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The preferences, experience and level of comfort of anaesthetists in managing difficult intubation and 'cannot intubate, cannot ventilate' scenarios

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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, Lize Buitenweg, declare that this research is my own work. It is submitted for the admission to the degree of Master of Medicine in Anaesthesiology in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

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11th day of April 2016

Abstract

Background: The "cannot intubate cannot ventilate" (CICV) scenario is a rare occurrence but can lead to significant morbidity and mortality if not managed appropriately. International data shows that anaesthetists lack knowledge of and fail to employ difficult airway algorithms.

Method: A prospective, contextual, descriptive study was done to determine the preferences, experience and level of comfort of anaesthetists in the Wits Department of Anaesthesiology to manage difficult intubations and CICV situations. A previously validated questionnaire was adapted for local use and distributed to all available anaesthetists.

Results: A total of 111 (88.1%) participants knew the location of the difficult airway trolley, but 43 (38.8%) stated that the trolley is not easily accessible.

Ninety two (73%) participants preferred the videolaryngoscope as first choice device when facing a difficult airway. The predominant second choice devices were the flexible fibre-optic scope, chosen by 52 (43%) and the intubating laryngeal mask, chosen by 48 (38.1%). The majority of participants had no experience with the retrograde wire set, optical stylet and rigid bronchoscope.

The most popular device for cricothyroidotomy, chosen by 47 (37.3%), was an IV cannula, but only 34.9% was comfortable with using this option. The majority of anaesthetists have no experience with the internationally recommended open surgical method. Sixty-three (50%) of the participants have experienced a CICV scenario in clinical practice.

Conclusion: Airway training can be improved in our department. The location of the difficult airway trolley is not known by everyone and many believe that it is not readily available in an emergency. The videolaryngoscope is the preferred difficult airway device and the IV cannula the first choice in a CICV scenario. There is a significant difference in the comfort level of consultants and registrars with the use of most advanced airway devices.

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List of abbreviations

ASA	American Society of Anaesthesiologists
CAFG	Canadian Airway Focus Group
CHBAH	Chris Hani Baragwanath Academic Hospital
CICV	Cannot intubate, cannot ventilate
cLMA™	Classic Laryngeal Mask Airway
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
DAS	Difficult Airway Society
GEM	Gum elastic bougie
HJH	Helen Joseph Hospital
ICU	Intensive Care Unit
ILMA™	Intubating Laryngeal Mask Airway
LMA™	Laryngeal Mask Airway
LT™	Laryngeal Tube
LTS™	Laryngeal Tube Suction
NAP4	Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society
PCK™	Portex Cricothyroidotomy Kit
PLMA™	ProSeal Laryngeal Mask Airway
RMMCH	Rahima Moosa Mother and Child Hospital
SASA	South African Society of Anaesthesiologists
SAD	Supra-glottic airway device
SLMA™	Supreme Laryngeal Mask Airway
UK	United Kingdom
WDGMC	Wits Donald Gordon Medical Centre

CHAPTER 1: Overview of the study

1.1 Introduction

This chapter is a brief overview of the study and includes the background of the study, the problem statement, the aim and objectives, as well as the research assumptions, demarcation of the study field, research methodology, significance of the study, research report outline and a summary.

1.2 Background

The “cannot intubate cannot ventilate” (CICV) scenario is a rare but serious occurrence in anaesthetic practise (1, 2), as illustrated by the case of Elaine Bromiley in the United Kingdom (UK) in 2005 (3). Anaesthetists generally have the necessary expertise to evaluate and predict difficult airways. This prediction is however not always accurate and unanticipated difficulties may arise. A simulation study done in a large teaching hospital in Glasgow, UK (4) demonstrated that the majority of anaesthetists and anaesthetic assistants are not well prepared for a CICV situation. Almost two-thirds of the participants in the study could not even locate the equipment needed to manage a difficult or failed intubation.

Several different guidelines have been published by various anaesthetic societies on how to manage the anticipated and unanticipated difficult airway (2, 5-8). The guidelines of the American Society of Anaesthesiologists (ASA) Task Force on the Management of the Difficult Airway were initially published as a result of the numerous peri-operative adverse events related to airway management. These guidelines are not simple to follow but offer a variety of options depending on the skills and preferences of the anaesthetist (9). In 2004, the Difficult Airway Society (DAS) from the UK published guidelines for the management of the unanticipated difficult intubation, of which an update was published in 2015 (7, 10). These guidelines have a sequence of flow-charts in which the authors suggest the use of back-up plans if the initial plan fails (7, 10). Similar guidelines have been published by the Canadian Airway Focus Group (CAFG) (11).

Established protocols help ensure that time critical management options are not ignored or delayed in emergency situations. Observation has however shown that adherence to these

protocols may be compromised in circumstances with high stress and time pressures. The "Vortex" approach was devised in 2008 by Australian anaesthetist Nicholas Chrimes. This approach uses an uncomplicated "cognitive aid", instead of the progression through a complicated algorithm. (2)

The South African Society of Anaesthesiologists (SASA) is the professional body for anaesthetists practising in South Africa. In 2008 they published recommendations for South African hospitals and clinics on suggested airway management resources in operating theatres. These guidelines include suggestions on airway assessment as well as necessary routine and emergency airway equipment required in the different settings. An update of these guidelines was published in 2014. (12)

In unanticipated difficult airway situations, early insertion of a supraglottic airway device (SAD) is now standard practice, as long as the patient has adequate mouth opening. The specific SAD chosen should be one that the anaesthetist is familiar with and that is easy to insert. While SADs are often effective, success cannot be guaranteed. (13)

The respective difficult airway guidelines all end with the CICV scenario, recommending either a needle or surgical cricothyroidotomy as the next step (2, 7, 9, 10). In an ASA Closed Claims Analysis of the 179 claims for difficult airway management from 1985 to 1999, the authors found that repeated intubation attempts were related to an outcome of death or brain damage in claims where a perioperative CICV emergency developed (14). It can be assumed that the anaesthetists involved in these claims did not manage to secure a surgical airway timeously.

Klein (15) emphasises the significance of prior experience in the development of skills for use in acute situations. It has been shown that proficiency in cricothyroidotomy performance requires repeated practice and a clear mental algorithm instead of episodic past experience (1).

1.3 Problem statement

The CICV scenario is a rare occurrence but can lead to significant morbidity and mortality if not managed appropriately (2, 16). It has been shown internationally that anaesthetists generally lack knowledge of difficult airway algorithms or fail to employ them in emergency

situations (4). Although many advances have been made in airway management, adverse respiratory events still form a large part of malpractice claims (14, 17, 18). Medical officers and registrars working in the Department of Anaesthesiology at the University of the Witwatersrand (Wits) are occasionally in a situation where help from a senior anaesthetist is not immediately available, should an airway emergency present itself. The preferences, experience and level of comfort of anaesthetists in this department to manage difficult intubations and CICV situations and use available airway adjuncts are not known.

1.4 Aim and objectives

1.4.1 Aim

The aim of the study was to describe the preferences, experience and level of comfort of anaesthetists in the Wits Department of Anaesthesiology in managing difficult intubation and CICV scenarios.

1.4.2 Objectives

The objectives of this study were to**:**

- describe the knowledge of anaesthetists regarding the location of the "difficult airway trolley" in the various hospitals affiliated to Wits;
- describe the preferences of anaesthetists with different airway devices and techniques when faced with a difficult intubation or CICV scenario; and
- describe the experience and comfort level of anaesthetists when managing a difficult airway or CICV scenario.

1.5 Research assumptions

The following definitions will be used in the study**.**

Anaesthetist: is a qualified doctor working in the Department of Anaesthesiology including medical officers, registrars and consultants**.**

Medical officer: is a qualified doctor practising in the Department of Anaesthesiology under specialist supervision**.** Medical officers with more than 10 years of experience are career medical officers and are regarded as consultants.

Registrar: is a qualified doctor who is registered with the Health Professions Council of South Africa as a trainee anaesthetist**.**

Consultant: is an anaesthesiologist who has completed all criteria and passed the required South African College of Medicine examinations, or equivalent. They are regarded as specialists in the field. Career medical officers are in included in this definition.

Difficult airway: for this study, a difficult airway will refer to a scenario where the anaesthetist involved has difficulty with either mask ventilation, laryngoscopic view of the vocal cords and/or intubation of the trachea.

CICV scenario: refers to the "cannot intubate, cannot ventilate" situation. This is an emergency situation in which the anaesthetist fails to secure the patient's airway and is unable to deliver oxygen to the patient's lungs.

1.6 Demarcation of study field

The study was conducted in the Department of Anaesthesiology, affiliated to the Faculty of Health Sciences of the University of the Witwatersrand. The associated hospitals include Chris Hani Baragwanath Academic Hospital (CHBAH), Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), Helen Joseph Hospital (HJH), Rahima Moosa Mother and Child Hospital (RMMCH) and the Wits Donald Gordon Medical Centre (WDGMC).

The Department of Anaesthesiology consists of 208 anaesthetists, including 22 medical officers, 112 registrars and 74 consultants.

1.7 Research methodology

A prospective, contextual, descriptive research design was followed in this study. The study population consisted of anaesthetists working in the Department of Anaesthesiology. In this study a convenience sampling method was used, questionnaires were distributed to all the accessible anaesthetists working in the Wits Department of Anaesthesiology. Inclusion and exclusion criteria were defined.

An extensive review of the literature was done and a questionnaire developed by Wong et al (16) in 2005 was identified as appropriate for the study. The questionnaire was adapted for local use and validated by four airway management experts in the Department of Anaesthesiology.

Data was collected by distributing questionnaires at academic meetings at the various hospitals as well as at combined departmental meetings, during the months of June to December 2015. Approval to conduct this study was obtained from the relevant authorities. This study was conducted according to the principles of the Declaration of Helsinki (19) and the South African Guidelines for Good Clinical Practice (20). Several measures were taken to ensure the validity and reliability of the study.

Data was captured onto spread sheets using Microsoft Excel® 2010 and analysed using GraphPad InStat® in consultation with a bio-statistician. Descriptive and inferential statistics were used.

1.8 Significance of the study

The CICV situation is a rare but serious occurrence in the practice of anaesthesia that has devastating consequences if not managed appropriately (2, 16). It has been shown internationally that anaesthetists generally lack knowledge and skill to manage CICV scenarios (4). It is therefore of paramount importance to determine whether anaesthetists working in the Department of Anaesthesiology are comfortable in managing unanticipated difficult airway and CICV scenarios. If the results of this study reveal that there is lack of experience and comfort in managing difficult airway and CICV scenarios, it may contribute to the development of an ongoing departmental educational programme.

1.9 Research report outline

The report will be discussed as follows:

Chapter 1: Overview of the study

Chapter 2: Literature review

Chapter 3: Research methodology

Chapter 4: Results and discussion

Chapter 5: Summary, limitations, recommendations and conclusion.

