THE INDUCTION OF ANAESTHESIA IN PATIENTS LIKELY TO VOMIT WITH SPECIAL REFERENCE TO INTESTINAL OBSTRUCTION

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SUMMARY

Vomiting or regurgitation during the induction of anaesthesia is a special hazard and the type of patient at risk is detailed. The preparation of such patients for operation is described and the care that must be taken over aspiration of the stomach contents is emphasized. The use of cricoid pressure during induction is considered to be valuable. The induction of anaesthesia using intravenous agents is described for cases in whom the advantages outweigh the risk of regurgitation, but the method preferred by the author is a purely inhalational technique. This method is described in detail and is based on a nitrous-oxide, oxygen, ether sequence using carbon dioxide as a respiratory stimulant. The disadvantages of a thiopentone-relaxant technique are considered and some of the reasons for believing that an inhalational technique is safer are given. Aspects of the recommended technique examined include the effects of hyperventilation on the vomiting mechanism, the carbon dioxide levels used, and the subsequent course of anaesthesia. Other techniques which may be used in special circumstances, with special reference to intubation whilst the patient is conscious, are considered.

Vomiting or regurgitation during the induction of anaesthesia has for long been recognized as one of the most important single causes of mortality and morbidity amongst patients submitted to anaesthesia. The early accounts of accident and disaster, reviewed by Snow (1847, 1858), dealt mainly with the occurrence of excitement and syncope, but the danger of vomiting was realized by the earliest administrators (Crockett, 1857).

In 1951, a committee of the Association of Anaesthetists was set up to investigate deaths under anaesthesia, and it found that, during the first eighteen months, forty-three of the reports received contained details of death resulting from regurgitation or vomiting. It was decided to issue an immediate report on this aspect alone (Morton and Wylie, 1951), in the belief that general anaesthetic techniques could be made safer by setting out an appreciation of the causes of vomiting and by suggesting precautions to be taken. Later, in a further report (Edwards et al., 1956), the danger was re-emphasized and an analysis of 1,000 deaths showed that 11 per cent were due to vomiting or regurgitation.

The problem of induction of general anaesthesia in patients likely to vomit has claimed the attention of many but, as yet, there is no general agreement amongst anaesthetists with regard to details of the most suitable general anaesthetic technique. There is, in fact, a divergence of opinion between those who favour inhalational, and others who favour intravenous, techniques. This may cause confusion, unless the problem be carefully evaluated, and this paper is intended as a review of the subject, together with an account of a technique of inhalational induction which is preferred by the author.

Recognition of the type of case likely to vomit during induction.

An awareness of the type of case likely to vomit is necessary so that precautions may be taken to lessen or obviate the risk. A concise classification of such cases has been made by Morton and Wylie (1951), and forms the basis for this review.

If there be material in the stomach or oesophagus, then vomiting or regurgitation is likely.

1. The stomach or oesophagus is almost certain to contain such material.
   (a) After a recent meal.
   (b) When fluids have been given for therapeutic reasons, e.g., glucose solutions in the pre-operative
preparation of diabetics. These are often hypertonic and may remain in the stomach for an unexpectedly long time. Fluids given for stomach washouts may not be adequately removed, etc.

(c) When blood has been swallowed after an accident or an operation on the nose, mouth or throat, or when there is bleeding from an ulcer, neoplasm or operation site in the stomach or oesophagus.

(d) In the presence of alimentary obstruction. This includes oesophageal obstruction from neoplasm or stricture, pyloric obstruction and intestinal obstruction.

2. Cases in which the stomach is very likely to be full because of delayed emptying.

(a) Where there is abdominal distension.

(b) In severe illness, especially with toxemia.

(c) When drugs such as morphine have been given, especially in large doses.

3. Vomiting is likely in certain special circumstances.

(a) Oesophageal pouch or fistula or in oesophageal obstruction due to a foreign body.

(b) In the presence of previous operations on the stomach, especially gastro-enterostomy; when there is acute dilatation of the stomach and in cases of diaphragmatic or hiatus hernia.

The preparation of patients, likely to vomit, for anaesthesia.

