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## One lung ventilation at high altitude (11600 ft) for video assisted thoracoscopic surgery (VATS) in a case of covid-19 sequela-empyema thoracis

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### Abstract

Lung isolation for surgical facilitation by means of one lung ventilation (OLV) is seeing widespread use in all age groups due to increasing incidence of thoracoscopy and video-assisted thoracoscopic surgery (VATS). Lung isolation is most commonly achieved by use of double-lumen endotracheal tubes with or without a bronchial blocker. Development of intraoperative hypoxaemia (arterial oxygen saturation <90%) caused by OLV is a known hazard. In high altitude area (HAA), the lowered amount of O<sub>2</sub> caused by a decrease in the barometric pressure (BP) leads to hypobaric hypoxia. Covid 19 directly impacts the lungs and damages the alveoli in the affected individuals exacerbating the hypoxia. Though rare, respiratory long-term sequelae of COVID-19 such as lung abscess can occur. The management of hypoxia in the course of lung isolation was a challenge especially in the high-altitude scenario with a Covid-19 background.

The present report is of an adult male with high COVID-19 antibody titres who underwent video-assisted thoracoscopic surgery at a service hospital located in a high-altitude area (HAA) with altitude 11600 ft. One lung ventilation was performed with a 39 Fr left double lumen tube. Correct placement was confirmed with fiber optic bronchoscopy. The surgery was uneventful and the patient was electively ventilated postoperatively for 48 hrs. No complications were noted peri-operatively. The soldier was subsequently discharged for convalescence.

**Keywords:** one lung ventilation, lung isolation, high altitude area, double lumen tube covid-19

### Introduction

**Case summary:** The present report is of an adult male with high COVID-19 antibody titres who underwent video-assisted thoracoscopic surgery at a service hospital located in a high-altitude area (HAA).

### Patient details

Age/sex	Induction in HAA	Comorbidities	Smoking history	Presenting complaints
30y/male	In HAA since May 2020	No known	Non-smoker	Individual de-induced from 17000 ft with complaints of fever & cough (5 days) with DOE * 4days

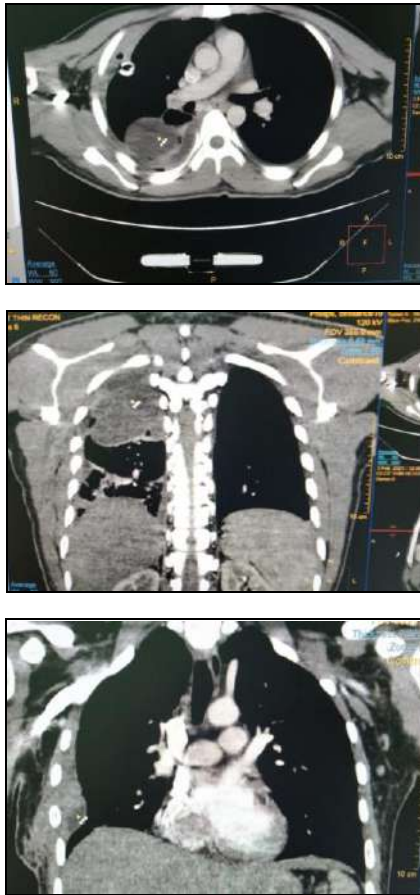
**Clinical condition on admission:** PR-106/min, regular; Spo 2-72% (room air); BP-106/72 mm hg.

**Systemic exam:** Chest: crackles + Rt. Infra scapular area & Infra axillary area. CXR PA view (22/1/21)-pleural effusion with consolidation RLZ; CECT chest + CTPA (23/1/21)-consolidation RLL with loculated pleural effusion. RT-PCR Covid-19-Negative. In view of his clinical profile, CT findings, dry tap under USG guidance, suspicion of Empyema thoracis raised.

ICD was inserted .10 ml fluid drained. Pleural fluid exam-Neutrophilic predominance, no AFB seen with normal ADA levels.

Repeat CECT chest (01/2/21)-consolidation RLL with Empyema thoracis.

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**Fig 1, 2, 3:** Rt lung lower zone consolidation with sub thoracic wall collection

In view of persistent fever & minimally improving radiological picture, patient underwent VATS procedure on 10/2/21.

Major peri-operative findings: 1. vascular adhesions of lung parenchyma with overlying pleura extensively 2. Consolidated lung apical segment (Upper Lobe). Placed on 2 ICDs. Patient was electively ventilated for 48 hours. He improved subsequently. Afebrile, ↓ dyspnea, ↓ cough.

