

# Rapid sequence induction: its place in modern anaesthesia

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## Key points

Aspiration is the largest cause of death associated with airway management in UK anaesthesia.

The risk of aspiration should be assessed in all patients presenting for anaesthesia.

Rapid sequence induction (RSI) remains the technique of choice for minimizing this risk.

Modification of the traditional RSI may have benefits for individual patients.

In 1958, aspiration was credited as the largest cause of anaesthesia-related death by Snow and Nunn.<sup>1</sup> Surprisingly, this remains the case in 2011.<sup>2</sup> The Royal College of Anaesthetists National Audit Project (NAP4) calculated the incidence of fatal aspiration during general anaesthesia as one in 340 000, but acknowledging that as a probable underestimate, reported that it may be as common as one in 45 000. The risk of aspiration itself is estimated at one in 2–3000 during elective surgery and one in 6–800 during emergency surgery.<sup>3</sup> Potential consequences of aspiration include chemical pneumonitis, bacterial aspiration pneumonia, acute respiratory distress syndrome, and death. While recognizing the lack of a clear definition, NAP4 recommended that, in those patients at risk of regurgitation and subsequent aspiration, a rapid sequence induction (RSI) with cricoid pressure should be the technique of choice to induce anaesthesia. However, RSI as a practice is not without risk, particularly in the critically ill population. Risks include hypoxia, failed intubation, oesophageal trauma, cardiovascular compromise, and awareness. We will describe how modern practice has deviated from the traditional, standardized RSI to an approach where management of the patient at increased risk of aspiration involves an assessment of all risks to identify suitable techniques designed to minimize those risks for that individual.

## RSI: the history

Mendelson first described the deleterious effects of aspiration in 1946. Succinylcholine was introduced in 1951 and cricoid pressure first described by Sellick in 1961. These were collated by Stept and Safar in 1970 to describe a technique they called Rapid Sequence Induction and Intubation.<sup>4</sup> It consisted of preoxygenation, induction with a predetermined dose of thiopental followed by succinylcholine, application of cricoid pressure at loss of consciousness, avoidance of positive pressure ventilation, and finally tracheal intubation

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with a cuffed tube before removal of the cricoid pressure. This technique was designed to minimize the unprotected airway time and so reduce the risk of aspiration during that short period. We could consider this the *traditional* RSI. There is no evidence to show that this practice reduces aspiration or improves outcome. Despite this, RSI remains a recognized standard of care in the UK and many other countries.

## Recognizing the at-risk patient

NAP4 criticized the failure to identify those at risk of aspiration. Many factors influence the degree of risk (Table 1).

Having recognized risk, it is imperative that consideration is given to identify a suitable anaesthetic technique to minimize this risk. The WHO checklist has a question relating to aspiration risk. Its presence may help to improve the recognition of and therefore subsequent management of that particular danger.

## Reducing the risk from regurgitation

The volume, pH, and constituents of gastric regurgitant are important in any subsequent pathological process after aspiration.

It is therefore important to ensure adequate fasting and, if appropriate, it would seem sensible to make attempts to empty the stomach before anaesthesia. While being unable to confirm complete emptying, volume of any gastric contents can be reduced by the placement and aspiration of a nasogastric tube.

The pH of gastric contents can be reduced by pharmacological treatments. These include antacids, a group of drugs that react with hydrochloric acid to raise pH, H<sub>2</sub> receptor antagonists that competitively inhibit histamine release from gastric parietal cells reducing acid production, and proton pump inhibitors (PPIs) that irreversibly bind to and inactivate the hydrogen-potassium ATPase, inhibiting gastric acid secretion. When

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1002

denitrogenation atelectasis are more than balanced by the increased safety provided by improving the time to desaturation. Application of continuous positive airway pressure (CPAP) during preoxygenation can overcome these effects and minimize atelectasis.

### Positive pressure

PEEP/CPAP has been shown to reduce absorption atelectasis, improve  $P_{aO_2}$ , and increase time to desaturation in all patient groups. If a patient is already receiving non-invasive ventilation (NIV) or has a degree of respiratory compromise, the evidence suggests that continuing or commencing NIV for a short period while setting up for intubation is better protection against desaturation than standard preoxygenation.

