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Original Research

Apneic Oxygenation May Not Prevent Severe Hypoxemia During Rapid Sequence Intubation: A Retrospective Helicopter Emergency Medical Service Study

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A B S T R A C T

Objective: This study sought to determine the effectiveness of apneic oxygenation in preventing hypoxemia during prehospital rapid sequence intubation (RSI).
Methods: We performed a case-cohort study using a pre-existing database looking at intubation management by a single helicopter emergency medical service between July 2013 and June 2015. Apneic oxygenation using high-flow nasal cannula (15 L/min) was introduced to the standard RSI protocol in July 2014. Severe hypoxemia was defined as an incidence of oxygen saturation less than 90%. We compared patients who received apneic oxygenation during RSI with patients who did not using the Fisher exact test.
Results: Ninety-three patients were identified from the database; 29 (31.2%) received apneic oxygenation. Nineteen patients had an incidence of severe hypoxemia during RSI (20.43%; 95% confidence interval, 12.77%-30.05%). There was no statistically significant difference between the rate of severe hypoxemia between patients in the apneic oxygenation group versus the control group (17.2% vs. 21.9%, $P = .78$).
Conclusion: In this study, patients who received apneic oxygenation did not show a statistically significant difference in severe hypoxemia during RSI.

Rapid sequence intubation (RSI) is a technique in which intubation is aided by the administration of sedatives and neuromuscular blockade in rapid succession. In the prehospital setting, the use of RSI has a high success rate for intubation when performed by experienced providers.[1] This technique may also improve the outcomes of some patients, particularly those with severe traumatic brain injury.[2] However, RSI may result in hypoxemia during intubation attempts because of the absence of respiratory effort and inadequate preoxygenation.[3-5] This can be deleterious to patient outcomes.[6]

To prevent hypoxia during RSI, apneic oxygenation, which uses high-flow oxygen via nasal cannula (15 L/min), has been promoted. The nasal cannula is placed at the start of the preoxygenation phase and is maintained until the airway is secure.[7] The technique has been shown to increase alveolar oxygenation even in the absence of respiratory effort. Furthermore, by using a nasal cannula, oral intubation is still possible because there is no mask covering the mouth. Two randomized controlled trials using a nasal cannula at 5 L/min in the in-hospital setting showed that the technique can increase the saturation reserve, prolonging adequate oxygenation saturation ($SpO_2 > 95\%$) when compared with room air.[8,9] Furthermore, a recent before and after study in the intensive care unit using high-flow nasal cannula showed significant improvement in oxygenation during the intubation of patients with mild to moderate hypoxemia.[10]

However, there are few studies examining the effectiveness of this technique in the prehospital environment. This study sought to determine the effectiveness of apneic oxygenation performed by a helicopter emergency medical service in the prehospital environment.

Methods

The study was reviewed and approved by the Penn State College of Medicine Institutional Review Board. We performed a case-cohort study using a pre-existing database from a quality improvement project looking at airway management by a single helicopter

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emergency medical service (HEMS). The program provides air medical transport within a 10-county region in south central Pennsylvania using flight nurse/flight paramedic teams. They perform RSI in patients who meet indications for active airway management and use a video laryngoscope for their initial intubation attempts per their standard airway management protocols. The providers continuously monitor multiple patient parameters, including SpO_2 from Intellivue MP2 patient monitors (Phillips, Amsterdam, Netherlands), from when they arrive at the scene until they transfer care at the receiving hospital. The providers manually transfer these parameters from the monitor's record at 5-minute intervals (or less) into their electronic medical record (emsCharts, Inc, West Mifflin, PA). If there is an incidence of SpO_2 less than 90% during RSI, the providers record this as a complication in the patient record.

A quality improvement project was conducted by using airway management data from the HEMS program's electronic medical records. The investigators used a convenience sample by extracting from a quality improvement data set from July 2013 to June 2015. In July 2014, apneic oxygenation using high-flow nasal cannula (15 L/min) was added to the standard RSI protocol. The nasal cannula was to be used from the preoxygenation phase and maintained until the airway was confirmed and secured. This was supplemented with bag valve mask (BVM) ventilation if needed. The data extracted included only patients aged 18 years or older who underwent oral endotracheal intubation using RSI in the prehospital setting by the HEMS providers. Patients were excluded if they did not receive intubation with RSI, such as patients in whom a crash airway technique was used. The data set included age, estimated weight, sex, prehospital diagnosis, hemodynamic status before intubation, preoxygenation technique, difficult airway assessments by HEMS providers, complications during RSI, first-attempt intubation success status, and laryngoscopic views (using the Cormack-Lehane view). The difficult airway assessments included both difficult ventilation and difficult intubation. “Difficult ventilation” referred to a risk of difficult BVM ventilation in prehospital patients and was identified by HEMS providers using the MOANS mnemonic.[11] Similar to the difficult ventilation, “difficult intubation” was an increased risk of difficult oral endotracheal intubation, as identified by HEMS providers using the LEMON mnemonic.[11]

We divided the data set into 2 groups: the apneic oxygenation group, defined as patients who received apneic oxygenation during RSI, and the control group, defined as patients who received the standard RSI technique. Our primary outcome was severe hypoxemia, defined as patients whose SpO_2 dipped under 90% during RSI. The 2 groups were compared using the Fisher exact test. We also analyzed data to indicate factors associated with severe hypoxemia during RSI using the Fisher exact test. Statistics were calculated using SAS version 9.4 (SAS Institute Inc, Cary, NC).

