INHALED FOREIGN BODIES

BY

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The problems associated with *inhaled* foreign bodies usually receive little attention in the medical curriculum and in textbooks. This is in contradistinction to the *ingested* foreign body, which is well documented at every stage of its journey. The importance of the inhaled foreign body is demonstrated by the Registrar-General's (1954) statistics for deaths in England and Wales from this cause. There were 11 due to inhalation, as compared with 29 due to ingestion (Tables I and II).

TABLE I.—Total Deaths from Foreign Bodies in England and Wales, 1954

Trachea, bronchus, and lung	..	..	..	11
Digestive tract	..	..	..	29
Pharynx and larynx	..	..	..	443
Genito-urinary tract	..	..	..	5
Ear	..	..	..	1
Nose	..	..	..	1

TABLE II.—Ages of 11 Subjects who Died From Inhaled Foreign Bodies in Trachea, Bronchi, and Lungs in England and Wales in 1954

Age:	-1	-5	-15	-25	-35	-45	-55	-65	-75	-85
No.	4	1	0	0	0	1	1	1	1	2

A foreign body may be overlooked in diagnosis for many reasons. The highest incidence is in children who are too young to give a history (Fig. 1). The typical

FIG. 1.—Age incidence of cases.

tended by a baby-sitter when the foreign matter is inhaled (Table III, Cases 5 and 12). Again, a patient may choke and cough, and think that the object has been expelled, whereas in fact it has been inhaled from a larger sensitive tube to a smaller insensitive one (Case 8). Further, a small metallic foreign body may not cause any immediate disturbances, and only come to light years later from its pressure effects (Case 2). An object may also be inhaled when a patient is asleep, under the influence of alcohol, during an epileptic seizure, or during anaesthesia (Case 15). The foreign body is often thought to have been swallowed and that it will be passed by the bowel. Sometimes the early history is not known, and the presenting symptoms may simulate those of bronchitis, pneumonia, tumour, lung abscess, bronchiectasis (Case 6), tuberculosis, or emphysema (Coope, 1948).

Protective Reflexes

The inhaled object may stimulate the laryngeal mucosa and cause adduction of the cords. The patient chokes and coughs, and may expel the object. A large object which is not dislodged will cause complete obstruction of the larynx and death from asphyxia in a few minutes.

The cough reflex is normally protective for the trachea and bronchi, but each cough is preceded by a deep inspiration, and at this time, before the burst of explosive coughing, the object may be inhaled into the trachea. From here the further passage depends on the size and sharpness of the object. The tendency is for it to be inhaled as far as its size and shape will allow it to go.

If it is large, it will remain in the trachea, causing paroxysms of coughing; as it moves up and down and strikes the glottis from below it makes an "audible slap." If the movements are forcible in the trachea they may be easily perceptible as a "thud" or, if less forcible, as a "flutter" (Jackson and Jackson, 1950).

A smaller foreign body will pass into the right bronchus more commonly than the left, because of the larger diameter and the less acute angle at which this bronchus leaves the trachea. The posterior segmental bronchi are more commonly affected than the anterior.

Pathology

The nature of the foreign body determines the degree of further reaction. Metallic foreign bodies cause very little immediate inflammation, but in the course of time they become oxidized and the edge roughens, with consequent penetration and pressure. Organic substances such as nuts and beans cause an intense inflammation with oedema, granulations, and pus due to the contained fatty acids. As the material absorbs moisture and swells it progressively blocks the lumen of the passage in which it lodges. The younger the patient the more dangerous it is.

A foreign body lodging in a bronchus may occlude it either completely or partially. *Complete* obstruction is followed by atelectasis of the portion of the lung supplied by that bronchus (Asherson, 1953). Subsequently the inflammatory changes may take the form of pneumonia, bronchiectasis, lung abscess, and empyema. Partial obstruction may either allow relatively easy passage of air in both directions, in which case the later effects are due to local inflammation only, or it may take the form of a ball-valve obstruction. Air enters the lungs during inspiration when the bronchus dilates, but cannot pass out in the reverse direction during expiration because the bronchial mucosa becomes approximated to the sides of the foreign body. This results in obstructive emphysema.

Occasionally, combinations of these features occur. When a foreign body causes atelectasis of a lobe the remainder of that lung may become "emphysematous" even though it is not directly affected by the object. This is a process of "compensatory emphysema."

