REFERENCES

- Aron, M., and Benoit, J. (1931). *C.R. Soc. Biol., Paris*, **108**, 784.
 Astwood, E. B., Greer, M. A., and Ettlinger, M. G. (1949). *J. biol. Chem.*, **181**, 121.
 Baumann, E. (1895). *Hoppe-Seyl, Z.*, **21**, 319.
 Bérard, L., and Dunet, C. (1924). *Le Cancer Thyroïdien*. Doin, Paris.
 Chatin, A. (1852). *Gaz. Hôp., Paris*, **25**, 14, 38, 50, 82, 86, 94.
 Chesney, A. M., Clawson, T. A., and Webster, B. (1928). *Bull. Johns Hopk. Hosp.*, **43**, 261.
 Coindet, J. R. (1820). *Ann. Chim. Phys.*, **15**, 49.
 Greer, M. A., Ettlinger, M. G., and Astwood, E. B. (1949). *J. clin. Endocr.*, **9**, 1069.
 Halsted, W. S. (1896). *Johns Hopk. Hosp. Rep.*, **1**, 373.
 Hellwig, C. A. (1931). *Arch. Path.*, **11**, 709.
 Hercus, C. E., and Purves, H. D. (1936). *J. Hyg., Camb.*, **36**, 182.
 Hitzig, Th. (1894). *Arch. klin. Chir.*, **47**, 464.
 Kennedy, T. H. (1942). *Nature*, **150**, 233.
 Loeser, A. (1935). *Klin. Wschr.*, **14**, 4.
 McCarrison, R. (1917). *The Thyroid Gland*. Baillière, Tindall and Cox, London.
 — (1931). *Indian J. med. Res.*, **18**, 1311.
 — and Madhava, K. B. (1932). *Indian med. Res. Mem. No. 23*. Thacker, Spink and Co., Calcutta.
 — Newcombe, C., Viswanath, B., and Norris, R. V. (1927). *Indian J. med. Res.*, **15**, 207.
 Marine, D. (1935). *J. Amer. med. Ass.*, **104**, 2334.
 — Baumann, E. J., and Cipra, A. (1929). *Proc. Soc. exp. Biol., N.Y.*, **26**, 822.
 — Spence, A. W., and Cipra, A. (1932). *Ibid.*, **29**, 772.
 — Webster, B., and Cipra, A. (1933). *J. exp. Med.*, **57**, 121.
 — and Lenhart, C. H. (1909a). *Arch. intern. Med.*, **3**, 66; **4**, 440.
 — (1909b). *Ibid.*, **4**, 253.
 Michaud, L. (1906). *Virchows Arch.*, **186**, 422.
 Murray, M. M., Ryle, J. A., Simpson, B. W., and Wilson, D. C. (1948). *Med. Res. Coun. Mem. No. 18*. H.M.S.O., London.
 Prévost (1830). Quoted by St. Lager (1867).
 Renaud, A. (1923). *Rev. méd. Suisse rom.*, **43**, 433.
 Répin, Ch. (1911). *C.R. Soc. Biol., Paris*, **71**, 225.
 Richter, C. P., and Clisby, K. H. (1941). *Proc. Soc. exp. Biol., N.Y.*, **48**, 684.
 Rienhoff, W. F., jun. (1931). *Medicine*, **10**, 257.
 St. Lager, J. (1867). *Etudes sur les Causes du Crétinisme et du Goitre Endémique*, p. 239. Baillière, Paris.
 Sandberg, M., and Holly, O. M. (1933). *J. biol. Chem.*, **99**, 547.
 — Spence, A. W. (1932). *Brit. J. exp. Path.*, **13**, 157.
 — (1934). *St. Bart's Hosp. Rep.*, **67**, 203.
 — Walker, F. H. A., and Scowen, E. F. (1933). *Biochem. J.*, **27**, 1992.
 Thompson, J. (1932). *J. Nutr.*, **5**, 359.
 — (1933). *Arch. Path.*, **16**, 211.
 Virchow, R. (1863a). *Die krankhaften Geschwülste*, **3**, 4. Berlin.
 — (1863b). *Ibid.*, **3**, 15.
 Wilson, D. C. (1941). *Lancet*, **1**, 211.

ACUTE CIRCULATORY FAILURE DURING SURGICAL OPERATIONS

BY

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For as long as surgery has been practised deaths have occurred during operation. Presumably most of these were at first due to shock and loss of blood, though it is said that Greek surgeons sometimes gave their patients narcotic drugs to diminish pain, and that on occasion these drugs themselves caused death.

