In Man

Seven subjects undergoing investigation (Burt and Graham, 1950) were given T.E.A.B. intravenously in doses of 250–500 mg. in two to four minutes. In six no abnormal reactions occurred. The remaining subject, a healthy woman aged 22, developed paralysis of curariform type after being given 300 mg. of T.E.A.B. intravenously over two minutes. The pulse rate immediately rose from 70 to 80. After 15 minutes she became drowsy, was unable to speak or to raise her upper eyelids, and showed loss of power in neck and arm muscles with periodic twitchings of limb muscles. There was paralysis of intercostal respiration; diaphragmatic respiratory movements increased in magnitude, affecting blood-flow tracing in the foot, and the respiratory rate rose from 18 to 30 a minute. The skin colour remained good. The drowsiness deepened into a state in which there was no response to questions or commands. When the eyelids were lifted up the pupils were found to be moderately dilated with loss of light reflex, and both eyes rolled irregularly. During this time the blood pressure rose from 126/86 to 136/90, and there was a rise both in blood flow and in skin temperature in the hand, and a transient but not marked rise in the foot. An hour after injection the subject could partly open her eyes, and after tilting her head backwards could count fingers. Power of hand muscles and of speech was returning, though cerebation was still very slow. Two hours after injection walking was possible. There were no further after-effects.

Discussion

Previous reports of toxic effects following the use of tetraethylammonium compounds suggest that these are similar in man and in animals. Marshall (1912, 1913) demonstrated the curariform actions of the quaternary ammonium salts in animals. Birchall *et al.* (1947) produced alarming curariform effects in man with doses of 32 mg./kg. of tetraethylammonium chloride. Artificial respiration was required to compensate for the intercostal nerve paralysis and insufficient diaphragmatic breathing. Asthmatic subjects seem particularly prone to respiratory distress after the administration of T.E.A.B.

Schwartz (1949) found that asthma was aggravated in four out of seven cases; one subject "became pulseless, gasped for breath a few times, stopped breathing, became unconscious," and died after only 230 mg. of T.E.A.B. Schwartz believed that the most likely explanation was "a sudden excessive hypotension due either to lowering of the blood pressure or to ventricular fibrillation analogous to the paroxysmal tachycardia" observed by Friedlich *et al.* (1948). Their case was also an asthmatic, and developed ineffectual gasping respiration of an alarming nature, followed by hyperventilation. However, the mode of death in the case reported by Schwartz is similar to that of the animals in the present report, which is attributed to respiratory failure.

Although Lyons *et al.* (1947) believe that large doses of T.E.A.B. cause death from central respiratory depression without curariform paralysis of respiratory muscles, the evidence presented above suggests that the latter effect is the more common. The close similarity between the toxic effects of T.E.A.B. in animals and those in man has not been sufficiently stressed, and indicates that curariform paralysis is a danger to which both are prone.

Summary

Toxic effects in animals and man following the administration of tetraethylammonium bromide are reported. Out of 20 dogs to which T.E.A.B. was administered in large doses seven died—five from curariform paralysis of intercostal and diaphragmatic muscles, and two probably from central respiratory paralysis. A similar but not fatal curariform paralysis in man is reported.

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THE MANAGEMENT OF HEAD INJURIES FROM THE ANAESTHETIST'S POINT OF VIEW

BY

R. BRYCE-SMITH, M.A., B.M., B.Ch., D.A.

First Assistant, Nuffield Department of Anaesthetics, University of Oxford

The anaesthetist has much to contribute to the care of the unconscious patient, no matter what the cause may be. In respect of their management, patients suffering from barbiturate poisoning, poliomyelitis, and acute head injuries have much in common, though the last group provides the greatest variety of problems.

Factors Against a Clear Airway

The maintenance of a clear airway is the immediate consideration, since this may be menaced by any of four factors or by a combination of them.

1. *Depression of Reflexes.*—Quite apart from the fact that in any unconscious patient the tongue may fall back and cause a respiratory obstruction above the glottis, a head injury may be severe enough to obtund reflexes essential to life. If the cough reflex is in abeyance the trachea is no longer protected from invasion by foreign bodies.

