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Brief Report

Inclined position is associated with improved first pass success and laryngoscopic view in prehospital endotracheal intubations

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ABSTRACT

Purpose: In hospital-based studies, patients intubated by physicians while in an inclined position compared to supine position had a higher rate of first pass success and lower rate of peri-intubation complications. We evaluated the impact of patient positioning on prehospital endotracheal intubation in an EMS system with rapid sequence induction capability. We hypothesized that patients in the inclined position would have a higher first-pass success rate.

Methods: Prehospital endotracheal intubation cases performed by paramedics between 2012 and 2017 were prospectively collected in airway registries maintained by a metropolitan EMS system. We included all adult (age ≥ 18 years) non-traumatic, non-arrest patients who received any attempt at intubation. Patients were categorized according to initial positioning: supine or inclined. The primary outcome measure was first pass success with secondary outcomes of laryngoscopic view and challenges to intubation.

Results: Of the 13,353 patients with endotracheal intubation attempted by paramedics during the study period, 4879 were included for analysis. Of these, 1924 (39.4%) were intubated in the inclined position. First pass success was 86.3% among the inclined group versus 82.5% for the supine group (difference 3.8%, 95% CI: 1.5%–6.1%). First attempt laryngeal grade I view was 62.9% in the inclined group versus 57.1% for the supine group (difference 5.8%, 2.0–9.6). Challenges to intubation were more frequent in the supine group (42.3% versus 38.8%, difference 3.5%, 0.6–6.3).

Conclusion: Inclined positioning was associated with a better grade view and higher rate of first pass success. The technique should be considered as a viable approach for prehospital airway management.

1. Introduction

1.1. Background

Emergency tracheal intubation in prehospital setting is an uncommon but potentially lifesaving procedure. Rapid sequence induction (RSI) is a technique to optimize intubating conditions while minimizing the risks of aspiration. Traditionally, patients are placed supine with the head in a "sniffing position" to optimize line-of-sight to the glottis during direct laryngoscopy. While substantial evidence informs optimal head and neck position, less is known about the potential effects of a patient's body position and intubation success.

1.2. Importance

In hospital, the inclined position during emergency tracheal intubation was associated with better glottis views, greater first pass success, and a reduction in airway-related complications compared to those intubated in the conventional supine position [1]. In an emergency department setting, a greater degree of bed inclination was associated with higher rates of first pass success [2]. Yet in a randomized trial conducted among critical care fellows performing tracheal intubation in an intensive care unit, first pass success was lower in the patients assigned to incline positioning [3]. The influence of patient position has not been

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investigated in the prehospital setting among paramedic-attempted intubations, where intubating experience and circumstances may be different [4,5]. Patient positioning is a potentially modifiable factor that may help optimize intubating conditions thereby decreasing the overall risk related to airway management.

1.3. Goals of this investigation

We sought to evaluate the impact of patient positioning on prehospital endotracheal intubation in an emergency medical services (EMS) system with RSI capability. We hypothesized that patients in the inclined position would have superior intubating conditions and therefore have a better laryngoscopic view, a higher first pass success rate, and fewer reported challenges to intubation.

2. Methods

2.1. Study design and setting

We performed a retrospective analysis of attempted prehospital intubations performed by paramedics between June 2012 and April 2017 using two prospectively collected airway registries maintained by a metropolitan EMS system. We included all adult non-traumatic, non-arrest adult patients who received attempted intubation in the prehospital setting. We a-priori excluded those with a *Do Not Intubate* order, those with pre-existing endotracheal or tracheostomy tubes, and those <18 years of age (Fig. 1). For analysis, patients were categorized into three cohorts based on positioning: supine, inclined (defined as partially inclined or sitting), or unknown. This study was reviewed and approved by the Institutional Review Board for Human Subjects Research at the University of Washington.

