and the increase in the nutrition figure; that is to say, the *greater* the increase in the nutrition index (indicative of improvement in nutrition) the *less* the increase in caries. At age 6 the same relation exists: the correlation figure is rather low (-0.261), but it is significant statistically, being more than twice its standard error. At age 7 no correlation was found between the two conditions, but, as explained, this group is not so satisfactory because many of the deciduous teeth were already shed.

No association existed between the amount of caries found at the first inspection and the weight/height index at that time. Again, when the increase in the average caries figures was correlated with the weight/height index at the first inspection and at the last, no association could be found between them at any age. This was perhaps to be expected, as these indices only give an indication of nutrition at the time when taken and are not necessarily representative of past physical conditions which may have helped to produce defective and carious teeth, whereas the difference found to occur in the nutrition indices over a period shows what change, if any, is taking place in the child's physique during that time and whether its increase in weight is keeping pace with its growth in stature. It is interesting, however, to note that eight out of the twelve correlation coefficients calculated are negative, showing that the trend is frequently in the same direction—i.e., the better the nutrition the less the onset and spread of caries.

Conclusion

To sum up, it has been shown that, owing to the fact that the nutrition of an individual may vary from time to time, it is extremely difficult to relate it to any other condition at any given period; the complete picture from birth onwards is required. With the knowledge now in our possession, however, it is possible to fit together some of the pieces in the dental picture. It has been shown conclusively in animals that good dental structure can be produced by dietary methods (Mellanby, 1929), and in the investigations carried out in Birmingham by the Dental Disease Committee of the Medical Research Council (1936) there were indications (nursery school) that the same was true for children. Good structure, making the teeth more resistant to disease, is, then, the first line of defence. Post-eruptive influences, though less strong, appear to provide secondary protection, but it is not known how they are exerted. In Birmingham (where the average age of the children was higher than in this series) it was shown that vitamin additions to the diet *before eruption* of the teeth had a definitely beneficial effect in reducing the amount of decay which developed, and also that these dietary additions, even when given after *full eruption*, tended to delay the onset and spread of caries in the permanent teeth. In extension of these findings the present survey would appear to suggest that even in children who have not received any special dietary treatment an improvement in general nutrition, as gauged by the weight/height index, is found in conjunction with increased resistance of the deciduous teeth to dental disease.

Summary

120 elementary school children were examined over a period of one year for dental caries and surface structural defects of the teeth. It was found that:

(1) The lower incisors and canines showed the best surface structure and the molars the worst, the upper incisors and canines being intermediate; the structurally soundest teeth are therefore those of which the greatest part is formed *in utero* before dietary deficiencies are normally felt by the child.

(2) A definite association existed between the quality of the structure of the teeth and the amount of caries present: the better the structure the greater the resistance to dental disease.

(3) An improvement in physical condition as judged by an increase in the nutrition (weight/height) index at ages 5 and 6 was found to be fairly strongly associated with a smaller increase in dental caries.

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ANAESTHESIA FOR MAJOR DENTAL SURGERY

AN ALTERNATIVE TO THE ENDOTRACHEAL METHOD

BY

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Pernasal endotracheal inhalation anaesthesia is now firmly established as a method of choice for major dental and oral surgery. It has, however, long been felt that in spite of the obvious advantages attached to the method the liability to trauma of the mouth and pharynx would make a simpler but equally satisfactory alternative desirable for major dental surgery. The oral surgeon expects his patient to be "well" soon after the operation is over, because both he and the public, with a certain amount of justification, do not regard the removal of an impacted wisdom tooth or a cosmetic dental operation, in an otherwise healthy person, sufficient reason for a convalescence of several days or more to recover from the effects of the anaesthesia or from the operations of the anaesthetist.

To obtain the minimum of post-anaesthetic sequelae the anaesthetist must avoid the deeper planes of anaesthesia—the first plane of the third stage is all that is necessary for this work; trauma to the mouth and pharynx; lipid-soluble agents—nitrous-oxide-oxygen is still the most suitable one for the type of surgery involved.

Advantages and Disadvantages of Endotracheal Inhalation Anaesthesia

Before describing alternative methods the advantages and disadvantages of the endotracheal route will be briefly stated so that comparison may be made.

Advantages.—(1) A perfect airway is obtained which is not obstructed by altering the position of the head or by depression of the lower jaw. As a result the patient breathes quietly and without effort. (2) There is no danger of inspiration of blood, mucus, or operative debris, because the oral pharynx can be packed with gauze or an inflatable cuff round the tube can be used. (3) The mouth is left as a clear field for the surgeon to work in, with no anaesthetic apparatus to get in his way. (4) The anaesthetist is able to stand some distance away from the patient and still maintain efficient observation and control of the anaesthesia. (5) Post-operative vomiting is reduced, because if a lipid-soluble agent has been used direct impregnation of the saliva during maintenance is reduced. (6) Air is easily excluded, enabling nitrous-oxide-oxygen to be used exclusively and without pressure.

