fluid and proceeded to pass its first stool, consisting of opaque gelatinous ovoids with a few darker pellets, slightly bloodstained.

Straight X-ray of the abdomen showed the presence of gas in the stomach, but none elsewhere in the bowel.

Operation the same day under local anaesthesia later supplemented with cyclopropane and oxygen. Grossly dilated small bowel was delivered and followed to a blind end, where there was a gap of several inches before collapsed gut began. The mesentery was present opposite the undeveloped segment but was very thin. The proximal loop was emptied by putting a catheter into it and a

large quantity of thin, bile-stained mucus was aspirated. A side-to-side anastomosis was performed between the proximal and distal loops 90 ml. of glucose saline was given into the internal jugular vein.

The child's condition was satisfactory for 36 hours after operation, but thereafter vomiting recurred, the stomach aspirations were large and, in spite of intravenous infusions, its condition deteriorated and death occurred on the fourth post-operative day.

Post-mortem examination (Fig. 11) showed complete absence of a segment of the upper jejunum, the proximal bowel being grossly distended.

The author wishes to thank the physicians of the Westminster Children's Hospital for permission to publish cases referred by them, and Mr. Albert Davis for his kindness in obtaining X-rays showing gas shadows in the intestines of newborn infants.

ANAESTHETIC EMERGENCIES

By J. ALFRED LEE, M.R.C.S., L.R.C.P., M.M.S.A., D.A., F.F.A., R.C.S.

Consultant Anaesthetist to The General Hospital, Southend; The General Hospital, Rochford; King George Hospital, Ilford, etc.

Emergencies are always hiding round the corner, waiting to pounce on the anaesthetized patient, and it is axiomatic that throughout the whole of the administration the anaesthetist should be intelligently alert. The price of safety is constant watchfulness—in *somno securitas*.

Anaesthetic emergencies cannot always be treated successfully, and it is a melancholy reflection that deaths under anaesthesia are not decreasing. When calculated on a quarter of a million cases from five teaching hospitals in three countries, the death rate was about one in a thousand (Gillespie, 1944). The operating theatre is no place for a display of virtuosity, and it is always wiser to use an agent or method with which one is familiar than to employ a technique with which one is not *au fait*, just because it may be theoretically indicated.

Crises can arise in the anaesthetic room, in the operating theatre or during the immediate post-operative period.

Anaesthetic Room Emergencies

It will occasionally happen that a patient arrives for operation in a state of depression consequent on the ill-judged dosage of sedative premedication. The writer has known operations postponed for this reason. Now and again opium derivatives seem to exert an overwhelming effect even if the dosage is appropriate, and the patient may be breathing no more than six or eight times a minute. Bromethol, likewise a respiratory depressant, may seriously reduce the rate and depth of breathing.

If minor degrees of obstruction of the upper respiratory tract also exist in these patients, they may soon become quite seriously hypoxic, and they are in addition physically handicapped, a state of emergency may soon develop.

The remedy here is partly preventive and partly curative. The dosage of powerful drugs should be 'tailor made' to suit the type and constitution of each individual patient. It should be remembered that old people, those suffering from chronic debilitating disease, those of hypothyroid constitution and those already receiving sedative drugs, will probably require less opiate or barbiturate than the average patient. The modern treatment of Graves' disease may produce in the thyrotoxic patient a temporary hypothyroidism which will make it difficult for him to deal with doses of bromethol normally suitable for such patients before operation. When these depressed patients are transferred to the care of the anaesthetist, their condition should improve. He is able to administer mixtures rich in oxygen, secure a good airway and make a smooth induction. He should, however, bear in mind that if he uses more respiratory depressants during anaesthesia he must be prepared to assist the normal respiratory effort of the patient.

Scopolamine hydrobromide is a useful drug for two reasons; it reduces secretions from the upper respiratory tract and it produces amnesia. It should not be used as a routine, however, in patients over 60 years of age, because occasionally a state of restlessness or even delirium may

arise. In these old people atropin should be substituted.