Results

During the identified 24-month time period, there were 93 patients who had received RSI. Twenty-nine patients (31.2%) were in the apneic oxygenation group. After implementation of apneic oxygenation in the RSI protocol, 55.8% (29/52) of patients who received RSI were given apneic by our HEMS providers. Nineteen patients (20.43%; 95% confidence interval, 12.77%-30.05%) had an incidence of severe hypoxemia during RSI. Demographic data for the apneic oxygenation group and the control group are provided in Table 1. There was no statistically significant difference in prehospital diagnoses within the groups ($P = .16$). The most common prehospital diagnosis was isolated head injury (31.0% in the apneic oxygenation group vs. 45.3% in the control group). There was no significant difference between the groups for patients who had SpO_2 greater than or equal to 90% before intubation (86.2% in the apneic oxygenation group vs. 82.8% in the control group, $P = .77$). The HEMS providers achieved a 75.9% first-attempt intubation success rate in the apneic oxygenation group, which was not statistically significantly different from the control group (73.4%, $P = 1.00$). However, patients who were in the apneic oxygenation group received BVM ventilation during the preoxygenation phase significantly less often than patients in the control group (24.1% vs. 50.0%, $P = .024$). There was no statistically significant difference between the rate of severe hypoxemia between patients in the apneic oxygenation group versus the control group (17.2% vs. 21.9%, $P = .78$).

Table 1
Demographic Data Comparing Patients Who Received Apneic Oxygenation and Patients Who Did Not

	Apneic Oxygenation Group (n = 29)	Control Group (n = 64)	*P* Value
Men, n (%)	18 (62.07)	47 (73.44)	.330
Age, year, mean ± SD	45.46 ± 19.24	45.36 ± 22.12	.983
Estimated weight, kg, mean ± SD	83.62 ± 21.38	90.00 ± 20.66	.176
Prehospital diagnosis, n (%)			.163
Isolated head injury	9 (31.03)	29 (45.31)	
Isolated chest injury	1 (3.45)	1 (1.56)	
Multiple trauma injury	7 (24.14)	15 (23.44)	
CVA/stroke	4 (13.79)	13 (20.31)	
Others	8 (27.59)	6 (9.38)	
Oxygen saturation ≥ 90% before intubation, n (%)	25 (86.21)	53 (82.81)	.770
Preoxygenation with BVM ventilation, n (%)	7 (24.14)	32 (50.00)	.024
Preoxygenation with NRM ventilation, n (%)	19 (65.52)	30 (46.88)	.119
Difficult airway assessments by HEMS providers			
Difficult ventilation, n (%)	3 (10.34)	11 (17.19)	.537
Difficult intubation, n (%)	10 (34.48)	24 (37.50)	.820
First intubation attempt success, n (%)	22 (75.86)	47 (73.44)	1.000
Cormack-Lehane view, n (%)			.630
Grade I	13 (54.17)	25 (43.10)	
Grade II	10 (41.67)	24 (41.38)	
Grade III	1 (4.17)	6 (10.34)	
Grade IV	0 (0)	3 (5.17)	

BVM = bag valve mask; CVA = cerebrovascular accident; HEMS = helicopter emergency medical services; NRM = nonrebreathing mask; SD = standard deviation.

When the HEMS providers achieved first-attempt intubation success, patients had severe hypoxemia during RSI significantly less than patients who received multiple intubation attempts (7.25% vs. 58.33%, $P < .0001$). Furthermore, patients who had an SpO_2 less than 90% before initiating RSI had a significantly higher rate of severe hypoxemia during RSI than patients who had an SpO_2 more than 90% (66.67% vs. 11.54%, $P < .0001$).

Discussion

An important goal of prehospital advanced airway management is the prevention of hypoxemia during transport. Unfortunately, advanced airway management, particularly RSI, can cause hypoxemia during the procedure.[5] Apneic oxygenation, using high-flow oxygen via nasal cannula along with conventional techniques such as BVM ventilation, has been a somewhat controversial topic. Our study found no statistically significant difference in the rate of hypoxemia during RSI between the patients who received apneic oxygenation from those who did not.

There were several possible reasons our study did not show a difference in the rate of hypoxemia between the groups. First, our patients had a high rate of severe hypoxemia ($SpO_2 < 90\%$) before initiating RSI, a common characteristic of patients requiring active airway management in the prehospital setting. Moreover, the rate of severe hypoxemia in our patients was different from the previous