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Lobectomy for cavitating lung abscess with haemoptysis: strategy for protecting the contralateral lung and also the non-involved lobe of the ipsilateral lung

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We describe the anaesthetic management of a patient undergoing lobectomy for cavitating lung abscess complicated by haemoptysis. Surgery for lung abscess is one of the absolute indications for the use of a double-lumen tube (DLT). Because pus or blood could impede fibreoptic-assisted DLT placement, a traditional, blind placement of the DLT was performed. To protect the uninvolved parts of the operated lung, ventilation of the lung with the abscess was not performed until the resection of the involved lobe had been completed.

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Current management of lung abscess[1–3] in the main involves appropriate antibiotics, physiotherapy and, where indicated, chest tube drainage: thoracotomy tends to be restricted to those cases not responding to intensive and prolonged medical management or those complicated by haemoptysis,[4] empyema, malignancy or suspected malignancy. Thus, unlike the era before antibiotics, today the thoracic anaesthetist has limited experience in anaesthetizing patients with cavitating lung abscesses. One of the main aims of anaesthesia is to protect the so-called good lung from contamination, and the introduction of the endobronchial tube and the double-lumen tube (DLT) in the 1950s overcame the need to employ awkward and inconvenient patient positioning, such as the Parry Brown or the Overholt positions. The former relied upon intra-operative drainage by gravity of infective material via the trachea, while the latter relied upon retention by gravity within the abscess cavity. Now, the use of a DLT or a tube-and-blocker is mandatory during thoracotomy for lung abscess or for frank haemoptysis.[5]

Even so, when planning anaesthesia for a patient with a high risk of purulent material and/or blood draining by gravity into the major airways, the anaesthetist and surgeon still face several dilemmas. First, should the patient stay in the sitting or semi-sitting position until lung separation is achieved? Secondly, what is the operative team's preferred DLT placement plan for such a case? Thirdly, should an effort be made to minimize the dissemination of infective material throughout the operated lung as well as the good lung?

Case report

Pneumonia that had failed to resolve over a 12-month period, in a 32-yr-old previously well woman, led to a consolidated left lower lobe with a large cavitating lung abscess. Early in this disease, she had developed haemoptysis and on many occasions had coughed varying amounts of frank blood, sometimes in excess of an estimated half-teacup. Later, she was coughing purulent sputum streaked with blood. She said that the episodes of haemoptysis were caused by her lying flat, and as a consequence she slept in a sitting position and would not allow herself to be placed otherwise. Such was her fear of further haemoptysis that she refused physiotherapy and totally rejected any suggestion of postural drainage. Her weight decreased from 75 to 46 kg, and she developed marked clubbing of the fingers and toes. The preoperative chest x-ray and CT scan are shown in Figures 1 and 2 respectively.

Extensive investigation failed to identify any underlying pathology. There was no evidence of immunosuppression or aspiration. Bronchoscopy revealed no endobronchial lesion and washings were positive for *Pseudomonas aeruginosa*. She was admitted on several occasions with fever, increas-

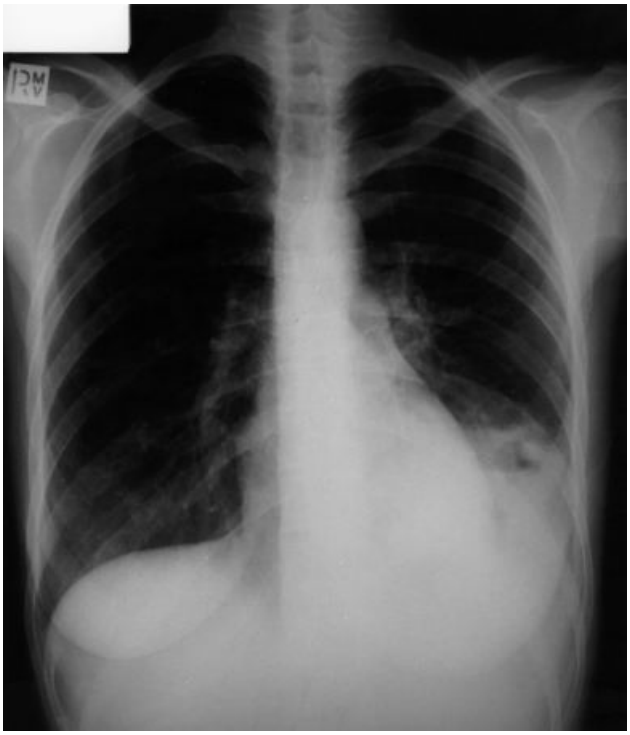

Fig 1 Posteroanterior chest x-ray revealing a left lower lobe opacity and an abscess with fluid level.

