ANAESTHETIC ASPECTS OF BRONCHIAL FISTULA

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Since the term bronchial fistula can, from the practical point of view, be applied to any abnormal connection between the inside of the intrathoracic respiratory system and the outside, it includes a very wide assortment of cases. Fistulae vary in their acuteness and duration from a few minutes up to thirty years or more (Huizinga and Smelt, 1950), and in their consequences from the rapidly fatal to the almost insignificant. Although the anaesthetic management of these cases falls mainly within the province of those working in specialized units, any anaesthetist may be caught unawares from time to time. Quite apart from this consideration the subject is well worth discussing because of its intrinsic interest and because it has probably called for as much anaesthetic ingenuity and resourcefulness as any other subject within the specialty.

AETIOLOGY

There are many ways in which a bronchial fistula may arise, but it is usually sufficient to bear in mind the commoner and more important ones. An empyema very frequently communicates with the bronchial tree and, conversely, a lung abscess sometimes opens into the pleura. In either of these cases there is a grave danger of pus flooding the respiratory tract. A lung cyst or an emphysematous bulla may burst and give rise to leakage of air from the lung, and in the case of a ruptured tuberculous cavity there is obviously danger from both these complications.

Accidental trauma to the chest may cause a bronchial tear or rupture, and the deliberate trauma of pneumonectomy or resection may result in a fistula, usually as a consequence of infection in the bronchial stump.

DIAGNOSIS

The diagnosis of bronchial fistula is surprisingly often in doubt, and therein lies one of its chief dangers to the anaesthetist. The features of the condition depend upon whether the chest is open or closed, and in the latter case upon whether the fistula is valvular or not. A valvular opening in a closed chest, for example, will allow air to enter the pleural space from which it cannot then escape, and the result is a tension pneumothorax, with dyspnoea, cyanosis, and displacement of the mediastinum to the opposite side. If the air is able to leak around the pleura as well, and into the mediastinum, the pneumothorax may not be severe, but there will be surgical emphysema, sometimes sufficient to blow up the whole body like the Michelin man of the advertisements. At the opposite extreme, a nonvalvular fistula in an open chest, for example in an old empyema which has been draining through a sinus or a tube for twenty or thirty years, will present no dramatic features at all, and the patient's only complaint may be that the noise of his air leak makes people think he is carrying a small animal in his coat pocket.

Various things may suggest the presence of a fistula, the coughing up of foul sputum in a case of empyema, for instance, especially with change in posture; or the persistent bubbling of a water seal drain postoperatively. There are various useful diagnostic tests which may be carried out. Firstly, if a pneumothorax is aspirated, in the absence of a fistula it is obviously possible to reach a stage at which practically all the air has been withdrawn, and the intrapleural pressures will then show a positive-negative swing approximating to the normal range. But, in the presence
of a communication between the bronchial tree and the pleura, the pneumothorax is constantly refilled from the lung, and it is possible to go on aspirating air indefinitely without ever producing a negative intrapleural pressure. Secondly, if a radio-opaque dye is put into the chest to replace aspirated fluid and outline the extent of a sinus, the appearance of a partial bronchogram is conclusive proof of the presence of a fistula (fig. 1), and conversely the same is true if lipiodol from a bronchogram appears in the pleural space. As an alternative to this test methylene blue may be injected into the pleura, and in the presence of a fistula it will often appear in the sputum. It is also interesting to remember, as Coope mentions, that because of the different rates of diffusion of oxygen and carbon dioxide in a self-contained pneumothorax, as opposed to one which communicates with a bronchus, it is possible to diagnose the presence of a fistula by gas analysis (Coryllos, 1937; Coope, 1951).

For convenience, the main causes and effects of different types of fistula are roughly summarized in table I.

**TREATMENT**

Once diagnosed, the treatment of a fistula depends on its cause, and need not be discussed in detail here. However, in many cases it is to assist in the treatment, by operation, that the anaesthetist is called upon to do his work. It should go without saying that every one of these cases must be assessed on its individual merits and fully discussed with the surgeon before anything is done.

The patient may come to theatre with a closed chest, or with an open drainage tube, or with an underwater seal drain, or with a "stoma", which simply means a hole in the chest wall to facilitate drainage. In any case he should be accompanied by a postero-anterior and lateral X-ray of his chest taken not more than a few hours previously, and in the absence of these films he is best left severely alone. The first point in the anaesthetic management of these cases is to see just what is inside the chest in the way of fluid or pus, and just where it is; and in order to be of any value at all this information must be right up to the minute.