Diagnosis

The original accident is often dramatic, accompanied by choking, prolonged coughing, cyanosis, and dyspnoea. It cannot be overemphasized that such a history should be sought repeatedly from parents, guardians, and baby-sitters. Occasionally, however, a foreign body is inhaled into a distal bronchus without setting up any reflex during its passage. The diagnosis of metallic foreign body is easy, for, although it may cause few signs apart from those of bronchitis, it is clearly seen in either a postero-anterior or lateral radiograph. The diagnosis of a non-opaque foreign body can be made from physical examination. The presence of atelectasis will be shown by diminished movement, dullness to percussion, decreased air entry, with the trachea and apex

beat perhaps displaced to the same side and the diaphragm high (Fig. 2). Obstructive emphysema is characterized by decreased movement, overexpansion of the affected part of the chest, a hyperresonant or tympanic percussion note, and poor breath sounds, except in the early case when air is still entering in the inspiratory phase. Clinically this may be mistaken for pneumothorax, but radiographs taken in inspiration and expiration are diagnostic. A comparison of these two pictures shows the shift of the mediastinum away from the affected side on expiration, and the flattened diaphragm, with of course some lung markings in the emphysematous area (Fig. 3). The contrast in transparency of the two sides is not so evident on inspiration, for the compensatory increased movement of the sound lung fills it so well with air that there may be little difference between the translucencies of the two sides.

FIG. 2.—Case 4. Postero-anterior chest radiograph: atelectasis of left lung, with mediastinum drawn to the same side, high diaphragm, crowding of ribs, and ground-glass appearance of lung field.

FIG. 3.—Case 8. Postero-anterior chest radiograph: obstructive emphysema right lung, with mediastinum to opposite side, diaphragm depressed, and greater translucency of lung.

Differential Diagnosis

The differential diagnosis may be difficult if the history of inhalation is not obtained. Or if it is obtained and a foreign body is suspected the signs of laryngo-tracheitis *per se* will simulate those of a foreign body. This happened in a case not reported in this series:

A child went to bed sucking a boiled sweet, and was heard to cough and choke later. Although it had signs of laryngeal stridor and bronchospasm, there were none of localized obstruction radiologically. The child was prepared for bronchoscopy, but before the scope was introduced the cords were seen to be oedematous. This was thought (and proved) to be sufficient to cause the symptoms. The symptoms subsided with nursing in a steam tent and the administration of antibiotics.

Pressure on the bronchi from without, due, for example, to enlarged lymph nodes or mediastinal abscess, may give a clinical picture similar to that of inhaled foreign body. A good example is a foreign body lodged in the oesophagus, which may press on the trachea and cause partial obstruction.

If there is a reasonable likelihood of a non-opaque foreign body being in the air passages in a patient suffering from bronchiectasis, unresolved pneumonia, lung abscess, or obstructive emphysema he should have the benefit of a direct inspection of the air passages by an experienced bronchoscopist.

Treatment

The hope that a foreign body may be coughed up is unjustifiable, for this course of events occurs in only 3% of cases (Jackson and Jackson, 1950). The practice of inverting the patient and shaking him to displace the object is dangerous, for the object may move, become impacted in the glottis, and cause suffocation. It is imperative that a skilled bronchoscopist should remove the foreign body as soon as possible, under anaesthesia administered by a competent anaesthetist. There is one caution to this rule: if a child has had unsuccessful attempts at bronchoscopic removal when first seen, and is suffering from laryngeal oedema, this should be treated first and time allowed for the oedema to subside before another attempt is made (Case 3).

Anaesthesia

The importance of expertly administered anaesthesia for the successful removal of foreign bodies from the respiratory tract cannot be overemphasized. As Fig. 1 shows, the majority of our patients were infants and children, in whom it is notoriously difficult to administer safely an efficient anaesthetic for bronchoscopy. Several of our patients (Cases 1, 3, 8, 9, 11, and 15) had had previous unsuccessful attempts at removal of the object by bronchoscopy, probably necessitated by inefficient anaesthesia. Many of them suffered from anoxia of varying degree, sometimes with gross respiratory obstruction. Anaesthesia must provide the bronchoscopist with a tranquil oxygenated patient in whom all the tracheal and bronchial reflexes have been eliminated so that as much time as is needed can be spent in finding, seeing, and removing the foreign body.