The first anaesthetic death in the modern sense, however, occurred in Newcastle-upon-Tyne on January 28, 1848: it was due to the use of chloroform (Beecher, 1941). A similar case occurred in Manchester four years later (Anon., 1853). By 1874 experimental cardiac massage had restored the heart beats in dogs anaesthetized with chloroform, and the first human life was saved in this way in 1902. A review of the results (Barber and Madden, 1945) of cardiac massage showed that in 1906 there were 22.5% complete recoveries, while for the years 1924-45 the reported success rate had risen to 52%. It is, of course, unlikely that the real

expectation of survival is as high as this, as a single success is more likely to appear in the literature than a single failure.

The causes of sudden heart failure in the operating theatre have already been reviewed (Ruzicka and Nicholson, 1947; Lahey and Ruzicka, 1950). For our purposes it is sufficient to recognize that they fall into three main groups: (1) those due to or associated with pre-existing disease, usually the disease for the relief of which operation is being performed; (2) those resulting from what may be termed the immediate general complications of surgery, notably shock, haemorrhage, and air embolism; and (3) those due to the anaesthetic agent or technique.

Group 1

In these cases the only possible treatment is to try to undo the damage as quickly as possible. If cardiac massage is used at all (as in Case 2) it is only incidentally.

Case 1: Cardiac and respiratory failure due to acute medullary compression; attempted relief of compression and cardiac massage; death.—A 3-months-old girl was about to undergo the excision of an occipital encephalocele. After a normal induction of anaesthesia with intubation her head was for a moment allowed to rest directly on the encephalocele. There was an immediate slowing of respiration, which recovered in a few minutes. She was then turned on to her face for the operation, and immediately the respiration slowed again, both it and the pulse failing completely within a few minutes. Immediate aspiration of cerebrospinal fluid from the encephalocele, intracardiac injection of procaine-adrenaline solution, and, finally, cardiac massage were unsuccessful. At necropsy there was found to be a gross malformation of the hind-brain (Arnold-Chiari malformation); abnormally long cerebellar tonsils had prolapsed through the foramen magnum and given rise to strangulation of the medulla oblongata, hence the respiratory and cardiac arrest. Such a case cannot be saved by any normal resuscitative measure.

Case 2: Asphyxia, with cardiac failure, due to respiratory obstruction; relief of obstruction; artificial respiration and cardiac massage; temporary recovery.—A middle-aged woman was admitted to hospital in the last stages of asphyxia due to haemorrhage into a thyroid cyst. She was rushed to an operating theatre, but as she was laid upon the table her heart stopped. A stiff intratracheal tube was rapidly inserted, the lungs were inflated with oxygen, and within another two minutes cardiac massage was begun. The heart and respiration restarted, and it was then possible to deliver and remove the thyroid swelling, some local analgesic being used in the later stages of the operation. When the intratracheal tube was removed the patient was actually able to thank the surgeon for saving her life, but she went into coma some 12 hours later and died within two days. At necropsy there were found to be multiple petechial haemorrhages throughout the brain. The appearances were characteristic of those seen in patients who have undergone long periods of asphyxia. It is of interest to recall that in certain cases of carbon monoxide poisoning there may also be temporary recovery of consciousness followed by coma and death, with similar post-mortem appearances.

Group 2

Cardiac massage has of course little or no part to play in resuscitation from shock and haemorrhage. We have used it unsuccessfully in one case of air embolism. This case is unusual enough to merit a brief report.

Case 3: Air embolism resulting from air encephalography; cardiac massage; death.—A boy aged 2 years was undergoing air encephalography by the lumbar route under bromethol narcosis with a little ethyl chloride to maintain relaxation. He had been knocked down by a lorry one month before and had since been subject to attacks of vomiting and what might have been minor epileptic fits. The air encephalogram was regarded as desirable to clear up the diagnosis, since there were no signs of increased intracranial pressure. Just as a 30-ml. replacement of cerebrospinal fluid by air was completed the patient became cyanosed, with sighing respiration. Thereafter the pulse failed completely. Four minutes later, forced insufflation of oxygen having failed to improve him, a left paramedian abdominal incision was made and the heart palpated. It was found to be flaccid, but after a

short period of massage a few spontaneous beats returned, only to die away again within a minute. At necropsy the right auricle and both ventricles of the heart were found to be filled with a mixture of air and blood, and the superficial cerebral vessels contained multiple air emboli. The portal of entry of the air is not absolutely certain, but a small tear was found in the dura mater of the left side of the posterior fossa of the skull. This did not involve any of the major venous sinuses, but there was some laceration of the cerebellum beneath it. We think it conceivable that the air entering the subarachnoid space in this region was carried into either one of the diploic veins of the skull, or possibly one of the cerebellar veins.