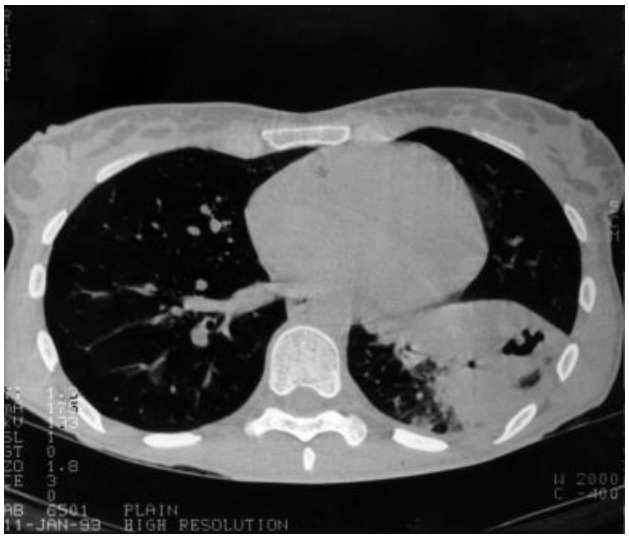

Fig 2 CT chest scan at the level of the apical segment of the left lower lobe, revealing consolidation and cavity formation.

ing dyspnoea and/or haemoptysis, and although on each occasion there was a response to broad-spectrum intravenous antibiotics, lobectomy was advised when the haemoptysis became more voluminous and she became significantly anaemic. The favoured preoperative diagnosis was either localized bronchiectasis or pulmonary sequestration. Histopathology of the resected lobe revealed an actinomycosis abscess but no other underlying abnormality.

The patient was anaesthetized in a semi-sitting (50° head-up) position, with meticulous preoxygenation, midazolam 1 mg, fentanyl 200 μg in divided doses, an initial dose of propofol 80 mg and rocuronium 40 mg. While the patient was maintained in the 50° head-up position, gentle hand ventilation with oxygen was performed for 3 min. The patient was then placed horizontally and, without further ventilation, elective rigid bronchoscopy was performed by the surgeon to assess bronchial anatomy/pathology and to perform tracheobronchial suction. An estimated 3 ml of purulent material was removed by direct suction from the trachea and airways, and the surgeon advised that the major airways were small.

In the light of this comment, and with fibreoptic bronchoscope and left and right Robertshaw DLTs immediately at hand, a 35 FG Left Sheridan DLT was inserted blind, to the perceived desired depth. Inflation of the bronchial cuff to a tension greater than usual in the 5 ml inflating syringe and the pilot cuff was achieved with a relatively small volume of air. Cautious hand ventilation via a single catheter-mount connected to the DLT bronchial lumen was observed to produce left chest movement. Transfer of ventilation to the tracheal lumen produced right chest movement, and the tracheal cuff was inflated to produce a seal. Next, the single catheter mount was transferred back to the bronchial lumen and auscultation over the anterior apical region of the left chest during gentle hand ventilation confirmed the presence of vesicular breath sounds. From that point onward, single-lung intermittent positive pressure ventilation was restricted to the right lung until the left lower lobe resection had been completed. During the period when it was not ventilated, the left lung was connected to a 3-litre oxygen reservoir at ambient pressure.[6] For reasons that will be discussed, the fibreoptic bronchoscope was not used either before or after positioning the patient for surgery.

During the chest incision and until the thoracic cavity was opened, the reservoir bag was seen to distend and collapse as expected with each cycle of single-lung ventilation to the dependent lung.[6] This tidal movement of the reservoir bag was in this case less pronounced than usual and, although this was most likely a consequence of the left lower lobe pathology, the possibility of distal migration of the DLT to occlude or partially occlude the left upper lobe bronchial orifice was also considered. However, because the peak and plateau inflation pressures in the ventilated dependent right lung were as expected and because there was no reduction in pulse oximetry while performing single-lung ventilation with a fresh gas flow of 50% N_2O/O_2, no intervention was thought necessary or justifiable. This decision was vindicated by prompt left upper lobe collapse when the chest was opened and easy re-expansion when the surgery was completed.

