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Variation in rapid sequence induction and intubation: a survey on current practice in the Department of Anaesthesiology at the University of the Witwatersrand

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Medicine in Anaesthesiology, Johannesburg, 2016

DECLARATION

I, Lindsey Elizabeth Redford, declare that this research report is my own work. It is submitted for the admission to the degree of Master of Medicine in Anaesthesiology by the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

…… (Signature of candidate)

Signed at: The University of the Witwatersrand

On this day: 4th July 2017

Abstract

Variation in rapid sequence induction and intubation (RSII): a survey on current practice in the Department of Anaesthesiology at the University of the Witwatersrand (Wits)

Background: Aspiration remains one of the major, preventable complications of general anaesthesia. Controversy regarding various aspects of RSII exists and there are no South African guidelines. The aim of this study was to describe the current practice of RSII by anaesthetists in the Department of Anaesthesiology at the University of the Witwatersrand.

Method: A prospective, contextual, descriptive study was done. Questionnaires consisting of seven vignettes were distributed to survey current clinical practice. A 60.1% response rate was achieved.

Results: There was considerable deviation from the original technique of RSII, with regard to induction agents, timing of NMBA administration and opioid use prior to induction. The induction agent and neuromuscular blocking agent (NMBA) of choice was propofol and succinylcholine. Succinylcholine was used for 83 (67.5%) of appendicectomies, 118 (96.7%) of Caesarean sections and 83 (68.0%) for bowel obstructions. Alternative NMBA were used for the other scenarios. The majority of the respondents, 97 (77.6%), considered the use of a NMBA other than succinylcholine to describe a modified RSII. No statistically significant variation in technique between senior and junior anaesthetists was evident, with the exception of the NMBA used for appendicectomies (p= 0.0017) and neonates (p=0.0297).

Conclusion: Despite little variation in technique of RSII between consultant and trainee anaesthetists at Wits, their current practice shows marked variation from the technique originally described. This change in practice may be the result of advancement in knowledge, equipment, technique and available drugs. Furthermore, it is in keeping with international practice.

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List of Abbreviations

BMV	Bag mask ventilation
CP	Cricoid pressure
FRC	Functional residual capacity
LOS	Lower oesophageal sphincter
NGT	Nasogastric tube
NMBA	Neuromuscular blocking agent
RSII	Rapid sequence induction and intubation
UK	United Kingdom
USA	United States of America
Wits	University of the Witwatersrand

Chapter 1

1.0 Overview of the study

1.1 Introduction

This chapter on rapid sequence induction and intubation (RSII) will address the background, problem statement, aim, objectives of this study as well as the research assumptions. It will discuss the study population, location of the study and the research methods used. It will further discuss the ethical considerations whilst performing the study. Finally it will provide an overview of the study and its significance.

1.2 Background

Anaesthesiologists are responsible for the safe management of the airway during a procedure (1). It has been suggested that as a community the most important focus of anaesthetic education should be on the reduction in both the frequency and severity of airway complications (2).

Aspiration remains one of the major, preventable complications of general anaesthesia (1, 3, 4). The first case of anaesthetic aspiration-associated pneumonia was described by Simpson in 1848 (5). Currently, the incidence of aspiration during general anaesthesia varies according to different studies (6, 7), but is quoted to be between one in 2000 to 3000 for adults (1, 8) and accounts for nearly 50% of reported serious incidents, including death (1). Aspiration occurs most commonly:

- during emergency procedures;
- as a result of inadequate anaesthesia (8); and
- due to failure to identify and alter the anaesthetic technique when aspiration is a risk despite generally accepted risk factors (1, 8).

The consequences of aspiration and regurgitation are well recognised and include prolonged intensive care admission, aspiration pneumonia, hypoxic brain damage and death amongst others (3).

Sellick (9), one of the pioneers of cricoid pressure (CP) described the Sellick manoeuvre in 1961. It was the method by which the oesophagus could be compressed during a rapid sequence induction to prevent the aspiration of gastric contents. It later became one of the cornerstones of RSII as well as one of the most controversial practices in today's practice (9). Subsequently, in 1970 Stept et al. (10) published an article describing the classical method of RSII, which was initially adopted by anaesthetists worldwide. The method they proposed involved oxygen administration, rapid injection of a predetermined dose of thiopental immediately followed by succinylcholine, application of CP, and avoidance of positive pressure ventilation before tracheal intubation with a cuffed endotracheal tube (10).

Recent surveys have shown a movement away from this technique as the drugs, knowledge and equipment have evolved (11-16). This has resulted in increased treatment variation, particularly through the use of neuromuscular blocking agents (NMBA) as well as the practices adopted when performing a RSII. The variation is largely determined by the patient presented to the practitioner at the time of surgery. Furthermore, there seems to be some distinction between methods and drugs adopted by more experienced practitioners compared to those still in training (11, 12). There is no clear consensus in the literature with regard to the definitions of the various practices or the techniques that should be used to achieve rapid induction and intubation of patients at risk of aspiration (14). What is striking is the continued morbidity and mortality resulting from aspiration during anaesthesia despite on-going developments in drugs, airway devices and anaesthetic techniques (3).

International guidelines on preventing anaesthetic associated aspiration focus on the different aspects of aspiration prevention and management that are extensively debated within the literature (1, 17). Of note, is the failure to reach consensus on the application of CP, positive pressure ventilation, placement of a nasogastric tube (NGT) and patient positioning during performance of a RSII (1, 17). This is in part the result of varying beliefs and concerns with regard to the varying techniques when performing a RSII. Failure to identify appropriate guidelines and reach a consensus on these issues, continues to contribute to the on-going morbidity and mortality of anaesthetic related aspiration (18).

A review of the national literature has not identified any studies focusing on the current practice of practitioners. Furthermore, it yielded no national guidelines pertaining to the practice of RSII.

1.3 Problem statement

Internationally there is controversy regarding the technique of a RSII including the use of CP, positive pressure ventilation, patient positioning, placement of a NGT and the drugs used during the RSII. Failure to reach consensus on the technique to achieve rapid intubation in the face of aspiration, has resulted in further reports of patients aspirating. (18)

With the introduction of additional anaesthetic agents the potential for modification of the original RSII has developed. Thus a modified approach may be adopted in certain clinical situations to achieve improved outcomes and a reduction in risk exposure.

Failure to provide standardisation of the techniques to be adopted in patients at risk of aspiration has resulted in a variety of techniques being applied to different clinical scenarios. There is further discrepancy in the management of these patients, between experienced practitioners and trainees (11).

No guidelines have been identified for the performance of a RSII, on patients at risk of aspiration, in the South African literature. Despite the low incidence of aspiration as quoted in the international literature, the high morbidity and mortality associated with aspiration is a cause for concern (2, 4, 6, 8). Furthermore, there is no literature on the current clinical practice with regard to RSII in the Department of Anaesthesiology at the University of the Witwatersrand (Wits).

1.4 Aim and objectives

1.4.1 Aim

The aim of this study was to describe the current practice of anaesthetists in the Department of Anaesthesiology at Wits when performing a RSII using seven clinical vignettes.

1.4.2 Objectives

The primary objectives of this study were to:

- determine the proportion of anaesthetists who recognise patients at risk of pulmonary aspiration;
- describe the choice of induction agent used for a RSII;
- describe the choice of NMBA used for a RSII;
- describe the technique used when performing a RSII.

The secondary objectives of this study were to:

- compare the difference in technique between the consultant and trainee anaesthetists;
- compare the difference in induction agents between the consultant and trainee anaesthetists;
- compare the difference in NMBA between the consultant and trainee anaesthetists;
- describe the anaesthetists definition of a modified RSII.

1.5 Research assumptions

The following definitions were used in this study.

Rapid sequence induction and intubation (RSII)	The practice of inducing anaesthesia and intubating a patient using preoxygenation, a predetermined dose of an induction agent, cricoid pressure, succinylcholine and a cuffed endotracheal tube with the absence of bag mask ventilation. For the purpose of this study a RSII will be considered to have been performed when both a cuffed endotracheal tube and CP are used. When considering the technique of a RSII the induction agent and NMBA used as well as the method and timing of administration will be considered. Furthermore, the use of adjuncts including opioids, benzodiazepines, insertion of a NGT and bag mask ventilation will be analysed.
Modified rapid sequence induction and intubation	Any change in practice from the originally described technique of performing a rapid sequence induction and intubation including titration of an induction agent, exclusion of cricoid pressure, an alternative neuromuscular blocking agent and bag mask ventilation.
Anaesthetist	Any qualified doctor currently working in the Department of Anaesthesiology including registrars, medical officers, interns and specialist consultants.
Consultant	A doctor who has completed and obtained their specialisation from the Colleges of Medicine in South Africa or an international equivalent and is

	registered with the Health Professional Council of South Africa.
Registrar	A qualified doctor who is registered with the HPCSA as a trainee anaesthetist in the speciality of anaesthesiology.
Medical Officer	A qualified doctor practising in the Department of Anaesthesiology under specialist supervision.
Intern	A doctor who has completed a university degree but is currently undergoing practical training prior to registration with the HPCSA as an independent practitioner.
Trainees	All respondents (including registrars, medical officers and interns) other than consultants.

1.6 Demarcation of study

The study was conducted in the Department of Anaesthesiology affiliated to the University of the Witwatersrand. This included anaesthetists practicing at the Charlotte Maxeke Johannesburg Academic Hospital, Chris Hani Baragwanath Academic Hospital, Rahima Moosa Mother and Child Hospital and Helen Joseph Hospital.

1.7 Ethical considerations

Approval to conduct this study was obtained from relevant authorities. Consent was implied upon completion of the anonymous self-administered questionnaire. The study was conducted adhering to good clinical research practice in accordance with the South African Good Practice Guidelines (19) and the Declaration of Helsinki (20).

1.8 Research methodology

1.8.1 Study design

The research design used in this study was a prospective, contextual, descriptive design.

1.8.2 Study population

The study population included anaesthetists in the Department of Anaesthesiology at Wits.

1.8.3 Study sample

The sample size was determined in consultation with a biostatistician. Sampling was done using a convenience sampling method.

1.8.4 Inclusion and exclusion criteria

All the anaesthetists in the Department of Anaesthesiology were invited to participate in the study. Inclusion and exclusion criteria were defined.

1.8.5 Data collection

Data collection instrument and method

A questionnaire including seven vignettes based on the Questionnaire used in the Wales study(11), was used to survey current clinical practice. During the study period questionnaires were handed out during the various departmental meetings to the anaesthetists in the Department of Anaesthesiology.

1.8.6 Data analysis

A Microsoft Excel™ spreadsheet was used to capture all recorded data. The data was analysed in conjunction with a biostatistician using Microsoft Excel™ and GraphPad InStat™. Descriptive and inferential statistics were used.

1.9 Significance of the study

Aspiration remains one of the leading causes of anaesthetic-related morbidity and mortality (2). Despite the low incidence of aspiration, it is a genuine concern for the anaesthetist. In the Fourth National Audit Project of the Royal College of Anaesthetists it was found that aspiration was the most common cause of anaesthetic-related deaths reported, accounting for up to 50% of all anaesthetic related deaths. (2)

The technique of RSII used for a patient recognised to be at risk of aspiration will be influenced by the patient comorbidities. In addition, the development of new techniques, drugs and equipment has resulted in a wide variation in the practice of a RSII. (3, 11-14) This variation, in practice, may account for the ongoing occurrence of aspiration.

The results of this survey have helped to identify the different practices regarding the RSII in the Department of Anaesthesiology at Wits. Moreover, it has allowed an assessment of whether the appropriate practice is being applied to the appropriate patient. This may influence not only academic teaching, but may serve to improve patient safety.

1.10 Validity and reliability

Measures were taken to ensure the validity and reliability of the study.

1.11 Overview

The chapters in this study include:

Chapter 1: Overview of the study

Chapter 2: Literature review

Chapter 3: Research methodology

Chapter 4: Results and discussion

Chapter 5: Summary, limitations, recommendation and conclusion

1.12 Summary

In this chapter, an overview of the study has been given. The literature review is presented in the following chapter.

Chapter 2

2.0 Literature review

2.1 Introduction

"There is one skill above all else that an anaesthetist is expected to exhibit and that is to maintain the airway impeccably"(21) *M Rossen and IP Latto 1984*.

Since 1946, the risk of aspiration as described by Mendelson, has been a concern following induction of anaesthesia in "at risk patients" (22). It was Stept et al. (10) in 1970, who developed a set of guidelines to achieve rapid sequence induction and intubation in these patients (10). However, despite the worldwide acceptance of this technique, the on-going development of drugs and equipment has resulted in some adaptation of this originally described technique (3, 11, 13, 14). Moreover, the continued occurrence of aspiration and the problem it poses to the anaesthetist, in addition to the potential for adverse sequelae, has resulted in further investigation regarding the technique.

2.2 Aspiration

Aspiration is described as a witnessed regurgitation or aspiration of gastric contents often associated with coughing or choking. It may be witnessed or suspected based on radiological findings (4, 8). Pulmonary aspiration results in three clinically described scenarios.

- Aspiration of particulate matter results in airway obstruction causing either lobar collapse or complete obstruction and suffocation. Patients present with cyanosis, tachypnoea, and consolidation.
- Acid aspiration presents in two phases. In the primary phase, chemical burns to the airways occurs within five seconds of the aspiration. At six hours there is evidence of cilia and type II pneumocyte destruction. There is further increase in blood-gas interface permeability with alveolar and pulmonary oedema. The

second phase, is associated with an inflammatory response resulting in acute lung injury, acute respiratory distress syndrome and death.

- Superimposed bacterial infection is often associated with pneumonia and a preponderance to abscess formation and cavitation. (3)

Although the incidence of aspiration as quoted in the literature is as infrequent as one per 2000 to 3000 in adults (6, 8, 23), it still remains a leading cause of airway associated morbidity contributing to up to 50% of complaints and airway associated deaths (24, 25). It is recognised that the risk of aspiration occurs more commonly after hours, with emergency procedures, obstetric patients and extremes of age (3, 6, 23). There is furthermore, a correlation between the American Society of Anaesthesiology (ASA) physical status and risk of aspiration. There is a recognised increase in morbidity and mortality associated with the patient's ASA status(26). The generally accepted risk factors for aspiration include:

- incompetence of the lower oesophageal sphincter (LOS) (hiatus hernia, gastro-oesophageal reflux, oesophageal disease);
- increased gastric volumes (gastric outlet obstruction, bowel obstruction, ileus, use of opioids, pneumoperitoneum secondary to laparoscopy);
- obesity;
- pregnancy;
- patient position (lithotomy, Trendelenburg);
- inadequate anaesthesia;
- neurological deficit including inadequate reversal of neuromuscular blockade. (3, 24, 27)

The risk of aspiration in "at risk patients" exists throughout the anaesthetic. It occurs most commonly at the time of induction. However, risk can continue throughout maintenance and extubation where incidences of aspiration have been described. (25)

Although debate exists as to the efficacy with which a RSII reduces the incidence of aspiration, it is still widely adopted for patients identified as being "at risk"(26). The problem arises where there is a patient contraindication to various elements of the technique. The RSII as described with the use of propofol and thiopentone in

predetermined doses is considered to be a relatively haemodynamically unstable form of induction (18, 28). Furthermore, the multiple contraindications to succinylcholine limit its use in a large subset of patients. However, this has largely been superseded with the use of rocuronium and other NMBAs via various techniques. (29)

2.3 Technique

RSII is a technique designed to facilitate rapid intubation of "at risk patients" whilst minimising the duration between induction and placement of a cuffed endotracheal tube (18). The originally described method included 15 steps.

