One Lung Anaesthesia

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INTRODUCTION

Endobronchial or one lung anaesthesia is the term applied to the technique by which gases are deliberately excluded from the whole or part to one lung. It is employed in thoracic surgery for the following reasons:

1. Prevent the spread of infected secretions from the pathological to the normal lung during pulmonary resections.
2. Improve operative conditions by providing a quiet unventilated lung on the side to be operated on.
3. Improve access to other thoracic organs such as the oesophagus and aorta.

DOUBLE LUMEN ENDOBRONCHIAL TUBES

The current method of providing one lung anaesthesia is by the use of double lumen endobronchial tubes. These are tubes with a double lumen, one of which is long enough to reach into one of the bronchi while the other terminates in the trachea. The advantage of this method is that it enables either or both lungs to be ventilated independently and at will. Separation of the gas flow to each lung, and also of infected material in the bronchical tree is achieved by the inflation of a cuff placed on the endobronchial portion of the longer lumen. A tracheal cuff placed just above the opening of the shorter lumen prevents leakage of gas during positive pressure ventilation. Tubes are designed for both right and left main bronchi. In the former the lateral aspect of the bronchial cuff is fenestrated so that gas exchange with the right upper lobe is possible. At the oral end of these tubes the two lumens are connected to the anaesthesia machine by a device permitting inspired gas to be diverted to one or both lumens. This device allows.

1. Each lumen to be opened to atmospheric pressure separately so that gas may escape from an unventilated lung or
2. That a suction catheter may be passed down one lumen while ventilation of the other lung continues.

When surgery is performed on the right lung a left sided tube is used. For surgery on the left lung a right or left sided tube can be used. However, use of a right sided tube poses the problem of right upper lobe collapse if the ventilation slot is not closely apposed to the right upper lobe orifice. For this reason some anaesthetists use a left sided tube for all cases requiring one lung ventilation. In cases where clamping of the left main stem bronchus is necessary the tube can be withdrawn into the trachea at the time and used as a single lumen tube (The bronchial cuff is deflated and both lumens are used to ventilate the right lung).

Correct positioning of the double lumen tube is the most important determinant for the safety of one lung ventilation cases. Any doubt in the position of the tube may be resolved by the use of fibre optic bronchoscopy.

PHYSIOLOGICAL FACTORS EFFECTING GAS TRANSFER DURING ONE LUNG ANAESTHESIA

During one lung endobronchial anaesthesia the area of lung over which respiatory exchange takes place is reduced where as the metabolic processes that determine respiratory demand remain unchanged. Consequently changes develop in arterial oxygenation, and carbon dioxide clearance.

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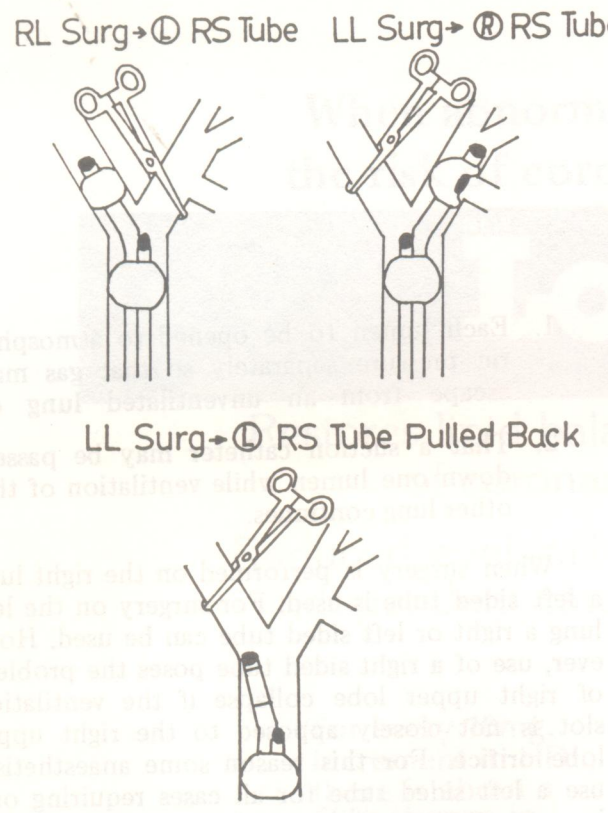

FIGURE 1 Position of left and right-sided double lumen tubes.

1. ARTERIAL OXYGENATION

Arterial Oxygenation is effected by several important factors such as intra-pulmonary shunt, inspired oxygen tension, function of the ventilated lung, cardic output and residual gas in the unventilated lung.