Disadvantages.—(1) Under the light anaesthesia used for dental work considerable skill is necessary to pass the tubes blindly and without trauma into the trachea. (2) It is sometimes necessary to use ether or other lipid-soluble agent to perform laryngoscopy if blind intubation is not successful. (3) There appears to be an increased liability to post-operative pulmonary complications (Dawkins, 1937). (4) The possibility of trauma to the mouth or throat (Gould, 1935; Clausen, 1932). From the patient's and also to a large extent from the surgeon's point of view the greatest disadvantage of the endotracheal method is the post-operative "sore throat" which sometimes results. Careful observation and questioning of 1,500 consecutive cases revealed that minor discomforts occurred more often than had been previously admitted. In all these cases great care had been taken to avoid rough handling, unclean tubes, dry gauze, and unnecessary instrumentation. In 15% the operation was outside the mouth (i.e., cases for which the operation *per se* could not be blamed). When carefully questioned on the day after operation nearly 10% of these patients complained of some symptom. This was usually trivial from a medical point of view, but was often distressing to the patient. The symptom was either "dryness of the back of the throat," "a tickling feeling over the soft palate," or definite soreness over the palate and back of the mouth. In some the symptoms were more severe, such as difficulty in swallowing and, in one case, hoarseness of voice. In all cases the symptoms cleared up in two or three days with simple palliative treatment or none at all. The cause of the faucial and palato-pharyngeal varieties of "sore throat" appeared to be abrasion of the mucous membrane by gauze packing or bruising by surgical instruments (retractors and suckers). The patient with the laryngitis was an adult whose operation for the removal of an impacted wisdom tooth lasted over two hours. Trauma, infection, or prolonged pressure of the catheter may have been the causal factor. Whatever precautions are taken it seems almost impossible to eliminate completely these "sore throats" in some cases.

Alternatives to the Endotracheal Method

To be satisfactory any alternative inhalation method must permit of the mouth or pharynx being efficiently packed. Nasal nitrous-oxide-oxygen can be used very successfully for dental operations lasting hours. Its disadvantages are: (1) The nose-piece is apt to get in the way of the surgeon, particularly in operations in the upper incisor region. (2) The pharynx cannot be packed, as the airway will be occluded, but packing can be placed around and under the tongue. This is efficient only if performed carefully and if a sucker is in use during the operation. (3) The surgeon must be gentle, so as not to disturb the nose-piece or pack. The method is thus unsuitable for the "heavy-handed" surgeon. (4) The method may be extravagant in gas, as pressures of 10 to 20 mm. Hg may have to be used in some cases to maintain nasal breathing. An intermittent-flow machine such as the McKesson is practically essential. (5) Full premedication must be used to obtain uniformly successful results. This is included as a disadvantage because, although I much favour nasal anaesthesia, many anaesthetists are chary of using the necessary premedication. (6) The airway is easily obstructed by the surgeon. Constant vigilance is necessary on the part of the anaesthetist, who usually has to support the lower jaw throughout the operation.

Nasopharyngeal Use of Nitrous Oxide and Oxygen

The use of pharyngeal tubes is not new. Silk (1919) described a nasal tube almost identical in size with those to be described later. His description of the method of its

introduction can still be read with advantage. Silk intended his tube only as an alternative to an oral airway with an open-mask administration. Connell (1925) introduced nasopharyngeal *insufflation* of ether by twin nasal tubes, but the method is unsuitable for oral surgery as the pharynx cannot be packed. Pharyngeal *inhalation* anaesthesia with the pharynx packed was first described by Coburn (1921), who used a rubber tube covered with spiral wire and connected to a bag and expiratory valve. This tube was, however, passed through the mouth.

Nasopharyngeal inhalation of gas-and-oxygen has probably been used at some time or other by most anaesthetists. It has not been adopted as a routine procedure, and the following reasons may indicate some of the causes of dissatisfaction: (1) Usually only one nostril is intubated and air-leaks through the other are difficult to eliminate. (2) The diameter of the tubes used is usually too small to enable the patient to ventilate his lungs adequately. Nitrous-oxide-oxygen anaesthesia is difficult to maintain under these conditions without the use of pressure. (3) The tubes are usually too short, and are easily obstructed by the pack in the mouth or pharynx or by the position of the head. (4) The shortness of the tube makes an efficient pack almost impossible. (5) The use of ether becomes almost inevitable.

A technique has therefore been evolved in which two tubes of as large a bore as possible are passed, one through each nostril. The ends of these tubes lie just beyond the epiglottis and opposite the glottis. The tubes are then connected to a McKesson machine, and the pharynx or mouth is packed with gauze. A state of affairs is obtained which has the advantages of the endotracheal method without most of its disadvantages. The only causes of obstruction of the respiration, if the tubes are the correct length, are spasm of the glottis—a condition rarely seen with nitrous-oxide-oxygen anaesthesia—and depression of the jaw by the surgeon, which can usually be countered by the anaesthetist.