Once the chest was opened and the operated lung was able to collapse down, the oxygen reservoir was temporarily

detached from the bronchial lumen of the DLT while further purulent material was removed by suction. Only then was some air cautiously removed from the DLT bronchial cuff to return it to a more usual tension. This was performed whilst listening with an ear pressed to the reservoir bag in order to immediately identify possible gas leakage past the cuff during the inspiratory phase of ventilation.[6]

At surgery, the left lower lobe was distended and also patchily consolidated. It was densely adherent over a large part of its diaphragmatic surface, but, apart from the need to divide these adhesions, the lobectomy was uneventful and the chest was closed with an apical and a basal drain. Before the re-expansion of the left upper lobe, the bronchial tree on that side was again cleared by suction via the DLT bronchial lumen. At this time it was noticed that a considerable volume of purulent material had drained from the operated lung, filling the DLT bronchial lumen and extending into the tubing leading to the reservoir bag.

Throughout the period of single-lung ventilation and an $F_{I_{O_2}}$ reading of approximately 0.4, the $S_{p_{O_2}}$ remained between 98 and 100%.

Postoperative recovery was uneventful, and the patient was able to lie happily in whatever position she liked.

Discussion

With a cavitating lower lobe abscess, the first dilemma facing the anaesthetist and surgeon is whether or not to aim to achieve DLT lung separation while the patient is maintained in a steep sitting or semi-sitting position. With the case described, this decision was influenced by the fact that a preoperative rigid bronchoscopy was planned in order to make a surgical assessment of the pathology, to clear secretions and to identify any atypical bronchial anatomy. Conacher has said for the same reasons, with regard to the need for rigid bronchoscopy in the assessment or therapy of bronchopleural fistula, that 'most experienced personnel prefer to base the anaesthetic technique around this requirement'.[7]

For the rigid bronchoscopy, the patient was anaesthetized in the semi-sitting position (about 50° from horizontal) but was put in the horizontal position with the onset of good muscle relaxation. The bronchoscopy and bronchial suction under direct vision were performed without delay, and no further ventilation was performed until after the DLT was positioned and the bronchial cuff inflated. Even so, some management teams might strive to retain the patient in the semi-sitting position for the bronchoscopy and until such time as lung separation is secured.

The course of action chosen depends on the preferred practice of the individual surgical/anaesthesia team and by the clinical circumstances of the individual patient. Rigid bronchoscopy with the patient 50° head-up used to be the accepted management for sputum retention after pulmonary resection, but today it is a disappearing skill. Any partial reduction of the degree of head-up tilt of our patient might well have resulted in spillage of infective material into the lower lobe bronchus of the 'good' lung.

Alternatively, performing or attempting to perform fibreoptic assessment and fibreoptic-assisted intubation with a patient maintained in the sitting position can be difficult or prolonged if secretions obscure vision.

Should suxamethonium have been used? Probably not in this patient, but it would certainly be advisable in any patient in whom difficulties might be expected with gentle face-mask hand-ventilation.

Should anaesthesia have been induced with the patient sitting on the horizontal lower half of an operating table that is broken at the mid-point, with the patient's thorax reclining, abscess-side dependent, against the steeply angulated upper half? Probably, yes! Once asleep and paralysed, the patient could easily have been maintained abscess-side dependent, and the head-up tilt could have been reduced if necessary to facilitate bronchoscopy and intubation.

The next dilemma relates to the choice of DLT and the plan for its placement. The necessary decisions will depend on previous experience and preferences. In this case, a range of DLTs and a fibreoptic bronchoscope were immediately at hand. The first management option was the blind placement of a 35 FG Left Sheridan DLT, because it was felt that pus or blood might obscure the view at fibreoptic bronchoscopy. A plastic tube was chosen in preference to a Robertshaw DLT because the external diameter of a medium Robertshaw could have been too tight for the reputedly small airways. Otherwise, the more firmly anatomically shaped Robertshaw tube would have been chosen. This DLT frequently appears to drop into place and, in the authors' view, is less likely to become dislodged by surgical traction in the course of the operation.