With the appreciation that a particular case is likely to vomit, preparation for anaesthesia should have two objects: firstly, to ensure as far as possible that the stomach is empty and is kept empty; secondly, to institute resuscitative measures, if necessary, to make sure that the patient is in the best possible general condition.

Emptying the stomach.

In the case of the patient who has had a recent meal, the urgency of operation must be the deciding factor. If surgery be not urgent, then time should be allowed for the stomach to empty normally. Although, in the normal healthy person, it may be safe to assume that the stomach will empty within a period of 4½ hours, it is now well recognized that the emptying time is frequently prolonged. Emotional states such as pain, fear and shock, an accident or peritoneal irritation can cause reflex inhibition of stomach movements and the pylorus may remain closed. The stomach then retains its contents and, if a meal has been taken just before the stimulus, e.g., an accident, there will be a large amount of undigested material waiting to be vomited. Bourne (1962) cites an accident involving two patients who were severely burned after a meal and, in both cases, vomiting took place during induction of anaesthesia 13 hours later. If surgery cannot be delayed, as when life or limb are in danger, or in obstetric cases, then the stomach must be emptied. Apart from the recent meal, the stomach may be full to a varying extent in the circumstances described. Moreover, in cases of intestinal obstruction, the stomach may continue to fill having once been emptied, and it is necessary to ensure that removal of stomach contents continues up to and during induction.

For these purposes a Ryle's tube is inadequate. It is too narrow to permit the rapid removal of the quantities of fluid that may be produced, it is easily blocked and it is very doubtful if it be more pleasant for the patient. It requires the active co-operation of the patient if it is to be successfully swallowed, and this may be difficult, unpleasant or even impossible for some patients.

A wider, stiffer tube overcomes these difficulties and a No. 12 English catheter gauge (7 mm diameter) is the best compromise. This may be easily passed, well lubricated, through the nose and any unpleasantness can be reduced by spraying the nose beforehand with 4 per cent lignocaine.

Considerable care must be expended on this procedure since, if the stomach can be emptied in this way, the risk is much reduced. Positive evidence that the tube is in the stomach must be obtained, either by the aspiration of gastric contents or by the injection of air down the tube, when it may be heard passing into the stomach on auscultation over the left hypochondrium. The anaesthetist himself must carefully aspirate the tube prior to induction and, by moving the tube into different positions and aspirating with the patient on his left side, ensure that all material has been removed.

It is probable (Morton and Wylie, 1951) that the material most likely to cause sequelae is fluid in large quantity and that solid material is much less likely to cause trouble, unless it become impacted in the pharynx or a piece of fruit skin cause a
flap valve effect over the glottis. Solid, undigested food cannot be removed unless a wide-bore (13 mm diameter) stomach tube and repeated stomach washouts be employed. The passage of the wide-bore tube itself often causes active vomiting, which empties the stomach.

The special circumstance of the obstetric case is dealt with elsewhere in this issue, but since all patients in labour are potential subjects for anaesthesia, it would seem sensible to provide a light low fat content, low residue diet as described by Crawford (1962). The stomach contents can then, if need arise, be aspirated easily.

Stomach contents may be removed by active vomiting induced by the administration of apomorphine. This method is not widely favoured, because of the distress which it may cause to the patient. There is often a fall in blood pressure and the salivation, which is usual, may be a nuisance and may complicate induction, even although atropine be given afterwards; the method is described by Holmes (1956) and used by Crawford (1962). A solution containing apomorphine 3 mg in 10 ml water is injected slowly by the intravenous route until nausea occurs. Usually, 1 mg is sufficient.

The general condition of the patient.
The extremely ill, the shocked, the toxic and the near-moribund are mentioned by Morton and Wylie (1951). In these cases, there is often little defence against the aspiration of regurgitated stomach contents, and the protective reflexes may be markedly depressed. In such cases, it is possible to pass the oesophageal tube into the trachea inadvertently. The tube may be tolerated, giving no indication of its potentially dangerous situation, and the voice, in two instances seen by the author, was not noticeably altered.