- "Establishment of an intravenous infusion.
- Equipment check including tracheal tube, cuff and stylet.
- Insertion of a large-bore NGT and application of intermittent strong suction to decompress the stomach.
- Removal of foreign material from the mouth and pharynx.
- Preoxygenation of the lungs for at least two minutes.
- Positioning the patient in a semi sitting, V-position, to counteract gravity.
- The use of an ECG or precordial stethoscope to monitor the heart.
- Initiation of sequence with the administration of 3mg/70kg of d-tubocurarine.
- Administration of a predetermined does of thiopental (the recommended dose of 150mg/70kg).
- The application of CP following loss of consciousness.
- Administration of succinylcholine at a dose of 100mg/70kg immediately following the dose of thiopental or loss of consciousness.
- Apnoea and full neuromuscular blockade as determined by a nerve stimulator.
- Removal of mask whilst maintaining CP to intubate the trachea rapidly (the absence of bag mask ventilation prior to intubation).
- Once tracheal intubation is achieved the endotracheal tube cuff is inflated, CP is released and ventilation commenced.
- Finally the NGT if not already in situ is placed into the stomach." (10)

A modified RSII has become more common in daily practice (11, 13, 14). However, there is no uniform description of what modification implies (26). Currently, the term modified is applied to variation in the induction agent used, the NMBA used as well as the technique by which it is administered, the application and timing of CP and finally the use of manual ventilation prior to securing the airway. (13, 14) In a survey conducted in the United States of America, the majority of respondents considered a modified RSII to include:

1. The administration of oxygen prior to induction of anaesthesia.
2. The application of CP.
3. An attempt to manually ventilate the lungs with positive pressure prior to intubation. (14)

Although the originally described RSII is considered "standard of care" in some parts of the world (30), the lack of RSII protocol (owing partially to the lack of consensus of the various components) has resulted in a large variety of practices and techniques, when faced with an "at risk patient" (18).

The following review will focus on those aspects of a RSII which are considered to be both vital to the performance of a RSII as well as those which remain controversial.

2.4 Insertion of nasogastric tube

In 1951, Morton et al. (31) in addressing the practical aspect of deaths related to aspiration described the use of a Ryle's tube in the preparation of patients suspected of having a full stomach. The Ryle's tube was to be placed on suction prior to induction of anaesthesia. The use of gentle negative pressure was emphasised, as excessive suction would result in occlusion by the stomach lining or collapse of the tube itself. Following aspiration of gastric fluid, performing lavage with water until the aspirates cleared, was suggested, the process being repeated in the prone and lateral positions. It was noted that use of a Ryle's tube was only of benefit in determining the nature of the gastric contents and the removal of gastric fluid just prior to induction. The limitations regarding the effectiveness of the Ryle's tube to reduce aspiration in certain scenarios, including intestinal obstruction, were recognised. It was reported that in seven of the

cases despite the use of a Ryle's tube fatal aspiration did occur. However, this was attributed to the incorrect positioning of the tube, poor technique and inadequate experience of staff (31).

In 1961, Sellick (9) emphasised the danger in assuming an empty stomach after the above described process. He suggested that because of the potential for incompetence of the upper and lower oesophageal sphincters in the presence of a NGT, there was a need to remove it prior to induction. It was also noted that the tube's presence might interfere with oesophageal compression when applying CP (9).

Stept et al. (10) recognised the controversy of whether or not to leave the tube in situ at the time of induction and intubation. In their recommendations of how to perform the RSII, there was no commitment with regard to either method. Instead, it stated the opposing arguments comparing the risk-benefit of the NGT in its potential to facilitate regurgitation and conversely to provide continuous decompression of gastric contents (10).

In 1986, the efficacy of single and double lumen NGTs for gastric decompression were assessed and compared. It was found that although the double lumen sump tube was superior to the single lumen stomach tube in removing gastric contents; both tubes provided an inaccurate and unreliable means for emptying gastric contents (32).

Nagler et al. (33) further examined the effect of short term intubation with a NGT on gastro oesophageal reflux. It was found that the normal barriers to reflux, with a NGT in situ for 10 minutes, were not disrupted. In addition, there was no apparent change in these barriers 10 minutes after removal of the NGT (33). This is in contrast to studies conducted in critically ill patients where the incidence of oesophagitis was found to be increased as a result of vomiting or prolonged intubation with a NGT. These findings were attributed to the slight reduction of the LOS pressure in the presence of an NGT. However, the observations were only made in patients who were supine, presumably because of the failure of gravity to assist in clearance of acid from the lower oesophagus (34).

More recently, a study to determine the effect of the NGT on LOS competence and pressures was conducted. A comparison of both the pH and pressure in two groups undergoing elective laparotomy was conducted. The first group was intubated with a NGT, pressure transducer and pH probe, whilst the second group was only intubated with the pressure transducer and pH probe. It was found that although the presence of the NGT lowered the pressure of the LOS it was not significant enough to account for the observed increased incidence of gastro oesophageal reflux in the first group. Furthermore, it was surmised that the contributing factors to this observation were increased acid production, increased episodes of gastro oesophageal reflux and reduced clearance of refluxed acid from the lower oesophagus. The increased acid secretion is thought to be the result of gastric mucosal stimulation by the NGT, which in turn causes vagal mediated acid secretion (35).

In 1989, Dilorenzo et al. (36) showed a relationship between increased intra-abdominal pressure and increased lower oesophageal pressure. This mechanism is known to prevent gastro oesophageal reflux in up to 92% of patients; however, there is concern that the presence of the NGT will impair this physiological function (36).

Transient lower oesophageal sphincter relaxation is described as the abrupt decrease in LOS pressure to that of the intragastric pressure not triggered by swallowing. This is further associated with complete and selective relaxation of the crural diaphragms. Transient lower oesophageal sphincter relaxation is recognised as the most common mechanism underlying gastro oesophageal reflux (37). It has been shown that in dogs and cats under anaesthesia there is complete suppression of transient lower oesophageal sphincter relaxation (38).

However, pharyngeal intubation, a potent stimulus for increased transient lower oesophageal sphincter relaxation, independently causes an increased rate of occurrence, associated with the duration of pharyngeal intubation. This is thought to be the result of superior laryngeal nerve stimulation. Noordzij et al. (39) confirmed this hypothesis as greater relaxation of the LOS occurred with stimulation of the arytenoid cartilage and epiglottis (both supplied by the superior laryngeal nerve), compared to stimulation of the tongue (39, 40). In contrast to previous studies it was found that

although laryngopharyngeal mechanical stimulation caused a reduction in LOS pressure, there was a paradoxical increase in the pressure of the crural diaphragm. The failure of crural diaphragm inhibition precluded this reaction from fitting the criteria for a transient lower oesophageal sphincter relaxation. Furthermore, there was no recorded case of gastro oesophageal reflux despite the reduced LOS pressure (39).

The Scandinavian Clinical Practice Guidelines(17) do not include the routine insertion of a NGT before emergency surgery, particularly in patients at risk of organ rupture, cervical spinal injury or raised intraocular and intracranial pressure. It is recommended, that when already present the NGT should be placed on suction to remove gastric content and further it should remain in situ for induction (17). They support the finding of Vanner et al. (41) that presence of a NGT will not affect effective application of CP.

2.5 Patient position

Following preparation and procedures to decrease gastric contents and risk of aspiration, the patient is positioned such that should regurgitation or vomiting occur, the risk of aspiration is minimised. However, there is no current agreement on the ideal patient position at the time of induction of anaesthesia.

In Sellick's (9) first description of CP, he commented on Morton et al.'s (31) suggestion to place the patient in the sitting position to allow for management of regurgitation. However, he cited two disadvantages to this position; first was the predisposition to haemodynamic instability in the critically ill patient at the time of induction and second the likelihood that a sitting position would facilitate the aspiration of gastric contents especially in the period between loss of consciousness and muscle relaxation (9). Instead the use of a supine or lateral position with a slight head-down tilt at the time of induction was advocated as it was suggested that should vomiting occur, the vomitus would be directed away from the airway passages aided by gravity (9).

However, Stept et al. (10) encouraged the use of a V-sitting position with emphasis on the elevation of the trunk to 30°, which would allow gravity to counteract the effect of

regurgitation. Furthermore, elevation of the feet was considered a measure to offset the potential haemodynamic effects of the various drugs (10).

Various studies looking at the effect of the supine or semi recumbent position in patients in intensive care units who are mechanically ventilated with a NGT in situ, have shown that irrespective of position gastro oesophageal reflux resulting in micro-aspiration occurs commonly. However, the studies did show that in the supine group contamination of bronchial secretions was increased compared to both the baseline measurements and patients in the semi recumbent position (42-44). Whilst these observations regarding patient position and aspiration can be applied primarily to the maintenance period of anaesthesia, there is no clear evidence for its application at the time of induction in the event of vomiting or aspiration. Once the patient is optimally positioned and following preoxygenation, induction of anaesthesia is commenced.

2.6 Induction agent

The ideal agent for RSII is described as one with a fast, reliable onset of action that provides rapid loss of consciousness. Furthermore, it should improve conditions for laryngoscopy, have minimal effects on cardiovascular parameters and possibly blunt the physiological reaction to laryngoscopy and intubation (18). Table 2.1 provides a summary of the properties of the various induction agents pertinent to RSII.

An important concept in determining effectiveness of the induction agent used is the k_{eo} (i.e. the first order rate constant that describes the time to equilibration between plasma and effect-site). There is an almost immediate rise in plasma concentration of an agent following a bolus, however, there is a delay in clinical effect as the time to peak effect site or biophase concentration is delayed (45, 46). This delay is the function of the physicochemical and molecular structures of an agent which determine the time taken for the agent to enter the biophase. It is this delay which is described by the k_{eo}, a first order rate constant that determines the rate of onset and the end of the drug effect (45). Agents with a high k_{eo}, show a long lag time between peak blood concentration and peak effect concentration. These agents show an effective effect site concentration

at a low percentage of the plasma concentration initially achieved. As a result, too small an initial bolus may show no effect at all. Conversely, for agents with a small k_{e0}, the time to peak effect site concentration occurs at a higher percentage of the initial plasma concentration (46). Thus, a smaller rate constant will require a higher peak blood concentration to achieve the target concentration with an increased risk of unwanted side effects especially haemodynamically. Whereas, a larger rate constant requires a lower peak blood concentration to achieve the desired effect site concentration (47).

Table 2.1 Properties of induction agents (48)

Induction agent	K_{eo} (min^{-1})	Dose (mg/kg)[a]	Effect on airway reflexes	Haemodynamic effect	Precaution/ contraindications
Thiopental	0.51	3-5 mg/kg	Reactive	↓BP , ↑HR ↓CO ↓PVR Direct negative inotrope	Intra-arterial injection, extravasation into surrounding tissue causes tissue necrosis. Contraindicated in asthma.
Propofol	0.3-0.1	1-2.5 mg/kg	Blunted. Can be used for intubation in absence of NMBA	↓BP, ↔HR ↓PVR High concentrations direct myocardial depressant	Allergy to egg yolk, soybean oil, EDTA. Caution in shocked patients and elderly, consider reduced dose.
Ketamine	-	1-2 mg/kg	Preserved	↑BP, ↑HR, ↑CO Direct myocardial depressant in absence of endogenous catecholamines	Concern over ↑ICP and IOP. Associated with hallucinations and emergence delirium. Increased salivation and bronchial secretions.
Etomidate	0.34	0.2-0.3 mg\kg	Blunted [b]	Minimal effect on CVS even if hypovolemic Slight ↓PVR, BP ↔ CO, HR ↔ contractility	Adrenal insufficiency. Use with caution in patients who are septic or in septic shock. Consider corticosteroids.
Midazolam	0.17	0.5-1.5 mg/kg	Blunted	Minimal effect on CVS unless patient haemodynamically unstable.	Respiratory depression. Paradoxical excitation especially in the young and elderly.

K_{eo}, first order rate constant that describes the time to equilibration between plasma and effect-site; BP, blood pressure; HR, heart rate; CVS, cardiovascular; CO, cardiac output; ICP, intracranial pressure; IOP, intraocular pressure.

[a] The dose described only applies to the use of a predetermined dose of intubation agent.
[b] In the absence of opioids poor intubation conditions.

Originally thiopental was the drug of choice as it provides rapid loss of consciousness with rapid recovery. However, it is acknowledged that in the presence of a critically ill or comatose patient, the rapid administration of thiopental would likely not be

tolerated. Thus, in such clinical scenarios it was originally suggested that the induction agent be omitted (10).

However, following Stept et al.'s (10) publication in 1970, numerous other induction agents were introduced. In 1982, White (49) compared the use of thiopental, ketamine and midazolam when performing a RSII. It was found that although onset of anaesthesia was on average less than 30 seconds in most patients, a quarter of those receiving midazolam had a delayed onset of up to 60 seconds. Furthermore, an adequate depth of anaesthesia was found in all patients except one in the midazolam group, who proved to be a difficult intubation probably compounded by inadequate muscle relaxation. Recovery was rapid except for in the group receiving midazolam (49).

In terms of cardiovascular parameters, it was found that thiopental significantly decreased the mean arterial pressure whilst ketamine caused a 10% increase in the mean arterial pressure and a combination of ketamine and midazolam had little effect on the mean arterial pressure. All combinations resulted in an increase in heart rate, however, this was least when a combination of ketamine and midazolam was used. It was also found that thiopental was the least likely to result in amnesia, in addition to it being the most likely agent to require additional administration of opioids (49).

In a comparison between propofol and thiopental, it was shown that propofol provided excellent conditions for intubation more often than thiopental. In addition, successful intubation was more likely to occur in a patient receiving propofol (50). These results are in keeping with Sparr et al. (51) who found that in the presence of alfentanil, propofol was more likely to produce good to excellent condition for intubation compared to a combination of alfentanil and thiopental (51). This observation is thought to be the result of the greater airway depression, as well as reduced vocal cord adduction, when propofol is used (52).

For patients with haemodynamic compromise the agents of choice are etomidate and ketamine. In a study using etomidate and thiopental in combination with rocuronium for RSII, it was found that although intubating conditions were comparable at 60

seconds, etomidate attenuated the diaphragmatic response to intubation more reliably than thiopental (53).

In 1998, Skinner et al. (54) found that following induction with propofol, the systolic blood pressure was significantly reduced. However, following intubation there was an increase in the systolic blood pressure in both groups with that in the etomidate group being significantly higher. The heart rate pre- and post-induction were comparable (54). These findings were in keeping with Gill et al. (55) who demonstrated that the haemodynamic stability associated with etomidate induction produced a more rapid onset of neuromuscular blockade when compared to propofol.

