Rapid sequence induction: an old concept with new paradigms

Rapid sequence induction of anaesthesia is a technique used to secure a patient's airway in situations where induction of anaesthesia is urgently required. It may be used in both elective and emergency settings (e.g. in theatres, accident and emergency, intensive care, during cardiac or peri-arrest scenarios, and in pre-hospital medicine), and is most commonly used to minimize the risk of pulmonary aspiration of gastric contents. Rapid sequence induction can be achieved in various ways, which involve specific pre-medications, planning, patient positioning, provision of equipment, careful use of anaesthetic drugs, airway manipulation and suitably trained personnel.

The concept of rapid sequence induction (also known as rapid sequence induction and intubation) was borne out of necessity. In the 1950s, aspiration of gastric contents was found to be the most common cause of death relating to anaesthesia (Edwards et al, 1956). Half a century later, the Royal College of Anaesthetists Fourth National Audit Project (NAP4), investigating major complications of airway management, demonstrated this still to be the case. The incidence of fatal aspiration during anaesthesia could be as common as 1 in 45 000 cases, with non-fatal aspiration occurring in 1 in 3000 cases for elective surgery, and 1 in 800 for emergencies. It was therefore recommended that anaesthetists must assess the risk of aspiration in all patients, and should consider rapid sequence induction if the risk of aspiration is 'high' (Cook et al, 2011).

Unfortunately, however, while this seems a reasonable approach, a multitude of factors define the risk of aspiration, and thus it can be hard to designate patients as high or low risk, and consequently make a dichotomous decision about the need for a rapid sequence induction. Furthermore, rapid sequence induction is not without risk in itself, so careful and considered decisions must be made as to whether it is appropriate, and exactly what form it should take – the classic 'thio, sux, tube' is certainly not a panacea.

This article gives an update on rapid sequence induction – the risks and benefits associated with the procedure, the practicalities of performing the procedure itself, and the advantages and disadvantages of the numerous drugs that are now commonly used.

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History

In 1946, Curtis Mendelson (an American obstetrician) published a retrospective analysis of over 44 000 births detailing 66 cases of pulmonary aspiration during anaesthesia (Mendelson, 1946). He named the resulting lung pathology 'Mendelson's syndrome', and in an attempt to minimize the incidence, triggered a concerted effort to investigate the pathophysiology and risk factors associated with aspiration. Following this the Association of Anaesthetists of Great Britain and Ireland formed a committee to investigate the causes of death under anaesthesia, which led to Morton and Wylie's (1951) case series of 43 deaths resulting from gastric regurgitation and aspiration. This publication offered some sage advice to the anaesthetic community in the form of their suggested induction technique: 'thiopentone immediately followed by a full dose of muscle relaxant… a foot-down tilt of at least 20 degrees… and preoxygenation with all agents other than nitrous oxide'. By 1959, Snow and Nunn added to this 'rapid induction and paralysis' technique, and suggested that 'the anaesthetic equipment and sucker should be carefully checked before induction' and 'a sterile bronchoscope should be available in every theatre'.

In 1961, the Sellick manoeuvre was introduced (the technique of providing cricoid pressure to occlude the oesophagus which sits posterior to the trachea and its ring-shaped cricoid cartilage), and Wylie (1963) advised abstaining from positive pressure ventilation until the endotracheal tube is placed for fear of distending the stomach and increasing the chances of regurgitation.

Finally, the first formal description of a technique for 'Rapid induction-intubation for prevention of gastric content aspiration' was published in 1970 by Stept and Safar. This includes all the essential features of rapid sequence induction accepted today as part of the classic technique: 'denitrogenation' of the lungs, predetermined doses of both an anaesthetic and paralytic drug (traditionally thiopentone and suxamethonium), cricoid pressure when consciousness is lost, and the avoidance of positive pressure ventilation until the endotracheal tube is secure. Since then, the practicalities of undertaking a classic rapid sequence induction have changed very little (i.e. rapidly intubating a paralysed patient), but the latter two steps remain the subject of much debate within anaesthetic communities, with many choosing to avoid the use of cricoid pressure and/or promoting gentle bag mask ventilation of patients following loss of consciousness.