We condemn as unsafe the use of relaxants to obtund respiratory tract reflexes in these circumstances. Suppression of these reflexes by this means occurs coincidentally with respiratory arrest. Unless the surgeon is interrupted continually by the need to ventilate the patient, serious and possibly fatal oxygen lack follows. We know of deaths that have occurred in this way. Surface analgesia with cocaine or, if desired, a similar but longer-lasting drug, forms the essential basis of the method of anaesthesia which we recommend. In adults unconsciousness is rarely indicated. Sedation with papaveretum and hyoscine followed by careful surface analgesia of the pharynx, larynx, and trachea is generally adequate.

Children below the age of 10 years are anaesthetized in a manner similar to that which we use for bronchography (Mushin and Lake, 1951). They are put to sleep in bed with a suitable dose of basal narcotic such as rectal bromethol.

In the theatre, anaesthesia is slowly and carefully induced with trichlorethylene and oxygen. When laryngoscopy is possible the cords and pharynx are sprayed with local analgesic, and a further 1 ml. of solution is injected through a fine catheter into the trachea.

Overdose with local analgesics is a possible danger, and is avoided by carefully limiting the dose used (Mushin and Lake, 1951). Anaesthesia is maintained with a stream of nitrous oxide, oxygen, and trichlorethylene into the side tube of the bronchoscope.

At the end of the operation, and when the bronchoscope has been removed, the child is carefully watched in case laryngeal spasm occurs. This is liable to happen when the operation has lasted longer than expected and the effect of the local analgesic is wearing off. Children are not allowed to leave the operating theatre until free respiration is present.

Bronchoscopy

Bronchoscopic removal of foreign bodies in children is specially hazardous. The patient usually has a degree of laryngospasm and bronchospasm, and if these become extreme during the procedure the bronchoscope must be immediately withdrawn as the first step in overcoming it. Needless to say, manipulations must be gentle. Because a small instrument is necessary, the grasping of the foreign body in children is always "blind"—not an easy accomplishment with an elusive object. The risk of dropping an object on which a tenuous hold is maintained is considerable: the seriousness of this accident might be imagined if an object is being removed from an atelectatic lung and it drops into the opposite main bronchus. For this reason the table should be kept tilted in a slight Trendelenburg position, and a portable x-ray machine should be available in the theatre. The instruments which have been used routinely are shown in Fig. 4.

FIG. 4.—Photograph of two instruments used for removing foreign bodies from bronchus. (Made by Thackrays from German model by H. Pfau.)

When the object has been grasped the forceps and the bronchoscope are removed simultaneously in a smooth motion, so that the object will not be dropped at the point where it may catch—the cords, the epiglottis, and the back of the tongue. Repeated attempts at removal of fragile objects—for example, nuts—may be necessary, and occasionally smaller pieces may be removed with a sucker. Sharp objects whose points are uppermost should be manipulated so that the sharp end is protected in the beak of the bronchoscope; with safety-pins the point is drawn into the scope and the "keeper" may safely trail (Fig. 5).

After removal, an x-ray film is taken on the table, and if all the material has come away the film will show a dramatic improvement in any previous obstructive emphysema or atelectasis. If there is still some slight evidence of retention of fragments the patient is encouraged to cough before