Hans et al. (56) looked at the effect of ketamine compared to thiopental when using rocuronium. It was found that intubating conditions were adequate in the entire ketamine group and only half of the thiopental group. Excellent conditions were reported in a significant proportion of those receiving ketamine, whilst the poor vocal cord conditions that were seen in a significantly higher proportion of those receiving thiopental, further highlighted this difference. Finally, the mean arterial pressures prior to intubation were significantly higher in the ketamine group compared to the thiopental group, with little difference in the mean heart rates recorded (56).

In a recent, multicentre randomised controlled trial the authors assessed the use of etomidate and ketamine when performing a RSII on acutely ill patients. It was found that intubation was not affected by the choice of drug. Furthermore safety parameters including change in systolic blood pressure and diastolic blood pressure, saturation and cardiac arrest during intubation were not statistically different. The study did confirm the greater potential for adrenal insufficiency following the use of etomidate. However, it acknowledged that critical illness itself has an effect on the function of the adrenal axis. Finally, it found no increase in the morbidity and mortality between the two groups (57). See Table 2.2 for a summary of the above mentioned studies.

Table 2.2 Comparison of induction agents' effect on intubation and haemodynamics

Study	Induction agents compared	Intubation conditions	Haemodynamics	Comment
White et al. [49]	Thiopental, ketamine and midazolam	Intubation in, 30s with thiopental and ketamine. 30-60s in 25% midazolam.	Thiopental ↓↓↓MAP. Ketamine 10% ↑MAP. Ketamine and midazolam no change in MAP. All ↑HR.	Thiopental least likely to cause amnesia. Thiopental required additional opioid administration.
Dobson et al. [50]	Propofol and thiopental	Propofol superior intubating conditions.		Successful intubation more likely with propofol.
Sparr et al. [51]	Propofol, etomidate, alfentanil with propofol and alfentanil with thiopental	Alfentanil and propofol superior intubating conditions.		Propofol greater airway depression with less vocal cord adduction.
Fuchs-Buder et al. [53]	Etomidate and thiopental	Comparable intubating conditions at 60 s.		
Skinner et al. [54]	Etomidate and propofol		Significant ↓in SBP with propofol. Following induction ↑SBP etomidate> propofol.	
Hans et al. [56]	Ketamine and thiopental	Intubating conditions adequate in 100% ketamine cases vs 50% of thiopental cases.	Higher MAP with ketamine. HR equivalent.	Poor vocal cord conditions significantly higher with thiopental.
Jabre et al. [57]	Ketamine and etomidate	Intubating conditions equivalent.	SBP, DBP and SATS comparable.	No difference in morbidity and mortality between the two groups.

MAP, mean arterial pressure; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; SATS, oxygen saturation.

From the preceding text, it is clear that it is the patient's clinical status which may influence the choice of induction agent to be used. This is further determined by the choice of NMBA used. When succinylcholine is used for RSII, the choice of the induction agent used has little effect on intubating conditions. However, propofol has proven superior when using rocuronium. In addition in patients in whom hypotension would not be well tolerated, etomidate or ketamine would be the agent of choice (18).

The other controversy surrounding induction agents is the use of a predetermined dose versus titration to effect. Originally Stept et al. (10) described the use of a predetermined dose of thiopental. However, the use of predetermined doses is associated with the risk of either underdosing and awareness or overdosing and the potential for haemodynamic instability (26). Thus, the use of titration to effect has been advocated to not only reduce the dose of agent administered and therefore the potential for cardiovascular side effects, but also to prevent awareness as the endpoint is loss of consciousness. There is concern that titration will delay administration of the NMBA and as a result increase the risk-interval for aspiration (18). However, Barr et al. (58) showed that there was no appreciable difference between time to intubation between the two techniques. Contrary to belief they demonstrated a shorter time to intubation in the titration group (58). There is a paucity of data comparing the risk of aspiration with a longer induction time, haemodynamic stability and awareness in groups using both the predetermined and titration techniques for induction (18).

Finally, there is data looking at the effect of intravenous agents, more specifically propofol and dexmedetomedine, on the lower oesophageal sphincter(59) pressure (60-62). However, the majority of these studies either look at infusions of these agents for sedation (60, 62), or the effect of propofol in conjunction with cricoid pressure on lower oesophageal sphincter pressure. Furthermore, doses quoted were less than those usually used for induction (59). The literature varies quoting a linear relationship between depth of anaesthesia and a decrease in lower oesophageal sphincter tone (62). Conversely other studies found little appreciable change in the pressure (59, 61, 63). Thus, additional studies looking at induction doses of commonly use induction agents and the effect on lower oesophageal sphincter tone would be necessary to determine

whether there truly is a benefit to fixed versus titrated doses in the prevention of aspiration.

2.7 Cricoid Pressure

One of the most controversial aspects of the RSII has been the use of CP. A recent review article by Priebe (64) discussed some of the more pertinent aspects of CP in the literature. The most important controversy exists around the effect of CP on the management of an emergency airway in addition to the actual effect on anatomy at the time of use. CP is the application of backward pressure on the cricoid ring resulting in occlusion of the oesophagus against the 5th cervical vertebra (64, 65). Its application was reported to prevent the presence of regurgitated material or vomitus into the pharynx (18, 64).

CP has been shown to reduce the risk of gastric insufflation with manual ventilation especially in the paediatric population (see section on Bag mask ventilation in RSII). However, it was associated with an increased incidence of airway obstruction and reduced tidal volumes, which prevented adequate ventilation in some patients. The use of CP has been suggested as one of the main causes for the increased incidence of a difficult airway in an emergency situation. The application of CP results in a highly variable effect on conditions for laryngoscopy but, with application of the suggested 10-40 N it was found that more often than not the laryngeal grade worsened. There is evidence that the amount of force applied correlates with the degree to which laryngoscopy is affected. In the event that a rescue airway is required, it has been demonstrated that successful insertion of a laryngeal mask airway is reduced in the presence of CP. Additionally successful intubation through the laryngeal mask airway is also impaired (64-66).

The application of CP was originally described with the neck in extension, however, preliminary data was collected in patients in whom hyperextension was applied to achieve positive pressure ventilation and intubation (9, 18, 64). There is some concern that this hyperextension would cause tethering of the oesophagus, but result in less evident or absent occlusion in the more commonly used sniffing position (18, 64). In

the report, Sellick (9) did not describe the amount of pressure applied during the manoeuvre and there was no standardisation of the anaesthetic performed (64, 65).

However, despite these limitations the study demonstrated the ability to prevent aspiration up to 100 cmH_2O. This in addition to the presence of gastric contents in the pharynx on release of CP in 6 patients, resulted in CP becoming standard of care (9). Subsequent studies conducted primarily on cadavers involved the instillation of H_2O or saline into the oesophagus. It was demonstrated that CP reliably prevented presence of gastric contents in the pharynx up to 100 cmH_2O (64, 65).

In contrast to the cadaveric studies, magnetic resonance imaging studies demonstrated an increase in lateral displacement of the oesophagus from 53 to 91% with the application of CP. There was an additional increase in the incidence of incomplete occlusion when the oesophagus was already laterally displaced. Furthermore, it was found that the application of CP itself caused lateral oesophageal displacement and an increased incidence of failure to oppose the oesophagus against the underlying vertebrae (26, 64-66). Currently it is believed that it is not the oesophagus which is occluded but rather the hypopharynx which acts as an "anatomical unit" when occluded and as a result displacement of the oesophagus is immaterial (64, 66). Rice et al. (67) also demonstrated that regardless of lateral displacement there is still occlusion against the left longus colli muscle. Concern has arisen over the elasticity of the muscle compared to the bone, and thus potential for oesophageal expansion when regurgitated material is present in the upper oesophagus (64, 66).

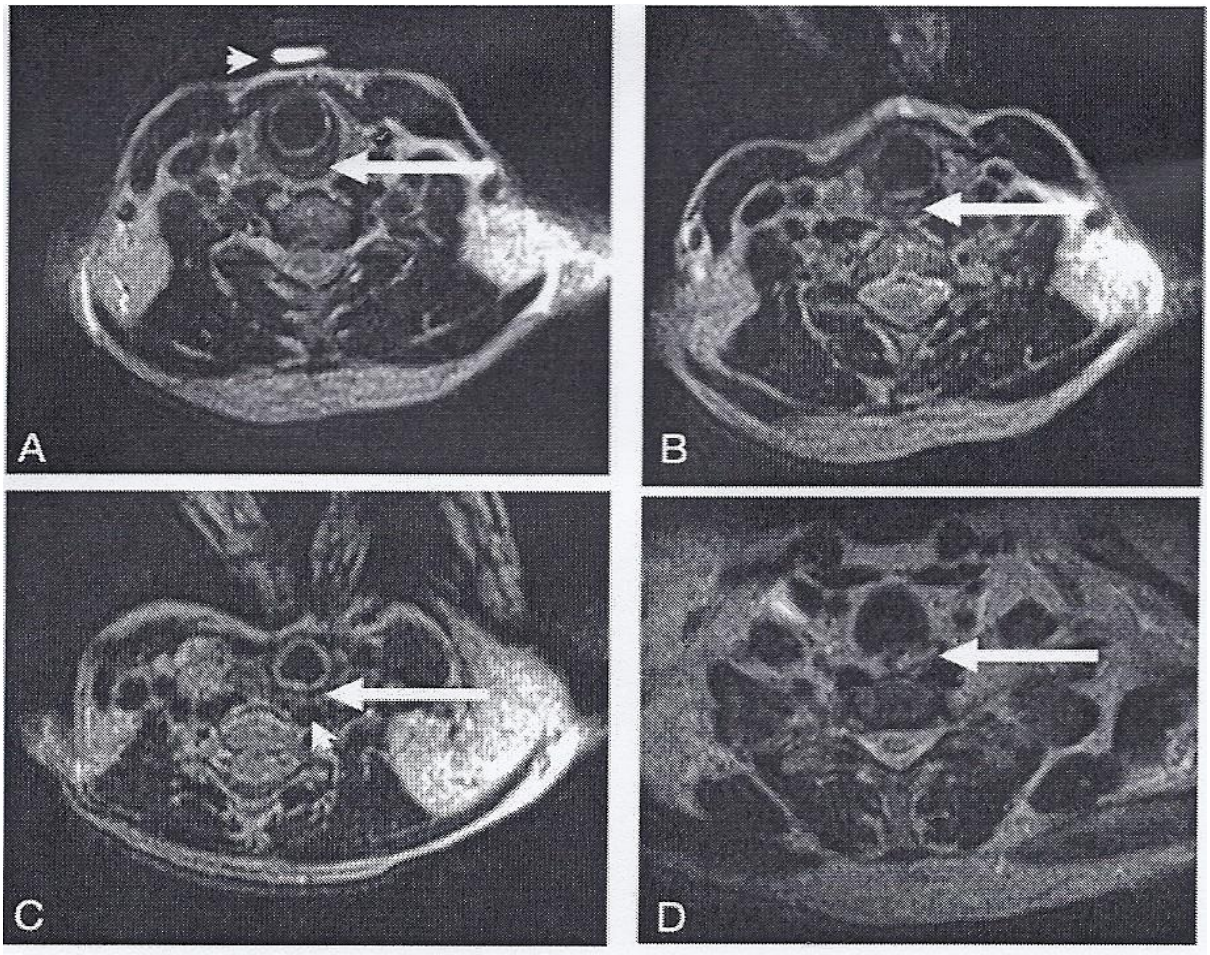


Figure 2.1. "Axial magnetic resonance images in the sniffing position, without (A) and with (B) cricoid pressure. A, shows the postcricoid hypopharynx (arrow) and the Vitamin E marker (arrowhead) placed by the anesthesiologist before imaging. C, an example of postcricoid hypopharynx compression (arrow) lateral to the vertebral body with cricoid pressure. In this image, the postcricoid hypopharynx is compressed against the longus colli muscle group (arrowhead). D, an image 2 cm inferior to the cricoid ring distinctly showing the cervical esophagus (arrow) lateral to the vertebral body. In Panels (B) and (C), the anesthesiologist's thumb and index finger can be seen pushing on the cricoid cartilage. The axial image chosen for each study (A–C) was the image at the most inferior level of the cricoid cartilage."(67)

There is evidence that CP has a physiological influence on the functioning of the LOS (64, 65). Closure of the upper oesophageal sphincter at the end of swallowing causes the LOS to open. As the application of CP mimics the action of the upper oesophageal sphincter, the studies have shown that CP causes relaxation of the LOS and thus potentially increases the risk of aspiration as well as gastric insufflation with positive

pressure ventilation (64, 65). See Table 2.3 for the normal gastric and LOS pressures and how these pressures are affected by various scenarios.

Table 2.3 Intragastric and lower oesophageal sphincter pressure

	Gastric pressure	**Lower oesophageal pressure**
Normal	< 7 mmHg	38 mmHg
Spontaneous reflex vomiting	25-35 mmHg	45 mmHg
Fasciculation from succinylcholine	40 mmHg	45 mmHg
General anaesthesia		7-14 mmHg
Cricoid pressure		Decreases ++

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The timing of CP application and the force to be used is widely varied and debated. Sellick (9) advised the cricoid cartilage be identified and held "lightly" between the thumb and second finger. With induction of anaesthesia the pressure applied was to be increased to a "firm" pressure. In one of the articles, it was stated that even a conscious patient would tolerate "moderate" pressure (9). When Stept et al. (10) described its application in the RSII, the timing of the CP was to coincide with loss of consciousness. Subsequently, there have been suggestions that the application of "light" (previously equating to 20 N and more recently 10 N) in an awake patient should be well tolerated (64, 65). The arguments against its application in the conscious patient include patient discomfort, obstruction to ventilation, retching and vomiting. This is further compounded by the risk of oesophageal rupture in a patient vomiting against applied CP (66).

The amount of force that is adequate to prevent aspiration is once again indeterminate. Previously it was believed that a force of 44 N should be applied, this was later revised to a firm force of 30 N. It was found however, that despite theoretical knowledge of force to be applied; practically there was a wide variation in both technique and pressure used. Application of CP was shown to be superior when applied by an experienced anaesthetist or following training (64-66).

Additional quoted risks of CP include conjunctival haemorrhage if a patient coughs whilst CP is applied, haemorrhage into a goitre, haemodynamic effects and concern over the potential to cause movement in a cervical spinal injury (65).

However, advocates of CP argue that the adverse events associated with this manoeuvre are the result of infrequent use of CP as well as incorrect application, timing, technique and use of the incorrect amount of force. Another subset of practitioners argue that the risk associated with the manoeuvre is low and because of its potential to prevent aspiration in a certain percentage of patients, the use of CP should be continued (18).

With regards to CP in the paediatric population specifically, a survey conducted in the UK including members of the Association of Paediatric Anaesthetists, it was found that only 40-50% of anaesthetists used CP during emergency surgery on a child (68). The reason for this reduced incidence may be associated with two factors, namely the anatomical difference of the paediatric airway under eight years of age as well as the potential to distort the laryngeal view and thus potentially affect airway management.

