REVIEW ARTICLE

RAPID SEQUENCE INTUBATION. THE CURRENT STATE OF KNOWLEDGE

Sekwencja szybkiej intubacji. Aktualny stan wiedzy

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Abstract

Rapid sequence intubation is a widely practiced method for handling the airway during anaesthesia induction in patients with gastric problems or those susceptible to regurgitation or aspiration. Preparation involves gathering essential equipment and medications for emergency intubation, including oxygen, suction, bag-valve mask, laryngoscope, endotracheal tubes with stylets, resuscitation gear, and rescue tools. Despite its consistent use for over five decades, debates persist regarding the efficacy of specific elements of the method, such as cricoid pressure and the assessment of fasting in urgent surgical cases. The absence of standardised rapid sequence intubation techniques and universally accepted guidelines has resulted in discrepancies in published data. Cricoid pressure, also known as the Sellick manoeuvre, is a controversial element of rapid sequence intubation that has both supporters and critics. While it has been used for decades and is recommended by many countries to prevent pulmonary aspiration during anaesthesia, recent research has raised questions about its effectiveness. In patients undergoing emergency surgery, ultrasound of the gastric antrum may help evaluate the size of gastric contents in order to minimise the risk of aspiration pneumonia. Techniques and variants of anaesthetic induction in the rapid sequence intubation algorithm should be adapted to a wide range of clinical groups – particularly in children, obese patients and pregnant women. In paediatric anaesthesia and for obese patients, the traditional rapid sequence intubation with apnoea is not commonly used due to their limited respiratory reserve. Despite its numerous side effects, succinylcholine remains the most frequently employed drug for rapid sequence intubation.

Streszczenie

Sekwencja szybkiej intubacji jest powszechnie stosowaną techniką zabezpieczania dróg oddechowych podczas indukcji znieczulenia u pacjentów ze schorzeniami żołądka, ryzykiem zarzucania treści pokarmowej do przełyku (regurgitacji) lub zachłyśnięcia (aspiracji). Procedura wymaga przygotowania sprzętu do szybkiej intubacji w trybie nagłym oraz leków: tlenu, ssaka, worka ambu z maską twarzową, laryngoskopu, rurek dotchawiczych z prowadnicą, zestawu do resuscytacji i niezbędnego sprzętu ratowniczego. Choć metoda jest wykorzystywana już od ponad 50 lat, nadal toczą się dyskusje na temat skuteczności niektórych jej elementów, takich jak ucisk na chrząstkę pierścieniowatą czy ocena stanu opróżnienia żołądka w nagłych wypadkach wymagających interwencji chirurgicznej. Brak ujednoliconych standardów dotyczących technik szybkiej intubacji oraz ogólnie przyjętych wytycznych postępowania prowadzi do rozbieżności w danych literaturowych. Ucisk na chrząstkę pierścieniowatą, zwany także manewrem Sellicka, jest kontrowersyjnym elementem szybkiej sekwencji intubacji, który ma zarówno swoich zwolenników, jak i przeciwników. Technika ta jest wprawdzie wykorzystywana już od kilkudziesięciu lat i zalecana w wielu krajach w celu zapobiegania aspiracji treści pokarmowej do płuc, jednak wyniki niedawnych badań wzbudziły wątpliwości co do zasadności jej stosowania. U pacjentów poddawanych zabiegom chirurgicznym w trybie nagłym badanie ultrasonograficzne żołądka może pomóc w ocenie objętości treści żołądkowej w celu zminimalizowania ryzyka zachłystowego zapalenia płuc. Metody i warianty indukcji znieczulenia w algorytmie szybkiej sekwencji intubacji wymagają dostosowania do specyfiki różnych grup klinicznych, zwłaszcza dzieci, osób otyłych i kobiet w ciąży. W znieczuleniu pediatrycznym i u pacjentów otyłych klasyczna szybka intubacja z okresem bezdechu nie jest powszechnie stosowana ze względu na ograniczoną rezerwę oddechową. Pomimo wielu działań niepożądanych lekiem najczęściej używanym w szybkiej sekwencji intubacji pozostaje suksametonium.

Keywords: rapid sequence induction and intubation; airway management; emergency treatment; complications

Słowa kluczowe: sekwencja szybkiej indukcji i intubacji; zarządzanie drogami oddechowymi; leczenie w nagłych przypadkach; powikłania

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Introduction

The RSI ("Rapid sequence intubation", "Rapid sequence induction", "Crush intubation", "Crush induction") is an airway management technique used for induction of anaesthesia in patients with gastric content or at risk of regurgitation or aspiration. The procedure is a special form of anaesthetic induction that has been a mainstay in clinical anaesthesia and emergency medicine for more than 50 years [1]. The components and sequence have remained the same for many years; the clinical value of cricoid pressure or even the assessment of fasting in patients with urgent surgical indications are topics of ongoing discussion [1, 2]. Other problems include the non-homogeneity of RSI techniques in the published data and the lack of internationally accepted RSI guidelines [1, 3].

