THE MUSCLE RELAXANTS AND THE CARDIA, INCLUDING THE CLINICAL
MANAGEMENT OF PATIENTS LIKELY TO VOMIT AND REGURGITATE

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It became apparent soon after the introduction of muscle relaxants into clinical practice that one of their side effects was a tendency to allow passive regurgitation of gastric contents into the pharynx with subsequent flooding of the bronchial tree which was sometimes fatal. The actions of relaxants on mechanisms at the cardio-oesophageal junction, which prevent reflux of gastric contents, have, therefore, become of increased significance to anaesthetists.

THE CARDIAC “SPHINCTER”
The region of the oesophageal cardia is normally capable of resisting high pressure from the gastric aspect, but the arrangements also permit vomiting and low pressure eructation of gas. There must, therefore, be an integrated reflex control which must be of great complexity.

To explain these properties of the “sphincter”, three principal mechanisms have been suggested:

An extrinsic sphincter action by the diaphragm.
Valvular mechanisms and other mechanical factors.
Intrinsic sphincter activity.

An extrinsic sphincter action by the diaphragm.
Chevalier Jackson (1922) regarded the diaphragm as all-important in preventing reflux of gastric contents and described the mechanism as a “pinchcock” action which occludes the oesophagus during inspiration. This attractive hypothesis cannot, however, be reconciled with present-day knowledge. It is known, for example, that a deep inspiration always precedes the act of vomiting and also that paralysis of the diaphragm by relaxant drugs does not significantly affect resistance to reflux. Perhaps the most impressive evidence against the “pinchcock” hypothesis is the photograph produced by Sinclair (1959) showing a gaping gastro-oesophageal orifice during forceful inspiration. The momentary delay at the level of the diaphragm of a barium swallow during inspiration, previously thought to support the “pinchcock” hypothesis, can be explained by the pressure difference between the abdomen and the thorax—which may reach 80 mm Hg during obstructed respiration (Dornhorst et al., 1954).

It is also of interest to note that ruminant animals initiate regurgitation by inspiring against a closed glottis, and that tracheostomy hinders rumination.

Although the phrenico-oesophageal ligament and the margins of the diaphragmatic hiatus indirectly reinforce the resistance at the cardia by stabilizing the anatomical relations of the region (Peters, 1955), there is no reason to believe that the diaphragm itself acts as an extrinsic sphincter.

Valvular mechanisms and other mechanical factors.
Marchand’s experiments on the cadaver (Marchand, 1955) and Greenan’s observations in the anaesthetized subject (Greenan, 1961) show the importance of the acute angle of entry of the oesophagus into the stomach. In addition, Dornhorst and others (1954) were able to show that an area of high resistance limited to 3 or 4 millimetres exists at the cardio-oesophageal junction, an observation suggesting the presence of a simple valve.

Whilst it is now generally accepted that mechanical factors play some part in maintaining competence at the cardia, it is considered that these cannot fully account for the complex and adjustable opening and closure mechanisms.

Intrinsic sphincter activity.
There can be no doubt that the cardio-oesophageal junction displays sphincteric properties, but the issue is confused by the fact that no anatomical sphincter exists and that Heller’s operation, in which the circular muscle coat of the oesophagus is divided, does not normally cause reflux of gastric contents. The sphincter must, therefore, lie elsewhere than in the lower oesophagus.
Clark and Riddoch (1962) have inferred from good experimental evidence that contraction of the muscularis mucosa of the stomach retracts the mucosal folds which normally occlude the cardio-oesophageal orifice, thus diminishing resistance to reflux. Of great interest to anaesthetists is their finding that vagotomy or atropine administration almost doubles the pressure that the cardia is able to withstand from the gastric aspect, but does not affect the resistance of the cardia to pressure from above.

