

Intraoperative use of noninvasive ventilation during spinal anaesthesia in patients with severe chronic obstructive pulmonary disease undergoing orthopaedic surgery: A case report

Journal of International Medical Research

50(5) 1–7

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DOI: 10.1177/03000605221103968

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Abstract

Compared with invasive mechanical ventilation, noninvasive ventilation (NIV) improves patient comfort and neurocognitive function; and reduces the likelihood of nosocomial infections and the need for sedation. NIV can also be used perioperatively to prevent postoperative pulmonary complications. This current report describes a case of a 64-year-old female patient with chronic obstructive pulmonary disease and chronic respiratory failure that underwent spinal anaesthesia during surgery. She was sedated with propofol. She brought her home ventilator equipment to the operating room and it was used in biphasic-positive airway pressure mode for immediate treatment of respiratory depression.

Keywords

Noninvasive ventilation, chronic obstructive pulmonary disease, respiratory failure, pulmonary tuberculosis, anaesthesia

Date received: 10 November 2021; accepted: 12 May 2022

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Introduction

The application of perioperative noninvasive ventilation (NIV) can reduce the incidence of postoperative complications during high-risk surgeries and in patients with certain respiratory diseases; and it also reduces the length of stay in the critical care unit after surgery.¹ However, the literature on the use of NIV during the intraoperative period in patients with poor respiratory function is limited to a few case reports.²⁻⁴ This current case report describes successful spinal anaesthesia using NIV for orthopaedic surgery in a patient with severe chronic obstructive pulmonary disease (COPD) and chronic respiratory failure.

Case report

In September 2020, a 64-year-old female patient (height, 148.4 cm; weight, 37.4 kg; American Society of Anesthesiologists status IV) was admitted to the Department of Orthopaedic Surgery, Soonchunhyang University Bucheon Hospital, Bucheon, Republic of Korea for the surgical repair of a left femur neck fracture. Her medical history included COPD, chronic respiratory failure and rectal cancer. Twenty years previously, she underwent a left pneumonectomy due to a tuberculosis-destroyed lung as a sequela of pulmonary tuberculosis (Figure 1). The patient was given 3l/min oxygen through a nasal cannula during the day and used a home ventilator



Figure 1. Preoperative chest radiography of a 64-year-old female patient that was admitted for the surgical repair of a left femur neck fracture showing evidence of a left pneumonectomy that was undertaken 20 years previously for tuberculosis-destroyed lung that was the sequela of pulmonary tuberculosis.

(Astral150TM; ResMed, San Diego, CA, USA) in biphasic-positive airway pressure mode while sleeping. Arterial blood gas analysis showed an arterial pH of 7.48, partial pressure of carbon dioxide (PaCO₂) of 50 mmHg, partial pressure of oxygen (PaO₂) of 113 mmHg (Table 1) and HCO₃⁻ level of 37.2 mmol/l. A preoperative pulmonary function test showed that the forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC) 0.34 l (19%) and 0.51 l (20%), respectively (Table 2). The FEV1/FVC ratio was 68%. The left ventricular ejection fraction was 50%. Echocardiography revealed that the right ventricular chamber was enlarged and right ventricular function was impaired. Spinal anaesthesia was used considering the patient's respiratory status.

On the day of surgery, the patient brought their home ventilator (with the inspiratory and expiratory positive airway pressure set at 16 and 4 cm H₂O, respectively) to the operating room. Upon arrival, an OptiflowTM device (Fisher and Paykel Healthcare Ltd., Auckland, New Zealand) provided oxygen through a nasal cannula at a rate of 30 l/min. A 22-gauge catheter was inserted into the left radial artery and three-lead electrocardiography, pulse oximetry and noninvasive blood pressure monitoring were performed. The initial blood pressure

and saturation of percutaneous oxygen (SpO₂) were 155/77 mmHg and 100%, respectively. For spinal anaesthesia, the patient was placed in the lateral decubitus position. Through the paramedian approach, 10 mg 0.5% hyperbaric bupivacaine was injected into the L4–L5 subarachnoid space using a 25-gauge Quincke needle. Sensory blockade up to the T10 dermatome was verified using the cold pressor test 5 min after intrathecal injection. After applying surgical drapes, the patient began to complain of anxiety. The patient continued to complain of severe anxiety and struggled on the operating table to such an extent that the operation became

Table 2. Preoperative pulmonary function test for a 64-year-old female patient that was admitted for the surgical repair of a left femur neck fracture.

