GAS ANAESTHESIA UNDER POSITIVE PRESSURE *

BY

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The advantages of gas anaesthesia under positive pressure are so often overlooked by anaesthetists that their recapitulation may be useful. At the same time little can be added to what has been said on the subject by the late E. I. McKesson, who may be regarded as the originator of the method.

With the standard gas-anaesthesia apparatus the gases are delivered to the patient at a pressure little above the atmospheric. In the positive-pressure technique, special apparatus is used by which the anaesthetic mixture may be delivered at any desired pressure, from 0 to 40 mm. Hg above the atmospheric, without alteration in its percentage composition. Two such machines are in use in Australia—namely, the McKesson apparatus and the Austox, its local imitation. Both possess a graduated dial which, when rotated, actuates a set of levers increasing the pressure of delivery to the desired extent. With both, the mask or inhaler must fit the face closely if the increased pressure is to be effective. It then remains only to increase the spring tension on the exhalation valve so that the gas shall not be uselessly dissipated, and to adjust the rebreather by a spring so that it shall not remain a distended and useless bag, but shall continue to close during inhalation and to expand during exhalation. Pressure anaesthesia will be very wasteful of gas if these adjustments be not accurately made.

It is now proposed to describe the circumstances under which the use of positive pressure is helpful and often imperative, and to illustrate them by some personal experiences.

Mask Anaesthesia

When gas is given by the mask method, it is desirable to do so under a pressure of 2–3 mm. Hg, thus facilitating free inhalation and aiding the diffusion of gases through the lung alveoli. This pressure may need to be increased to 7–10 mm. Hg or more under the following circumstances: (a) where the mask fits badly, so that gas shall escape through the gap rather than air enter by it and affect the plane of anaesthesia; (b) where respiration is shallow, as from shock or narcotic overdose; (c) where respiration is obstructed, as when the trachea is manipulated during thyroidectomy; (d) where the diffusion of gases through the lungs is imperfect, as in emphysematous patients. The improvement in the patient's condition when ineffective respiration is thus aided is often very marked.

Respiratory Arrest

In cases of respiratory depression or failure, pure oxygen may be delivered to the patient under pressure. In the McKesson apparatus it suffices to close the exhalation valve with the thumb and to press a button to release an instantaneous flow of oxygen under high pressure. The lungs are forcefully inflated, but cannot in practice be injured, because the mask will be blown out of contact with the face before harmful pressures are reached. Provided the circulation remains unimpaired the oxygen is rapidly absorbed and soon effective. Two

or three such lung inflations, at intervals of about twenty seconds, will ordinarily overcome the respiratory depression of fourth-stage nitrous oxide anaesthesia, as the accompanying chart shows.

Before inflating the lungs with oxygen the anaesthetist must make sure that the respiratory depression be not due to presence of vomitus or foreign matter in the air passages. A case is reported from an Australian city in which, the patient becoming cyanotic, lung inflation was performed. The patient, however, became more deeply asphyxiated and died. Necropsy showed that the bronchial tree was full of vomitus, packed closely into it by the gaseous "vis a tergo." In such cases, before oxygen is insufflated, the head should be lowered, the pharynx cleaned, the larynx intubated, and the bronchial tree cleared by aspiration. Only in a grave emergency should any risk be taken. Thus, in a case of emergency surgery I encountered respiratory arrest due to vomiting of a full meal. Lowering the head and clearing the pharynx were of no avail. As facilities for intubation and aspiration were not at hand, the risk of trying to force oxygen past the obstruction was wittingly taken. Fortunately the cough reflex was thus soon restored and the foreign matter (mainly green peas) expelled without subsequent ill effects. The rule still holds, however, that lung inflation with oxygen should be avoided, if possible, in cases where foreign matter is present in the pharynx.

Endotracheal Anaesthesia

The standard wide-bore catheters for endotracheal gas anaesthesia seldom form a gastight fit in the glottis. If, then, the supplementary packing be inefficient or inapplicable air or even blood may enter the gap. This may be obviated by the use of a pressure of 5–10 mm. Hg, converting the potential air inlet into a gas escape. Flagging respiration may be assisted by the use of positive pressure in endotracheal as in mask anaesthesia, and I have found it of great assistance in combating the grave respiratory depression encountered in cerebral operations, especially in those upon the posterior cerebral fossa in patients suffering from high intracranial tension. Further, low-pressure endotracheal gas anaesthesia necessitates the use of a wide-bore catheter, so that an adequate passage may be provided for respiration. On two occasions I was unable to expose the larynx sufficiently for such a catheter to be inserted. A small gum-elastic catheter was accordingly used and anaesthesia maintained by insufflation at a pressure of 25 mm. Hg. The waste of gas was naturally great, but the alternative would have been the abandonment of gas anaesthesia had positive pressure not been available.

