Effect of Oxygen Supplement via Nasal Cannula on Peripheral Oxygen Saturation during Early Postoperative Period in Patients with Thoracotomy

Sirilak Suksompong MD, MSc*,
Viranut Tirasuntornwong MD**, Benno von Bormann MD*

** Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand*
*** Department of Anesthesiology, Rajavithi Hospital, Rajathewi, Bangkok, Thailand*

Objective: *To determine the incidence of hypoxemia (peripheral oxygen saturation less than 95%) in patients receiving oxygen supplementation via oxygen cannula during the early postoperative period after lung resection.*
Material and Method: *This prospective cohort study in a post-anesthetic care unit (PACU) of a university hospital included 35 patients with ASA physical status I-III undergoing thoracotomy under general anesthesia and continuous epidural analgesia. Oxygen supplementation via oxygen cannula 5 L/min was given during transportation and in the PACU for two hours postoperatively. Peripheral oxygen saturation (SpO_2) was continuously monitored using pulse oximeter and recorded at interval until 2 hours after surgery.*
Results: *Three patients (8.6%) experienced hypoxemia in PACU. The main causes were secretion obstruction, oxygen delivery system malfunction and pain medication with over sedation. The average SpO_2 at 30 minutes after operation in 32 non-hypoxemic patients was 99.8$\pm$0.5%. Thirty percent of the patients had satisfaction score for having nasal cannula of 8. The average satisfaction score of nasal cannula was 6.7$\pm$2.0. Nearly 66% of the patients did not remove oxygen cannula during oxygen supplementation.*
Conclusion: *Though oxygen cannula can be used for prevention and treatment postoperative hypoxemia in most of the patients undergoing lung resection surgery with general anesthesia and postoperative epidural analgesia. But closed monitoring is still mandatory.*

Keywords: *Oxygen cannula, Lung surgery, Desaturation, PACU*

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Early postoperative hypoxemia is one of the common complications in post-anesthetic care unit (PACU), but depends on the extent of surgery. Xue et al showed that 52% of patients underwent esophagectomy with thoracoabdominal incision experienced hypoxemia during the first 2-hour postoperative period, which was higher than those with upper abdominal or peripheral surgery[1]. Oxygen supplement can be given via nasal cannula, simple mask, face mask with bag and venturi mask. The choice of device depends upon the requirement of oxygen concentration and humidity, patient's preference and cost effectiveness. Ayhan et al[2] demonstrated that, regarding peripheral oxygen saturation (SpO_2), nasal cannula was more effective than simple face mask due to the removal of the equipment. Zevola et al[3] confirmed that nasal cannula could be safely used in most patients after cardiothoracic surgery.

In our institute, oxygen supplementation is routinely used in PACU via simple face mask and switched to nasal cannula before discharge back to ward. At the ward, patients would receive nasal cannula 3 to 5 L/min till the next day. In 2013, 448 patients underwent thoracic surgery at our institute; and according to our usual practice, each patient use both simple mask and oxygen cannula which costs 950 US Dollar per year. If the routine oxygen therapy in this institute is modified to use via only nasal cannula, the expense for postoperative oxygen equipment would decrease to 300 US Dollar per year and the average amount of 650 US Dollar a year could be saved.

Thus the primary objective of this study is to

Correspondence to:
Suksompong S, Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, 2 Wanglang Road, Bangkoknoi, Bangkok 10700, Thailand.
Phone: +66-2-4197978, Fax: +66-2-4113256
E-mail: sirilak.suk@mahidol.ac.th

demonstrate the effectiveness of nasal cannula application during the immediate postoperative period in thoracotomy patients. The peripheral oxygen saturation during 2 postoperative hours and patient's satisfaction of receiving nasal cannula were also evaluated. If applying oxygen via nasal cannula can prevent hypoxia, the routine oxygen therapy will be modified in the next step.

