GENERAL ANAESTHESIA AND THE TEMPERATURE OF INHALED GASES

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It would appear that for long there have been misconceptions regarding the temperature of gases and vapours as presented to the patient for inhalation. There have also been differences of opinion on the advisability of warming these gases. The idea seems particularly to have prevailed that ether vapour must necessarily have the objectionable quality of coldness. Gwathmey (Hewitt, 1912), in 1908, stressed the need for raising the temperature of the vapour in order to prevent the loss of heat by the patient incurred in warming up a cold vapour in his air passages. Seeling (Hewitt, 1912), on the other hand, in 1911, concluded that the warming of anaesthetic vapours was unnecessary. In 1918 Pembrey and Shipway advocated warming the vapour, with a view to maintaining the patient's body heat; Shipway's warmed-ether apparatus was introduced at that time. Minnitt and Gillies (1944b) do not consider that warming the gases is essential when administered by modern methods, but "if, however, the old method of insufflation is used, in which there is no reflux of exhaled gases, and especially if the gases are blown through ether at a fairly high flow-rate—say 8 litres per minute—then the resultant mixture passing into the lungs is of a sufficiently low temperature to be detrimental, and some form of heating is advantageous." Minnitt and Gillies (1944c) state: "There can be little doubt that the blowing of a cold mixture of gas, oxygen, and ether at a high rate of flow—10 litres or more per minute—into the patient's lungs is a major cause of the high incidence of post-anaesthetic respiratory complications, which are frequently noted when continuous-flow machines of the Boyle type are used, or, perhaps one should say, abused."

The closed circuit and the Oxford inhaler are both commended by some because they maintain a *warm* anaesthetic mixture for inhalation. Open ether, when ether is administered by a perhalation system, is almost invariably associated with the appearance of patches of snow on the gauze, and doubtless this suggests to many the inhalation of a "frosty anaesthetic vapour." Referring again to Minnitt and Gillies (1944a), when the subject of shock and anaesthesia is under discussion a factor contributing to shock production is given—namely, "heat loss by exhalation, and particularly if the patient has to breathe through ether on an open mask."

To test the various opinions expressed on this subject the following observations were made. Temperatures are expressed in degrees Fahrenheit, and were taken with a sensitive chemical thermometer. When obviously unimportant, fractions of a degree were not recorded.

The ether in a drop-bottle, the ether, and the ether vapour and air mixture in the ether bottle of a Boyle machine were all at theatre temperature—73°. The face-piece was removed from the 30-in. wide-bore delivery tube of the machine, and the thermometer was inserted well within the face-piece end of the tube. When a mixture of 1 litre of oxygen and 5 litres of nitrous oxide was allowed to flow the temperature was 73°. The mixture was allowed to pass over the ether in the ether bottle—temperature 73°, and then to bubble through the ether in the ether bottle—temperature 73°. Two litres of oxygen and 10 litres of nitrous oxide were now allowed to bubble through the ether; in 10 minutes the outer surface of the bottle was coated with ice; the temperature of the mixture gradually fell to 69°, at which it remained stationary.

Temperatures of the mixtures as actually inhaled by the patient during anaesthesia were recorded in a large number of cases. *Open ether*:—The mask was a simple one covered with 16 layers of surgical gauze. The temperature was taken by inserting the bulb of the thermometer through a small aperture in the gauze, so that it was situated in the mixture of air and ether vapour within the mask. It was noticeable that the lower temperatures were recorded when the patient's respirations were vigorous, and the higher temperatures when the breathing was quiet. The lowest temperature recorded was 80° and the highest 91°. *Boyle's machine*:—Gas, oxygen, and ether

with limited rebreathing; the temperature of the mixture within the face-piece was 90 to 97°. *Closed circuit*:—Temperature within the face-piece was 92 to 95°.

The conversion of liquid nitrous oxide into a gas and of ether into a vapour are both associated with loss of heat, but the gas and vapour apparently at once acquire the temperature of their environment, and when inhaled are above room temperature, owing to their admixture with the warm exhaled gases. The results obtained in estimating the temperature of the inhaled mixture when the perhalation method is employed may give rise to some surprise. Presumably the important factor here is that 16 layers of gauze, with the entangled air, form a very efficient non-conductor of heat. It can be demonstrated that if a mask of this description is placed in position over the patient's face the temperature of the air within the mask rises in about two minutes from 73° (room temperature) to 87°, and in about the same time becomes saturated with water vapour. The formation of patches of snow is a phenomenon similar to the freezing of the skin with the ethyl chloride spray.