Local Analgesia

It is becoming increasingly popular to use cocaine or cocaine substitutes to obtund the reflexes of the pharynx, larynx and bronchi before operation, and states of collapse, from acute intoxication, may arise suddenly if care is not taken. Macintosh (1949) advises concerning cocaine that a dose of 20 mg. per stone should not be exceeded, with a maximum of 200 mg. It is useful to employ a 4 per cent. solution instead of the more frequently used 10 per cent. or 20 per cent. solution. Before such operations as bronchoscopy under local analgesia, it is wise to employ a barbiturate as premedication to counteract the possible toxic effects of the local analgesic. This antagonism between cocaine and barbiturates was pointed out as long ago as 1925 by Tatum and his associates, and has led to increased safety in the use of the cocaine group of drugs.

Emergencies following intoxication by cocaine or its derivatives can assume one of two forms; circulatory depression with pallor, hypotension and collapse, or central nervous system effects, with convulsions and consequent respiratory difficulty. Treatment for the first group consists in the administration of 100 per cent. oxygen together with intravenous adrenaline; for the second group it is 100 per cent. oxygen with intravenous thiopentone. These emergencies are rare, but they demand prompt management.

Mention must be made here of the patient whose general condition when he arrives in the theatre is so serious that, in the anaesthetist's opinion, surgical interference should be postponed. It is far better to resuscitate such a patient with blood, rest, warmth and perhaps morphine before operation than to be faced with a grave collapse on the table.

Emergencies During Induction

Intra-Arterial Injection of Thiopentone

This is a serious emergency threatening not life, but limb. As stressed by Cohen (1948) the brachial artery divides above the elbow joint in 10 per cent. of cases and when it does so the ulnar artery may reach the forearm by running superficial to the flexor muscles either superficial or deep to the deep fascia. The essential lesion produced is an arterial thrombosis which may not become complete for a fortnight, but venous thrombosis and mechanical blocking of small vessels by drug precipitation are not unknown.

This accident can be prevented by careful palpation of the area of injection after seeing that the tourniquet has not obliterated the radial pulse.

In addition, the injection of 1 ml. of solution should be made and then the patient should be asked if pain is caused in the hand. Fortunately early pain is a warning sign and if it occurs further injection is stopped. The use of 2½ per cent. thiopentone solution instead of 5 per cent. solution is another safety measure.

If intra-arterial injection is suspected Cohen (*vide supra*) advises abandoning the operation, giving heparin and dicoumarol and, if necessary, cutting down on the artery to remove clot. The vasoconstrictor fibres coming to the arm from the sympathetic ganglia can be blocked at the brachial plexus, above the clavicle, with a long-acting analgesic, so increasing the blood supply to the limb. Should the operation be urgent, general anaesthesia can be induced, preferably with cyclopropane, to ensure vasodilatation, a result produced as effectively by this means as by sympathetic block. Further treatment consists in elevation of the arm which should be wrapped in sterile wool and towels to minimize heat loss. Papaverine, intravenous ether and tetraethyl ammonium bromide can be used to promote peripheral blood flow. In spite of all these measures, amputation of the arm or hand is a not infrequent result of this calamitous occurrence.

Other emergencies occurring in the anaesthetic room are usually due to hypoxia resulting from an imperfection of the airway. Some are due to a sense of rush or hurry born of a desire on the part of the anaesthetist to avoid keeping the surgeon waiting. The following emergency situations can be dealt with in a little more detail.

(a) Simple loss of airway. This is most likely to be experienced in the sturdily built patient with good teeth. Keeping the jaw well forward, inserting a pharyngeal airway or the passage of a nasopharyngeal tube to a point just above the glottis, are the measures recommended to remedy this condition. Occasionally an endotracheal tube will have to be inserted.

(b) A common cause of trouble is due to obstruction of the airway by stomach contents. The anaesthetist should firmly refuse to anaesthetize any patient who is suspected of having a partially digested meal in his stomach. Apprehension and anxiety delay stomach emptying, so no food should be taken within eight hours of a non-emergency operation. Many deaths have been due to neglect of this fundamental rule. If there is any chance that the stomach is not empty and a general anaesthetic is to be given, either the operation must be postponed or one of the following methods must be used to avoid the danger of inhalation of stomach contents:—A large stomach tube should be inserted in the conscious patient, before induction of anaesthesia, and the stomach

washed out, or a cuffed endotracheal tube should be passed in the conscious patient under topical laryngeal analgesia. Both these procedures are unpleasant for the patient, but they may be life saving and therefore should not be neglected. In cases of intestinal obstruction, the prevention of soiling of the airway is of paramount importance, and in these patients it must be remembered that retroperistalsis from the small bowel may provide a continuous flow of noxious material into the stomach.