This concept of the physiological sphincter also fits in well with other experimental evidence. For example, stimulation of the vagus in cats causes relaxation of the cardia (Clark and Vane, 1961) and distension of the upper oesophagus causes the cardia to open by a reflex mechanism (Atkinson et al., 1957).

These findings are of obvious practical importance in the anaesthetic management of cases likely to regurgitate.

Resistance at the cardia and regurgitation during anaesthesia. There is no evidence to suggest that muscle relaxants significantly affect the resistance to regurgitation at the cardia.

Measurements of resistance in anaesthetized patients in whom relaxants were used show wide variation (Greenan, 1961; Clark and Riddoch, 1962) but mean values lie between 20 and 30 cm H₂O, only slightly lower than the estimate of resistance in conscious subjects by Marchand (1955) and well above intragastric pressure during quiet respiration. Of greater interest is O'Mullane's investigation into the mechanism of regurgitation (O'Mullane, 1954). He showed that, whilst relaxants did not appear to affect resistance at the cardia, obstructed respiration invariably produced regurgitation into the oesophagus.

There is good reason to believe that many patients with a distended abdomen already have impaired resistance at the cardia. Gross gastric distension is known to reduce resistance by a reflex mechanism, and deformation of the normal anatomical relations by distended viscera may further impair resistance, allowing raised intra-gastric pressure to produce free regurgitation into the oesophagus.

A small but significant number of patients without abdominal pathology regurgitate during anaesthesia. Such patients may have a pre-existing low resistance at the cardia and a minor degree of respiratory obstruction, such as may occur in the absence of attention to the airway following the administration of thiopentone, will then cause a pressure gradient sufficient to "force" the cardia.

A substantial proportion of pregnant women develop symptoms of reflux during the antenatal period and are known to be particularly likely to regurgitate during anaesthesia. The precise mechanism can only be speculative, but there is little doubt that the closure mechanisms at the cardia are temporarily deranged.

It may be asked, therefore, why do these patients not regurgitate into the pharynx whilst conscious? The most logical explanation is that regurgitation is prevented in these circumstances by the action of the cricopharyngeus muscle, which encircles and blends with the upper part of the oesophagus (O'Mullane, 1954; Sinclair, 1959).

Although no evidence has been produced to suggest that they affect resistance at the cardia, muscle relaxants certainly abolish the tone of the cricopharyngeus, allowing passive regurgitation into the pharynx when the cardia is already incompetent. Simultaneously, these drugs remove the final protection against aspiration—the laryngeal reflex.

CLINICAL MANAGEMENT OF CASES LIKELY TO VOMIT OR REGURGITATE Since the precise closure mechanisms at the cardia remain incompletely elucidated and gastric emptying time is known to be immensely variable, all patients in whom there is any possibility of a full stomach should be regarded as at risk of aspiration of gastric contents.

The general condition of the patient has an important influence upon the chances of aspiration due to vomiting and upon the outcome should this accident occur. Patients for minor surgery appear to be in comparatively little danger from aspiration, even though vomiting frequently occurs. Wolfson (1962) refers to 60,000 patients anaesthetized for minor emergency operations by simple methods in the casualty department, without a fatality or a single case of serious respiratory complication.
Local anaesthesia.

Consideration should always be given to local anaesthesia when applicable. Regional block, for example, is particularly useful for soft tissue injuries of the limbs, and pudendal block has greatly reduced the danger of forceps delivery. Spinal anaesthesia can be rarely justifiable for emergency surgery and, in any event, does not provide absolute protection against aspiration of gastric contents.

General anaesthesia.

General anaesthesia is, therefore, clearly essential in most circumstances and, with the exception of very short operations, the lung fields must be protected by the presence of a cuffed endotracheal tube, thus limiting the risk of aspiration to the induction period.