It has been found that lateral displacement of the oesophagus occurs in a significantly greater proportion of children less than eight years of age when CP is applied [difference in rates was 30% (95% CI 14%-46%)] (69). Furthermore, Walker et al (70) found that the force necessary to occlude the airway by at least 50% in the less than eight years of age group, is significantly less with a mean of 10.5 N and as little as 5 N for those less than one year of age. Thus, use of CP at forces typically used for adults (30 N) could seriously compromise the ability to efficiently manage the paediatric airway in an emergency (70). However, the current recommendations for cricoid pressure in children is for between 22.4 N and 25.1 N (71). With the development of a controlled RSII as advocated for the paediatric population, the use of CP may further fall out of favour.

The relatively low incidence of aspiration does not allow for a study to determine the effect of CP on the incidence of aspiration. Furthermore, as it is considered standard of care it is unlikely to get ethics approval to conduct a randomised controlled trial to fully determine the effectiveness of CP. (18, 64, 65) What is apparent from studies on current practice is that the technique, timing and use of CP in the RSII is variable (11-13, 15, 16).

2.8 Neuromuscular blocking agent

Following the introduction of succinylcholine in 1951, it was incorporated into the classic RSII method (10, 18). Questions regarding the optimal dose of succinylcholine have resulted in multiple studies and reviews. It was noted that although a dose of 1 mg/kg provided optimal and rapid paralysis, the duration of blockade tended to exceed the duration necessary for desaturation (72). Thus, in 2004 El-Orbany et al. (72) studied the effect of a reduced dose of succinylcholine on both the duration of action and intubating conditions. As an additional aim they looked at the effect of the reduced dose on intubation conditions. It was found in two separate studies, that a dose of 0.6 mg/kg was as effective in providing 100% twitch depression, although the time to maximal effect was slightly prolonged in the 0.6 mg/kg group (72, 73).

Similarly Naguib et al. (74) found that there was no significant difference in intubating conditions at 60 seconds between 0.56 mg/kg and 1 mg/kg of succinylcholine (74). It was further noted that the time to either 10% twitch recovery of adductor pollicis or sustained spontaneous ventilation was dose dependant with an average time of 4 minutes in the 0.6 mg/kg group compared to 6 minutes with 1 mg/kg. Thus, spontaneous respiration prior to desaturation (saturation <90%) was more likely to occur in patients receiving the lower dose (72, 75).

However, despite the rapid onset and the optimal conditions succinylcholine provides for laryngoscopy, the poor side effect profile has resulted in the development of alternative agents. Side effects of concern include:

- hyperkalaemia (especially in burns victims, spinal cord lesions and prolonged immobility)
- scoline apnoea
- malignant hyperthermia
- masseter muscle spasm
- raised intracranial and intraocular pressure
- bradycardia or transient cardiac arrest (especially in children)

- myalgia and fasciculation.

Vecuronium gained popularity in the 1980s with much of the literature focusing on the priming and timing techniques (76-78). However, as it is an intermediate acting agent with an onset of two to three minutes, when administered in the conventional manner time to optimal conditions for intubation would increase the risk of aspiration. It was found that by giving a priming dose of 0.015 mg/kg of the 0.1 mg/kg total dose two to three minutes prior to induction, the onset was reduced to an average of 60 seconds. At the time, the authors thought the onset and laryngoscopy conditions to be comparable to succinylcholine but with the absence of undesirable side effects (76).

The unpredictability and long duration of action associated with the priming technique prompted a study looking at the timing principle whereby patients were given the full dose of vecuronium with the induction dose only being administered with the onset of weakness. Once again they found intubating conditions to be comparable to succinylcholine at 60 seconds although deep blockade was questioned in the face of haemodynamic responses to laryngoscopy (77). Similar studies and conclusions were seen in a study using the timing principle with atracurium (79). In 1990, a study comparing the two different techniques with vecuronium and succinylcholine showed little difference in the intubation scores between the priming technique and succinylcholine; however, there was a marked increase in time to recovery of first twitch in the train-of-four in both the priming and timing group (78).

Controversy exists regarding the safety of both the priming and to a lesser extent the timing dose in patients at risk of aspiration. Although it has been shown that a priming dose of 10% of the total dose to be administered is unlikely to cause little more than heavy eyelids, blurred vision, and difficulty in swallowing, there is a subset of patients who will exhibit more serious adverse effects including the inability to swallow. Patient sensitivity to the effects of a non-depolarising NMBA, is not predictable thus placing such patients at increased risk should aspiration be a real concern (80).

The popularity of rocuronium is attributable to the rapid onset and excellent laryngoscopy conditions. Two studies to determine the optimal dose of rocuronium for RSII have shown that conditions comparable to those of succinylcholine are achieved with a dose of 1.0-1.2 mg/kg (81, 82). Furthermore, it was demonstrated that

regardless of the dose of rocuronium, the intubating conditions were superior when using rocuronium with propofol as opposed to the other commonly used induction agents (50). However, concern arose as the duration of action was dose related, lasting up to one hour with the recommended dose. The introduction of sugammadex is likely to change the practice of NMBAs used in RSII as it will provide rapid reversal of rocuronium, even in the face of deep blockade. Initially, it was thought that the time to reversal would be comparable if not more rapid than the time taken for recovery from succinylcholine (83). However, what has emerged is that the time to recovery of spontaneous ventilation, recovery of T_1 10% and recovery of T_1 90% from both time of injection and intubation, is more rapid with rocuronium-sugammadex compared to succinylcholine. In terms of safety profile both drugs appear well tolerated (84, 85).

Suggamadex is currently not available in state hospitals although it has become available in the private sector. The cost per ampule is approximately R830.00 and reversal from neuromuscular blockade would require between one and four ampules. As a result the South African Society of Anaesthesiologists issued a position statement on the use and supply of suggamadex in September 2015. The position they hold is for the responsible use of suggamadex by clinicians in situations (emergency cases, difficult airways or patient benefit perioperatively) deemed appropriate. In addition they advocate the use of neuromuscular transmission monitoring as a minimum, to guide Suggamadex use(86).

Gantracurium, an onium fumarate, is a non-depolarising muscle relaxant that has a rapid onset, is ultra-short acting and provides comparable conditions to succinylcholine. In its favour is the lack of adverse side effects as well as the presence of a naturally occurring reversal agent resulting in reversal of paralysis within three minutes of an intubating dose (83).

2.9 Preoxygenation

Rapid sequence induction is associated with an increased incidence of a difficult airway and failed intubation compared to the population of patients undergoing elective induction, particularly outside the operating theatre (87-89). Preoxygenation forms part of the originally described RSII. The purpose of preoxygenation is to fully

oxygenate or denitrogenate the function residual capacity (FRC) thereby providing a reservoir for on-going oxygenation during the period of apnoea. This allows the provider a longer duration of apnoea without desaturation and thus, to secure the airway (90).

There are various studies that have looked at surrogate markers of adequate preoxygenation, including arterial oxygen partial pressure, achieving a saturation of 100%, an end-tidal oxygen fraction of greater than 0.9, end-tidal nitrogen or carbon dioxide fraction of less than 0.05, in order to delay the time to desaturation (90).

Two techniques of preoxygenation have been described, namely the slow and fast techniques. In the slow technique the anaesthetic circuit is primed with 100% oxygen and the facemask is placed with a good seal over the patient's face. The patient is asked to inhale at normal tidal volume for three minutes (3 TVB) or until an end-tidal oxygen fraction of greater than 0.9 is achieved. The fast technique involves the patient hyperventilating in an attempt to preoxygenate the FRC more rapidly. Two methods to achieving fast preoxygenation are described including four deep breathes (4 DB) over 30 seconds and eight deep breathes (8 DB) over 60 seconds (90, 91).

In a study comparing the 3 TVB to the 4 DB in 30 seconds, it was found that the 3 TVB was superior in achieving adequate preoxygenation (92). Furthermore when the 4 DB in 30 seconds and 8 DB in 60 seconds fast methods were compared, it was found that once again the 4 DB in 30 seconds was the inferior method (93-95). When the three minute tidal volume breathing was compared to the eight deep breathes in 60 seconds it was found that the markers, namely end-tidal oxygen fraction and duration of apnoea without desaturation, were comparable (90).

It is suggested that in the emergency setting the use of the fast 8 DB in 60 seconds may be the technique of choice provided the patient is co-operative (90). Further considerations with regard to preoxygenation include special patient groups and patient position. Patient populations of concern include the pregnant, obese, paediatric, elderly, those with increased metabolic rate as well as the critically ill. These are often the subset of patients presenting for emergency surgery, requiring a RSII. However, despite adequate oxygenation these patients may still show shorter duration of apnoea without desaturation. (90, 91, 96)

To optimise these patients prior to induction patients can be placed in a head-up position rather than supine as this increases the FRC. There is also a suggestion of applying positive end expiratory pressure with 100% oxygen in an attempt to reduce atelectasis and recruit alveoli (90). Weingart (91) suggested that in the high risk patients application of non-invasive ventilation may be applicable . However, this once again requires a co-operative patient.

Despite the improved preoxygenation seen in morbidly obese patients when continuous positive airway pressure is applied, it is recognised that time to desaturation is not significantly improved. This is thought to be the result of a return to pre continuous positive airway pressure volume in the FRC once the continuous positive airway pressure mask is removed for intubation (97). In later studies, the use of 10 cmH_2O continuous positive airway pressure together with oxygen during preoxygenation for five minutes, has been shown to in fact increase the time to desaturation in obese patients (98, 99). In addition, this technique is associated with only 2% atelectasis compared to 10% in the non- continuous positive airway pressure group, as seen on computed tomography (99). Delay et al performed a randomized controlled study in which they looked at the impact of preoxygenation using non-invasive ventilation including pressure support of eight cmH_2O and positive end expiratory pressures of six cmH_2O, they found that 95% of patients achieved the target expiratory fraction of 0.9 compared to only 50% in the oxygen only group. However, it was noted that despite this improvement in preoxygenation, no difference in arterial blood gas was noticeable five minutes post intubation between the groups (100).

In 2007, Baraka et al. (101) looked at the effect of nasal oxygen insufflation in the morbidly obese patient. They found that insufflation of 100% oxygen via a nasal tube increased the mean time to desaturation in morbidly obese patients, following adequate preoxygenation. It is thought that the sub atmospheric pressure created by the movement of oxygen from the FRC into the capillaries, allows the movement “en masse” of the ambient oxygen into the lungs (101). There is concern that both continuous positive airway pressure and nasal oxygen insufflation may lead to gastric insufflation in a patient already at risk of aspiration.

There is literature addressing the possibility of maintaining a spontaneously breathing patient after induction to allow adequate and additional preoxygenation prior to muscle relaxation. This is particularly of interest in the hypoxic and hypercapnic patient who may be uncooperative and not allow adequate preoxygenation whilst still conscious (91).

The method of delayed sequence induction that is proposed by Weingart (91) includes the use of an induction agent such as ketamine or dexmedetomedine to induce the patient, prior to preoxygenation, whilst still maintaining spontaneous ventilation and airway reflexes. This is followed by preoxygenation to achieve a saturation of 100%, with an additional two to three minutes of oxygenation to achieve denitrogenation. The muscle relaxant is administered with apnoea occurring in 45 to 60 seconds and the airway is then secured. There is also some thought that the use of an induction agent in sedative doses may allow improvement of respiratory parameters precluding the need for intubation in the emergency department (91).

The latest concept in preoxygenation is transnasal humidified rapid insufflation ventilatory exchange or "THRIVE". It combines the use of modest continuous positive airway pressure for preoxygenation via high flow transnasal insufflation of humidified 100% oxygen and the concept of aventilatory mass flow to extend the period of apnoeic oxygenation and thus the time to hypoxaemia (102, 103). Preoxygenation is achieved with flow rates as high as 70 $l.min^{-1}$ (102). In one study the apnoeic time was extended to a mean time of 17 minutes without desaturation to values below 90%. There is still some concern over the inability to remove carbon dioxide which thus increases linearly (102). However, Patel et al (102) failed to demonstrate any of the commonly associated problems with carbon dioxide toxicity including cardiac arrhythmias.

2.10 Bag mask ventilation in the RSII

The classically described RSII emphasised the negation of bag mask ventilation following induction of anaesthesia and onset of apnoea until the airway was successfully secured (10). For many years literature has supported the notion that in the case of aspiration risk, avoidance of positive pressure ventilation is necessary to avoid insufflation of the stomach and further contribute to the risk of regurgitation and

vomiting. However, recognition of the high proportion of patients at risk of hypoxaemia who undergo RSII supports the argument for manual ventilation (30).

In a study done by Lawes et al. (104) in 1987 it was recognised that with sufficient preoxygenation and the use of a rapid NMBA, there is often no need for bag mask ventilation. However, under certain circumstances with the rapid onset of hypoxia, manual ventilation would be required to prevent adverse sequelae (90, 104). It was identified that the use of a priming technique with the NMBA would be a situation in which CP and the application of manual ventilation would still be prevalent (104).

Subsequently, it was demonstrated that in the absence of CP a minimum pressure of 20 cmH_2O was necessary to cause gastric insufflation. This pressure was lower than the mean pressure of 16,5 cmH_2O necessary for adequate respiratory excursion. Furthermore, with the application of CP the peak circuit pressure generated was 44,7cm H_2O and at no pressure was gastric insufflation recorded. These pressures are possible provided the CP is correctly applied. They also made a comment on the risk of occluding the airway and preventing adequate ventilation with the application of CP particularly in the elderly (104).

In 1989, Petito et al. (105) did a study on low risk patients to determine the difference in gastric insufflation between those in whom bag mask ventilation was performed both with and without CP. In the control group the amount of gas aspirated after ventilation of two minutes was between 0 to 1000 mls with an average of 168 mls. In comparison, when CP was applied aspirates of 0 to 580 mls with an average of 39 mls was aspirated, once again highlighting the role of CP in decreasing gastric insufflation. Of note was the observation that patients who were difficult to bag mask ventilation had similar aspiration volumes regardless of whether or not CP was applied (105).

The risk of gastric insufflation with bag mask ventilation in infants and children is associated with not only an increased risk of gastric aspiration but also a reduction in the FRC as well as venous return and cardiac output. In a study conducted on 59 children between the ages of two weeks and eight years, it was found that CP reduced the gastric insufflation in 100% of cases regardless of paralysis. They observed that gastric insufflation occurred at lower peak inspiratory pressures in the presence of paralysis; however, they noted that the presence of CP tended to increase the pressure

at which gastric insufflation occurred in the presence of paralysis. (106) Finally their finding that insufflation was unlikely at peak pressures of less than 15 cmH_2O with or without CP, which was in keeping with the findings of Lewis et al. (104).

The Difficult Airway Society in the United Kingdom (UK) published guidelines on RSII performance in which they state that gentle manual ventilation at pressures of less than 20 cmH2O is considered acceptable practice by some of the more experienced practitioners (24, 30). The change in practice to allow gentle positive pressure ventilation either before and/or after administration of a NMBA was confirmed in a recent survey in which 94% of the respondents regarded it acceptable to attempt manual ventilation during a RSII (13).

2.11 Current practice

From 2001to 2016 there have been five studies looking at the variation and current trends in the performance of a RSII by anaesthetists, in various institutions including in Wales, the UK, the USA and Germany (11, 12, 14-16).