Lab Inv: (on discharge) Hb-14.5 gms %, TLC-9000/, CRP-ve; Ser. Urea/creat-27/1.0.

His Covid antibody testing-strongly positive. He had been managed with IV antibiotics for 28-30 days (PIPTAZ/TARGOCID/CLINDAMYCIN).

Discharged for convalescence as a C/O EMPYEMA THORACIS(RT) with Consolidation (COVID Antibody +ve).

**Case description:** The two lungs are two separate organs morphologically, but act in synchrony to maintain the normal blood levels of oxygen and CO<sub>2</sub>. certain surgical

requirements mandate selective ventilation of the two lungs for surgical manipulation. This separation of two lungs, is termed as 'lung isolation'. This provides improved exposure of the surgical field, and protection of healthy lung from the affected one. The most widely used method of lung isolation is with double lumen tubes (DLTs). They have significant advantages over the other methods used for lung isolation, such as the ease of insertion and confirmation of position and the ability to isolate, selectively ventilate or collapse either lung independently according to operative requirement.

Patient was planned for video-assisted thoracoscopic surgery (VATS) under general anaesthesia. As a part of premedication, patient was administered i.v. 0.2 mg of Glycopyrrolate, 4mg of Ondansetron, 100 mcg of Fentanyl. A thoracic epidural catheter was placed for postoperative analgesic requirements. Preoxygenation was performed for a full 5 min followed by administration of intravenous Propofol 2 mg/kg. Bag and mask ventilation of the patient was confirmed prior to administration of intravenous suxamethonium 2 mg/kg. The patient's Cormack Lehane (CL) score was graded as class 1. A 39 Fr Mallinckrodt left DLT was chosen considering the patient's gender, weight and height.



**Fig 4:** Placement of double-lumen tube

As a standard precaution, the DLT was checked for its patency, integrity of cuff, the proper connections including the soft rubber extensions, the Y-connector to the circuit and finally the availability of the clamps used for blocking one side of the tube while checking the correct position. Under direct laryngoscopic vision, the DLT with its stylet in the bronchial lumen was introduced in the oral cavity, with the bronchial lumen facing anteriorly and advanced into the larynx. Once the bronchial cuff is beyond the glottis, the stylet was removed and the tube rotated by 90° on its long axis towards the left side. Further negotiation of the tube was done by pushing the tube slowly till a definite resistance was encountered.



**Fig 5, 6, 7, 8, 9:** Siting of the left sided double lumen tube under general anaesthesia

### Confirmation of position of double-lumen tube was done by

1. Sequentially inflating the respective cuffs, blocking the individual components of the DLT (tracheal or bronchial) with a clamp and observing the entry and exit of air through the unblocked component, observing the unilateral expansion of the chest and finally auscultating the chest for presence or absence of breath sounds.

The fiber-optic bronchoscope (FOB) was used to see inside both tracheal and bronchial lumina of DLT; when in tracheal lumen, the scope at the Carina, showed the blue-coloured bronchial stem of DLT entering into the left bronchus. Use of FOB to directly visualize the position of the DLT has been shown to increase the success rate of DLT insertion, to save time and reduce the complication rate and is strongly recommended [1, 2, 3, 6].



**Fig 10:** Confirmation with FOB

2. Right lung deflation was confirmed via chest auscultation during clamping of the tracheal lumen. This was further reconfirmed by direct visualization of the successfully deflated right lung by the surgical team during thoracoscopy.

Both lungs of the patient were initially ventilated with fraction of inspired oxygen (FiO<sub>2</sub>) 1.0. General anaesthesia was maintained with intravenous atracurium 5 mg/kg and sevoflurane. OLV was commenced by clamping the tracheal cuff. Lung protective strategies, namely, low TV of 4-6 ml/kg, PEEP of 5-10 cm H<sub>2</sub>O [15] and FiO<sub>2</sub> of 1.0 were employed during OLV, maintaining generating SpO<sub>2</sub> >92%. The tidal volume (TV) and Peak Inspiratory Pressure (PIP) achieved were 320-380 ml and 32-35 cmH<sub>2</sub>O, respectively. During the OLV, Arterial Blood Gases (ABG) test did not show any worsening hypoxaemia with maintained oxygenation.