The principal advantage of the induction of anaesthesia with inhalational agents alone is said to be that, should vomiting occur, the laryngeal reflexes will prevent aspiration. However, seriously ill patients have sluggish laryngeal reflexes and are, in fact, likely to inhale fluid present in the pharynx, very small quantities of which may be fatal. Furthermore, a minor degree of respiratory obstruction, common during an ether induction, is particularly likely to cause regurgitation when resistance at the cardia is impaired, and it is in these circumstances that it may be technically difficult to visualize the larynx in order to intubate or apply suction.

A rapid induction of anaesthesia by an intravenous agent, or by a few breaths of a potent inhalational agent followed by a muscle relaxant in full dosage, almost eliminates the vomiting hazard, but carries a greatly increased risk of passive regurgitation. This type of induction of anaesthesia has the advantage, however, of rapidly providing easy access to the larynx and, except in special circumstances, is now widely regarded as the method to be preferred.

Attempts to inflate the lungs before intubation should be avoided, since accidental distension of the stomach or the upper oesophagus may impair the efficiency of the cardia or cricopharyngeus muscle and precipitate regurgitation.

In view of its influence upon the sphincteric mechanism at the cardia, atropine premedication is essential.

The danger of aspiration due to regurgitation can be minimized by the use of one or a combination of the following procedures.

Emptying the stomach pre-operatively.

It is notoriously difficult to empty the stomach completely with small-bore gastric suction tubes, but the modern plastic tube is somewhat more efficient than its predecessor. It is also unreasonable to subject every patient remotely at risk to gastric suction. Patients in labour find gastric intubation very unpleasant and it is sometimes (for example, in cases of antepartum haemorrhage) dangerous to attempt it. However, when clearly indicated for other reasons, as in acute abdominal surgery, the anaesthetist should take full advantage of the tube, since careful suction not only reduces intragastric pressure, but reduces the volume of fluid present—an important matter should regurgitation occur.

The tube may impair the efficiency of the cardia, and, it is considered by some, should therefore be removed immediately before the induction of anaesthesia, and replaced before tracheal extubation.

Wide-bore stomach tubes sometimes fail to empty the stomach, and their use can be rarely justified.

Neither spontaneous nor apomorphine-induced emesis can guarantee complete gastric emptying (White, 1959). In addition, apomorphine may cause central depression of the nervous system (Goodman and Gilman, 1955).

Oesophageal blockers.

The oesophagus, being a readily distensible viscus, would appear to be basically unsuited to occlusion by cuffed tubes or other blockers.

However, from time to time, reports of the use of cuffed oesophageal tubes to prevent regurgitation have appeared. Sinclair (1959) states that, in his experience, a cuffed oesophagogastric tube, with the cuff in the oesophagus, has never failed to prevent regurgitation.

Oesophageal occlusion by cricoid compression.

Sellick (1961) showed, radiologically, that a soft-walled tube lying in the oesophagus, and inflated to a pressure of 100 cm of water, could easily be occluded by backward pressure upon the cricoid cartilage, which compresses the oesophagus against the vertebral column without interfering
with the patency of the airway. Cricoid compression, properly performed, can therefore be expected to provide protection against regurgitation during the induction of anaesthesia with relaxants, since intragastric pressure will never reach 100 cm H₂O in a paralyzed patient.

In practice, the patient is anaesthetized with the neck more extended than usual to fix the trachea and oesophagus in the midline, and cricoid compression is effected by an assistant as consciousness is lost.

This promising new method has the advantage that it is applicable to all types of patient at risk from aspiration, with the exception of those with nasopharyngeal bleeding. No special apparatus or preparation is required and, in addition, the lungs may be inflated with oxygen before intubation without fear of precipitating regurgitation. Cricoid compression can theoretically be combined with postural methods of preventing regurgitation or of rendering regurgitation innocuous, thereby offering a double protection.

No attempt should be made to control active vomiting by this method in view of the danger of damage to the oesophagus (Sellick, 1962).

Prevention of aspiration by the use of posture.