Material and Method

This prospective cohort study was approved by the Institutional Review Board (Si 573/2012). Informed consent was obtained from patients admitted for thoracotomy between November 2012 to May 2013. Thirty-five patients with the American Society of Anesthesiologists (ASA) Physical Status I-III, aged more than18 years, having baseline preoperative SpO_2 $\geq$95%, undergoing elective thoracotomy with lung resection were included. Patients with problems in communication were excluded.

Premedication comprised oral midazolam 5 to 15 mg 1 hour before surgery. After arriving at the operative room, a venous cannula was inserted and standard monitoring including noninvasive blood pressure, electrocardiography and pulse oximetry was applied. Epidural catheter was placed at level T_{5-6} or T_{6-7} for intra- and postoperative analgesia. Then general anesthesia with double-lumen endobronchial tube was started. Capnography and esophageal temperature were also monitored during anesthesia. The choice of anesthetic agents depended on anesthesiologists' discretion. Either lidocaine or bupivacaine was given via epidural catheter during intraoperative period. At the end of surgery, the neuromuscular blockade was reversed.

After extubation, all patients received oxygen supplementation via nasal cannula 5 L/min with bubble humidifier which continued during transferring and staying in PACU. All patients were in 25 to 30° Fowler's position. Low dose bupivacaine with morphine and/or fentanyl was given via epidural catheter for postoperative analgesia.

At PACU, the patients were monitored with continuous oxygen saturation for a 120-minute postoperative period. The lower alarm limit was set at oxygen saturation reading <95%. If the pulse oximetry alarmed, the nurse would recheck the finger probe. If the probe was in the proper position, the nurse would call one of the authors to manage the situations such as airway obstruction from secretion or oversedation. When desaturation (SpO_2 <95%) persisted after solving the cause, the patient received oxygen via a simple face mask 7 L/min for 5 minutes which could be increase 1 L/min every 5 minutes until SpO_2 was 95%.

Pain score and sedation score were evaluated after arrival at PACU 30, 60, 90 and 120 minutes after surgery. Pain score was graded using a numeric rating scale score from 0 to 10 (0 = no pain and 10 = the worst imaginable pain). Sedation score was graded as 0 = fully awake, 1 = somnolence, responses to verbal call, 2 = somnolence, responses to tactile stimulation, 3 = asleep, response to painful stimulation and S = asleep.

At 2 hours postoperative in PACU, oxygen flow via cannula was decreased to 3 L/min until 24 hours postoperatively, and then according to the patient's condition. At the ward, peripheral oxygen saturation was routinely measured once every 8 hours both during receiving oxygen cannula flow 3 L/min in first postoperative day and room air afterward. Satisfaction score, number of spontaneous removal of oxygen cannula by the patients, incidence of postoperative hypoxemia, numbers of hospital days were also recorded.

Statistical analysis

According to previous study[1], the incidence of early postoperative hypoxemia was 35% in patients underwent upper abdominal surgery and not receive oxygen supplementation. Due to oxygen supple mentation via nasal cannula in this study protocol, the incidence of hypoxemia was expected to be 15%. Using an error of 12%, a sample of 35 patients was required. Data were analyzed using PASW Statistics for Windows, Version 18.0 Chicago: SPSS, Inc. Continuous data were presented as mean $\pm$ standard deviation (SD). Categorical data were presented as number and percentage.

Results

A total of 35 patients were included in this study. Patients' baseline characteristics were presented in Table 1. Three patients had history of cardiac diseases including paroxysmal supraventricular tachycardia (1) and history of coronary artery disease (2). Six patients had respiratory diseases including well-controlled asthma (4), history of tuberculosis with complete medical treatment (1) and tracheal tumor status post tumor removal and end to end anastomosis (1). Twenty-six patients (74.3 %) in this study underwent lobectomy (Table 2).