2.2. Methods and measurements

The EMS system serves the City of Seattle and surrounding King County, Washington with a size of approximately 2100 mile^2 and a 2017 population of 2.1 million people. The EMS system employs a two-tier emergency response: initial evaluation by firefighter-EMTs providing basic life support and a second tier of a paired intensive care paramedic team trained in advanced life support. Approximately 250 intensive care paramedics serve this population, with 26 paramedic units in service at any one time.

Paramedics are initially trained in airway management in both field and operative settings including use of RSI in patients with airway reflexes. The paramedics follow a common airway management algorithm and perform at least twelve intubations annually after completing initial training [6]. Additional airway adjuncts including the iGel laryngeal mask airway (Intersurgical, Berkshire, UK) and bougie stylet are part of the paramedic scope of practice. Paramedics use continuous end tidal carbon dioxide monitoring and chest auscultation to confirm correct endotracheal tube position. Paramedics did not receive any specific training on patient positioning and was determined based solely upon clinical judgment.

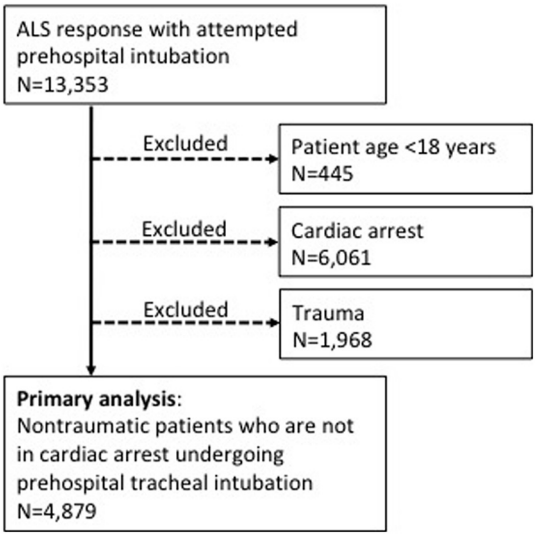

Fig. 1. Study flow diagram.

2.3. Data variables and collection

The Seattle Fire Department and the King County EMS Division each maintain registries detailing advanced airway management by paramedics [5]. Following a patient encounter that involves an attempted intubation or other advanced airway procedure, the paramedic operator completes a web-based form in order to fulfill requirements for continuous practice improvement. Patient positioning, first attempt Cormack-Lehane laryngoscopic grade of airway view, and specific challenges to intubation are primary data elements in the airway registries. Positioning is categorized into either supine or inclined/upright. This form also captures patient characteristics, method and outcome for each attempt, the use of any adjunctive medications, and details related to the procedure process.

An endotracheal intubation attempt is defined by the introduction of a laryngoscope past the teeth and concludes when the laryngoscope is removed from the mouth, regardless of whether or not an endotracheal tube is inserted. Intubation with RSI is defined as any attempted intubation involving pre-medication with a paralytic agent. We defined an intubation attempt as successful if correct endotracheal tube position was confirmed by capnography. Prior investigation using hospital information has validated successful placement as documented by paramedic information in the study EMS system [5]. RSI induction medications were added to the airway registry form as of 2015. Frequency of RSI among this cohort was estimated by the use of succinylcholine, rocuronium or both during induction.

2.4. Outcomes

The primary outcome measure was first pass success rate. Secondary outcomes include laryngoscopic view on first attempt and reported challenges to intubation.

2.5. Analysis

Statistical analysis used chi-square methods to compare outcomes between patients in supine and inclined positions. Subgroup and sensitivity analyses stratified outcome comparisons by grade view and age (< and ≥65 years). Statistical analyses were conducted with MedCalc comparison of proportions calculator; https://www.medcalc.org/calc/comparison_of_proportions.php.

