Title: Comparing post-induction hypoxemia between ramped and supine position endotracheal intubations with apneic oxygenation in the emergency department

Running Title: Ramped vs. Supine Position with Apneic Oxygenation

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TITLE

Comparing post-induction hypoxemia between ramped and supine position endotracheal intubations with apneic oxygenation in the emergency department

ABSTRACT

Introduction

Ramped position and apneic oxygenation are strategies to mitigate hypoxemia; however, the benefits of these strategies when utilized together remain unclear. Therefore, we compared first attempt, post-induction hypoxemia between adult emergency department (ED) endotracheal intubations performed with apneic oxygenation in the ramped vs. supine positions.

Methods

We used the National Emergency Airway Registry (NEAR), a multicenter registry of data on ED intubations from 25 academic and community sites. We included first attempt intubations with direct (DL) and video (VL) laryngoscopy in subjects ≥18-years-old with non-trauma indications receiving apneic oxygenation. We examined patient characteristics (e.g., sex, obesity, etc.) and key intubation outcomes, including hypoxemia (primary outcome), first pass success, and other

adverse events (e.g., bradycardia). In addition, we examined unadjusted odds ratios (OR) and adjusted ORs (aOR) for key variables and stratified by laryngoscope type.

Results

We included 210 ramped cases and 1820 supine cases in the DL cohort and 202 ramped and 1626 supine cases in the VL cohort. Rates of post-induction hypoxemia were similar between supine and ramped position in both the DL cohort (supine 6.5% and ramped 7.6%, aOR 0.96 [95% CI 0.55, 1.67]) and VL cohort (supine 10.1% and ramped 12.4%, aOR 0.97 [0.60, 1.56]). Other outcomes were also similar between groups.

Conclusion

Using this large national dataset, we did not identify a difference in post-induction hypoxemia between ramped and supine positions in this cohort of ED intubations with apneic oxygenation.

Introduction

Endotracheal intubation is a critical part of emergency airway management. Peri-intubation hypoxemia is a common complication occurring in up to 9.3% of emergency department (ED) intubations.[1,2] Hypoxemia is also a risk factor for peri-intubation cardiac arrest.[3,4] Interventions intended to prevent peri-intubation hypoxemia are pivotal to successful ED intubation.

Ramped position is an intervention intended to mitigate peri-intubation hypoxemia. It involves elevating the head and trunk above the legs to allow gravity to shift body tissues away from the chest, thereby improving pulmonary compliance and functional residual capacity.[5-9] It facilitates preoxygenation and has been associated with reduced peri-intubation complications, including hypoxemia.[10-15] Despite the theoretical benefits of ramped position, its use did not improve the lowest oxygen saturation compared to supine position in a multicenter, randomized trial of intensive care unit intubations. However, apneic oxygenation may have been a confounder in this analysis.[16]

Apneic oxygenation may reduce hypoxemia during ED intubations.[17,18] It refers to placing a nasal cannula on a patient before the intubation and leaving it in place with continuous oxygen flow throughout the intubation. Emerging evidence suggests this technique may be used in conjunction with face masks during pre-oxygenation without causing mask leak or a decrease in end-tidal oxygenation.[19,20] When combined with ramped position, apneic oxygenation may synergistically mitigate post-induction hypoxemia. Therefore, we sought to compare post-induction hypoxemia and other adverse events between the ramped and supine positions in ED intubations with apneic oxygenation.

Methods

Study Design and Setting

This study is a secondary analysis of the National Emergency Airway Registry (NEAR). The registry includes 25 academic and community EDs. Each participating site obtained local institutional review board approval before participating. The details of NEAR have been published previously.[2] We have reported our findings in accordance with the STROBE Guidelines.[21]

Data Collection

The intubating clinicians at each site completed a web-based form for each intubation (StudyTRAX; version 3.47.0011; ScienceTRAX, Macon, GA). Each site must submit data forms for ≥90% of ED intubations to remain compliant.

Study Population

We included subjects aged 18 years and older who underwent emergency intubation during the most current iteration of NEAR, January 1, 2016 to December 31, 2018. We excluded non-oral routes (e.g., nasal) and upright / sitting position as these conditions often require non-standard intubation maneuvers (e.g., face-to-face intubation).[22-24] We excluded trauma indications and intubations performed during cardiac arrest because ramped position can theoretically interfere with other critical interventions in those scenarios (e.g., spinal precautions and chest compressions). We also excluded cases in which the providers utilized alternative devices and techniques, such as video stylets, digital (finger) intubation, channel blades, bronchoscopy-assisted intubation, and surgical airways. We included only the first attempt to limit confounding that rescue attempts may introduce. We defined apneic oxygenation as receiving oxygen before and during the intubation by nasal cannula and is a specific variable collected in NEAR. We excluded non-apneic oxygenation intubations and stratified the remaining intubations by laryngoscopy modality (direct [DL] or video [VL]) and position (supine or ramped).