1.10 Summary

This chapter provided a brief overview of the study. Chapter 2, the literature review, follows.

CHAPTER 2: Literature review

2.1 Introduction

In 2005, an anonymous independent report on the death of Elaine Bromiley was prepared by Professor Michael Harmer (Professor of Anaesthetics and Intensive Care Medicine at the Wales College of Medicine, Cardiff) and published with permission of her husband, Martin Bromiley, for learning purposes. (3)

Elaine Bromiley was a 37 year old female who presented for routine endoscopic sinus surgery and septoplasty on 29 March 2005 at a well-staffed and well-equipped clinic. During the pre-operative assessment, done by a consultant anaesthetist, the only findings of note on history and physical examination were congenitally fused vertebrae in her neck and "slightly restricted neck movements". This however was noted not to be a problem during previous general anaesthetics. (3)

After induction of anaesthesia, the involved anaesthetist's airway plan was to insert a laryngeal mask airway (LMA™), but this technique failed, which was perceived to be as a result of inadequate depth of anaesthesia. An additional dose of the induction agent was administered but the anaesthetist was still not able to insert the LMA™ or to inflate the lungs with bag mask ventilation. At this stage, the patient's oxygen saturation started to deteriorate and her heart rate started dropping. The anaesthetist then proceeded to attempt tracheal intubation after giving a dose of atropine to treat the bradycardia and suxamethonium, but was unable to visualise the larynx. He was then faced with the CICV scenario and a second consultant anaesthetist was called to assist. (3)

Up to this point, the actions of the involved doctors were thought to be appropriate and in keeping with acceptable practise, but their subsequent management of the CICV scenario did not follow prescribed practice guidelines. For twenty minutes after the patient first became hypoxic, the anaesthetists persevered in trying to intubate the trachea, using different methods and adjuncts. Even with a qualified ear, nose and throat surgeon in theatre, they did not attempt a surgical airway. After insertion of an intubating laryngeal mask airway, they were able to improve her oxygen saturation to 90%, but continued with attempts at tracheal intubation through the LMA™, which were unsuccessful and led to

further desaturation. Only at this stage did they decide to abandon the procedure and allow the patient to wake up. The LMA™ was removed, an oral airway was inserted and the patient was taken to the recovery room once it was established that she was breathing adequately. She did however not regain consciousness and was later admitted to the intensive care unit where a definitive airway was established. She had suffered severe hypoxic brain damage and was taken off ventilatory support a week later and subsequently demised. (3)

During an interview with the involved anaesthetist, it was established that he did not keep track of time. He said that had he been aware of how much time had passed, he would have performed a surgical airway much sooner. This anaesthetist has been described by his colleagues as “a very diligent and caring doctor who practices careful anaesthesia”. (3)

This untimely death of a young, healthy mother of two young children, is just one example of how even experienced anaesthetists can be ill prepared and poorly trained to manage a CICV situation, with devastating consequences.

2.2 Pathophysiology of hypoxia

Hypoxia as a result of airway complications and failure to ventilate, has deleterious effects on the structure and function of essential organs, especially the heart and the brain. The high energy requirements in relation to the low energy reserves of neural tissue, make the brain particularly susceptible to hypoxia. Even though the brain makes up only 2% of total body weight, it is responsible for 20% of oxygen consumption. Under normal physiological circumstances, the higher demand for oxygen leads to a proportional increase in cerebral blood flow. During incidents of hypoxia, the brain is not capable of significant anaerobic metabolism as a result of the high metabolic rate of the neurons. The more prolonged the hypoxia, the more diffuse and extensive the regions of the brain that are affected. The most susceptible regions are the brainstem, hippocampus and cerebral cortex. Injury continues to progress and ultimately becomes irreversible if oxygenation is not re-established. Necrosis mainly results from acute cell death, but delayed apoptosis may also occur following the hypoxic episode. Even though it is essential to save the tissue, reperfusion of oxygenated blood may also lead to cell death, primarily due to the production of reactive oxygen species and inflammatory cell infiltration. (21, 22)

Cardiac muscle requires approximately 1.3 ml of oxygen per 100 g of myocardial tissue per minute, but receives about 8 ml per minute under normal physiological conditions. If the oxygen supply falls to critically low levels, energy metabolism changes from mitochondrial respiration to anaerobic glycolysis. At the same time, effective myocardial contractions decrease, the patient becomes bradycardic and eventually contractions terminate. Lactate and protons accumulate in cardiac myocytes, leading to acidosis, increased osmotic load and cellular oedema. Intracellular calcium rises, most likely as a result of the joint action of the Na^+/H^+ and Na^+/Ca^{2+} exchangers triggered by cellular acidosis. If sustained, this will ultimately result in cell necrosis. (22, 23)

Restoration of oxygenated arterial flow is essential to re-establish aerobic metabolism and save the hypoxic cardiac myocytes. Similar to neuronal tissue, the reperfusion in itself will however lead to further injury. “Myocardial stunning” is a type of reperfusion injury, which was defined by Braunwald and Kloner (24) as “prolonged, post ischemic dysfunction of viable tissue salvaged by reperfusion”. Even though the myocardium is viable and aerobic, it displays momentary contractile failure. Reactive oxygen species during reperfusion is presumably the basis of the contractile failure. Changes in calcium homeostasis, instead of “alteration of the contractile apparatus” are most likely the result of the production of reactive oxygen species and the cause of the dysfunction. (22-24)

2.3 Incidence of airway complications

The incidence of the difficult airway published in the literature varies considerably. This may be due to different definitions regarding the difficult airway, different patient populations and varying levels of clinician experience, making it difficult to compare figures. (11)

In 1990, a closed claims study of 1541 adverse anaesthetic outcomes (mostly occurring between 1975 and 1985) was published by the ASA. It revealed that adverse outcomes related to respiratory events were responsible for most of the claims (34%), of which 85% led to death or permanent brain damage. The majority of the respiratory events occurred due to one of three mechanisms: inadequate ventilation (33%), oesophageal intubation (18%) and difficult tracheal intubation (17%). Most adverse consequences were considered avoidable with pulse oximetry, capnometry or both. In 76% of the claims, care was judged to be substandard. (17)

In a subsequent closed claims analysis published by ASA in 2005, 179 claims for difficult airway management from 1985 to 1999 were reviewed. Claims were divided into two time periods, 1985-1992 and 1993-1999 (after introduction of the ASA Difficult Airway Guidelines) to compare outcomes. Death or brain damage for claims related to induction of anaesthesia decreased significantly from 1993-1999 compared to 1985-1992. This reduction may be as result of better airway management by following the ASA guidelines, but may also be due to improved safety with use of new airway devices such as SADs and awake intubation techniques. (14)

Although the closed claims studies give us access to information about adverse events, they have limitations that should be considered when interpreting the data. In these studies, there was no information about the number of anaesthetics performed during this time period. There is therefore no denominator to calculate the risk of anaesthetic injury. In addition to that, the closed claims datasets only collect data from cases that led to litigation. Some patients will not claim even after serious injury, while other patients will file claims without any obvious injury. Another limitation of the closed claims studies is that the information is collected and interpreted retrospectively. (18, 25)

A retrospective study by Connelly et al (26) in a tertiary teaching hospital in the United States in 2006, reviewed the management of unanticipated difficult airways over a seven year period. Over this time period, an unanticipated difficult airway occurred in 446 patients of the 168 000 general anaesthetics performed, making the incidence 0.26%. Face mask ventilation was only impossible in five of these patients and none of them required a surgical airway.

In 2011, Cook et al (27) published the results of the “Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society” (NAP4) regarding the major complications of airway management in all of the 309 National Health Service hospitals in the UK. It was a prospective study that included all the cases of complications of airway management that resulted in “death, brain damage, the need for an emergency surgical airway, unanticipated ICU admission, or prolongation of ICU stay”. A total of 133 complications related to anaesthesia occurred over the period of a year (airway complications in the intensive care unit or emergency department was audited separately).

The number of anaesthetics administered over the same period was approximately 2.9 million, making the estimated incidence of difficult airway incidents one in 22 000 cases. The authors however commented that this figure is most likely an underestimation and that several factors may have led to under-reporting. They stated that there may have been individual or institutional reluctance to release information due to expected litigation or investigation. Statistical analysis indicated that the actual incidence might be four times higher than reported by the involved hospitals. This was the largest study of its nature performed to date.

The "Saving Mothers 2008-2010: Fifth report on the Confidential Enquiries into Maternal Deaths in South Africa" provided statistics regarding airway complications for this country. Of the 121 anaesthesia related maternal deaths for these three years, 16 deaths were during general anaesthesia, of which 8 (50%) were as a direct result of failed intubation. (28)

These different studies give an indication of the incidence of complications related to airway management, but they also show that it is challenging to obtain accurate statistics.

2.4 Difficult airway algorithms

The ASA Task Force on management of the difficult airway defined a difficult airway as "the clinical situation in which a conventionally trained anaesthesiologist experiences difficulty with facemask ventilation of the upper airway, difficulty with tracheal intubation, or both. The difficult airway represents a complex interaction between patient factors, the clinical setting, and the skills of the practitioner." (9)

Several algorithms and guidelines for management of the difficult airway have been formulated by national societies as well as by local institutions (2, 5, 7, 11). Developing guidelines for the emergency management of the difficult airway poses a unique challenge. The reason for this is that there are numerous options and the most appropriate choice depends on the specific clinical setting. These guidelines therefore need to be simple and easy to follow but they also need to provide enough guidance for a wide range of clinical scenarios. (2)

The ASA Practice Guidelines for the Management of the Difficult Airway

The ASA published the "Practice Guidelines for the Management of the Difficult Airway", which was initially issued in 1993, in response to the closed claims study (6). These guidelines have been updated twice since the original publication (9, 29). According to the ASA, practice guidelines are "systematically developed recommendations" that assist the physician and patient to make appropriate health care decisions (9). These recommendations can be "adopted, modified or rejected" according to the requirements and limitations of an institution, but they are not supposed to substitute local protocols and their use cannot guarantee any definite result (9).

