Original Article

The incidence of oxygen desaturation during rapid sequence induction and intubation

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BACKGROUND: Rapid sequence induction and intubation (RSII) is an emergency airway management technique for patients with a risk of pulmonary aspiration. It involves preoxygenation, administration of predetermined doses of induction and paralytic drugs, avoidance of mask ventilation, and laryngoscopy followed by tracheal intubation and keeping cricoid pressure applied till endotracheal tube cuff be inflated. Oxygen desaturation has been seen during RSII. We assessed the incidence of oxygen desaturation during RSII.

METHODS: An institution-based observational study was conducted from March 3 to May 4, 2014 in our hospital. All patients who were operated upon under general anesthesia with RSII during the study period were included. A checklist was prepared for data collection.

RESULTS: A total of 153 patients were included in this study with a response rate of 91.6%. Appropriate drugs for RSII, equipments for RSII, equipments for difficult intubation, suction machine with a catheter, a monitor and an oxygen backup such as ambu bag were not prepared for 41 (26.8%), 50 (32.7%), 51 (33.3%), 38 (24.8%) and 25 (16.3%) patients respectively. Cricoid pressure was not applied at all for 17 (11.1%) patients and 53 (34.6%) patients were ventilated after induction of anesthesia but before intubation and endotracheal cuff inflation. A total of 55 (35.9%) patients desaturated during RSII ($\text{SPO}_2 < 95\%$). The minimum, maximum and mean oxygen desaturations were 26%, 94% and 70.9% respectively. The oxygen desaturation was in the range of $<50\%$, 50%–64%, 65%–74%, 75%–84%, 85%–89% and 90%–94% for 6 (3.9%), 7 (4.6%), 5 (3.3%), 10 (6.5%), 13 (8.5%) and 14 (9.2%) patients respectively.

CONCLUSION: The incidence of oxygen desaturation during RSII was high in our hospital. Preoperative patient optimization and training about the techniques of RSII should be emphasized.

KEY WORDS: General anesthesia; Rapid sequence induction and intubation; Oxygen desaturation

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INTRODUCTION

Rapid sequence induction and intubation (RSII) is the administration of a potent induction agent followed by a rapidly acting neuromuscular blocking agent to induce unconsciousness and motor paralysis for tracheal intubation for patients with the risk of pulmonary aspiration.^[1] Cricoids pressure is applied from the moment the patient loses consciousness until the endotracheal cuff is inflated.^[2]

Desaturation is defined as oxygen saturation $<$

90% from the initial SPO_2 of $>90\%$ or a decrease from a baseline of less than 90%.^[3] The rate of oxygen desaturation during apnea is affected by body hemoglobin concentration and oxygen consumption.^[4] Desaturation $<70\%$ puts patients at risk for dysrhythmias, hemodynamic decompositions, hypoxic brain injury, and death.^[5] Desaturation $<90\%$ developed during rapid sequence intubation in 15 (15%) of 101 patients with trauma managed by anesthesiologists and in 19 (18%) of 99 patients managed by emergency physicians.^[6]

Suxamethonium was recognized the muscle relaxant of choice for RSII because of its fast onset of action.^[7] RSII could be performed when there was an increased risk of pulmonary aspiration of gastric content.^[8]

In a study,^[9] the administration of thiopental and suxamethonium 1.0 mg/kg, without assisted ventilation but close monitoring of oxygen saturation levels, patients showed desaturation to $\text{SPO}_2 < 80\%$. Another study^[10] found that the reduction of suxamethonium dose from 1.0 mg/kg to 0.6 mg/kg slightly lowered the incidence of oxygen desaturation $< 90\%$ (from 85% to 65%).

An American study^[11] revealed that after 3 minutes of preoxygenation, the patients were given sedatives and muscle relaxants to decrease their saturation from 100% to 95%. Desaturation of less than 90% appeared during rapid sequence intubation in 15 (15%) of 101 patients with trauma managed by anesthesiologists and in 19 (18%) of 99 patients managed by emergency physicians.^[12]

The mean recovery time was 43 (39–48) seconds in succinylcholine vs. 36 (33–38) seconds in rocuronium.^[13] Desaturation to below 70% puts patients at risk for dysrhythmia, hemodynamic decomposition, hypoxic brain injury, and death.^[14]

A study^[15] from China showed that apnea was always present during rapid sequence induction of general anesthesia in obese patients. Patients might have an increased risk of hypoxia due to the diminished oxygen reserve during the induction of general anesthesia whose body mass index was $> 26 \text{ kg/m}^2$.^[16] Preoxygenation provides an oxygen reservoir that will delay the depletion of oxygen in the absence of ventilation (after paralysis) for up to 8 minutes in healthy adults.^[17]

Many patients with the risk of pulmonary aspiration have been operated on under general anesthesia with RSII in our hospital. Oxygen desaturation has been seen during RSII. The present study was to assess the incidence of oxygen desaturation during RSII.