There were three patients (8.6%) experiencing early postoperative hypoxemia and the other 32 patients

Table 1. Patient baseline characteristics

	Total (n = 35)
Age (yr)	57.6±12.9
Gender: Male	14 (40)
Body mass index (kg/m^2)	22.8±3.9
American Society of Anesthesiologists Physical Status	
I	16 (45.7)
II	17 (48.6)
III	2 (5.7)
Cardiac disease	3 (8.6)
Respiratory disease	6 (17.1)
Smoking	11 (31.4)
Renal disease	1 (2.9)
Hypertension	10 (28.6)
Diabetes mellitus	2 (5.7)
Diagnosis	
Right lung nodule	17 (48.6)
Left lung nodule	15 (42.8)
Bronchiectasis	3 (8.6)

Data presented as mean ± SD or number (%)

Table 2. Perioperative Data

	Total (n = 35)
Operation	
Right lobe lobectomy	11 (31.4)
Left lobe lobectomy	11 (31.4)
Bi-lobectomy	3 (8.6)
Right lobe lobectomy lobectomy with wedge resection	1 (2.8)
Segmentectomy	1 (2.8)
Wedge resection	8 (22.8)
Anesthetic time (min)	175.1±43.5
Operation time (min)	111.7±35.0
Intraoperative crystalloid transfusion (mL)	905.7±353.7

Data presented as mean ± SD or number (%)

had no episode of hypoxemia during 120-minnute admission in PACU. The median (minimum, maximum) of peripheral oxygen saturation in 32 non-hypoxemic patients upon arrival at PACU, 5 minutes interval until 30 minutes, 15 minutes interval until 60 minutes and 30 minutes interval up to 120 minutes postoperative were 100 (97, 100). Upon arrival at PACU, 29 patients (82%) had sedation score 0 to 1 (Fig. 1). Their median pain score was less than 5.

Three patients with preoperative peripheral

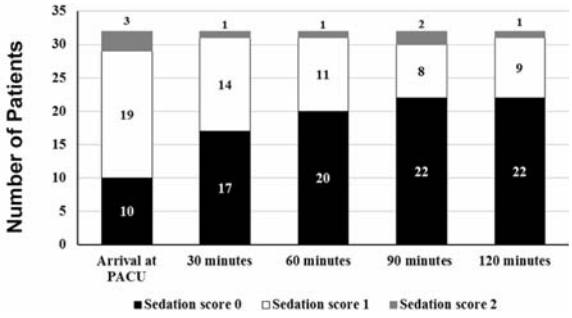

Fig. 1 Distribution of 32 patients' sedation score upon post-anesthetic care unit (PACU) and every 30 minutes until 2 hours postoperative.

oxygen saturation 98% and underwent wedge resection experienced peripheral oxygen saturation <95% at various time in PACU. They were 71, 63, and 65 years old. The first patient's peripheral oxygen saturation was 90% upon arrival at PACU. After clearing his secretion, his oxygen saturation was 94% at 5 and 10 minutes and increasing after then. His sedation score was 2 upon arrival at PACU and was only 1 afterward. His pain score was 2 to 4 during that period. His peripheral oxygen saturation during on oxygen cannula 3 L/min at ward was 97 to 100% and SpO_2 while breathing room air on postoperative day 1 was 95 to 97%. He was discharged on postoperative day 3.

The second patient had no underlying disease and no history of smoking. But his BMI was 34.2 kg/m^2. During the intraoperative period he received 0.1% bupivacaine 10 mL and then 5 mL/hr via epidural analgesia. When the operation was finished, he received 0.028% bupivacaine with morphine 0.01 mg/mL without loading dose of epidural morphine. Upon arrival at PACU, his oxygen saturation was 94% with a pain score of 10. After receiving intravenous meperidine 25 mg, his sedation score was 3 and his oxygen saturation at 5 minute was 93%. After changing to oxygen mask with bag 7 L/min, his SpO_2 at 10 and 15 minutes were 94% and increasing afterward. The oxygen cannula was reapplied at 60 minutes when his sedation score was 0 and his oxygen saturation was 95 to 97%. At the ward, his peripheral oxygen saturation during on oxygen cannula 3 L/min was 95 to 99%. His peripheral oxygen saturation while breathing room air on the next day was 94%. So oxygen cannula was reapplied with the flow of 1 L/min. On the second postoperative day, his peripheral oxygen saturation was 95 to 99% during breathing room air and he was discharged.