3. Results

3.1. Characteristics of study subjects

Of the 13,353 patients with at least one attempt at field intubation by paramedics during the study period, 4879 were adult (age ≥ 18 years), non-traumatic, non-arrest cases (Fig. 1). Males comprised 51.6% of patients. Mean age was 59.5 years overall; 55.9 years (SD ± 19.6) among the supine group and 64.8 years (SD ± 17.7) among the inclined group (Table 1). The most common indication (non-exclusive diagnostic categories) for attempted intubation were airway protection (66.8%) and respiratory failure (49.1%). RSI was performed in 97.2% of cases, explicitly not performed in 0.4%, and unknown in 2.5% of cases.

Table 1
Patient demographics and characteristics of attempted intubations among non-traumatic patients who were not in cardiopulmonary arrest

		Row total		Patient position						Difference inclined vs. supine	
				Supine		Inclined		Unknown			
		N	%	N	%	N	%	N	%	%	(95%CI)
Total		4879	100.0%	2725	55.9%	1924	39.4%	230	4.7%		
Age	Mean	59.5		55.9		64.8		57.3			
	Std Deviation	19.4		19.6		17.7		20			
Gender	Male	2031	51.6%	1135	52.9%	825	50.4%	71	45.5%	−2.6%	(−1.9–7.0)
	Female	1907	48.4%	1009	47.1%	813	49.6%	85	54.5%		
Indication category*	Respiratory failure	2397	49.1%	941	34.5%	1366	71.0%	90	39.1%	36.5%	(32.5–40.3)
	Airway protection	3260	66.8%	2172	79.7%	920	47.8%	168	73.0%	−31.9%	(28.2–35.5)
	Shock	170	3.5%	107	3.9%	53	2.8%	10	4.3%	−1.1%	(−7.7–7.0)
	Expected clinical course	129	2.6%	86	3.2%	38	2.0%	5	2.2%	−1.2%	(−9.5–7.6)
	Humanitarian	11	0.2%	8	0.3%	3	0.2%	0	0.0%	−0.1%	(−56.0–32.6)
First attempt laryngeal view: Cormack and Lehane grade	I	2711	59.1%	1456	57.1%	1147	62.9%	108	50.9%	5.8%	(2.0–9.6)
	II	1067	23.3%	622	24.4%	394	21.6%	51	24.1%	−2.8%	(−2.6–8.0)
	III	399	8.7%	230	9.0%	151	8.3%	18	8.5%	−0.7%	(−5.6–6.3)
	IV	194	4.2%	120	4.7%	65	3.6%	9	4.2%	−1.1%	(−7.0–7.0)
	Unknown	215	4.7%	123	4.8%	66	3.6%	26	12.3%	−1.2%	(−6.8–7.1)
First attempt success	Yes	4094	83.9%	2247	82.5%	1660	86.3%	187	81.7%	3.8%	(1.5–6.1)
	No	784	16.1%	478	17.5%	264	13.7%	42	18.3%		
Number of attempts to successful intubation	1	4094	85.0%	2247	83.7%	1660	87.1%	187	82.7%		
	2	539	11.2%	325	12.1%	185	9.7%	29	12.8%	−2.4%	(0.6–4.2)
	≥3	181	3.8%	111	4.1%	60	3.1%	10	4.4%	−1.0%	(−0.1–2.1)
Challenges to the 1st intubation**	Yes	1582	41.0%	889	42.3%	624	38.8%	69	44.5%	−3.5%	(0.6–6.3)
	No	2281	59.0%	1211	57.7%	984	61.2%	86	55.5%		
Challenge: Secretions, emesis or blood	Yes	594	15.4%	389	18.5%	184	11.4%	21	13.5%	−7.1%	(5.0–9.1)
Challenge: Obesity	Yes	522	13.5%	260	12.4%	246	15.3%	16	10.3%	2.9%	(0.9–5.0)
Challenge: patient position	Yes	251	6.5%	101	4.8%	140	8.7%	10	6.5%	3.9%	(2.4–5.4)

*Indications for intubation were non-exclusive categories thus do not sum to 100%.
**Challenges to intubation: Specific challenges not reported until 2015, thus reflecting a smaller sample.