The Trendelenburg position. Although the capacity of the hypopharynx is increased by the head-down position, fluid may still reach the glottis if copious regurgitation occurs. Any inspiratory effort at such a time may, therefore, result in aspiration despite the effect of gravity. In addition, during continuous regurgitation, a considerable time may elapse before suction is able to provide a clear view of the larynx, and serious anoxia may result.

The foot-down or sitting-up position. This widely used, but controversial, method is based upon the apparently sound principle that, provided that the abdominal muscles do not contract and the larynx is maintained at a height above the cardia greater than the intragastric pressure, regurgitation into the pharynx cannot occur. Since intragastric pressure may reach 18 cm H₂O (O'Mullane, 1954) a 40-degrees foot-down tilt which places the glottis 19 cm above the cardia, should be used (Snow and Nunn, 1959).

It has recently been shown experimentally that the muscle fasciculations of suxamethonium can raise intragastric pressure (Anderson, 1962; Roe, 1962) and Anderson describes a rise of 40 cm of H₂O in one case.

It is difficult to reconcile these findings with Hodges's series of 2,000 obstetric cases anaesthetized in the foot-down position, using suxamethonium and intravenous barbiturate, with only two minor episodes of regurgitation (Hodges and Tnusall, 1961). However, it is now known that regurgitation does occasionally occur and at a time when the patient is particularly vulnerable. It would seem unwise, therefore, in the light of present knowledge, to rely exclusively upon this posture, particularly if suxamethonium is to be used.

The combination of cricoid compression with foot-down tilt provides increased safety.

The lateral position, together with head-down tilt. Bourne (1962) has stressed the safety of this posture, and uses the left lateral position to facilitate intubation. He recommends a halothane oxygen induction followed by suxamethonium given through a previously inserted cannula.

The principal advantage of this method is that, since the larynx is always above the level of fluid in the pharynx, it is possible to intubate whilst regurgitation is actually taking place, a manoeuvre frequently impossible when any other posture is used. It has the slight disadvantage that intubation must be performed in a somewhat unfamiliar position.

The time-honoured lateral position is the only safe position in which to induce anaesthesia in domiciliary practice if normal anaesthetic equipment is not available, but relaxants should not be used in these circumstances.

Preliminary intubation.

Infants within a few weeks of birth can easily be intubated before the induction of anaesthesia, and this procedure has several advantages, including protection from aspiration of gastric contents to which they are very vulnerable.

Since patients with gross faciomaxillary injuries are exposed to the combined hazard of an insecure airway, nasopharyngeal bleeding, and a full stomach, it is a great advantage to intubate before the induction of anaesthesia. It should be remembered, however, that topical anaesthesia induced in patients who are liable to vomit may be dangerous, because of the abolition of the
laryngeal reflex. Preliminary tracheostomy, using a cuffed tube, is a safe alternative in these cases.

CONCLUSION

It is impossible to state, with certainty, that any one technique is superior to all others, since good results in anaesthesia for emergency surgery are related to technical skill and good judgment as well as to the inherent safety of the procedure adopted.

A purely inhalational induction is sometimes advocated as being the safest technique since the patient is able, to some extent, to protect his own bronchial tree from aspiration. A "smooth" inhalational induction, particularly with ether, requires a degree of skill and artistry which may take years to acquire. The intelligent employment of carbon dioxide to produce over breathing, however, overcomes many of the difficulties involved (Inkster, 1963). On the other hand, an enthusiastic trainee anaesthetist very quickly acquires great skill at laryngoscopy and venepuncture. A halothane induction alone is fairly easy to perform, but its application is somewhat limited by the fact that circulatory depression may occur when such an induction is followed by tubocurarine, nitrous oxide and intermittent positive pressure respiration, the most reliable maintenance anaesthetic for abdominal surgery.

Careful pre-operative assessment of the individual patient, followed by correct resuscitation before induction of anaesthesia, is essential. A difficult intubation can usually be forecast.

REFERENCES


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