NIV in obese surgical patients specifically has been shown to improve preoxygenation.<sup>7</sup> Concerns about increasing aspiration by gastric distension can be balanced by adopting upright positioning to reduce the risk of passive regurgitation and by limiting airway pressures. Gastric distension and regurgitation risk are low if pressures are kept below 25 cm H<sub>2</sub>O.

### Apnoeic oxygenation

As a result of differences in solubility of O<sub>2</sub> and CO<sub>2</sub>, once the patient is apnoeic, more O<sub>2</sub> leaves the alveoli and enters the bloodstream than CO<sub>2</sub> or N<sub>2</sub> enter them, creating a slightly negative pressure (increasing atelectasis). This negative pressure can be used to an advantage by maintaining a patent airway and continuing administration of oxygen that then reaches the alveoli by bulk flow. The application of nasal prongs (with flows increased once the patient is unaware), in addition to face mask oxygen, allows this process to continue during laryngoscopy and has been shown to increase time to desaturation after apnoea in both normal and obese surgical populations.<sup>7</sup>

### Positioning for preoxygenation

FRC is lower in the supine position. Evidence in normal, obese, and pregnant populations suggests that adopting a head-up position (20–35°) increases FRC and thereby improves preoxygenation. This has been shown to be clinically significant by increasing the time from apnoea to desaturation.

## Drug choice

### Induction drug

When Stept and Safar described the traditional RSI in 1970 using a predetermined dose of thiopental, many of the i.v. induction agents currently available were not fully established in clinical practice. Even now, the ideal i.v. induction agent does not exist, with individual drugs harbouring benefits and disadvantages (Table 2). National surveys of clinical practice reveal that all induction agents are used across various clinical scenarios. The choice of i.v. induction agent should be guided by informed clinical reasoning and not by dogma. Propofol, for example, will provide the best intubation conditions and hence may be used when it is deemed that potential airway

difficulty is the key clinical issue in a specific patient undergoing RSI. Predetermined dosing may be appropriate in those at high risk of aspiration in order to minimize the time spent with reduced protective laryngeal reflexes. This does, however, increase the risk of both under-dosing with potential awareness and also overdosing with the risk of cardiovascular collapse. In certain patients, the risks posed by haemodynamic instability will clearly outweigh the risks of aspiration. If there is significant risk of hypotension, then drug choice should reflect this and administration should be titrated to effect. A survey of current practice in Wales stated that the administration of induction drug varies, with some anaesthetists always using predetermined doses, some never doing so, and 65% varying their practice based on the clinical situation.<sup>8</sup>

### Neuromuscular blocking agent

Succinylcholine is the depolarizing neuromuscular blocking agent that has traditionally been used in RSI because of its fast onset and offset; with the presumption being that, in the event of failure to intubate, ventilate, or both, recovery of spontaneous ventilation would reliably rescue the situation. However, due to its relatively rapid onset and immediate reversibility, the non-depolarizing neuromuscular blocking agent rocuronium is increasingly used as an alternative.

The key issues regarding neuromuscular block (NMB) and RSI are as follows:

- (i) Time to complete paralysis and the quality of those intubation conditions.
- (ii) Potential reversal (spontaneous or otherwise) of this effect.
- (iii) Duration of action.
- (iv) Side-effects and contra-indication profile.

In all trials performed, succinylcholine results in faster paralysis and a quicker time to intubation when compared with rocuronium. In patients at the highest risk of aspiration, minimizing the time to achieving a protected airway may be clinically significant. A large meta-analysis performed by the Cochrane Collaboration reported that succinylcholine was superior to rocuronium (0.6–1.2 mg kg<sup>-1</sup>) in providing both ‘excellent’ and clinically ‘acceptable’ intubating conditions, but there was no statistical difference when making comparisons with the recommended rocuronium dose for RSI of 1.2 mg kg<sup>-1</sup>.<sup>9</sup> Timing of NMB administration also varies. In one survey, just over half of all anaesthetists stated that they routinely wait for unconsciousness before administering; 10% never wait and immediately administer after induction dose; while the remainder vary their practice.<sup>8</sup> Theoretically, immediate injection shortens the time to establishing a protected airway, but there is no evidence that this is clinically important.