METHODS

Patients

An institution-based observation study was conducted from March 3 to May 4, 2014.

All (elective, emergency, major, minor, obstetrics, gynecological and surgical) patients who were operated upon under general anesthesia with RSII at our hospital were included.

Patients who were below 18 years old, contraindicated for succinylcholine, had difficult intubation warranting

awake fiberoptic intubation, absence of a qualified anesthetist, and those who were operated on under spinal anesthesia, general anesthesia with sedation and laryngeal mask airway were excluded.

Variables

Socio-demographic variables included sex, age, ASA status, type of operation, surgical subspecialty, presence of respiratory disease, history of cigarette smoking, preoperative alcohol intake, seniority of anesthetist, service year of anesthetists, RSII training after graduation, prophylactic agents for pulmonary aspiration, pre-induction desaturation, pre-induction vital signs (before 5 minutes), and patient position during induction of anesthesia.

Preoperative airway was assessed in terms of OPV status, airway deformity, preoperative airway obstruction, and preoperative oxygen desaturation.

Before operation, equipments for RSII, equipments for difficult intubation, suction machines, monitoring devices, oxygen, and oxygen backup.

In prevention of pulmonary aspiration, cimetidine, sodium citrate, and metoclopramide were administered before anesthesia.

Intubation agents included thiopental, ketamine, propofol, succinylcholine, vecuronium, and pancuronium.

Monitoring equipments included ECG, pulseoximeter, capnograph, thermometer, glucometer, etc.

Factors related with techniques of RSII

Preoxygenation, suction machine connected with a suction catheter connected and turned on (before induction, after induction, not done), type of induction drugs used, landmark identification for cricoid pressure (before induction of anesthesia, after induction of anesthesia but before loss of consciousness, both after induction of anesthesia and loss of consciousness, not done), qualification of assistant who applied cricoid pressure, number of laryngoscopy attempts during RSII, oxygen desaturation during RSII and difficult intubation during RSII (type, measure).

Complications of RSII included hypertension, hypotension, tachycardia, bradycardia, bronchospasm, laryngospasm, pulmonary aspiration, and cardiopulmonary arrest.

Operational definitions

According to the WHO definition, the patients were classified as having desaturated if the oxygen saturation was $< 95\%$.^[21] A decrease in oxygen saturation was found

by continuous monitoring with pulseoximetry at any time between the start of induction of anesthesia and the completion of the intubation. Recovery period: The time lasted from the initiation of ventilation after desaturation during RSII to the time when the oxygen saturation returned to >95%.

Definition of RSII: A technique used by a practising anesthetist consisted of preoxygenation, rapid administration of predetermined doses of both induction and paralytic drugs with rapid onset and offset of actions, concurrent application of cricoid pressure, avoidance of bag and mask ventilation, and direct laryngoscopy followed by tracheal intubation using a suction machine with a suction catheter and cricoid pressure applied till the inflation of endotracheal tube cuff.

Time of cricoid pressure application: The anatomic landmark for cricoid pressure was identified before induction and application of cricoid pressure after loss of consciousness or anatomic landmark or both anatomic landmark identification and cricoid pressure application were done after induction and loss of consciousness.

If anatomic landmark is identified before the induction of anesthesia, 10 N can be applied and continues with 20–30 N after induction till the endotracheal tube cuff is being inflated. Since it is a critical and life-saving technique, it should be applied for every patient with risk of aspiration unless there is a special consideration.

Data processing and analysis

The checklist was checked for completeness, cleaned manually, entered and analyzed using SPSS version 20.0 for windows. Frequencies and cross tabulations were used to summarize the descriptive statistics of the data, and tables were used for data presentation.

Ethical approval was obtained from the Ethical Review Committee of School of Medicine, Gondar College of Medicine and Health Sciences, University of Gondar. Confidentiality was ensured using an anonymous checklist and keeping the checklist locked.

RESULTS

Socio-demographic characteristics of the participants

A total of 286 patients were operated upon under general anesthesia during the study period. One hundred and sixty-seven of the 286 patients were operated on under general anesthesia with rapid sequence induction and intubation. Fourteen of the 167 patients were excluded from the study due to incomplete filling of the checklist.

