Review article

Rapid sequence induction-intubation and cricoid pressure – facts and fallacies

Shreepathi Krishna Achar*, Nanda Shetty

Email: drshreepathi@gmail.com

Abstract

Rapid sequence induction-intubation (RSII) is *'the standard of care'* practice since decades while anaesthetising a full stomach patient or during emergency airway management. Cricoid pressure (CP), an important manoeuvre, labelled as the *'linchpin of rapid sequence induction-intubation'*, when not performed properly can lead to catastrophic results. The purpose of this review of literature is to discuss if rapid sequence induction and application of cricoid pressure is a safe and effective technique in managing a full stomach patient. Literature from multiple sources was searched for key words, subject headings and text entries on rapid sequence induction, rapid sequence induction and intubation, and cricoid pressure. Outcomes such as prevention of aspiration and prevention of other airway complications such as airway trauma could not be evaluated based on the literature available at present. There is lack of clear cut evidence from randomised controlled trials on the safety and effectiveness of rapid sequence induction-intubation and cricoid pressure. Despite wide acceptance of RSII, its role in emergency airway management is still debated. CP as an essential skill, lacks in its uniformity among clinicians, technicians and nurses, and simulation based training hold promise in this regard.

Keywords: Cricoid force, cricoid pressure, emergency airway, rapid sequence induction, rapid sequence induction-intubation

Introduction

The abbreviation RSI has been interchangeably used both for rapid sequence induction and rapid sequence intubation; hence the abbreviation 'RSII' for rapid sequence induction-intubation. Alternatively, it is also called as 'crash' induction. The history dates back to 1951, ever since succinylcholine was introduced into clinical practice. Morton and Wylie in 1951 stated that barbiturate/muscle relaxant/rapid induction technique in the sitting position is useful while managing a full stomach patient. Dr Brian A Sellick in 1961 described *cricoid pressure* for the first time.[1] He stated that the rapid induction of anaesthesia in the sitting position leads to cardiovascular collapse in a seriously ill patient and it facilitates the entry of gastric contents into the lung during vomiting. Amidst controversies, the technique has evolved and has been modified over a period of time. RSII still plays a major role in emergency anaesthesia and obstetric general anaesthesia.[2] However, prospective studies to prove the safety and efficacy of RSII in preventing pulmonary aspiration syndrome are lacking. An evidence-based clinical update concluded that the decision to use RSII can neither be supported nor discouraged due to lack of evidence from randomised controlled trials.[3] With this background, it is wise to look into the facts and fallacies of RSII and cricoid pressure.

Shreepathi Krishna Achar, MD, DNB
Associate Professor, Department of Anaesthesiology, Kasturba Medical College, Manipal, India

Nanda Shetty, MD
Specialist, Department of Anaesthesiology, Corniche Hospital, Abu-Dhabi, UAE

Rapid sequence induction-intubation

The basic intention of RSII is to reduce the time between loss of consciousness and securing the

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airway with an endotracheal tube so that the time these patients are at risk of aspiration of gastric contents into the lungs is shortened. The steps of RSI include preoxygenation with 100% oxygen, inducing with a precalculated dose of an induction agent, applying cricoid pressure and avoiding positive-pressure ventilation till the confirmation of intubation of airway by cuffed endotracheal tube.[4,5] This technique is frequently used in emergency room for unplanned airway management to facilitate intubation both in adults and paediatric patients.[6-10] Preparedness for failed intubation is always necessary for RSI.[11-13]