Succinylcholine shows considerable variation in its duration of action due to genetic and acquired deficiencies in plasma cholinesterase, the enzyme responsible for its inactivation. The average recovery from succinylcholine 1 mg kg<sup>-1</sup> is 8.5 min. Even healthy volunteers will desaturate before the return of spontaneous respiratory effort without receiving assisted ventilation.<sup>10</sup> Furthermore,

**Table 2** Induction agent considerations

Induction agent	Advantages	Disadvantages	Suggested use
Sodium thiopental 3–7 mg kg <sup>-1</sup> (traditionally used)	Clear endpoint; rapid one arm brain circulation time	Postoperative nausea and vomiting Potential harm from extravasation Antanalgesic	Traditional choice for RSI in obstetric practice
Propofol 2–4 mg kg <sup>-1</sup> (use increasing)	Greater suppression of laryngeal reflexes Familiarity	CVS depression	When intubating conditions are a concern
Etomidate 0.3 mg kg <sup>-1</sup> (use decreasing)	CVS stability	Adrenal suppression	CVS instability; caution/avoid in sepsis and, if used, early hydrocortisone is recommended
Ketamine 1–2 mg kg <sup>-1</sup>	Bronchodilation CVS stimulant; maintains cerebral perfusion pressure in hypotensive situations	Increases ICP	Asthma Shocked states Avoid in patients with IHD or with non-traumatic CNS pathology
Midazolam	Not routinely used as an induction agent in the UK	Longer to take effect and long duration of action	Probably no role as a single agent
Opiate	Not routinely used as an induction agent in the UK	Unreliable amnesic. Not recommended as a general anaesthetic	Probably no role as a single agent

with a return in spontaneous respiration, the upper airway may remain completely obstructed in an unconscious patient.

Rocuronium followed by sugammadex results in a comparatively faster return to spontaneous ventilation. However, it is unclear if this would be replicated in actual clinical practice.<sup>11</sup> To facilitate this, it is suggested that, when using rocuronium in an RSI, the rescue dose of sugammadex 16 mg kg<sup>-1</sup> should be pre-calculated and immediately available for an assistant to draw up and administer on instruction.

The more prolonged action of a non-depolarizing agent such as rocuronium may be advantageous. First, it is well recognized that considerable difficulties with airway management can arise when the succinylcholine paralysis is wearing off and airway conditions become suboptimal. Secondly, in certain RSIs, 'wake up' is not a feasible option and the reversibility of the induction technique not an issue, for example, the patient with the ruptured abdominal aortic aneurysm or the critically ill patient with respiratory failure. In these scenarios, use of a drug that provides the best airway management conditions for more than a few minutes would seem the most effective strategy.

Succinylcholine is a drug with a number of potentially life-threatening side-effects. Potassium efflux occurs at depolarization; this is increased significantly in conditions that result in up-regulation of nicotinic receptors, such as burns, crush injuries, and chronic neurological conditions, including spinal cord injury, stroke, and critical illness polyneuropathy. It causes malignant hyperthermia in susceptible individuals. Rocuronium is a relatively cleaner drug; the only absolute contraindication being allergy. There is increasing evidence that the incidence of rocuronium allergy is higher than that of other non-depolarizing neuromuscular blocking agents.<sup>12</sup>

### Opioids

Traditionally, opioids were not used as part of an RSI—the belief being that they could contribute to an increase in the time to recovery of spontaneous ventilation and consciousness in the event of a

'wake up' after a failed RSI intubation. Opioids reduce intraocular, intracranial, and cardiovascular adverse effects associated with laryngoscopy and should be considered in situations where these effects could be potentially harmful. They also reduce the dose of hypnotic agent required. The majority of anaesthetists now include opioids as part of their preferred technique. For example, remifentanyl, alfentanil, fentanyl, and morphine are used in up to 92% of UK anaesthetists' practice.<sup>8</sup> Alfentanil has the potential advantage of bolus delivery and a more rapid onset and shorter recovery than fentanyl or morphine.

### Non-opioids

Many drugs have been used in an attempt to reduce the presser response to laryngoscopy, including  $\beta$ -blockade. Evidence for the use of lidocaine and magnesium in this setting is at best equivocal.