**ANAESTHETIC PROBLEMS**

The problems peculiar to these cases, from the anaesthetic point of view, may be grouped under two headings:

1. Spillover of fluid.
2. Leakage of air and gases:
   - (a) to the outside;
   - (b) into the pleural space.

**Spillover of fluid.**

The fluids most likely to enter a fistula are pus from an abscess or empyema, and blood from an operation site. Apart from the immediate mechanical danger of gross respiratory obstruction through blockage, with pus there is the danger of pneumonitis and pulmonary suppuration, and with blood there is the danger that once having entered the bronchial tree, which it may do quite silently, it will clot and be irremovable by suction (Mushin and Rendell-Baker, 1953).
## Table I

**Classification of Fistulae**

<table>
<thead>
<tr>
<th>Cause</th>
<th>Type of fistula</th>
<th>Features</th>
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<tbody>
<tr>
<td>CONGENITAL</td>
<td>Tracheo-oesophageal.</td>
<td>Inhalation of feeds, etc.</td>
</tr>
<tr>
<td>TRAUMATIC</td>
<td>Stove-in chest, fractured ribs with damaged lung.</td>
<td>Paradox.</td>
</tr>
<tr>
<td></td>
<td>Open chest with damaged lung or bronchus.</td>
<td>Haemopneumothorax.</td>
</tr>
<tr>
<td></td>
<td>Tear or rupture of bronchus in closed chest.</td>
<td>Paradox, mediastinal flap, hae-morrhage, channelling.</td>
</tr>
<tr>
<td></td>
<td>Rupture of subpleural bleb, emphysematous bulla, lung cyst or tuberculous cavity, in a closed chest.</td>
<td>Pneumothorax, may be bleeding. Surgical emphysema.</td>
</tr>
<tr>
<td>Operative:</td>
<td>Air leak into closed A.P.</td>
<td>Haemopneumothorax.</td>
</tr>
<tr>
<td>(2) Bronchotomy at opn.</td>
<td>(1) Stitch hole leakage.          (2) Bronchiolar fistula.</td>
<td>Persistent blow of drainage tube.</td>
</tr>
<tr>
<td></td>
<td>(3) Frank B-P fistula.            (4) Bronchiolar pocket.</td>
<td>Pyopneumothorax, with or without drain or stoma.</td>
</tr>
<tr>
<td>INFECTIVE</td>
<td>Bronchopleural, or long standing bronchocutaneous.</td>
<td>Cough. Foul sputum with posture.</td>
</tr>
<tr>
<td></td>
<td>Rupture into bronchus in closed chest.</td>
<td>Danger of drowning in spill-over.</td>
</tr>
<tr>
<td></td>
<td>Bronchobiliary, etc. Closed chest.</td>
<td>Characteristic sputum.</td>
</tr>
<tr>
<td>NEOPLASTIC</td>
<td>Bronchopleural, oesophageal or mediastinal, or postop.</td>
<td>Pneumothorax, may be bleeding or abscess, or surgical emphysema.</td>
</tr>
</tbody>
</table>

There are essentially three methods of guarding against spillover:

1. Positive pressure.
2. Posture.
3. Occlusion and exclusion.

Magill (1936) pointed out that not only is positive pressure respiration justifiable in the presence of a fistula, which acts as a safety valve, but that it is also very useful as a means of preventing fluid from entering the bronchial tree. A constant outgoing stream of gases will tend to blow fluid away from the opening and keep it clean, and in practice this is a very satisfactory way of handling a small fistula in a relatively dry field. It is the method commonly adopted of necessity when a blocker has not been used and the surgeon inadvertently opens a bronchus with bleeding going on in the vicinity, and it may well be adopted from choice in selected cases.

**Case 1.** Mr. H. W. had a left upper lobectomy and corrective thoracoplasty in a Swiss sanatorium in 1953. He was seen in Cheshire in 1955, after he had started to cough up considerable quantities of sputum, and suspicion of a bronchopleural fistula was confirmed by chest aspiration and a methylene blue test. A stoma was made, and the patient did well; later he was admitted to the Chest unit in Liverpool to have his sinus widely laid open for skin grafting.