Outcome Measures

The primary outcome was the difference in post-induction hypoxemia between supine and ramped positions in subjects who underwent apneic oxygenation during their ED intubation. Secondary outcomes included any post-induction adverse event, first pass success, first pass success without adverse events, and Cormack-Lehane view. Post-induction adverse events examined included hypoxemia, bradycardia, esophageal intubation, vomiting, and hypotension. We selected these outcomes as they were relevant, patient-oriented, and physiologically related to the study question.

Data Analysis

We compared baseline demographics, difficult airway characteristics, intubation management variables, and outcomes between ramped and supine positions. Baseline demographics included age, sex, body habitus, medical indication for intubation, subjective impression of a difficult airway, and objective measures of a difficult airway. Objective difficult airway findings included reduced neck mobility, Mallampati score 3 or 4, reduced mouth opening (<3 fingers), reduced thyromental distance (<3 fingers), airway obstruction, facial trauma, and blood or vomit in the airway. Although cases with trauma indications for intubation were excluded, cases with medical indications for intubation and reported facial trauma were not excluded. Intubation management variables included paralytic, estimated time of preoxygenation, highest oxygenation device used, hypoxemia (oxygen saturation <90%) at the start of intubation, and intubator level of training. Our primary outcome was post-intubation hypoxemia, defined as a post-induction oxygen saturation <90% or drop >10%, a specific variable collected in NEAR. Other outcomes included the other adverse events listed above, first pass success, first pass success without adverse events, Cormack-Lehane view grade 3-4, desaturation at any point, and lowest oxygen saturation for cases where post-induction hypoxemia occurred. In addition, missing data points were reported but excluded from analyses.

We used the Test of Equal Proportions (two-proportions z-test) for categorical data and the Mann-Whitney test for continuous data to compare measured variables with 95% confidence intervals (CI). All continuous variables compared between groups were non-parametric. We used a multivariable logistic regression model to calculate adjusted odds ratios (aOR) with 95% CIs

for hypoxemia. We selected variables for the model prior to analysis that we thought would conceptually affect post-induction hypoxemia, including position, obesity, level of training, Cormack-Lehane view grade 3-4, preoxygenation >3 minutes, preoxygenation with nasal cannula alone, post-induction hypotension, oxygen saturation <90% at the start of intubation, subjective impression of difficult airway, any objective difficult airway finding, and bougie use. Rather than including multiple preoxygenation devices in the model, preoxygenation with nasal cannula alone was included to avoid multicollinearity. Variance inflation factors were <4 for all variables indicating no significant multicollinearity. We used both a multivariable logistic regression model with the preselected variables and a stepwise multivariable logistic regression model where predetermined variables with p values <0.25 for their estimates were included in stepwise selection based on Akaike Information Criterion to build the final model. However, the selection process removed position from the stepwise model; therefore, we reintroduced it into the model after variable selection. We assessed model fit using Hosmer & Lemeshow Goodness of Fit Test and Akaike Information Criterion. Interaction terms between obesity and subjective impression of difficult airway, the presence of any objective difficult airway finding, and Cormack-Lehane view grade 3-4 were considered but were not significant; therefore, they were not included in either model.

As ramped position has been primarily recommended in obese patients undergoing intubation,[25] we also conducted a post-hoc, secondary subgroup analysis by body habitus, a unique NEAR variable. First, we calculated unadjusted odds ratios (OR) for first attempt hypoxemia with the ramped position for very thin / thin, normal, and obese / morbidly obese subjects using Fisher exact test. We then used the Mantel-Haenszel chi-squared test with continuity correction to calculate an overall aOR. Finally, we used the Woolf test to determine homogeneity.

We stratified the primary analyses by laryngoscope type (DL or VL) as previous work has suggested that VL may be associated with lower rates of hypoxemia and other adverse events.[26] We did not stratify the secondary subgroup analysis by laryngoscope due to small numbers in the very thin / thin subgroup. We downloaded data from ScienceTRAX as a Microsoft® Excel® (Microsoft Corporation, Redmond, WA) file and performed analyses with RStudio® (RStudio, PBC, Boston, MA, Version 1.4.1106).

Results

During the study period, there were 19,071 ED intubations at 25 sites. We included 2,030 DL and 1,828 VL cases from 23 sites. There were 210 ramped cases and 1,820 supine cases in the DL cohort. And, there were 202 ramped and 1,626 supine cases in the VL cohort (Figure 1).

Age and sex were similar despite laryngoscope type and position (Table 1). Obesity and subjective impression of difficult airway were lower in the supine cohorts compared to ramped. The proportion of patients with obesity was 27.3% for supine vs 40.5% for ramped (% difference and 95% confidence interval [CI], -13.3 [-20.5, -6.1]) in the DL group and 33.4% vs 55.4% (-22.1 [-29.6, -14.5]) in the VL group. The proportion of patients with a subjective impression of difficult airway was 18.1% for supine vs 30.0% for ramped (-11.9 [-18.6, -5.2]) in the DL group and 33.2% vs 56.4% (-23.2 [-30.7, -15.7]) in the VL group. In the VL group, the proportion of patients with any objective difficult airway finding was 60.6% for supine vs. 71.3% for ramped (-10.7 [-17.7, -3.8]) and continuous positive airway pressure or bilevel positive airway pressure was less common in the supine position, 11.4% vs. 20.3% (-8.9 [-15.0, -2.9]).