Aim

The aim of the study was to discuss the induction of anaesthesia in the RSI algorithm in various clinical situations with particular emphasis on the role of ultrasound assessment and the Sellick manoeuvre.

Material and methods

The work is based on the available literature and the authors' experience.

Results and discussion

Indications for rapid sequence intubation

Rapid sequence intubation is indicated for patients in acute respiratory failure due to poor oxygenation or ventilation, and for patients who cannot protect their airway due to altered mental status. RSI may also be used in patients with an acute upper gastrointestinal bleed at a high risk of aspiration. Absolute indications for RSI are presented in table 1 and relative indications in table 2.

Table 1. Absolute indications (classical rapid sequence induction) (Mencke et al.) [4]

Ileus and/or stenoses in the upper gastrointestinal tract
Acute abdomen
Wound disruption
Coma with concomitant multi-organ trauma
Emergency caesarean sections

Process of "classical" rapid sequence induction

"Classical RSI" consists of seven steps (7P) including **p**reparation (monitoring of vital signs, intravenous line insertion, position of the patient before anaesthesia induction), **p**reoxygenation, **p**retreatment (intravenous anaesthetic induction), **p**aralysis with induction (an intravenous muscle relaxant drug with a rapid onset), **p**rotection and **p**ositioning (the Sellick manoeuvre), **p**lacement of the tube in the trachea, and **p**ostintubation management [5]. The main components of RSI are summarised in table 3.

Table 2. Relative indications (modified rapid sequence induction possible) (Mencke et al.) [4]

Patients with gastric content who have not fasted at least 6 hours after their last meal; however, there is no safe limit time for non-selective surgery
Obesity ([Body Mass Index] ≥35kg/m^2). Also applies to patients after bariatric surgery
Gastroesophageal reflux disease; this applies mainly to patients with symptomatic reflux and no Proton Pump Inhibitor therapy
Hiatal hernia and Zenker's diverticulum
Gastropathy (diabetes, stage 5 chronic kidney disease, and liver failure)
Patients with painful injuries without multi-organ trauma

Table 3. Main components of "classical" Rapid Sequence Induction (Mencke et al.) [4]

Prepared workplace (environment and equipment)
Placement of gastric tube before induction of anaesthesia
Additional assistance
Elevation or lowering of the patient's upper body by 30°
Removal of gastric tube before intubation
Preoxygenation (at least 3 min; alternatively 8 deep breaths over 60 s); effectiveness of denitrogenation can be monitored by end-expiratory oxygen concentration
Rapid application of anaesthetics
1.0 mg/kg succinylcholine (dosage according to absolute body weigh) or at least 1.0–1.2 mg/kg rocuronium (dosage according to normal/ideal body weigh)
No intermediate ventilation
In case of threatening hypoxia, cautious mask ventilation should be carried out (do not exceed a peak ventilation pressure of 15–20 cm H_2O); cricoid pressure should be considered
Endotracheal intubation with an intubating stylet
Insertion of a gastric tube

Preparation involves having all the necessary equipment and supplies including medications that may be needed for emergency intubation such as oxygen, suction, bag-valve mask, laryngoscope and blades, endotracheal tubes (ET) with a stylet with one size larger and smaller than the anticipated ET size, resuscitation equipment, and supplies for rescue manoeuvres (e.g. laryngeal mask airway or cricothyrotomy) [6].

Preoxygenation can be achieved in 3 to 5 minutes by having the patient breathe 100% oxygen via a tight-fitting facemask or, if time is limited, with four-eight vital capacity breaths. Positive pressure ventilation should be avoided during the preoxygenation step because of a risk for gastric aspiration and possible regurgitation. In the preoxygenation phase, replacing the nitrogen reservoir in the lungs with oxygen allows 3 to 5 minutes of apnoea without significant hypoxemia in the normoxic adult [7].

Muscle relaxants are a standard practice in the induction of anaesthesia in life-threatening conditions. Muscle relaxation in RSI has the advantage of significantly improving intubation conditions and reducing the need for intravenous anaesthetics, which prevents an increase in intracranial pressure. However, if intubation fails, there is a prolonged lack of spontaneous breathing, and the patient's life is threatened. A "can't ventilate, can't intubate" situation may also occur. It is also important to be aware of the numerous side effects of succinylcholine [8].

