American Journal of Emergency Medicine 35 (2017) 1320–1323

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Brief Report

The effect of the apneic period on the respiratory physiology of patients undergoing intubation in the ED

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ARTICLE INFO

Article history:
Received 9 December 2016
Received in revised form 26 March 2017
Accepted 30 March 2017

ABSTRACT

Objectives: We sought to examine the physiological impact the apneic period has on the respiratory physiology of patients undergoing intubation in the emergency department and whether DAO, the delivery of 15L oxygen by nasal cannula during apnea, can affect the development of respiratory acidosis.

Methods: This was a prospective observational cohort study conducted at an urban academic level 1 trauma center. A convenience sample of 100 patients was taken. Timed data collection forms were completed during the periintubation period. We report the mean ABG and end-tidal CO2 (EtCO2) values between those with normal and prolonged apnea times (>60 s) and between those who received DAO and those who did not.

Results: 100 patients met our inclusion criteria. There were no significant differences in the pre-RSI ABG values between those who received DAO and those who did not and between those with apnea times less than or >60 s. Only in the group of patients with apnea times >60 s did significant changes in respiratory physiology occur. DAO did not alter the trend in respiratory acidosis during the periintubation period. EtCO2 increased as apnea times were prolonged, and DAO altered this trend.

Conclusions: Post-RSI EtCO2 increased as apnea times were prolonged. DAO may alter this trend. Statistically significant changes in pH and PaCO2 (mean differences of 0.15 and 12.5, respectively) occurred in the group of patients who had mean apnea times of >60 s but not in those with apnea times <60 s.

1. Introduction

Rapid sequence intubation (RSI) is the preferred method of securing a definitive airway in the emergency department (ED). A great deal of emphasis is placed on optimizing larnygoscopic and intubating conditions to avoid hypoxemia [1], which can quickly progress to dangerously low levels during the apneic period. Although there are no studies demonstrating that transient hypoxemia is associated with adverse outcomes in the general ED population, prolonged hypoxemia can potentially cause hemodynamic decompensation or brain injury if not addressed [2-5]. In healthy patients, the first minute during the apneic period is thought to increase pCO2 by 8 to 16 mm Hg and then approximately 3 mm Hg per minute thereafter [6]. However, little is known about the effect of the apneic period on respiratory physiology during intubation when it is performed as a life-saving measure.

During the apneic period after sedation and neuromuscular blockade, the normal pressure gradient between the outside world and the alveoli is absent. Pre-oxygenation alone may be insufficient to prevent oxygen desaturation, and experts have recommended diffuse apneic oxygenation (DAO), the delivery of 15 L oxygen by nasal cannula during apnea, in order to prevent hypoxemia and extend the safe apneic period [1]. Recent studies have shown mixed results on the effect of DAO to lower the incidence of hypoxemia in critically-ill patients undergoing intubation [7-10]. Apneic oxygenation by nasal cannula has been demonstrated to delay the onset of hypercarbia in healthy patients undergoing elective intubation [11], yet whether DAO can facilitate enough gas exchange to affect the rate of PaCO2 retention during the peri-intubation period in patients undergoing emergent intubation in the ED has yet to be studied. We sought to examine the physiological impact the apneic period has on $PaCO_2$ retention in patients undergoing RSI in the ED and whether DAO can affect the development of respiratory acidosis during the peri-intubation period.

2. Methods

2.1. Study design and setting

This was a prospective observational cohort study conducted at an urban academic level 1 trauma center with an annual census of approximately 170,000 patients in New York City from January to April 2016. This institution has an ACGME-accredited 4-year emergency medicine (EM) residency program, and ED intubations are performed by an EM

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http://dx.doi.org/10.1016/j.ajem.2017.03.076
0735-6757/

resident under direct supervision by an EM attending. The residents have extensive training in airway management through a simulation lab, critical care, and anesthesia rotations. The study was approved by the Institutional Review Board. Since a convenience sample of 100 patients was taken, a sample size and power analysis was not performed.

2.2. Selection of participants

All adult patients requiring endotracheal intubation were screened for inclusion. Exclusion criteria included patients in cardiac or traumatic arrest, those where awake intubation technique was used, those where pre-oxygenation was not performed, and those where an arterial blood gas (ABG) was not obtained both prior to and after intubation.

2.3. Methods and measurements

An ED intubation timed data collection form was completed for the real-time documentation of the following: indication for intubation, patient demographic data, first pass success rate, oxygen saturations, preoxygenation methods, pre-oxygenation time, the use of DAO, and nasal cannula end-tidal CO2 (EtCO2). In addition, the collection form included a measurement of apnea time during the peri-intubation period and the post-intubation EtCO2 measured after confirmation of endotracheal tube placement. This information was collected by an ED provider, an EM resident or attending, assigned to observe and collect data for each intubation. At the time of data acquisition, the collection form was recorded for a quality improvement database, and the providers were unaware of our hypothesis. Apnea was confirmed by waveform capnography when the waveform was flat at 0 mm Hg mark. We chose to use 60 s as cutoff for identifying patient with a prolonged apneic period, because the rate of PaCO2 rise was previously described as highest during the first minute of apnea [6]. ABGs were collected prior to the RSI process and within 15 min after confirmation of intubation.