The third patient with history of hypertension

and BMI was 28.9 kg/m^2. On arrival at the PACU, her peripheral oxygen saturation was 93%. At that time her sedation score and pain score were 0. Oxygen mask with bag 7 L/min was given and her oxygen saturation during the first 25 minutes was 91 to 95%. At 30 minute after the operation her oxygen saturation was 85%. Finally, the investigator found that there was a problem with the oxygen delivery system. When it was fixed, she received oxygen cannula 5 L/min with oxygen saturation 100% afterward. Her oxygen saturation during on oxygen cannula 3 L/min was 96 to 98%. On the first postoperative day, her peripheral oxygen saturation during breathing room air was 92%. So oxygen cannula 3 L/min was continued. On the second postoperative day, her peripheral oxygen saturation during breathing room air was 92 to 93%. She was discharged on postoperative day 3.

The average of minimum of peripheral oxygen saturation during patients received oxygen cannula 3 L/min at ward was 97.6% and the maximum was 99.5%. On the first postoperative day when breathing room air (32 patients), the average of minimum of peripheral oxygen saturation was 96.1% and the maximum was 97.6%. There were three patients that continuously received oxygen cannula 1 to 3 L/min i.e. stroke (1), pneumonia (1), surgeon's order (1). The peripheral oxygen saturation was 94% and he was discharged on postoperative day 2. There was one patient who was given oxygen cannula again due to dyspnea from pleural effusion. Her peripheral oxygen saturation was 95 to 99% during on oxygen cannula 3 L/min. She was discharged on postoperative day 6.

The satisfaction score of receiving nasal cannula and the number of removal of nasal cannula were evaluated in 34 patients except one patient who developed postoperative stroke. Fourteen patients (39.0%) had satisfaction score 8 to 10. The average satisfaction score of all patients was 6.7$\pm$2.0. One patient rated satisfaction score 0 because of irritation feeling in her nasal mucosa. Most patients (65.7%) did not remove oxygen cannula (Fig. 3). Those who occasionally removed oxygen cannula were due to having meal or taking bath.

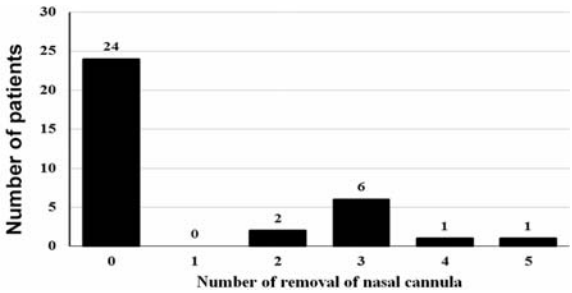

Fig. 2 Number of patients who removed the nasal cannula at various frequency.

Discussion

The incidence of hypoxia in patients underwent thoracic surgery and received oxygen 5 L/min via oxygen cannula during the first 2 hours postoperative was 8.6%. Siddiqui et al[4] demonstrated that 0.8% of the patients who received oxygen supplementation during transportation from operating room to PACU experienced oxygen desaturation on arrival PACU. They found three significant predictive factors for having SpO_2 <90% upon arrival PACU were 1) no oxygen supplement during transportation, 2) low respiratory rate and 3) patient's sedation score. Labaste et al[5] showed that 19% and 6% of the patients who were transported with and without oxygen supplement had hypoxia, respectively. Three risk factors for desaturation were sedation score >2, SpO_2 <96% before leaving the operating room, and body mass index >30 kg/m^2.

But Maity et al study[6] showed no incidence of hypoxia in patients underwent elective noncardiothoracic surgery who received oxygen 2 L/min via oxygen during the first 4 hours postoperative. Zevola et al[3] also demonstrated that 80.5% of the patients in cardiothoracic surgical ICU met their criteria for nasal cannula after extubation. And 95.5% of those patients were successful for maintaining their SpO_2 >90%. Only 4.5% of them needed oxygen mask for maintaining their SpO_2 >90%. One of the 3 patients had blood encrustation in his nose and nasal cannula could be used later on. The other patient had an exacerbation of his COPD on postoperative day 8 which was unrelated to the use of nasal cannula.

