS = third-pass success; ROSC = return of spontaneous circulation.

performed.[33] Studies of nonanesthesiologists in the intensive care unit also found that more airway management experience correlated with a lower incidence of multiple intubation attempts[31] and that a higher number of previous attempts[31] correlated with greater first-pass success.[30]

DISCUSSION

Although it seems intuitively obvious that the first intubation attempt during emergent airway management should be optimized for success, real-world considerations often intervene. Among these are equipment availability, practical issues, and cost. Unfortunately, airway managers often lack accurate data to help them decide the value of a successful first-pass intubation. We found that multiple intubation attempts were associated with an increased rate of severe morbidity, such as hypoxia, aspiration, and bradycardia (Table 1). Succeeding with the first intubation attempt is also important because intubation conditions may deteriorate substantially after an unsuccessful initial attempt.[13,34] Thus, targeting a high first-pass intubation success rate during emergency airway management may reduce severe airway management-related complications.[1]

Available data suggest that both amount (number of previous intubations) and type (in-hospital or anesthesia specialty [versus nonanesthesia personnel]) of airway training play a role in increasing first-pass success. However, particularly for nonanesthesiologists, sufficient experience can be difficult to obtain. Observations from a large database (n = 129,000) of emergency medical service calls in Germany revealed that intubation of severely injured patients outside the hospital is performed less than once a month per provider,[35] suggesting that maintaining airway management skills is difficult with on the job experience alone.

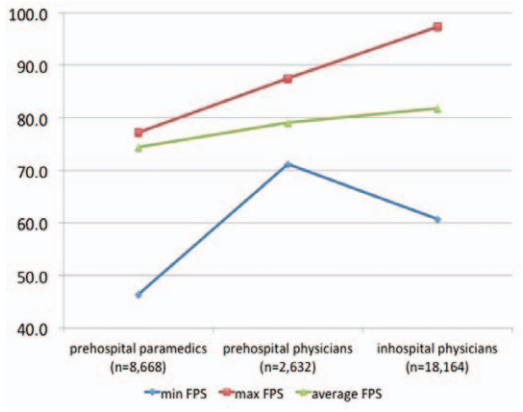
The question arises: How much training do airway providers need to optimize the first-pass intubation success rate? We found that anesthesia residents did better than nonanesthesia residents at all levels of training.[31] Further, in our own hospital, at least 150 intubations were needed to reach a "plateau" in terms of future intubation success.[33] However, even an individual with several hundred intubations may not be considered fully competent.[8] UK Guidelines recommend that health care personnel providing prehospital airway care: "should have the same level of training as an individual who is allowed to provide in-hospital emergency airway management unsupervised using rapid sequence induction in the emergency department"[36] and suggest a minimum of 2 years of training in emergency subspecialties and at least 1 year of anesthesia.

Although our literature search was remarkably consistent regarding the importance of first-pass success,