Post-induction hypoxemia occurred in 6.5% of supine intubations and 7.6% of ramped intubations in the DL cohort (% difference -1.1 [95% CI -5.1, 2.9]), and occurred in 10.1% of supine intubations and 12.4% of ramped intubations in the VL cohort (-2.3 [-7.3, 2.8]). First pass success, first pass success without adverse events, grade 3-4 Cormack-Lehane view, desaturation at any point, and rates of other adverse events were similar between groups (Table 2).

Ramped position was not associated with a reduction in post-induction hypoxemia compared to supine position in either laryngoscope cohort (stepwise model aOR 0.96 [95% CI 0.55, 1.67] for DL and 0.97 [0.60, 1.56] for VL) (Tables 3 and 4). In the direct laryngoscopy cohort, obesity, Cormack-Lehane View Grade 3-4, preoxygenation >3 minutes, and oxygen saturation <90% at the start of intubation were associated with post-induction hypoxemia in both adjusted models (Table 3). In the VL cohort, obesity, Cormack-Lehane View Grade 3-4, subjective impression of

difficult airway, and bougie use were associated with post-induction hypoxemia in both adjusted models (Table 4).

Ramped position was not associated with post-induction hypoxemia in any body habitus subgroup (very thin / thin, normal, or obese / morbidly obese) (Figure 2). The Mantel-Haenszel aOR for post-induction hypoxemia adjusted for body habitus was 1.06 (0.75, 1.50). There was homogeneity among body habitus subgroups (p = 0.97) (Table S1).

Discussion

In this cohort of ED intubations with apneic oxygenation from a large national database, we found no association between first attempt, post-intubation hypoxemia and the ramped position when compared to the supine position. However, obesity and subjective impression of difficult airway were more common in the ramped cohorts (Table 1) and independently associated with post-induction hypoxemia (Tables 3 and 4). In adjusted analyses, obesity, Cormack-Lehane Grade 3-4 view, preoxygenation >3 minutes, oxygen saturation <90% at the start of the intubation, subjective impression of difficult airway, and bougie were predictive of post-induction hypoxemia in at least one of the cohorts (DL or VL). Conceptually, these would be expected as they are markers of difficult intubations, anatomically or physiologically. In the VL cohort, level of training post-graduate year 3-4 in the stepwise model was the only variable to be protective against post-induction hypoxemia, adjusted OR 0.68 (95% CI 0.49, 0.95). As most sites in the registry are academic, the most proficient intubators are likely senior residents who also intubated more frequently in this cohort (Table 1) and might be better at preventing complications such as hypoxemia.

There is equipoise regarding the benefit of ramped position in the acute care setting. Although it has been associated with higher first pass success and reduced complications, including hypoxemia,[14,15] a high-quality randomized control study of intensive care unit intubations revealed that ramped position did not improve lowest oxygen saturation and was associated with worse glottic views and increased laryngoscopy attempts.[16] Similarly, another NEAR study found an association between non-supine positions and increased adverse events compared to the

supine position, though there was no difference in first pass success.[27] Our study did not find a benefit in post-induction hypoxemia with ramped over supine position in this cohort of ED intubations receiving apneic oxygenation. Though, we also did not find any associated adverse effects such as worse glottic views.

Although high-quality evidence in the acute care setting is limited, multiple peri-operative studies support the use of ramped position, especially in obese patients.[28-30] Anesthesia guidelines recommend routine use of ramped or sitting positions during induction and recovery of obese patients.[31] Therefore, we examined the effect ramped position has on post-induction hypoxemia in this cohort across body habitus subgroups. Ramped position was not associated with post-induction hypoxemia in either body habitus subgroup, very thin / thin, normal, or obese / morbidly obese (Figure 2). In addition, the overall effect of ramped position across body habitus subgroups was not associated with post-induction hypoxemia (Table S1).

Our results differ from the prior NEAR study mentioned above.[27] The prior NEAR study found an increased proportion of post-induction hypoxemia with the non-supine positions compared to supine, 10.5% vs. 7.2%, respectively (OR [95%CI] 1.5 [1.2, 2.0]). Similarly, both studies had a greater proportion of obese and subjective impression of a difficult airway patients in the non-supine cohorts, which were independently associated with post-induction hypoxemia in the univariate analyses of our study (Tables 3 and 4). Therefore, the lack of difference in post-induction hypoxemia between positions in our study may be attributed to either the combination of ramped position with apneic oxygenation or apneic oxygenation alone, which has been associated with reduced post-induction hypoxemia.[17]

Prior studies on ramped position in the acute care setting did not measure or control for apneic oxygenation, which may explain the conflicting results.[14-16,27] This study does not indicate a reduction in risk of post-induction hypoxemia among patients undergoing intubation with apneic oxygenation placed in a ramped vs. supine position. However, given the inability to completely control for confounders, measured and unmeasured, with our observational design, a randomized trial in the ED comparing ramped and supine positions is warranted.