Preoxygenation is normally achieved by making the patient breathe 100% oxygen with a flow rate of 5 L/min for tidal volume breathing for 3 to 5 minutes with a good mask fit. In an emergency situation, it can also be achieved by a series of four vital capacity breaths of 100% oxygen at a flow rate of 10 L/min.[13] Thiopental is still the most popular induction agent for RSI whereas propofol is now being used extensively in emergency room.[13] Other less popular induction agents are ketamine and etomidate.[14,15] The most popular neuromuscular agent for RSII is succinylcholine.[13] Rocuronium has been effectively used in patients where succinylcholine is contraindicated. Studies have demonstrated that rocuronium at a dose of 0.8 to 1.2 mg/kg provides similar intubating conditions as succinylcholine at 1 mg/kg.[16,17] However, rocuronium at this dose has a longer duration of action making situations worse in difficult airway.[18] Though the introduction of sugammadex into clinical practice has improved the safety of rocuronium in RSII, it has been widely suggested as not an acceptable rescue in the event of *'cannot intubate, cannot ventilate (CICV)'* situation.[19-22]

In conventional RSII technique, positive pressure ventilation is strictly avoided to prevent gastric insufflation and hence pulmonary aspiration. This precludes one's ability to check for mask ventilation, thereby missing vital information about patient's airway before paralysing. Inability to secure an airway can proceed to multiple attempts resulting in trauma to the airway, hypoxia and hypercarbia with associated morbidity and even mortality. To circumvent these eventualities, a modification of conventional RSII was accepted by most clinicians. This modified technique includes an additional step of gentle positive pressure ventilation before and after the administration of the muscle relaxant. It is always reasonable to weigh the risk of inability to secure the airway against the risk of pulmonary aspiration in a given situation because both of them can be equally dangerous when not managed properly.

Neilipovitz and Crosby in a structured, evidence-based, clinical update came out with some conclusions.[3] Regarding the impact of RSII in prevention of aspiration, they concluded that aspiration is rare and very large number of patients needs to be studied. Most of the investigations on assessment of RSII protocols are on airway management such as ease and success of intubation, mostly on healthy subjects who are not representative of actual patients. They also opined that further investigation is required to study the utility of RSII in prehospital and emergency room setting and probably improve the likelihood of successful intubation with less number of attempts and reduced airway morbidity.

Preoxygenation either by tidal volume breathing for 3 minutes or eight deep breaths in 60 seconds is an essential component of RSII that provides enough safe apnoea time following induction.[23,24]

There is no single ideal induction agent which provides stable haemodynamics, good intubation conditions and reliable amnesia and anaesthesia.[11] As compared to etomidate, ketamine and midazolam, intubation success in the first attempt was better documented with thiopental, methohexital and propofol.[25,26] Etomidate is preferred in patients with poor cardiac reserve and unstable haemodynamics but is better avoided in sepsis.[27,28]

Evidence supports the use of succinylcholine as the drug of choice for paralysis in RSII as it provides excellent intubating conditions in a shorter time than does rocuronium. A dose of ≥ 1 mg/kg is required to ensure excellent intubating conditions and doses ≤0.5 mg/kg are often associated with poor intubating conditions.[29,30] A dose ≥ 0.6 mg/kg is associated with a similar measure of acceptable conditions as is 1 mg/kg and may result in shorter apnoea times.[31,32] Either may result in hypoxaemia if the patient cannot be intubated or oxygenated in time.[33-35] Rocuronium, at a dose of ≥ 0.6 mg/kg, is likely to provide acceptable conditions but will less frequently provide excellent conditions when compared to succinylcholine.[36] Rocuronium is an acceptable alternative to succinylcholine for RSI in situations where latter is contraindicated or unavailable. Sugammadex has improved the safety of rocuronium while dealing with a full stomach patient. However, experts opine that sugammadex is not an acceptable rescue in the event of 'cannot intubate, cannot ventilate (CICV)' situation.[19-22]

Adjuvants are the drugs used in combination with induction agents either to suppress intubation response, to reduce the overall amount of induction agent or to avoid untoward haemodynamic consequences.[37] Commonly used adjuvants in clinical practice are opioids, lignocaine, and esmolol.[11,25] Studies have proved the usefulness of adjuvant drugs including esmolol or opioids during RSII when clinical assessment dictates so.[38,39]