According to the standard procedure, the time for intubation is reached when the jaw becomes flaccid due to administration of paralytics. ET tube placement should be confirmed by the usual visualisation techniques.

Sellick manoeuvre

Cricoid pressure, also known as the Sellick manoeuvre, is an element of the RSI that has a high ratio of supporters and critics, but on the other hand has been well researched scientifically in recent years. The technique – first introduced by Sellick in 1961 – quickly established itself in everyday clinical practice – particularly in the United Kingdom. The pathophysiological effect is the closure of the oesophagus as it is pressed against the longus colli muscle rather than the cervical spine, because the oesophagus is displaced laterally rather than dorsally when the cricoid cartilage is compressed [9].

Although cricoid pressure has been used in clinical practice for decades, and it is recommended by most countries during RSI due to its effectiveness in preventing pulmonary aspiration, it may also have deleterious effects such as airway-related complications (interference with laryngeal exposure, difficult tracheal intubation and mask ventilation) [10]. In 2019, Birenbaum et al. conducted a large randomised, double-blinded clinical trial in patients undergoing anaesthesia with RSI, which failed to demonstrate the non-inferiority of a sham procedure as compared with cricoid pressure in preventing pulmonary aspiration. The researchers did not observe any significant differences in the occurrence of pneumonia, length of stay, and mortality [10].

It is important to remember that cricoid pressure may significantly worsen intubation conditions (higher grades 3 and 4 according to Cormack and Lehane in the "cricoid group"), resulting in longer intubation times. In RSI, where rapid and safe intubation is particularly important, this can be particularly problematic.

Additionally, it should be noted that optimal peak ventilation pressure should be 15–20 cm H_2O to avoid regurgitation [2].

In 2017, a study of the proper execution of the Sellick manoeuvre was carried out on a group of 206 doctors and nurses employed in Mazovian hospitals (Poland). Half of the respondents applied pressure to an incorrect area of the neck and the vast majority applied inappropriate force during compression. Therefore, the use of cricoid pressure in patients should be preceded by training on properly prepared trainees [11].

Crucially, laryngeal compression must be applied with the force necessary to cause oesophageal closure; this is 30 Newtons (N) (equivalent to 3.0 kg) for men and 20 N (equivalent to 2.0 kg) for women [12]. For educational purposes, a practical method to learn is by using a commercially available perfusion syringe filled with air to 50 ml and then squeeze it to 38 ml (20 N, women) or 33 ml (30 N, men) [13].

Gastric content and ultrasound

The aim of RSI is to prevent pulmonary aspiration which can lead to pneumonia and in the worst case to acute respiratory distress syndrome. A distinction is generally made between elective, urgent, and emergency surgery. In elective patients, it is sufficient to postpone the operation until a 6-hour fasting period has been achieved; in the absence of additional risk factors for pulmonary aspiration, the risk of aspiration remains unchanged. For emergency surgery, the risk of aspiration is usually increased even after 6 hours of fasting and affects at least 30% of all patients [2]. Ultrasound allows qualitative and quantitative assessment of the gastric antrum in patients who are still not fasting after 12 hours or more.

Several studies showed ultrasound as the most effective method for evaluating the gastric antrum. The probability of detecting the gastric antrum was 98%–100%. The right lateral position is the ideal position for scanning the antrum (with the highest sensitivity and specificity) because it is when the antrum is at the lowest point of the stomach [14]. The cross-sectional area (CSA) of the antrum can reflect the whole gastric volume (GV), and a remarkably positive correlation exists between CSA and GV [15]. Upon visualisation of the stomach during ultrasound, the gastric antrum has an ellipsoid shape, and the section area could be obtained by the antero-posterior (AP) diameter and craniocaudal (CC) diameter. The formula for estimating the risk of aspiration is [16]:

$$Risk = \frac{CSA}{bodymass} = \frac{AP \times CC \times 0{,}8}{bodymass}$$

The critical gastric volume associated with an increased risk of aspiration is still debatable. Healthy fasting patients regularly show a gastric volume of up to 1.5 ml/kg as basal gastric secretion, i.e., approximately 100 ml in a 70 kg patient [17]. Therefore, in the current recommendations, the cut-off is set at 1.5 ml/kg, i.e., if <1.5 ml/kg of clear fluid is found, the risk is low; if >1.5 ml/kg is found, the risk of aspiration is increased [14,17] Therefore, if no gastric fluid is found, the risk of aspiration is minimal.

