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Case Report

Causes and treatment of hypoxia during total hip arthroplasty in elderly patients: case report

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Abstract There are several causes of hypoxia during and after surgery, and atelectasis is a common symptom that occurs during surgery. In particular, elderly patients are more vulnerable to hypoxia due to their existing lung diseases or respiratory muscle weakness. This study presents the cases of two elderly patients who developed hypoxia during total hip arthroplasty under general anesthesia. Positive end expiratory pressure, recruitment maneuver, and increased fraction of inspired oxygen improved hypoxia only temporarily, and patients' oxygen saturation level again dropped to 79%–80%. We suspected that hypoxia was caused by atelectasis and, therefore, resumed spontaneous respiration. Thereafter, both the patients showed an improvement in hypoxia. Intraoperative hypoxia that is suspected to be caused by atelectasis can be improved by securing sufficient lung volume for respiration through increased muscle tone with spontaneous respiration

Keywords: Atelectasis, Hypoxia, Old age, Spontaneous respiration

1. Introduction

Respiratory functions deteriorate with aging,(1) and general anesthesia, particularly in mechanical ventilation, increases the possibility of respiratory malfunction during surgery, thereby elevating the risk for hypoxia in elderly patients.(2, 3) Atelectasis is one of the many causes of hypoxia that commonly occurs in patients receiving general anesthesia;(4) it is an important condition that must not be overlooked because hypoxia caused by impaired gas exchange due to atelectasis can prolong postoperative pulmonary complications.Here, we report two cases of elderly patients with a sudden

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onset of hypoxia during total hip arthroplasty under general anesthesia and describe how their condition improved upon inducing spontaneous respiration and how the surgery could proceed under inhalation anesthesia with spontaneous respiration.

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2. Case Presentation

Case 1: The first patient was a 79-year-old female individual with a history of hypertension, heart failure, and middle cerebral artery infarction. Blood pressure control and cardiac function were in good condition before surgery, and no brain neurological complications were currently found. The patient's pulmonary function test result was normal, although her chest X-ray revealed pneumonia in the right middle lobe, for which she had been treatedThe patient underwent total hip arthroplasty under general anesthesia. Before the general anesthesia, the patient was attached to various monitoring devices, including electrocardiography, a noninvasive blood pressure monitor, pulse oximeter, and bispectral index (BIS) monitor. The BIS was maintained at 40–60. Anesthesia was induced with propofol (2 mg/kg) and rocuronium (0.8 mg/kg), and intra-arterial cannulation was performed for continuous blood pressure monitoring. Approximately 20 min into the surgery, the patient's oxygen (O_2) saturation level dropped from 93.1% to 83.1%. While being ventilated at a fraction of inspired oxygen (FiO_2) of 0.4, her arterial blood gas showed that the partial pressure of oxygen (PaO_2) dropped from 161.6 to 51.2. We increased the positive end expiratory pressure (PEEP) to 10 cm H_2O and FiO_2 to 1.0 and performed a recruitment maneuver; however, her O_2 saturation level increased only temporarily and dropped again to 81%. Upon suspecting atelectasis due to a collapsed lung, we reversed muscle relaxation and induced spontaneous respiration during surgery. Although it was an audacious decision, the O_2 saturation level recovered to 90%, and we continued the surgery with spontaneous respiration. After surgery, the patient's O_2 saturation level recovered to the preoperative state of 98%.

Case 2: The second patient was an 89-year-old male individual with a history of hypertension and delirium. Before surgery, his blood pressure was well controlled, and although he was taking dementia medicine, the patient was able to follow commands well. His pulmonary function test results indicated an obstructive pattern. Total hip arthroplasty was performed using the same anesthetic regimen used for the first patient. While ventilating at an FiO_2 of 0.4, the patient showed an onset of hypoxia, with O_2 saturation level dropping from 100% to 80% and PaO_2 dropping from 129 to 53.0. This patient also showed an improvement of O_2 saturation level from 81% to 88% after recovering spontaneous respiration by administering a muscle relaxant reverse agent. His O_2 saturation level improved to 90% with continuous positive airway pressure. Similar to the first patient, this second patient's O_2 saturation level improved to 98% after surgery.

Neither patient developed any respiratory complications after surgery. The first patient had no notable findings on postoperative chest X-ray, whereas the second patient showed subsegmental atelectasis on the right middle lobe upon postoperative chest X-ray compared with the preoperative findings (Figure 1).

Figure 1.A finding that atelectasis was formed in the right lower lobe(arrow) of the lung after

Surgery, which was not in the lung(left) before surgery in the second patient

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3. Discussion

Intraoperative and postoperative causes of hypoxia include old age, obesity, American Society of Anesthesiologists status, and operation duration, and anesthesiologists commonly encounter hypoxia in general anesthesia of elderly patients.(5)

The elastic recoil force and vital capacity of the lungs decrease with age, and chest wall expansion diminishes. Furthermore, weakening of the respiratory muscles increases the risk of hypoxia and other respiratory complications.(2) While mechanical ventilators assist respiration in patients under general anesthesia and those with diminished respiratory functions, mechanical ventilation can trigger volutrauma, atelectrauma, and lung inflammation.(3) Moreover, various factors, such as loss of intercostal muscle function and surgical manipulation during general anesthesia, provoke and exacerbate atelectasis.(6) Lung computed tomography (CT) in the supine position can show normal findings during spontaneous respiration, although atelectasis can be observed under general anesthesia (Figure 2).