In a national survey on the practice of RSII in the UK, Morris et al. (12) found that preoxygenation was used by 100% of respondents. However, the method in which preoxygenation was achieved varied from the use of 100% oxygen for three minutes by 82% of the respondents, to the use of a vital capacity based breathing techniques in the minority. (12) Similarly, Ehrenfeld et al. (14) found that all respondents in the USA administered oxygen to patients prior to induction of anaesthesia. However, the exact method by this was achieved was not stated. Instead it was noted that preoxygenation generally lasted between three and five minutes, with no appreciable difference between trainee anaesthetists and anaesthesiologists (14).

The most recent survey conducted in the UK by Sajayan et al. (15) found that of the respondents only 1 trainee and 3 consultants did not routinely perform preoxygenation. The most common technique adopted by respondents was to monitor the end tidal oxygen concentration, looking for a value of greater than 0.9. Other techniques used included 3 minute tidal volume breathing, 1 minute vital capacity breathing and a

combination (15). Although preoxygenation was used by the majority in Germany, use of an end tidal oxygen concentration to determine adequacy only accounted for approximately 40% of the techniques used (16).

The use of continuous positive airway pressure during preoxygenation was an additional technique for preoxygenation in the UK. Of the respondents 42% stated that they used continuous positive airway pressure, with the majority being used for the preoxygenation of obese patients. They further found that 76% of the respondents routinely used a head up position of 20-25° for preoxygenation, whilst a further 11% chose a head up tilt of 45°. No mention was made of the position adopted at the time of induction(15). Use of the head up position was also most commonly described in the German survey with only 3% adopting the Trendelenburg position (16).

NGT insertion was used by 65% of the German respondents when performing a RSII for a small bowel obstruction. The NGT was placed prior to induction of anaesthesia and left in situ throughout (16).

The most commonly used induction agents in the UK were thiopental (88%), propofol (58%) and etomidate (54%) with midazolam and ketamine being used by only a small minority. In Wales, it was found that the use of propofol for induction had exceeded that of thiopental. However, in specific clinical scenarios, namely caesarean section and bowel obstruction, thiopental and etomidate respectively, were considered the induction agent of choice. In contrast to the study in 2001 in the UK, Sajayan et al. (15) found that propofol was the most commonly used induction agent particularly amongst the consultants, whilst a larger proportion of trainees still used Thiopentone most commonly.

Only the study from Wales looked at the use of predetermined and titration techniques for administration of the induction agent. It was found that amongst anaesthetists there was no significant difference between those that chose predetermined doses compared to those that chose to use the titration method. Furthermore, there was no difference between trainee anaesthetist and anaesthesiologists in terms of technique preference (11).

Opioid use during RSII occurred in 80% of respondants in the 2016 UK survey. Although reported use was higher in consultants, the difference was not significant (p=0.022). The most commonly used agent was fentanyl followed by alfentanyl, remifentanil and morphine respectively (15).

CP was applied by all the respondents in the original UK study (12) and 86-94% in the USA study (14). In contrast, Sajayan et al. (15) showed that CP was only applied 92% of the time with the remaining 8% choosing to use CP for select cases only. It was also found that of the respondents, trainees were more likely to always apply CP compared to the consultants (15). Conversely, in Germany only two thirds of the respondents used CP. Of those respondents, only 50% viewed two specific clinical scenarios, namely small bowel obstruction and upper gastrointestinal bleeding, as indications for CP (16). The timing of application was during the induction of anaesthesia in the majority of respondents in both of the UK studies and the USA survey. (12, 14, 15) In the German study, the majority applied cricoid pressure only once the patient was asleep (16).

Other interesting observations with regard to the use of CP from the Germany survey, included the practice of reducing or releasing CP, by two-thirds and one-third of respondents respectively, should the initial attempt at intubation fail. It was also noted that 25% of the respondents had observed an episode of regurgitation either at the time of CP application or following its release. It was further found that the incidence of an observed regurgitation increased in accordance with the number of years of experience of the respondents (16).

Koeber et al. (11) found that the clinical scenario dictated the use of a cuffed tracheal tube and CP such that for bowel obstruction 100% of respondents used CP, but for an asymptomatic hiatal hernia only 25% would use CP (11).

The use of bag mask ventilation prior to administration of NMBAs was considered to be a defining feature of a modified RSII in the USA (14). The likelihood of using bag mask ventilation during a RSII was higher in anaesthesiologists compared to trainee anaesthetists. Bag mask ventilation was more commonly practiced by

anaesthesiologists for moderate to morbidly obese patients, as well as those with gastro oesophageal reflux. The majority described limiting bag mask ventilation to less than five breathes in an attempt to ventilate the lungs prior to muscle relaxation. (14) In the UK, only 17% of respondents used "gentle" bag mask ventilation following apnoea, whilst a further 6% chose to use oxygen insufflation via a nasal catheter (15).

Succinylcholine still remains the most commonly used agent for neuromuscular blockade. However, it was found that of the respondents in the UK, trainee anaesthetists were more likely than anaesthesiologists to use rocuronium routinely in a RSII The majority of respondents in the UK (12, 15) and Wales (11)only administered NMBAs after signs of loss of consciousness were recognised, which is in contrast to the traditional technique which called for the administration of succinylcholine immediately following induction (10). In Germany the majority of respondents use either succinylcholine(70%) or rocuronium(40%). However, the use of rocuronium was more common amongst respondents at an academic hospital as compared with those at either a district or community hospital. There were a further 24% who use both the priming and timing techniques when using a NDMR (16).

The Wales (11)study concluded that the use of a RSII was less often employed by anaesthesiologists compared to trainee anaesthetists. Furthermore, when performing the RSII the anaesthesiologists were less likely to use the classic combination of thiopental and succinylcholine (11).

A lot of emphasis has been placed on the use of a classically described RSII and whether it is still appropriate for use in the paediatric population. A retrospective study conducted on children aged three to twelve years of age showed that despite preoxygenation the risk of hypoxia (saturations <90%) was 3.6% with severe hypoxaemia (saturations <80%) occurring in 1.7%. Furthermore, incidence of bradycardia and hypotension were 0.8% and 0.5% respectively. As a result an alternative approach described the controlled RSII is being advocated in the paediatric population (107). This approach includes:

- “continuous aspiration on an NGT if in situ or the insertion of one after the tracheal tube is secured
- patient positioned head up at 20° for preoxygenation and induction
- titration of an induction agent to produce unconsciousness followed by the use of atracurium at 1mg/kg (although any NMBA may be used provided optimal relaxation is guaranteed, thus advocating the use of neuromuscular block monitoring)
- gentle bag mask ventilation (keeping insufflation pressures <12 cmH_2O) before intubation
- intubation following loss of all twitches on the train-of-four, on a nerve stimulator, thus ensuring a deep level of anaesthesia and adequate neuromuscular blockade.”(108)

2.11 Conclusion

From the above literature it is clear that many controversies still exist with regard to performing a RSII. There still exists debate as to the appropriate use of a NGT, CP and bag mask ventilation. The absence of internationally standardised guidelines has resulted in a variety of techniques to achieve rapid induction and intubation largely based on the patient status, clinical scenario and level of experience. The concern over the incidence of aspiration provides a setting for a review of current practice with regard to RSII in the University of Witwatersrand’s Department of Anaesthesiology.

Chapter 3

3.0 Research Methodology

3.1 Introduction

This chapter will describe the research methodology of the study. It will include research design, study population, the sampling process and study methods.

The problem statement, aims and objectives from Chapter 1 will be repeated to ensure consistency.

3.2 Aim and objectives

3.2.1 Aim

The aim of this study was to describe the current practice of anaesthetists in the Department of Anaesthesiology at Wits when performing a RSII using seven clinical vignettes.

3.2.2 Objectives

The primary objectives of this study were to:

- determine the proportion of anaesthetists who recognise patients at risk of pulmonary aspiration;
- describe the choice of induction agent used for a RSII;
- describe the choice of NMBA used for a RSII;
- describe the technique used when performing a RSII.

The secondary objectives of this study were to:

- compare the difference in technique between the consultant and trainee anaesthetists;

- compare the difference in induction agents between the consultant and trainee anaesthetists;
- compare the difference in NMBA between the consultant and trainee anaesthetists;
- describe the anaesthetists definition of a modified RSII.

3.3 Ethical considerations

Approval to conduct this study was obtained from the Graduate Studies Committee (Appendix A) and the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (Appendix B).

The study was conducted prospectively and the identifying information of the respondents remained anonymous. Anaesthetists in the Department of Anaesthesiology at Wits, were invited to take part in the study and those that agreed were given an information letter (Appendix C). Informed consent was implied by completion of the questionnaire. Questionnaires were sealed in an envelope and returned to a secure box. Participation in the survey was voluntary, thus, respondents could withdraw from the study at any time should they so choose.

All the data collected was kept confidential as only the researcher and supervisors had access to the raw data. The data will be stored securely for six years after completion of the study.

The study was conducted adhering to good clinical research practice in accordance with the South African Good Practice Guidelines (19) and the Declaration of Helsinki (20).

Should the audit find that the identification of at risk patients by anaesthetists at Wits is poor, further education and training will be suggested to improve patient outcome.

3.4 Research methodology

3.4.1 Study design

The research design used in this study was a prospective, contextual, descriptive design.

A prospective study is defined as a study in which individuals are selected because of specific factors that are to be examined for an outcome. In this study questionnaires were completed by anaesthetists and the clinical practices of RSII determined.

The context refers to a body or world and the concerns unique to the individuals arising from this world (109). The study was contextual as it only evaluated the current practice of RSII amongst the anaesthetists in the Department of Anaesthesiology affiliated to Wits.

A descriptive study is used to identify phenomena and the associated variables (109). This study was a clinical survey to describe the current practice of RSII in the Department of Anaesthesiology.

3.4.2 Study population

The study population included all the anaesthetists in the Department of Anaesthesiology from Wits.

3.4.3 Study sample

Sample size

The sample size was determined in consultation with a biostatistician. The department consists of 107 registrars, 74 specialist anaesthesiologists, 27 medical officers and interns, whose number vary depending on the rotation. Questionnaires were administered to the accessible population. A response rate of 60% (124) was considered acceptable but as this was a clinical audit a response rate of 80% (166) was targeted.

Sampling method

Sampling was done using a convenience sampling method. This is defined as a non-random sampling method resulting in participants being selected because of the ease of

volunteering or selecting a unit because of ease of accessibility (110). The anaesthetists from Wits formed a readily accessible population to sample.

3.5.4 Inclusion and exclusion criteria

All the anaesthetists in the Department of Anaesthesiology were invited to participate in the study.

The following exclusion criteria were applied to the study:

- anaesthetists on annual or sick leave during the study period, and
- anaesthetists who decline to participate in the study.

3.4.5 Data collection

Data collection instrument

A questionnaire including seven vignettes was used to survey current clinical practice (Appendix D). Peabody et al. (111) evaluated the validity of using clinical vignettes to measure the quality of health care. The authors found that vignettes provide an accurate and inexpensive method of measuring quality of health care comparable to the use of a standardised patient. However, it is recognised that the decisions made do not have a direct impact on a patient's health practically. (85)

Koeber et al. (11) used five vignettes for the assessment of clinical practice of RSII in Wales (Appendix E). These vignettes were deemed appropriate for this audit and permission was obtained from the authors to use and adapt where appropriate (Appendix F).

The vignette describing RSII in a Caesarean section was adapted from an elective, healthy mother undergoing surgery, to an emergency caesarean section in a mother with HELLP syndrome and low platelets. This was considered more appropriate in the context of South African practice.

In addition to the aforementioned vignettes, two additional vignettes were developed to address chronic renal failure and the neonate which are considered important clinical scenarios. These vignettes were validated by a panel of four expert anaesthesiologists from the Department of Anaesthesiology to ensure face and content validity.

The seven vignettes will include:

1. Emergency appendectomy in a 25 year-old male, starved for over 6 hours, with abdominal pain and not dehydrated.
2. Elective day case knee arthroscopy in a 40 year-old male with an endoscopically proven hiatus hernia and symptoms of reflux.
3. Elective day case knee arthroscopy in a 40 year-old male with an endoscopically proven hiatus hernia without symptoms of reflux.
4. Emergency Caesarean section in a mother with HELLP syndrome with a platelet count of 80.
5. Emergency laparotomy for bowel obstruction in an 80 year-old female who is septic and dehydrated.
6. Elective in-patient arterio-venous shunt insertion in a 40 year-old patient known with chronic renal failure and hypertension, with deranged urea and creatinine and a normal potassium. The patient has features of autonomic dysfunction but has been starved for 6 hours.
7. A 10-day old neonate with a distended abdomen, for emergency exploratory laparotomy.

It was stated that for all of these clinical vignettes, the patients were not considered to have a difficult airway and regional anaesthesia had been refused.

The following practices were assessed for each vignette:

- preoxygenation
- choice of induction agent
- application and timing of CP
- choice of NMBA
- the use of an opioid and benzodiazepine prior to induction
- insertion of NGT
- use of bag mask ventilation.

In addition we assessed:

- dose of induction agent used (predetermined vs. titrated)
- technique for administration of NMBA

Furthermore, the following demographic information was requested from the respondents:

- age
- gender
- category of anaesthetist and
- years of experience.

Data collection method

During the study period questionnaires were handed out at the various departmental meetings. In the event that staff members could not attend these meetings, questionnaires were handed out to the anaesthetists in the respective departments at each of the hospitals.

Anaesthetists were invited to participate in the audit and an information letter was made available (see Appendix G). Agreeing to complete the questionnaire was regarded as implied consent. Questionnaires were allocated a study number to monitor the number of questionnaires returned. To ensure anonymity no identifying data was collected. Anaesthetists placed the completed questionnaires in an unmarked envelope, sealed it and placed it in a sealed data collection box placed in the departmental tea room.

3.4.6 Data analysis

A Microsoft Excel® spreadsheet was used to capture the data. The data was analysed aided by a biostatistician using Microsoft Excel® and GraphPad InStat™. Descriptive

and inferential statistics were used to analyse the data. For categorical data, frequencies and percentages were used. Furthermore, for comparison between groups, a chi-squared test was used. A level of significance of 0.05 and 95% confidence intervals was used.

3.5 Validity and Reliability

Validity and reliability were used to ensure that the study's conclusions were in keeping with the study design and results analysis. The validity is the extent to which a measurement represents a true value. Threats to validity can occur throughout the research process and include factors external to the study. Reliability ensures the consistency of the result achieved. (112)

The validity and reliability of this study were ensured by:

- the use of an appropriate study design and data gathering techniques
- five of the seven vignettes were based on a previously validated questionnaire in the study by Koeber et al (11)
- the seven vignettes were validated by four consultants from Wits to ensure they had both face and content validity
- emphasis was placed on anonymity to ensure participants answered in accordance with their current practice.

3.6 Summary

The research methodology was discussed in this chapter. In the following chapter the results and discussion are presented.

Chapter 4

4.0 Results and discussion

4.1 Introduction

The sample realisation, results of the study according to the objectives and the discussion are presented in this chapter.

The primary objectives of this study were to:

- determine the proportion of anaesthetists who recognise patients at risk of pulmonary aspiration;
- describe the choice of induction agent used for a RSII;
- describe the choice of NMBA used for a RSII;
- describe the technique used when performing a RSII.