The patient was anaesthetized with thiopentone and suxamethonium; his larynx and trachea were sprayed with 4 per cent lignocaine and, after intubation, anaesthesia was maintained with nitrous oxide and oxygen and small supplements of thiopentone. There was a definite air leak, but the sinus was quite dry until, during the operation, considerable bleeding was encountered from branches of the cephalic vein. From
this time until the end of the operation the anaesthetist kept his hand on the bag, gently assisting the respiration and maintaining a slight positive pressure. No blood entered the bronchial tree.

The question of posture raises the theoretical possibility of two schools of thought, rather as in the case of acute intestinal obstruction. Either the patient must be tilted so that the fluid stays where it is, at the lowest point of the chest, or else he must be tilted to an extreme degree in the opposite direction so that fluid will drain through the trachea without spilling to the unaffected parts of the lungs. As a rule this latter method is impracticable and fraught with danger, and there is fairly general agreement on this point. It has been taught for years that rib resection for drainage of an empyema or abscess should be performed under local anaesthesia with the patient sitting up, to prevent spillover and drowning (Brock, 1952; Lee, 1953), and there is no doubt that, as Barrett tersely remarks, “this accident happens” (Barrett, 1950). Belcher and Grant (1955), in discussing the management of postoperative fistula, stress that on no account should postural drainage through the communicating bronchus be attempted as this will almost invariably lead to aspiration pneumonia. In practice, although the drainage position looks quite safe, there are two objections: firstly, the outpouring of pus can be so copious that by the time it is sucked out the patient is hopelessly anoxic, and secondly, there is an inevitable time interval while the positioning of the patient is going on, during which he is in an unsafe position. If the fistula is small, and the quantity of fluid in the chest is also small, it is reasonably safe to put the patient in the lateral position and maintain controlled respiration with a slight positive pressure, bearing in mind that if spillover does occur at any stage the table must immediately be tilted and effective suction instituted. In the presence of a large fistula and a chest full of fluid, to turn the patient into the lateral position with the affected side uppermost is asking for trouble.

The opposite principle of posturing, the anti-drainage principle, is often summarized by saying that the fistula must be kept above the fluid level (Mushin and Rendell-Baker, 1953). It will usually be the case that when the patient arrives in the theatre, in whatever position he may be, his fistula will be above his fluid level, and in the case of a fistula near the hilum, such as may follow pneumonectomy, for example, this must be so, or he would already be drowned. But it is not always either true or necessary that this should be the case; a patient with a large empyema and a fistula somewhere in the lower lobe may come to theatre sitting up, with his fistula submerged in pus, but he comes to no harm, and he will continue to be safe as long as his position is such that the communicating bronchus inclines upwards out of the fluid at a sufficient angle. It is, of course, dangerously misleading to interpret the dictum as meaning that the patient must be arranged so that the fistula is above the fluid level. In the example given above, for instance, this could be done by tilting the patient head down, but any such manoeuvre would almost certainly result in emptying the whole empyema into the bronchial tree.

As an alternative to the sitting position, which is inconvenient if the surgeon wishes to operate towards the back of the chest, the face down position may be used. The patient is rolled on to his face with the affected side passing underneath, and is then fixed in position with the chest at a slight angle so that the side to be operated on is still lower than the normal side. In this way a collection of pus in the lower chest can be prevented from spilling, especially if a head up tilt is also maintained throughout.

Although the following case is not one of bronchial fistula, it is a good illustration of the value of posture.

Case 2. Miss A. W., suffered from gross bronchiectasis of the left basal segments and lingula, and in spite of prolonged pre-operative postural drainage it was feared that secretion would be copious during resection of the affected segments. After induction with thiopentone and tubocurarine, bronchoscopy was performed in the supine position, and suction was carried out. With percussion of the left side of the chest during the bronchoscopy it was possible to remove a considerable quantity of sputum. A Magill tube was then passed, and anaesthesia continued with nitrous oxide and oxygen. The patient was turned into the face down position, with approximately a 30 degree head up tilt, and in this position the surgeon was able to secure the bronchi and vessels without disturbing the dependent position of the lower lobe and lingula. In spite of the fact that the lower lobe was virtually a bag of pus, there being a cavity in the anterior basal
segment 2.5 x 1.5 cm, no difficulty was experienced by the anaesthetist, and no secretion was aspirated during the operation.