1. INTRA PULMONARY SHUNT

Intra pulmonary shunt is the most significant factor effecting arterial oxygen tension during one lung anaesthesia. Blood passing through the collapsed and unventilated lung does not become oxygenated and when it is mixed with oxygenated blood from the ventilated side will lower the resultant arterial oxygen tension. This blood constitutes the intra-pulmonary shunt. Blood flow through the unventilated lung may be affected by several passive mechanical, and active vaso constrictor mechanisms during surgery, the most significant being hypoxic pulmonary vaso constriction.

The normal response of the pulmonary vasculature to atelectases is increased pulmonary vascular resistance (P. V. R). This is thought to be due almost entirely to hypoxic vasoconstriction. During one lung anaesthesia, therefore, pulmonary vascular resistance in the collapsed lung will increase, therby diverting blood flow from the unventilated lung & conseqnently decrease, therby diverting blood flow from the unventilated lung & consequently decreasing intra pulmonary shunt.

Various drug used in clinical anaesthesia can inhibit this flow liversion. Those specifically studied are systemic vaso dilators such as nitroglycerine and nitroprusside and also dobutamine and B2 agonist such as isoproterenol and salbutamol. Vaso constrictor drugs such as dopamine, epinephrine and phenylepherine appear to constrict normoxic lung vessels thereby diverting blood flow to atelactatic lung and so increasing shunt.

The halogenated anaesthetic agents have been shown to exhibit dose dependant inhibition of (H. P. V) hypoxic pulmonary vaso constriction in animal studies, where as the intravenous do not. Recent studies in patients undergoing thoracotomy in the lateral decubitus position indicate that Halothane and isoflurane in approximately IMAC doses do not decrease arterial oxygenation any more than intravenous anaesthesia during stable one lung conditions.

Since these frugs also have a number of desirable properties (Permit use of higher inspired oxygen concentration are repidly aliminated and have few negative Cardiovascualr effects at IMAC doses) hereby are statisfactor anaesthesics during one lung anaesthesia.

The other factors effecting blood flow to the unventilated lung are gravity, surgical compression of the lung and ligation of pulmonary vessels.

Thoracic surgery is usually carried out with the patient in the lateral decubitus position with the lung to be operated on upper most. The use of this position will alter the distribution of blood flow so that especially in a paraysed patient and one with a thoracotomy the majority of blood passes to the lower lung under the influence of gravity. However once the lugn is

collapsed and lies at the level of the heart this effect should be minimal.

Measurement of blood flow through the unventilated lung in man is difficult. Direct measurement with an electromagnetic flow meter has been attempted but the technique is limited by the shortness and inaccessebility of the pulmonary artery. The flow is usually assessed by measuring differences in alveolar to arterial oxygen tension.

2. THE FUNCTION OF THE VENTILATED LUNG

During one lung anaesthesia the efficiency of the ventilated lung is of Vital importance in insuring adequate arterial oxygenation. During thoractomy in the lateral position the efficiency of the dependent lung is impaired as its volume is reduced by the compression of the unsupported Mediastinum and the paralysed raised inferior diaphragm. Both functional residual capacity (FRC) and tidal volume are reduced. While both lungs are being ventilated the inspired gas is distributed preferentially to the upper exposed lung because its compliance increase while that of the lower lung falls. Also in the lateral decubitus position the dependent lung lies almost completely below the level of the heart, so that in the presence of low airway pressure, high atrial pressure or both, there will be a tendency for pulmonary vascular congestion and interstitial oedema. Thus the combination of low functional residual capacity, tidal volume and hydrostatic effects all increase the likelihood of atelectasis and decrease in oxygenating ability (increase in intra-pulmonary shunt).

Patients in whom this lung is already compromised by disease adequate arterial oxygenation may be impossible even with an inspired 02 concentration (Fl 02) of 100%.

Preoperative assessment of patients selected for one lung anaesthesia should therefore include careful clinical and Radiological examination of what is to be the ventilated lung, particularly in the presence of aspiration following tracheal injuries broncho-pleural fistulae and severe Bilateral pulmonary disease.

In practice it is possible to minimise the effect of attelectases in the dependent lung by

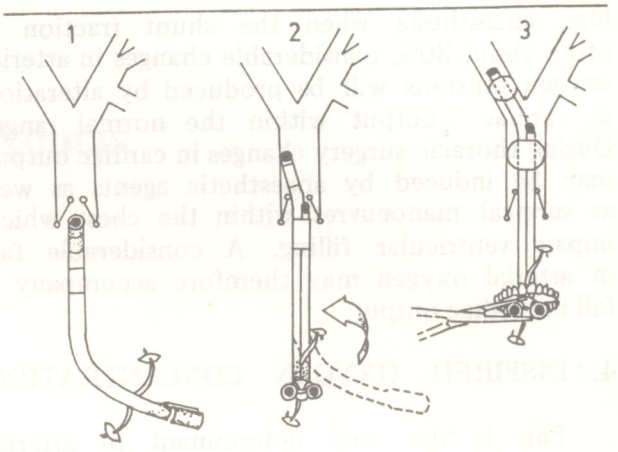

FIGURE 2 Positioning of left-sided double-lumen tube during insertion.

the use of large tidal volumes. Nilson Slater and Greenberg found that the increase in shunt fraction between the beginning and end of 17. Thoracic operation was well corelated with the percentage fall in tidal volume, at the commencement of one lung anaesthesia.