Decision making: is a rapid sequence induction necessary?

Before embarking on a rapid sequence induction, careful thought must be given as to why it is necessary. Rapid sequence induction is a high-risk procedure, associated with risks beyond those of a conventional induction. These can include raised intracranial or intraocular pressure, cardiovascular instability, airway trauma, and an increased incidence of both awareness and failed intubation (Mort, 2007). The decision should be informed by the perceived risk of gastric aspiration which, although difficult to determine, may include consideration of the following (Maltby, 2004):

Factors affecting the gastrointestinal tract and the intra-abdominal pressure

Recent consumption of food and drink (<2 hours for water, <6 hours for food and particulate fluid), acute abdominal pathology, history of regurgitation, reflux, dyspepsia or aspiration, hiatus hernia, previous upper gastrointestinal surgery – particularly bariatric surgery, or incompetent oesophageal sphincter.

The physiological state of the patient

Pain, anxiety, agitation – any sympathetically driven state (commonly in critical illness or major trauma) will increase the risk of regurgitation and aspiration. Pregnancy decreases the tone of the lower oesophageal sphincter, and a gravid uterus beyond 20 weeks significantly increases intra-abdominal pressure.

The medical history

Diabetic neuropathy slows gastric emptying, as does opiate use, Parkinson's disease and other neurological conditions.

Remember that the best way to reduce the risk associated with emergency intubation is to avoid general anaesthesia if not essential. Regional techniques such as peripheral nerve blocks or central neuraxial blockade can be considered or, if safe to do so, surgery may be delayed until the patient's condition is optimized, e.g. simply waiting a few hours nil by mouth to allow gastric emptying. Good communication between the anaesthetic and surgical team is essential in order to make these complex decisions.

Preparation and performance

As part of safe preparation for rapid sequence induction, a checklist is often used (*Table 1*). This may be particularly useful when a rapid sequence induction is to be performed in an unfamiliar scenario outside of a theatre environment, for example in intensive care, accident and emergency or pre-hospital. The checklist serves as an aide memoire, and helps to minimize the chances that potentially life-saving resources are overlooked (e.g. Yankeur suctioning or a bougie), although not all the suggested steps or equipment will be appropriate for every patient.

A number of aspects of this checklist are worthy of particular mention:

Table 1. Emergency intubation checklist outlining key resources for safe rapid sequence induction

Patient		■ Premedication – H_2 antagonist, prokinetic, sodium citrate ■ Nasogastric tube sited and suctioned ■ Intravenous access and fluid running ■ Positioning, e.g. 30° head up, ramped
	Monitoring	■ Non-invasive blood pressure +/- invasive ■ Capnography ■ Oxygen saturations ■ Continuous electrocardiogram
	Pre-oxygenation	■ Consider apnoeic oxygenation with nasal cannula or high flow nasal oxygen
Equipment		■ Oxygen supply ■ Tilting trolley ■ Consider neuromuscular monitoring
	Airway	■ Facemasks ■ Laryngoscopes ■ Endotracheal tubes ■ Cuff syringe ■ Cuff pressure gauge ■ Suction ■ Bougie or stylet ■ Tube tape or tie
	Drugs	■ Induction agent ■ Muscle relaxant ■ Consider opioid ■ Emergency drugs ■ Maintenance of anaesthesia
Team	Assign roles	■ First intubator ■ Second intubator ■ Cricoid pressure (skilled assistant) ■ Drug administration ■ Other, e.g. in-line stabilisation
	Is help available if needed?	■ Senior anaesthetist ■ Ear, nose and throat surgeons
Difficulty		■ Airway plan verbalised and agreed with team ■ Self-inflating bag ■ Videolaryngoscope ■ Supraglottic airways – sizes and types ■ Difficult airway trolley available ■ 'Laryngeal handshake' and/or ultrasound and mark cricothyroid membrane