Obstetric patients receiving a general anaesthetic for delivery are especially liable to vomit during induction because they have been given drinks intermittently during the course of their labour. The danger is made worse because the bed quite frequently will not tip head down, and suction may not be available. One of the arguments in favour of the use of regional analgesia in labour is this danger of the inhalation of stomach contents during general anaesthesia.

Patients are sometimes seen who do not settle down well with thiopentone. After the injection of 0.1 or 0.2 g. a patient of this type will bring his cords together or cough, with the result that hypoxia soon appears. If such a patient is fat or suffers from weakness of the myocardium, an alarming condition can soon develop. Treatment consists in forcing oxygen into the chest during the short intervals when the cords are partially abducted. A little trilene often has a sedative effect on these reflexes, and as the colour improves, more thiopentone can be cautiously injected. Such a patient is likely to repeat his awkward behaviour later in the operation.

If intubation is attempted under thiopentone anaesthesia alone, the larynx may go into rigid spasm and serious hypoxia may soon become apparent. To avoid this happening the larynx should be cocainized before intubation is attempted, or curare should be used before the thiopentone to remove the tone from the adductors of the cords. Once a spasm is established, oxygen must, if possible, be forced into the chest. If the slow, bounding pulse of serious hypoxia is felt, or if the myocardium shows signs of grave embarrassment, the cords should, as an emergency measure, be forced apart with a narrow gum elastic catheter with olivary end and side holes. After this is in place, the anaesthetist can immediately blow into the patient's lungs and later oxygen can be insufflated.

Few instruments are more important than the anaesthetist's laryngoscope, and few experiences more dangerous than suddenly finding the light out when trying to visualize the cords of an apnoeic patient. Before beginning the administration, the anaesthetist should always examine his

laryngoscope and worry it like a dog with an old slipper. Only by shaking it vigorously will he be able to determine that the current does not fail at the moment which may truly be called critical.

Damage to teeth will continue to occur occasionally, even in skilled hands. Should a tooth be avulsed and disappear, a state of emergency certainly exists as the tooth may have entered the trachea. If this is considered possible a portable X-ray should be taken to be followed, if necessary, by bronchoscopy.

Endotracheal tubes sometimes find themselves acting as oesophageal tubes with the result that the airway may not be patent, and what is more serious, the stomach may become distended with gas. Under these circumstances, it only requires positive pressure breathing to be used by the anaesthetist for rupture of the stomach to become a possibility. As the bulk of the tube hides the glottis as seen through the laryngoscope, this incorrect insertion of the tube is not rare. If the anaesthetist is in doubt as to which of these passages holds his tube, he should gently blow down it while watching the patient's chest. With a correctly-placed tube the thorax will expand, and as the mouth is taken away it will fall again with passive expiration. This does not happen if the tube is in the oesophagus.

Emergencies During Operation

Apart from those dependent on anaesthetic overdose or an inadequate airway, one of the commonest emergencies seen during operation is the rapid onset of shock. Common sense dictates the great advantage of putting up a drip at the beginning of the operation in all patients in whom shock is anticipated. This can be started with glucose saline, blood being added when necessary. It is better to replace blood as it is lost than to give several pints to a shocked, exsanguinated patient as the operation is nearing its close. If severe shock arises unexpectedly and it is impossible to set up a workmanlike intravenous drip, many ounces of blood can be forced into the circulation from a large-bore needle inserted into the medulla of the sternum. The inner table of the bone, of course, must not be pierced during this procedure.

There are factors against and others in favour of keeping a regular five- or ten-minute blood pressure chart during major operations. With such a chart there may be a temptation for the anaesthetist to paint an unduly black picture of the patient's condition to the surgeon, which may discourage him from being properly radical in his technique. On the other hand, to be forewarned to be forearmed.