Limitations

Our study has a few important limitations. First, this study is observational. Therefore, we are unable to establish causation, only correlation. Confounding by indication is a major limitation that we attempted to mitigate by controlling for confounding variables that may influence our measured outcomes using multiple logistic regression and the Mantel-Haenszel methods. However, we are unable to control for unmeasured confounders. We also performed the body habitus subgroup analysis post-hoc and did not adjust for within-site correlations of outcomes which are potential sources of bias. Next, intubating clinicians complete the data forms; therefore, recall and observer bias may influence the results. In addition, intubating in the ramped position is a skill, and experience may impact the success of the procedure. Furthermore, the optimal way to perform ramped position intubation has not been established. We could not measure certain variables, including bed height and angle, which may impact ramped position intubation outcomes.[32] Lastly, these results do not apply to trauma patients, those in cardiac arrest, or those intubated in the upright position.

Conclusions

In first attempt ED intubations from the NEAR database receiving apneic oxygenation, there was no association between position, ramped or supine, and post-induction hypoxemia with either DL or VL. In addition, there was no difference in post-induction hypoxemia with ramped position across body habitus subgroups.

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TABLES

Table 1. Baseline Demographics and Intubation Management

	Direct Laryngoscopy			**Video Laryngoscopy**		
Position	Supine	Ramped	% Difference (95% CI)*	Supine	Ramped	% Difference (95% CI)*
Total number in group, n	1820	210		1626	202	
Baseline Demographics						
Age in years, median [IQR]	55 [37, 67]	55 [37, 67]	0.0 [-3.0, 3.0]	57 [43, 69]	59 [47, 68]	-1.0 [-4.0, 2.0]
Female, n (%)	657 (36.1)	75 (35.7)	0.4 (-6.7, 7.5)	628 (38.6)	68 (33.7)	5.0 (-2.3, 12.2)
Obese or Morbidly Obese, n (%)						
Yes	495 (27.3)	85 (40.5)	**-13.3 (-20.5, -6.1)**	543 (33.4)	112 (55.4)	**-22.1 (-29.6, -14.5)**
Missing	6 (0.3)	0 (0.0)	0.3 (-0.2, 0.9)	5 (0.3)	0 (0.0)	0.3 (-0.2, 0.9)
Medical indication, n (%)**						
Non-overdose AMS	529 (29.1)	50 (23.8)	5.3 (-1.1, 11.6)	420 (25.8)	52 (25.7)	0.1 (-6.4, 6.6)
Overdose	365 (20.1)	47 (22.4)	-2.3 (-8.5, 3.9)	242 (14.9)	26 (12.9)	2.0 (-3.2, 7.2)
Seizure	170 (9.3)	16 (7.6)	1.7 (-2.4, 5.8)	136 (8.4)	15 (7.4)	0.9 (-3.2, 5.1)
Intracranial hemorrhage	118 (6.5)	16 (7.6)	-1.1 (-5.2, 2.9)	147 (9.0)	4 (2.0)	**7.1 (4.4, 9.7)**
Other	511 (28.1)	62 (29.5)	-1.4 (-8.2, 5.3)	90 (5.5)	10 (5.0)	0.6 (-2.9, 4.1)
Missing	127 (7.0)	19 (9.0)	-2.1 (-6.4, 2.2)	2 (0.1)	0 (0.0)	0.1 (-0.2, 0.4)
Subjective impression of difficult airway, n (%)						
Yes	329 (18.1)	63 (30.0)	**-11.9 (-18.6, -5.2)**	540 (33.2)	114 (56.4)	**-23.2 (-30.7, -15.7)**
Missing	3 (0.2)	0 (0.0)	0.2 (-0.2, 0.5)	3 (0.2)	0 (0.0)	0.2 (-0.2, 0.6)
Any Objective Difficult Airway Finding, n (%)[+]						
Yes	811 (44.6)	109 (51.9)	-7.3 (-14.7, 0.1)	985 (60.6)	144 (71.3)	**-10.7 (-17.7, -3.8)**
Missing	5 (0.3)	0 (0.0)	0.3 (-0.2, 0.8)	4 (0.2)	0 (0.0)	0.2 (-0.2, 0.7)
Intubation Management						
Paralytic, n (%)						
Rocuronium	1001 (55.1)	126 (60.0)	-5.0 (-12.3, 2.3)	878 (54.0)	122 (60.4)	-6.4 (-13.8, 1.0)
Succinylcholine	813 (44.7)	84 (40.0)	4.7 (-2.6, 11.9)	746 (45.9)	80 (39.6)	6.3 (-1.2, 13.7)
Vecuronium	4 (0.2)	0 (0.0)	0.2 (-0.2, 0.7)	2 (0.1)	0 (0.0)	0.1 (-0.2, 0.4)

