Case Report


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1. Introduction

The development of lung isolation and one lung ventilation (OLV) accelerated the evolution of thoracic surgery as a sub-specialty. Before the introduction of endotracheal tube and the cuffed endotracheal tube, only select few intrathoracic procedures were feasible. Rapid lung movement and quickly developing respiratory distress made the surgical procedures difficult and risky. Selective ventilation of one lung changed this scenario. It was first described in 1931 by Gale and Water and quickly led to increasingly complex lung resection surgery, with the first published pneumonectomy for cancer in 1933 [1]. Techniques and apparatus used for OLV have changed significantly in recent years. These changes have come largely in response to an increased use of OLV during lung surgery and the advent of newer, minimally invasive surgical procedures, whereas OLV in the operating room or intensive care unit was once viewed as a complex endeavor largely managed by experts in academic institutions. The introduction of newer limited access thoracic and cardiac procedures has made it necessary as anesthesia staff members to master lung isolation techniques. Modification of OLV technique is sometimes needed during the procedure to face the potential problems that could change the plans and covert the procedure to conventional lung ventilation. The well-known methods of increasing FIO₂, applying PEEP to the ventilated lung, use of CPAP to the nonventilated lung, or intermittent reinflation of the collapsed lung may not work to improve hypoxia and hypercarbia associated with OLV.

In this case report we are presenting a modification of the differential lung ventilation technique for managing hypoxia and hypercarbia during robotic assisted thymectomy using OLV [2].

2. Case Report

A 35-year-old female Asian patient who is known to be nonsmoker and nonalcoholic referred by the infection control department to the cardiothoracic surgery team after...
being treated from military tuberculosis by short-term anti-
tuberculous regimen for 4 months. She had no neurological
signs or symptoms of note. Her physical examination was
unremarkable. She was a small-sized person with a body
weight of 42 Kg and height of 142 cm.

Routine laboratory works were within normal limits;
sputum microscopy was negative for acid-fast bacilli and no
mycobacterium was isolated with culture and sensitivity tests.
Also serology tests are negative for HbsAg, HCV, and HIV.

CT scan of chest had shown an anterior mediastinal mass,
which measured 1.8 cm in its maximum anteroposterior
diameter and 4.8 cm in its side-to-side dimensions with
multiple peripherally located reticulonodular opacities sug-
gestive tuberculous infection. Chest X-ray showed multiple
faint nodular opacities noted in the right apical region with
midprominence of the right hilar vascular shadows. The left
lung field and both costophrenic angles were clear.

Patient was scheduled for robotic assisted thymus tumor
excision with a working diagnosis of Thymic TB versus
Thymoma.

On the day of the operation, her vital signs were HR
120/min, sinus rhythm, BP 150/80 mmHg, and SpO2 98% on
room air.

In the operation theater, patient was prepared by applying
left peripheral venous cannula and right radial arterial can-
nula. Monitoring intraoperatively consists of 5 leads ECG,
pulse oximetry, invasive and noninvasive blood pressure,
nasopharyngeal temperature, urine output, and Bispectral
index. Respiratory parameters monitoring consisted of peak
inspiratory pressure, gas analyzer, and O2 monitor.

Anesthesia was induced by intravenous injection of
propofol 2.5 mg/kg, fentanyl 1.5 mcg/kg, and cisatracurium
0.2 mg/kg followed by endotracheal intubation by dou-
ble lumen Rusch Robertshaw Endobronchial Tubes Left
Bronchus of 35F size and secured at 30 cm at lip level.
Position is confirmed by routine breath sound auscultation
algorithm. Tube position could not be checked by fiberoptic
bronchoscopy only in this instance, as it was not available
in theatre on the day of surgery for logistic reason of repair
and disinfection. Two anesthetists reconfirm the position by
auscultating all chest quadrants and again after port access
to the surgical field, and I : E ratio range from 1 : 2 to 1 : 3. Patient
maintained SpO2 of 99-100% and ETCO2 remained below 40 mmHg. ABG done after 10 min-
utes of this mode of ventilation showed PaO2 of 217 mmHg and
PaCO2 of 44 mmHg. Portable ventilation is connected to
the nonventilated lung double lumen tube limb with pediatric
mode of ventilation of tidal volume of 60 mL, respiratory rate
of 35/minute, PEEP of 2 cm H2O in order not to interfere with
the surgical field, and I : E ratio from 1 : 2 to 1 : 3. Patient
maintained SpO2 of 99-100% and ETCO2 of 35–38 mmHg all
through the procedure. The dependent lung was continued
to be ventilated through the anesthesia machine ventilator
at the same starting parameters. Surgery was accomplished
robotically with complete excision of the tumor without any
interfering effect of this mode of ventilation to the collapsed
right lung.