The secondary objectives of this study were to:

- compare the difference in technique used between the consultant and trainee anaesthetists;
- compare the difference in induction agents used between the consultant and trainee anaesthetists;
- compare the difference in NMBA between the consultant and trainee anaesthetists;
- describe the anaesthetists' definition of a modified RSII.

4.2 Sample realisation

A total of 126 questionnaires were distributed in the Department of Anaesthesiology at academic meetings from June 2015 to February 2016. Thus, only 60.1% of the Department of Anaesthesiology at the University of the Witwatersrand was surveyed with regard to the performance of RSII. One questionnaire was excluded as it was

returned blank. Therefore, a total of 125 questionnaires were included in the statistical analysis with a 99.2% response rate.

For the purpose of fulfilling the secondary objectives of this research report, the designated groups were regrouped into two grades. The first grade consisted of consultants (n=39). The second grade consisted of all those considered to be trainees including registrars, medical officers and interns (n= 86).

4.3 Results

All percentages in the results will be reported according to the number of complete answers obtained for each question. The percentages will be presented to one decimal place. When presenting data regarding the seven vignettes in tables, the headings for each vignette will be represented by a corresponding number (Table 4.1). The use of both a cuffed endotracheal tube and CP must be present in order for a respondent to fulfil the criteria for a RSII.

Table 4.1 The seven vignettes with their corresponding number

Vignette	Number
Appendicetomy	1
Symptomatic hiatus hernia	2
Asymptomatic hiatus hernia	3
Caesarean section	4
Bowel Obstruction	5
Renal Failure	6
Neonate for laparotomy	7

4.3.1 Demographics

Demographic data of the 125 respondents collected during the study is illustrated in Table 4.2.

Table 4.2 Demographics of the respondents

Variable	*n* (%)
Gender	*n=124*
Female	79 (63.7)
Male	45 (36.7)
Grade	*n=125*
Consultant	39 (31.2)
Registrar	61 (48.8)
Medical officer/ intern	25 (20.0)
Year of experience	*n=125*
0-5	101 (80.8)
6-10	9 (7.2)
≥ 11	15 (12.0)

Respondents were asked to indicate whether or not they had experienced a suspected or confirmed aspiration in the preceding year. An incident of aspiration was reported by 23/125 (18.4%) respondents.

4.3.2 Objective: to determine the proportion of anaesthetists who recognise patients at risk of pulmonary aspiration

The respondents were asked to provide a technique for each of the seven vignettes in terms of securing the airway. It was determined that the use of both an endotracheal tube and cricoid pressure would be considered necessary in order to fulfil the criteria for a RSII. Thus, a technique in which the use of both techniques was not used, was considered to be a non-RSII. The overall ability of the respondents to recognise the risk for pulmonary aspiration and need for a RSII across the seven vignettes was 598/824 (72.6%) (95% CI 69.5%-75.6%).

Vignettes: 1. Appedicetomy; 2. Symptomatic hiatus hernia; 3. Asymptomatic hiatus hernia; 4. Caesarean section; 5. Bowel obstruction; 6. Renal failure; 7. Neonate for laparotomy

Table 4.3 The technique of induction and airway management

Technique	Vignettes						
	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	6 n (%)	7 n (%)
RSII	97 (79.5)	93 (78.1)	38 (33.0)	113 (93.4)	114 (95.0)	89 (76.0)	54 (49.1)
Non-RSII	25 (20.5)	26 (21.9)	77 (67.0)	8 (6.6)	6 (5.0)	28 (24.)	56 (50.9)
n	122	119	115	121	120	117	110

4.3.3 Objective: to describe the choice of induction agent used for a RSII

The use of induction agent did not differ with regard to the seven vignettes. Propofol was the most commonly employed agent with the exception of the bowel obstruction and neonate vignettes. For the bowel obstruction vignette, etomidate was the agent of choice, with 70 (57.9%) respondents choosing to use it compared to the other agents. Although propofol was still used by the majority in the neonate vignette, it was only used by 76 (63.3%) of the respondents. Table 4.4 shows the choice of induction agent for each vignette.

Table 4.4 Induction agents used for RSII in seven vignettes presented to the respondents

Induction agent	Vignette						
	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	6 n (%)	7 n (%)
Propofol	121 (98.4)	116 (99.2)	115 (99.1)	98 (80.3)	41 (33.9)	110 (91.7)	76 (63.3)
Etomidate	1 (0.8)	1 (0.9)	1 (0.9)	12 (9.8)	70 (57.9)	10 (8.3)	3 (2.5)
Thiopentone	1 (0.8)	0	0	10 (8.2)	1 (0.8)	0	2 (1.7)
Other	0	0	0	2 (1.6)	9 (7.4)	0	38 (31.7)
n	123	117	116	122	121	120	119

4.3.4 Objective: to describe the choice of NMBA used for a RSII

The NMBA used varied between the different vignettes. Succinylcholine was the agent of choice by 83 (67.5%) of respondents for the appendicectomy, 118 (96.7%) for the Caesarean section and 83 (68.0%) for the bowel obstruction vignettes respectively. Most of respondents 57(47.9%) still chose to use succinylcholine as their NMBA of choice for the symptomatic hiatus hernia, however, a large proportion, 36 (30.3%), considered the use of rocuronium for this vignette.

Vignettes: 1. Appedicetomy; 2. Symptomatic hiatus hernia; 3. Asymptomatic hiatus hernia; 4. Caesarean section; 5. Bowel obstruction; 6. Renal failure; 7. Neonate for laparotomy

In contrast, rocuronium was the agent most commonly chosen for the asymptomatic hiatus hernia by 40 (34.2%) respondents. The remainder of the respondents were fairly evenly split between succinylcholine 26 (22.2%), other 25 (21.4%) and none 26 (22.2%).

For the neonate the most commonly chosen agent was "other" by 44 (37.0%) of respondents with the remainder being divided between the remaining choices. Finally, for the renal failure vignette the use of NMBA ranged between 8 (6.8) and 46 (39.0). Table 4.5 shows the choice of NMBA for each vignette.

Table 4.5 NMBA used for RSII in seven vignettes presented to the respondents

Neuromuscular blocking agent	**Vignette**						
	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	6 n (%)	7 n (%)
Succinylcholine	83 (67.5)	57 (47.9)	26 (22.2)	118 (96.7)	83 (68.0)	43 (36.4)	26 (21.9)
Rocuronium	28 (22.8)	36 (30.3)	40 (34.2)	3 (2.5)	34 (27.9)	21 (17.8)	25 (21.0)
Other	12 (9.8)	24 (20.2)	25 (21.4)	1 (0.8)	4 (4.1)	46 (39.0)	44 (37.0)
None	0	2 (1.7)	26 (22.2)	0	1 (0.8)	8 (6.8)	24 (20.2)
n	123	119	117	122	122	118	119

4.3.5 Objective: to describe the technique used when performing a RSII.

The techniques used for RSII and non-RSII

Use of drugs and whether a non-RSII was used, is shown in Table 4.6. The use of a RSII was used less frequently for the asymptomatic hiatus hernia, whilst the choice of induction technique for the neonate in this scenario was fairly similar for both RSII and non-RSII (49.1% vs 50.9%). Of those who chose to use a RSII, the majority of respondents used a combination other than thiopental and succinylcholine. For the symptomatic hiatus hernia, asymptomatic hiatus hernia and renal failure vignettes, no respondents chose to use this combination. Although more respondents chose this combination for the Caesarean section, it still only comprised 8 (6.6%) out of the respondents.

Vignettes: 1. Appedicetomy; 2. Symptomatic hiatus hernia; 3. Asymptomatic hiatus hernia; 4. Caesarean section; 5. Bowel obstruction; 6. Renal failure; 7. Neonate for laparotomy

Table 4.6 Induction technique used by respondents

	Vignette						
Rapid sequence*	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	6 n (%)	7 n (%)
Thiopental and succinylcholine	1 (0.8)	0 (0.0)	0 (0.0)	8 (6.6)	1 (0.8)	0 (0.0)	1 (0.9)
Other drugs†	96 (78.8)	93 (79.5)	38 (34.2)	105 (86.7)	113 (93.4)	89 (75.4)	53 (47.3)
N	97	93	38	113	114	89	54
Non-rapid sequence ‡	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	6 n (%)	7 n (%)
Tracheal tube Without cricoid Pressure	25 (20.5)	24 (20.5)	39 (35.1)	8 (6.6)	6 (5.00)	22 (18.6)	55 (49.1)
No tracheal Tube	0 (0.0)	2 (1.7)	38 (34.2)	0 (0.0)	0 (0.0)	6 (5.1)	1 (0.9)
N	25	26	76	8	6	28	56

*rapid sequence defined as use of tracheal tube and cricoid pressure
†other drugs refers to any combination of induction agent and NMBA that does not include thiopental and succinylcholine
‡non-rapid sequence is any technique in which a tracheal tube and/or cricoid pressure are not used

Technique of induction administration and timing of NMBA

Respondents' preference for either a calculated or titrated dose of induction agent, as well as the timing of NMBA administration is shown in Table 4.7. Of the respondents, 62 (49.6%) indicated that they would vary the method of administering an induction agent, namely administering a calculated dose or titrating the dose to effect, depending on the clinical scenario. Of the remaining respondents, 54 (43.2%) always administer a predetermined calculated dose whilst only 9 (7.2%) always titrate the induction agent to effect. In terms of timing for the administration of a NMBA the most common response was to always wait for unconsciousness prior to NMBA administration by 51 (40.8%) respondents.

Table 4.7 Technique for administration of induction agent and timing of NMBA administration when performing RSII

Induction agent (*n*= 125)	n (%)
Variable depending on clinical scenario	62 (49.6)
Always calculated dose	54 (43.2)
Always titrated	9 (7.2)
Neuromuscular blocking drug (*n*= 124)	
Always after unconsciousness	51 (40.8)
Sometimes wait for unconsciousness	46 (36.8)
Always before unconsciousness	27 (21.6)

Vignettes: 1. Appedicetomy; 2. Symptomatic hiatus hernia; 3. Asymptomatic hiatus hernia; 4. Caesarean section; 5. Bowel obstruction; 6. Renal failure; 7. Neonate for laparotomy

Non-depolarising NMBA appropriateness and technique for RSII

The technique for the use of a non-depolarising NMBA when performing a RSII was determined for each of the agents available in the four hospitals. Table 4.8 shows the agents considered appropriate for RSII and the technique used by respondents when using that particular agent. It is noted that respondents could answer "yes" to both a fixed dose and priming technique for each of the agents. Rocuronium is the most commonly used non-depolarising NMBA with 104 (84.6%) of respondents using a fixed dose technique and only 23 (18.6%) indicating that they would use a priming technique when using this agent. Of the remaining agents the only other commonly used non-depolarising NMBA was atracurium. Respondents indicated that when using this agent a priming technique was preferable compared to a fixed dose [47 (37.6%) vs 22 (17.6%)].

When using a fixed dose technique for rocuronium respondents quoted doses from 0.9mg/kg to 1.2mg/kg. In terms of the doses used for a priming technique there was a wide variation in the percentage of the total dose (priming dose) administered prior to administering the induction agent. Doses ranged from 5% to 50% of the total calculated dose, with the mode dose quoted as being 10% of the total calculated dose. One respondent indicated that they would give the total calculated dose of rocuronium when performing a priming technique prior to administering the induction agent.

Table 4.8 Technique of administering non-depolarising NMBA administration when performing a RSII

Agent	Technique	
	Priming n (%)	Fixed dose n (%)
Rocuronium	23 (18.6)	104 (84.6)
Atracurium	47 (37.6)	22 (17.6)
Cisatracurium	17 (13.6)	10 (8.0)
Vecuronium	6 (4.8)	1 (0.8)
Pancuronium	1 (0.8)	1 (0.8)

Vignettes: 1. Appedicetomy; 2. Symptomatic hiatus hernia; 3. Asymptomatic hiatus hernia; 4. Caesarean section; 5. Bowel obstruction; 6. Renal failure; 7. Neonate for laparotomy

Adjuncts to RSII

Table 4.9 shows the frequency with which adjuncts, namely opioid and benzodiazepine administration, NGT insertion and BMV were performed for each of the seven vignettes. Of interest is the high rate of opioid administration prior to induction for a Caesarean section by 85 (71.4%). Unfortunately no data was requested in terms of agent used and indication for opioid use.

The use of a benzodiazepine prior to the induction agent was less common than that of an opioid. Use ranged between 2 (2.5%) for the Caesarean section and 18 (24.0%) for the asymptomatic hernia, the vignette in which it was most commonly used.

The insertion of a NGT prior to induction varied depending on the clinical vignette. For the bowel obstruction and neonate vignettes the majority of respondents, 105 (89.7%) and 94 (79.0%) respectively, reported the insertion of a NGT prior to induction. The rate of insertion for the remaining scenarios varied greatly as is seen in Table 4.9.

The use of BMV occurred with greater frequency in the vignettes in which a non-RSII was most commonly cited [asymptomatic hiatus hernia 56 (47.5%) and neonate 33 (28.0%)]. Of the respondents who elected to use BMV for the symptomatic hernia, 82.3% did not meet the criteria for a RSII (use of both a tracheal tube and cricoid pressure). For the remaining vignettes, BMV was used by between 5 (4.1%) and 26 (22.2%) of the respondents prior to intubation of the patient.

Vignettes: 1. Appedicetomy; 2. Symptomatic hiatus hernia; 3. Asymptomatic hiatus hernia; 4. Caesarean section; 5. Bowel obstruction; 6. Renal failure; 7. Neonate for laparotomy

Table 4.9 The use of opioids, benzodiazepines, BMV and a NGT when performing a RSII

Technique adjuncts	Vignettes						
	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	6 n (%)	7 n (%)
Opioid before induction	114/121 (94.2)	110/116 (94.8)	111/118 (94.1)	85/119 (71.4)	102/118 (86.4)	102/112 (91.1)	72/114 (63.2)
Benzodiazepine before induction	7/84 (8.3)	15/77 (19.5)	18/75 (24.0)	2/81 (2.5)	7/76 (9.2)	9/68 (13.2)	6/66 (9.1)
Insertion of NGT	15/123 (12.2)	6/114 (5.3)	3/117 (2.6)	2/119 (1.7)	105/117 (89.7)	8/113 (7.1)	94/119 (79.0)
Bag mask ventilation	12/123 (9.8)	23/119 (19.3)	56/118 (47.5)	5/121 (4.1)	4/121 (3.3)	26/117 (22.2)	33/118 (28.0)

4.3.6 Secondary objective: to compare the difference in technique used between the consultant and trainee anaesthetists

A Pearson chi-squared test for independence was performed to determine if there was any difference in terms of technique (RSII vs non-RSII) used between grades for each of the vignettes. There was no statistically significant difference in technique between the consultants and trainees. Table 4.10 shows the induction technique used by the different grades for each vignette and the associated p-value.