TABLE III.—Summary of Cases

Case No.	Age in Years	Sex	Duration of Symptoms	History and Examination	X-ray Findings	Findings at Bronchoscopy	Comment
1	12	M	8 days	Inhaled dressmaker's pin which he had in mouth while watching an aeroplane	Pin deeply placed in basal segment R.L.L. (Fig. 6)	Attempt to remove it bronchoscopically elsewhere failed, in spite of using magnet and obtaining "radiological" contact with pin	Right thoracotomy, attempt to remove pin by bronchotomy at basal stem bronchus failed; pin then pushed out through visceral pleura
2	25	F	12 months	Frequent chest colds with mucoid sputum. Consequently recalled swallowing or inhaling safety-pin at a party 17 years previously	Open safety-pin R.M.B. (Fig. 5)	Pin in R.L.M.B., surrounded by granulation tissue. Removed easily, keeper trailing	Cough subsided in one week
3	14	M	9 days	Definite history of inhaling foreign body. Previous bronchoscopy at another hospital unsuccessful. Considerable laryngeal stridor. T. 101° F. (38.3° C.); P. 130; R. 36	Atelectasis of basal segments R.L.L.	Two attempts at bronchoscopic removal, the second successful in extracting granite chip from R.M.B.	First bronchoscopy delayed 2 days after admission and second one for 5 days. Nursed in steam tent
4	8	F	2 "	"Swallowed" nut while running. Coughed and spluttered. Pain in upper abdomen on coughing and spontaneously. O.E., cyanosis. Atelectasis left lung; T. 100° F. (37.8° C.); P. 140; R. 30	Atelectasis and consolidation left lung (Fig. 2)	Part of nut and shell removed from L.M.B. Mucopus distal to this aspirated	Slow expansion apical segment L.L.L.; but complete in 7 days
5	9	F	24 hours	While eating raw carrot, choked, became dyspnoeic and wheezy (history obtained from "sitter" one day later). O.E., cyanosed and very dyspnoeic. Obstructive emphysema. Left lung. T. 99° F. (37.2° C.); P. 140; R. 30	Slight obstructive emphysema left lung. Cervico-dorsal scoliosis convexity to right	Piece of carrot removed from L.L.L.B.	The diaphragm regained normal position, but the mediastinum did not (owing to scoliosis). Asymptomatic 6 days
6	11	F	7 years	Pneumonia; no complications. Recurrent haemoptyses and wheezing from age 4	Bronchiectasis R.L.L.	No evidence of foreign body. Slight narrowing middle lobe orifice	Right lower lobectomy. Privet leaves found in L.L.B. Had been seen with them in her mouth when aged 4
7	4	F	1 week	Severe bouts of coughing and vomiting. Sputum purulent. Treated for "pneumonia" with some improvement	Screw in right bronchus. Atelectasis basal segments R.L.L.	Screw removed with difficulty, owing to bronchospasm, from R.L.L.B.	Good recovery
8	3	M	6 weeks	While eating peanuts, choked, went blue, and was gasping for breath. Father "coughed" him and colour improved but wheeze persisted. Bronchoscopy 9 days later at another hospital—fragments of nut removed from R.L.L.B. Initial improvement, then relapse with wheeze and stridor, pyrexia, and purulent sputum	Obstructive emphysema right lung (Fig. 3)	Several pieces of nut removed from R.L.L. and pus aspirated	Complete recovery in 12 days