The evidence for the preparation of the ASA guidelines was obtained from two major sources: scientific evidence from literature published in peer-reviewed journals, and opinion-based evidence from survey findings of expert consultants and active ASA members. The consultants and ASA members, who participated in the survey, strongly agreed that anaesthesiologists ought to have a pre-planned strategy for intubation of the difficult airway. This should include an approach to an awake intubation for an anticipated difficult airway, a patient who is difficult to intubate but who can still be ventilated, and for the emergency CICV scenario. The most recent ASA guidelines include suggestions on evaluation of the airway, preparation for difficult airway management, strategy for the intubation of the difficult airway, strategy for extubation of the difficult airway and follow-up care. (9)

In these guidelines, non-invasive interventions include awake intubation techniques, video-assisted laryngoscopy, intubating stylets or tube-exchangers, SADs, intubating laryngeal mask airways (ILMA™), rigid laryngoscopic blades of different design and size, fibre-optic intubation and lighted stylets or light wands. Confirmation of tracheal intubation should be done using capnography. Regarding invasive airway access, the guidelines suggest surgical or percutaneous airway, jet ventilation or retrograde intubation. (9)

The algorithm based on these guidelines starts with advice on airway assessment as well as management options that should be considered before induction of anaesthesia. It then goes through a series of steps, stating options at each stage of the management of the difficult airway scenario. (9)

Critique of this algorithm is that it is complicated and allows for too many management choices at each stage, making it difficult to recall and apply in an emergency situation. (2, 7)

Canadian Airway Focus Group recommendations

In 1998, the Canadian Airway Focus Group (CAFG) developed "strategies for the management of the unanticipated difficult airway", of which an update was published in 2013. The focus group involved in the update included nineteen experts with backgrounds in anaesthesia, emergency medicine and intensive care. For the development of these guidelines, literature searches were conducted and the quality of the evidence was reviewed. Where the quality of the evidence was poor or lacking, "expert opinion" was sought through consensus. (8, 11)

An algorithm for "difficult intubation encountered in an unconscious patient" was developed based on the CAFG guidelines. This straightforward algorithm progresses through a limited number of steps, including the "primary approach to tracheal intubation" (Plan A), "the alternative approach to tracheal intubation" (Plan B), and an exit strategy. (11)

For the primary approach (Plan A) to succeed, it is suggested that conditions should be optimised by adequate preparation, familiarity with airway adjuncts, proper positioning of the patient and appropriate pharmacotherapy. If difficult direct laryngoscopy is encountered, there is strong evidence for external laryngeal manipulation to improve the view. The tracheal tube introducer is an effective aid when restricted view of the larynx is encountered and the CAFG suggests its immediate availability at all airway management locations. If mask ventilation is found to be difficult, exaggerated head extension (unless contra-indicated), placement of correctly sized oropharyngeal and/or nasopharyngeal airways and using a "two-handed technique" are suggested. (11)

Should the initial intubation plan (Plan A) fail after two attempts, but ventilation is still adequate, a different device or operator (Plan B) should be employed. Various alternatives to direct laryngoscopy have been proven to be effective, including the ILMA™, intubating lighted stylets, several different videolaryngoscopes and fibreoptic intubation devices. The CAFG recommend that all anaesthetists should be familiar with at least one of these alternative techniques and that the equipment should be easily accessible. Attempts at

tracheal intubation must be minimised as repeated attempts increases patient morbidity. (11)

Exit strategies in an adequately oxygenated unconscious patient includes awakening the patient if feasible and appropriate, proceeding with surgery using a face mask or SAD, obtaining equipment and/or more skilled help or, in rare circumstances, proceeding with surgical airway access. (11)

If oxygenation is unsuccessful, an emergency strategy is suggested without delay. The emergency strategy involves calling for help, one attempt at a SAD if not already attempted and progression to a cricothyroidotomy if unsuccessful. The CAFG suggests capnography after tracheal intubation or cricothyroidotomy to confirm correct tube or cannula placement. (11)

The CAFG recommendations include special considerations with regards to obstetric and paediatric airway management. (11)

Difficult Airway Society Guidelines for the management of the unanticipated difficult airway

In 2004 the Difficult Airway Society (DAS) from the UK developed guidelines for the management of the unanticipated difficult intubation in an adult, non-obstetric patient (7). In response to the findings of NAP4 (27), Frerk et al (10) published an update of the DAS guidelines in 2015, to keep up with the change in clinical practice, the development of new pharmacological agents as well as the introduction of new equipment such as videolaryngoscopes. These guidelines provide a sequence of plans to manage the unanticipated difficult airway in order to assist the anaesthetist in the decision-making process in an emergency situation. Human factors are recognised and discussed in the guidelines, as a detailed analysis of the NAP4 study identified “human factor influences” in all the cases of adverse airway outcomes.

Plan A consists of facemask ventilation and the initial tracheal intubation plan. Optimal intubating conditions should be ensured by proper positioning, adequate pre-oxygenation and appropriate choices of an induction agent and a neuro-muscular blocking agent. Suggestions to improve difficult mask ventilation include airway manoeuvres such as “chin-

lift" and "jaw-thrust", as well as oro- and nasopharyngeal airways. The guidelines suggest that all anaesthetists should be trained in using a videolaryngoscope and that it should be readily available. During laryngoscopy, external laryngeal manipulation should be applied if the laryngeal view is poor and the use of a gum-elastic bougie (GEM) should be considered. The DAS agrees that attempts at laryngoscopy should be limited to three, as multiple attempts carries significant morbidity for the patient and can lead to a CICV situation due to airway trauma. Tracheal intubation should be confirmed with capnography. (10)

If Plan A has failed, Plan B should be employed, which consists of maintaining oxygenation by inserting a SAD, preferably a second generation SAD. If the insertion of the SAD was successful and ventilation has been confirmed with capnograhy, the anaesthetic team should stop and consider the following options: allow the patient to wake up, intubate the trachea through the SAD with a fibre-optic scope, proceed with the surgery or in rare circumstances, proceed to a surgical airway. If Plan B fails after three attempts (with different types or sizes of SADs), Plan C should be implemented. (10)

Plan C involves a final attempt at face-mask ventilation. If it is possible to oxygenate the patient with face-mask ventilation, the neuro-muscular blockade should be reversed and the patient should be woken up. If face-mask ventilation is impossible, it is advised to fully paralyse the patient again to optimise intubating conditions and one last attempt should be made at rescuing the airway with a non-surgical technique. Re-paralysing the patient is a new recommendation and this suggestion is different from all of the other guidelines. If it fails, Plan D should be implemented without delay. (10)

Plan D involves obtaining emergency "front-of-neck" access. The scalpel cricothyroidotomy has been shown to be the quickest and most reliable technique of securing the airway in a CICV situation and it is the technique that is advised in these guidelines. (10)

These guidelines end with post-operative care and follow-up of the patient. The anaesthetist should inform the patient about the airway difficulties experienced and an "airway management plan" should be documented. (10)

The Vortex approach

In 2008, Nicholas Chrimes, an Australian anaesthesiologist, in conjunction with medical and nursing staff experienced in anaesthetics, emergency medicine or intensive care, devised the Vortex approach. This approach serves as a straightforward “cognitive aid”, to encourage a structured approach rather than “progression through a linear algorithm”, when dealing with a difficult airway. (2)

The Vortex model emphasises that alveolar oxygen delivery is the most important goal of airway management, even if it is achieved with a different method than what was initially planned. The secondary goals such as carbon dioxide elimination and airway protection may have to be compromised. Repeated attempts at trying to establish a definitive airway with excessive airway manipulation may turn a situation where oxygen delivery was possible, into a CICV situation due to airway trauma and oedema. (2)

The three frequently used non-surgical techniques to ensure ventilation and oxygen delivery are a face-mask, a SAD and an endotracheal tube. In case of the unanticipated difficult airway, success at establishing delivery of oxygen will be most likely with techniques that the anaesthetist is most comfortable with. The Vortex approach suggests only three attempts at each of the non-surgical methods. If optimal attempts have been made and there is no sign of recovery and spontaneous ventilation, progression to a surgical airway is indicated, irrespective of the patient’s oxygen saturation. The surgical methods can be classified into the emergency surgical airway and the definitive surgical airway. (2)

The Vortex model metaphorically describes airway management as a funnel (Figure 2.1). The horizontal surface at the top of the funnel is termed the “Green Zone”, which describes the situation where alveolar oxygenation is maintained and there is time to consider alternative management options before commencing with any further airway manipulations. (2)

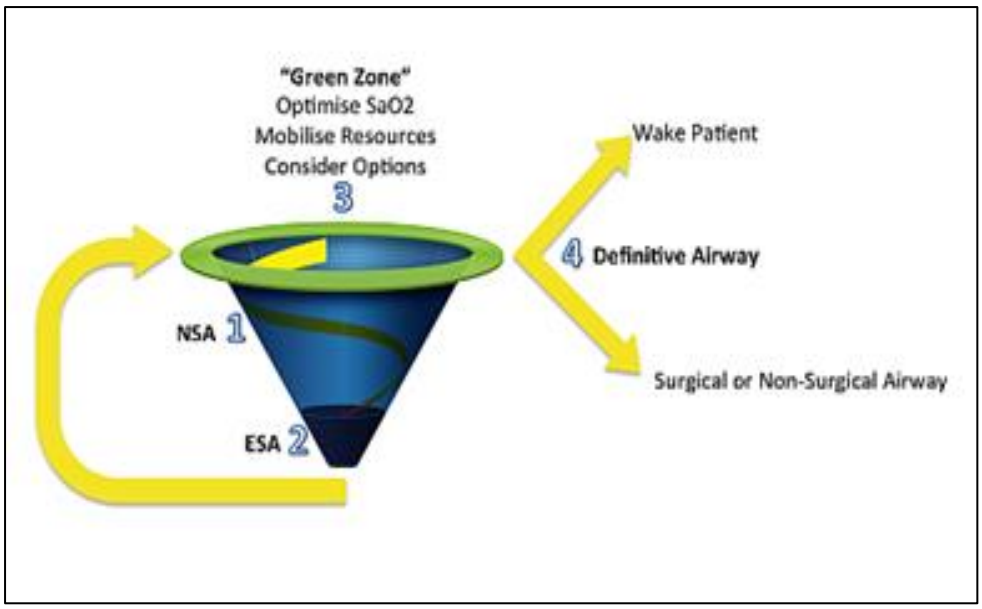

Figure 2.1 The airway management funnel of the Vortex model

The funnel component symbolises any situation where airway patency is not ensured and "optimal attempts" at the three non-surgical airway techniques should be made in any order appropriate to the clinical situation, as seen on the overhead view of the funnel in Figure 2.2. The narrowing of the funnel emphasises the fact that time and options are diminishing and eventually spirals down to where all non-surgical techniques are exhausted. In this case, the anaesthetist should progress to a surgical airway without delay.