Missing	2 (0.1)	0 (0.0)	0.1 (-0.2, 0.4)	0 (0.0)	0 (0.0)	0.0 (0.0, 0.0)
Preoxygenation, n (%)						
>3 minutes	1516 (83.4)	188 (89.5)	**-6.2 (-11.0, -1.5)**	1354 (83.3)	182 (90.1)	**-6.8 (-11.6, -2.0)**
Missing	2 (0.1)	0 (0.0)	0.1 (-0.2, 0.4)	0 (0.0)	0 (0.0)	0.0 (0.0, 0.0)
Highest preoxygenation device, n (%)						
Nasal Cannula	181 (9.9)	12 (5.7)	**4.2 (0.5, 7.9)**	184 (11.3)	19 (9.4)	1.9 (-2.7, 6.5)
Non-Rebreather Mask	1197 (65.8)	128 (61.0)	4.8 (-2.4, 12.0)	966 (59.4)	105 (52.0)	7.4 (-0.1, 15.0)
CPAP/BPAP	152 (8.4)	20 (9.5)	-1.2 (-5.6, 3.3)	185 (11.4)	41 (20.3)	**-8.9 (-15.0, -2.9)**
BVM	199 (10.9)	33 (15.7)	-4.8 (-10.2, 0.6)	199 (12.2)	27 (13.4)	-1.1 (-6.4, 4.1)
Other	88 (4.8)	17 (8.1)	-3.3 (-7.3, 0.8)	90 (5.5)	10 (5.0)	0.6 (-2.9, 4.1)
Missing	3 (0.2)	0 (0.0)	0.2 (-0.2, 0.5)	2 (0.1)	0 (0.0)	0.1 (-0.2, 0.4)
Oxygen saturation <90% at start of intubation, n (%)						
Yes	48 (2.6)	3 (1.4)	1.2 (-0.8, 3.2)	54 (3.3)	7 (3.5)	-0.1 (-3.0, 2.7)
Missing	120 (6.6)	6 (2.9)	**3.7 (0.9, 6.5)**	58 (3.6)	6 (3.0)	0.6 (-2.2, 3.4)
Bougie used, n (%)						
Yes	456 (25.1)	40 (19.1)	**6.0 (0.1, 11.9)**	307 (18.9)	29 (14.4)	4.5 (-1.0, 10.0)
Missing	6 (0.3)	1 (0.5)	-0.1 (-1.3, 1.0)	1 (0.1)	0 (0.0)	0.1 (-0.1, 0.2)
Level of training, n (%)						
Post-Graduate Year 1	200 (11.1)	40 (19.0)	**-8.1 (-13.8, -2.3)**	236 (14.5)	26 (12.9)	1.6 (-3.6, 6.8)
Post-Graduate Year 2	554 (30.4)	66 (31.4)	-1.0 (-7.9, 5.9)	488 (30.0)	88 (43.6)	**-13.6 (-21.0, -6.1)**
Post-Graduate Year 3-4	946 (52.0)	95 (45.2)	6.7 (-0.6, 14.1)	680 (41.8)	75 (37.1)	4.7 (-2.7, 12.1)
Fellow or Attending	105 (5.8)	6 (2.9)	**2.9 (0.2, 5.7)**	150 (9.2)	4 (2.0)	**7.2 (4.6, 9.9)**
Missing	15 (0.8)	3 (1.4)	-0.6 (-2.5, 1.3)	72 (4.4)	9 (4.5)	0.0 (-3.1, 3.0)

CI, confidence interval; COPD, chronic obstructive pulmonary disease; AMS, altered mental status; CPAP, continuous positive airway pressure; BPAP, bilevel positive airway pressure; BVM, bag valve mask

*Absolute differences were calculated with the Test of Equal Proportions (two-proportions z-test) for categorical variables and the Mann-Whitney test for continuous variables.

** Four most common medical indications for intubation.

[+] Difficult airway characteristics coded as yes if the patient had at least one of the following: reduced neck mobility, Mallampati score 3 or 4, reduced mouth opening (<3 fingers), reduced thyromental distance (<3 fingers), airway obstruction, facial trauma, or blood or vomit in airway.