Description of Apparatus

Tubes.—By experiment and checking with laryngoscopic examination two average lengths were determined: for men, 6½ inches; for women, 5½ inches. The tubing is that used for endotracheal work by Magill (the thin-walled variety) cut with a short bevel (45 degrees). The anaes-

FIG. 1.—The apparatus.

thetist should be prepared to cut tubes for any individual patient. This will be particularly indicated in children and adolescents, for whom it is no use keeping standard lengths. The measuring is done by rapidly passing the lubricated tube through one nostril and listening at the open end. When the maximum tubular breathing is heard, but before the glottis is actually entered (a point

easy to determine with practice), the tube is pinched close to the nostril, withdrawn, and cut.

Connexions.—Two right-angled Rowbotham connectors are used, one in each tube. The connexion to the McKesson machine is by a specially designed Y-piece which has the following features: (1) Each nasal arm is of wide bore (1 cm. internal diameter). (2) A plate covered with rubber to rest on the forehead. This keeps the nasal arms the correct distance away from the face and prevents marking the forehead by pressure of metal. (3) An expiratory valve incorporated in the Y-piece. This was suggested by Dr. de Caux, and avoids a multiplicity of small parts, making for simplicity in connecting up. (4) Two small studs for fastening the whole thing to the patient with an elastic band and avoiding the use of strapping. Fig. 1 shows the apparatus complete.

Technique

The patient is given the usual premedication (I use 2/3 grain of omnopon and 1/150 grain of scopolamine for a normal adult, with occasionally a small dose of evipan in bed). A number of tubes of suitable diameter and length are selected and placed ready, with their right-angled connexions inserted and their ends well lubricated with vaseline. Anaesthesia is induced with nitrous oxide, and when the patient is in deep third-stage anaesthesia the face-

FIG. 2.—The apparatus in use.

piece is quickly lifted and one of the tubes of large diameter (8–10 Magill tube) is passed through whichever is the larger nostril. The tube should be inserted at right angles to the face and the point kept in contact with the floor and septal wall of the nasal fossa. The face-piece is replaced and the patient re-anaesthetized. The second tube is then inserted in like manner. As a rule the two sides of the nose differ in size, and a smaller tube will be used for the other side. The face-piece is discarded and the Y-piece connected up to the nasal tubes and to the McKesson machine (Fig. 2). The patient is now stabilized with oxygen, the pressure of the gases being increased, if necessary, to 10 to 15 mm. Hg to overcome air leakage through the mouth while the pack is inserted. As a rule the mouth can be easily opened at this stage, and the pharynx or mouth packed. If the jaw muscles remain tight secondary saturation may be performed or a little vinesthene added to the mixture. A dental prop should not be used from the start, because it will be found difficult to fit a face-piece over both the open mouth and the right-angled connectors protruding from the nostrils. The packing is of 2-inch ribbon gauze well wrung out in liquid paraffin. It should be carried back beyond the soft palate, so that air leakage does not take place round the tubes via the nares. As a rough guide the anaesthetist should pack in exactly the same way as for an endotracheal tube, but not quite so far back towards the glottis. An equally effective method, but one which is very often

preferable, is to use a rectangular gamgee pad of about 3½ by 4½ inches, which is tucked around and under the tongue, reaching back to the fauces on each side. If this latter method is used a sucker is essential.

Results

Altogether 230 patients have been anaesthetized in this manner, the majority at the Royal Dental Hospital, for a variety of dental operations—mostly for impacted molars, dental cysts, and fractures of the mandible. From the surgeon's point of view they were all satisfactory, and in about half the cases he was not aware until after the operation that an endotracheal tube had not been used. Post-operative symptoms which could conceivably be due to the tubes were absent, except in two cases—in one there was an epistaxis twelve hours after operation, and in the other a "blocked nose" for two days. Both these might have been prevented by a more liberal use of vaseline on the tubes or perhaps by a little cocaineization. In a few cases in which the jaws could not be opened easily a few breaths of vinyl ether overcame the difficulty. In no case was it necessary to use ether. With the exception of the two mentioned all the patients had completely recovered from the anaesthetic within twenty-four hours and were fit to go home if the local surgical condition allowed.

Contraindications

The method described above has its limitations. In my opinion it is not a satisfactory procedure in the following cases. (1) Large muscular men and patients with short fat necks: depression of the jaw by the surgeon easily obstructs the respiration, and holding the jaw forward to overcome this may be difficult or even impossible. (2) Children under the age of 5 years give better results with endotracheal anaesthesia. In one case adenoids were seen, through a laryngoscope, to obstruct the ends of the pharyngeal tubes. (3) If it is known or discovered that one or both sides of the nose are blocked an endotracheal method is indicated.

Summary of Conclusions

Although endotracheal anaesthesia has many advantages for major dental surgery the occurrence of post-operative sore throat in a number of cases should restrict its use to those in which it is indispensable.

Nasal gas-and-oxygen not being universally applicable, a nasopharyngeal method with the throat packed has been developed.

It has been satisfactory in use to both surgeon and anaesthetist.

It should not be used in patients in whom obstruction due to depression of the mandible is difficult to overcome or in young children.

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Among some sixty students from abroad who are taking courses at Leeds University are five from Poland, one from Greece, and five from Germany. Most of the ten students from the British Dominions and Colonies are studying medicine.