Recent studies have shown that bedside ultrasound can provide reliable information about the volume and nature of gastric contents. With this technology, anaesthesiologists can make individual decisions to minimise the risk of perioperative aspiration. According to a 2020 study, routine ultrasound of the stomach in 100 patients led to a change in anaesthetic technique in nine cases (9%) [18].

Differences in rapid sequence intubation in specific clinical situations

In certain clinical circumstances, a modified technique is implemented in an attempt to optimise patient outcome and reduce excess risk exposure. Potential variations between the classic and modified RSI procedures include: (1) selection of a different neuromuscular blocking drug (NMBD); (2) timing of NMBD administration in relation to induction; (3) use of positive pressure ventilation before securing the airway; (4) timing of cricoid pressure application [19].

Rapid sequence intubation in children

The key features of a properly executed paediatric RSI include the avoidance of cricoid pressure, effective induction of sufficiently deep anaesthesia, and confirmation of complete muscle paralysis prior to tracheal intubation [20]. Intravenous access in "at-risk" patients is obtained as a standard practice. Intraosseous access represents a suitable alternative for children requiring resuscitation for emergency surgery and in whom intravenous access cannot be established [21].

Neonates, infants, and small children have a reduced apnoea tolerance in comparison with adults. A direct consequence is that hypoxaemia is very likely to occur in the period between the induction of anaesthesia and re-establishment of ventilation through the tracheal tube during a "classic" RSI. Therefore, to avoid hypoxemia and hypercapnia, it is important to use gentle ventilation, which includes the use of a pressure-limited mask ventilation with 100% oxygen for 4 minutes and with pressures not exceeding 10–12 cm H_2O [22].

Subjective sense of thirst or hunger cannot be used as a reliable method to judge the quantity of gastric contents, and bedside ultrasound is the only non-invasive technique to estimate gastric volume in infants.[26] Recent research indicates that the previously recommended fasting time might be too conservative, while ultrasonography before anaesthesia plays an important role in assessing the risk of aspiration in paediatric patients [23].

Rapid sequence intubation for caesarean sections

Pregnant women have a threefold higher risk of aspiration compared to other patients, which has been reported in the literature. This may be due to increased gastric pressure in late gestation [24]. In addition, mortality after aspiration is significantly higher compared to non-pregnant adult patients (3.5% vs. 12%) [25]. Among many other factors, the shift from general anaesthesia to regional procedures near the spinal cord in obstetrics has significantly reduced maternal mortality in recent decades [26]. Also for this reason, the regional procedure without additional sedation is used in patients who are at risk of aspiration.

General anaesthesia in the context of caesarean section is currently reserved mainly for emergency sections or where central blocks have been technically unsuccessful or are contraindicated. This is because approximately 1–2% of maternal deaths can be directly or indirectly attributed to anaesthesia [23]. In elective or active emergency incisions. prevention of aspiration includes the administration of an H_2-receptor antagonist 60 min before surgery, possibly with the addition of metoclopramide. In emergency surgery, an antacid is administered orally prior to incision (0.3 mol sodium citrate 30 ml) [27]. Of the intravenous anaesthetics, thiopental has historically been used for the induction of anaesthesia, and it is still often the drug of choice, although propofol may be a better alternative. There are no supplementary recommendations for opioids and muscle relaxants, as well as the use of the Sellick manoeuvre and airway management [3]. An opioid can be given in a low dose for induction, this is typically done only after the baby has been extracted [25].

Rapid sequence intubation in obese patients

In morbidly obese patients, RSI or fast intubation is still considered the preferred method of induction to general anaesthesia, except for expected difficult airways, where fibre optic intubation is better [28]. In addition, dosing medications based on total body weight may lead to overdose in obese patients, whereas dosing based on ideal body weight may lead to underdosing. According to a retrospective review, obese patients undergoing RSI in the ED were more likely to be underdosed with both etomidate and succinylcholine [29]. For obese patients, a dose of 1.5 mg/kg seems to be required — according to absolute or (note) actual body weight. Improper dosing of medications for RSI has the potential to lead to prolonged paralysis or suboptimal intubating conditions. It can be particularly detrimental given the challenges associated with airway management in obese patients, including more difficult mask ventilation and more rapid desaturation during apnoea. Since obesity is an independent risk factor for full stomach, and airway management may be difficult in these patients, preoperative gastric ultrasound is recommended to assess the risk of aspiration [29].