Table 2. Outcomes Stratified by Position

	Direct Laryngoscopy			**Video Laryngoscopy**		
	Supine	Ramped	% Difference (95% CI)*	Supine	Ramped	% Difference (95% CI)*
Total number in group, n	1820	210		1626	202	
First Attempt AEs, n (%)						
Hypoxemia	119 (6.5)	16 (7.6)	-1.1 (-5.1, 2.9)	164 (10.1)	25 (12.4)	-2.3 (-7.3, 2.8)
Bradycardia	2 (0.1)	0 (0.0)	0.1 (-0.2, 0.4)	7 (0.4)	1 (0.5)	-0.1 (-1.1, 1.0)
Esophageal intubation	14 (0.7)	1 (0.1)	0.3 (-1.0, 1.6)	2 (0.1)	1 (0.5)	-0.4 (-1.6, 0.9)
Vomiting	13 (0.7)	2 (1.0)	-0.2 (-1.8, 1.4)	11 (0.7)	2 (1.0)	-0.3 (-2.0, 1.4)
Hypotension	48 (2.6)	11 (5.2)	-2.6 (-6.0, 0.8)	58 (3.6)	11 (5.4)	-1.9 (-5.4, 1.7)
Any AE**	178 (9.8)	26 (12.4)	-2.6 (-7.5, 2.3)	225 (13.8)	36 (17.8)	-4.0 (-9.8, 1.8)
FPS, n (%)						
Yes	1632 (89.7)	183 (87.1)	2.5 (-2.5, 7.5)	1478 (90.9)	185 (91.6)	-0.7 (-5.0, 3.7)
Missing	4 (0.2)	0 (0.0)	0.2 (-0.2, 0.7)	1 (0.1)	0 (0.0)	0.1 (-0.1, 0.2)
FPS without AEs, n (%)						
Yes	1494 (82.1)	163 (77.6)	4.5 (-1.7, 10.6)	1305 (80.3)	154 (76.2)	4.0 (-2.4, 10.5)
Missing	4 (0.2)	0 (0.0)	0.2 (-0.2, 0.7)	1 (0.1)	0 (0.0)	0.1 (-0.1, 0.2)
First Attempt Cormack-Lehane View Grade 3-4, n (%)						
Yes	165 (9.1)	25 (11.9)	-2.8 (-7.7, 2.0)	103 (6.3)	9 (4.5)	1.9 (-1.5, 5.2)
Missing	12 (0.7)	0 (0.0)	0.7 (0.0, 1.3)	2 (0.1)	0 (0.0)	0.1 (-0.2, 0.4)
Desaturation at any time post-induction, n (%)[+]						
Yes	125 (6.9)	16 (7.6)	-0.8 (-4.8, 3.3)	173 (10.6)	30 (14.9)	-4.2 (-9.6, 1.2)
Missing	52 (2.9)	3 (1.4)	1.4 (-0.6, 3.5)	33 (2.0)	4 (2.0)	0.0 (-2.0, 2.1)

Lowest oxygen saturation post-induction, median [IQR][++]	80 [70.0, 86.0]	78 [68.7, 85.0]	2.0 [-3.0, 8.0]	80 [70.0, 85.0]	80 [75.0, 86.0]	-1.0 [-5.0, 2.0]

CI, confidence interval; AE, adverse event; FPS, first pass success

*Absolute differences were calculated with the Test of Equal Proportions (two-proportions z-test) for categorical variables and the Mann-Whitney test for continuous variables.

**Adverse events included hypoxemia, bradycardia, esophageal intubation, vomiting, and hypotension.

[+]Not limited to first attempt.

[++]Values are only for patients who experienced post-intubation desaturation less than 90% any time after initiation of intubation.

Table 3. Odds ratios (OR) for first attempt post-induction hypoxemia with direct laryngoscopy

Variable	Univariate OR (95% CI)	Multivariable Model aOR (95% CI)*	Stepwise Model aOR (95% CI)**	Stepwise Model with Position aOR (95% CI)[+]
Ramped	1.07 (0.61, 1.88)	0.91 (0.51, 1.62)		0.96 (0.55, 1.67)
Obese or Morbidly Obese	**2.1 (1.47, 3.01)**	**1.96 (1.32, 2.89)**	**1.96 (1.33, 2.89)**	**1.97 (1.34, 2.89)**
Level of training				

Post-Graduate Year 1	Reference	Reference		
Post-Graduate Year 2	0.86 (0.47, 1.55)	0.81 (0.44, 1.49)		
Post-Graduate Year 3-4	0.91 (0.52, 1.57)	0.92 (0.52, 1.64)		
Fellow or Attending	1.10 (0.47, 2.56)	1.04 (0.44, 2.50)		
First Attempt Cormack-Lehane View Grade 3-4	**2.01 (1.23, 3.31)**	**1.68 (1.00, 2.82)**	**1.82 (1.10, 3.00)**	**1.82 (1.10, 3.00)**
Preoxygenation >3 minutes	1.69 (0.96, 2.99)	**1.90 (1.06, 3.41)**	**1.92 (1.07, 3.41)**	**1.92 (1.08, 3.43)**
Nasal Cannula preoxygenation only, n (%)	1.45 (0.85, 2.47)	1.69 (0.97, 2.94)	1.61 (0.94, 2.79)	1.61 (0.93, 2.78)
Post-induction Hypotension	1.35 (0.53, 3.46)	1.33 (0.51, 3.46)		
Oxygen saturation <90% at start of intubation	**2.54 (1.17, 5.52)**	**2.85 (1.28, 6.34)**	**2.66 (1.20, 5.89)**	**2.65 (1.20, 5.88)**
Subjective impression of difficult airway	**2.00 (1.36, 2.94)**	1.40 (0.90, 2.19)	1.47 (0.97, 2.25)	1.48 (0.97, 2.25)
Any Objective Difficult Airway Finding	1.33 (0.93, 1.90)	1.16 (0.80, 1.70)		
Bougie used	1.08 (0.72, 1.61)	1.11 (0.72, 1.69)		
Hosmer & Lemeshow Goodness of Fit Test	NA	X-squared = 14.25 DF = 8 P value = 0.08	X-squared = 3.6 DF = 8 P value = 0.89	X-squared = 3.7 DF = 8 P value = 0.88
Akaike Information Criterion	NA	942.95	946.77	948.755