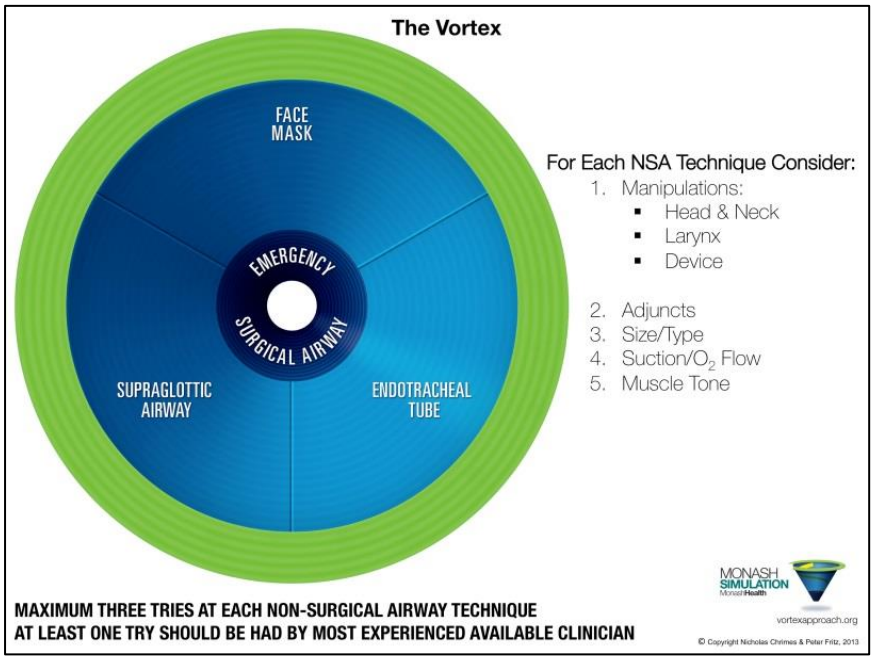

Figure 2.2 The overhead view of the funnel of the Vortex model

The Vortex approach encourages five “optimisation strategies” that should be employed in the emergency situation of a difficult airway, including:

- *manipulation manoeuvres* of the head and neck and applying external laryngeal pressure;
- using airway *adjuncts*, such as oropharyngeal airways, introducers, bougies and stylets;
- changing the *size and type* of equipment;
- *suctioning* the airway to remove blood and secretions; and
- optimising *pharyngeal muscle tone*, either by giving a muscle relaxant to optimise intubating circumstances or by allowing the patient to wake up and maintain his/her own airway. (2)

SASA Airway Management Recommendations

In 2008, SASA published recommendations for South African hospitals and clinics on suggested airway management resources in operating theatres. These guidelines include suggestions on airway assessment as well as the necessary routine and emergency airway equipment required in the different settings. They included both the 2004 DAS and 2003 ASA difficult airway algorithms and suggestions on difficult airway management. An update of these guidelines was published in 2014. This update includes new airway equipment that was introduced since the previous guidelines were published as well as the 2013 ASA difficult airway algorithm, the 2012 DAS guidelines for extubation of a difficult airway and the Vortex approach. (12)

2.5 Airway management equipment

In 2013 Paolini et al (30) published a review article in which they stated: “Thirty years ago, anaesthesiologists had to rely solely on bag-and-mask ventilation, and/or direct laryngoscopy (DL) with tracheal intubation to oxygenate the patient. Several alternative tools are now available including a variety of supraglottic devices, intubating laryngeal mask airways, gum elastic bougies or stylets, fibreotic bronchoscopes, modifications of blades, and videolaryngoscopes (VL’s)”. In this section, these and other airway devices will be briefly discussed.

Oropharyngeal and nasopharyngeal airways

To maintain a patent airway in an anaesthetised patient, simple manoeuvres like the jaw-thrust and/or extension of the atlanto-occipital joint are often sufficient. If these techniques are ineffective, the pharyngeal obstruction must be alleviated and the easiest way to ensure this is by inserting an oropharyngeal or nasopharyngeal airway. (31)

The oropharyngeal airway is designed to open the pharynx by separating the tongue and epiglottis from the posterior pharyngeal wall thereby creating an artificial airway. The most widely used oropharyngeal airway is the Guedel airway. The Guedel airway is available in a selection of sizes. These devices may function as a bite block in an intubated patient, but dental damage may occur. In a patient whose pharyngeal reflexes are still present, inserting an oral airway may lead to gagging, retching or laryngospasm. (31)

The nasopharyngeal airway should be inserted through the nares and passed along the floor of the nasal passage to beyond the soft palate to allow the tip to lie in the oropharynx, above the epiglottis. To prevent loss of the tube into the nose and limit depth of insertion, it has a flange or “lip” at the proximal end. The right size can be measured from the tip of nose to the trachus of the ear. Nasopharyngeal airways are better tolerated than oropharyngeal airways during light anaesthesia. Insertion may be complicated by epistaxis and their use should be avoided in patients with a known coagulopathy. (31)

Bougies and stylets

If the larynx cannot be visualised during laryngoscopy, or only the epiglottis is visible, intubation can be achieved by either manipulating the curvature of the endo-tracheal tube with a plastic-coated pliable metal stylet or by passing a “gum-elastic bougie”(GEM) into the trachea and rail-roading the tracheal tube over it (31). The GEM was designed in the 1970’s by Dr. P Venn as the “Eschmann Tracheal Tube Introducer” (32). A study done by Gataure et al (33), compared the efficacy of the stylet and the GEM in a 100 simulated difficult intubations. The GEM was successfully placed in the trachea after two attempts in 96% of patients, while the intubations with the intubating stylet were only successful after two attempts in 66% of cases. These authors recommended that the GEM should be easily accessible and used in preference to a stylet when the view of the larynx is poor.

Kidd et al (34) evaluated the two signs that are used in confirming tracheal placement, namely “clicks” that are produced when the tip of the bougie slides over the tracheal cartilages and “hold-up” when the bougie is advanced and the tip reaches the smaller bronchi. Out of 98 cases, “clicks” were documented in 88 cases and “holp-up” occurred at 20 to 40 cm in all cases of correct tracheal placement.

The GEM has been shown to be extremely effective due to its angled tip and the “memory” of the material to keep the curvature (31). In a study done by Latto et al (35) in 2002, 199 out of 200 difficult airways were successfully intubated with the GEM, of which 89% of first attempts were successful. Nolan and Wilson (36) evaluated the routine use of the GEM to aid intubation, versus conventional intubation. In cases where only the epiglottis was visible, the use of a GEM was only ten seconds longer than conventional intubation and the bougie was used in three cases where conventional intubation failed. The incidence of a sore throat and hoarseness between the two groups was not significantly different.

Light wand and Trachlight™

The lighted stylet or light wand developed from the intubating stylet to allow for trans-illumination of the trachea as an aid to position the tracheal tube correctly. The original devices are now essentially outdated, as they have been replaced by newer improved developments such as the Trachlight™ and optical stylets. The Trachlight™ is a form of blind intubation and was designed to enable intubation without laryngoscopy. In a clinical trial by Hung et al (37), 950 elective surgical patients were divided into two groups, either to be intubated via direct laryngoscopy or using the Trachlight™. The time to intubation was similar in both groups but the Trachlight™ group had a significantly lower incidence of airway trauma (10 versus 37 patients) and sore throat post-operatively. Success rates of intubation were similar in both groups, but the ease of intubation with the Trachlight™, in contrast to laryngoscopy, did not appear to be affected by the anatomical variations of the upper airway. (31, 37)

Supra-glottic airway devices

The SAD has transformed airway management as it provides a very effective alternative to endo-tracheal intubation and face mask ventilation. It has also been proven to be an excellent rescue device when faced with a difficult intubation or CICV scenario and it is

recommended in all the difficult airway algorithms for this purpose. In a study by Parmet et al (38), the SAD was successful in 94% (16 out of 17) of cases for rescue ventilation in a CICV scenario. (39)

Some common features of SADs are:

- an inflatable cuff (bowl) that is placed above the level of the larynx;
- laryngeal visualisation is not needed for insertion (can be inserted blindly);
- soft distal tip that lodges in the proximal oesophagus behind the cricoid cartilage;
- tracheal isolation from gastric contents cannot be ensured if reflux or vomiting occur;
- large bore airway tube can serve as a conduit for other devices such as endo-tracheal tubes or fibreoptic scopes; and
- standard 15 mm connector. (31)

The original SAD was the classic laryngeal mask airway (cLMA™), which came into use in 1988. This device has been extensively studied and its use is widely advocated in the literature. It is used in approximately 50% in anaesthetics in the UK. Limitations of the cLMA™ are however that is does not protect against aspiration and does not allow for ventilating pressures of more than 20 cmH_2O. The higher incidence of obesity in the surgical population (and therefore higher incidence of gastro-esophageal reflux), the rise in laparoscopic procedures, as well as the fact that more procedures are being done in the lithotomy position, have limited its use in certain settings. (40)

The ILMA™ or Fastrach™ was designed to aid tracheal intubation, usually using a blind technique, but can also be assisted with a fibreoptic scope. The ILMA™ was manufactured by the same company as the original cLMA™, but has a significantly different design. It has a shorter, wider airway tube with a 110° angle, constructed of stainless steel covered with silicone. The device comes with a soft silicone tracheal tube that is specifically designed to easily pass through the curve of the airway tube. (31)

When the ILMA™ became available in 1997, Kapila et al (41) did a preliminary assessment of the device in 100 patients. Intubation was successful in 93 patients, and seven of the failures occurred during the first 20 intubations. This demonstrated that there is a learning

curve associated with the use of the ILMA™. Baskett et al (42) followed with a multicentre trial in 1998 where the ILMA™ was used in 500 patients by 17 different anaesthetists. The success rate of blind intubation was 96.2 % (481 cases). Of the 19 failed intubations, 17 occurred within the anaesthetist's first 20 attempts, confirming the learning curve suggested by Kapila. The authors recommended that the ILMA™ should form part of the difficult airway equipment in theatres and emergency departments. In a review by Caponas (43) of nine studies that evaluated the ability of the ILMA™ to facilitate blind intubation, the success rate of intubation was 95.7% in 1110 patients included in the various trials.

The Laryngeal Tube (LT™) was first manufactured in 1999 and the initial design has since then been modified several times. It consists of airway tube with a distal cuff (designed to lie in the oesophageal inlet) and a larger proximal cuff (to lie in the oropharynx). Ventilation occurs through openings between the two cuffs. A study by Ocker et al (44) in 2002, compared the LT™ with the LMA™ in 50 patients undergoing general anaesthesia. Ventilation and oxygenation of the two devices compared well, and the LT™ allowed for slightly higher ventilation pressures. Cook et al (45) followed with a similar study in 2003 in 72 patients, that also showed that there were no significant differences in the adequacy of ventilation and that both devices had a similar incidence of post-operative complications. A major drawback of the LT™ is that there is a high frequency of partial or complete airway obstruction (2-40%) because of its small ventilation orifices and the fact that the tube-like shape allows for axial rotation in the airway. (31, 45, 46)

Cook (40) classifies SADs into first generation and second generation devices. The first generation devices include the simple airway tubes discussed above, while the second generation devices are those designed with the ideal of decreasing the risk of aspiration of gastric contents. These include the LMA™ Pro-Seal (PLMA™), the supreme LMA™ (SLMA™), the i-gel™, the laryngeal tube suction (LTS™) and the Combitube™.