In our study, three patients had SpO_2 <95% during the first 2 hours after surgery. The average SpO_2 at 30 minutes after thoracotomy with lung resection of 32 non-hypoxemic patients was 99.8$\pm$0.5% (95% CI 99.6 to 99.9%). This was consistent with a randomized controlled trial in patients who underwent thyroidectomy[2]. They demonstrated that the SpO_2 at 30 minutes after the operation in patients receiving oxygen via nasal cannula and mask were 98.4$\pm$1.0% and 96.3$\pm$3.0% respectively, which was statistically significant. The reason that the peripheral oxygen saturation was lower in the mask group was due to more patients in mask group removing the device more often than nasal cannula group (75.5% vs. 3.8%).

We did not try to wean the oxygen supplementation in 2 patients on the first postoperative day because they had stroke (1) and pneumonia (1). The average of minimum of peripheral oxygen saturation during patient breathing oxygen in room air was 96.1% and the maximum was 97.6%. We found that 3 patients had oxygen saturation <95%. They were discharged on postoperative day 2 and 3. The cause may be from atelectesis. Drummond and Milne[7] demonstrated that 2 out of 6 patients who underwent thoracotomy with lobectomy had lower PaO_2 while breathing room air when compared to the preoperative value. But no patients had PaO_2 <95%. Entwistle et al[8] also demonstrated that 90% of the patients after thoracotomy experienced hypoxemia on the night after surgery. Meanwhile, Kawai et al[9] demonstrated that the duration rate of SpO_2 <90% during night time on postoperative day 3 in lobectomy group was statistically higher than the gastrectomy group but did not reach the desaturation index. The duration rate of peripheral oxygen saturation less than 90% and the desaturation index during night time on postoperative day 3 and 14 were statistically higher in patients of posterolateral thoracotomy group than in video-assisted thoracic surgery (VATS) for lobectomy group. But Yano et al[10] demonstrated that the mean peripheral oxygen saturation of the patients having lung resection on postoperative day 1, 2, 3 and 7 were more than 95%. Only 3.4% of the patients required oxygen supple mentation after removal of the oxygen device because of non-fatal pulmonary embolism.

The reasons for not adhering to nasal cannula in this study were having meal and bed bath. Ahyan et al[2] demonstrated that 3.8% the patient in the nasal group removed the device because of nasal irritating and disturbing. While 75.5% of the patient in the mask group removed the device because feeling of distress (68.3%), feeling of nausea (21.1%), talking (5.3%), expectoration (5.3%), having meal, taking oral medication and sometimes doctor and nurses removed the device because they wanted to assess the patient's speech quality and understanding what the patients said. Therefore average oxygen saturation in nasal cannula group was higher than the mask group. One of our patient also graded satisfaction score zero because of nasal irritation. The higher incidence of nasal cannula removal in our study may be due to the longer time period that patients had to receive oxygen supplementation.

The median satisfaction score of using nasal cannula in this study was 7 and most patients (65.7%) did not remove oxygen cannula. In the study by Ahyan et al[2], the average satisfaction score of the nasal cannula group and the mask group were 9.1 ± 1.3 and 6.7 ± 3.5, respectively, which was statistically significant.

The limitations of this study are 1) it is not a randomized study 2) no continuous oxygen saturation monitoring at ward, so we may not detect desaturation in some periods. Most of our patients underwent lobectomy (60%), but there were also segmentectomy (2.8%) and wedge resection of lung (22.8%), which less lung tissue was resected. The more lung tissue resected, the more likely the incidence of low peripheral oxygen saturation may occur. Therefore, further study in patients undergoing pneumonectomy and bi-lobectomy will result in more clinical applications. We do not have the mask group to compare the peripheral oxygen saturation and satisfaction score.

