Rapid sequence induction

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Rapid sequence induction (RSI) is an established method of inducing anaesthesia in patients who are at risk of aspiration of gastric contents into the lungs. It involves loss of consciousness during cricoid pressure followed by intubation without face mask ventilation. The aim is to intubate the trachea as quickly and as safely as possible. This technique is employed daily during emergency surgery.

History

Pulmonary aspiration of gastric contents has long been recognized as a risk during anaesthesia. In 1950, the Association of Anaesthetists of Great Britain investigated deaths associated with anaesthesia and found 43 deaths caused by regurgitation and aspiration. By 1956, there were a further 110 deaths attributable to aspiration of gastric contents.[1]

Historically, a 'classical' RSI has employed thiopental as an induction agent and succinylcholine for neuromuscular block. Thiopental was used in WWII for military anaesthesia and succinylcholine was introduced in 1951. It was a further 40 yr until the introduction of etomidate, and another 20 yr until propofol was available. Tracheal intubation was not frequently employed until the 1940s. Despite their longevity, thiopental and succinylcholine remain useful, predictable agents.

In 1961, Sellick first described his 'simple manoeuvre' for controlling regurgitation of gastric or oesophageal contents before intubation with a cuffed endotracheal tube. Since then, cricoid pressure has been utilised to occlude the upper end of the oesophagus by compressing the cricoid cartilage against the bodies of the cervical vertebrae.[1] Before this, anaesthesia was induced in an upright position to provide airway protection.

Over the past decade, the practice of RSI has evolved with the availability of new drugs, equipment and knowledge. A recent survey of both trainee and consultant anaesthetists showed that practice is varied. Several induction agents and several alternatives to succinylcholine are used by many anaesthetists. These include non-depolarizing neuromuscular blocking agents and opioids. Indeed, this study suggested that many anaesthetists do not follow best practice.[2]

Rapid sequence induction is utilized less frequently in countries other than the UK. No comprehensive studies support the efficacy of RSI; nor do they demonstrate a contribution to reduction in morbidity or mortality. This article discusses the various aspects of RSI, and encourages the formation of a considered approach.

Consequences of aspiration

The sequelae of aspiration vary depending upon the pH and volume of fluid entering the bronchial tree. This was originally noted by Mendelson in 1946; he described two syndromes in response to aspiration of solid and liquid materials.[3] Mendelson likened the reaction after aspiration of liquids to an acute asthma attack rendering patients critically ill, but with stabilisation over 24–36 h.

Larger volumes of acidic stomach contents induce a more severe aspiration pneumonitis than smaller volumes of pH-neutral fluid. Hydrochloric acid causes bronchiolar spasm and peribronchiolar congestive and exudative reactions that interfere with normal intrapulmonary circulation. The second pattern is typified by obstruction of a bronchus or bronchiole by solids and results in distal collapse and atelectasis. Massive lobar collapse ensues with cyanosis, tachycardia, dyspnoea, mediastinal shift, consolidation and greater morbidity. Chemical pneumonitis impairs gas transfer, as do collapse, consolidation and oedema resulting from obstruction and the inflammatory response.

An overall mortality after aspiration of 1 in 71 829 was reported for all elective and emergency cases by Warner and colleagues.[4] A French study conducted in 1993 detected aspiration in 1 of 7 400 cases, accountable for death in 1 of 33 000 anaesthetics.

Key points

Rapid sequence induction (RSI) is performed to prevent aspiration of gastric contents in patients who are inadequately starved, have impaired gastric emptying or are known to have a history of gastric reflux.

The essential features of RSI are preoxygenation, i.v. induction using a predetermined induction dose, cricoid pressure and insertion of a tracheal tube prior to mechanical ventilation of the lungs.

It may often be appropriate to use an opioid during rapid sequence induction of anaesthesia.

There are alternative non-depolarizing neuromuscular blocking agents available with rapid onset times which provide an alternative to succinylcholine.

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Indications

During emergency anaesthesia, aspiration of stomach contents is a potential risk in all patients with an incompetent larynx. Preoperative fasting and prokinetic agents reduce this risk but are not always appropriate or available before essential emergency surgery where there are time constraints on patient optimization. Passing a nasogastric tube can allow removal of some of the stomach contents.

Factors associated with a high risk of aspiration include: (i) abdominal pathology, especially obstruction or ileus; (ii) delayed gastric emptying (e.g. pain, trauma, opioids, alcohol, vagotomy); (iii) incompetent lower oesophageal sphincter, hiatus hernia, gastro-oesophageal reflux disease; (iv) altered conscious level resulting in impaired laryngeal reflexes; (v) neurological or neuromuscular disease; (vi) pregnancy; (vii) difficult airway; and (viii) metabolic disturbances. The risk of aspiration in these patients is present throughout the perioperative period, especially during induction and emergence from anaesthesia.

Warner and colleagues reported aspiration in 1 of 8 000 anaesthetics given to ASA grade I and II patients; there was greater incidence in ASA III and IV patients (1/343).[4] Rapid sequence induction is employed to minimize this risk.