The PLMA™ was introduced in 2000 and is a valuable addition to airway management. It's design provides a better seal during controlled ventilation and it has a port for the passage of a gastric drainage tube (31, 47). A review article by Cook et al (47) revealed that first time success with insertion of the PLMA™ is 8% lower than the cLMA™ (85% versus 93%). If a bougie-guided technique is however used to insert the PLMA™ (by placing a bougie into the

oesophagus with the aid of a laryngoscope and rail-roading the PLMA™ over it) the success rate is almost 100%. This review also found that the PLMA™ has a 50% better airway seal that the cLMA™ and it has been used successfully in laparoscopic and abdominal surgery as well as in obese patients. The PLMA™ has been effective in airway rescue situations and might be the most logical choice for failed intubation after a rapid sequence induction (31, 48).

The supreme LMA™ (SLMA™) was introduced in 2009 (31). It is a single use device with design features of both the ILMA™ (fixed curved airway tube for easy insertion) and the PLMA™ (port for gastric access, bite block and high seal cuff to prevent aspiration) (49). A pilot study by Van Zundert and Brimacombe (50) in 22 patients showed that successful insertion at first attempt was obtained in all patients as well as insertion of a gastric tube through the port. The average seal pressure was 37 cmH_2O, which is significantly higher than the cLMA™. Several studies done comparing the SLMA™ to the Pro-Seal™, found that ease of insertion and success of gastric tube insertion were similar and that the seal pressure was either similar or higher in the PLMA™ (49, 51, 52). The SLMA™ has been successfully used in the prone position. In a study by López et al (53), 40 patients were positioned prone and the SLMA™ was inserted after induction with propofol. All patients could be adequately ventilated and a gastric tube was successfully passed in all of them. The incidence of blood staining of the device and a sore throat post-operatively was 7.5% for both. In another study by Sharma et al (54), 205 patients for elective spine surgery were effectively ventilated with a SLMA™ and no cases of aspiration were recorded. The SLMA™ has also been described as an effective rescue airway even in a case where the patient was at very high risk of aspiration of gastric content (55).

The i-gel™ is a cuffless SAD made of “medical grade” elastomer gel. It has a short wide airway tube, an “anatomically” shaped bowl that does not need to be inflated, an elliptically shaped stem, an internal bite block and a tube permitting drainage of gastric content (31). In a study by Gatward et al (56) in 100 elective patients, first attempt insertion were successful in 86 patients. The median leak pressure obtained was 24 cm H_2O and one episode of regurgitation (but not aspiration) occurred. A study comparing the use of the SLMA™ to the i-gel™ by airway novices was done in 80 patients undergoing breast surgery by Razazzi et al (57). First time insertion success was significantly higher (77% to 54%) with the SLMA™ than

the i-gel™ and a higher seal pressure and more effective ventilation was found with the SLMA™.

A modification of the LT™ was introduced in 2002, namely the Laryngeal Tube Suction (LTS™), of which an upgraded version, the LTS II™ was introduced in 2005. The LTS II™ has similar pharyngeal seal than the PLMA™ and appears to be an improvement of its predecessor (31). Evidence regarding the ease of insertion and the frequency of airway obstruction is still lacking and more studies should be conducted to compare it with the other second generation SADs (58).

The Combitube™ is theoretically different to other SADs as it is designed to provide effective ventilation after being blindly placed in either the oesophagus or trachea. Similar to the LT™, it has two cuffs. After blind insertion, the large proximal cuff is inflated to secure placement, and then the distal smaller cuff is inflated. Ventilation is first attempted through the first lumen that opens between the two cuffs. If this is successful, it means that the distal cuff is in the oesophagus. If the first lumen does not provide ventilation, the second lumen is tried, which if successful, will mean that the distal cuff entered the trachea. If the distal end is in the esophagus, the second lumen can be used to insert a gastric drainage tube. Complications with the use of the Combitube™ occur more frequently than in other SADs and oesophageal rupture have been reported. The Combitube™ may still play a role in the pre-hospital emergency setting, but not in routine anaeasthesia. Due to its cost, possible confusion with the different lumens and trauma associated with insertion, it has largely been replaced by other SADs. (31, 59)

SADs are complex because of the vast availability of devices and variants of each. For many of the newer generic devices not discussed here, there is not enough research to advocate their use and the ones that have been researched shows very little if any advantage over the cLMA™. Regarding second generation SADs, such as the SLMA™ and the PLMA™, evidence shows benefits and potential increase in safety compared to the cLMA™. (31)

Direct laryngoscopes

Laryngoscopes are instruments designed to obtain a view of the larynx and facilitate tracheal intubation. The two broad categories include “direct line of sight devices” such as the popular Macintosh laryngoscope and “indirect line of sight devices” which are optical

laryngoscopes with either a fibreoptic bundle, sequence of lenses or prisms, or small cameras to convey the image to the user. This allows the user to "see around corners", in other words the line of sight doesn't need to be direct. In this category, videolaryngoscopes are becoming increasingly popular. Laryngoscopes can also be divided into rigid laryngoscopes and flexible scopes. (31)

Intubation through visualisation of the larynx was popularised by Sir Robert Macintosh and Sir Ivan Magill in the 1940s. The Macintosh laryngoscope blade is slightly curved and the tip was designed for insertion anterior to the base of the epiglottis in adults. A variety of other laryngoscope blades are also available, including several blades with a straighter design than that of the Macintosh (for example the Miller and Seward designs). The Polio laryngoscope blade has the same curved design as the Macintosh, but the angle between the handle and the blade is increased from 90° to 135°, enabling easier insertion of the blade in patients with difficult anatomy such as restricted neck extension and large breasts. The McCoy blade has a hinge at the tip that can be controlled by a lever on the handle. By flexing the tip, further elevation of the vallecula and epiglottis can be obtained. It has been shown however that it does not improve a grade four laryngoscopic view (in other words if the epiglottis cannot be visualised). (31, 60, 61)

Rigid optical laryngoscopes

Apart from the fact that rigid optical laryngoscopes removes the need for a "direct line of sight" they also offer the potential advantages that they have the ability to obtain a view of the larynx with limited mouth opening and the operator does not need to apply the same amount of force than with direct laryngoscopy. This leads to decreased cardiovascular stimulation and enable their use in awake patients (with topical anaesthesia of the airway only).

Rigid optical laryngoscopes can be divided into three groups based on their design, namely:

- in the form of a optical or videostylet, with the device inserted into the endotracheal tube as a guide;
- a device with an incorporated channel that acts as a conduit for the endotracheal tube; and

- bladed laryngoscopes (or videolaryngoscopes) without a channel, that requires an independent stylet to guide endo-tracheal tube insertion. (31, 62)

Optical stylets consist of either a pre-formed rigid or pliable metal introducer enclosing an optical system (usually a fibreoptic system). The optical system allows the image from the tip of the stylet to be viewed at the distal end either directly or displayed on a camera screen. A tracheal tube is pre-loaded onto the stylet and advanced over it through the vocal cords. To avoid trauma to the trachea, it is suggested that the stylet itself should not be advanced into the trachea. Examples of the optical of videostylets include Bonfils™ intubating fibrescope, the Shikani Optical Stylet™, the Levitan FPS™ and the SensaScope™. In a study done by Bein et al (63), the Bonfils™ intubating fibrescope was used as the first choice for airway rescue in patients presenting for cardiac surgery. Intubation via conventional direct laryngscopy failed in 25 out of 1430 patients during the study period. Using the Bonfils™, 22 out of the 25 patients were successfully intubated on the first attempt and two more on the second attempt. Most other optical stylets lack formal assessment and have not been studied extensively. (31)

Rigid optical laryngoscopes with a channel to house the tracheal tube and act as a conduit, include the Pentax Airwayscope (Pentax AWS™), the Airtraq™ and the LMA CTrach™. A limitation of the conduit laryngoscopes is that the channel contributes to the bulkiness of the device and therefore require larger mouth opening. Another drawback is that the use of tracheal tubes of different sizes and design will change the “angle of exit” of the tube and may have a negative impact on intubation success. The Pentax AWS™ consists of a flexible stem, with a disposable plastic mount that integrates a channel for the tracheal tube as well as one for a suction catheter. The image is displayed on a “liquid crystal display” (LCD) screen. The Airtraq™ is a single-use, disposable device that uses a sequence of prisms and mirrors to present an illuminated image into a “viewfinder”. The LMA CTrach™ is a modified version of the ILMA™ that consists of an ILMA™ containing fibre-optic bundles to display an image onto a screen. According to a systematic review by Healy et al (62) in 2012, all three of these devices have demonstrated a high overall success rate in cases of predicted difficult airways as well as for use as a rescue device after failed direct laryngoscopy. (31)

Bladed optical laryngoscopes include the Bullard™ laryngoscope, the McGrath Series 5™, the GlideScope™ and the C-Mac™. The Bullard™ laryngoscope was the "standard" choice in this group for years, but has now largely been replaced by newer developments. It was designed to be used for patients with limited mouth opening and neck extension and uses fibreoptic technology to display and image into an eyepiece. The McGrath™ is a videolaryngoscope with a detachable metal curved "CameraStick" that is covered with a disposable clear plastic laryngoscope blade. It has been shown to be useful in difficult intubations but no large scale comparative studies have been done. The C-Mac™ consists of metal reusable laryngoscope blade encasing a camera and a light emitting diode at its tip, transmitting the image onto a screen. The GlideScope™ consists of a curved plastic blade with the same shape as the Macintosh blade. It has a camera on the tip that transmits the image to a screen. In a retrospective review Aziz et al found that the Glidescope™ was successful in 98% of cases where it was used as the primary method of intubation, and in 94% of cases where it was used as rescue technique after unsuccessful direct laryngoscopy. They found that previous neck surgery, radiation or a neck mass were the strongest predictors of unsuccessful intubations with the Glidescope™. Both the C-Mac™ (and its predecessor the V-Mac™) and the Glidescope™ have been extensively studied and reviews done by Healy et al (62) as well as Paolini et al (30) demonstrated a high success rate with strong evidence supporting their use. A potential drawback of these devices is the fact that even if easy visualisation of the vocal cords is obtained, inserting the tracheal tube may be difficult or problematic. Most of these devices therefore need to be used with a pre-curved intubating stylet introduced into the tracheal tube. Aziz et al (64) stated that anaesthetic providers "should maintain their competency with alternate methods of intubation, especially for patients with neck pathology." (31)

Flexible fibreoptic scopes

The technique of fibreoptic intubation has become the "gold-standard" for awake intubation in cases where a difficult airway is expected and should be mastered by every anaesthetist. The advantages of the fibreoptic scope are its flexibility and ability to "see around corners". It can be placed through SADs, it can be used in awake patients, it can be placed further into the bronchial tree than any other device and it can be inserted nasally. It is not the answer to every airway problem but occasionally the only practical solution. It is

however a very expensive device that is easily damaged and requires a lot of practice and skill to be used effectively. This limits its use in emergency airway management in certain settings. The three leading manufacturers of flexible fibreoptic scopes in South Africa are Karl Storz, Pentax and Olympus. (31, 65)

Retrograde intubation

Retrograde intubation involves inserting a guidewire through the larynx, through the cricothyroid membrane in a cephalad direction and using this as a guide to railroad a tracheal tube from above. Several techniques have been described and different retro-grade intubation sets are manufactured commercially. It is typically done in an awake patient with an anticipated difficult airway, but it has a place in the unanticipated difficult airway as well. Advantages of this technique is that it can be used when there are blood or secretions in the upper airway, as a direct glottic view is not required to perform this technique. It is less invasive than performing a needle or surgical cricothyroidotomy, but should be avoided when a patient has a bleeding disorder or when there is infection or tumour over the access site. Complications of this technique include bleeding or haematoma formation, surgical emphysema and infection. (31, 66)

2.6 Cricothyroidotomy

Methods and devices for performing a cricothyroidotomy

A cricothyroidotomy is not a permanent solution, but it is an urgently indicated, life-saving procedure when a patent airway cannot be established by non-surgical means (67). It can be accomplished by a surgical incision or by puncturing the cricothyroid membrane. Puncturing can be done with a narrow-bore (internal diameter of ≤2mm) kink-resistant needle, a wide-bore (internal diameter of ≥ 4mm) “cannula-over-trocar” or wire-guided (Seldinger) technique, with dilatation (13). The use of 14-16 gauge intra-venous cannulae is commonly described, but these cannulae are not kink-resistant and their use for this purpose should be avoided (68).