At the end of the procedure, patient was extubated on the
operating table and transferred to the recovery room for 2
hours monitoring and then transferred to wardroom. Patient
was discharged from the hospital on the 5th postoperative day
and followed up in the thoracic surgery clinic with normal
postprocedure course.

3. Discussion

Differential lung ventilation is a well-known technique for
ventilating patient with unilateral lung disease in the critical
care settings in the ICU [3]. However, using this technique
intraoperatively in the operative suite setting is rarely applied.
Conventional one lung ventilation technique provides satis-
factory gas exchange in the majority of cases. However, in
some cases hypoxemia may occur secondary to the obligatory
right to left transpulmonary shunt through the nonventilated,
nondependent lung [4]. Another factor which could be
added to the presented case is the past history of miliary
pulmonary tuberculosis 6 months prior to the procedure.
These factors will result in a much larger alveolar arterial
blood flow to the nonventilated lung is usually reduced by
gravity in the complete lateral decubitus position, active
hypoxic pulmonary vasoconstriction in the nonventilated
lung, and nondependent lung collapse [5]. Watanabe et al.
had investigated the effect of gravity as a major determinate
of shunt and perfusion during thoracotomy procedures.
Patients undergoing right thoracotomy were divided into
two groups. One group was supine, one group was placed
in the left semilateral decubitus position, and the third
group was placed in the left full-lateral position. All patients were ventilated with 100% oxygen, and arterial blood gas samples were analyzed every 5 min after intentional collapse of the right lung. PaO₂ progressively decreased in all groups after two-lung ventilation (TLV) was discontinued. Nine out of 11 patients in the supine group experienced arterial oxyhemoglobin saturation (SaO₂) of less than 90% and had to have TLV reinstated. Only one out of nine patients in the semilateral group and one out of 13 patients in the full-lateral group experienced that degree of hypoxemia. The time for PaO₂ to decrease to 200 mmHg after the start of SLV was very rapid: 354 s in the supine group compared with 583 s in the semilateral group and 794 s in the full-lateral group [6].

Bardoczky et al. compared the effects of position and fraction of inspired oxygen (FiO₂) during thoracic surgery. Randomly assigned patients were ventilated with a FiO₂ of 0.4, 0.6, or 1.0 during periods of TLV and SLV in the supine and lateral positions. PaO₂ decreased more during SLV compared with TLV in all groups in both positions. In all three groups PaO₂ was significantly higher during SLV in the lateral than in the supine position [7]. Those studies demonstrated that, during SLV with a patient in the full-lateral position, gravity augments the redistribution of perfusion to the ventilated lung, resulting in a better V/Q match and a higher PaO₂.

As a result of these factors, the degree of shunt and hence conventional ventilation with 100% oxygen is usually associated with accepted PaO₂ values. As in robotic thoracic surgery, partial lateral decubitus position with 30–45 degree surgery side up is utilized; blood flow to the nondependent lung is not completely reduced to decrease the shunt fraction, attributing to patient hypoxia as another added factor. As we had CPAP breathing circuit applied to the nondependent limb of the double lumen tube, the main advantage of this breathing circuit is that it has small reservoir bag that can be utilized for manually ventilating the collapsed lung with small pediatric tidal volumes simulating baby lung ventilation. Manually ventilating the lung all throughout the whole length of the procedure is not practically feasible in all situations and subjected to personal variations. Mechanically ventilating the nondependent lung with portable ventilator utilizing the pediatric mode of ventilation can replace this manual technique. We find it very effective in improving the oxygenation of the patient with decreased FiO₂ of the ventilated lung to 0.8 and at the same time, not disturbing the operative field.

Differential lung ventilation can be used during thoracotomy, VATS procedure, or robotically assisted thoracoscopic cardiac or thoracic surgery whenever OLV is followed by hypoxemia despite adequate ventilation of the dependent lung with 100% oxygen and failed other techniques to maintain oxygen saturation [8].

**Conflict of Interests**

The authors declare that there is no conflict of interests regarding the publication of this paper.

**References**