2. *Gastric Motility.*—War injuries repeatedly showed that injury reduces gastric motility, and as a result the stomach will retain its contents for many hours afterwards (Macintosh, 1949). Since so many head injuries occur on the roads after "closing-time," a full stomach must be expected. If the patient remains conscious this offers no danger to life, but in one whose reflexes are depressed, as a result of either a head injury or a general anaesthetic, vomiting may lead to a fatal respiratory obstruction.

Case 1.—A man aged 69 was admitted to hospital with a compound fracture of the frontal bones, the result of being knocked off his bicycle. In the casualty department he was deeply unconscious, but his general condition was satisfactory and his airway good. He was therefore sent direct to a ward. After he had been lifted into bed it was noticed that his respiration

was stertorous. He was then slightly cyanosed and his pulse rapid and feeble. An anaesthetist was called, but by this time respiration had stopped. A laryngoscopic examination revealed a considerable quantity of stomach contents in the pharynx and trachea. This was aspirated immediately and artificial respiration started, but the patient died within ten minutes. At necropsy the lungs were found to be full of vomitus.

3. *The Direct Results of Injury.*—These include fractures of the mandible, which make it difficult to retain the tongue forward, and bleeding from the mouth, nose, tongue, or from the base of the skull. In an unconscious patient particularly, these can lead to a serious respiratory obstruction.

4. *Pulmonary Oedema of Central Origin.*—Although this complication is more common some days after injury it may develop almost immediately, and it is most frequently associated with injury to the mid-brain. Experimentally, the condition, which resembles the pulmonary oedema of heart failure, has been reproduced in animals by the injection of fibrinogen into the fourth ventricle. Cameron (1948) reports that at necropsy pulmonary oedema was found in 67% of patients with non-traumatic intracranial haemorrhages and in 63% of patients with fractured skulls. He believes that the condition is due to a disturbance of intracranial pressure.

The treatment of the patient unconscious as a result of a head injury is important, for not only may it be life-saving but it may also influence the later management of such cases.

Immediate Treatment

A stomach tube should be passed at the earliest possible moment. There is no justification for not doing this, for even if the stomach is empty no harm can result. The procedure may be of inestimable value, particularly when the patient is to be moved any distance, short or long, for during transit skilled attention and facilities for treatment are unlikely to be at hand.

An adequate airway may be maintained by (a) posture, (b) manual control of the jaw and tongue, or (c) artificial airways; but even an endotracheal tube is not foolproof unless properly supervised; nor, unless a means of suction is at hand, can it overcome the respiratory embarrassment caused by excessive bronchial secretion or blood. Case 2 illustrates four undesirable sequelae of intubation in an attempt to ensure an airway.

Case 2.—A man aged 42 was found unconscious on the roadside after a motor-cycle accident. He was taken to the local cottage hospital, where he was intubated through the mouth with a No. 8 Magill tube before being transferred to a larger centre. When I first saw this patient, 14 hours after injury, his respirations were rapid and stertorous, and he was slightly cyanosed. Respiratory obstruction was suggested by indrawing of the chest wall on inspiration, and this was confirmed by the character of the breath sounds through the tube, which showed that the latter was not fulfilling its function. The tube was therefore removed, and under direct vision a quantity of thick purulent mucus was aspirated from the pharynx and trachea. The cords were seen to be ulcerated and there was a gross tracheitis. Forty-eight hours later the patient died, and at necropsy the ulceration of the posterior borders of both cords was confirmed and a tracheitis which amounted to frank ulceration extended to the carina. The trachea was full of purulent mucus.

Examination of the endotracheal tube after its removal showed that it was so long that the tip must have entered a bronchus: this was not diagnosed during life, as the clinical picture was complicated by multiple fractured ribs. The lumen of the tube was greatly reduced by mucopus, which had become so inspissated and adherent to the inner wall of the tube that it

could not be removed by aspiration. A transverse marking on the concave border of the tube was probably the result of repeated kinking caused by movement of the patient's head during the ambulance journey. Finally, the severity of the tracheitis suggested that the irritation might be chemical rather than mechanical, and suspicion became a strong probability when the fumes of formalin detected by the nose were strong enough to cause lacrimation.