Adapted from Cook et al (2011)

Apnoeic oxygenation

Apnoeic oxygenation refers to the provision of oxygen to the oropharynx or nasopharynx during induction, to allow bulk flow of oxygen to the alveoli during apnoea. This aims to prevent desaturation in either prolonged intubation attempts, or in those patients who may desaturate rapidly (e.g. critically unwell or obstetric patients.) High-flow humidified nasal oxygen (Optiflow or THRIVE) has been used under such circumstances, and there is

KEY POINTS

- Gastric aspiration is the greatest risk to the patient of induction of anaesthesia.
- Assessing a patient's risk of aspiration during induction can be difficult, and is based on many factors.
- Rapid sequence induction is a technique used during induction of anaesthesia, with the aim of reducing the risks associated with pulmonary aspiration.
- Rapid sequence induction is a high-risk procedure which involves swiftly and safely securing a patient's airway with an endotracheal tube. It requires careful preparation and planning, and the use of drugs to induce anaesthesia and muscle relaxation.
- With the advent of new drugs, numerous medications can be used, all of which have associated advantages and disadvantages.

ongoing research to determine whether safe apnoea times are indeed prolonged when it is used during rapid sequence induction.

Positioning

Positioning aims to both optimize direct vision of the larynx and maximize the functional residual capacity of the patient. Functional residual capacity is the volume of the lung which is pre-oxygenated, so the larger this is, the less likely the patient is to desaturate. A tilting trolley is advised in case of regurgitation, whereupon the patient can be put head down to allow gastric fluid to drain away from the airway. This may be impractical if, for example, the patient has suffered spinal trauma.

Cricoid pressure

Theoretically, pressure applied to the complete ring structure of the cricoid cartilage occludes the oesophagus which sits posteriorly. However, in practice the pressure is often applied in the wrong place or with the incorrect force, and intubation may in fact be made more difficult without mitigating the risks of aspiration. UK guidelines suggest cricoid pressure should be used routinely in rapid sequence induction, but removed as a priority when intubation is difficult or the view at laryngoscopy is impaired (Frerk et al, 2015). Some anaesthetists have abandoned its use entirely given the lack of high quality evidence supporting its use (Sajayan, 2016), and in some countries (such as the Scandinavian ones) guidelines do not mandate its use, but allow anaesthetists to make the decision on a case by case basis (Jensen et al, 2010).

Identify the cricothyroid membrane

The laryngeal handshake (Levitan, 2014) and/or ultrasound imaging of the neck can be used to help accurately identify the cricothyroid membrane before induction of anaesthesia. This is the anatomical structure through which emergency 'front of neck access' is obtained in the event of a 'can't intubate, can't oxygenate' scenario. Identifying and marking its position before induction should always be considered if significant difficulty is predicted.

Drugs used

Anaesthesia and muscle relaxation are fundamental requirements to enable rapid sequence induction, and since the early days there have been many pharmacological advances to facilitate this. *Table 2* outlines their characteristics and clinical applications.

While the drugs available today are not perfect, and there is not one sole agent with which to perform rapid sequence induction under all circumstances, different combinations confer distinct benefits. The choice of drugs used must be tailored to the clinical scenario at hand, and in many acute, peri-arrest situations where cardiovascular compromise is a major issue, this can also involve high doses of midazolam or fentanyl. Such an approach minimizes the required amount of a conventional induction agent (e.g. thiopentone or propofol), sparing their hypotensive effects. The concept of 'modified rapid sequence induction' is often referred to in this context, i.e. that the technique has deviated from that originally described. In the pre-hospital context, for example, a combination of ketamine, fentanyl and rocuronium is usually used. This is favoured over previous opiate-free techniques that precipitated potentially harmful haemodynamic responses in certain patients (Perkins et al, 2013).