The third method of avoiding spillover of fluid, the theoretically ideal method, is to block off the fistula in some way or exclude it from the rest of the bronchial tree. However, since this is also an important method of controlling air leak through a fistula, it will be more convenient to discuss it in that connection.

Leakage of air and gases.

The air leak through a fistula may be so slight that the anaesthetist is unaware of it until the surgeon points it out, or it may be so gross that with gas flows up to 20 l./min it is impossible to inflate the patient. If the chest is open the air leak results in channelling of gases along the line of no resistance, that is between the trachea and the fistula, with the result that the remainder of the lungs are underventilated, or not ventilated at all. This in turn has two consequences; firstly, hypoxia and carbon dioxide retention are inevitable, and secondly it is impossible to keep the patient asleep with an inhaled anaesthetic. The danger of explosion through leakage is considerably stressed in the literature (Hewer, 1944), but not many people nowadays regard an intact pleura as a reliable safeguard, so that in any chest case the use of diathermy with explosive agents is uncommon.

If the chest is closed, air leak through a fistula leads to a tension pneumothorax, with increasing cyanosis, and resistance to inflation. The mediastinum is displaced, and in the presence of spontaneous breathing shows a marked respiratory shift, the great veins are compressed and cardiac action is thus enfeebled. Once recognized this state of affairs is dramatically relieved by putting a needle into the chest. It should also be remembered that a distensible lung cyst can be blown up to a remarkable extent and can produce exactly the same picture in the absence of any fistula at all (Gray and Edwards, 1948).

Another occasional complication of air leakage is surgical emphysema, which may be alarmingly increased by positive pressure inflation. This sometimes happens also with rupture of the oesophagus when the patient is inflated with a face mask (Dundee, 1955; Schweizer and Holland, 1956).

In the management of air and gas leakage there are again three possible methods of approach:

(1) Spontaneous respiration.
(2) Controlled respiration with positive pressure.
(3) Occlusion and exclusion.

It has been mentioned that a patient may live for many years with a bronchial fistula and suffer relatively little inconvenience. In such cases the physiological effects of the lesion are minimized by pleural thickening and rigidity of the mediastinum, and the same can be said for many postoperative cases. With a fistula after pneumonectomy, for example, if the mediastinum is fairly fixed and the remaining lung is healthy, there is no reason to expect gross distress. With a good sized drainage tube to ventilate the empty hemithorax, or with a stoma, the patient is just as well off breathing through a bronchial stump as through his nose and mouth; he has in fact the advantage of a greatly reduced dead space, one better than a tracheotomy from the functional point of view, but regrettably inaccessible to the anaesthetist. In many cases of this kind there is everything to be said for letting the patient breathe spontaneously throughout the operation, provided he can be kept asleep. It is certainly the method of choice for the anaesthetist who is not an expert at manipulating blockers, and for small operations on the patient who is too ill to tolerate much instrumentation. If the chest is dry, the patient may be placed in any position which suits the surgeon's convenience. If there is pus in the chest and the operation is such that the patient must be in a position which threatens spillover, it is essential to block or exclude the fistula.

Case 3. This middle-aged man complained of haemoptysis, and chest X-ray showed shadowing of the right upper lobe suggestive of tuberculosis or neoplasm. Bronchoscopy was inconclusive, due to bleeding from the upper lobe opening, and a thoracotomy was carried out. This revealed a carcinoma for which an upper lobectomy was performed, but during the procedure bleeding into the bronchus was profuse and the anaesthetist was unable to cope with the situation in spite of a steep head down tilt. Bronchoscopy and suction were carried out, and the operation continued successfully. Postoperatively the patient did not do well, presenting a variety of
symptoms and signs which suggested a diagnosis of periarteritis nodosa. He was treated with cortisone, and shortly afterwards his bronchial stump broke down and left a full bore fistula of the right upper lobe bronchus. He was ill and emaciated, but his chest had been drained and was fairly dry. Intubation was performed under local anaesthesia, and nitrous oxide and oxygen were then administered with a high flow-rate, the expiratory valve being kept closed. By this means, with the occasional addition of a little trichloroethylene, it was possible to anaesthetize the patient sufficiently to enable the surgeon to open the chest and control the air leak. Suxamethonium was then given, and controlled respiration instituted, with a high flow of gases. The patient made a good recovery from the operation, but subsequently died.