In conclusion, oxygen supplementation via nasal cannula can be used for preventing postoperative hypoxemia in patients undergoing thoracotomy with segmentectomy or wedge resection or lobectomy with general anesthesia and epidural analgesia in selected cases.

What is already known in this topic?

After lung resection, patient need oxygen supplementation during the early postoperative period. It can be given via various equipment.

What this study adds?

Oxygen supplementation with nasal cannula for patient after lung resection can be used.

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Trial registration

Clinicaltrials.gov (NCT01725464).

Potential conflicts of interest

None.

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การให้ผู้ป่วยผ่าตัดปอดสูดดมออกซิเจนผ่านสายยางเข้าช่องจมูกในระยะพักฟื้นหลังผ่าตัด

ศิริลักษณ์ สุขสมปอง, วีรนุช ธีระสุนทรวงษ์, เบนโน วอน โบแมน

วัตถุประสงค์: *เพื่อประเมินอัตราการเกิดภาวะออกซิเจนต่ำ (ความอิ่มตัวของออกซิเจน <ร้อยละ 95) ในผู้ป่วยสูดดมออกซิเจนทางสายยางเข้าช่องจมูกในระยะแรกหลังการผ่าตัดปอด*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษาแบบเก็บข้อมูลไปข้างหน้าในห้องพักฟื้นของโรงพยาบาลมหาวิทยาลัยในผู้ป่วย 35 รายที่มี ASA physical status 1-3 และได้รับการผ่าตัดปอดโดยการระงับความรู้สึกแบบทั่วไปร่วมกับการหยดยาแก้ปวดทางสายอิปิดูรัล ผู้ป่วยได้รับออกซิเจนระหว่างการเคลื่อนย้ายและในห้องพักฟื้นทางสายยางเข้าช่องจมูก 5 ลิตร/นาทีตลอดเวลา 2 ชั่วโมงหลังผ่าตัด ติดตามค่าความอิ่มตัวของออกซิเจน (SpO_2) อย่างต่อเนื่อง และบันทึกค่าเป็นระยะจนถึง 2 ชั่วโมงหลังผ่าตัด บันทึกความดันเลือด อัตราการเต้นของหัวใจ คะแนนความปวดและระดับความสงบที่เวลาเดียวกัน*

ผลการศึกษา: *ผู้ป่วย 3 ราย (ร้อยละ 8.6) เกิดภาวะออกซิเจนในเลือดต่ำในระยะที่อยู่ในห้องพักฟื้นจนถึง 2 ชั่วโมงหลังผ่าตัด สาเหตุที่ภาวะออกซิเจนในเลือดต่ำได้แก่ เสมหะอุดกั้นทางหายใจ (1) ระบบการให้ออกซิเจนขัดข้อง (1) และง่วงซึมรุนแรง (1) ค่าเฉลี่ยความอิ่มตัวของออกซิเจนที่ 30 นาทีหลังผ่าตัดของผู้ป่วย 32 รายที่ไม่พบภาวะความอิ่มตัวของออกซิเจนในเลือดต่ำเท่ากับร้อยละ 99.8±0.5 พบว่าร้อยละ 30 ของผู้ป่วยให้คะแนนความพึงพอใจต่อการใช้สายยาง เข้าช่องจมูกเท่ากับ 8 โดยมีค่าความพึงพอใจเฉลี่ย 6.7±2.0 เกือบร้อยละ 66 ของผู้ป่วยไม่ได้ถอดสายยางตลอดการใช้*

สรุป: *การให้ออกซิเจนทางสายยางเข้าช่องจมูกอาจช่วยป้องกันและรักษาภาวะออกซิเจนในเลือดต่ำในผู้ป่วยที่ได้รับการผ่าตัดปอดโดยรับการระงับความรู้สึกแบบทั่วไปร่วมกับการหยดยาแก้ปวดทางสายอิปิดูรัล แต่ยังคงต้องเฝ้าระวังอาการผู้ป่วยอย่างใกล้ชิด*