Major peri-operative findings: 1. vascular adhesions of lung parenchyma with overlying pleura extensively 2. consolidated lung apical segment (Upper Lobe). Placed on 2 ICDs. A 36 Fr sized chest drain was sited in the left pleural space (figure 4). Intraoperatively, the patient remained hemodynamically stable. he received a total of 3 L of crystalloids and colloids. and four units of packed cells for an operative blood loss of 1.5 L. At the end of the operation, both lungs were ventilated, and the right lung was carefully reinflated under direct visualisation before closure of the thoracic wound. The DLT was then replaced with an 8.0 mm PVC ETT before the patient was transferred to the

intensive care unit for postoperative care.

### Images 11,12,13-thoroscopic exposure showing loculated empyema left lung lower lobe with pleural adhesions

The total duration of anaesthesia and surgery was 3hrs and 2-5hrs respectively. The patient was electively ventilated for 48 hours. He was uneventfully extubated 2 days later. Subsequent serial CXRs showed resolving lung collapse and pleural effusion (figure 14). He improved subsequently and was Afebrile, ↓ dyspnea, ↓ cough. However, his Covid antibody titres was strongly positive.

### Outcome and follow-up

At 4 weeks postoperatively in the hospital, the patient had an improved clinical picture and was discharged on 6 weeks convalescence sick leave with pulmonology review at a tertiary facility of the armed forces.

### Discussion

Since the advent of OLV, the anaesthetic and surgical techniques have come a long way. Indications for OLV range from surgical to nonsurgical. Commonly performed thoracic surgeries under OLV are Lung resection procedures like Pneumonectomy, lobectomy, Wedge resection, Video-assisted thoracoscopic surgery (VATS).

The safety has increased and complications reduced significantly due to improvement in technique and equipment. Lung isolation is now being widely used in more versatile indications.

This case report is very significant in several aspects. It depicts the use of one lung ventilation (OLV) in an high altitude setting in the background of high Covid-19 antibody titres.

The patient tested positive for covid-19 antibody serological test with a high IgG titres level, though his RT-PCR test was negative. Serological tests for SARS-CoV-2 are antibody-based assays that measure an individual's humoral immune response to SARS-CoV-2. Therefore, unlike nucleic acid amplification tests (NAATs, RT-PCR s), which detect viral RNA, serological tests do not directly detect pathogens. A positive serology result may indicate either a current or past infection and does not differentiate between the two. SARS-CoV-2 antibodies typically become detectable approximately 2 or more weeks after the onset of symptoms [16]. It seems both IgM and IgG rise around the same time. Current IDSA guidelines suggest using IgG antibody to provide evidence of COVID-19 infection symptomatic patients with a high clinical suspicion and repeatedly negative NAAT testing [17].

Our patient developed consolidation of his right lower lung zone with associated empyema thoracis. He had persistent high-grade fever with rising TLC counts in spite of prolonged multi-antibiotic regimen. This was confirmed by serial contrast-enhanced chest CT scans. Right sided VATS was planned requiring OLV for optimum surgical exposure. The successful placement of the left DLT was confirmed clinically as well as by FOB, as there is strong evidence supporting the routine use of it as diagnostic and troubleshooting tool [3, 4]. Fortunately, this open surgical repair was conducted entirely in an almost-supine position, thus not much of patient repositioning was required. *Inoue et al.*, reported 1.0 cm of movement can cause DLT malpositioning, jeopardizing OLV [7].

High-altitude (HA) environments have adverse effects on the normal functioning of people accustomed to living at low altitudes because of the change in barometric pressure

which causes decrease in the amount of oxygen leading to hypobaric hypoxia. Sustained exposure to hypoxia has adverse effects on body weight, muscle structure and exercise capacity, mental functioning, and sleep quality [10]. The partial pressure of O<sub>2</sub> (PaO<sub>2</sub>) in the atmosphere falls as barometric pressure falls. Therefore, the change in BP at HA is the basic cause of decrease in the amount of O<sub>2</sub> leading to hypobaric hypoxia (HH). Atmospheric pressure and the PaO<sub>2</sub> decrease at increasing altitude in a logarithmic fashion. The atmospheric PaO<sub>2</sub> is 159 mm Hg at sea level and 53 mm Hg on the summit of Mount Everest.

Maximal Oxygen Consumption (VO<sub>2</sub> Max) is the maximum capacity of an individual's body to transport and use O<sub>2</sub> during exercise, which reflects the physical fitness of the individual.

VO<sub>2</sub> Max begins to decrease significantly above an altitude of 1600 m. For every 1000 m above that it drops by approximately 8-11%.