In a study by Craven and Vanner (69), a lung model was created and used to determine the efficiency of different modes of available cricothyroidotomy devices. They showed that after insertion of a narrow-bore cannula (the 13 gauge commercially available Ravussin cannula),

a high-pressure oxygen source is required to adequately ventilate the lungs (69). However, for adequate expiration to occur, the upper airway needs to be patent. With increasing upper airway resistance, the end-expiratory pressure increases due to air-trapping, and eventually leads to the inability to ventilate, barotrauma and haemodynamic instability (13, 69). Partial or complete upper airway obstruction frequently accompanies a CICV situation, due to laryngospasm, airway oedema (possibly as a result of multiple intubation attempts) or distorted anatomy. A neuromuscular blocking agent might help relieve laryngospasm and should be considered during high-pressure ventilation. If there is no high-pressure ventilation system or kink-resistant cannula available, or the operator is not comfortable with high pressure ventilation, it is advisable to rather perform another technique. (13)

Insertion of a wide-bore cannula (>4 mm internal diameter) has the advantage of providing better minute volumes and better conditions for expiration (69, 70). This can be explained by using Poiseuille's law, which states that "flow is proportional to the fourth power of the radius" (71). A conventional breathing system can be used with these devices. If the device is uncuffed, significant air-leaks through the upper airway can however lead to lower tidal volumes (69, 70). Craven and Vanner (69) suggested that by artificially increasing upper airway resistance, alveolar ventilation could be improved, but Sulaiman et al (70) disagree, stating that this technique "has not been formally studied and requires an additional, potentially unreliable, manoeuvre in a crisis situation." Hamaekers and Henderson (13) agree that the use of uncuffed tubes should be avoided in the emergency situation and that only methods that provide reliable re-oxygenation ought to be employed.

Several different cricothyroidotomy sets have been developed and are available commercially (71). The wide choice makes it difficult to know what device is most appropriate to use in an emergency (71). The Quicktrack II® (manufactured by VBM) and the Portex® cricothyroidotomy kit (PCK®) are examples of cuffed, needle-over-trocar devices. A study done by Murphy et al (72) in a porcine model, favoured the Quictrack II® above the PCK®, due to the higher success rate of insertion and lower complication rate. The insertion of the PCK® was associated with a high incidence of posterior tracheal wall injury and creation of false tracts.

Wire-guided cricothyroidotomy airways use the Seldinger technique for insertion, a technique familiar to most anaesthetists (68). The Cook Melker® is an example of a commercially available wire-guided cricothyroidotomy device and a variety of cuffed and uncuffed sizes are available (13, 68). Sulaiman et al (70) found that the ease and success rate of insertion of a cuffed Melker® compared well with a larger uncuffed device. The cuffed device was significantly more effective in attaining adequate ventilation. Murphy et al (72) found that the insertion time for the Melker® was significantly longer than the Quicktrack II® and the surgical approach, but participants rated the Melker® significantly easier to use than all other devices tested in this study.

In summary, the ideal characteristics of an emergency cricothyroidotomy device include:

- internal diameter of ≥ 4 mm in order to provide an adequate canal for both oxygenation and ventilation;
- cuffed devices, to provide protection against aspiration and prevent air leakage;
- ability to connect to 15 mm standard anaesthetic circuit;
- features that minimises collateral damage;
- intuitive and easy to use designs;
- long shelf life;
- durability; and
- kink resistant cannulae. (67, 73)

Based on the findings in the NAP4 (27) study, the latest DAS guidelines suggest the surgical cricothyroidotomy as the “fastest and most reliable method of securing the airway” in a CICV situation (10). A meta-analysis by Hubble et al (74) of the success rate of alternative airway devices and cricothyroidotomy techniques when managing a difficult airway or CICV scenario in the pre-hospital setting, showed a success rate of 65.8% for the needle cricothyroidotomy vs 90.5% for the surgical cricothyroidotomy. In the closed claims analysis published by the ASA in 2005 (14), disastrous implications of the failed needle cricothyroidotomy were reported, as well as incidences of successful surgical technique after the failure of a needle or cannula cricothyroidotomy. The authors stated that “for a surgical airway to be successful as a rescue option, it must be instituted early in the management of the difficult airway.”

There are several techniques to perform a surgical cricothyroidotomy, and no technique has been shown to be superior, but according to the DAS guidelines the common steps include: "neck extension, identification of the cricothyroid membrane, incision through the skin and cricothyroid membrane, and insertion of a cuffed tracheal tube." Complete neuromuscular blockade is also suggested, while using a SAD, mask or nasal insufflation to administer 100% oxygen. (10)

Anatomy relevant to the performance of a cricothyroidotomy

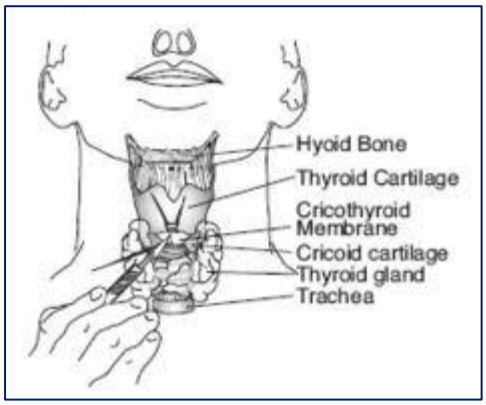

Figure 2.3 Anterior midline structures in the neck

The anterior midline structures in the neck from superior to inferior are the mandible, floor of the mouth, hyoid bone, thyrohyoid membrane, thyroid cartilage, cricothyroid membrane and cricoid cartilage, as depicted in Figure 2.3. The cricothyroid membrane consists of thick fibro-elastic tissue. The cricoid cartilage is situated at the level of the sixth cervical vertebra and is the only complete cartilaginous ring in the larynx and trachea. It functions as a stent to keep the airway patent and protects the esophagus from injury during a cricothyroidotomy. The true vocal cords are approximately 10 mm above the cricothyroid space. No major arteries, veins or nerves are present in the region of the cricothyroid membrane. Superficial veins might be present in the pre-tracheal and superficial cervical fascia. Therefore, venous haemorrhage may occur even when a midline cricothyroidotomy is performed. In some people, part of the thyroid gland may extend to the level of the hyoid bone and can be injured during a cricothyroidotomy. (68, 75)

In children, the thyroid cartilage is difficult to palpate as it only develops in during adolescence. The cricothyroid membrane is situated more cephalad and is shorter than in adults (3 mm compared to 10 mm). The cricoid cartilage is the narrowest segment of the infant airway, and has a higher chance of being damaged during a cricothyroidotomy. It is

easier to inadvertently penetrate the posterior tracheal wall because of the narrow, more flexible airway. Children are more prone to subglottic stenosis because of the more fragile, looser, softer mucosa. For these reasons, only a needle cricothyroidotomy or a formal tracheostomy should be performed in children younger than 12 years of age. (75)

2.7 Implementation of and adherence to algorithms – what prevents us?

Despite the availability of prescribed guidelines and algorithms, as well as a wide array of airway equipment, it has been shown that anaesthetists do not use these resources appropriately when faced with an airway emergency (4, 76, 77).

A simulation study in a large teaching hospital in Glasgow, UK in 2009 assessed the readiness of anaesthetists and anaesthetic assistants to manage the CICV scenario. Ninety-seven anaesthetists with different levels of experience and 63 assistants were included in the study. The participants' knowledge of the location of the difficult airway trolley was tested, which showed that 62.9% of anaesthetists could not locate either of the two difficult airway trolleys in the theatre complex. A CICV scenario was simulated and success was regarded as being able to insufflate a dummy lung. Several different devices were available to perform a cricothyroidotomy, but were only given to the anaesthetist if specifically requested. Only 37.1% of anaesthetists chose a surgical airway technique in keeping with the (then most recent) DAS guidelines, which was either a surgical airway or a percutaneous technique with a kink-resistant cannula. Of the 36 anaesthetists who chose jet ventilation, 15 could not find the correct oxygen supply outlet. Even though this study only included anaesthetists from one hospital, it emphasised the fact that anaesthetists are not well prepared for CICV scenarios and do not apply guidelines in clinical practice when in high-pressure situations. (4)

Two Danish studies done in 2001 and 2004 respectively, showed that there is definite room for improvement in airway training of anaesthesiologists. Kristensen and Møller (76) did a survey among all the members of the Danish Society of Anaesthesiologists asking about their "experience, behaviour and availability of various items of equipment". Of the 436 respondents, approximately two thirds had access to a fibre-optic scope, but 67% had little

or no experience in performing awake intubations for patients with suspected difficult airways, as is suggested by the ASA algorithm. Furthermore, 46% of junior registrars, 25% of senior registrars and 18% of specialists replied that they were not exactly certain how to oxygenate through the cricothyroid membrane. Only 54% to 71% of anaesthetists always had a SAD available as a rescue device. Rosenstock et al (77) did a smaller single-blinded study among 36 Danish anaesthesiology registrars that consisted of a written test on the theory of difficult airway management. The registrars then had to attempt management of a CICV scenario on a simulator that was able to mimic different difficult airway scenarios. Only 17% of registrars passed the written test and 97% stated that they could not recall the ASA algorithm for the management of a difficult airway. Even though 78% had a fibre-optic scope available, only 14% would consider using it for awake intubation in an anticipated difficult airway. In the simulation scenario, only a small percentage of registrars made sure that the basic difficult airway equipment was available before proceeding. Most of the registrars were able to establish ventilation by inserting an LMA™, but did not follow the accepted algorithms correctly. Fourteen percent immediately performed a cricothyroidotomy without trying optimisation techniques. These studies showed that there is a lack of knowledge and practical skills in anaesthetists when managing difficult airway scenarios.

