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Original article

THE IMPACT OF A RAPID SEQUENCE INTUBATION ON ARTERIAL BLOOD GASES DURING THE PREOXYGENATION PHASE PERFORMED IN A HOSPITAL EMERGENCY DEPARTMENT

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Abstract: **Aim:** During rapid sequence intubation (RSI), the O_2 reserve limits the intubation duration. The study objective was to examine the impact of RSI on arterial blood gases (ABG) during the preoxygenation phase.

Methods: This open, prospective clinical study examined samples of patients who had endotracheal intubation (ETI) as RSI between March 2014 and September 2014 in our emergency department. The variations in ABG PaO_2 and $PaCO_2$ before and after preoxygenation and after intubation were examined and compared with demographic and clinical variables.

Results: The study included 67 patients (46 male, 21 female) with a mean age of 69.9 years. SBP, DBP, and MABP decreased, while pulse rate and SpO_2 increased. No difference was observed between PaO_2 values and demographic and clinical variables; however, a statistically significant relationship was found between the difference (Δ) between PaO_2 values measured after endotracheal tracheal intubation (ETI) and after preoxygenation and the ABG SpO_2 and the SpO_2 classification before preoxygenation.

Conclusion: The relationship between SpO_2 and its classification following ETI and increased ABG SpO_2 was statistically significant. Our real-life study emphasises that deciding on intubation without desaturating patients could have positive effects on intubation success. Regardless, increasing SpO_2 prior to ETI will contribute positively to the O_2 reserve by the end of ETI.

The ΔPaO_2, before and after preoxygenation, was not affected by age; gender; body mass index (BMI) and its classification; GCSS; vital signs and ABG findings gathered before preoxygenation; respiration rate (RR) during preoxygenation; preoxygenation duration; oral air passage usage or air leakage.

***Keywords**:* Rapid sequence intubation, preoxygenation, emergency ward.

INTRODUCTION

Rapid sequence intubation (RSI) is the standard airway management practice in the emergency department (ED) because it provides rapid sedation and paralysis. Clinical treatment requires quick recognition of respiratory failure since a decision for endotracheal intubation (ETI) may be difficult for emergency physicians, and the ETI must be performed fast when indicated.

Preoxygenation generates a potential O_2 reserve by allowing an exchange of nitrogen and oxygen in the alveolar area during a few minutes of apnea (1). When an ETI is considered, preoxygenation must be started in the shortest possible timeframe. In RSI, all patients, including those without manifest hypoxia, are preoxygenated. Preoxygenation provides a security buffer between hypoventilation and apnea and prolongs the safe apnea duration(the period required to maintain peripheral capillary oxygen saturation (SpO_2) between 88–90% until a permanent airway is ensured). If preoxygenation is not performed, the SpO_2 drops to very critical levels (< 70%) within minutes (1, 2, 3).

Although the ideal preoxygenation duration is debatable, the general advice is to deliver 100% O_2 at 15 L/min for 3–5 minutes with a non-backflow respiration mask. Consequently, 8 minutes is provided for desaturation. This period is shortened for critical patients and patients with advanced metabolic disturbances (1, 2, 3).

There are different ways to perform preoxygenation. In patients with spontaneous respiration O_2 support can be provided with an oral mask or nasal catheter and then requesting the patients to inspire deeply (4). In patients with insufficient respiration and variable consciousness levels, preoxygenation can be applied with a non-backflow respiration balloon mask. Another recently welcomed preoxygenation method is the use of non-invasive mechanical ventilation. Some publications indicate a higher success rate using non-invasive mechanical ventilation with elective hypoxia cases (5, 6).

In this study, the effects of the preoxygenation phase parameters (such as breath count and preoxygenation duration) on arterial blood gas (ABG) were examined in ED patients who underwent RSI. The primary efficacy endpoint was an increase in the ABG partial oxygen pressure (PaO_2). The secondary efficacy endpoint was a decrease in the ABG partial carbon dioxide pressure ($PaCO_2$).

MATERIAL AND METHODS

This study was an open, prospective clinical study conducted on patients who underwent ETI in the adult ED between March 1st, 2014, and September 30th, 2014 in Istanbul Education Research Hospital. Approval was granted by the hospital ethics committee (21.02.2014/433) and the research budget committee (28.01.2014/852).