3.2. Main results

Overall, 1924 patients (39.4%) were intubated in an inclined position (Table 1). First pass success was 86.3% among the inclined group compared with 82.5% for the supine group, a difference of 3.8% (95% CI: 1.5–6.1). First attempt laryngeal grade I view was 62.9% in the inclined group compared with 57.1% for the supine group, difference of 5.8% (95% CI: 2.0–9.6). Challenges to intubation were more frequent in the supine group (42.3% versus 38.8%, difference 3.5%, 95% CI: 0.6–6.3), particularly regarding presence of airway secretions, emesis, or blood (18.5% versus 11.4%, difference 7.1%, 95% CI: 5.0–9.1).

Sensitivity analyses were performed to stratify outcome by grade view (Table 2) and patient age (Table 3). When stratified by age, first pass success rate was greater in the inclined position by a similar magnitude of 4.5% (95% CI: 1.6–7.2) and 3.9% (95% CI: 0.7–7.1) among those aged <65 years and those ≥65, respectively. When stratified by grade view, there were no statistically significant improvements in first pass success in the inclined position within each grade view group.

4. Discussion

We report the current practice of patient positioning for attempted tracheal intubations and its relationship with first pass success in a large metropolitan RSI-capable EMS system. We observed that more than one-third of field intubations are attempted in the inclined position among non-traumatic, non-arrest cases. Inclined positioning was associated with higher rates of first pass success and grade 1 view on laryngoscopy when compared with patients intubated in the supine position. These findings suggest that intubation in the inclined position may be associated with improved success and is a viable, useful technique be considered in training and clinical airway practice for the prehospital setting.

The inclined position is used in the hospital to achieve intubation in selected patients [1,2]. However there is little understanding about the extent of its use in the prehospital setting, where tens of thousands of persons undergo attempted intubation in the US each year [7]. In the current study, inclined patient position was used in about 16.3% of attempted intubations overall and over a third of the study-specific non-traumatic, non-arrest patients. Although the study does not have

Table 2
First pass success stratified by grade of laryngocscopic view and patient position among non-traumatic patients who were not in cardiopulmonary arrest undergoing attempted tracheal intubation

First attempt laryngeal grade view	Total			Patient position									Difference inclined vs supine	
				Supine			Inclined			Unknown				
	N	First pass success (N)	%	N	First pass success (N)	%	N	First pass success (N)	%	N	First pass success (N)	%	%	(95% CI)
I	2761	2662	96.4%	1489	1428	95.9%	1160	1125	97.0%	112	109	97.3%	1.1%	(−0.4–2.5)
II	1123	997	88.8%	658	576	87.5%	412	375	91.0%	53	46	86.8%	3.5%	(−0.4–7.1)
III	505	261	51.7%	288	149	51.7%	193	102	52.8%	24	10	41.7%	1.1%	(−8.0–10.1)
IV	380	110	28.9%	233	64	27.5%	130	42	32.3%	17	4	23.5%	4.8%	(−4.8–14.8)
Unknown	92	75	81.5%	48	38	79.2%	23	20	87.0%	21	17	81.0%	7.8%	(−13.3–23.7)

Missing data: 1 case without known first pass success among unknown patient positioning row.

Table 3
First pass success stratified by age category and patient position among non-traumatic patients who were not in cardiopulmonary arrest undergoing attempted tracheal intubation

Age	Total	Patient position									Difference inclined vs supine	
		Supine			Inclined			Unknown				
	N	N	First pass success (N)	%	N	First pass success (N)	%	N	First pass success (N)	%	%	(95% CI)
<65 years	2732	1739	1446	83.2%	851	746	87.7%	142	118	83.1%	4.5%	(1.6–7.2)
65 years or older	2144	984	800	81.3%	1073	914	85.2%	87	69	79.3%	3.9%	(0.7–7.1)

Missing data: 1 case without known first pass success among unknown patient positioning row; 2 cases of unknown age among the supine group.

specific details about chronic health conditions or final acute-illness diagnosis, we do observe that the inclined position is used relatively more often for respiratory failure (71.0% vs. 34.5%) and less often for airway protection (47.8% vs. 79.7%) than conventional supine position. As a potential explanation, the paramedic may have selected the inclined position when there was a concern that laying the patient flat may induce additional respiratory distress and clinical deterioration. Proposed benefits of inclined positioning include improved respiratory physiology by enhancing alveoli gas exchange and/or improving functional residual capacity [8].