Rationale behind skipping the step of positive pressure ventilation with bag and mask following induction is to avoid the possibility of gastric insufflation and regurgitation.[40] Avoiding this step is always at the expense of safe apnoea time that is available to secure the airway before significant desaturation develops, more so in the background of failed intubation. However, cause-effect relationship between continuing bag-mask ventilation and increased risk of aspiration is unfounded.[41,42] Maintaining peak airway pressure below 15 to 20 cmH_2O will allow for ventilation without increasing the risk of air entry into the stomach. Application of cricoid pressure reduces the likelihood of gastric insufflation in most patients during mask ventilation but may complicate airway management.[42]

Cricoid pressure

Cricoid pressure (CP) has been described as the "linchpin of the rapid sequence induction".[43] In patients with full stomach, it is considered as a standard of care during anaesthesia and to a lesser extent during resuscitation.[13,43,44] CP is also known as Sellick's manoeuvre or 'The SEllick's', named after Dr Brian A Sellick who first introduced it into clinical practice in 1961.This manoeuvre consists of temporary occlusion of the upper end of the oesophagus by applying backward pressure of the cricoid cartilage against the bodies of the cervical vertebrae. The patient lies supine with the head and neck extended. The assistant identifies the cricoid cartilage before induction of anaesthesia. He/she begins applying pressure on to the cricoid cartilage with the thumb and middle finger while the index finger presses on the cricoid posteriorly to compress the oesophagus. A conscious patient can tolerate moderate pressure without discomfort but as soon as consciousness is lost, firm pressure can be applied without obstructing the patient's airway. Pressure is maintained until intubation, inflation of the cuff of the endotracheal tube is completed and position confirmed. He also stated that during CP the lungs can be ventilated using intermittent positive pressure without the risk of gastric distension and intubation is performed in the usual way. The basis for this technique was that the cricoid cartilage is the only complete cartilage in the larynx/trachea. It is signet shaped and is a complete ring. The oesophagus begins at the lower border of the cricoid cartilage, and the cricopharyngeus muscle guards the oesophageal opening.

CP is nothing but a force measured in Newtons (N), 9.81 N = 1 kg = 2.2 lb. Brimacombe in his review on CP concluded that, if CP has to be a standard practice during induction of anaesthesia, it is necessary to show that it is safe and effective.[43] Further knowledge of its advantages and limitations, improved training in its use, and guidelines on optimal force and method of application should lead to better patient care. The cricoid force should be sufficient enough to prevent the back flow of gastric contents. This depends on multiple factors such as oesophageal pressure, gastrointestinal pathology, intragastric pressure, upper and lower oesophageal sphincter pressure and also the effectiveness of the CP. Most of the clinical investigations have agreed that a minimum of 44 N (4.48 kg) of cricoid force is required for the prevention of regurgitation of gastric contents in adults, in the standard or tonsillectomy position.[44-49] Hartsilver and colleagues in their study used the double lumen Salem sump tube in 20 females undergoing emergency caesarean delivery under general anaesthesia and found the mean gastric pressure to be 11 mm Hg.[50] A study done in cadavers found that a cricoid force of 30 N (3.05 kg) was sufficient to prevent regurgitation of oesophageal contents when the intragastric pressure was raised to 42 mm Hg.[51] Further studies have demonstrated that a cricoid force of 30 N is adequate and decreases the risk of oesophageal rupture.[52,53] The amount of CP required in paediatric patients of different age groups is controversial. It was found in an observational study that a mean cricoid force of 22.4 to 25.1 N (2.28 kg – 2.56 kg) is sufficient for a 5 year old subject.[54]