Open-mouth Operations

Major dental operations demand endotracheal anaesthesia, but minor procedures may be performed under gas anaesthesia nasally maintained, with the mouth packed securely. To ensure lung aeration, and to obviate mouth breathing around the pack, a pressure of about 10 mm. Hg is necessary. If the packing be inefficient, pressures of from 20 to 40 mm. Hg may be required. Hence, uniformly satisfactory results can only be secured by using apparatus capable of delivery at high pressures. I experienced a complete fiasco in the case of an ambulant patient, seen for the first time in a dentist's surgery. Her nose proved to be almost wholly obstructed, so that delivery at 40 mm. Hg, supplemented by the use of a mouth tube, failed to prevent gross mouth breathing. Anaesthesia could not be maintained long enough for the operation to be wholly completed.

* Read in opening a discussion in the Section of Pharmacology at the Annual Meeting of the British Medical Association, Melbourne, 1935.

In nose and throat surgery it happens occasionally that an operation must be performed upon a patient in whom endotracheal anaesthesia is for some reason (for example, acute laryngitis) undesirable or inapplicable. Gas anaesthesia is then selected because of the possibility of quickly recalling the cough reflex under it, and is maintained by the nasal route under pressure. At the same time it must be remembered that the bronchial tree is unguarded, so the operation must be severely limited in scope and every care taken in regard to the posture of the patient and the thorough aspiration of the pharynx. I have been obliged to handle in this way two or three cases of pharyngeal abscess, surgical access having been impossible without an anaesthetic, and intubation of the larynx having been prevented by fear of rupturing the abscess and by gross swelling of the posterior pharyngeal wall. The patients were placed in the Trendelenburg

Thoracic Surgery

Modern thoracic surgery is rendered possible by two things—namely, the introduction of the non-toxic and non-irritating gaseous anaesthetics and the use of endotracheal anaesthesia, by which aeration of the blood may be secured even though one or both lungs be collapsed by the thoracic incision.

Patients for thoracic surgery usually present some disease condition which hinders the diffusion of gases through their lungs. Diffusion is further affected by collapse of the operated lung and by postural embarrassment of the sound lung. Administration of the anaesthetic at positive pressure will thus greatly aid oxygenation of the blood. For relatively minor procedures, such as rib section for empyema, administration by mask may suffice. For major operations, especially those upon

Nitrous Oxide Overdose: Respiratory Arrest (McKesson "Nargraf" Record). The heavy black line on the extreme right indicates the volume of rebreathed anaesthetic; the short projecting spikes show the tidal lung capacity at those times. Respiration may be seen to become irregular and incomplete and finally to fail. Prompt recovery is shown after lung inflation with oxygen. The line in the centre of the chart indicates the oxygen concentration, which was increased after respiratory depression became evident. The horizontal lines each represent a reading of the blood pressure, the systolic value being shown by the extreme right-hand end of each line, and the diastolic by the left-hand end. The crossed line indicates pulse rate and the dotted line respiration rate. The interrupted line on the extreme left shows the pressure of delivery of the gas mixture. The sharp spike on it indicates the sudden rise of pressure beneath the mask during lung inflation with oxygen.

position and anaesthetized by the nasal route under pressure. As soon as the mouth could be opened the abscess was incised and the pus aspirated; meanwhile the cough reflex was restored by administering oxygen. The risk of asphyxia or of inhalation of pus is, however, so great that the method should not be used where avoidable. One case nearly ended in tragedy.

The patient suffered from retropharyngeal abscess, oedema of the glottis, and dyspnoea; the last-named was less obvious when the gas-oxygen mixture was given at high pressure. On opening the mouth, however, the swollen tongue was forced back over the oedematous glottis and produced asphyxia. Incision of the abscess and aspiration of the pus was necessarily a rather deliberate procedure, and at its conclusion the patient was almost dead of asphyxia, needing to be revived by intubation of his larynx and insufflation of oxygen.

the lung itself, endotracheal anaesthesia is desirable, preferably with two catheters, so that one may be used for aspiration of blood or pus from the bronchi. In either case positive pressure should be employed. It aids diffusion of gases through the sound lung and partially re-expands the collapsed one, making it absorptive of oxygen. By further increasing the pressure this lung may be brought up into the wound for inspection or "anchoring" by the surgeon. Bronchial fistula will be demonstrated by the escape of gas through them; indeed, the fistulous patient may be difficult to anaesthetize unless positive pressure be available to replace lost gas and to check inhalation of air through the fistula. At the end of operation the pressure is increased so as fully to expand the lung, thus expelling clot and exudate from the pleural cavity. The lung is kept expanded until gas-

tight closure of the chest wall has been effected ; in this way post-operative pneumothorax may be lessened or even obviated.

Conclusion

Enough has been said to illustrate the many advantages of positive-pressure gas anaesthesia. A warning may now be given as to its pitfalls. Gases diffuse rapidly under pressure, and a slight alteration in the oxygen percentage in the anaesthetic mixture may be followed by a marked and rapid change in the plane of anaesthesia. The anaesthetist must therefore recognize the potency of his apparatus, must be thoroughly acquainted with the signs of gas anaesthesia, and must be ever vigilant. Without these safeguards he may find his positive-pressure apparatus a rather dangerous, precisely because a highly efficient, instrument.