OR, odds ratio; aOR, adjusted odds ratio; CI, confidence interval; CPAP, continuous positive airway pressure; BPAP, bilevel positive airway pressure; BVM, bag valve mask; AE, adverse event; X-squared, Chi-Squared; DF, degrees of freedom

*Multivariable logistic regression model. Variables were selected prior to analysis that were thought to conceptually affect post-induction hypoxemia.

**Stepwise multivariable logistic regression model. Variables from the multivariable logistic regression model with p values <0.25 for their estimates were include in stepwise selection based on Akaike Information Criterion which was used to select the final stepwise model.

[+]Stepwise multivariable logistic regression model with position. Position was reintroduced into the stepwise model as it had been removed during the variable selection process.

Table 4. Odds ratios (OR) for first attempt post-induction hypoxemia with video laryngoscopy

Variable	Univariate OR (95% CI)	Multivariable Model aOR (95% CI)*	Stepwise Model aOR (95% CI)**	Stepwise Model with Position aOR (95% CI)[+]
Ramped	1.28 (0.82, 2.01)	1.01 (0.63, 1.63)		0.97 (0.60, 1.56)
Obese or Morbidly Obese	**2.58 (1.89, 3.51)**	**2.29 (1.63, 3.21)**	**2.22 (1.59, 3.11)**	**2.23 (1.59, 3.12)**
Level of training				
Post-Graduate Year 1	Reference	Reference		
Post-Graduate Year 2	0.94 (0.59, 1.50)	0.94 (0.58, 1.52)		
Post-Graduate Year 3-4	0.80 (0.51, 1.26)	0.67 (0.42, 1.09)	**0.68 (0.49, 0.95)**	**0.68 (0.49, 0.95)**
Fellow or Attending	1.17 (0.64, 2.12)	1.14 (0.61, 2.13)		
First Attempt Cormack-Lehane View Grade 3-4	**2.65 (1.61, 4.33)**	**2.37 (1.42, 3.96)**	**2.34 (1.41, 3.89)**	**2.34 (1.41, 3.89)**
Preoxygenation >3 minutes	1.07 (0.70, 1.65)	1.03 (0.66, 1.62)		
Nasal Cannula preoxygenation only, n (%)	0.95 (0.58, 1.57)	1.19 (0.71, 1.99)		
Post-induction Hypotension	1.68 (0.86, 3.28)	1.83 (0.90, 3.69)	1.82 (0.92, 3.60)	1.82 (0.92, 3.61)
Oxygen saturation <90%	1.09 (0.49, 2.43)	1.03 (0.44, 2.40)		

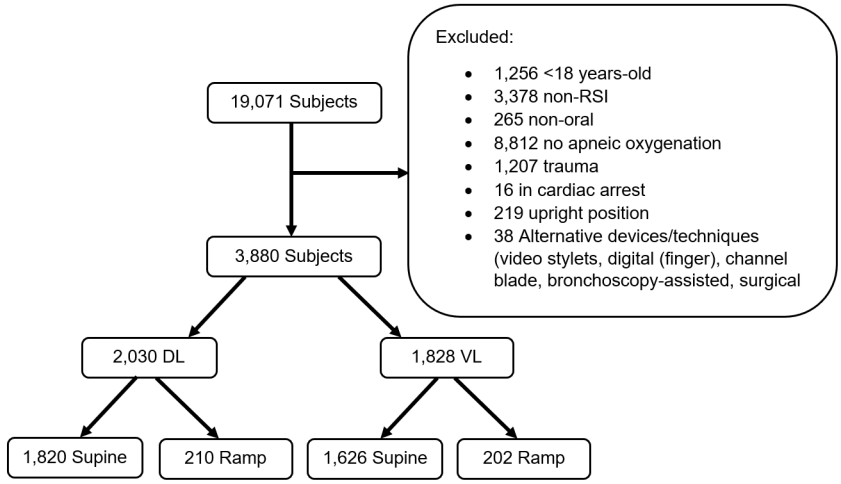
at start of intubation				
Subjective impression of difficult airway	**2.14 (1.58, 2.92)**	**1.53 (1.07, 2.19)**	**1.59 (1.14, 2.22)**	**1.60 (1.14, 2.24)**
Any Objective Difficult Airway Finding	**1.45 (1.04, 2.01)**	1.13 (0.79, 1.63)		
Bougie used	**1.76 (1.25, 2.49)**	**2.11 (1.44, 3.08)**	**2.13 (1.46, 3.10)**	**2.13 (1.46, 3.10)**
Hosmer & Lemeshow Goodness of Fit Test	NA	X-squared = 9.3 DF = 8 P value = 0.32	X-squared = 5.2 DF = 8 P value = 0.74	X-squared = 4.9 DF = 8 P value = 0.77
Akaike Information Criterion	NA	1117.54	1123.49	1125.50