Reference has already been made to the second method, controlled respiration with positive pressure. Magill (1936) pointed out that a fistula acts as a safety valve and renders positive pressure safe, and this technique is frequently used. With a large fistula it may be quite impossible to keep up with the leak, even with both oxygen and nitrous oxide by-passes down, but it is usually feasible to keep the patient going until the surgeon can stop the leak, or reduce it, with a pack.

**Occlusion and exclusion.**

It is now necessary to consider the question of bronchial occluders and endobronchial intubation. The idea of blocking off a diseased part of the lung, or excluding it from the rest of the respiratory tract, has caught the imagination of anaesthetists since the earliest days of major thoracic surgery. Gale and Waters (1931) discussed the use of one-lung anaesthesia; Magill did much work on it in the nineteen-thirties; and Nosworthy (1941), speaking of broncho-pleural fistulae in his classic paper on thoracic anaesthesia, described one-lung anaesthesia as the ideal method. It is widely appreciated among thoracic anaesthetists that to block off the lower lobe or the whole lung on either side is comparatively easy, but the upper lobes, and the right upper lobe in particular, present a much more difficult problem.

In a case of empyema or abscess, with a fistula in the lower lobe, spillover and air leak can be controlled quite simply by passing a bronchus blocker into the affected lower lobe bronchus under direct bronchoscopic vision (fig. 3a). The Vernon Thompson blocker is preferable to the Magill, being less likely to slip, but it should be remembered that neither is infallible in this respect. Two points about this procedure are worth stressing; firstly it must be performed without putting the patient into a position in which spill-over can occur, and, secondly, the patient must not be allowed to become anoxic. If the patient is cyanosed to begin with, and has a large fistula, it is extremely dangerous to give suxamethonium and rely on inflating with oxygen; the value of this oxygen is negligible if it just blows straight out through the fistula, and if the chest is closed or the drainage tube is clamped off, there is the additional risk of producing a tension pneumothorax. There are no cases in which prolonged pre-oxygenation is more valuable than these, since it may offer the only hope of providing enough oxygen to last the patient until the blocker is in place: in the very ill, it is inadvisable to abolish or depress respiration even for one or two minutes, and the blocker should be placed in position under topical anaesthesia.

Postoperative fistulae present a special problem, because the bronchial stump is nearly always too short to hold a blocker of any kind.

After pneumonectomy there is nothing on the affected side into which to place a blocker, and the best way of dealing with such a case is to intubate the opposite side. With a left sided fistula, it is quite easy to pass a long Magill endotracheal tube into the right main bronchus and blow up the cuff at the carina. In this position the air leak is controlled, and the right upper lobe opening is not interfered with (fig. 2a).

**Case 4.** When this patient came to the theatre for a stoma operation following left pneumonectomy, he was thought to have a fistula. After induction with thiopentone and tubocurarine a long No. 10 Magill tube was passed blindly into the right main bronchus, and the cuff inflated. There was no air leak and nothing to be sucked out, and the anaesthetist began to doubt the existence of a fistula. At the end of the operation, however, atropine and neostigmine were given, and the trachea being quite dry, the cuff was deflated. The patient immediately woke up, coughed out his tube, and simultaneously the surgeon remarked that the fistula was blowing vigorously.

With a right sided fistula, the left main bronchus may be intubated either under vision with a Magill endobronchial tube, or blindly with a
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FIG. 2  
Main Bronchus Fistulae

(a) Endotracheal tube in right main bronchus with cuff occluding fistula after left pneumonectomy. If the short bevel is cut in the plane shown, the right upper lobe opening need not be blocked.

(b) Carlens tube in use after right pneumonectomy, showing how right side of tube can be used for suction and drainage. Testing for leakage after repair of the fistula is possible by blowing gases down this right side lumen.

Carlens tube (fig. 2b) or an M-L tube (Macintosh and Leatherdale, 1955). Blind intubation of the left main bronchus with an ordinary Magill endotracheal tube is much more difficult and uncertain, and the danger of attempting it in these cases is that if the tube enters the wrong side it may go straight through the fistula into the empyema.