2.4. Outcomes and analysis

Descriptive statistics were used for demographic data. We compared all ABG and EtCO2 values before and after intubation. Student's *t*-test was used for parametric data to compare physiologic variables within the study population. Ninety-five percent confidence intervals (95% CI) and p-values are reported. A p-value of <0.05 was used to determine significance. We also report the 95% CI of the differences between the means of the pre-RSI and post-RSI ABG and EtCO2 values. We also attempted to correlate apnea time as a continuous variable and plot it against individual first EtCO2 measurements after confirmation of endotracheal intubation using a scatter plot. All statistical analysis was perfumed using the Statplus (Analysoft, Walnut, CA) and XLSTAT (Addinsoft, New York, NY) statistical software packages.

3. Results

A total of 100 patients were enrolled. The average age of the cohort was 56 (95% CI 53.4 to 59.3). Fifty-nine patients were male and 41 were female. A majority of patients were intubated for primary pulmonary pathologies. 51 patients received DAO during the study period. The mean SpO2 prior to preoxygenation, preoxygenation time, SpO2 after preoxygenation were 93% (95% CI 91 to 94), 813 s (95% CI 662 to 965), and 98% (95% CI 97 to 96) respectively. The mean apnea time was 65 s (95% CI 57 to 73). We found a first pass success rate of 88%. The median laryngoscopic view based on the Cormack-Lehane classification system was 1 with an interquartile range (IQR) of 1 to 2. The median American Society of Anesthesiologists (ASA) classification was 2 (IQR 1 to 3). Table 1 demonstrates the patient demographics of the cohort.

Statistically significant, through likely clinically insignificant, changes in pH, PaO2, PaCO2, and EtCO2 levels occurred during the peri-intubation period. The mean ABG values before and after the intubation are demonstrated in Table 2. The differences between the pre-RSI and post-RSI means of the pH, PaO2, PaCO2, and EtCO2 levels were 0.05 (95% CI 0.01 to 0.09), 174.5 (95% CI 138.5 to 10), 11.5 (95% CI 2.5 to 20.5), and 8.7 (95% CI 5.3 to 11.7), respectively. In 48 patients, the apnea time exceeded 60 s. Differences in the fall in pH and rise of PaCO2 levels occurred in this group as compared to the 52 patients with apnea times <60 s. In patients with prolonged apnea times, the differences between the means of the pH and PaCO2 levels were 0.15 (95% CI 0.11 to 0.18) and 12.5 (95% CI 4.5 to 29.5), respectively. In comparison, the differences between the mean pH and PaCO2 levels of patients with apnea times <60 s were 0.05 (95% CI 0 to 0.1) and 6.2 (95% CI 2.1 to 14.5). Table 3 demonstrates the differences in ABG and EtCO2 values between those patients who received DAO during RSI and those that did not among the 48 patients with apnea times >60 s. The Fig. 1 shows the scatter plot of first EtCO2 measured after confirmation of endotracheal intubation versus apnea time, and the linear regression trend line showed a positive correlation for those not receiving DAO and negative correlation for those who received DAO.

Table 1
Demographics of included patients.

Demographics (n = 100)		95% CI
Past medical history (%)	–	–
HTN	48	–
DM	29	–
Asthma	15	–
COPD	12	–
Cardiac	11	–
Liver disease	10	–
Other	19	–
Indication for intubation (%)	–	–
Pulmonary	66	–
Trauma	13	–
Neurologic	10	–
Cardiac	8	–
Other	3	–
Abnormal auscultation (%)	65	–
SpO2 Prior to Pre-Ox (μ)	93	91 to 94
Pre-oxygenation time (s)	813	662 to 965
SpO2 After Pre-Ox (μ)	98	97 to 99
Apnea time (s)	65	57 to 73
First pass success rate (%)	88	–
SpO2 after confirmation (μ)	99	98 to 99

Abbreviations: HTN, hypertension; DM, diabetes; COPD, chronic obstructive pulmonary disease; SpO2, peripheral oxygen saturation; Pre-ox, preoxygenation.

Table 2
Mean arterial blood gas analysis values and end-tidal CO2 before and after intubation.

Variable	Pre-RSI	Post-RSI	Difference	95% CI	p-Value
All patients	n = 100	n = 100			
pH	7.29	7.24	− 0.05	0.01–0.09	0.035
aO2	71.5	246	174.5	138.5–210	0.001
aCO2	43.9	55.4	11.5	2.5–20.5	0.04
Bicarb	22.2	27.1	4.9	1.9–11.7	0.3
EtCO2	28.8	37.5	8.7	5.3–11.7	0.001
SpO2	97.4	95.7	− 1.7	0.7–4.1	0.072
Apnea time < 60s	n = 52	n = 52			
pH	7.49	7.44	− 0.05	0–0.1	0.42
aO2	69	225	156	107–205	0.001
aCO2	42.3	48.5	6.2	2.1–14.5	0.16
EtCO2	29	36.9	7.9	3.6–12.2	0.005
SpO2	98	97	− 1	0.7–2.7	0.44
Apnea time > 60s	n = 48	n = 48			
pH	7.5	7.35	− 0.15	0.11–0.18	0.023
aO2	73	265	192	138–246	0.001
aCO2	47	59.5	12.5	4.5–29.5	0.014
EtCO2	28	38	10	2–18	0.001
SpO2	97	94	− 3	0.6–6.6	0.09