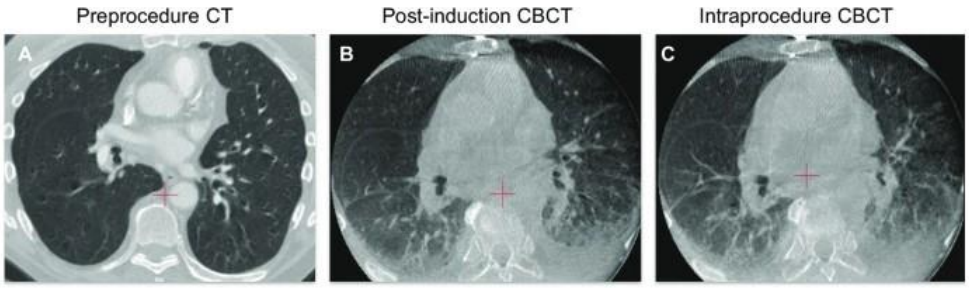

Figure 2.(A) A patient's lungs before anesthesia induction.(B)Atelectasis on the dependen portion of both the lungs after anesthesia induction. Cone-beam CT(CBCT)showing exacerbated atelectasis during the surgery(7)

It is argued that recovery from atelectasis occurs within 24 h of surgery and that no special preventive measures are required.(8) However, leaving atelectasis untreated may allow hypoxia to persist or to induce pneumonia after surgery; therefore, atelectasis must not be neglected.(9) Atelectasis can induce systemic hypoxia or lung inflammation by causing a collapse of the alveoli (Figure 3).(3, 4) Hypoxia can be resolved by increasing the FiO_2 or tidal volume, monitoring the tube position, and applying PEEP. In addition, shifting from inhalational anesthetics to intravenous anesthetics (propofol) can help improve hypoxia.(10) In our cases, these reported methods for alleviating hypoxia were attempted except for the method of shifting from inhalational anesthetics to propofol, although it was only temporarily improved, and hypoxia recurred. In our study, it was thought that hypoxia occurred due to the occurrence of atelectasis, such as the collapse of pulmonary alveolus due to the decrease in the muscle tone of the patient. Therefore, hypoxia improved when we—rather boldly—reversed muscle relaxation during surgery and maintained spontaneous respiration under inhalation anesthesia.

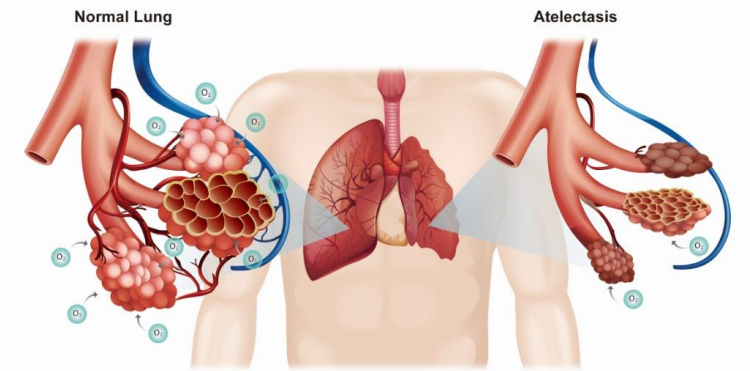

Figure 3.Diagram of ineffective gas exchange in a left lung due to atelectasis compared with findings in a normal right lung

We suspected that hypoxia improved as the cephalad displacement of the diaphragm caused by muscle relaxation was reversed. This process occurred as the patients' muscle tone improved through administration of a muscle relaxant reverse agent,(4) which led to inflation of the lungs and a reduction in atelectasis. Thus, conversion to spontaneous breathing may be effective for treating perioperative hypoxia that does not respond to other treatment modalities. The second patient

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showed a further improvement in hypoxia with continuous positive airway pressure (CPAP) along with conversion to spontaneous respiration. CPAP appeared to have facilitated ventilation and gas exchange, presumably by re-expanding the collapsed alveoli.(11)

One limitation of this case report is that we cannot definitely confirm that hypoxia was caused by atelectasis, as imaging studies, such as chest X-ray or lung CT, cannot be performed during surgery after a sudden onset of hypoxia. Furthermore, the second patient did not show any abnormal find ings after surgery, other than mild atelectasis in the right lower lobe, compared with the patient's preoperative condition.

However, although we had suspected perioperative pulmonary aspiration due to old age and decu bitus position,(5) we were able to rule out hypoxia caused by aspiration based on the lack of secre tions in trachea suctioning, crackle sound on auscultation, and aspiration pneumonia findings on postoperative chest X-ray. We also considered the possibility of a bronchospasm, although bron chospasm was ruled out based on the lack of wheezing sound on auscultation (12) and improvement of hypoxia solely through spontaneous breathing, without a bronchodilator.

After conversion to spontaneous respiration, there were no notable movements at the surgical site until conclusion of the surgery. This is presumably attributable to the fact that elderly patients are more sensitive to anesthetics with a 1 Monitored Anesthesia Care(MAC) of 1.48% compared with the 2.49% in children and 1.71%–2.056% in adults.(13) Furthermore, inhalational anesthetics in hibit motor responses to harmful stimuli.(14) However, additional studies on muscle relaxation caused by inhalational anesthetics are needed due to the lack of study data on surgeries that only use inhalational anesthetics without the use of any muscle relaxants.

4. Conclusions

Since atelectasis due to general anesthesia can cause hypoxia during surgery and pulmonary complications after surgery, various measures should be considered to improve hypoxia. If hypoxia is not resolved using the treatment modalities reported previously, resuming spontaneous respiration can be a viable alternative to treat hypoxia.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board and Human Research Ethics Committee of Soonchunhyang University Cheonan Hospital (IRB No. 2021-09-021).

Informed Consent Statement: Any Written informed consent has been obtained from the patient(s) to publish this paper Data Availability Statement: Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

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Abbreviations: PEEP;Postive end expiratory pressure, CT;Computed Tomography,CPAP;Continuous positive airway pressure, MAC(Monitored Anesthesia Care)

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