Case 5. This patient came to theatre for attempted closure of a bronchopleural fistula following a right radical pneumonectomy for carcinoma. He was given thiopentone and tubocurarine, and intubated; but on inflation it was found that the air leak was unmanageably large. Atropine and neostigmine were given, and the patient was maintained on nitrous oxide and oxygen and trichloroethylene, with spontaneous respiration. The repair was not successful, and some days later, in the ward, the patient turned on his left side, flooded his bronchial tree, and nearly died. A second attempt at closure of the fistula was therefore made. Under thiopentone-tubocurarine anaesthesia, a bronchoscope was passed, but the instrument immediately filled with pus from the fistula, and the situation got out of hand. An attempt was made to pass a Magill endotracheal tube blindly into the left main bronchus, but it entered the fistula and inflation was impossible. The patient was gravely anoxic, and the heart stopped beating. Intracardiac adrenaline was ineffective, and cardiac massage was quickly instituted. The heart started again, and the operation was rapidly completed with the Magill tube in the trachea.

Closure of the fistula was successful, and the following morning the patient was awake, but was aphasic, and had a paresis of the right arm. There is no doubt that he had irreversible damage to the central nervous system due to anoxia, and he died a few days later.

After lower lobectomy, a blocker can be placed in the main bronchus immediately above the fistula. Such a blocker will often occlude the the upper lobe opening, especially on the left side, and thus produce an unaerated upper lobe which will slowly collapse as the operation proceeds (fig. 3b). In spite of the theoretical disadvantage of arteriovenous shunting, this is a practicable method which has the advantage of safety. There should be no difficulty in inflating the upper lobe again at the end of the operation, and it may be recalled in this connection that Organe (1949) has described the technique of deliberately intubating the right side for cases of patent ductus. The important thing is that the blocker should be as low as possible; there must be no opening into the upper lobe (or middle lobe, if this remains) below the blocker, or else this lobe is very likely to be flooded (fig. 3c).

The problems associated with occlusion and exclusion are greatest in the case of a fistula following upper lobectomy. It is not possible to use a blocker in the main bronchus above the upper lobe opening, or perhaps partly occluding it, since this would leave the lower lobe open to the fistula and liable to be flooded (fig. 4a). The same objection applies to intubation of the opposite side, which is only justifiable if the chest is perfectly dry. Actual occlusion of the upper lobe opening may be attempted by packing with ribbon gauze, as in Crafoord’s (1938) technique, although if this is done it is usually impossible to maintain an opening to the lower lobe (Halton, 1943); otherwise, it is necessary to use an endobronchial tube with a cuff to block the fistula, and side holes above this through which the opposite lung can be ventilated (fig. 4b) (Mansfield, 1947; Vellacott, 1954). For an upper lobe abscess, a special blocker, such as Mully’s (1950) may be used, but after upper lobectomy the only blocker likely to be practicable is Halton’s.

Case 6. Mr. A. A. had a right upper lobectomy for tuberculosis in 1954 followed by fistula. The danger of spillover was anticipated during repair of the fistula, and a suitable tube was improvised. A No. 8 Magill
(a) Showing blocker in left lower lobe bronchus.
(b) After lower lobectomy, if the blocker is introduced too far it may pass through the fistula, or be dislodged by the surgeon.
(c) If the bronchial stump is short, the blocker will necessarily occlude the upper lobe opening.

More serious than this is the danger that if the blocker is too high in position there will be flooding of the upper lobe behind it.

Depending on the position of the patient and the amount of fluid in the chest, it may be possible to rely on continuous suction through the catheter incorporated in the blocker to prevent this accident.

Endotracheal tube with a short cuff was selected, and the distal end cut off with a slight bevel immediately beyond the cuff. Several holes of about 1/4 inch diameter were cut in the tube above the cuff, around the circumference (it is not necessary for these holes to lie directly opposite the left main bronchial orifice; with a tube of this size there is enough space between the tube and the tracheal wall to allow ventilation of the left side without appreciable resistance). The whole tube was left rather long, and passed blindly into the right main bronchus. A second, detachable, cuff was fitted above the holes, to make an airtight fit in the trachea, so that controlled respiration could be used, and the operation proceeded without incident.