Further, the convenience of nasal and pharyngeal insufflation of gaseous anaesthetics has led certain anaesthetists, particularly in America, where the pressure technique was evolved, to extend its routine use into questionable fields, such as nose and throat surgery. In such operations the best safeguard for respiratory function and for the integrity of the bronchial tree is endotracheal anaesthesia, and nasal or pharyngeal administration provides neither a safe nor an adequate substitute for it. Positive pressure is a valuable, and sometimes an essential, adjuvant to gas anaesthesia, but its application should be limited always by a due discretion.

ADVANCES IN OUR KNOWLEDGE OF HYDATID DISEASE DURING THE TWENTIETH CENTURY*

BY

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Hydatid disease first came into prominence as an Australian medical problem in the 'sixties of last century. As time went on, and more and more patients harboured cysts which were both old enough and large enough to produce symptoms, the frequency with which the disease was recognized rapidly increased, and it reached its peak incidence in the 'nineties. The clinicians of this time had unrivalled opportunities for its clinical study, and as this period coincided with the rise of active medical schools and with great advances in general pathology and medicine, we find that they made full use of these opportunities. They met with hydatid disease in all its manifestations, and made numerous original observations as to its clinical aspects. In addition, the revolution in surgical procedures resulting from the introduction of Listerian methods brought more patients under direct observation and led to great advances in regard to treatment. The transactions of the various medical congresses of the latter part of the century, and the files of the local medical journals, show how carefully this disease was observed and discussed, and to the student of the subject are still of extreme interest.

In spite of their great experience, however, clinicians and pathologists were still puzzled over some of the manifestations of the disease. It is therefore of interest to review shortly the steps by which, during the next thirty years, nearly all the problems of immediate practical importance were solved. As each sectional advance is dealt with I propose to indicate briefly some of the problems which still await elucidation.

The Modern Period, 1900-35

All the essential aetiological factors—the close association of sheep, dogs, and men, at times living under primitive conditions—which led to the establishment of the disease in this country still exist ; but owing to dissemination of knowledge as to the life-history, to better education in hygienic matters generally, and to active public health propaganda the disease—although still relatively common—has much diminished in frequency. It has become recognized, as in all other countries, that the most common source of human infestation is direct contact with infected dogs, and that such factors as infected water supplies, raw vegetables, etc., are of little importance.¹ There is no doubt that the disease is readily preventable, and that it should be fairly easy to control, as the parasite can be attacked in various ways at different periods of its life-cycle. It should be possible to reduce the incidence still further, and no diminution of public health propaganda should be allowed.

We still require more accurate statistical studies of incidence and distribution, and it is hoped that the Hydatid Registry of the Royal Australasian College of Surgeons will provide these in the future. In addition, experimental work is needed to throw light on such problems as the survival of ova and scolices under natural conditions, while further information as to the distribution and control of the disease in animals and as to the relative importance of the various aetiological factors is also wanted.

General Pathological Advances

Advances in our knowledge of hydatid pathology have kept abreast of those made in other countries ; in this respect we are particularly indebted to observers in France and South America. The greatest single advance in our knowledge of the pathology of the disease came when Dv first proved experimentally the fact that secondary echinococcal disease could occur.² He proved that germinal elements in the form of relatively differentiated scolices derived from a fertile primary cyst could, if shed into tissues, into serous cavities, or even into the blood stream, undergo a complete metamorphosis and become in their turn fertile secondary cysts. That this could happen had been tentatively suggested many years before, and had been strongly maintained by a number of Australian surgeons, who had ample opportunities for observing the dissemination of hydatid disease in operation scars and in the peritoneal cavity.³ This possibility, however, had been scouted by most pathologists and helminthologists, as it seemed contrary to the rules laid down by van Beneden. The experimental work of Dv, and later of others in Australia and South America, together with many clinical observations, abundantly proved, however, that this phenomenon was not only possible, but that it was relatively common. Recognition of this fact revolutionized our ideas about hydatid pathology, and explained many things which had hitherto seemed inexplicable. It led at once to an understanding of the difference between primary and secondary cysts, of the nature of recurrent cysts, of multiple cysts of the serous cavities and elsewhere, and of the very interesting metastatic cysts. As a result, too, it led to important modifications of the method of treatment. Another important addition to our knowledge has been a more complete understanding of the histogenesis of the parasite and its study in all stages of its development. This has led to an appreciation of its peculiar structure, its mode of growth, and its diverse pathological appearances in both man and animals. The phenomenon of daughter cyst formation and the pathology of the peculiar forms found in animals has also received much attention, although there are some interesting points, mainly of academic interest, still to be decided.⁴ It is

* Read in opening a discussion in the Section of Surgery at the Annual Meeting of the British Medical Association, Melbourne, 1935. The lecture was illustrated by lantern slides.