Sudden Heart Failure

This may be due to prolonged carbon dioxide excess and oxygen lack; to the sensitizing of the automatic conductive tissue of the heart by adrenaline during cyclopropane or chloroform anaesthesia; to the effects on the coronary circulation of prolonged hypotension associated with shock; to pulmonary embolism or to overdosage of the anaesthetic agent, e.g. ethyl chloride or chloroform. Then other cases occur which are difficult to explain without recourse to such doubtful diagnoses as vagal inhibition or status thymicolymphaticus.

Mention should be made of sudden collapse during ethyl chloride anaesthesia in children. If a child, receiving ethyl chloride, suddenly stops breathing and shows signs of circulatory collapse, either from overdosage or from other cause, resuscitative measures must be commenced at once. A small child can be suspended by its feet while its tongue is pulled out with a swab or a tongue forceps. In this inverted position the chest should be rhythmically compressed. A larger child should have its head lowered, its airway made patent, while oxygen or air should be insufflated into its lungs with a facepiece, either from a reservoir bag of an anaesthetic machine or from the anaesthetist's own mouth.

If it is suspected that the heart has stopped beating the anaesthetist must ask the surgeon to feel one of the great vessels or to put his ear to the precordium, and then, should his suspicions be confirmed, instant action is necessary if the life of the patient is to be saved. The oxygen-greedy cells of the cerebral cortex seldom recover completely if the period of their anoxia exceeds three or four minutes. While the anaesthetist lowers the head of the table, establishes a good airway and institutes artificial respiration with oxygen, the surgeon prepares for cardiac massage through a mid line upper abdominal incision. The heart should be rhythmically compressed from below the diaphragm while counter pressure is exerted by the other hand on the lower thorax. Massage should last, if necessary, for ten minutes. If it has been impossible to maintain rigidly aseptic measures the wound should be liberally dusted with penicillin sulphathiazole powder; it can then be closed. Fluids must be added to the circulation, and if the blood pressure remains low methedrine, 15 mg., should be injected intravenously. Cardiac massage, first employed by Arbuthnot Lane in 1902, will, in Hamilton Bailey's words, 'often recall some of those whom Charon has started to ferry across the waters of the Styx.'

Cardiac puncture is probably harmful as it wastes time and delays the all-important artificial

cardiac systole. It can be used as a final gesture after prolonged cardiac massage has failed to restart contraction. Adrenalin, 1 ml., can be injected into the cavity of the left ventricle from a point 2 in. lateral to the sternal border in the fourth left intercostal space. If after massage the surgeon's hands detects ventricular fibrillation, then 20 ml. of 2 per cent. procaine should be injected into the left ventricle in an effort to establish ventricular systole.

Deep Ether Convulsions

This is a serious condition with a mortality of between 10 per cent. and 20 per cent. The cause is not known although many etiological theories exist such as alkalaemia, a specific neurotoxin, a congenital tendency to convulsions as shown by electroencephalography and hyperthermia, etc. The fits usually occur in children or young adults whose body temperature is raised either from their own disease or from environmental causes such as paralysis of sweating by atropin, too many blankets or mackintosh sheets, etc. These patients frequently require rather more ether than is usual to get relaxation, and the onset of the convulsions often coincides with such a stimulus as pulling on the peritoneum. Twitching starts in the muscles of the face and neck, and rapidly spreads to the trunk, limbs and muscles of respiration, until the whole table shakes. Progressive hypoxia results from clonus of the diaphragm and intercostals.

The correct treatment is to discontinue ether, institute adequate assisted breathing with oxygen, through an endotracheal tube if necessary, promote cerebral ischaemia by raising the head, and injecting serial small doses of thiopentone intravenously, until the turmoil ceases. Small doses of tubocurarine may also be used, but it must be remembered that both thiopentone and curare are respiratory depressants, so that assisted breathing may be required for some time after their use.

Explosions

Although these are fortunately rare, the anaesthetist must constantly have the possibility of their occurrence in mind. He must plan his technique to suit the needs of the surgeon, concerning diathermy, endoscopes, radiology, etc., while he should enquire at frequent intervals as to the integrity of the electrical machinery in the theatre. His only non-explosive agents, apart from local analgesics, are nitrous oxide, thiopentone, trilene and chloroform. The prevention of static electric sparks is more difficult than the control of explosive anaesthetic mixtures, but both these problems are now nearer solution with the employment of the Vapotester and the Statometer

(Uhl, *et al.*, 1949). The Vapotester employs the principle of the Wheatstone bridge to enable the anaesthetist to measure the concentration of the anaesthetic agent and the explosibility of the mixture. The Statometer detects the presence of static electricity, its source and its intensity.