The patient's fistula subsequently broke down again, and he was readmitted to hospital in 1957 for a further repair. At this time the chest had been adequately drained for two and a half years, and there was no question of any fluid being present. Accordingly, the anaesthetist passed an ordinary endotracheal tube and allowed the patient to breathe spontaneously. The surgeon plugged the air leak at an early stage, and there was no difficulty at any time.

A variety of situations may be encountered in the case of traumatic fistulae. A tear of the main bronchus can be excluded by intubating the opposite side as indicated above; the tear may extend into the trachea, but this is of no consequence as long as the tube is airtight. After repair of the bronchus, the surgeon will usually wish to test for leaks and see whether the lung on the affected side is inflatable, and to allow this the tube can be withdrawn into the trachea. If a Carlens tube has been passed, it is merely necessary to connect up the affected side to the apparatus and inflate.

Case 7. This patient was investigated for dysphagia, and found to have a large round shadow in the right upper mediastinum. Bronchoscopy was normal, radio-active iodine studies were normal, and a test with 1 mg of tubocurarine showed no sensitivity suggestive of thymic tumour. At thoracotomy a bronchial cyst was found, adherent to the superior vena cava and the right side of the trachea, and during the dissection a hole was made in the trachea. Air leakage made adequate ventilation difficult until the hole had been sutured.

Postoperatively, the patient developed an air leak, with surgical emphysema, and at midnight on the second postoperative day it was decided to re-explore the operation site. A Carlens tube was passed under thiopentone-tubocurarine anaesthesia, and the left lung was inflated with nitrous oxide and oxygen. A good deal of muco-pus was aspirated from the right side when the patient was turned into the lateral position,
Upper Lobe Fistulae

(a) A blocker placed above the upper lobe opening has the same functional result as intubation of the opposite side. In either case the lower lobe is left wide open to the fistula. Accurate placing of the blocker so that it completely occludes an upper lobe fistula is so uncertain and difficult that it should not be relied on, except by an expert (Halton's upper lobe blocker was designed for this purpose). If an attempt is made to pack the fistula with ribbon gauze, the lower lobe bronchus will inevitably be blocked as well, but in a really difficult case this is a small price to pay for the prevention of flooding.

(b) On the right side it is much easier to place a balloon or cuff opposite the upper lobe opening with accuracy. The drawing illustrates the use of a fenestrated endotracheal tube with two cuffs.

and thoracotomy revealed a hole 2 × 2 mm in the trachea. It was possible to close this defect with stainless steel wire sutures and wire mesh, and the surgeon then wished to test the airtightness of the trachea. As a suitable Y-connection was not to be found at this time of night, the anaesthetist attached each bronchial tube to a separate Waters circuit, and maintained independent inflation of the two lungs. The trachea proved to be airtight, and recovery was uneventful.

It sometimes happens that the surgeon produces an unmanageably large fistula during a lung operation before the vessels are dissected, or while bleeding is going on. In addition to the anaesthetist's worries, the surgeon is irritated by the blowing of sputum into the operative field, and a certain mutual lack of sympathy quickly becomes apparent. Under these circumstances, the most satisfactory answer is for the surgeon to put a Crafoord clamp across the whole hilum. This effects a functional pneumonectomy for the anaesthetist, and gives the surgeon a clean dry field with an immobile lung.

Anaesthetic Management

As far as nonthoracic operations for unassociated conditions are concerned, only comparatively fit patients with long standing fistulae are likely to be presented, and they should give little trouble. Spontaneous respiration should be preserved wherever possible, and there is a place here for local and regional methods. The only other type of case which may give rise to difficulty is the spontaneous pneumothorax or the artificial pneumothorax who turns out, when inflated, to have a fistula. As long as the possibility of a tension pneumothorax is remembered, and treatment is not delayed, all will be well.

In the case of chest operations directly related to the lesion, the first choice to be made is between local and general anaesthesia. Many small procedures, such as rib resection, can be performed under local, but there are circumstances which often make general anaesthesia desirable:
the condition of the patient, sepsis in the operation area, doubt as to the diagnosis and extent of the operation, long and major procedures, nervousness of the patient, and childhood may be given as examples. In these cases there is a second choice to be made in selecting one of the possible general anaesthetic techniques. Many of the specific indications for particular methods of anaesthesia have already been discussed in relation to the characteristic problems involved, and it is hardly possible to say more about this without expressing merely individual preferences. The number of bronchial fistulae coming to surgery is quite small, and no one anaesthetist sees enough cases to be dogmatic about their management. Furthermore, in this condition it may safely be assumed that in some respect each case will be quite different from all the rest. The main purpose of this paper is to indicate the basic principles involved in the handling of fistulae; if these principles are applied to the individual case it will be found that the possible methods of approach are reduced to, at most, two or three, and the final choice will usually be determined by the anaesthetist's personal experience with the various techniques (table II).

