Application of indigenous continuous positive airway pressure during one lung ventilation for thoracic surgery

Rahul Yadav,
Arvind Chaturvedi,
Girija Prasad Rath,
Keshav Goyal

Department of Neuroanaesthesiology, All India Institute of Medical Sciences, New Delhi, India

ABSTRACT

During one lung ventilation (OLV) hypoxemia may occur due to ventilation-perfusion mismatch. It can be prevented with application of ventilation strategy that prevents atelectasis while minimally impairing perfusion of the dependant lung. Here, two cases are reported who required OLV and in whom hypoxemia could be prevented with the application of continuous positive airway pressure to the deflated or non-dependant lung, using an indigenous technique. We suggest use of this technique which is easy to be employed during the intraoperative period.

Address for correspondence:
Dr. Girija Prasad Rath,
Department of Neuroanaesthesiology,
Neurosciences Center,
6th Floor/Room No. 9, A.I.I.M.S.,
New Delhi - 110 029, India.
E-mail: girijarath@yahoo.co.in

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INTRODUCTION

One-lung ventilation (OLV) is required for surgeries involving lung, esophagus, aorta, or mediastinum. During OLV, one of the lungs is ventilated, however, both are perfused. Perfusion of the non-ventilated lung leads to increased trans-pulmonary shunting, impaired oxygenation, and hypoxemia.[1,2] Here, we report two cases who required OLV and in whom hypoxemia could be prevented with the application of continuous positive airway pressure (CPAP) to the non-dependant lung, using an indigenous technique.

CASE REPORT

CASE 1

A 36-year-old man with prolapsed intervertebral disc at $D_{8\text{-}9}$ and $D_{9\text{-}10}$ was scheduled for video-assisted thoracoscopic discectomy. After induction of anesthesia with a standard technique, the airway was secured with 37F left-sided double lumen tube (DLT). Apart from standard monitoring, left radial artery was cannulated for invasive blood pressure (BP). The duration of anesthesia was 8 hours and 40 min and OLV was done for 6 hours. The anesthesia machine did not have an in-built CPAP device, hence, an indigenous method with modified Jackson-Rees' (Mapleson F) circuit was used [Figure 1]. Tail of the reservoir bag was partially occluded with elastoplast and oxygen insufflated continuously at approximately 4-5 L/min, which generated a pressure of 4-5 mmHg. The SpO_2 was maintained at more than 94% throughout OLV. Arterial blood gases (ABG) revealed acidosis owing to hypercapnea [Table 1], however, no intervention was needed. The surgery was uneventful at the end of which the patient was shifted to intensive care unit (ICU) for elective ventilation. The trachea was extubated after 12 hours and he had an uneventful hospital stay, thereafter.

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CASE 2

A 42-year-old female with D_8 vertebral space occupying lesion was scheduled for right lateral thoracotomy, corpectomy, and decompression. After induction with a standard anesthetic technique, rocuronium was administered to facilitate tracheal intubation with 35F left-sided DLT. Anesthesia was maintained with air in

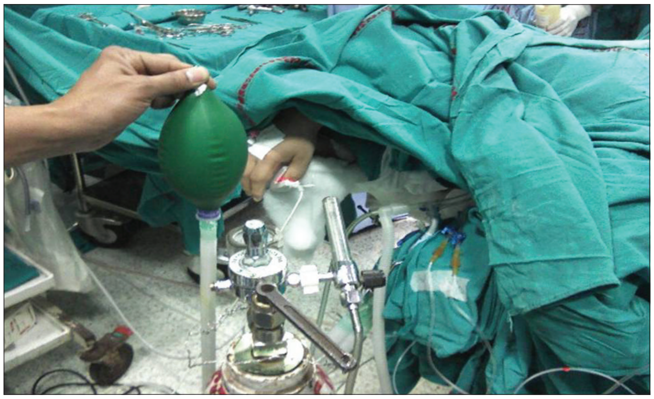

Figure 1: Modified Jackson-Rees' circuit for CPAP application

Table 1: Arterial blood gases in patient # 1 at various intervals

pH	pO_2	pCO_2	HCO_3	BE	SaO_2 (%)
7.23	75	56	22.2	−4.1	94
7.20	80.4	55	22	−4.3	95

Table 2: Arterial blood gases in patient # 2 at various intervals

pH	pO_2	pCO_2	HCO_3	BE	SaO_2 (%)
7.26	80.8	51.3	22.5	−3.4	95
7.25	79.1	51.2	21.8	−3.9	94.3

oxygen and sevoflurane. The duration of surgery was 8 hours. OLV was done for 5 hours, and CPAP was applied to the non-dependent lung using the same indigenous technique. Total blood loss was 1000 ml, and 2 units of packed red blood cells (RBC) were transfused. ABG showed acidosis due to hypercapnea [Table 2]. She had an uneventful postoperative recovery.

DISCUSSION

During ventilation in the lateral position, approximately, 35 and 55% of cardiac outputs take part for gas exchange in the non-dependent and dependent lungs, respectively. OLV creates an obligatory right-to-left transpulmonary shunt through the non-ventilated/non-dependent lung. Theoretically, an additional 35% should be added to the total shunt fraction during OLV. However, assuming active and uninhibited hypoxic pulmonary vasoconstriction, blood flow to the non-dependent hypoxic lung is reduced by 50% making an additional requirement of 17.5%. Another 5% must be added to it, which is the obligatory shunt through the non-dependent lung. Hence, the total shunt through non-dependent lung is 22.5%. With 5% shunt in the dependent lung, total shunt during OLV is 22.5+5=27.5%. This results in an arterial oxygen tension (PaO_2) of 150 mmHg (FiO_2 = 1.0).[3] Other considerations that impair optimal ventilation to the dependent lung are absorption atelectasis, accumulation of secretions, and the formation of fluid transudate in the dependent lung, which create a low ventilation/perfusion (V/Q) ratio and a large P(A-a) O_2 gradient.

The single most effective maneuver to increase PaO_2 during OLV is the application of CPAP to non-dependent lung. Oxygen administration to the non-dependent lung is mostly used to prevent and treat hypoxemia which can be done with or without CPAP. A CPAP level of as low as 3 mmHg have been shown to be effective for oxygenation.[4,5] It maintains patency of the non-dependent lung alveoli, thereby allowing uptake of oxygen. CPAP can be applied to the non-dependent lung using simple systems, all of which have essentially the same features such as an oxygen source, usually insufflated with 5 L/min of oxygen, a pressure relief valve, and a pressure gauge. Routine CPAP may not only improve oxygenation, but also be beneficial in reducing injury to the non-ventilated lung as re-expansion of non-ventilated lung after OLV leads to release of oxygen radicals, thereby causing reperfusion injury.[6,7] The above cases demonstrate the clinical effectiveness of CPAP application to the non-dependent lung during prolonged OLV for prevention and treatment of hypoxemia with the use of commonly available Jackson-Rees' circuit, albeit utilizing minor modifications.

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