During the study, ETI was performed on 273 patients; 144 (52.7%) underwent RSI. Of the latter, 77 patients (53.5%) were excluded for the following reasons: cardiac arrest during ETI (49 patients, 34%), age < 18 years (5 patients, 3.5%), ABG measurement error (missing data, measurement failure, inappropriate sample) (13 patients, 9%), consent not given by the family (10 patients, 7%). In total, 67 patients (46 men and 21 women) were included in the final analysis.

Preoxygenation was performed on patients in a supine position. The patients were provided with 100% O_2 support with a balloon mask with a reservoir by a one-handed C-E technique according to the 2010 American Heart Association Resuscitation Guideline. The goal was to provide 8–10 breaths/minute as per 1 breath in 6–8 seconds and to support spontaneous respiration. The patients were monitored for SpO_2 during breath giving. The ABG measurement was used to assess the sufficiency of O_2 provision sufficiency. For ABG measurement 2 ml of arterial blood was obtained from the radial or femoral artery while respecting the asepsis–antisepsis rules at the end of preoxygenation and just before drug administration, without delaying the ETI. The blood was drawn into heparinized injector syringes (BD Preset & BD A-Line, Becton, Dickinson and Company, Belliver Industrial Estate, Plymouth, UK) and analyzed in an ABG device (RAPID Lab 1200 Systems, Siemens Healthcare Diagnostics Inc., NewYork, USA).

Descriptive analyses were conducted for all data and study parameters (SP) listed below. The differences between ABG PaO_2 (ΔPaO_2) andABG $PaCO_2$ ($\Delta PaCO_2$), both before and after preoxygenation, were calculated. The second ΔPaO_2 (i.e. the ΔPaO_2 between the end of preoxygenation [second measurement] and following the ETI [third measurement]) and the similarly measured second $\Delta PaCO_2$ between the end of preoxygenation and after ETI were then calculated.

The correlations were investigated between the following SP and the ΔPaO_2 and $\Delta PaCO_2$; and the second ΔPaO_2 and second $\Delta PaCO_2$:

- Age
- Gender
- BMI and its classification
- GCSS
- Parameters before preoxygenation:
  - Mean Arterial Blood Pressure (MABP)
  - SpO_2 and its classification
  - ABG SpO_2
  - Respiration rate (RR)
- Preoxygenation parameters:
  - Provided breath count
  - Preoxygenation duration
  - Airway usage
  - Air escape

SPSS 15.0 for Windows was used for statistical analysis. In descriptive statistics, we used numbers and percentages for categorical variables, whereas using the mean, standard deviation, and minimum and maximum values for numerical variables. When a normal distribution could not be met, comparisons of two independent groups were performed using the Mann Whitney U test. The Kruskal Wallis test was applied for comparisons of multiple groups. Chi-square analysis was used to test the independent proportionalities of categorical variables between groups. A bivariate normal model for correlation detection was used as correlation pH0 = 0, alpha error probability 0.05, and correlation pH1 = 0.3. The statistical significance threshold was $p < 0.05$.

RESULTS

The patients' demographic and clinical characteristics are shown in Table 1. The vital signs before and after preoxygenation, according to the Joint National Committee (JNC)-8, classification are shown in Table 2.

Table 1. *Second ΔPaO_2 and its relationship with SP-2*

		ΔPaO_2 **3rd - 2nd measurement**	
		Mean ± SD	p
Gender	Male	159.3 ± 124.7	0.111
	Female	99.0 ± 76.4	
Airway usage	Yes	127.9 ± 102.5	0.671
	No	148.3 ± 122.4	
Air Escape	No	148.7 ± 118.5	0.250
	Yes	98.3 ± 85.6	
BMI classification	Normal	153.5 ± 127.4	0.855
	Slightly overweight	128.4 ± 99.7	
	Obese	134.2 ± 117.9	
SpO_2 classification before preoxygenation	< 90	98.6 ± 95.4	**0.008**
	90 and > 90	174.3 ± 119.0	
Induction Agent	Midazolam	152.5 ± 123.4	0.780
	Ketamine	104.7 ± 80.1	
	Thiopental	127.1 ± 97.5	
	Propofol	64.8 ± 45.0	
	Etomidate	95.1	
Paralyzing Agent	Vecuronium	143.5 ± 118.2	0.845
	Rocuronium	129.7 ± 104.7	