Group 3

We have already noticed that deaths in this group first occurred after the use of chloroform. More recently, cardiac arrest with successful resuscitation has been reported after spinal analgesia (Lium, 1946; Hyde and Moore, 1950), inhalation of cyclopropane (Adams and Hand, 1942), and even "the failing of an oxygen cylinder" (Primrose, 1950).

It is generally agreed that the greatest bar to success in managing these cases is waste of time. The brain cannot be expected to, though it may sometimes, survive more than three minutes of complete anoxia without suffering irreversible damage.

While not denying that the arrested heart may respond from time to time to the injection of certain substances, or even to the prick of a needle, we have found that it is much more often by cardiac massage than by intracardiac injections that success is eventually achieved. Again, as a matter of practical experience we found that it might often take less time to institute cardiac massage than to find, measure, and administer an intracardiac injection, and we knew of no case of morbidity or fatality due to the epigastric incision used in cardiac massage. Finally, we had a clear example of the efficiency of early massage.

Case 4: Primary chloroform heart failure; cardiac massage; recovery.—A man of 60 was undergoing a prostatectomy by the suprapubic route under gas, oxygen, and ether anaesthesia. Half-way through the operation the surgeon asked for the anaesthesia to be deepened. The anaesthetist (who was only recently qualified) chose to do this by suddenly administering a strong concentration of chloroform vapour, with the result that the patient's heart promptly failed. On finding what had occurred, the surgeon ordered the administration of chloroform to be discontinued and forthwith opened the peritoneum through his suprapubic incision and palpated the heart. Since there was no sign of any activity, cardiac massage was begun immediately. Within less than a minute the heart had restarted and another five minutes later the whole emergency was at an end. The patient took some six to eight hours to regain consciousness after his operation, but he made a complete recovery and is to-day a normal man.

It seemed, therefore, that we needed a carefully rehearsed routine which should be put into practice the moment there was a real suspicion of an impending catastrophe. This principle has of course long been advocated with great distinction by Hamilton Bailey (1941), though his actual technique was later modified (Bailey, 1947). The one which we have adopted is original in only one respect. We make the anaesthetist rather than the surgeon the captain of the team for the duration of the emergency. It is his responsibility to raise the alarm; he gives the order for each successive step. The surgeon, having made the operative site safe to leave for a while, puts himself at the anaesthetist's disposal.

Details of our Practice

1. When there is anything in the patient's pre-operative condition to suggest difficulty in giving the anaesthetic, induction is begun only when the surgeon is scrubbing up.

2. If at any time during the administration of the anaesthetic any impairment of circulation occurs the anaesthetist gives the alarm to the whole theatre. We regard the appearance of cyanosis with pallor on the exposed parts of the body as the cardinal sign of this condition.

3. The lungs are first inflated three or four times with pure oxygen. In advocating this step we wish to make it quite clear that we recognize that the pallor with cyanosis which has been mentioned is due to failure of the heart rather than simply of pulmonary ventilation. Precious time can only too easily be spent in artificial respiration when what is required is cardiac massage, but we have found a class of case in which prompt inflation of the lungs with oxygen seems to break a vicious circle and allow an embarrassed heart to return to normal.

Case 5: Reflex cardiac arrest due to sudden mechanical obstruction of the respiratory pathway; restoration of airway and insufflation of oxygen; recovery.—A month-old child with congenital oesophageal atresia was undergoing thoracotomy with a view to establishing a normal oesophagus. During the operation the endotracheal tube which was being used for anaesthesia was accidentally pulled out. The heart, which was under direct vision, was seen to stop beating at once. The operation was therefore suspended while the tube was replaced. The anaesthetist then inflated the lungs several times with pure oxygen. Immediately spontaneous heart beats returned and the operation was continued without further incident.

4. If there is no response to this last step the surgeon, who should have had ample time to make the operative field safe to leave, is asked to perform cardiac massage. This is done through a midline epigastric incision. We neither open the diaphragm as a routine nor hesitate to do so in a difficult case.

5. While massage is being performed, 9.5 ml. of 1% procaine mixed with 0.5 ml. of 1 in 1,000 adrenaline solution is injected into the right auricle by an assistant. We have avoided the intraventricular injection of adrenaline because of the risk of fibrillation. Meanwhile, of course, the administration of pure oxygen is being continued.