The body heat of the patient during anaesthesia was also studied.

The patient's temperature was taken in the axilla, first immediately before induction and then at frequent intervals—as a rule every 10 minutes. In short simple operations variations in temperature were negligible. A fall of from one to two degrees was noted in the more severe cases; occasionally there would be a rise of temperature. Duration of anaesthesia was in this respect an unimportant factor as compared with the nature of the surgical procedures. A particular study was made of the patient's temperature where open ether was the method of administration throughout the operation. There was quite definitely no fall in the patient's temperature on completing induction, and the temperature was maintained at the pre-induction level during lengthy operations not involving severe surgical measures. Colporrhaphies, for example, lasting 50 minutes, gave records such as 97.2°, 97°, 97.2°, 97.4°, 97.4°. As an example of a more severe operation, a panhysterectomy with difficult adhesions, duration 80 minutes, showed variations in temperature which were obviously associated with the surgical manipulations; before and after induction the temperature was 97.8°, falling after 50 minutes to 96.5°, and rising to 97.2–97.5° on closing the peritoneum. Partial gastrectomies and resections of bowel gave very similar figures. The most marked fall of temperature (from 98° to 96°) was recorded when the operation was an osteotomy of the femur, duration 90 minutes—anaesthesia, cyclopropane and ether, closed circuit.

Discussion

The maintenance of the patient's body heat during anaesthesia is an important matter, but it would appear that in this respect the influence of the temperature of the inhaled anaesthetic gases has been unduly stressed. According to the physiologists (Starling, 1941), in the adjustment of the temperature in man, regulation of the heat loss plays a greater part than heat production. Of the heat loss 80% is by the cutaneous circulation and evaporation of sweat, 11% by evaporation of water in the expired air, 4% in the liberation of carbon dioxide from the lungs, and 5% in warming food and air from 58° to 99° F. It is obvious that a very small percentage will be lost in warming up the air from 75° to 99°. Buxton (1914), quoting Kappeler, states that the body temperature is reduced 0.5 to 2.7° under ether. The body temperature is, however, susceptible to many different influences: it falls with loss of blood, and markedly so, in surgical shock. Many factors during an operation may influence the patient's temperature. It, moreover, is obvious that the warming of gases not only is unnecessary but is impracticable. The warmed gases would be at room temperature by the time they reached the face-piece.

Conclusions

It is not necessary to warm the gases or vapours when conducting inhalational anaesthesia.

Open ether should not be condemned as presenting a "cold vapour" to the patient for inhalation.

There is no evidence that general inhalational anaesthesia is associated with loss of body heat.

The variations in the patient's temperature during operation are due to other factors.

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FOREIGN BODIES IN THE BRONCHI AND OESOPHAGUS IN CHILDREN

BY

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Out of a number of cases of foreign bodies in the bronchi and oesophagus which have passed through my hands during the past five years it is thought that the following five are worth reporting as they illustrate various points which may materially affect the ease or difficulty with which these bodies may be removed.

Foreign bodies are less common in the bronchi than in the oesophagus. On account of the more rigid structure and small diameter of the bronchus, especially in children, removal is always more difficult in these cases. Removal is also complicated by the fact that, unless the foreign body is impacted, it tends to move up and down the lumen of the bronchus with respiration and cough, thus causing irritation of the mucous membrane and producing a varying amount of oedema, which may ultimately occlude any view of the offending article. The lumen of the oesophagus is considerably larger than that of the bronchus, even in a child, and the walls are lax and distensible, providing more space for manipulation, which considerably facilitates the removal of a foreign body.

Case I

A male child aged 5 was admitted to hospital on April 24, 1944, with a history of having inhaled two glass beads three days previously. One of these he had subsequently coughed up before admission, and it had been retrieved. Several severe attacks of coughing were accompanied by partial respiratory obstruction, alarming enough for the practitioner in charge of the case to send the child to hospital. On admission the patient appeared comfortable and continued so as long as he remained in one position. Any change, however, tended to bring on an attack of coughing, which at times was accompanied by signs of dyspnoea. This was explained, and subsequently demonstrated at the time of removal, by the bead being forced up into the trachea and impinging on the lower surface of the vocal cords. There were no signs of collapse of the lung, and x-ray examination revealed the bead situated in the left main bronchus.