Table 2. *The relationship of second ΔPaO_2 with SP*

		Rho/Value	**Mean ± SD**	**P**
Age		0.232		0.059
Gender	Male		159.3 ± 124.7	0.111
	Female		99.0 ± 76.4	
GCSS		0.074		0.550
BMI		-0.111		0.372
BMI Classification	Normal		153.5 ± 127.4	0.855
	Slightly overweight		128.4 ± 99.7	
	Obese		134.2 ± 117.9	
MABP		0.193		0.117
SpO_2		0.319		**0.009**
SpO_2 classification	< 90		98.6 ± 95.4	**0.008**
	≥ 90		174.3 ± 119.0	
ABG SpO_2		0.266		**0.030**
Provided breath count		-0.028		0.825
Preoxygenation duration (sec)		-0.156		0.208
Airway Usage	Yes		127.9 ± 102.5	0.671
	No		148.3 ± 122.4	
Air Escape	Absent		148.7 ± 118.5	0.250
	Present		98.3 ± 85.6	
ETI duration		0,186		0.132
Induction Agent	Midazolam		152.5 ± 123.4	0.780
	Ketamine		104.7 ± 80.1	
	Thiopental		127.1 ± 97.5	
Paralyzing Agent	Vecuronium		143.5 ± 118.2	0.845
	Rocuronium		129.7 ± 104.7	

A) Before preoxygenation:

Mean PaO_2 = 80.2% ± 49.8 (range 26.8–257.1%)

Mean $PaCO_2$ = 51.8% ± 26.8 (12.8–122.9%).

The second ΔPaO_2 and its relationship with the general parameters are shown in Table 2,

B) Following the ETI:

Mean PaO_2 = 253.8% ± 135.6 (33.3–532.2%)

Mean $PaCO_2$ = 46.1% ± 20.7 (17.9–115.7%).

C) Mean ΔPaO_2 = 33.3 ± 59.8 (-43.4–336.8)

Mean $\Delta PaCO_2$ = -1.2 ± 9.7 (-27.8–17)

D) Mean second ΔPaO_2 = 140.4 ± 1147 (-8.4–396.5)

Mean second $\Delta PaCO_2$ = -4.0 ± 19.7 (-55–91).

No statistically significant difference was noted between the effects of different SPon ΔPaO_2 ($p > 0.05$).

The ΔPaO_2 between the end of preoxygenation (second measurement) and that following ETI (third measurement) (i.e. the second ΔPaO_2) were compared with the SP in Table 2.

The relationships of the second ΔPaO_2 with the SpO_2 and SpO_2 classification before preoxygenation and preoxygenation SpO_2 were statistically significant ($p < 0.05$). A statistically significant positive correlation was found between the SpO_2 before preoxygenation and the second ΔPaO_2 ($p = 0.009$). No other correlations were detected between the second ΔPaO_2 and the other SP. No statistically significant difference was noted between the other groups (Table 2 and Table 1 below).

Table 2 shows a statistically significantly higher mean of the second ΔPaO_2 for patients with $SpO_2 \geq 90$ than $SpO_2 < 90$.

DISCUSSION

RSI studies typically involve induction and comparison of paralyzing techniques, RSI indications, and contraindications (2,7). No study has yet assessed the preoxygenation efficiency in RSI. Our study calculated the authentic ΔPaO2 values before and after preoxygenation in RSI, the relationship between these changes and the patients' demographic characteristics, vital signs, and preoxygenation parameters.

Chroniere et al. (8) found that voluntary hyperventilation before RSI did not cause a decrease in $PaCO_2$ after ETI. This supports our findings of no statistically significant relationship between preoxygenation parameters in RSI (i.e.the preoxygenation duration, breath count provided, ETI period, and ΔPaCO2 before and after preoxygenation).

In our study, the most important factors regarding O_2 level in patients who underwent RSI were their SpO_2 prior to RSI and their SpO_2 category. Nearly all the previous studies have shown that O_2 support given prior to an ETI had to be continued during the ETI. This indicates that a higher O_2 level prior to an ETI will lead to a lower and insignificant SpO_2 decrease at the end of the ETI. Several factors influence the efficiency of O_2 support given prior to an ETI. However, in our study, the efficiency of O_2 support given prior to an ETI was directly correlated with the O_2 amount provided before the ETI.

Therefore, the decision for intubation without desaturating patients could have positive effects on the intubation procedure. No matter how increased SpO_2 is obtained prior to an ETI, the increase will contribute positively to the O_2 reserve until the end of the ETI. The ΔPaO2 before and after preoxygenation was not influenced by the SP. The relationships between SpO_2 and its classification, following the ETI and the increase in SpO_2, were found to be statistically significant.

A study by Davis et al. investigated the impact of hypoxia and hyperventilation on the outcome after RSI performed by paramedics on severely head-injured patients and pointed to the critical importance of correct RSI application for reduction in the mortality rate of these patients (4). Hyperventilation and severe hypoxia during paramedic RSI were associated with an increase in mortality.