Since at altitude the transfer of O<sub>2</sub> to the active muscles is reduced, particularly during whole body exercise or respiratory pathology, fatigue occurs at lower work rates. The reduction at HA is usually ascribed to the reduction in mitochondrial PO<sub>2</sub>, which interferes with the function of the electron transport chain responsible for providing cellular energy [3, 8].

The incidence of hypoxia during one-lung ventilation (SpO<sub>2</sub> of <90%) is about 5%. Development of hypoxaemia (arterial oxygen saturation <90%) caused by OLV can be explained by following three factors.

1. Reduction in oxygen stores of the body.
2. Poor oxygenation.
3. Compromised ventilation.

Directly due to the underlying Covid-19 disease process and also the collapse of one-lung, the functional residual capacity and hence the oxygen stores of the body get significantly reduced in a situation of OLV. These as well as effects of anaesthesia and the semi-lateral decubitus position make the patient highly prone to hypoxia. Compression of ventilated, dependent lung by the weight of mediastinum and by abdominal contents after diaphragmatic paralysis further adds to the severity of atelectasis of the ventilated lung and hence ventilation-perfusion mismatch, finally terminating in hypoxia.

Given this background, prevention and treatment of hypoxaemia during one-lung ventilation is paramount. pre-operative lung function was optimised. bronchodilators were administered 24hrs prior for airway dilatation. mucolytic agent administration and chest physio-therapy to remove secretions was done.

The maximum possible SpO<sub>2</sub> was targeted so that an adequate margin of safety is available in case of emergency. A planned approach to combat intraoperative hypoxia helped prevent complications.

An experienced surgeon was leading the surgery to reduce operation time and minimize complications. Intraoperatively following measures were taken

1. Clear airway of mucous secretions or blood in ventilated lung
2. Increase PEEP up to 10 cm of water to ventilated lung (left). 10 cm of PEEP improves the FRC of dependent lung.
3. Use of lower tidal volumes 5-6 ml/kg [15].
4. FiO<sub>2</sub>: 100%.
5. Suction catheter connected to auxiliary O<sub>2</sub> port was placed in lumen of non-ventilated lung airway.
6. Optimisation of cardiac output by administration of

fluids titrated to CVP.

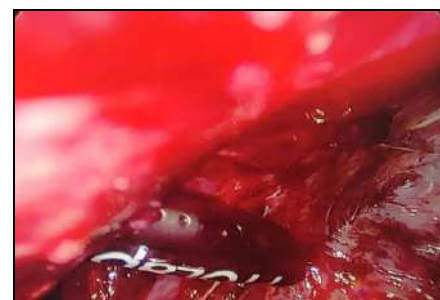
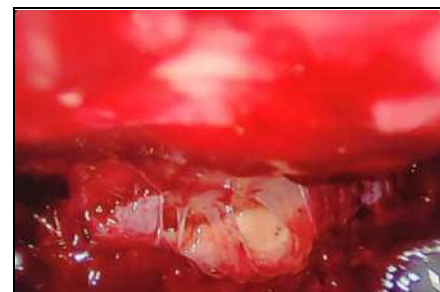
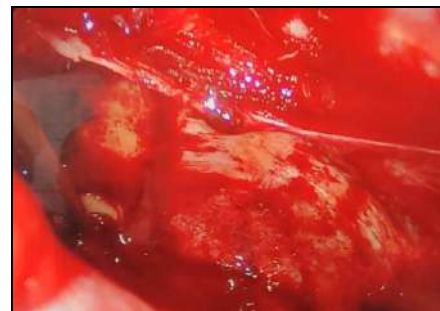
Undoubtedly, these measures had helped us to ensure an uneventful outcome of the surgery in a safe environment.

**Abbreviations:** One lung ventilation=(OLV); FOB=fiberoptic bronchoscopy; VATS=video-assisted thoracoscopic surgery; DLT=double lumen tube; HAA= high altitude area.

**Attachments:** Images 11,12,13-thoracoscopic exposure showing loculated empyema left lung lower lobe with pleural adhesions with attempted surgical decortication.

#### Acknowledgments

I am thankful to the patient for giving the consent to share the experience of handling his case. I also thank all my operating room assistants (ORA s) for the active cooperation with this case. Thank you all.



**Fig 11, 12, 13:** Thoracoscopic exposure showing loculated empyema left lung lower lobe with pleural adhesions with attempted surgical decortication



**Fig 14:** Subsequent serial CXRs showed resolving lung collapse and pleural effusion

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