Mode of application:

a. *Head and neck position:* Sellick's classical description was the tonsillectomy position, without a pillow, with CP applied at C5 vertebra.[2] Benumof pointed out that, this mode of application of CP deteriorates the laryngoscopic view.[55] Baxter argued that CP in sniffing position did not worsen the laryngoscopic view.[56]

b. *Timing and force:* The earlier recommendation was to apply a moderate force when patient is conscious and to increase slowly as the patient goes to sleep to a full force of 44 N. Applying a full force of 44 N in a conscious patient produces discomfort, retching and vomiting and can also produce complete airway obstruction.[57,58] Vomiting with cricoid pressure *in situ* can lead to death from pulmonary aspiration or a ruptured oesophagus.[59,60] It has been reported that applying CP using a cricoid yoke can decrease discomfort in an awake individual.[45] Fracture of cricoid cartilage is also reported.[61] The practice today is to apply a smaller force of 20 N when patient is awake and to increase it to 30 N as the patient loses consciousness.[62]

c. *Single - handed cricoid pressure:* In this technique, the thumb and middle finger are placed on either side of the cricoid cartilage, and the index finger is placed above to prevent movement of the cricoid sideways.[1] The laryngoscopic view is better with head in sniffing position and with single-handed CP when compared with double-handed CP.[63] Cowling proposed a more comfortable way of applying CP by placing the palm of the hand on the sternum, applying pressure with only the index and middle finger.[64] In infants and children, little or middle finger of the hand holding the mask can be used to compress the cricoid cartilage.[65] It is recommended that the assistant applying the CP should be on the left side of the patient for a comfortable laryngoscopy.

d. *Double-handed (bimanual) cricoid pressure:* In this technique, the CP is applied as described in the single-handed method. In addition, the assistant's right hand is placed beneath the cervical vertebrae for neck support. Selwyn-Crawford and Miller mention counter-pressure with a hand beneath the cervical vertebrae to support the neck. They also described the use of a 'contra-cricoid' cuboid aid to facilitate extension of the neck as an alternative to bimanual approach.[66] Purpose of this manoeuvre was to support the hyperextended arch of the vertebral column to maintain the efficacy of the CP and optimise the laryngoscopic view. Variation of this technique includes placing the left hand under the head and holding the extended head to maintain the sniffing position.

Despite its wide acceptance in emergency airway management, surveys on CP among anaesthesia assistants and emergency room nurses revealed that they lack in consistency with respect to the duration, technique and the force.[67] Too little force is ineffective but overenthusiastic efforts can restrict ventilation, worsen laryngoscopic view and airway management.[67]

Learning/teaching cricoid pressure

Traditional teaching says that pressure on one's own nasal bridge until it hurts and pressure on one's own cricoid cartilage until it prevents swallowing of saliva is useful in judging the approximate pressure that would be required. However, pressure on nasal bridge is very much subjective and pressure of 20 N over cricoid cartilage almost always evokes retching. Thus, utility of these feedback techniques are always questioned.[58] Cricoid yoke, a strain gauge based yoke designed by Lawes has been used to apply a measured and consistent cricoid force.[68] Despite its versatility, cricoid yoke has fallen in to disfavour because of a few case reports of deformation of cricoid cartilage by the cricoid yoke.

Laryngo-tracheal model placed over a series of infant scales has been investigated as one of the feedback techniques in teaching CP.[69] An apparatus designed out of 50 ml syringe by Flicker and colleagues, in which the amount of force can be felt by depressing the plunger of the syringe has been studied and found useful as a trainer.[70,71] Cricoid pressure trainer designed by Owen *et al*, is a state of the art simulator wherein real time feedback of the technique including the direction, duration and the amount of force exerted is available.[72]

A systematic review on the effectiveness of technology-enhanced simulation training by Johnson *et al* concluded that simulation training with force feedback significantly improves the efficacy of CP application.[73] However, they also opined that further investigation is essential to study its clinical impact in real life situation.

Conclusion

Rapid sequence induction-intubation, though a widely accepted technique is not devoid of controversies. Inability to test the efficacy and effectiveness of cricoid pressure in preventing aspiration lies in its inherent difficulty in testing in a real life scenario. However, technology enhanced simulation training hold promise in learning effective cricoid pressure in turn its effectiveness and clinical utility.

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