Despite its limitations, I believe that an endotracheal tube may be recommended as a means of retaining an airway, provided that the dangers are fully recognized, and provided that a proper airway cannot be maintained by simpler measures—that is, manual control, a Waters airway, or correct posture. The last-named is, in any case, of the greatest importance. The supine position must be condemned not only because it permits the tongue and jaw to fall back and occlude the pharynx but also because the direction of the trachea prevents drainage of secretions from the lungs and encourages blood and vomit to run down the respiratory tract. The presence of an endotracheal tube does not prevent this, since it does not occlude the glottic opening in the deeply unconscious patient, whose cords may be widely separated. Thus the semi-prone or "tongue" position with a head-down tilt should be adopted, for this encourages drainage from the trachea, prevents the inhalation of foreign bodies, and allows the jaw and tongue to hang forwards (Macintosh and Bannister, 1947).

Management in the Later Stages

This period starts as soon as the patient is in bed in a ward and continues until consciousness is regained. Once more the overriding consideration is that of maintaining an airway, because even a minor degree of obstruction, if allowed to persist, may lead to pulmonary oedema and cardiac failure (Macintosh and Mushin, 1946). It is well known that an endotracheal tube will cause ulceration of the cords and trachea if left *in situ* for a long time. What period may elapse before harm results is unpredictable, but I consider that twenty-four hours should be regarded as the time limit. It is therefore essential to make an assessment of the probable period of unconsciousness as early as possible. This estimate may be wide of the mark, but an opinion should be formed whether the patient is likely to regain consciousness in a few days or only after a matter of weeks.

In cases of prolonged unconsciousness an endotracheal tube is out of the question, and with the best will in the world manual control of the jaws is inefficient, especially as this duty is commonly relegated to a junior nurse. Further, the longer the patient remains unable to clear his own secretions by coughing, the more essential does it become to remove them by other means. Pharyngeal toilet alone can never be completely effective, and, since repeated intubation is both undesirable and impracticable, an early tracheotomy is indicated.

Tracheotomy

Not many years ago oxygen was administered, not for any therapeutic value, but as an inevitable last rite to the dying. To-day tracheotomy is regarded in much the same light, and the advantages it has to offer are never seen, because more often than not the operation is performed on a moribund patient. A timely tracheotomy, in fact, ensures a safe airway and a ready access for tracheo-bronchial toilet, without which the patient will assuredly die from a combination of asphyxia and lung infection. A minor operation in the hands of a competent surgeon, tracheotomy is a small price to pay for the

advantages it bestows. To regard tracheotomy as too drastic an undertaking shows a failure to appreciate the gravity of the issues at stake. All too frequently patients with head injuries die, not from their primary injury, but from a chest complication which might have been avoided altogether, or at least mitigated, if efficient bronchial drainage had been established early.

A tracheotomy by itself is not sufficient. It must be combined with frequent changes of posture, at least hourly, to allow secretions from the various lobes of the lungs to drain into the more accessible bronchi or trachea, from which they may be removed by suction. A warning is necessary if a tracheotomy is considered only after an endotracheal tube has been in place for a long time. If there is any degree of tracheitis or ulceration of the cords there is a risk that the tracheotomy wound may become infected, and this in turn will lead to fibrosis, and possibly to stenosis of the glottis and a permanent tracheostomy.

Case 3.—A man aged 28 was admitted to hospital with a severe head injury as a result of a road accident. He was intubated soon after arrival, and except for short intervals the tube remained in position for four days. By this time his cords were ulcerated and an attempt was made to maintain an airway by a relay of nurses holding his lower jaw forward. After three days a tracheotomy was performed. A clear airway was assured, and the patient, though remaining unconscious, was kept free from lung complications for a whole year. The improvement of his cerebral condition was slight, but as the cough reflex returned an attempt was made to close the tracheotomy; this had to be abandoned because of a complete stenosis of the glottis. The criticism here is not that a tracheotomy was performed but that it was performed too late.