	Predicted value	Measured value	Percentage of predicted value
FVC, l	2.54	0.51	20%
FEV1, l	1.83	0.34	19%
FEV1/FVC, %	73	68	–
FEF 25–75%, l/s	2.24	0.20	9%
PEF, l/s	5.15	1.27	25%

FVC, forced vital capacity; FEV1, forced expiratory volume in 1 s; FEF 25–75%, 25–75% of forced expiratory flow; PEF, peak expiratory flow.

Table 1. Perioperative arterial blood gas analysis test values for a 64-year-old female patient that was admitted for the surgical repair of a left femur neck fracture.

	pH	PaCO ₂ , mmHg	PaO ₂ , mmHg	BE, mEq/l	SaO ₂ , %	FiO ₂
PreOP	7.48	50	113	11.8	100	0.21
IntraOP_1	7.36	70	251	11.0	100	1.00
IntraOP_2	7.49	50	208	12.7	99	1.00
PostOP	7.49	47	107	10.9	99	0.21

pH, arterial pH; PaCO₂, arterial partial pressure of carbon dioxide; PaO₂, arterial partial pressure of oxygen; BE, arterial base excess; SaO₂, arterial oxygen saturation; FiO₂, fraction of inspired oxygen; PreOP, 1 day before the day of surgery; IntraOP_1, intraoperative period, during the event of decreased saturation of percutaneous oxygen; IntraOP_2: intraoperative period, after the use of noninvasive ventilation; PostOP, approximately 10 h after the end of the operation.

impossible and threatened her safety. Therefore, 1 mg of midazolam was administered intravenously for sedation. Subsequently, 2% propofol was administered using a target effect-site controlled infusion pump (Agilia®; Fresenius Kabi, Bad Homburg, Germany) set at 0.8 µg/ml, based on the Marsh pharmacokinetic model. Simultaneously, a bispectral (BIS) index monitor was attached to the patient to observe the depth of sedation. Approximately 6 min after propofol administration, the SpO₂ decreased to 95%. The oxygen concentration of the Optiflow™ device was increased to 70 l/min, but the SpO₂ did not change. Arterial blood gas analysis revealed hypercarbia, so the nasal cannula was removed and NIV was applied using the home ventilator and oronasal mask. After 40 s, the SpO₂ increased to 100%. In the arterial blood gas analysis performed at the same time, SaO₂ was 99% and PaCO₂ decreased (Table 1). The SpO₂ concentration was maintained within the normal range until the end of the operation through the provision of NIV. Propofol was titrated until sedation was achieved, based on a BIS index of 70–80. The target effect-site concentration of administered propofol to maintain this BIS index was 0.8–1.0 µg/ml. The operation was completed without any complications and the patient was transferred to the intensive care unit. The total anaesthesia time was 1 h 32 min and the total operation time was 46 min. On the day after surgery, the patient was transferred to the general ward and discharged 24 days after the operation.

Written informed consent was obtained from the patient for the publication of this report and any accompanying images. The study was approved by the Institutional Review Board of Soonchunhyang University Bucheon Hospital (no. 2021-11-012). The report conformed with the CARE guidelines.⁵ The patient was informed

about the anaesthesia method that would be used before the surgery.

Discussion

This current case report describes the successful use of NIV during spinal anaesthesia in a patient with severe COPD undergoing surgical repair of a femur neck fracture. The patient had previously undergone pneumonectomy due to a tuberculosis-destroyed lung, as a sequela of pulmonary tuberculosis. Due to respiratory depression during sleep, she had been using a home ventilator for bilevel positive airway pressure support.