6. We persist with cardiac massage until either the heart is maintaining an adequate circulation or it is agreed that further treatment is useless.

To recapitulate: We try always to remember the possibility of cardiac arrest occurring, we have a set routine, and we have rehearsed it with one another. If the emergency materializes, the anaesthetist directs treatment either until circulation and respiration have been restored or until death is felt to be certain. We are convinced that hesitation is our biggest enemy and that an epigastric wound is a small price to pay for a saved life.

Recent Successful Cases

The measure of our success is shown by the following cases, which represent our total experience of sudden cardiac failure due to anaesthetic causes in the three years since the routine we have described was put into operation.

Case 6: Cardiac failure following asphyxia due to laryngeal spasm; restoration of airway and cardiac massage; recovery.—An 8-months-old girl was to undergo a second stage operation for chronic subdural haematoma. She had already undergone a preliminary operation without incident. Induction of anaesthesia was with ethyl chloride followed by A.E.C. mixture. As intubation was required the laryngoscope was inserted, whereupon a severe laryngeal spasm occurred which rapidly passed into circulatory failure. An intratracheal tube was passed and insufflation of oxygen begun. There was, however, no return of circulation, so a midline epigastric incision was made, the existence of cardiac arrest confirmed by palpation, and cardiac massage begun. After about 40 seconds normal heart action and respiration returned, and within 15 minutes the child was fully conscious. Some weeks later she was again anaesthetized, and the operation was completed without incident.

Case 7: Cardiac failure following asphyxia due to laryngeal spasm; cardiac massage; recovery.—A girl aged 4½ months was to have a lumbar meningocele excised. Anaesthesia was induced with 50% cyclopropane and oxygen. Insertion of a laryngoscope blade induced a laryngeal spasm which could not be overcome by administering oxygen via a facepiece or by manual compression of the chest. An endotracheal tube was therefore passed and oxygen insufflation started, but the intense cyanosis was not relieved. Instead it began to give way to pallor and the surgeon was asked to massage the heart. He made the usual midline

epigastric incision, inserted two fingers under the diaphragm, and palpated the heart, which was flaccid. After massage for a few seconds heart beats began to return, and a short period of artificial ventilation with oxygen induced the child to breathe normally. Anaesthesia with 50% cyclopropane and oxygen was maintained for about 15 minutes for closure of the abdominal wound. A month later general anaesthesia was again induced and the meningocele removed; nothing untoward occurred.

Case 8: Cardiac and respiratory arrest during bronchoscopy; cardiac massage; recovery.—A man aged 30 had a right lower and middle lobectomy, with segmental resection of the right upper lobe, for bronchiectasis on February 15, 1950. He developed a collapse of the remains of his right upper lobe. On March 2 it was intended to carry out a bronchoscopic aspiration of his right upper lobe and to crush his right phrenic nerve. Premedication was by $\frac{1}{4}$ gr. (16 mg.) of morphine and 1/100 gr. (0.65 mg.) of atropine. Induction was with tubocurarine and 0.7 g. of sodium thiopentone. Respiratory arrest occurred during the bronchoscopy. The theatre lights were switched on to reveal the characteristic cyanosis fading to pallor to which we have already drawn attention. The bronchoscope was removed and artificial ventilation of the lungs carried out, using a facepiece. There being no improvement in the patient's colour, a midline epigastric incision was made; the heart was found to be flaccid, and massage was carried out through an incision in the diaphragm. In about one minute the heart began to contract, but the circulation of the head and neck, as judged by persistent extreme dilatation of the pupils and cyanosis of the ears, was in abeyance for some five minutes. The pulse and colour, however, returned to normal within ten minutes. Spontaneous respiration did not return for three hours, but part of this delay was felt to be due to overventilation. About half an hour after the heart began to beat intermittent rhythmical movements were noticed in the tongue and lips. Rigidity of the arms soon appeared, and persisted. The temperature was now subnormal.

Eight hours later the patient was still unconscious, with laboured respiration and signs of pulmonary oedema; his temperature had risen to 99.4° F. (37.4° C.). Twelve and a half hours after cardiac arrest he was becoming restless and at 18 hours consciousness was returning. At 24 hours he was drowsy but could be roused to answer questions. By the third day he was sitting up in bed fairly well orientated though somewhat argumentative and easily confused. His chest symptoms were much improved and he began to get up. At the eighth day he was slightly euphoric, with a loss of memory from thirteen days before to four days after the cardiac arrest, though islets of memory persisted up to the time of the accident. Sixteen months later he was still euphoric, but was taking a full-time clerical course. He reported having great trouble in learning shorthand, and is probably going to show some slight permanent intellectual impairment, but not enough to prevent him earning his living.