The use of the inclined position was associated with a higher rate of first pass success compared to the supine position, potentially because it led to a better laryngeal view and fewer documented obstacles to successful intubation. Longer apnea time and improved glottic views on direct laryngoscopy have been described with inclined patient positioning [9,10]. Prior work from the study system and elsewhere has described a positive relationship between a better grade view and successful intubation, suggesting that efforts to improve grade view can improve intubation success [5,11]. In this specific study cohort, we observe a similar relationship whereby first-attempt success overall is 96.4% for grade 1 airways and falls steadily with increasing grade to 28.9% for grade 4 airways. We also observed that those in the inclined position had less soiled airway challenges. The mechanism by which inclined positioning achieves higher first pass success likely has to do with achieving better grade view on laryngoscopy. After stratifying by grade view, the beneficial relationship between inclined position and first attempt success was not observed within each airway grade group.

We cannot be certain if the better view among the inclined patients was directly due to positioning or is a confounding characteristic for patients intubated in the inclined position. For example, the observed difference may be due to operator effect, whereby top performing paramedics more frequently employ maneuvers such as inclined positioning, yet their success is related to a higher level of proficiency with airway management and independent of positioning. Regardless of the mechanism, the better grade view associated with the inclined position likely contributes to the higher rate of first pass success.

4.1. Limitations

The data for this study was derived from a single, large predominantly urban-suburban RSI-capable EMS system, a setting and circumstance that may limit generalizability of the findings. Although the registry was populated without specific knowledge of the current study aims, the information is provided by self-report from the paramedic airway operator, and thus is subject to recall bias. This analysis did not link airway registries to EMS clinical reports or hospital records, and thus we cannot report on specific clinical context or patient outcomes beyond what is gathered in the registry. Importantly, the airway registries did not capture degree of inclination, but rather denote patient positioning as a binary function (supine versus inclined) and cannot provide insight into the optimal degree of inclination. Ultimately, these limitations should be considered in the context of the strengths of large sample size of consecutive intubation attempts with capture of airway descriptive characteristics and processes in an RSI-capable EMS system.

As an observational study, the study cannot establish causality. We believe that those in the inclined position likely represent a different clinical group and so the goal is not to claim that the inclined position is superior. Rather we report and contrast the airway performance for supine versus inclined so that the reader may appreciate that the inclined position can provide a viable approach in selected patients.

The airway registries did not capture peri-procedure desaturation events. Considering the proposed rationale for longer safe apneic times in patients intubated in the inclined position, this is a clinically meaningful question that remains for future study.

Finally, we a-priori excluded patients suffering cardiac arrest or trauma who received attempted intubation as we believed their intubation circumstance and conditions would be distinct and would generally be performed in the supine position. Indeed, we observed that 93.8% of cardiac arrest and 92.1% of trauma intubations were in the supine position while just 1.5% and 4.4% were in an inclined position, respectively with the remainder in an unknown position.

4.2. Conclusions

We observed that the inclined position is a viable approach to prehospital emergency intubation that can achieve a high level of first-pass success in non-arrest, non-traumatic patients. Thus the technique should be considered for advanced airway training and clinical practice. Future efforts should investigate the optimal clinical indications for inclined positioning, the mechanisms that provide relative benefit, and additional operational details (extent of inclined position) to further improve airway performance.

Ethics approval

This study was reviewed and approved by the Institutional Review Board for Human Subjects Research at the University of Washington.

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Conflict of interest

All authors declare that they have no conflict of interest.

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