The World Health Organization estimated that, in 2020, approximately 10 million people were diagnosed with tuberculosis worldwide and approximately 1.5 million died of the infection.⁶ Tuberculosis imposes a burden on health systems in many countries and is thus considered a major public health problem. Airborne transmission of *Mycobacterium tuberculosis* can cause diseases of various organs, but the lungs are the most frequently affected. Tuberculosis-destroyed lung is defined as extensive damage to one or both lungs due to a lack of adequate treatment in the early stages of pulmonary tuberculosis.⁷ In 2018, tuberculosis was reported as an independent risk factor for COPD.⁸ COPD increases postoperative mortality, morbidity and the length of hospital stay;⁹ and it is also a risk factor for postoperative respiratory complications.¹⁰ In addition, compared with regional anaesthesia, the use of general anaesthesia, which requires endotracheal intubation and administration of neuromuscular blocking agents, increases the incidence of postoperative pulmonary complications.¹¹ Therefore, it was expected that spinal anaesthesia would reduce the likelihood of postoperative complications and improve the prognosis of this current patient with COPD.

In the current patient, spinal anaesthesia provided the necessary sensory blockade for surgery. Appropriate percutaneous oxygen saturation was maintained by high-flow oxygen, administered through a nasal cannula, until sedation. However, the patient began to complain of considerable discomfort and anxiety due to the lateral decubitus position and surgical drape. Even after the operation had started, the anxiety continued and she moved her body to stop the operation, thereby threatening her own safety. Therefore, sedative agents had to be administered. Thereafter, the operation proceeded without any problems, although respiratory depression and hypercarbia occurred. The main advantage of sedation via regional anaesthesia is increased patient satisfaction.¹² The sedative agents administered in this current case, particularly propofol, can cause respiratory depression, increase blood carbon dioxide tension and suppress the ventilatory response to hypoxia.¹³ Considering these disadvantages of propofol, dexmedetomidine may be considered for sedation in severely ill patients. Dexmedetomidine has been widely used for sedation over the past decade, not only in the operating room, but also in intensive care units. Dexmedetomidine is an α_2 -receptor agonist that suppresses the sympathetic nerves, reduces the need for analgesics and anaesthetics during surgery, and exerts sedative and analgesic effects.¹⁴ As it has minimal ventilatory effects, it reduces the risk of respiratory depression, hypoxaemia and hypercapnia during sedation.¹⁵ However, despite these benefits, there is a possibility of unexpected haemodynamic changes, which can be fatal. A case of patient death due to refractory cardiogenic shock after dexmedetomidine sedation was reported several years ago.¹⁶ A randomized controlled trial comparing blood pressure reduction among several sedatives reported significantly reduced blood pressure and heart rate after

dexmedetomidine administration.¹⁷ Therefore, in situations where sedation is required during surgery, the patient's physical status should be evaluated before the administration of sedatives and vital signs such as haemodynamic changes and oxygen saturation should be carefully monitored.

The current patient brought her home ventilator equipment to the operating room and it was used in biphasic-positive airway pressure mode for immediate treatment of respiratory depression. Noninvasive positive pressure ventilation, along with continuous positive airway pressure, provide NIV and mechanical ventilatory support that do not require artificial airways; thus, there is no need for endotracheal intubation or tracheostomy.¹⁸ Noninvasive positive pressure ventilation can measure inspiratory effort, and the positive end-tidal pressure is maintained when the inspiratory flow decreases below a certain threshold. Therefore, as in this current case, noninvasive positive pressure ventilation is usually used for hypercapnic patients. NIV can be used at any time during the perioperative period to prevent postoperative pulmonary complications and treat related sequelae.¹ However, it is mainly used after surgery, although successful intraoperative use has been reported recently for patients with COPD, sleep apnoea, old age and morbid obesity.^{2-4,19,20}

In conclusion, spinal anaesthesia for orthopaedic surgery in patients with severe COPD can help improve the prognosis. Moreover, NIV is a safe and useful treatment option for respiratory depression, hypoxaemia and hypercapnia caused by the administration of sedatives during regional anaesthesia.

Author contributions

M.L. was the anaesthesiologist for the patient, designed the report and wrote the manuscript. J. S. and Y.W. reviewed the literature and collected the data. J.J. reviewed the manuscript. Y.H.C.

analysed and interpreted the data. B.S.K. revised the manuscript and supervised the work. All authors read and approved the final manuscript.

Declaration of conflicting interests

The authors declare that there are no conflicts of interests.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Soonchunhyang University Research Fund.