Essential features

Performance of RSI requires prevention of aspiration, rapid achievement of intubation and preparation for the possibility of failure to intubate or prevent regurgitation. It is important to remember that 50% of difficult intubations occur without predictive preoperative signs.

Technique

Because RSI involves loss of consciousness and neuromuscular block without assurance of the ability to mechanically ventilate the patient's lungs, the anaesthetist must be prepared for all eventualities before commencing RSI. This should include good preparation for safe induction, equipment to remove secretions or vomit, and a pre-planned drill to follow should intubation fail. Full monitoring and an assistant, trained in the application of cricoid pressure, are essential.

The equipment must be checked and include working suction, capnography, and an adequate selection of endotracheal tubes and laryngoscopes. The trolley must tip to a head-down position easily. A wide bore i.v. cannula is connected to running fluid to ensure speedy circulation of drugs to the brain. The patient should be positioned in the optimal intubating position.

Pre-oxygenation with oxygen 100% is essential to maximize the oxygen available to the patient from their functional residual capacity during induction. Oxygen is administered for 3–5 min or until the expired oxygen fraction is >85%.

A pre-calculated dose of induction agent is administered, followed immediately by a neuromuscular blocking agent. Cricoid pressure (at 20–40 N or 2–4 kg) is applied before loss of consciousness. After the jaw has relaxed and succinylcholine-associated fasciculations have ceased, the trachea is intubated. Placement of the endotracheal tube must be confirmed by ventilation, capnography and/or auscultation of the chest. After tube position and adequate seal are confirmed the cricoid pressure may be released.

Table 1 Essential features of rapid sequence induction

Pre-oxygenation with 100% oxygen
Predetermined induction doses of drugs
Cricoid pressure
Cuffed endotracheal tube
Equipment and strategy to manage failed intubation

Choice of induction agent

Intravenous induction facilitates loss of consciousness in one arm–brain circulation time, minimizing the time from loss of consciousness to intubation. Ideally, the chosen induction agent should provide a rapid onset and a rapid recovery from anaesthesia with minimal cardiovascular and systemic side effects.

Thiopental provides rapid loss of consciousness at a predictable dose (3–7 mg kg^{-1}) with a clearly defined end-point. It is noticeably quicker than both etomidate and propofol. However, it has a longer duration of action and its side effects are potentially life-threatening. Thiopental has a relatively high rate of anaphylaxis (1 in 20 000).

Propofol has the advantage of suppressing laryngeal reflexes and, thus, potentially assisting intubation. It has a slower onset than thiopental and greater cardiovascular depression occurs.

Etomidate has the major advantage of cardiovascular stability, so it is useful for the induction of anaesthesia in patients with severe cardiovascular disease. However, the slow speed of onset and potential adrenal suppression limit its use. These disadvantages outweigh the benefits gained through its cardiovascular stability in the majority of patients. During emergency anaesthesia where there is circulatory collapse, ketamine should be considered.

In summary, it is sensible to tailor the choice of induction agent to the patient to be anaesthetized. The most rapidly-acting agent should be used where there is greatest risk of aspiration and etomidate should be reserved for patients with major cardiovascular co-morbidity.

Choice of neuromuscular blocking agent

Historically, succinylcholine has been the agent of choice for neuromuscular block. The ideal characteristics of a neuromuscular blocking agent for RSI comprise a rapid onset of action to minimize the risk of aspiration and hypoxia, a rapid recovery to facilitate the return of ventilation if intubation fails and minimal haemodynamic and systemic effects. Despite being the traditional choice, succinylcholine does not fulfil these criteria. It does have a rapid onset and offset of action, but unfortunately there are many side-effects, some of which are life-threatening.

Succinylcholine can cause hyperkalaemia, muscle pains, bradycardia and malignant hyperpyrexia. It has a high incidence of anaphylaxis and histamine release. Raised intraocular, intracranial and intragastric pressure can occur with resultant passive regurgitation in the presence of an incompetent lower oesophageal sphincter. Succinylcholine apnoea, which occurs in genetically susceptible individuals, can hinder recovery of neuromuscular function in 0.001–0.03% of the population. Neuromuscular block can last between 20 min and several hours depending upon the pseudocholinesterase genotype.

Non-depolarizing neuromuscular block

It is only recently that non-depolarizing neuromuscular blocking agents have been developed with similar pharmacodynamic profiles to succinylcholine. Rocuronium has a more rapid onset than previous non-depolarizing blockers and is proposed as an alternative agent for RSI. When used at a dose >0.6 mg kg^{-1}, it can provide intubating conditions and speed of onset similar to succinylcholine. These conditions are further improved by the addition of an opioid. However, the duration of action of rocuronium is much longer than that of succinylcholine.[5]

The current development of a new non-depolarizing neuromuscular blocking agenr reversal agent, ORG-25969, may provide a safe method of antagonism allowing safer use of rocuronium for RSI. This drug promises to provide a method of antagonizing rocuronium by chelation, even when rocuronium has been given recently and in a large dose. Phase III trials are in progress.