Table 2. First-Pass Success and Other Variables of Emergency Airway Management

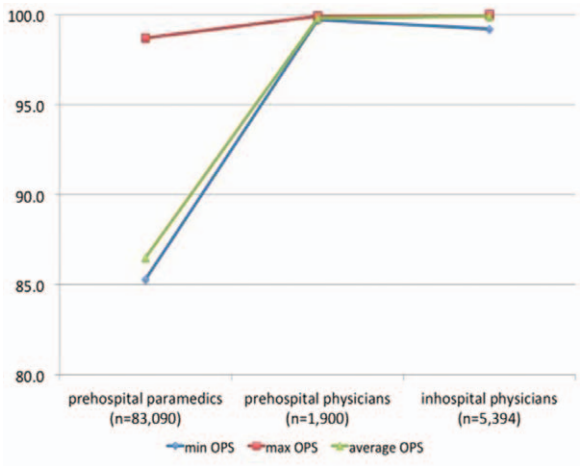
	Study design	*n*	FPS, *n* (%)	OPS, *n* (%)	Multiple intubation attempts, *n* (%)		Cormack/Lehane grade, *n* (%)	
					≥2	≥3	1/2	3/4
In-hospital physicians								
Sakles et al.[3]	Retrospective, ED	1828	1333 (72.9)	NR	495 (37.1)	NR	NR	NR
Fogg et al.[28]	Prospective, ED	295	246 (83.4)	295 (100.0)	49 (16.6)	10 (3.4)	219 (76.0)	27 (24.0)
Varga et al.[32]	Retrospective, ED	490	477 (97.3)	486 (99.2)	8 (1.6)	NR	NR	NR
Cho et al.[27]	Retrospective, ED	10,942	8774 (80.2)	NR	NR	NR	11,443 (85.1)	2001 (14.9)
Griesdale et al.[29]	Prospective, ICU	136	91 (66.9)	136 (100.0)	45 (33.1)	18 (13.2)	119 (88.1)	16 (11.9)
Hirsch-Allen et al.[31]	Prospective, mixed	191	116 (60.7)	191 (100.0)	75 (63.0)	30 (25.2)	165 (88.7)	21 (11.3)
Grissom et al.[30]	Prospective, mixed	4282	3824 (89.3)	4281 (100.0)	458 (10.7)	NR	4078 (91.4)	385 (8.6)
	Total	18,164	14,861 (81.8)	5389 (99.9)	1130 (23.0)	58 (9.3)	16,024 (86.7)	2450 (13.3)
Prehospital physicians								
Rognås et al.[19]	Prospective	683	530 (77.6)	681 (99.7)	153 (22.4)	NR	569 (83.7)	111 (16.3)
Harris and Lockey[25]	Prospective	400	350 (87.5)	399 (99.8)	50 (12.5)	4 (1.0)	323 (81.0)	76 (19.0)
Jabre et al.[26]	Prospective	817	582 (71.2)	816 (99.9)	235 (28.8)	NR	682 (83.5)	135 (16.5)
Peters et al.[22]	Retrospective	732	619 (84.5)	NR	NR	NR	548 (86.4)	86 (13.6)
	Total	2632	2081 (79.1)	1896 (99.8)	438 (23.1)	4 (1.0)	2122 (83.9)	408 (16.1)
Prehospital paramedics								
Prekker et al.[23]	Prospective	7521	5807 (77.2)	7425 (98.7)	1706 (22.7)	426 (5.7)	5004 (75.4)	1631 (24.6)
Diggs et al.[21]	Retrospective	74,993	NR	63,956 (85.3)	8024 (10.7)	1200 (1.6)	NR	NR
Peters et al.[22]	Retrospective	571	265 (46.4)	NR	NR	NR	424 (92.2)	36 (7.8)
Warner et al.[24]	Prospective, students	576	380 (66.0)	507 (88.0)	NR	NR	NR	NR
	Total	83,661	6452 (74.4)	71,888 (86.5)	9730 (11.8)	1626 (2.0)	5428 (76.5)	1667 (23.5)

% = related to reported data; ED = Emergency Department; FPS = first-pass success; ICU = intensive care unit; OPS = overall pass success; NR = not reported.



*note that calculation of standard deviations is not possible due to unavailability of raw data.

Figure 1. First-pass intubation success (FPS) of prehospital paramedics, prehospital physicians, and in-hospital physicians in emergency airway management. The calculation of SDs is not possible because of unavailability of raw data.



*note that calculation of standard deviations is not possible due to unavailability of raw data.

Figure 2. Overall pass intubation success (OPS) of prehospital paramedics, prehospital physicians, and in-hospital physicians in emergency airway management. The calculation of SDs is not possible because of unavailability of raw data.

we may not have identified all available studies. Of the ones we did identify, a control group was often lacking and patient factors may have contributed to intubation success. Because of lack of survival data, we could not determine whether intubation attempts correlated with survival. In addition, emergency airway management in the prehospital setting, emergency department, and intensive care units may differ, making studies harder to compare.

Our take-home message is more complex than "every effort should be made to secure the airway on the first, well-prepared intubation attempt", although the mnemonic "the first shot is often the best shot" is very appealing. First, anticipating severe adverse events if the first intubation attempt fails is an important aspect of a "first-shot best shot" approach. Second, anesthesiology training improves first-pass success rates, although whether such training requires 150 successful intubations as in a German study or 3 years of clinical training as in a UK recommendation is unclear. Third, sufficient optimization of first-pass success rates is difficult to obtain and/or to maintain for many airway managers because of a lack of experience with the procedure. Fourth, there are insufficient data for determining whether more simulation will improve first-pass intubation rates. Finally, when managing an airway, each individual should assess the odds of initial success versus possible problems or complications and build in an appropriate margin for safety.

DISCLOSURES

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Attestation: Michael Bernhard approved the final manuscript, attests to the integrity of the original data and the analysis reported in this manuscript, and is the archival author.
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