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References

- Jaber S, Michelet P and Chanques G. Role of non-invasive ventilation (NIV) in the perioperative period. *Best Pract Res Clin Anaesthesiol* 2010; 24: 253–265.
- Gonçalves GÂ, Prezzi ED, Carletti GM, et al. Use of noninvasive positive pressure ventilation and spinal anesthesia during hip replacement arthroplasty in a patient with severe chronic obstructive pulmonary disease: case report. *Rev Bras Ter Intensiva* 2008; 20: 313–317.
- Leech CJ, Baba R and Dhar M. Spinal anaesthesia and non-invasive positive pressure ventilation for hip surgery in an obese patient with advanced chronic obstructive pulmonary disease. *Br J Anaesth* 2007; 98: 763–765.
- Ferré F, Cuginin N, Martin C, et al. Regional anesthesia with noninvasive ventilation for shoulder surgery in a patient with severe chronic obstructive pulmonary disease: a case report. *A A Case Rep* 2017; 8: 261–264.
- Gagnier JJ, Kienle G, Altman DG, et al. The CARE guidelines: consensus-based clinical case reporting guideline development. *J Med Case Rep* 2013; 7: 223.
- World Health Organization. Global tuberculosis report 2021, <https://www.who.int/publications/i/item/9789240037021> (2021, accessed 14 October 2021).
- Bobrowitz ID, Rodescu D, Marcus H, et al. The destroyed tuberculous lung. *Scand J Respir Dis* 1974; 55: 82–88.
- Lin HH, Murray M, Cohen T, et al. Effects of smoking and solid-fuel use on COPD, lung cancer, and tuberculosis in China: a time-based, multiple risk factor, modelling study. *Lancet* 2008; 372: 1473–1483.
- Gupta H, Ramanan B, Gupta PK, et al. Impact of COPD on postoperative outcomes: results from a national database. *Chest* 2013; 143: 1599–1606.
- Arozullah AM, Daley J, Henderson WG, et al. Multifactorial risk index for predicting postoperative respiratory failure in men after major noncardiac surgery. The National Veterans Administration Surgical Quality Improvement Program. *Ann Surg* 2000; 232: 242–253.
- Canet J, Gallart L, Gomar C, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. *Anesthesiology* 2010; 113: 1338–1350.
- Wu CL, Naqibuddin M and Fleisher LA. Measurement of patient satisfaction as an outcome of regional anesthesia and analgesia: a systematic review. *Reg Anesth Pain Med* 2001; 26: 196–208.
- Blouin RT, Seifert HA, Babenco HD, et al. Propofol depresses the hypoxic ventilatory response during conscious sedation and isohypercapnia. *Anesthesiology* 1993; 79: 1177–1182.
- Bhana N, Goa KL and McClellan KJ. Dexmedetomidine. *Drugs* 2000; 59: 263–268.
- Belleville JP, Ward DS, Bloor BC, et al. Effects of intravenous Dexmedetomidine in humans: I. Sedation, ventilation, and metabolic rate. *Anesthesiology* 1992; 77: 1125–1133.
- Sichrovsky TC, Mittal S and Steinberg JS. Dexmedetomidine sedation leading to

- refractory cardiogenic shock. *Anesth Analg* 2008; 106: 1784–1786.
17. Frölich MA, Arabshahi A, Katholi C, et al. Hemodynamic characteristics of midazolam, propofol, and dexmedetomidine in healthy volunteers. *J Clin Anesth* 2011; 23: 218–223.
 18. Bauchmuller K and Glossop AJ. Non-invasive ventilation in the perioperative period. *BJA Education* 2016; 16: 299–304.
 19. Erdogan G, Okyay DZ, Yurtlu S, et al. Non-invasive mechanical ventilation with spinal anesthesia for cesarean delivery. *Int J Obstet Anesth* 2010; 19: 438–440.
 20. Hatipoglu Z and Ozcengiz D. Use of NIV in surgery procedures in elderly (noninvasive surgery): continuous spinal anesthesia. In: Esquinas AM and Vargas N (eds) *Ventilatory Support and Oxygen Therapy in Elder, Palliative and End-of-Life Care Patients*. Springer International Publishing, 2020, pp.155–161.