In cases of intestinal obstruction, there may be considerable loss of protein-containing fluid into the bowel, and there may be blood loss into the lumen of the bowel, if there be strangulation. These factors often result in a marked reduction in the blood volume, and careful resuscitation using plasma, sometimes whole blood, and electrolyte solutions is necessary to restore blood volume and blood chemistry to more nearly normal values before anaesthesia is induced. The drugs which should be given as premedication must be chosen as dictated by the requirements of any one particular case but, with few exceptions, it is wise to use atropine only. Sedative drugs under these circumstances may further delay stomach emptying and may significantly depress protective reflexes.

Precautions which may be adopted during induction of anaesthesia. It would be reasonable to hope that, by preventing material passing up the oesophagus, the problem of vomiting and regurgitation could be solved.

The concept of an oesophageal blocking tube has appealed to many, but the practical difficulties of design have made reliable functioning impossible, and it is unwise to depend on such a device for safety. The oesophagus is very distensible and it is difficult to distend any balloon mechanism tightly enough without causing damage. It is, too, usually impossible to foretell the extent to which such a mechanism must be inflated in order to maintain a reasonable seal. When it does fit well, the patient often finds it painful, and furthermore, during any attempt at active vomiting, there is probably an increase in diameter of the oesophagus and a previously efficient seal may be rendered useless.

More recently, Sellick (1961) has drawn attention to the fact that the oesophagus may be effectively compressed and, temporarily, occluded by backward pressure on the cricoid cartilage, forcing it against the bodies of the cervical vertebrae. This pressure is applied by an assistant just before induction, increased as consciousness is lost, and maintained until endotracheal intubation is achieved. This method has much to recommend it, and it has proved satisfactory in Dr. Sellick's hands. It is probably of most value if an induction technique using thiopentone and relaxant be chosen, and it is used as a method of preventing regurgitation rather than active vomiting. The method may still be effective if an oesophageal tube be in place, but it may be better to remove this immediately before induction, if the most effective compression is to be obtained.

The choice of induction technique. In all cases likely to vomit and certainly in all cases of intestinal obstruction, where there may be continuous refilling of the stomach, the aim is to achieve the placement of an endotracheal tube
as rapidly as possible without vomiting or regurgitation; the danger of aspiration is then overcome. Any technique must achieve this without major side effects on other systems.

The report by Morton and Wylie (1951) stimulated further work on induction techniques and, largely as a result of their suggestion that a foot-down tilt of 20° might prevent regurgitation during intravenous induction, most of the work since 1952 has been on these lines.

If it be felt that an intravenous induction has advantages which outweigh the risk of regurgitation, then it would seem prudent to adopt every possible precaution. With the patient lying on the operating table so that a head-down tilt be available in an emergency and with suction equipment in good working order at hand, the oesophageal tube is carefully aspirated. As soon as this has been done, sleep is induced with intravenous thiopentone as rapidly as possible without depressing respiration. Suxamethonium 50 mg is given intravenously as soon as sleep occurs. The help of a skilled assistant is necessary during this time to ensure that the airway does not become obstructed as consciousness is lost, and also to apply cricoid pressure. This must be commenced at exactly the right time and maintained until intubation is achieved. Only in this way can the advantage of suxamethonium in producing rapid and profound relaxation be retained, at the same time as its disadvantage, in causing a rise in intragastric pressure (Andersen, 1962), is circumvented.

The disadvantages inherent in a thiopentone-relaxant technique may be overcome by the use of a purely inhalational method of induction.

After careful preparation, in the way already described, and with a 12-gauge oesophageal tube in place, the patient is placed on the operating table in the supine position. Suction apparatus is tested and placed ready at hand. The machine, laryngoscope and endotracheal tubes are checked. The pulse and blood pressure are recorded, and the oesophageal tube is carefully aspirated and left to drain. Using a standard Boyle’s anaesthetic machine with a Magill semiclosed circuit, anaesthesia is induced as soon as the stomach has been aspirated. The details of the induction technique are summarized in table I.