Intubation without neuromuscular block

Performing intubation without a neuromuscular blocking agent has the advantage of avoiding succinylcholine in situations where it is potentially hazardous (e.g. myopathies, allergy, hyperkalaemia, burns and eye injuries). Studies show varied results regarding the best induction agent to use in the absence of neuromuscular block. Intubating conditions were improved by addition of opioids, but no studies have been performed in patients at risk of aspiration requiring emergency anaesthesia and RSI.

Opioids and alternatives

The advantages gained from administering a short-acting opioid before intubation are numerous: the sympathetic response to intubation is attenuated, there is a deeper plane of anaesthesia, decreased incidence of awareness and depressed cardiovascular and diaphragmatic response to intubation. Traditionally, the use of opioids has not been supported during RSI, but with the advent of shorter acting drugs, such as alfentanil, their use becomes safer.

Opioid-induced apnoea can hinder the recovery of spontaneous respiration after failed intubation. Short-acting drugs, such as alfentanil and remifentanil have short half-lives and are rapidly removed from the circulation. This results in rapid offset of action. Furthermore, the opioid receptor antagonist naloxone can be used as an i.v. antagonist to opioid action and expedite recovery of ventilation.

Several alternatives to opioids exist that may exert some of their beneficial effects during intubation and RSI. I.V. lidocaine (1.5 mg kg^{-1}) has been demonstrated to be an effective antipressor agent, and rapid-acting, short-acting β-blockers, such as esmolol, can efficiently prevent the rise in heart rate and blood pressure following laryngoscopy.

Cricoid pressure

Cricoid pressure was first described in 1961.[1] The oesophagus is occluded by extension of the neck and application of pressure over the cricoid cartilage against the body of the fifth cervical vertebra to obliterate the oesophageal lumen. Head and neck extension increases the anterior convexity of the cervical spine, stretches the oesophagus and prevents lateral movement of the oesophagus. Pressure of 20 N (2 kg weight) is applied by an assistant with thumb and finger either side of the cricoid cartilage. This is maintained until after intubation and cuff inflation.

Studies of the efficacy of cricoid pressure show varying success in preventing regurgitation. In Sellick's original study of 26 high-risk inductions, there were three cases of immediate regurgitation of gastric or oesophageal contents after release of pressure, suggesting that the procedure was effective at preventing regurgitation. Refinements to the original technique have quantified the timing and amount of pressure applied and also recognized that for the technique to be successful an assistant needs to be trained in application of cricoid pressure and use the skill regularly.[6]

Complications

It is imperative that the potential complications of performing RSI are appreciated before undertaking the procedure. The major risk stems from intubation without ascertaining whether it is possible to ventilate the patient. This can result in failure to ventilate a paralysed patient. Each anaesthetist needs to have a plan of action for this situation. Similarly, there is potential for a failed intubation and the need to wake the patient. Ideally this should be done whilst maintaining cricoid pressure to protect the airway.

The drugs most commonly used for RSI have relatively high incidences of anaphylaxis; the anaesthetist must be able to treat anaphylaxis and support a compromised patient. The risk of awareness during the procedure is unlikely to have a dangerous outcome but is very distressing for patients.

The complications of cricoid pressure application include failure to occlude the oesophagus, distortion of the larynx disrupting the view at laryngoscopy and, less commonly, oesophageal rupture during active vomiting. If active vomiting rather than passive regurgitation occurs the cricoid pressure should be released.

Terminating anaesthesia

Attention to detail is required during antagonism of anaesthesia in patients who have required RSI. It is during the transition

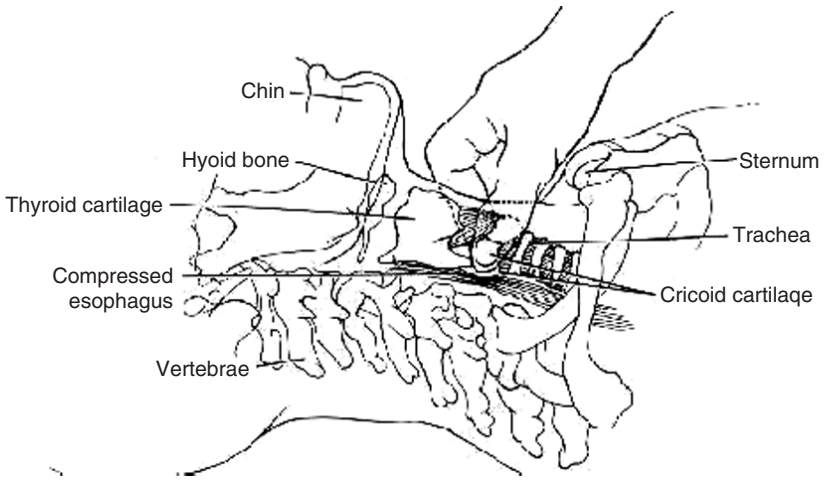

Fig. 1 Sellick's manoeuvre.

from deep anaesthesia to full consciousness and vice versa that the risk of aspiration is greatest. The patient should be completely awake and performing purposeful movements or responding to commands before extubation. This confirms that the patient can protect their own airway on removal of the cuffed tube.

Positioning the patient in a sitting position or in the left lateral position further protects the airway in the event of regurgitation.

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See multiple choice questions 34–36.