TABLE III.—*Summary of Cases—Contd.*

Case No.	Age in Years	Sex	Duration of Symptoms	History and Examination	X-ray Findings	Findings at Bronchoscopy	Comment
9	19	F	2 months	Aspirated piece of coconut. Violent cough for 10 minutes, then pain lower chest on inspiration and tightness. Three previous bronchoscopies elsewhere, when pus and inflamed mucosa only seen	Consolidation lateral basal segment, R.L.L.	Right basal stem bronchus appeared stenosed, owing to granulation tissue; some pus	Intensive physiotherapy, postural drainage, and antibiotics — progressive improvement. Bronchogram normal 1 month later
10	3	M	5 days	While eating peanuts, fell. Bout of coughing and constant wheeze. Obstructive emphysema left lung. Bilateral rhonchi	Obstructive emphysema left lung	Mucosa of L.M.B. oedematous. No foreign body seen at first, but gentle blind instrumentation recovered 2 sizable fragments of nut	Immediate x-ray film showed mediastinum central and emphysema cleared. Complete recovery
11	6/12	M	2 "	Swallowed peanut. Coughed and developed wheeze. Attempts at disposal by holding him upside down and shaking, and suction with endotracheal catheter unsuccessful	Collapse R.L.L. and obstructive emphysema	Half shell and several fragments of nut removed from R.M.B.	Mild laryngotracheitis for 24 hours, then normal
12	2½	F	11 "	On holiday with grandmother swallowed peanuts, choked and coughed. History not known till searching inquiry. Became feverish. Given tablets prescribed by chemist. Later penicillin course. Finally, breathing distressed and cyanosed. O.E., cyanosis, left chest hyperresonant. Air entry absent. T. 99° F. (37.2° C.); P. 140; R. 50	Obstructive emphysema left lung	Nut removed from L.M.B. with difficulty due to severe bronchospasm requiring removal of scope and reinsertion	Immediate improvement in general condition and air entry left lung, then some deterioration. Bulk of foreign body thought to have been removed; nursed in steam tent and recovered completely in 7 days
13	11	M	3 "	Inhaled drawing-pin which had been held in mouth; followed by choking and pain in right upper chest on coughing. T. 103° F. (37.8° C.); P. 96; R. 24	Obstructive emphysema left lung	Pin removed by grasping edge of head (not stem). It was dropped in the pharynx and recovered by direct laryngoscopy	Some laryngeal stridor. Recovery in 5 days
14	49	M	6 "	9 teeth extracted under inhalation anaesthesia. "Swallowed" last tooth. On recovery coughed for 15 minutes, dyspnoeic, chest wheezy and tight. Pain right lower chest, worse with breathing. Sputum stained. O.E., orthopnoeic, slight cyanosis, expiratory wheeze, dullness; decreased A.E. and V.R., R.L.L.	Molar tooth in R.M.B. with consolidation lateral subsegs. of ant. and post. segs. R.U.L., R.L.L., and L.L.L., and pneumoconiosis	Tooth in R.M.B. removed easily	Complete recovery in 3 weeks
15	9	F	2 "	3 molar teeth extracted under general anaesthesia. Immediate dyspnoea and vomiting. Attempted removal at another hospital, but lost when being withdrawn. (Slipped from right to left side.) T. 100° F. (37.8° C.); P. 136; R. 26	Tooth in L.M.B. Obstructive emphysema L.L.L.	Removed from L.M.B.; was dropped during extraction. X-ray film revealed position on right side and successful removal	Cords a little oedematous. Good recovery
16	6	F	3 months 2 weeks	Inhaled tooth. Choked and coughed. Malaise Rigors	L.U.L. atelectasis and emphysema, L.L.L.	Excessive granulation tissue in L.M.B. prevented adequate view through infants' scope and tooth not removed	Postural drainage and physiotherapy; x-ray film before thoracotomy and bronchotomy 5 days later showed tooth in stomach—it was loosened by attempts at removal, was coughed up and swallowed
17	6	M	6 days	Choked on peanut. Chronic bronchitis. Coughing and febrile since. T. 100° F. (37.8° C.), signs of consolidation R.L.L. and rhonchi diffusely	Patchy atelectasis R.L.L.	Peanut removed from R.L.L.	Readmitted a month later with consolidation post. basic seg. R.L.L. Re-bronchoscopy, but no foreign body seen. Cleared with antibiotics
18	11/12	M	3 weeks	Choked while eating mouthful of peanuts. Intermittent cough and wheezing. O.E., diffuse rhonchi, hyperresonance, and absent air entry, right lower zone	Obstructive emphysema R.L.L.	Nut removed from R.L.M.B.	Good recovery
19	1	M	1 day	Swallowed piece of bath sponge. Expiratory wheeze on exertion. T. 100° F. (37.8° C.); P. 166; R. 46	Atelectasis L.L.L. with obstructive emphysema L.U.L.	Carina obscured by sponge; which obstructed L.M.B.	" "
20	1½	F	3 hours	Swallowed sugar-coated almond. Coughed and became blue. Cough and wheeze since. O.E., wheeze; decreased air entry right chest anteriorly, rales posteriorly	Atelectasis R.L.L. emphysema R.U.L.	Fragmented foreign body R.M.B., white nut and brown skin. Much oedema of mucosa	" "
21	1½	F	5 weeks	Eating apple and choked. Since then occasional cough and wheeze on exertion. O.E., T. 98° F. (36.7° C.); P. 140; R. 24	Emphysema left lung	Piece of apple size of florin removed from L.M.B.	Recovered 4 days
22	1	M	2 "	Choking and cyanosis, while eating omelette. Later developed wheeze. Temperature lower after penicillin course but wheeze remained. T. 102° F. (38.9° C.)	Triangular piece of shell impacted in upper trachea	Difficult anaesthesia and instrumentation. Cords oedematous. Piece of shell removed through glottis and several pieces removed on sucker tip. More pieces removed through bronchoscope	Some signs of laryngeal stridor immediately; one hour later extreme cyanosis and unconsciousness required tracheotomy. Tube removed 10 days; recovered in 1 month
23	11/12	M	1 week	Inhaled walnut while on bus. Choked and became blue. Intermittent cough since. O.E., obstructive emphysema right lung	Atelectasis middle lobe and obstructive emphysema R.L.L.	Piece of walnut removed from R.L.M.B. at level of middle lobe orifice	Recovery 2 weeks
24	11/12	F	7 hours	Choked on liquorice all-sort. Cough and wheeze. O.E., generalized rhonchi. Decreased air entry R.L.L.	Obstructive emphysema R.L.L.	No foreign body found. Moderate amount of purulent secretions aspirated from lower lobes	Normal x-ray film following bronchoscopy. In retrospect, liquorice had dissolved after inhalation, causing immediate intense inflammation
25	13	F	6 weeks	Accidentally inhaled small gold safety-pin. No abnormal signs	Open pin, point up, in R.L.L.B. Basal mottling	Pin below M.L. orifice, with point embedded in mucosa. Several attempts at removal unsuccessful	Thoracotomy and bronchotomy. Head of pin lying below apical seg. of R.L.L.B. It was grasped and the pin gradually removed by straightening it out. Uneventful recovery