A total of 153 patients were included in this study with a response rate of 91.6%. Males accounted for 54.2% of the participants. The minimum, maximum and median ages of the patients were 18, 75 and 28 years respectively. The ages of 45 (29.4%) patients were in the range of 18–24, 36 (23.5%) in the range of 25–29, 36 (23.5%) in the range of 30–39, 23 (15%) in the range of 40–49, 7 (4.6%) in the range of 50–59, 2 (1.3%) in the range of 60–65 and 4 (2.6%) in the range of > 65 years old respectively.

Most of operations 87 (56.9%) were done by anesthetists with less than one-year services, 21 (13.7%) with 1–2 years of services, 29 (18.9%) with 3–5 years of services, and 16 (10.5%) with more than 5 years of services. The majority of 137 (89.5%) patients were emergency patients, whereas 14 (9.5%) were elective patients (Table 1).

Table 1. Socio-demographic characteristics of the participants (n=153)

Factors	Frequency	%
ASA status		
ASA1	124	81
ASA2	23	15
ASA3	5	3.3
ASA4	1	0.7
Type of operation		
Elective	16	9.2
Emergency	137	89.5
Urgency of operation		
Major	151	97.7
Minor	2	0.3
Surgical subspecialties		
General & urology	109	71.2
Obstetric	19	12.4
Gynecology	5	3.3
Orthopedic	8	5.2
Ear, nose, neck, head, extremity	7	4.6
Presence of documented respiratory disease		
No	148	96.7
Yes	5	3.3
History of documented cigarette smoking		
No	152	99.3
Yes	1	0.7
Preoperative documented significant alcohol intake		
No	141	92
Yes	12	7.8
Number of patients handled by the anesthetists with different qualifications		
BSc	111	27.5
Msc	42	72.6
Number of patients handled by the anesthetist with different years of services		
<1 Year	87	56.9
1–2 years	21	13.7
3–5 years	29	19
>5 years	16	10.5
Training about RSII after graduation		
No	153	100
Yes	0	0
Patient position during induction of anesthesia		
Supine	153	100
Lateral	0	0

Preoperative patient status and preparation for rapid sequence induction and intubation

No patient had a history of respiratory disease, cigarette smoking and significant alcohol intake. The preoperative vital signs of the patients were (5–10 minutes before the induction of anesthesia): BP=118±15.9/78 (78–70) mmHg [(mean±SD/mean (IQR))], PR=91.9±17.55 beats/minute (mean±SD), RR=22 (24–20) beats/minute and SPO₂=94.2%±10.12% respectively. Nine patients desaturated before anesthesia and surgery. The oxygen saturation of 4 (2.6%) patients was in the range of 85%–89%, 3 (2.0%) patients in the range of 74%–85%, 1 (0.7%) patient in the range of 65%–74% and 1 (0.7%) patient less than 50% respectively.

One hundred and sixteen patients were not subjected to prophylaxis for pulmonary aspiration. Fifteen (9.8%) patients were given cimetidine, 10 (6.5%) dexamethasone, 6 (3.9%) metoclopramide, 5 (3.3%) cimetidine and dexamethasone, and 1 (0.7%) was given cimetidine and metoclopramide respectively. Of these patients, 34 (22.2%) were given prophylaxis drugs before 30 minutes and 3 (1.9%) patients within 30 minutes before induction of anesthesia respectively.

Appropriate drugs for RSII, equipments for RSII, equipments for difficult intubation, suction machine with catheters, monitorings and oxygen backup such as ambu bag were not prepared for 41 (26.8%), 50 (32.7%), 51 (33.3%), 38 (24.8%) and 25 (16.3%) patients respectively (Table 2).

The techniques of rapid sequence induction and intubation

Patients were monitored with 3 lead ECG, pulseoximeter and NIBP during operation. Monitorings were used before induction of anesthesia in 129 (77.2%) patients, and after induction of anesthesia in 26 (15.6%) and 12 (7.2%) patients who were operated on without monitoring.