Although some cases present a clear cut picture with a definite pre-operative diagnosis, it is not uncommon to be confronted with a rather doubtful case, in which the presence, or the size, of a fistula is uncertain. The intended operation may be short, and there may be no clear indication for a special technique; the surgeon himself may wish to find out whether there is a fistula, or where it is blowing from, in order to effect a repair, and in either of these cases the use of a blocker is inconvenient to him. For cases of this kind, the following "safety first" method is suggested.

A dextrose drip is set up with a threeway tap, as a convenient route for injections, and in case blood transfusion is needed. Any drainage tube in the chest is unclamped, and the patient is pre-oxygenated for at least three minutes in a semisitting position. He is then given a sleep dose of thiopentone, and a small dose, about 25 mg, of suxamethonium, and allowed to continue breathing oxygen until respiration ceases. His larynx and trachea are then sprayed with 4 per cent lignocaine through a Macintosh spray, and he is intubated with a cuffed tube. The cuff is inflated and the patient is connected to a Waters bag and given nitrous oxide and oxygen. The lungs are then gently inflated, and if the apparatus is leakproof, the size of the fistula can be estimated. If, as is usually the case, it is a small leak, a canister is included in the circuit, and controlled respiration is continued with intermittent doses of suxamethonium. If the fistula is gross, or if at any stage during the operation the surgeon makes it so, the patient can be left to breathe spontaneously and given a little trichloroethylene if necessary. All this induction is carried out in the semisitting position, so that the anaesthetist has the opportunity of dealing with his problems one by one, and can make a fair appraisal of the air leakage difficulty before he gets into any trouble with the other difficulty, spillover of secretions. Once the induction is completed, the positioning of the patient is governed by his X-ray and the surgeon's requirements, but throughout the procedure the suction machine stands by the anaesthetist's side, switched on, and with catheter ready attached, so that instantaneous action can be taken if there is any sign of contamination of the airway during the changes of posture.

Finally there remains to be considered the anaesthetic management of chest injuries. Any major injury to the chest, open or closed, may be complicated by air leakage, either from lacerated pulmonary tissue or from a major bronchus. With an uncontrolled open pneumothorax, one of the most important factors contributing to the poor state of the patient is the presence of paradoxical breathing and mediastinal flap; the same applies to closed crush injuries with multiple fractured ribs, in which the stability of the chest wall is lost. Coughing is ineffective, and in the presence of a fistula, blood from the site of injury may be disseminated throughout the bronchial tree. In these cases controlled respiration is of enormous benefit: paradox and mediastinal flap are abolished, and the improvement in the patient's condition, often accompanied by a return to consciousness as carbon dioxide is washed out, is dramatic. As soon as is practicable, the bronchial tree should be thoroughly sucked out through a bronchoscope, and there is something
to be said for using a short acting relaxant to institute controlled respiration, in case it proves impossible to keep up with the airleak. The danger of tension pneumothorax may be guarded against, in a closed case, by putting a needle into one of the upper intercostal spaces anteriorly, and leaving it there.

The use of relaxants can make a great difference to the prognosis of these cases, and in the event of future hostilities, in which large numbers of chest injuries may occur, some provision for organized management would be well worth while.

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REFERENCES


XI CONGRESSO SOCIETÀ ITALIANA ANESTESIOLOGIA

SYMPOSIUM ON CURARE AND OTHER MUSCLE RELAXANT DRUGS

A Symposium dealing with curare and other muscle relaxant drugs will be held in September 1958, under the auspices of the Ospedale al Mare, Venice.

There will be discussions on the Chemical, Pharmacological, Physical and Clinical aspects of muscle relaxants. The meeting will be held in connexion with the 11th Congresso Societa Italiana Anestesiologia and enquiries should be made to the Organizing Committee, c/o Dr. Ruggero Rizzi, Ospedale al Mare, Venice, Lido, Italy.