The face mask is gently but rapidly lowered on to the patient’s face, nitrous oxide, 10 l/min, flowing from the machine. After the first ten breaths, the rotameters are adjusted so that nitrous oxide 8 l/min, carbon dioxide 2 l/min and oxygen 2 l/min are delivered. A further ten breaths of this mixture are allowed, and hyperventilation commences. Consciousness is lost late in the first phase or early in this, second, phase. During the third phase, i.e. the succeeding ten breaths, volatile agents are introduced. The nitrous oxide flow is reduced to 7 l/min and the carbon dioxide flow is reduced to 1 l/min. Ether vapour is introduced in stages so that, at the end of phase three, the tap of the vaporizer is fully open. During the fourth and last phase of the induction, the oxygen flow is increased to 3 l/min and the carbon dioxide flow is turned off or reduced to 500 l/min, depending on the extent to which the patient is hyperventilating. The ether concentration is further increased in stages until the plunger is fully depressed below the surface of the ether. This takes ten or fifteen breaths and,

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at the end of this time, the conditions required for intubation will have been achieved. Originally, the technique included the routine use of chloroform as an intermediate agent before the introduction of ether (Davison, 1962). Chloroform or halothane may be incorporated if preferred by the administrator, particularly if the patient be a very robust individual, but most often there is no need for an intermediate agent.

DISCUSSION

Current concepts of the mechanism of vomiting, the applied anatomy and the consensus of opinion regarding sphincter action at the lower end of the oesophagus are dealt with elsewhere in this issue. The anaesthetist meets clinically, and must consider, two forms: regurgitation and active vomiting.

Regurgitation occurs when the stomach contents pass up the oesophagus without co-ordinated contraction of abdominal muscles or breath-holding. It is a passive process; material leaves the stomach because it is at a pressure higher than atmospheric (O'Mullane, 1954) or because extra- or intra-abdominal manipulation causes compression of the stomach itself. It has been suggested that patients who regurgitate in this way have an incompetent sphincter mechanism at the cardia (Dinnick, 1957; Snow and Nunn, 1959). It has also been demonstrated that, if inspiration continues in the face of a degree of respiratory obstruction, a pressure difference can develop between the stomach and oesophagus which is sufficient to overcome any sphincter mechanism (Dornhorst et al., 1954). This emphasizes the paramount importance of maintaining a clear airway at all times. Regurgitation is much more likely in the head-down position and it has been shown that suxamethonium causes a marked rise in intragastric pressure as a result of muscle contraction during the depolarisation phase (Hodges et al., 1959). Andersen (1962) considers that the likelihood of regurgitation is greatly increased when this drug is used. Regurgitation occurs silently and without warning, often during a period of respiratory depression and when the protective reflexes are in abeyance, it is most likely when the thiopentone-relaxant technique is employed.

Relaxants act only on the striped muscle of the upper oesophagus and cricopharyngeal sphincter and it is pointed out by Sinclair (1959) that, in many cases of intestinal obstruction, it is probable that material passes the cardia and the lower part of the oesophagus is distended. This distension can be great and the lower oesophagus can hold a large quantity of fluid. This accumulation can be suddenly released with cricopharyngeal relaxation, consequent on the administration of thiopentone or relaxants. It is generally agreed that there is considerable danger of regurgitation of unexpected and large amounts of gastric contents when a thiopentone and relaxant technique is used in patients likely to vomit. Of the fatal cases due to vomiting in Morton and Wylie's series (1951), 53 per cent had been induced in this way.

Efforts to increase the safety of the technique have mainly been directed to providing conditions in which, even if regurgitation commences, material cannot reach the upper oesophagus. Snow and Nunn (1959) maintain that intravenous induction can be safe provided that the abdominal muscles do not contract and that a foot-down tilt be used, sufficient to raise the larynx to a height in centimetres above the cardia greater than the maximum expected intragastric pressure (18 cm water; O'Mullane, 1954). This can be achieved by a head-up tilt of not less than 40°. Several series of cases have been reported in which this technique has been used with good results (Hodges et al., 1959; Hodges and Tunstall, 1961; Snow and Nunn, 1959). The latter used gallamine in order to avoid the rise in intragastric pressure which occurs with succinylcholine. Recently, Crawford (1962) obtained good results using intravenous agents with the patient in a horizontal position.