All patients were preoxygenated with 100% oxygen for 3–5 minutes before induction of anesthesia. One hundred and two (66.7%) patients were anesthetized with ketamine, 16 (10.5%) with propofol, 3 (1.9%) with ketamine and halothane, 1 (0.6%) with ketamine and thiopentone, 1 (0.6%) with thiopentone and halothane, and 3 (1.9%) with thiopentone respectively. All patients were paralyzed with suxamethonium. In all the patients, 140 (91.5%), 10 (6.5%) and 3 (2.0%) patients were intubated with the first, second and third laryngoscopy attempts respectively. Analgesic drugs were used as

Table 2. Preoperative patient status and preparation for rapid sequence induction and intubation (n=153)

Factors	Frequency	%
Presence of airway obstruction		
No	153	100
Yes	0	0
Preoperative existed airway obstruction		
No	153	100
Yes	0	0
Documented pre-induction desaturation		
No	144	94.1
Yes	9	5.9
Preoperative OPV statuses		
OPV 1	125	81.7
OPV2	25	16.3
OPV3	1	0.7
Uncooperative	2	1.4
Appropriate drugs prepared RSII		
Yes	112	73.2
No	41	26.8
Equipments for RSII prepared		
Yes	103	67.3
No	50	32.7
Equipment for difficult intubation prepared		
Yes	102	66.7
No	51	33.3
Suction machine with a catheter prepared		
Yes	108	70.6
No	45	29.4
Appropriate monitoring prepared		
Yes	115	75.2
No	38	24.8
Oxygen prepared		
Yes	153	100
No	0	0
Oxygen backup prepared [ambu bag]		
Yes	128	83.7
No	25	16.3

follows: fentanyl in 88 (57%) patients, tramadol in 17 (11.5%), pethidine in 3 (1.9%), fentanyl and tramadol in 13 (8.5%), diclofenac and fentanyl in 8 (5.2%) and pethidine and fentanyl in 2 (1.3%) during the operation.

Suction machine with a catheter before induction of anesthesia was used in 118 (77.1%) patients and after induction in 18 (11.8%); but it was not used in 17 (11.1%) patients. The patients were ventilated by anesthetists after induction of anesthesia, but 53 (34.6%) of the patients were ventilated before intubation and endotracheal tube cuff inflation (Table 3).

The experiences of anesthetists markedly affected their techniques about RSII. Suction machine which was not connected with a catheter and was not turned on before induction of anesthesia in 7 (4.6%), 5 (3.3%), 3 (1.9%) and 2 (1.3%) patients by the anesthetists with services of <1 year, 1–2 years, 3–5 years and > 5 years respectively. Cricoid pressure was not used in

Table 3. Techniques of rapid sequence induction and intubation (*n*=153)

Factors	Frequency	%
Preoxygenation		
Yes	153	100
No	0	0
Suction machine connected with catheter & turned on		
Before induction	118	77.1
After induction	18	11.8
Not done	17	11.1
Landmark identification for cricoid pressure		
Before induction of anaesthesia	90	58.8
After induction of anaesthesia but before loss of consciousness	32	20.9
After induction of anaesthesia and loss of consciousness	14	9.2
Not done	17	11.1
Qualification of assistance who applied cricoid pressure		
MSc	17	11.1
BSc	55	35.9
3 rd year	22	14.4
4 th year	27	17.6
Others	15	9.8
Not done	17	11.1
Number of laryngoscopy attempts during RSII		
1	140	91.5
2	10	6.5
3	3	2
Ventilate after induction, before intubation and endotracheal tube cuff inflation during RSII		
No	100	65.4
Yes	53	34.6
Difficult intubation during RSII		
No		
Yes		
Oxygen desaturation during RSII		
No	130	85.0
Yes	23	15.0

7 (4.6%), 5 (3.3%), 3 (1.9%) and 2 (1.3%) patients by the anesthetists with services of <1 year, 1–2 years, 3–5 years and >5 years respectively.

The incidence of oxygen desaturation during RSII and other immediate complications

A total of 55 (35.9%) patients were desaturated during RSII (SPO₂ <95%). The minimum, maximum and mean oxygen desaturations were 26%, 94% and 70.9% respectively.

The range of oxygen desaturation was <50%, 50%–64%, 65%–74%, 75%–84%, 85%–89% and 90%–94% in 6 (3.9%), 7 (4.6%), 5 (3.3%), 10 (6.5%), 13 (8.5%) and 14 (9.2%) patients respectively. The minimum, maximum and mean oxygen desaturation periods during RSII were 1, 10 and 4.27 minutes respectively. Of the 55 patients, 6 had difficult airway. Only 18 of the 55 patients were ventilated with a facemask during desaturation till they recovered from hypoxia before intubation, and the rest 37

Table 4. Effect of different factors on the occurrence of oxygen desaturation during RSII (*n*=153)