Conclusions

Rapid sequence induction may be used as a life-saving technique to safely secure the airway when anaesthesia is induced as an emergency. While the basic premise has not changed, it remains a high-risk procedure requiring careful thought and planning. The classic notion of thio, sux, tube is somewhat outdated, and numerous medications, manoeuvres and adjuncts, with their associated advantages and disadvantages, should be considered. BJHM

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Table 2. Advantages, disadvantages and uses of drugs available for rapid sequence induction

Drug		Advantages	Disadvantages	Clinical use
Induction agents	Thiopentone (3–5 mg/kg)	■ Fastest onset ■ Reliable endpoint (e.g. loss of eyelash reflex) ■ Antiepileptic ■ ↓ Cerebral oxygen demand and intracranial pressure	■ Haemodynamic instability (i.e. hypotension, myocardial depression) ■ Extravasation injury	■ Obstetric anaesthesia ■ Head injury ■ Status epilepticus
	Propofol (2–3 mg/kg)	■ Familiarity with drug ■ Best intubating conditions ■ Anti-emetic	■ Haemodynamic instability (i.e. hypotension, myocardial depression) ■ Pain on injection	■ 'Routine' rapid sequence induction, e.g. a history of reflux ■ Predicted difficult airway
	Ketamine (1–2 mg/kg)	■ Increases blood pressure ■ Maintains airway reflexes ■ No respiratory depression ■ Bronchodilation ■ Potent analgesia	■ Increased intracranial pressure ■ Emergence phenomena ■ Laryngospasm in children	■ Pre-hospital ■ Shocked patients ■ Asthmatics
	Etomidate (0.3 mg/kg)	■ Maintains cardiovascular stability	■ Adrenal insufficiency ■ Pain on injection ■ Myoclonic activity	■ Cardiac patients
Muscle relaxants	Suxamethonium (1.5–2 mg/kg)	■ Fastest onset ■ Reliable endpoint (visible fasciculations) ■ Short duration: thus traditionally thought to allow for prompt recovery of muscle function with the ability to self-ventilate in the event of failed intubation	■ Potassium release ■ Increased intraocular pressure ■ Short duration: intubating conditions deteriorate quickly ■ Suxamethonium apnoea – an inherited deficiency in plasma cholinesterase which can prolong the effects of suxamethonium by many hours	■ High aspiration risk ■ No predicted difficulty with intubation (which would otherwise require prolonged paralysis to aid repeated intubation attempts under optimal conditions) ■ Contraindications: burns or crush injury, malignant hyperpyrexia, spinal cord injury (72 hours–6 months)
	Rocuronium (1–1.5 mg/kg)	■ Longer duration of favourable intubating conditions ■ Rapid reversal agent available (sugammadex)	■ Increased risk of anaphylaxis ■ No reliable endpoint (unless monitoring used)	■ Predicted difficulty ■ One-way induction ■ Pre-hospital ■ Head injury ■ Elevated intracranial pressure
Other	Fentanyl (2–5 µg/kg adjunct dose, or 50–100 µg/kg if opiate based anaesthetic)	■ Abolishes stress response to laryngoscopy or surgery ■ Relative preservation of blood pressure	■ Prolonged apnoea – effects can last many hours so not suitable if plan to extubate or assess	■ Haemodynamically unstable patients ■ Elevated intracranial pressure
	Alfentanil (20 µg/kg)	■ Quickest onset time (three times faster than fentanyl) ■ Abolishes stress response to laryngoscopy or surgery ■ Relative preservation of blood pressure	■ Prolonged apnoea – effects can last many hours so not suitable if plan to extubate or assess	■ Commonly used in paediatric population ■ Haemodynamically unstable patients ■ Elevated intracranial pressure
	Midazolam (0.1–0.3 mg/kg)	■ Potent amnesic, reduces incidence of awareness ■ Greater haemodynamic stability than standard induction agents	■ Prolonged apnoea ■ Slower onset ■ Paradoxical agitation ■ Delirium in elderly	■ Status epilepticus ■ Unstable patients at risk of awareness

Adapted from Peck and Hill (2014)