Several previous studies (9, 10, 11) support our findings of a positive effect of oxygenation on the peri-intubation SpO_2 increase and better patient outcomes:

1.With no preoxygenation, the starting SpO_2 dropped from 98% to 90% in 52 seconds with apnea. At the other extreme, following full preoxygenation with 100% O_2 for 3 minutes or more, SpO_2 remained at 100% for 7.75 minutes during apnea and dropped to 90% after another 75 seconds. Hyperventilation did not result in more rapid normalization of SpO_2, irrespective of the ventilation level (9).

2. Eighty-one patients (20%) were extubated and discharged from the ICU in 48 h or less; these patients had higher pre-RSI SpO_2 values (10).

3. A recent meta-analysis (11) conducted in 2017showed that apneic oxygenation was associated with decreased hypoxemia, first-pass intubation success, and increased lowest peri-intubation SpO_2.

In conclusion, our study is a real-life experience emphasizing how a timely decision for intubation could have positive effects on intubation success without desaturating patients and could improve patient clinical outcomes. No matter how the increase of SpO_2 is achieved before the ETI, it will contribute positively to the O_2 reserve until the end of the ETI.

Abbreviations

ES — Emergency Service
EI — Endotracheal Intubation
ET — Endo tracheal tube
LMA — Laryngeal Mask Airway

COPD — Chronic obstructive pulmonary disease
RSI — Rapid sequential intubation
IV — Intravenous
ARDS — Adult respiratory distress syndrome
SAO_2 — Oxygen saturation
$ETCO_2$ — End tidal CO2
İEAH — Istanbul Education and Research Hospital
ABG — Arterial Blood Gases
GKS — Glasgow Coma Scale
BMI — Body Mass Index
SBP — Systolic Blood Pressure
DBP — Diastolic Blood Pressure
MAP — Mean Arterial Pressure
PAO_2 — Partial Oxygen Pressure
$PACO_2$ — Partial Carbondioxide Pressure

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Sažetak

UTICAJ BRZE INTUBACIJE NA ARTERIJSKE KRVNE GASOVE TOKOM FAZE PREOKSIGENACIJE IZVRŠENE NA BOLNIČKOM ODELJENJU URGENTNE MEDICINE

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Cilj: Tokom brze intubacije (RSI), rezerva O_2 ograničava trajanje intubacije. Cilj studije bio je ispitati uticaj RSI na gasove arterijske krvi (ABG) tokom faze preoksigenacije.

Metode: Ova otvorena, prospektivna klinička studija ispitala je uzorke pacijenata koji su imali endotrahealnu intubaciju (ETI) kao RSI u periodu od marta 2014. do septembra 2014. godine u našoj hitnoj službi. Varijacije u ABG PaO_2 i $PaCO_2$ pre i posle preoksigenacije i nakon intubacije su ispitane i upoređene sa demografskim i kliničkim varijablama.

Rezultati: Studija je obuhvatila 67 pacijenata (46 muškaraca, 21 žena) sa prosečnom starošću od 69,9 godina. SBP, DBP i MABP su se smanjili, dok su se puls i SpO_2 povećali. Nije primećena razlika između vrednosti PaO_2 i demografskih i kliničkih varijabli; međutim, pronađena je statistički značajna veza između razlike (D) između vrednosti PaO_2 izmerenih nakon endotrahealne trahealne intubacije (ETI) i nakon preoksigenacije i ABG SpO_2 i klasifikacije SpO_2 pre preoksigenacije.

Zaključak: Odnos između SpO_2 i njegove klasifikacije nakon ETI i povećanog ABG SpO_2 bio je statistički značajan. Naša studija iz stvarnog života naglašava da bi odlučivanje o intubaciji bez desaturacije pacijenata moglo imati pozitivne efekte na uspeh intubacije. Bez obzira na to, povećanje SpO_2 pre ETI -a pozitivno će doprineti rezervi O_2 do kraja ETI -a. Starost nije uticala na $DPaO_2$, pre i posle preoksigenacije; pol; indeks telesne mase (BMI) i njegovu klasifikaciju; GCSS; vitalni znaci i nalazi ABG prikupljeni pre preoksigenacije; stopa disanja (RR) tokom preoksigenacije; trajanje preoksigenacije; upotreba vazdušnog prolaza ili curenje vazduha.

Ključne reči: Brza intubacija sekvenci, preoksigenacija, hitno odeljenje.

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