It is the author's opinion that the indications for the employment of this technique are very few and that the technique must be limited to those with considerable experience. A complication-free rate as high as that achieved in the series reported would necessitate a standard of skill throughout the country as high as that possessed by these authors. A high degree of adroitness with the laryngoscope is required, especially if the patient be in a steep head-up position, and experience is needed to calculate exactly the dosage of the drugs to be used. If all does not proceed as the administrator hopes and regurgitation does
occur, the protective glottic and tracheal reflexes are in abeyance. In the head-up position, gravity ensures that stomach contents travel towards the glottis, and aspiration is inevitable. Induction with the patient horizontal and with the employment of cricoid pressure is to be preferred. Lastly, it is evident that, despite the encouraging reports by the advocates of the technique, others (Sellick, 1961; Bourne, 1962) are not convinced, and they report instances of regurgitation and aspiration with these methods. The situation is one in which skill and judgment are pitted against time.

Although regurgitation can occur during an inhalational induction, it is only likely if there is respiratory obstruction and especially if this occur during violent respiratory effort. The principle of maintaining a clear airway must be assiduously practised. In the normal person, the last 2 cm of the oesophagus are intra-abdominal and any rise in intra-abdominal pressure will affect both the stomach and this portion of oesophagus. Any sphincter mechanism will therefore have to withstand only a little more than the intrinsic changes in gastric pressure (Lancet, 1961). Creamer et al., (1959) believe that, because this portion of the oesophagus is subjected to a higher pressure during inspiration than the intra-thoracic portion, it collapses, forming a flap valve and that this is, in effect, the sphincter. During hyperventilation, in the presence of a clear airway, it is probable that deep inspiration intensifies this effect and the valve is made more efficient. During the expiratory phase, in addition, the angle of entry which the oesophagus makes with the stomach is exaggerated and the sphincter effect at the gastro-oesophageal junction may be made more effective (Marchand, 1954).

With inhalational techniques of induction, the problem to be overcome is much more than the possibility of active vomiting. In the process of active vomiting, the diaphragm is fixed or descends and the stomach is compressed by the contraction of the abdominal muscles. The lower end of the oesophagus is relaxed and the stomach contents pass, often in a projectile manner, up the oesophagus into the oropharynx. This is a co-ordinated reflex resulting from the stimulation of the oropharynx during light anaesthesia by an airway or by the nauseous smell or irritation of anaesthetic agents. Slow induction of anaesthesia may also initiate active vomiting, the patient remaining too long in the phase of excitement when central stimulation of the vomiting centre may occur. Anoxia at this stage will further stimulate the vomiting centre.

In the technique of inhalational induction described, hyperventilation is provoked rapidly and early in induction. This is achieved by the use of carbon dioxide at concentrations higher than generally accepted levels. In order to stimulate the respiratory centre effectively, and at the right time, allowance must be made for dilution within the lungs of any particular concentration delivered from the anaesthetic machine. If a concentration of about 5 per cent be exhibited, stimulation of the respiratory centre will depend on the build-up of endogenous carbon dioxide and the process is inevitably too slow for our purpose. In the technique advocated, 16 per cent of carbon dioxide is exhibited for ten breaths and, during this time, with average values for lung volume, the alveolar carbon dioxide concentration will rise rapidly and, at the end of this phase, will approximate to that of the inspired gas. The necessary stimulus is provided and a reduction in concentration to 10 per cent is made in the third phase and again to 5 per cent or none at all in the fourth phase. This maintains the drive to the respiratory centre, overcoming any tendency to breath-holding, an essential preliminary to active vomiting, and, because of the increased pulmonary minute volume, unconsciousness beyond the level at which there is hyperexcitability is rapidly produced. At this point, intubation can be carried out safely and in an unhurried manner since spontaneous respiration continues.

When the drive to respiration is great, active vomiting is not initiated, the diaphragm is not easily halted and during descent, when the stomach could be compressed, the abdominal muscles are relaxed. In addition, the effects on the gastro-oesophageal junction during hyperventilation, when viewed as a whole, probably prevent material passing up the oesophagus.

In any major case, the probability is that anaesthesia will be conducted at a very light level of unconsciousness combined with relaxants. It is undesirable that any technique for induction and intubation should involve deep anaesthesia and slow recovery. Blood-ether levels have been
measured during this type of induction (Mackenzie et al., 1954), and a rapid rise to moderate levels, 55-70 mg per 100 ml, was found to occur. This is followed up by a steep fall to low levels. The level required for intubation was only a little deeper than that required for induction when ether anaesthesia was to be maintained at the lightest possible level. Deep anaesthesia is not required and in practice there is no delay in recovery of consciousness when a relaxant-nitrous oxide technique follows intubation. After intubation, high flow rates and, if a relaxant be used, hyperventilation with IPPR ensure that the carbon dioxide is rapidly eliminated.