Pre-treatment strategies

Pre-treatment agents are medications given before starting RSI to lessen the potential negative physiological responses, like high blood pressure and rapid increases in intracranial pressure. Despite their potential benefits, there is limited evidence linking their use to better patient outcomes, and they are not commonly used in clinical practice. Atropine, lidocaine, and fentanyl are commonly mentioned as pre-treatment agents, and they are ideally administered 2–3 minutes before induction to allow for their desired effects. Atropine, derived from belladonna, acts as a competitive antagonist to acetylcholine, boosting the heart rate by blocking vagus nerve signals. This counters bradycardia during intubation, especially in children. Despite recommendations, evidence supporting its routine use is limited. A recent study on 62 paediatric patients found that bradycardia rates were similar with or without atropine (4.3% vs. 6.6%). The recommended dose for pre-treatment is 0.01 mg/kg in adults and 0.02 mg/kg in paediatrics, with a typical maximum of 0.5 mg. Historical concerns of paradoxical bradycardia for doses <0.1 mg lack strong evidence, and overall, the benefit of atropine in preventing bradycardia, even in high-risk cases, remains uncertain. Lidocaine, a sodium channel blocker categorised as an antiarrhythmic class 1B and local anaesthetic, demonstrates multiple effects when administered intravenously, such as bronchodilation, cough suppression, and potential reduction in ICP, intraocular pressure, and MAP during intubation. In the context of RSI, lidocaine is utilised to counteract a surge in catecholamines, particularly in traumatic brain injury (TBI) patients. Despite these potential benefits, there is a lack of robust data supporting lidocaine's efficacy for this purpose. Lidocaine is believed to mitigate ICP increases resulting from coughing during RSI, potentially benefiting TBI patients. However, studies demonstrating lidocaine's cough suppression ability did not involve neuromuscular blocking agents (NMBA). To date, no study has shown significant differences in ICP reduction when lidocaine is administered for cough suppression during traditional RSI, and there is limited evidence of direct ICP reduction. Additionally, lidocaine is thought to prevent bronchoconstriction resulting from airway stimulation during intubation, especially in asthmatic individuals. However, research findings on this topic are inconsistent. The historically recommended dose for lidocaine pre-treatment is 1.5 mg/kg, with the peak effect on ICP observed two minutes after administration. Adverse effects include hypotension and bradycardia, mainly at higher plasma levels, beyond typical RSI dosing. Due to contradictory and generally low-quality data, the use of lidocaine for pre-treatment is discouraged. Fentanyl, a short-acting synthetic opioid often suggested as a pre-intubation treatment, aims to dampen the heightened sympathetic response to pain during laryngoscopy. Theoretically, by countering the pain-induced increase in mean arterial pressure (MAP), complications in patients with compromised cerebral autoregulation, acute coronary syndromes, and aortic dissection can be prevented. Fentanyl acts rapidly, with an effect duration of about 60 minutes. While historically used to lower MAP in traumatic brain injury (TBI), subsequent decreases in MAP post-intubation can negatively impact cerebral perfusion pressure (CPP), posing a concern for TBI patients. However, the varied findings and a lack of real-world, patient-centred clinical outcomes data hinder the widespread use of fentanyl for pre-treatment in RSI among TBI patients. Notably, guidelines for TBI management do not endorse its use. The historically recommended dose for fentanyl pre-treatment exceeds typical analgesic dosing (3 µg/kg). Smaller doses (e.g. 1 µg/kg) can be synergistically used with midazolam to reduce induction agent requirements. Adverse effects encompass hypotension and respiratory depression, with high doses posing a risk of accelerated respiratory depression. Chest wall rigidity, a rare complication often associated with higher doses, is unlikely with pre-treatment doses administered over 60 seconds. While fentanyl effectively lessens MAP increases during intubation in the operating room, its use in RSI is linked to post-intubation, dose-dependent hypotension in the emergency department. Considering the available literature, the potential benefits of blunting MAP increases during intubation do not outweigh the risk of post-intubation hypotension [30].

Conclusions

A modified RSI is used to prevent the occurrence of pulmonary aspiration. The classic RSI, including apnoea, is not implemented in paediatric anaesthesia, as is the case in the anaesthesia of obese patients. This is due to the lack of respiratory reserve in patients in these two clinical groups. Succinylcholine is most commonly used for RSI despite its numerous side effects; rocuronium is an alternative but a high dose is needed and Sugammadex protection is then required. Absolute indications for RSI include all gastrointestinal obstructions. Pre-treatment agents, administered before RSI, aim to alleviate adverse physiological responses. Despite their potential advantages, their use lacks robust evidence for enhancing patient outcomes, and they are not widely embraced in clinical practice.

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