Greenland et al (78) looked at the reasons for the reluctance in performing an emergency surgical airway in life-threatening airway emergencies. They identified three factors that can be addressed in improving the outcome of such cases, namely equipment, patient factors and the operator (or anaesthetist). Airway equipment and difficult airway trolleys should be standardised and personnel should be familiar with the different available devices. Greenland et al (78) highlighted the fact that following the introduction of supra-glottic devices, the CICV situation occurs even less frequently than before and therefore anaesthetists are becoming less familiar with the management thereof. Patient factors also influence the decision of when to perform a surgical airway. In a patient with distorted facial anatomy due to trauma, the decision will likely be made earlier than in a patient with less obvious distorted anatomy (for example an undiagnosed pharyngeal mass). To improve on this decision-making process, they suggested that training should be done in a variety of CICV scenarios, with mannequins and animal models. The training should be “frequent,

recent and relevant". They also suggest that anaesthetists should assist surgeons in performing elective tracheostomies. The most important barrier identified however, is the operator himself. Human factors that hamper decision-making in the emergency situation include anxiety, fixation errors and hazardous attitudes. Greenland et al (78) identified attitude problems from the aviation industry that may negatively affect decision making in crisis situations. They include attitudes of "anti-authority", impulsiveness, invulnerability, a "macho" or competitive attitude and an attitude of resignation. Attitudes can also be adversely affected by external pressures such as fatigue. To eliminate these human factors, they suggest that regular mortality and morbidity discussions or "debriefing" sessions should be held and that opportunities should be created to teach "situational awareness". An organisational change that can be made is improving communication between the different specialties to include the surgeon timeously in the surgical airway if appropriate. (78)

2.8 Formal airway training

The benefit of formal airway training is evident and therefore an increasing number of registrar training programs have implemented formal airway rotations as part of their curriculum.

In 2008, Smith and Koutantos (79) published a prospective audit to document the experience that registrars were obtaining with regards to airway management. They found that there seemed to be a decrease in the number of cases that were managed by registrars, which might be accounted for by the decreasing allowable working hours, as well as involvement of registrars in other duties including pain rounds, ward consultations, pre-operative assessment clinics, epidural services and study leave. They suggested that larger studies should be done to determine the number of cases necessary for adequate training. They also suggested that a formal airway teaching program should be instituted with prescribed minimum core skills and regular reinforcement thereof, and that the appropriate equipment should be readily available.

Koppel and Reed (80) performed a survey in 1995 to determine whether trainee anaesthesiologists are receiving formal airway management training with the various devices and techniques. They found that only 27% of the 143 American anaesthesiology

training programs have specific airway rotations as part of their training program, and most of these rotations were of short duration (one and a half weeks or less).

In 2003, Hagberg et al (81) found that 33% of American anaesthesiology training programs have a designated airway rotation, of which 61% were only of one week duration. Only 19% of the programs had a minimum number of cases required with the use of each device.

Pott et al (82) performed a similar survey in 2011 and found that 49% of the American and Canadian anaesthesiology registrar programs had prescribed airway training programs. This steady increase in airway training programs over the years shows that there seems to be an increased appreciation that the teaching of airway management skills forms a fundamental part in the training of anaesthesiology registrars. This survey also found that simulation training was used in 68% of the programs, compared with only 12% in the survey by Hagberg et al (81). Pott et al (82) recommended that by instituting formalised airway training programs, adverse peri-operative outcomes may be decreased.

Simulation training has shown to be an effective method to ensure skill retention and better compliance with difficult airway algorithms. Boet et al (83) performed a study in 2011 amongst 38 experienced anaesthetists who participated in a "high-fidelity simulated CICV scenario" training session. These anaesthetists were then randomised into either the 6 month or 12 month follow-up group. Both groups' cricothyroidotomy skills improved significantly from before the training and there were no significant difference between the two groups' retention of the skills after either 6 or 12 months. A similar study was performed by Hubert et al (84) in 2014 amongst 27 anesthesiology registrars. The participants' compliance to airway algorithms improved from 63% in the pre-training test to 100% in the post-test and cricothyroidotomy times decreased significantly. The participants were randomised into 3, 6 or 12 month follow-up groups and there was no significant increase in the time to perform a cricothyroidotomy between the three groups. Both these studies agree that cricothyroidotomy skills can be maintained for up to one year if it was taught in a "high fidelity simulated" environment.

An example of a formal airway teaching program for anaesthesiology trainees was published by Dunn et al (85) from the Tufts University School of Medicine in 2004. Their curriculum consists of a total of three months of airway training. The training consists of a series of

lectures, prescribed reading material and certain required practical skills. The registrars are required to do a minimum number of successful intubations with the fibreoptic scope, Bullard laryngoscope and the ILMA™. They also have uniformly stocked airway trolleys that are readily available in emergency situations. The level of comfort in their department in performing and teaching a fibreoptic intubation improved from 62% to 92% after this airway rotation was instituted. More than 90% of the consultants in the department also reported that the resident rotation improved their own airway skills, showing that a formal teaching program can be of benefit to the whole department.

2.9 Summary

In this chapter the literature review was presented. In the next chapter the research methodology will be discussed.

CHAPTER 3: Research methodology

3.1 Introduction

In this chapter the problem statement, aim and objectives, ethical considerations, research methodology, data analysis and the validity and reliability of the study are discussed.

3.2 Problem statement

The CICV scenario is a rare occurrence but can lead to significant morbidity and mortality if not managed appropriately (2, 16). It has been shown internationally that anaesthetists generally lack knowledge of difficult airway algorithms or fail to employ them in emergency situations (4). Although many advances have been made in airway management, adverse respiratory events still form a large part of malpractice claims (14, 17, 18). Medical officers and registrars working in the Department of Anaesthesiology at Wits are occasionally in a situation where senior help is not immediately available, should an airway emergency present itself. The preferences, experience and level of comfort of these anaesthetists to manage difficult intubations and CICV situations and use available airway adjuncts have not been previously described.

3.3. Aim and objectives

3.3.1 Aim

The aim of the study was to describe the preferences, experience and level of comfort of anaesthetists in the Wits Department of Anaesthesiology in managing difficult intubation and CICV scenarios.

3.3.2 Objectives

The objectives of this study were to**:**

- describe the knowledge of anaesthetists regarding the location of the “difficult airway trolley” in the various hospitals affiliated to Wits;
- describe the preferences of anaesthetists with different airway devices and techniques when faced with a difficult intubation or CICV scenario; and

- describe the experience and comfort level of anaesthetists when managing a difficult airway or CICV scenario.

3.4 Ethical considerations

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

Participants were invited to take part in the study at academic meetings. An information sheet (Appendix C) and a questionnaire (Appendix D) were provided to those who agreed to participate. Participation was voluntary and refusal to participate did not have any negative sequelae. Completion of the questionnaire implied consent.

Anonymity and confidentiality were ensured as no identifying information was requested from participants. Questionnaires were distributed in a group setting and after completion were immediately placed in sealed data collection boxes by the participants. Only the researcher and supervisors had access to the raw data.

Data will be stored securely for six years after completion of the study.

This study was conducted according to the principles of the Declaration of Helsinki (19) and the South African Guidelines for Good Clinical Practice (20).

3.5 Research methodology

3.5.1 Research design

A prospective, contextual, descriptive research design was followed in this study. In a prospective study, variables that occur over the course of the study are measured, as in the case of this study (86). A contextual study is one which is performed in a specific group or population. De Vos et al (87) defined this as a “small-scale world” or “micro” research. The “small-scale world” in this study is the Department of Anaesthesiology.

According to Brink et al (86), descriptive research aims to provide information from a representative sample of a certain population, in a field where data is still lacking, without trying to determine a “cause-effect relationship”. Burns and Grove (88) stated that it may be

used to “develop theory, identify problems with current practice, make judgments, or determine what others in similar situations are doing.” This study describes the preferences, experience and comfort level of anaesthetists in the Department of Anaesthesiology in managing difficult intubations and CICV scenarios.

3.5.2 Study population

The study population consists of anaesthetists working in the Department of Anaesthesiology.

3.5.3 Study sample

Sample method

In this study a convenience sampling method was used. According to Endacott and Botti (89) convenience sampling is a form of non-random sampling where the most readily accessible individuals are included in the study. Questionnaires for this study were distributed at all the Wits affiliated hospitals during academic meetings, as well as at combined departmental meetings during the study period, in order to reach the largest sample possible.

Sample size

The department consists of 22 medical officers, 112 registrars and 74 consultants. Questionnaires were administered to the entire accessible population. A response rate of 60% was considered as acceptable, but a response rate of 80% was targeted.

Inclusion and exclusion criteria

All available anaesthetists working in the Wits Department of Anaesthesiology willing to participate in the study were included.

Exclusion criteria in this study were:

- interns rotating in the department;
- anaesthetists that were on annual or sick leave during the study period; and
- questionnaires that were returned blank were excluded from the data analysis but were used to determine the response rate.

3.5.4 Data collection

Development of a questionnaire

An extensive review of the literature was done and a questionnaire developed by Wong et al (16) in 2005 was identified as appropriate for this study. In the original study the authors developed a survey to determine the preferences of Canadian anaesthesiologists in difficult intubation and CICV scenarios. Permission was obtained from Wong, via e-mail correspondence, to adapt the questionnaire for use in this study (Appendix E). The questionnaire was adapted for local use and validated by four airway management experts in the Department of Anaesthesiology, thereby ensuring content and face validity of the questionnaire.

The self-administered questionnaire (Appendix D) consisted of two sections.

Section 1 included demographic data of the participant, namely:

- gender
- professional designation
- years of anaesthetic experience
- recent attendance of an airway workshop
- use of airway algorithms and/or guidelines.

Section 2 consists of questions regarding:

- knowledge of the location of the difficult airway trolleys at the various Wits affiliated hospitals
- preference, experience and comfort level with different airway devices when managing a difficult intubation
- preference, experience and comfort level when managing a CICV scenario.

Data collection process

Data was collected by distributing questionnaires at academic meetings at the various hospitals as well as at combined departmental meetings during the months of June to December 2015. At the start of the meeting, the researcher asked permission from the convenor to address the potential participants. The researcher was present during

completion of questionnaires to assist with any queries. Before distribution, questionnaires were numbered to keep track of completed questionnaires and to calculate a response rate.

After brief introduction by the researcher to clarify the aim and objectives of the study, anaesthetists had the opportunity to decide whether they wanted to participate in the study. Those who agreed to do so received an information letter (Appendix C) along with the questionnaire (Appendix D). After completion of the questionnaire, the participant placed it into a sealed data collection box.

3.6 Data analysis

Data was captured onto spread sheets using Microsoft Excel® 2010 and analysed using GraphPad InStat® in consultation with a bio-statistician. Descriptive and inferential statistics were used to analyse the data. Categorical variables were described using frequencies and percentages. A sub-analysis was done to compare the level of comfort to the demographic variables using Fisher's exact tests. A p-value of <0.05 was considered statistically significant.