Variables	Oxygen desaturation during RSII	
	No	Yes (<i>n</i> , %)
Urgency of operation		
Emergency	114	23 (15)
Elective	16	0 (0)
Type of operation		
Major	128	23 (15)
Minor	2	0 (0)
Seniority of anesthetist		
MSc	36	7 (4.6)
BSc	94	16 (10.5)
Year of services of anesthetist		
< 1 year	75	12 (7.8)
1–2 years	17	4 (2.6)
3–5 years	25	4 (2.6)
>5 years	13	3 (1.9)
Documented preoperative desaturation		
No	125	19 (12.4)
Yes	5	4 (2.6)
Number of laryngoscopy attempts during RSII		
1	122	18 (11.8)
2	6	4 (2.6)
3	2	1 (0.7)
ASA status		
ASA1	105	19 (12.4)
ASA2	20	3 (1.9)
ASA3	5	1 (0.7)

patients were ventilated after intubation. The urgency of operation, type of operation, qualifications of anesthetists, and years of services of anesthetists markedly affected the occurrence of oxygen desaturation during RSII (Table 4).

Difficult airway also occurred during RSII in 23 (15%) patients. Difficult laryngoscopy was observed in 13 (8.5%) patients and difficult mask ventilation in 10 (6.5%) patients. The occurrence of difficult airway during RSII was also markedly affected by the urgency of operation, qualification and experiences of anesthetists. Of the 23 patients with difficult airway, 21 (13.7%) were emergency patients and 2 (1.3%) were elective patients. Sixteen of the 23 (10.5%) patients with difficult airway were seen in the patients handled by BSc anesthetists whereas 7 (4.6%) in those handled by MSc anesthetists. Of the 23 patients with difficult airway, 15 (9.8%), 3 (1.9%), 2 (1.3%) and 3 (1.9%) were encountered by the anesthetists with services of <1 year, 1–2 years, 3–5 years and > 5 years respectively.

Of the 23 patients with difficult airway, 4 (2.6%), 6 (3.9%), and 13 (8.5%) patients were intubated using pillow, stylet and bougie respectively. Other immediate complications occurred during RSII were hypertension in 20 (13.1%) patients, hypotension in 23 (15%), tachycardia in 50 (32.7%) and bradycardia in 8 (5.2%). No perioperative death occurred.

DISCUSSION

In the present study, the incidence of oxygen desaturation during rapid sequence induction and intubation was high (55, 35.9%). This finding was similar to a study conducted in Switzerland where oxygen desaturation was 34%.^[9] This might be due to inadequate preoxygenation and lack of updating training about the techniques of RSII.

In this study, 116 patients were not given prophylaxis for pulmonary aspiration, appropriate drugs for RSII, equipments for RSII, and equipments for difficult intubation. Suction machine with a catheter, a monitor and an oxygen backup such as ambu bag was not prepared for 41 (26.8%), 50 (32.7%), 51 (33.3%), 38 (24.8%) and 25 (16.3%) patients respectively. These rates were lower than those reported in a study from North Carolina.^[18] The difference could be due to the difference in the techniques of RSII used by anesthetists.

Moreover, anesthetists identified the anatomic landmark for cricoid pressure before and after induction of anesthesia but before loss of consciousness, or both after induction of anesthesia and loss of consciousness in 90 (58.8%), 32 (20.9%), and 14 (9.2%) patients respectively. Cricoid pressure was not applied in 17 (11.1%) patients, which was lower than that reported elsewhere.^[18] This discrepancy could be due to the difference in the training of anesthetists about the techniques of RSII.

In the present study, anesthetists ventilated the patients after induction of anesthesia but before intubation. Endotracheal tube cuff inflation was done in 53 (34.6%) patients, without connecting a suction machine with a catheter. The suction machine was turned on in 17 (11.1%) patients during RSII. This finding was similar to that reported in a study conducted in Boston where the patients were ventilated after induction of anesthesia but before (41%) and after administration of muscle relaxant (35%).^[19] The result might be due to the nature of study design (modified rapid sequence induction) and the different techniques of RSII used in different countries.

In this study, most patients (102, 66.7%) were anesthetized with ketamine and were paralyzed with suxamethonium. This rate was higher than that reported in a survey conducted in UK (ketamine use, 8%).^[20] This could be due to optimization of preoperative patients and ketamine use in our hospital, which attributed to its sympathomimetic effects. In conclusion, the incidence of oxygen desaturation during RSII was high in our

hospital. Optimization of preoperative patients and training of anesthetists in using the techniques of rapid sequence induction and intubation should be emphasized.

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Conflicts of interest: The authors do not have any conflict of interest.

Contributors: Endale Gebreegziabher conceived the study. All authors involved in proposal development, data collection, data analysis, paper writing and manuscript preparation. We authors approved the final manuscript and agreed to publish in WJEM.

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