OR, odds ratio; aOR, adjusted odds ratio; CI, confidence interval; CPAP, continuous positive airway pressure; BPAP, bilevel positive airway pressure; BVM, bag valve mask; AE, adverse event; X-squared, Chi-Squared; DF, degrees of freedom

*Multivariable logistic regression model. Variables were selected prior to analysis that were thought to conceptually affect post-induction hypoxemia.

**Stepwise multivariable logistic regression model. Variables from the multivariable logistic regression model with p values <0.25 for their estimates were include in stepwise selection based on Akaike Information Criterion which was used to select the final stepwise model.

[+]Stepwise multivariable logistic regression model with position. Position was reintroduced into the stepwise model as it had been removed during the variable selection process.



DL, direct laryngoscopy; VL, video laryngoscopy; RSI, rapid sequence intubation

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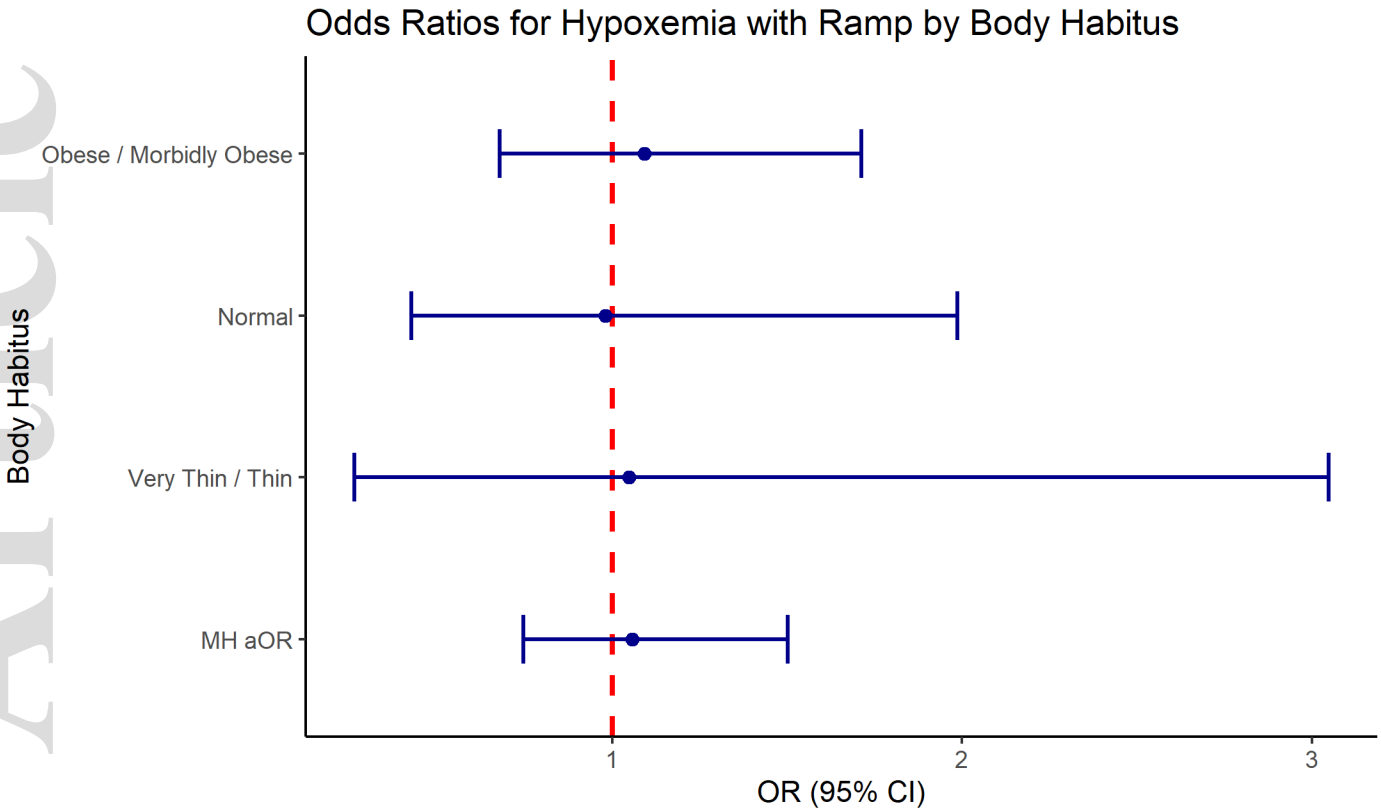

MH, Mantel-Haenszel; OR, Odds Ratio; aOR, adjusted OR; CI, confidence interval

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What the Area Offers:

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