Table 4.10 Induction technique used by the consultants and trainees

	Vignettes						
	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	6 n (%)	7 n (%)
Consultants	n = 37	n = 37	n=35	n=37	n=37	n=37	n=36
Rapid Sequence	26 (70.3)	26(72.2)	11 (30.6)	34 (91.9)	34 (91.9)	25 (67.6)	16 (44.4)
Non-rapid Sequence	11 (29.7)	11 (30.6)	24 (66.7)	3 (8.1)	3 (8.1%)	11 (32.4)	20 (5.6)
Trainees	n=85	n=81	n=80	n=84	n=83	n=80	n=74
Rapid Sequence	71(81.5)	67 (83.5)	27 (33.8)	79 (94.1)	80 (96.4)	64 (80.0)	38 (51.4)
Non-rapid Sequence	14 (16.5)	14 (17.3)	53 (66.3)	5 (6.0)	3 (3.6)	16 (20.0)	36 (48.7)
p-value	0.0954	0.1248	0.6386	0.6602	0.2969	0.1646	0.4966

Vignettes: 1. Appedicetomy; 2. Symptomatic hiatus hernia; 3. Asymptomatic hiatus hernia; 4. Caesarean section; 5. Bowel obstruction; 6. Renal failure; 7. Neonate for laparotomy

4.3.7 Secondary objective: to compare the difference in induction used between the consultant and trainee anaesthetists

The Pearson's Chi-squared test for independence was used to compare the use of both induction agents by consultants and trainees. For data where there were two columns with zeros in both cells, a Chi-squared test could not be performed, thus, a Fisher Exact was performed on the valid four cells. There were no statistically significant differences between the consultants and trainees in any of the vignettes with regard to induction agent used as seen in Table 4.11.

Table 4.11 Comparison of induction agent used by the consultants and trainees

	Vignettes						
	1	2	3	4	5	6	7
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Consultant	n=38	n=36	n=37	n=38	n=37	n=38	n=38
Propofol	37 (97.4)	35 (97.2)	36 (97.3)	31 (81.6)	14 (37.8)	35 (92.1)	22 (57.9)
Thiopentone	0 (0)	(0)	(0)	1 (2.6)	0 (0)	0 (0)	0 (0)
Etomidate	1 (2.6)	1 (2.8)	1 (2.7)	5 (13.2)	21 (56.8)	3 (7.9)	0 (0)
Other	(0)	(0)	(0)	1 (2.6)	2 (5.4)	0 (0)	16 (42.1)
Trainee	n=85	n=81	n=79	n=84	n=84	n=82	n=81
Propofol	84 (98.8)	81 (100.0)	79 (100.0)	67 (79.8)	27 (32.1)	75 (91.5)	54 (65.9)
Thiopentone	1 (1.2)	0 (0)	0 (0)	9 (10.7)	1 (1.2)	0 (0)	2 (2.4)
Etomidate	0 (0)	0 (0)	0 (0)	7 (8.3)	49 (58.3)	7 (8.5)	3 (3.7)
Other	0 (0)	0 (0)	0 (0)	1 (1.2)	7 (8.3)	0(0)	22 (26.8)
p-value	0.2606	-	-	0.3845	0.8028	-	0.2153
Fisher exact		0.3077	0.3190			1.0000	

4.3.8 Secondary objective: to compare the difference in NMBA used between the consultant and trainee anaesthetists

A Pearson chi-squared for independence was used for the comparison of the NMBA chosen between the different grades of anaesthetist. The results were not statistically significant for the seven vignettes with the exception of the appendicectomy and neonate (Table 4.12). For the appendicectomy, the use of succinylcholine by trainees was 66/85 (77.6%) compared to 17/38 (44.7%) for consultants (p= 0.0017). The neonate vignette presented a greater variation in terms of NMBA used. Although the use of a NMBA in the "other" category was highest in both groups [16 (42.1%) and 28

Vignettes: 1. Appedicetomy; 2. Symptomatic hiatus hernia; 3. Asymptomatic hiatus hernia; 4. Caesarean section; 5. Bowel obstruction; 6. Renal failure; 7. Neonate for laparotomy

(34.6%)], a larger proportion of trainees chose to omit the use of a NMBA in this vignette [22 (27.1%) vs 2 (5.2%)]. Furthermore, there was a higher proportion of consultants who chose to use succinylcholine as their agent of choice compared to the trainees [12 (31.6) vs 14 (17.3)]. Thus, there is a significant association with regards to the choice of NMBA used for the neonatal vignette and the grade of anaesthetist (p=0.0297).

Table 4.12 Comparison of NMBA used by consultants and trainees

	Vignettes						
	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	6 n (%)	7 n (%)
Consultant	n=37	n=38	n=37	n=38	n=38	n=35	n=38
Succinylcholine	17 (44.7)	17 (44.7)	8 (21.6)	36 (94.7)	25 (65.8)	10 (27.0)	12 (31.6)
Rocuronium	13 (35.1)	10 (26.3)	10 (27.0)	1 (2.6)	10 (26.2)	6 (16.2)	8 (21.1)
Other	7 (18.9)	11 (29.0)	6 (16.2)	1 (2.6)	3 (7.9)	19 (51.4)	16 (42.1)
None	0 (0)	0 (0)	13 (35.2)	0 (0)	0 (0)	2 95.4)	2 (5.2)
Trainee	n=85	n=81	n=80	n=84	n=84	n=81	n=81
Succinylcholine	66 (77.6)	40 (49.4)	18 (22.5)	82 (97.6)	58 (69.1)	33 (40.8)	14 (17.3)
Rocuronium	15 (17.7)	26 (32.1)	30 (37.5)	2 (2.4)	24 (28.6)	15 (18.5)	17 (21.0)
Other	4 (4.7)	13 (16.0)	19 (23.8)	(0)	2 (2.3)	27 (33.3)	28 (34.6)
None	0 (0)	2 (2.5)	13 (16.2)	0 (0)	0 (0)	6 (7.4)	22 (27.1)
p-value	0.0015	0.3241	0.1355	0.3263	0.1608	0.3016	0.0297

4.3.9 Secondary objective: to describe the anaesthetist's definition of a modified RSII

The majority of the respondents, 97 (77.6%), considered the use of a NMBA other than succinylcholine to best describe the method of a modified RSII. The preferred definition of a modified RSII by the remainder of respondents can be seen in Table 4.13.

Table 4.13 Definition of a modified RSII according to respondents

Definition of a modified rapid sequence induction	**n (%)**
The use of a neuromuscular blocking agent other than succinylcholine	97 (77.6)
The use of a neuromuscular blocking agent other than succinylcholine AND the use of gentle bag mask ventilation prior to intubation	12 (9.6)
Other	11 (8.8)
The use of gentle bag mask ventilation prior to intubation	4 (3.2)
All of the above	1 (0.8)

Vignettes: 1. Appedicetomy; 2. Symptomatic hiatus hernia; 3. Asymptomatic hiatus hernia; 4. Caesarean section; 5. Bowel obstruction; 6. Renal failure; 7. Neonate for laparotomy

4.4 Discussion

To date there have been a number of surveys conducted internationally looking at the technique used when performing a RSII (11, 12, 14-16). With time and medical advancement there has been considerable variation from the originally described technique in terms of both pharmacological agents used and sequence of events (10). There is evidence to suggest such variation may be associated with years of anaesthetic experience and the clinical scenario which is presented.

Although the risk of pulmonary aspiration remains low, the morbidity and mortality with which it is associated, is one of the important considerations of airway associated complications. The overall ability of respondents to recognise the need for a RSII, including a cuffed endotracheal tube and CP, was only 72.6%. This is in contrast to the survey conducted in 2009 by Koerber et al. (11) where a RSII was chosen by 95% of participants for all vignettes with the exception of those including the hiatus hernia, which was influenced by the presence or absence of symptoms, 83% and 25% respectively.

Respondents were asked to indicate if they had had an incidence of confirmed or suspected aspiration in the preceding year. Accordingly the incidence of anaesthetist who experienced an episode of aspiration was determined to be 18.4%. An incidence of aspiration could not be calculated as each anaesthetist performs multiple anaesthetics per year and the total number performed by all the respondents was not available for this calculation. However, the high incidence of respondents who had experienced an episode of aspiration could be associated with an inability to recognise patients at risk for aspiration and thus perform an induction using the appropriate technique. Unfortunately, there is insufficient data to determine whether the cases of aspiration were in patients know to be at risk or whether they occurred in the absence of an identifiable risk.

The results of the Wits study have been affected by 2 vignettes in particular, namely the asymptomatic hiatus hernia and neonate in which only 33.0% and 49.1% chose to perform a RSII. There is a paucity of literature pertaining to the risk of aspiration in patients known with asymptomatic hiatus hernia undergoing a general anaesthetic. A study done in America showed that up to 20% of asymptomatic controls had an

undiagnosed hiatus hernia (113). However, with the risk of a greater residual volume despite appropriate fasting periods, one needs to consider whether or not a RSII would be more appropriate in managing these patients. In addition it should be determined whether the use of appropriate pharmacological measures against aspiration alone, such as H_2-receptor antagonists, would be sufficient in patients known with an asymptomatic hiatus hernia. In our study, there was no statistically significant difference in the use of RSII between the consultants and trainees for the asymptomatic hiatus hernia (p=0.1422). This is in contrast to Koerber et al (11) who found that the consultant were more likely to perform a non-RSII compared to the trainees (p=0.004)

Although 50.9% of respondents did not perform a RSII according to the definition used in the Wits study for the neonate, one needs to consider the current literature and practice when using this technique in the paediatric population. In a survey conducted in the UK including members of the Association of Paediatric Anaesthetists, it was found that only 40-50% of anaesthetists used CP during emergency surgery on a child (68), a rate similar to that found in the Wits study. The reason for this reduced incidence may be associated with two factors, namely the anatomical difference of the paediatric airway under eight years of age as well as the potential to distort the laryngeal view and thus potentially affect airway management.

It has been found that lateral displacement of the oesophagus occurs in a significantly greater proportion of children less than eight years of age when CP is applied [difference in rates was 30% (95% CI 14%-46%)] (69). Furthermore, Walker et al (70) found that the force necessary to occlude the airway by at least 50% in the less than eight years of age group, is significantly less with a mean of 10.5 N and as little as 5 N for those less than one year of age. Thus, use of CP at forces typically used for adults (30 N) could seriously compromise the ability to efficiently manage the paediatric airway in an emergency (70). However, the current recommendations for cricoid pressure in children is for between 22.4 N and 25.1 N (71). With the development of a controlled RSII as advocated for the paediatric population, the use of CP may further fall out of favour. When reviewing the rate of RSII for the neonate in the Wits study, in the absence of the use of CP and according to the controlled RSII technique (108), up to 67.50% of the respondents would thus potentially have performed a RSII appropriate for this age group.

In terms of induction agent chosen, the use of propofol by both consultants and trainees has exceeded that of thiopentone in the Wits survey. This is in keeping with the studies by Koerber et al (11) and Sajayan et al (15) and may additionally represent the limited access and experience most of the respondents have with regards to Thiopentone. For the bowel obstruction vignette, the use of etomidate by the majority of respondents, 57.9 %, is also in keeping with the findings by Koerber et al (11) in 2009 where it was the agent most commonly used by 46% of respondents. As they remarked, the choice of etomidate in this scenario is the result of recognising the potential for haemodynamic instability on induction in this patient population (11).

The practice of general anaesthesia for a Caesarean section showed some variation from the findings of Koerber et al (11)with regards to the induction agent used for this vignette in the Wits survey. Thiopentone was the most commonly used agent in the survey by Koerber et al (11) with 85% electing to use it . This is in contrast to our survey where propofol was used by the majority, 80.3%, and only 8.2% of respondents chose to use thiopentone. There is little consensus in the literature regarding the effects of these two different induction agents on both maternal and neonatal outcome. Parameters that have been assessed include haemodynamic stability on induction, awareness and time to arousal for the mother as well as Apgar scores for the neonate. However, most of the literature that is available comparing the outcomes of the different induction agents was published in the 1980's and 1990's (114-116). Additional studies would be necessary to determine whether or not there really is an impact on both maternal and neonatal outcome between these two induction agents.

When interrogating the different aspects of the original RSII (10) a number of differences from the original technique were seen, with additional variation compared to other international surveys on RSII (11, 14, 15). Originally, the dose of induction agent to be used was described as being a fixed, predetermined dose (10). However, most of our respondents, 49.6%, agreed that they would use a variable approach with regards a fixed or titrated dose of induction agent, dependent on the clinical scenario with which they are presented. Of the remaining respondents a larger proportion agreed that a titrated dose was more appropriate compared to a predetermined fixed dose (43.2% vs. 7.2%). This shows variation to the study by Koerber et al. (11) where there was no difference between the use of a fixed or titrated dose.

The use of succinylcholine as the agent of choice when performing a RSII is in keeping with Morris et al. (12), Koerber et al (11) and subsequently those by Rohsbach et al. (16) and Sajayan et al. (15). However, in contrast to these studies, in this Wits study it was consultants and not trainees who were more likely to use high dose rocuronium, particularly for the appendicectomy vignette. There is little evidence to suggest that the use of high dose rocuronium results in inferior conditions for securing the airway, especially when propofol is used as the induction agent (50, 81, 82). The additional benefit of early recovery from succinylcholine should intubation fail, may become less of a consideration once suggamadex becomes available in the state hospitals. However, the cost of suggamadex may further influence the scenarios in which it is deemed appropriate to use rocuronium instead of succinylcholine. Certainly, this drug may change the NMBA agent most commonly used for the performance of a RSII especially in an emergency or difficult airway scenario.

The technique for the use of a non-depolarising NMBA in the performance of a RSII may vary between a fixed dose and priming technique. It is evident from this Wits study that the most commonly used non-depolarising NMBA is rocuronium in a fixed dose by 84.6% of respondents. Although there is literature to suggest that a priming technique using any of the other NMBA is acceptable, the conditions for intubation and rapidly securing the airway are thought to be inferior. Furthermore, because of the variable onset there remains the risk of aspiration should the patient become weak with impaired swallowing (117, 118). It is interesting to note that whilst the literature quotes a priming dose of 10% (118) and this is the most frequently quoted dose by 54.5% of the respondents in this Wits study, there was a large variation in the priming dose range quoted. This may indicate the variable time to onset of the NMBA when used with this technique or subsequent additional modification according to the respondents' experience with the technique.

Finally, most respondents admitted to either always waiting for signs of unconsciousness (40.8%) or to only sometimes waiting for signs of unconsciousness (36.8%) prior to giving the NMBA in a fixed dose technique. This is in contrast to the original description by Stept et al. (10) but in keeping with practices described by Koerber et al. (11)and Sajayan et al. (15).

The use of an opioid prior to induction is another practice not in keeping with the original RSII technique. Overall the majority of respondents, 63.2%-94.8%, admitted to using an opioid prior to induction of anaesthesia, a finding consistent with practice in the studies by Rohsbach et al. (16), Koerber et al. (11) and Sajayan et al. (15). There is surprisingly little difference for use of the opioid across the seven vignettes, with greatest interest in the routine use of an opioid prior to induction of a general anaesthetic for a Caesarean section by 71.4% of respondents.

There have been a number of studies looking at the use of an opioid to blunt the intubation response when performing a general anaesthetic for a Caesarean section, especially in the setting of preeclampsia. Although both alfentanil and remifentanil have proven effective in this respect, there is concern over the need for respiratory support of the neonate especially if born prematurely (116, 119, 120). Considering the availability of effective alternatives such as lignocaine and magnesium sulphate, for blunting the intubation response, particularly in the setting of preeclampsia (121), a study comparing the efficacy of remifentanil, alfentanil and magnesium sulphate in terms of attenuating the intubation response and the need to support neonatal ventilation post-delivery, would be of benefit. Unfortunately, in this Wits study we failed to ask for specifics with regard to the opioid agent used and the indication for its use.