leaving the table: a useful trick in the case of children is to blow cigarette smoke over the patient's face.

After bronchoscopy all these patients are treated on return to bed with postural drainage, physiotherapy, and a suitable antibiotic. If removal of a foreign body has failed owing to its impaction in granulation tissue the patient is sent back to bed and treated in the same way as the others. This may allow the oedema to subside and permit a better view at the next attempt. Occasionally a small object which has

FIG. 5.—Case 2. Postero-anterior chest radiograph. Open safety-pin in right main bronchus.

FIG. 6.—Case 1. Postero-anterior chest radiograph. Pin in posterior basal segment of right lower lobe.

magnetism of alloys depends on the amount of heat received during the processing. Furthermore, the power of a magnet is inversely proportional to the square of the distance from its object, and, while intervening tissues do not impair magnetism *per se*, their presence makes contact difficult. On the whole, metallic objects in main bronchi are more easily removed by direct methods, and in deeply placed situations will usually require bronchotomy.

Prevention

Loose teeth in an anaesthetized patient should always be carefully watched. Children should not be allowed to eat nuts until they have a full set of teeth, or, if they are, the nuts should be finely ground. Small objects such as pins, buttons, and coins should not be left within an infant's reach. A parent should not set a bad example for a child by holding tacks and pins in the mouth. Children should

not be allowed to play while eating, or eat too quickly without proper mastication. The adage is still true that if nothing except food was put in the mouth the inhalation of a foreign body would be a rare accident.

Summary

Experience has been gained with 25 cases of inhaled foreign body, mostly in children. The early history of an inhaled foreign body is often missed; the later results may simulate almost any chest disease. The diagnosis is made from the history and the presence on clinical examination of atelectasis or obstructive emphysema, and from chest radiography. The importance of early removal of the foreign body by a team consisting of an experienced bronchoscopist and an experienced anaesthetist is stressed. The essential part of the anaesthetic is surface analgesia of the trachea and bronchi. If removal by bronchoscopy fails, thoracotomy and bronchotomy is justified, with the sacrifice of any destroyed lung. The majority of inhalation accidents may be prevented: nuts should not be given to young children who have no molars, small objects must be kept out of an infant's reach, and care should be taken with loose teeth in an anaesthetized patient.

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TRACHEOSTOMY, AND MANAGEMENT OF THE UNCONSCIOUS PATIENT

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In recent years the indications for tracheostomy have been extended to include the management of tetanus, respiratory paralysis, and the unconscious patient. This simple operation has gained a highly valued place in neurosurgical practice, where the problem of maintaining a clear airway in comatose patients is often encountered. In the last four years in the Department of Neurological Surgery of St. Bartholomew's Hospital 16 tracheostomies have been performed. Selected cases are reported to illustrate the varying indications for the procedure. The mechanism whereby the normal gaseous exchange in the lungs is interfered with in these cases is discussed. The technique for ensuring adequate pulmonary ventilation and a satisfactory intracranial circulation in unconscious patients is also described.

Technique of Tracheostomy

It must be emphasized that so far as is possible this operation should be carried out as an elective procedure. It may be satisfactorily performed under local