Operation was performed under chloroform anaesthesia and the 25-mm. Irwin Moore bronchoscope passed down into the bronchus. The glass bead was easily visible in the bronchus, and was propelled up and down the lumen with each act of respiration. Attempts to seize the bead were found difficult for two reasons: (1) the extremely smooth surface of the bead, which allowed of no firm grip; and (2) although the bead was not impacted, there was hardly enough room to pass the forceps ends over it on either side in order to grip it. After several unsuccessful attempts the patient began to come round and the tube was withdrawn. While this was being done he coughed, and the bead was seen to be propelled into the trachea up against the lower surface of the cords, but before the forceps could be reintroduced it had been sucked back again into its original position. Under deeper anaesthesia the tube was reintroduced and a cotton-wool swab soaked in adrenaline held against the mucous membrane around the bead for a few seconds. This resulted in shrinkage of the tissues, and after one or two more attempts it was possible to secure a firm grasp of the bead and withdraw it into the lumen of the bronchoscope, and then to withdraw the whole. Further examination showed no damage to the bronchial mucous membrane. Beyond a slight laryngitis for a few days, the child suffered no ill effects, and was discharged about a week later.

Case II

A boy aged 3 was admitted to hospital on Jan. 9, 1945, at 3.30 p.m., having swallowed an open safety-pin at midday. Immediate x-ray examination showed the pin, open end downwards, lodged in the oesophagus just below the post-cricoid region (Fig. 1).

The interest in this case lies in the fact that the safety-pin had passed into the oesophagus point downwards—a very unusual occurrence, but one which considerably facilitates the removal. It is interesting to compare this case with the one reported by Mr. Ritchie Paterson in the *Journal* of Feb. 17, 1945, in which the pin entered the oesophagus point upwards. Mr. Ritchie Paterson described the dangers associated with the removal of a pin in this position and the dexterity required to effect this without perforating the oesophageal walls, with the possible consequence of mediastinitis.

FIG. 1

In the present case, on introduction of the oesophagoscope under general anaesthesia, the pin was seen lightly poised on the posterior wall of the oesophagus. The point had presumably been caught between two folds of the mucous membrane without actually perforating the tissues. It was an easy matter to seize the rounded end with the forceps and withdraw the pin into the lumen of the tube and then to remove the oesophagoscope and its contents in one act. There was no damage to the tissues, and the whole operation, including demonstrating to the nursing staff, took at the most five minutes. The patient was sent home next day, none the worse.

Case III

On Jan. 9, 1943, a girl aged 14 was admitted complaining of cough and pyrexia for two weeks before admission. Clinical examination showed signs of collapse of the right lung. Skiagrams of the chest revealed a very large paper-clip, with a round head and two prongs, lodged head downwards at the bifurcation of the right main bronchus (Fig. 2). Each prong of the clip was later found to be 3/4 in. long. A preliminary bronchoscopic examination was done under chloroform anaesthesia, as it was thought that a good deal of pus and oedema might be present and preventing a view of the clip, thus interfering with its removal by direct vision. This surmise proved correct, and even with gentle pressure with a long wool-carrier the foreign body could not be felt. It was therefore decided to defer any further attempt at removal until this could be done under the x-ray screen. Owing to the disproportion in size between the diameter of the bronchus and the length of the prongs, it was obviously impossible to manipulate the clip so as to remove it with the points dangling and thus avoid damage to the mucous membrane. The only hope was to attempt to seize the prongs about half-way down their length, close them as much as possible and draw them into the lumen of the bronchoscope.

The patient was laid on the x-ray table and chloroform anaesthesia induced. A further examination through the bronchoscope proved the clip still invisible by direct vision. Under the screen, however, it was clearly seen, with the head firmly lodged down the right main bronchus. A pair of forceps was then passed down the tube to the clip and several attempts were made to secure a hold of both prongs together, but these were not successful. It was felt that the clip must be removed at all costs, even at the risk of damage to the surrounding tissues. A firm grip of one of the prongs was therefore