In this survey, although there was variation in technique across the different scenarios, there was a smaller variation in technique between consultants and trainees at Wits. This is in contrast to the study conducted by Koerber et al. (11) and Sajayan et al. (15) where it was found that not only the use of a RSII but also the agents used varied between the consultants and trainees. This difference was particularly evident with regard to the more common use of propofol instead of thiopentone for induction by consultants only [($p \leq 0.001$ and $p<0.001$ respectively (11, 15)]. In view of our findings, it stands to reason that trainees are likely to perform a technique based on that used by those who teach them, in this case the consultants. There was little difference in this Wits study with regards to the decision to use a RSII for the seven scenarios between consultant and trainees ($p=0.0954$ to $p=0.6386$).

There is still no internationally accepted definition for a modified RSII. The most commonly cited definition from our study was the use of a NMBA other than succinylcholine (77.6%). This is in contrast to the survey conducted by Erhenfeld et al. (14) where it was the use of gentle bag mask ventilation(chosen by 77% of respondents) in addition to preoxygenation and CP that best represented a modified RSII.

Chapter 5

5.0 Summary, limitations, recommendations and conclusion

5.1 Introduction

In this chapter a summary of the study is presented. It will further address the limitations and recommendations from the study. The overall study conclusion will be presented.

5.2 Study summary

5.2.1 Aim

The aim of this study was to describe the current practice of anaesthetists in the Department of Anaesthesiology at Wits when performing a RSII using seven clinical vignettes.

5.2.2 Objectives

The primary objectives of this study were:

- to determine the proportion of anaesthetists who recognise patients at risk of pulmonary aspiration;
- to describe the choice of induction agent used for a RSII;
- to describe the choice of NMBA used for a RSII;
- to describe the technique used when performing a RSII.

The secondary objectives of this study were:

- to compare the difference in technique used between the categories of anaesthetist;
- to compare the difference in induction agents used between the categories of anaesthetist;
- to compare the difference in NMBA used between the categories of anaesthetist;

- to describe the anaesthetists' definition of a modified RSII.

5.2.3 Summary of the methodology

A contextual, descriptive, prospective study was performed. A questionnaire including seven validated vignettes was used to survey the current clinical practice of RSII in the Department of Anaesthesiology at the University of the Witwatersrand.

The questionnaires were distributed to anaesthetists during the departmental academic meeting from July 2015 and February 2016. All anaesthetists were invited to participate in the study. Those who agreed to participate received an envelope containing an information letter and the questionnaire. Questionnaires were placed in the blank envelopes provided and then into a sealed box at the meetings and department tea room, to maintain anonymity. Participation in the survey was voluntary, thus, respondents could withdraw from the study at any time should they so choose.

A response rate of 60.1% was achieved. The findings were described and the data analysed using descriptive and inferential statistics.

5.2.4 Summary of the main findings

The overall ability to recognise the patient at risk for pulmonary aspiration 72,57% (95% CI 69,53%, 75,62%).

The results showed considerable variation to the originally described technique of RSII, in particular with regard to the induction agent, timing of NMBA administration and opioid use prior to induction. Propofol was the induction agent of choice by the majority of respondents with the exception of the bowel obstruction scenario where etomidate was preferred. This is in contrast to the originally described use of thiopentone. The majority of respondents either always or sometimes waited for signs of unconsciousness prior to administering the NMBA. Finally, opioids were administered by the majority of respondents prior to the induction of anaesthesia.

There was little variation in clinical practice between the different grades of anaesthetist, with the exception of the NMBA used for the appendicectomy and neonate scenarios. For the appendicectomy consultants were less likely to use succinylcholine

as the NMBA of choice whilst the neonate scenario showed variation in the alternative to 'other' category between grades.

The majority of respondents felt the term to best describe a modified RSII to be the use of a NMBA other than succinylcholine.

5.3 Limitations

The limitations of this study include a low response rate, particularly in the consultant category, which may contribute to non-responder bias particularly with regard to the secondary objectives. The response rate of consultants was only 52% of consultants currently working in the department of anaesthesiology at Wits. The low response rate amongst consultants may have occurred due to lower participation at the academic meeting. Furthermore, they may have chosen not to partake in the study for fear of scrutiny despite guaranteeing anonymity throughout the study process.

The low consultant response rate may have resulted in the secondary objectives being underpowered to find a difference between the grades of anaesthetist. As a result, conclusions that are drawn from these comparisons need to be interpreted with caution.

The use of a self-administered questionnaire has a number of limitations including failure to complete the questionnaire, an inability to obtain additional information or clarification from the provider as well as respondents and finally, the desire to provide an answer which is considered correct rather than answering according to actual practice.

The questionnaire did not allow for open response particularly with regards the seven vignettes. Thus, additional information regarding practice may not have been identified. This is of particular relevance to the neonate scenario in light of the current literature and change in practice when performing a RSII in the paediatric population. Open responses would have allowed for the collection of richer data and thus allowed further insights.

The results of this study are specific for the Department of Anaesthesiology at Wits. As a result, the conclusions that are drawn may not be generalisable to other anaesthesiology departments in South Africa.

5.4 Recommendations

5.4.1 Clinical practice

The need to recognise a patient at risk for aspiration is fundamental in determining whether or not a RSII technique is used for a general anaesthetic. In order to minimise the risk to "at risk patients", there should be ongoing education with regard to who is at risk and how best to perform a RSII. To this end the development of clinical guidelines regarding RSII in both the adult and paediatric patient should be considered. Of importance is that there is no technique that is appropriate for all eventual scenarios, thus, ongoing training and professional development are crucial to minimise the associated morbidity and mortality associated with aspiration.

5.4.2 Further research

There is a still a need to provide more comprehensive data with regard to various aspects of performing a RSII. Of relevance to the public setting is the potential for change in NMBA use when sugammadex becomes available and how this will influence practice. Additional studies look at RSII practices specific to the paediatric population would help to clarify whether or not current practices are in keeping with both the literature and international practices.

5.5 Conclusion

Pulmonary aspiration remains one of the leading causes of significant morbidity and mortality during airway management. The ability to correctly identify "at risk patients" is considered one the keys to preventing such risk. However, even once "at risk patients" have been correctly identified, there is a lack of consensus regarding the performance of a RSII as there have been multiple advances in understanding and pharmacology since the first description of this technique. Furthermore, the paediatric population itself provides additional challenges when aspiration is considered a risk

during airway management. Guidelines for the performance of a RSII should be considered in order to facilitate decision making and the practice of this technique. However, it must be emphasised that clinical guidelines are only a guide to practice as there is no single technique that is appropriate for all scenarios.

6.0 References

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7.0 Appendices

Appendix A

Graduate Studies Committee approval

Faculty of Health Sciences
Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172040

Reference: Ms Thokozile Nhlapo
E-mail: thokozile.nhlapo@wits.ac.za

14 February 2014
Person No: 927575
PAG

Dr LE Redford
9 Canterburg Complex
St Christopher Road
St Andrews EXT3
2193
South Africa

Dear Dr Redford

Master of Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *Variation in rapid sequence induction and intubation in a Department of Anaesthesiology: A clinical audit* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Appendix B

Human Research and Ethics Committee (Medical) of the University of the Witwatersrand

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M140126

NAME: (Principal Investigator)	Dr Lindsey Redford
DEPARTMENT:	Department of Anaesthesiology CM Johannesburg Academic Hospital
PROJECT TITLE:	Variation in Rapid Sequence Induction and Intubation in a Department of Anaesthesiology: A Clinical Audit
DATE CONSIDERED:	31/01/2014
DECISION:	Approved uncontionally
CONDITIONS:	
SUPERVISOR:	Mrs Helen Perrie

APPROVED BY: _____
Professor PE Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL: 02/05/2014

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C

Information letter

Date 2014

Re: Variation in rapid sequence induction and intubation in a Department of Anaesthesiology: a clinical audit

Dear colleague,

Hello, my name is Lindsey, I am one of the registrars in our department. For my MMED I will be conducting a clinical audit to look at the various practices of rapid sequence induction and intubation in different clinical scenarios. Approval to conduct this study has been obtained from Postgraduate Committee and the Human Research Ethics Committee (number) of the University of the Witwatersrand. The aim of this study is to ensure good clinical practice to improve both patient safety and anaesthetic teaching.

I would like to invite you to take part in this audit and fill in the questionnaire that follows. The questionnaire consists of 7 clinical vignettes aimed to determine current practice with regard to rapid sequence induction and intubation. You will be asked to select the drugs and technique you deem appropriate for each of these scenarios. The questionnaire is not to test your knowledge, but rather to understand the different practices used for rapid sequence induction and intubation during your daily practice. Completion of this questionnaire will take 10-15 minutes. Participation in the study is voluntary.

Agreeing to complete the questionnaire will be taken as implied consent, however, you may withdraw from participating in the study at anytime. No identifying information will be requested on the questionnaire. All completed questionnaires will remain confidential and anonymity ensured. Please place the complete questionnaire in the unmarked envelope provided. The sealed envelopes can be placed in the sealed box provided. Participation in the study will help to benefit you both in ensuring patient safety and improving your ongoing anaesthetic training. The results of the study will be made available to you if requested.

If you have any queries you can contact me on 083 383 6988 or send an email on Lindsey@iatrocell.com. Further queries may be directed to the head of the ethics committee Prof Cleaton-Jones on 011 488 4397.

Thank you for your time,

Lindsey Redford

Appendix D

Questionnaire

Variation in rapid sequence induction and intubation in a Department of Anaesthesiology: a clinical audit

Rapid sequence induction (RSI) is one of the cornerstones of anaesthetic practice. This survey seeks to examine the RSI techniques used by Anaesthetists in practice (not exam answers).

Gender:		
	Male	
	Female	

Your Grade? (Please tick one)	Consultant	Registrar	MO	Intern

Years of experience in above grade	0-5	6-10	11+

What method of induction agent administration do you use during a rapid sequence induction and intubation? (Please tick one)

Always give a calculated dose	
Always titrate the dose against response	
Vary your method depending on clinical scenario	

If a non- depolarising muscle relaxant is used, please indicate the agent and technique you prefer to use. (More than one agent may be selected)

Agent	Do you use a priming technique (what priming dose?)	Do you use a fixed dose technique
Rocuronium		
Atracurium		
Cisatracurium		
Vecuronium		
Pancuronium		

Do you wait for signs of unconsciousness before giving muscle relaxant during a rapid sequence induction? (Please tick one):

Always	
Never	
Sometimes	

Have you had a suspected/ confirmed aspiration in the last year?

Yes	
No	

Please tick which definition you consider to represent a modified rapid sequence induction and intubation

The use of a neuromuscular blocking agent other than succinylcholine	
The use of gentle bag mask ventilation prior to intubation	
Other	

Attached please find 7 clinical scenarios. For each of following scenarios tick your preferred techniques:

(All patients refuse regional techniques and there are no concerns about difficult intubation)

Thank you for your time.

Scenario		Airway		Induction agent				Muscle relaxant given on induction				Cricoid Pressure		Before induction agent				NGT inserted prior to induction		Bag mask ventilation	
														Opioid		Benzo					
		ETT	Other	Propofol	Thiopental	Etomidate	Other	Succinylcholine	Roccuronium (> 0.9 mg/kg)	Other	None	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
1. Appendectomy, emergency, 25 year male, >6 hr since last meal (supper), has abdominal pain, not dehydrated.																					
2. Knee arthroscopy, elective day case, 40 year male, endoscopy proven hiatus hernia.	Symptoms of reflux																				
3.	No symptoms of reflux																				
4. Emergency caesarean section, for HELLP syndrome with platelets of 60																					
5. Laparotomy for bowel obstruction, emergency, 80 yr female, septic and dehydrated.																					
6. Arterial-venous fistula insertion, elective, 40 yr male, chronic renal failure, autonomic dysfunction, normal potassium																					
7. 10 day neonate with distended abdomen for emergency exploratory laparotomy.																					

Appendix E

Koeber et al Questionnaire

Rapid Sequence Induction Techniques
An All Wales Survey of Practice

Rapid sequence induction (RSI) is one of the cornerstones of anaesthetic practice. This survey seeks to examine the RSI techniques used by Anaesthetists in practice (not exam answers).

Your Grade? (please tick)

Consultant	SAS/NCCG	SpR	SHO

For the following scenarios tick your preferred techniques:
(all patients refuse regional techniques and there are no concerns about difficult intubation)

Scenario		Airway		Induction agent				Muscle relaxant given on induction				Cricoid pressure		Before induction agent			
														Opioid		Benzo	
		ETT	Other	Thiopentone	Propofol	Etomidate	Other	Suxamethonium	Rocuronium (~0.9mg/kg)	Other	None	Yes	No	Yes	No	Yes	No
Appendicectomy, emergency, 25 yr male, >6 hr since last meal, has abdominal pain, not dehydrated.																	
Knee arthroscopy, elective day case, 40 yr male, endoscopy proven hiatus hernia.	Symptoms of reflux																
	No symptoms of reflux																
Caesarean section, elective, refuses regional techniques.																	
Laparotomy for bowel obstruction, emergency, 80 yr female, septic and dehydrated.																	

What method of induction agent administration do you use during a rapid sequence induction? (tick one box):

Always give a calculated dose	
Always titrate the dose against response	
Vary your method depending on clinical scenario	

Do you wait for signs of unconsciousness before giving muscle relaxant during a rapid sequence induction? (tick one box):

Always	
Never	
Sometimes	

Thank you for your time. Good luck in the prize draw!

Appendix F

Letter of correspondence with Dr Koeber

Subject: RSI questionnaire
From: Jason Koerber <jason.koerber@internode.on.net>
Date: 2013-11-05 12:31 PM
To: "lindseyr@mweb.co.za" <lindseyr@mweb.co.za>

Hi Lindsey,

Attached is a copy of the questionnaire that I used. A database was used to track who had replied and reminders were sent out to people who hadn't yet replied. Everyone who replied was put in a prize draw for an iPod nano (new and desired in 2007). It is crucial to achieve as high response rate as possible. For publication you need about a 70% response rate.

Good luck and I look forward to hearing about your study,

Regards,

Jason Koerber
Flinders Medical Centre, Adelaide, Australia

On 5 Nov 2013, at 6:37 pm, lindseyr@mweb.co.za wrote:

> Good afternoon,
>
> I am an anaesthesiology registrar at the Charlotte Maxeke Academic Johannesburg Hospital in South Africa.
> I am doing a study to look at the common techniques and practices of rapid sequence induction in our academic hospitals,
> similar to your study in Wales. Would it be possible to look at a copy of your questionnaire scenarios with the possibility
> of adapting them to our setting. There would be full disclosure and I would obtain you permission should it arise that
> I would like to use your questionnaire as a framework.
>
> --
> Kind Regards
>
> Dr Lindsey Redford
>
> Sent from MWEB Message Centre - CONNECT AND YOU CAN