Summary

The causes of cardiac arrest during anaesthesia are considered. It is pointed out that treatment must be according to the cause, and that only a proportion of cases require cardiac massage.

Details are given of a routine which has proved effective in three successive cases. The essential feature of this routine is that once cardiac arrest has occurred the resuscitatory measures are controlled not by the surgeon but by the anaesthetist.

Our thanks are due to Professor John Morley for permission to record Cases 2 and 3, which were admitted to the Manchester Royal Infirmary under his care and operated upon by one of us; to Mr. A. Graham Bryce for permission to record Case 7; and to Mr. F. Nicholson for Case 4.

REFERENCES

- Adams, H. D., and Hand, L. V. (1942). *J. Amer. med. Ass.*, 118, 133.
Anon. (1853). *Lancet*, 1, 21.
Bailey, H. (1941). *British Medical Journal*, 2, 84.
— (1947). *Lancet*, 1, 5.
Barber, R. F. and Madden, J. L. (1945). *Amer. J. Surg.*, 70, 135.
Beecher, H. K. (1941). *Anesthesiology*, 2, 443.
Hyde, T. L., and Moore, L. V. (1950). *J. Amer. med. Ass.*, 143, 805.
Lahey, F. H., and Ruzicka, E. R. (1950). *Surg. Gynec. Obstet.*, 90, 108.
Lium, R. (1946). *New Engl. J. Med.*, 234, 691.
Primrose, W. B. (1950). *Anaesthesia*, 5, 36.
Ruzicka, E. R., and Nicholson, M. J. (1947). *J. Amer. med. Ass.*, 135, 622.

ELECTRIC CONVULSION THERAPY IN TREATMENT OF PROLONGED STUPOR

BY

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States of stupor of many years' duration and complete amnesia for prolonged periods are usually said to be hysterical in origin. A case, therefore, that presents these features with little evidence of hysterical aetiology is worthy of discussion, especially as such states are rather rare.

Case Report

A machine-hand aged 52 was admitted to Whittingham Hospital on August 4, 1950, on a summary reception order. On admission he was in a stuporous state, being content to lie in bed, taking no apparent interest in his surroundings, and making no response when spoken to. He showed no initiative, apart from eating his meals when they were placed in front of him and using the toilet when he was taken there. He appeared to be vaguely depressed, and his facial expression was one of slight apprehension. There was no impulsiveness or evidence of behaviour in response to delusions or hallucinations. Such movements as he made were well co-ordinated and purposive.

Physically, no abnormalities were noted apart from a right eye which was fixed in a position of lateral deviation and with a deformed pupil which did not respond to light or show the menace reflex. It was assumed to be blind. The blood W.R., C.S.F., chest x-ray film, and E.E.G. were all within normal limits.

On becoming an ambulant patient his behaviour did not alter. He sat in the ward and showed no initiative or attempt to contact his environment. Once again he ate his meals when they were placed in front of him and used the toilet when he was taken there. The general impression he gave was of a quiet well-trained domestic animal that had lost its usual drives. On casual inspection he seemed to be totally blind and deaf, though it was realized that the deviated and blind right eye made his facial expression more vacant than it might otherwise have been.

History

His wife stated that he was quite well until March, 1946, when, with his son, he attended a football match, at which, owing to a number of circumstances, the crowd became unmanageable. He was separated from his son, swept along helplessly, and sustained a traumatic "hydrocele" by being pressed against a barrier. He arrived home before he was expected, looking pale and ill. He seemed upset, and went to his room, where his wife could hear him pacing backwards and forwards. The son returned after the match, no worse for his experience. Later they learned that there had been several fatal casualties amongst the crowd.

He recovered sufficiently to go out that night, but he soon returned. The family doctor called the following day, told the patient that he must have an operation and on no account return to work. Accordingly he remained at home waiting for a hospital bed. He showed no evidence of mental abnormality at this time.

In October, 1946, he was admitted to a general hospital for his operation. This was quite uneventful, and he appeared to be satisfied and happy at the result. Visiting four days later, his wife was surprised to see the patient depressed, weeping, saying that he was a burden to everyone, that he was "finished" and not fit to live. Later the same day he cut his wrists deeply with a razor in an attempt at suicide. He was certified and admitted to a mental hospital