If the left-sided Sheridan DLT had entered the right rather than the left main bronchus, the plan was to replace it immediately with a medium or small left Robertshaw. If the left Robertshaw had also entered the right main bronchus, it was to have been replaced immediately with a right Robertshaw. Use of the fibreoptic bronchoscope to guide one of the left-sided clear plastic tubes down the left main bronchus was considered as a last resort in our team's order of priorities for this particular patient. However, since a plastic and not a Robertshaw DLT was being used, a good case could have been made for positioning a fibreoptic bronchoscope down the tracheal lumen and observing, if secretions had permitted, the passage of the bronchial component into the left main bronchus.[8 9]

A conscious decision was made not to check DLT placement with the fibreoptic bronchoscope that was immediately at hand. The small volume of air injected into the bronchial cuff of the left-sided DLT to produce an airtight seal, the free gas movement in and out of the right lung and the confirmation of vesicular breath sounds in the left upper lobe by the anaesthetist who was also performing the gentle hand ventilation were considered assurance

enough. With these findings and in this particular case, the anaesthetist would not have deflated the cuffs and pulled back the tube, even if bronchoscopy via the DLT tracheal lumen had failed to reveal any sign of the bronchial cuff.

The third dilemma relates to the protection of the healthy parts of the lung that contains the abscess. The frequent removal of secretions during surgery by suction via the DLT lumen on the diseased side is the standard recommendation.[5] A further and not previously reported measure is to refrain from ventilating the lung with the abscess until the risk of contamination is removed. If adopted, this will involve a period of single-lung ventilation while the chest is being opened and hence before the non-ventilated lung is able to collapse away from the chest wall. We recommend that the airway of the non-ventilated lung is connected to an ambient-pressure oxygen reservoir to prevent ambient air and therefore nitrogen from entering the non-ventilated lung.[10] This practice has several benefits, both theoretical and practical.[6]

One of the possible theoretical benefits while the patient is being positioned ready for surgery and while the chest is being opened is the oxygenation of the blood that continues to flow through the non-ventilated but not yet collapsed lung. This results in an atypical ventilation/perfusion mismatch, with good oxygenation of the shunted pulmonary blood flow but with no elimination of carbon dioxide once the P_{CO_2} of gas in the reservoir bag has equilibrated with that of the mixed venous blood. This atypical mismatch will in theory be expected to result in a small further increase in the relatively large arterial to end-tidal carbon dioxide gradient seen during thoracic anaesthesia.[11] Thus, if there is a delay in opening the chest and hence a delay in lung collapse, arterial blood gases may be required to guide the level of minute volume ventilation.

In the case presented, an additional practical benefit of the ambient-pressure oxygen reservoir was demonstrated. Once the chest was opened and surgery was progressing, the anaesthetist was able, by listening with the ear pressed against the reservoir bag,[6] to deflate the bronchial cuff carefully to a more usual tension without risk of creating an unidentified loss of the airtight seal.

The small tidal movement in the reservoir bag before the chest was opened was probably caused by the pathological process in the left lower lobe, and by infective material draining by gravity and obstructing or partially obstructing major airways on that side. It may also have been partly a consequence of dependent lung ventilation causing mainly diaphragmatic rather than mediastinal displacement in this very thin patient.[10]

In conclusion, anaesthesia for thoracotomy for cavitating lung abscess, with or without a history and hence risk of haemoptysis, should involve preoperative physiotherapy to reduce secretions, appropriate patient positioning with the lobe containing the abscess dependent relative to the rest of the bronchial tree, careful preoxygenation, and an anaesthesia plan that achieves prompt lung separation. Elective rigid bronchoscopy before DLT placement allows both surgical assessment of bronchial pathology and anatomy, and the efficient removal of secretions or pus. Once lung separation is achieved, not ventilating the lung with the abscess may reduce the risk of contamination of healthy parts of this lung. While the lung containing the abscess is not being ventilated, there are both theoretical and practical benefits in connecting this lung to an oxygen reservoir at ambient pressure. After the diseased lobe has been excised, suction via the DLT lumen on that side before re-expansion of the residual lobe will remove any purulent material that has drained from the abscess in the course of surgery.

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