When the same tidal volume (10-15 ml kg) was put into one lung as had previously been put into two, there was no significant deterioration in overall oxygenating ability as measured by shunt fraction. At the end of the operation when tidal volume was allowed to fall by 30-40% during one lung anaesthesia the shunt fraction was 10% more than at the beginning.

3. CARDIAC OUTPUT

The amount of change in arterial oxygen tension for a given change in cardiac output is related to the shunt fraction. During one

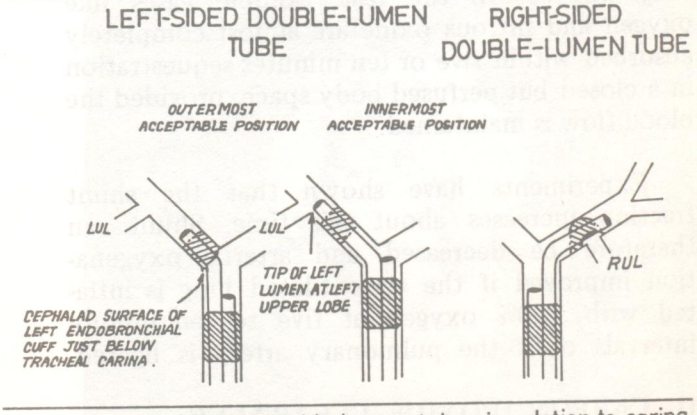

FIGURE 3 Position of double-lumen tubes in relation to carina upper lobe bronchi.

lung anaesthesia when the shunt fraction is often about 30%, considerable changes in arterial oxygen tensions will be produced by alteration in cardiac output within the normal range. During thoracic surgery changes in cardiac output may be induced by anaesthetic agents as well as surgical manoeuvres within the chest which impair ventricular filling. A considerable fall in arterial oxygen may therefore accompany a fall in cardiac output.

4. INSPIRED OXYGEN CONCENTRATION

This is the only determinant of arterial oxygen tension which is under the direct control of the anaesthetic. Because there are several variables which can have a profound effect on arterial oxygen tension it is difficult to predict arterial oxygen tension at any given inspired oxygen level. It would seen prudent therefore to use at least 95% inspired oxygen during the period of one lung anaesthesia to ensure adequate arterial oxygen. However if pre-operative ventilation and perfusion scanning and or differential bronchospironetry have indicated that perfusion of the un-ventilated lung is minimal then a lower inspired oxygen level may be used.

5. RESIDUAL GAS IN THE UNVENTILATED LUNG

The amount and composition of the gas left in the unventilated lung during one lung anaesthesia will exert a temporary effect on arterial oxygen tension. When ventilation of the exposed lung ceases the majority of gas escapes to the atmosphere through the open end of the double lumen tube; blood passing through the collapsed lung will absorb the rest. Soluble gases like oxygen and nitrous oxide are almost completely absorbed within five or ten minutes sequestration in a closed but perfused body space, provided the blood flow is maintained.

Experiments have shown that the shunt fraction increases about this time. Shunt can therefore be decreased and arterial oxygenation improved if the unventilated lung is inflated with 100% oxygen at five to ten minute intervals or if the pulmonary artery is ligated.

II. CARBON DIOXIDE CLEARANCE

When patients were allowed to breathe spontaneously during thoracotomy severe respiratory acidoses frequently developed. The use of controlled positive pressure ventilation almost invariably solved this problem. Observation of the effect of one lung anaesthesia on carbon dioxide clearance have been made by several groups of investigators. The consensus of opinion is that provided the minute volume of the one lung is maintained at the same level as the originally distributed to both, the carbon dioxide tension should not be expected to rise.

MANAGEMENT OF ONE LUNG ANAESTHESIA

Would therefore include the following:

1. Maintenance of large tidal volumes (at least 10 ml/kg) during periods of one lung anaesthesia, both to maintain Carbon dioxide clearance and minimise atlectases in the dependent lung.

2. High inspired oxygen level, at least 95% during the period of one lung anaesthesia.

3. Frequent checking of arterial oxygen tension and adjustment of inspired oxygen level with an aim to maintain arterial oxygen tension at 100-120 mm Hg.

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