The inherent safety of the technique results from the fact that if, in spite of precautions or because of lack of experience, vomiting does occur, the protective reflexes are still active. Because active vomiting is accompanied by heaving movements, breath-holding and obvious ejection of vomit, warning is given and corrective measures may be taken before irreversible damage is done.

This technique has proved the safest method of induction where there is a risk of vomiting or regurgitation and especially in cases of intestinal obstruction. It has been in use in the Royal Victoria Infirmary, Newcastle upon Tyne, for over fourteen years, during which time approximately 250,000 general anaesthetics have been administered. This figure includes all cases, elective, emergency and out-patient, and administrators of all degrees of skill and experience. During this time there has been no instance of fatality from inhalation of vomitus during induction of anaesthesia. The training of undergraduates and postgraduates has been based on this method of induction in the belief that some “rule of thumb” method must be employed until experience is gained. The use of such an apparently rigid routine does not mean that any of the usual signs or warnings exhibited by the patient are ignored and alteration in detail may be necessary as experience dictates.

Other techniques may be indicated in special circumstances. The use of inhalational induction using cyclopropane or halothane, when thiopentone is contraindicated, to produce sleep and then administering a relaxant must be considered. There is little risk of active vomiting and the laryngoscope is introduced as soon as relaxation starts so that, if regurgitation commences, it is seen and can be dealt with under direct vision. Intubation is rapidly completed. There is no doubt that in this way the length of time during which the patient is at risk is much reduced as compared with the thiopentone-relaxant technique and, combined with cricoid pressure, this may be the method of choice in frail, poor-risk cases.

The use of a technique in which intubation is performed while the patient is still conscious will, in selected cases, solve many difficult problems. The severe facial injury and some near-moribund patients are examples in this group. With patience and gentleness the procedure can be made no more unpleasant than the passage of an oesophageal tube. The head is carefully positioned with the neck flexed and the head extended at the atlanto-occipital joint. The patient is asked to open his mouth, and the tongue and soft palate are sprayed with 4 per cent lignocaine. The patient is told that a light will be used in his throat to put a tube in place, and the laryngoscope is slowly advanced, further lignocaine being used if gagging occur, but spraying of the glottis is avoided. The patient is instructed to relax and breathe deeply. As soon as the tube is in place and the cuff inflated, anaesthesia is rapidly induced, either by inhalation or intravenous means. It is important to have an airway in place before the laryngoscope is removed. This acts as a bite-block until anaesthesia is established.

In the neonates and children up to 6 or 7 lb. in weight, especially when they are emergency cases with intestinal obstruction, anaesthesia is safer and less difficult if conscious intubation be performed. Inhalational induction, because of the small tidal volumes of these children, is necessarily slow and therefore likely to be interrupted by incidents of breath-holding, spasm and vomiting. Intravenous techniques in ill babies are even more likely to result in regurgitation. Conscious intubation is easily accomplished with patience and practice.

The place of regional, spinal and extradural techniques have not been mentioned. These techniques may provide the answer in some cases where vomiting is likely, and should always be considered. The place of regional anaesthesia is most often when the operation is on an extremity.
The technique is usually fairly simple and the results reliable, so that operation may be undertaken safely without delay.

Spinal and extradural techniques have their devotees and sometimes advantages. There is usually a preference in this country for the patient to be asleep during an operation, and, from the anaesthetist's viewpoint, there is always a possibility that, because the patient may become unco-operative during the operation, general anaesthesia will then have to be induced under even more difficult circumstances.

Finally, it may not be mere coincidence that the full realization of the hazard represented by vomiting and more especially the danger of regurgitation during anaesthesia occurred in 1951, only five years after the introduction of relaxants into anaesthetic practice.

REFERENCES


Crockett, R. (1857). Death following the inhalation of a mixture of ether and chloroform. Amer. J. med. Sci., 34, 284.