Bronchoscopy is a valuable manoeuvre, and should be performed if there is evidence of atelectasis or if secretions cannot be removed by "blind" aspiration. The importance of early bronchoscopy must be stressed, for it will be of little value if withheld until secondary changes appear in the lungs as the result of infection or obstruction of the bronchi. By itself it is only a temporary measure, and must therefore be used as an adjunct to the general treatment already described.

The previous cases show the pitfalls which abound for those concerned with the management of the unconscious patient. Case 4 is included, therefore, to show how satisfactory the result may be when the treatment as advocated in this paper is followed and is instituted at the correct time.

Case 4.—A man aged 66 was admitted to hospital after a fall from his bicycle. He was unconscious and a diagnosis of subdural haemorrhage was made. In spite of a decompression he remained unconscious. Twelve days after the accident, during which time he had become increasingly "chesty," he developed a left lower lobe atelectasis. The temperature rose to 101° F. (38.3° C.), pulse to 110, and respirations to 30. He was slightly cyanosed. Bronchoscopy was performed and a quantity of mucus was aspirated, mainly from the left side. A tracheotomy was performed the same day, and a further quantity of mucus was removed. Changes of posture to encourage drainage from the lungs were made more frequently, and on the following day the temperature had fallen to 99° F. (37.2° C.), the pulse to 90, and the respirations to 25. Six weeks after injury the patient was co-operative and making a good recovery. The cough reflex had returned and the tracheotomy was therefore closed.

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CONGENITAL ATRESIA OF THE OESOPHAGUS

BY

R. H. R. BELSEY, M.S., F.R.C.S.

Consultant Thoracic Surgeon, Frenchay Hospital, Bristol

AND

C. P. DONNISON, M.D., M.R.C.P.

Consultant Paediatrician, Cheltenham General, Eye, and Children's Hospital

Congenital atresia of the oesophagus is commoner than is generally realized, and if recognized early can be amenable to surgical treatment. The condition is very readily overlooked, but if the possibility is borne in mind it can be diagnosed without difficulty. The purpose of this article is to report a series of cases in support of these statements and to describe the technique of treatment that has been carried out at the Department of Thoracic Surgery of the Frenchay Hospital.

Incidence

The incidence of congenital atresia of the oesophagus has been stated to be about 1 in 2,500 births (Franklin, 1947; Grey Turner, 1949). In our experience the incidence is much greater than this, presumably because many cases are not recognized and deaths are regarded as having been due to atelectasis or pneumonia.

One of us is a consultant paediatrician to a clinical area with a population of about 100,000 in which there are approximately 2,000 births annually. He has seen five cases during the course of two years. The first was in May, 1948, and the patient was 6 days old and very ill with pneumonia, which terminated fatally before surgical treatment could be arranged. The diagnosis was confirmed at necropsy. The remaining cases are described below, being Nos. 2, 4, 7, and 10.

The incidence of cases in this clinical area in which the diagnosis was confirmed was thus 1 in 800 births. It is not to be assumed that all such cases were referred for consultation or that they were diagnosed if so referred. Hence it is reasonably certain that the incidence is distinctly greater than 1 in 800. There is no justification for believing there may be a special incidence of the condition in the area where these observations were made. No epidemic of rubella or other disease that might cause it has been recognized and there has been no undue incidence of other congenital abnormalities.

It is easy to understand how the condition can be overlooked. It presents no easily recognized signs. The infant brings up some frothy mucus during the first day or two of life. Attempts at feeding lead to regurgitation, choking, and probably cyanosis. These events in a newly born infant may call for no special concern on the part of the nurse. By the third day chest symptoms are developing which are attributed to infection, and all further feeding difficulties and respiratory distress are attributed to pneumonia. This terminates fatally when the infant is about a week old, and the cause of death seems obvious. If a necropsy is performed the oesophageal condition is very easily overlooked.

In our cases we have noticed that the condition is often associated with atelectasis, particularly of an upper lobe. The reason for this is not altogether clear, but it may arise from inhalation of saliva, the right upper lobe being a common site for any inhalation phenomenon. Inhalation