### Ventilation

Ventilation after apnoea and before intubation is traditionally avoided in RSI owing to the assumption that such practice increases gastric distension and the risk of regurgitation. However, there is no good evidence for this as long as inflation pressures used are <15–20 cm H<sub>2</sub>O. Fit, healthy patients who have normal airway anatomy and are simple to intubate are unlikely to desaturate, but patients who have increased metabolic demands, reduced FRC, pre-existing hypoxia, respiratory pathology, or are not readily intubatable may desaturate before intubation despite adequate preoxygenation. These patients are likely to benefit from gentle ventilation with cricoid pressure applied before laryngoscopy. This has been referred to as *controlled* RSI.

### Management of failure

Airway management should not be commenced without formulating a patient-specific strategy, with particular emphasis on management plans in the event of failure. The Difficult Airway Society (DAS) guidelines<sup>13</sup> for the management of failed intubation and ventilation

are currently being revised. Knowledge and application of these or similar guidelines, including ensuring availability of and familiarization with airway rescue equipment, and an informed team-based approach may make the difference between patient safety and patient catastrophe. Initial attempts at laryngoscopy are commonly performed using a Macintosh laryngoscope, but an increasing number of anaesthetists are using videolaryngoscopy, if not for their initial attempts, as their rescue device, replacing alternative direct laryngoscopes such as the McCoy or straight blade. Aids such as intubating stylets or bougies should be immediately available. There is no evidence to support the use of any one of these devices over another and, in the absence of this, choice will relate to the clinical situation and professional preference. There should be a third person (anaesthetist, assistant, or suitable alternative) present and able to summon help or retrieve equipment required should unexpected difficulties arise. The default position in most RSIs where intubation is unsuccessful will be wake up. This may not be appropriate or possible in all patients and this should be factored in to the planned strategy.

## Extubation

Traditionally, patients who had had an RSI were extubated in the left-lateral head-down position after a full return of protective airway reflexes. More recently, there has been a trend towards extubation in the semi-recumbent position, which is likely to aid upper airway patency, respiratory function, and access to the airway, particularly in the obese patient. There is no good evidence to support one practice over another. The key issue as regards safe extubation is again having a clear strategy, which may be informed by the recently published DAS Extubation guidelines.<sup>14</sup>

## Management of process

After the implementation of a 10-point checklist/care bundle for intubation in a critical care unit, rates of severe hypoxaemia and cardiovascular collapse significantly decreased.<sup>15</sup> NAP4 recommended that an intubation checklist should be developed and used for the tracheal intubations of all critically ill patients. They suggested a checklist might identify issues regarding preparation of the patient, equipment, drugs, and personnel and help clarify the back-up plan. Some units have introduced these checklists for critical care and emergency medicine. The use of standard operating procedures may also be beneficial, such as the instruction on the preparation of sugammadex for potential reversal of NMB if rocuronium is to be used during an RSI. Local guidelines for RSI practice for junior trainees may also be advantageous to ensure safe and consistent practice.

## Summary

The available evidence does not allow strict guidance on when and when not to perform an RSI, nor does it clarify the precise components that should constitute this approach, so-called 'best practice'. In certain clinical scenarios, an anaesthetist may choose not to use

thiopental, not to use a pre-determined dose of induction agent, not to use succinylcholine, not to maintain cricoid pressure, or to deliberately assist ventilation before intubation. Future research may offer insight to guide the decision-making process and should be encouraged. With the development of new drugs, increasing comorbidities, and higher risk profiles of our patients, the traditional RSI has been modified to provide an optimal balancing of risks. This can be directed by locally adapted guidelines. A modified RSI as practiced in modern anaesthesia could be considered to be:

- (i) Physical and pharmacological reduction in regurgitation and aspiration risk.
- (ii) Maximal optimization of oxygen stores. This may involve assisted ventilation before intubation.
- (iii) Induction of anaesthesia appropriate to clinical conditions, with paralysis by a rapidly acting agent. Sugammadex should be immediately available if rocuronium is used.
- (iv) Application of cricoid pressure is advisable—unless it obscures the view at laryngoscopy or interferes with manual ventilation or SAD placement.
- (v) Tracheal intubation with a cuffed tracheal tube.
- (vi) Implementation of pre-planned strategy in the event of failure to intubate.

## Declaration of interest

None declared.

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**Please see multiple choice questions 25–28.**