Finally, the anaesthetist must be constantly on his guard to avoid those emergencies resulting from carelessness; from administering the wrong agent; from incorrect coupling of cylinders, etc.

Emergencies in the Immediate Post-Operative Period

Once again interference with the airway is a frequent source of trouble. The unconscious patient requires just as much skilled care and attention in the ward as he does on the operating table. Harm may result from a kinked or blocked endotracheal tube, from vomited material blocking the airway or from an atonic tongue occluding the pharynx. While there are advantages in sending the unconscious patient back to the ward with the tube in place, there are also disadvantages. The writer has twice seen fatalities result from the connection of an oxygen cylinder direct to an endotracheal tube when the nursing staff were asked to run a little oxygen down the tube from a small catheter. Laryngeal spasm following removal of the tube is also seen occasionally and this is better dealt with by the anaesthetist in the theatre than by a nurse in the ward or a porter in a dark corridor. Macintosh (1949) advises that all patients who are unconscious should leave the theatre in the tonsil position, semiprone with the lower arm behind the body and a pillow supporting the chest. If this advice were followed, many emergency calls to the wards would be avoided and lives would be saved.

It is important to see that the patient is breathing reasonably deeply before he leaves the table. Cyclopropane, thiopentone and curare are all respiratory depressants and their use singly or in combination may lead to danger from hypopnoea or may even cause apnoea. When cyclopropane has been forced into the patient by controlled breathing, great care is required to see that spontaneous respiration is maintained after operation. The writer has seen a case anaesthetized by

this technique who breathed naturally for five minutes after the mask was removed, only to relapse again into apnoea which proved fatal.

Post-Anaesthetic Depression

Now and again a patient is seen who, in spite of leaving the table in good condition, collapses soon afterwards. This state bears no relationship to post-surgical depression (shock), but is in some way associated with the withdrawal of the anaesthetic, especially cyclopropane given in a closed circuit. While surgical shock is usually accompanied by a rapid pulse, this form of depression is marked by bradycardia. Its cause is debatable, Dripps (1947) thinks that one cause may be removal, as the state of anaesthesia lightens, of the high blood carbon dioxide level associated with the shallow breathing of cyclopropane in a closed circuit. The condition can be alarming in a handicapped patient who has undergone a long or shock-producing operation, and it should be treated vigorously by intravenous fluids, together with ephedrine, gr. $\frac{1}{2}$ – $\frac{3}{4}$. A reasonable preventive measure is to give a dose of ephedrine to all patients who have had severe operations under cyclopropane anaesthesia before they leave the table.

Post-Anaesthetic Delirium

After deep cyclopropane anaesthesia a patient is sometimes seen who, on his return to the ward, becomes wildly restless. Morphine is ordered but fails to produce calm. If this tumult continues exhaustion both of patient and nurses may result. It should be treated by the intravenous injection of subemetic doses of apomorphine.

Post-Anaesthetic Encephalopathy

Hunter (1949) has recently described a series of cases which developed light coma without definite localizing signs of a lesion in the central nervous system following general anaesthesia. It is not due to fat embolism, hypoxia or to cerebral vascular lesions and it carries a bad prognosis. Seldon (1949) suggests that the cause is cerebral oedema and advises the intravenous injection of 100 ml. doses of 25 per cent. human serum albumen. In his hands this has produced benefit.

BIBLIOGRAPHY

- COHEN, S. (1948), *Lancet*, 2, 10 and 11.
 DRIPPS, R. D. (1947), *Anaesthesiology*, 8, 1.
 GILLESPIE, N. (1944), *British Journal of Anaesthesia*, January.
 HUNTER, A. R. (1949), *Lancet*, ? ? ? ? ?
 MACINTOSH, R. R. (1949), *British Journal of Anaesthesia*, 21, 3.
 SELDON, T. H. (1949), *Proceedings of the Staff Meetings of Mayo Clinic*, 24, 14.
 UHL, J. W., LIVINGSTONE, H. M., and TING, K. S. (1949), *Anaesthesiology*, 10, 4.