3.7 Validity and reliability of the study

According to Botma et al (90), validity represents the degree to which measurements represent the true value. To attain validity, the appropriate study design and data collection techniques should be used. (90)

Reliability refers to consistency of the measure achieved. The measuring instrument should therefore be able to produce the same results under different circumstances. (90)

The following measures ensured validity and reliability of this study:

- a validated questionnaire that was adapted for local use was used for data collection;
- the adapted questionnaire was validated by four airway management experts;
- the researcher was available to answer questions while questionnaires were being completed;
- all questionnaires were completed under the same circumstances;

- all questionnaires were completed anonymously and placed in sealed data collection boxes;
- 10% of data entries were checked for accuracy of entry; and
- data was analysed in consultation with a bio-statistician.

3.8 Summary

In this chapter the research methodology was presented. In the next chapter the results of the study are reported and discussed.

CHAPTER 4: Results and discussion

4.1 Introduction

In this chapter, the results of this study are presented, in keeping with the objectives of the study, and the discussion thereof follows. The objectives of this study were to:

- describe the knowledge of anaesthetists regarding the location of the "difficult airway trolley" in the various hospitals affiliated to Wits;
- describe the preferences of anaesthetists with different airway devices when faced with a difficult intubation or CICV scenario; and
- describe the experience and comfort level of anaesthetists when managing a difficult airway or CICV scenario.

4.2 Sample realisation

Data was collected at departmental meetings between June and December 2015. The department consists of 208 anaesthetists. At the time of data collection, it was determined that approximately 42 (20%) anaesthetists will not be available due to leave or rotations out of town, leaving a total number of 166 available. A total of 132 (80% of available anaesthetists) was targeted for this study, but 100 (60%) was deemed adequate. Of the 135 questionnaires distributed 126 (93%) were returned. This was 76% of the targeted number of anaesthetists.

4.3 Results

Percentages are rounded off to the first decimal place, and may not add up to exactly 100%, as with questions where participants could choose more than on option. The Likert scale data regarding the comfort level was converted to "comfortable" and "uncomfortable", as was done in the original study by Wong et al (16). The group that selected "equivocal" was excluded as it did not fit either category. The full break-down of the Likert scale data is shown in Appendix F. Subanalysis was done to compare the level of comfort with use of different airway devices between the consultants and registrars/MO's . A sample size was not calculated to determine if these comparisons would be adequately powered.

4.3.1 Demographics

The majority, 80 (63.5%) participants were female, 64 (50.8%) were registrars and 70 (55.6%) had 1 to 5 year of anaesthetic experience. Only 28 (22.2%) had never attended an airway workshop and of those who had, most attended less than a year ago. The majority, 103 (81.7%) participants use published algorithms and/or guidelines when managing a difficult airway and the ASA guidelines are the most widely used. The demographics of the participants are shown in Table 4.1.

Table 4.1 Demographics of participants

Demographic	**Number**	**Percentage**
n=126	**(n)**	**(%)**
Gender		
Male	46	36.5
Female	80	63.5
Professional designation		
Consultant	47	37.3
Registrar	64	50.8
Medical officer	15	11.9
Years of experience		
Less than 1	8	6.3
1-5 years	70	55.6
6-10 years	30	23.8
11-20 years	8	6.3
>20	8	6.3
No data	2	1.6
Attendance of an airway workshop		
Never	28	22.2
<1 year ago	48	38.1
1-2 years ago	38	30.2
2-4 years ago	7	5.6
>4 years ago	5	4.0
Use of guidelines		
No guidelines used	23	18.3
Unsure of the name	13	10.3
ASA	50	39.7
DAS	21	16.7
Vortex	13	10.3
Other	6	4.8

4.3.2 Objective: to describe the knowledge of anaesthetists regarding the location of the "difficult airway trolley" in the various hospitals

A total of 111 (88.1%) participants know the location of the difficult airway trolley, but 43 (38.7%) stated that the trolley is not easily accessible in case of an unanticipated difficult airway. This is shown in Figure 4.1. One participant did not answer the question.

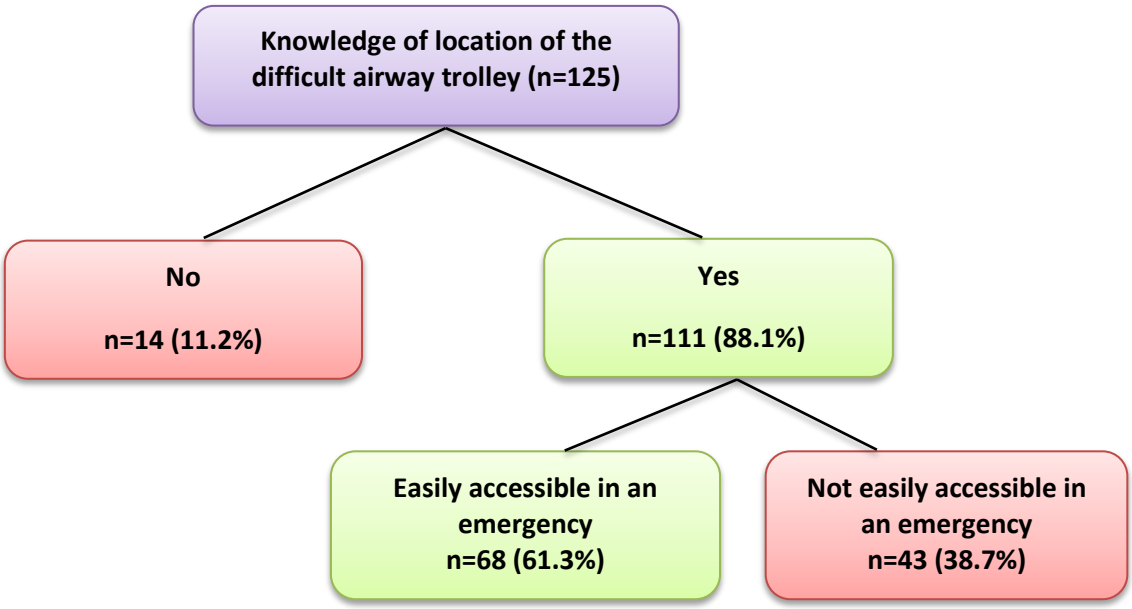

Figure 4.1 Overall knowledge of location of the difficult airway trolley

When looking at the different hospitals, 5 (14.3%) of the participants from CMJAH and 3 (12.5%) from HJH/RMMCH do not know the location of the difficult airway trolley, while at CHBAH the proportion is lower, with 6 (9.2%) not knowing. Of the participants who know the location of the trolley, 17 (56.7%) from CMJAH and 24 (40.7%) from CHBAH are of the opinion that it is not readily accessible in an emergency situation. At HJH/RMMMC the number is lower as only 2 (9.5%) feel that the trolley is not readily accessible in an emergency. See table 4.2 for the full breakdown of these results.

Table 4.2 Knowledge of the location of the difficult airway trolley at different hospitals

Hospital	Participants per hospital n (%)	Location unknown n (%)	Location known n (%)		
			Total	Accessible in emergency	Not accessible in emergency
CMJAH	35 (27.8)	5 (14.3)	30 (85.7)	13 (43.3)	17 (56.7)
CHBAH	65 (51.6)	6 (9.2)	59 (90.8)	35 (59.3)	24 (40.7)
HJH/RMMCH	24 (19.0)	3 (12.5)	21 (87.5)	19 (90.5)	2 (9.5)
WDGMC	1 (0.8)	0	1 (100)	1 (100)	0

4.3.3 Objective: to describe the preferences of anaesthetists for different airway devices

The majority, 92 (73%) participants chose the videolaryngoscope as a first choice device when facing a difficult airway scenario. The predominant second choice devices were the flexible fibre-optic scope, chosen by 52 (41.2%) and the intubating laryngeal mask, chosen by 48 (38.1%). The device preference for managing a difficult airway is illustrated in Figure 4.2. No one chose the retrograde wire or rigid bronchoscope as either their first or second option.

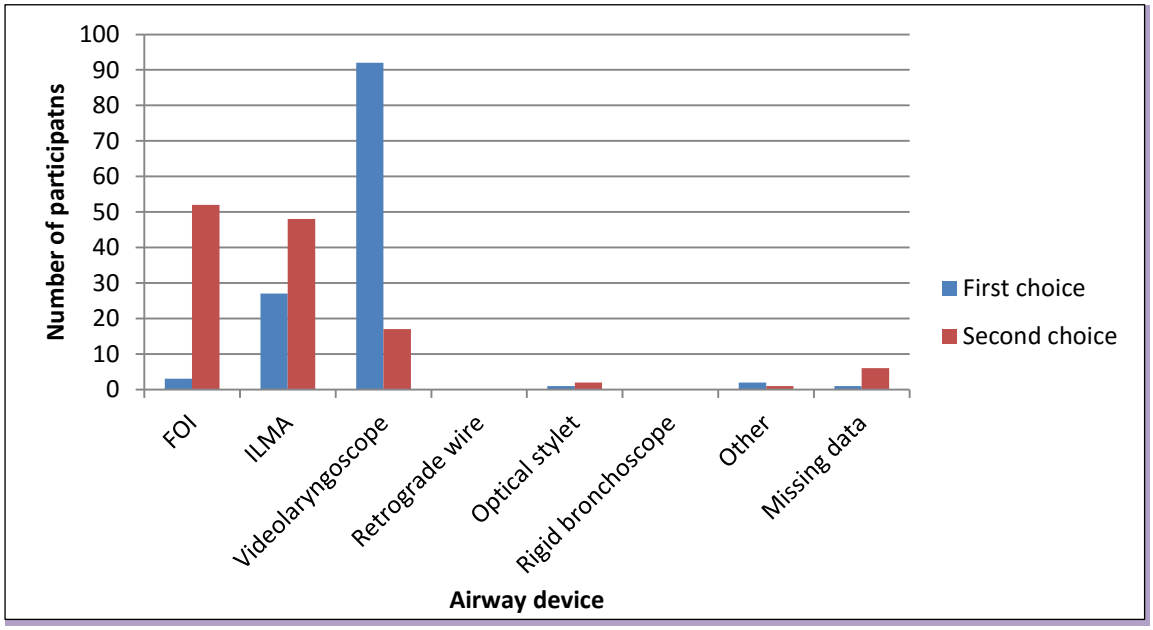

Figure 4.2 Device preferences for managing a difficult airway

The most popular choice for managing an airway in a CICV scenario is using an IV cannula to perform a cricothyroidotomy, with 47 (37.3%) participants selecting this as their first choice. As a second choice, 41 (32.5%) chose a tracheostomy by the surgeon. The open surgical method and tracheostomy by the anaesthetist were the least popular choices overall. Figure 4.3 shows the device preference in a CICV scenario.

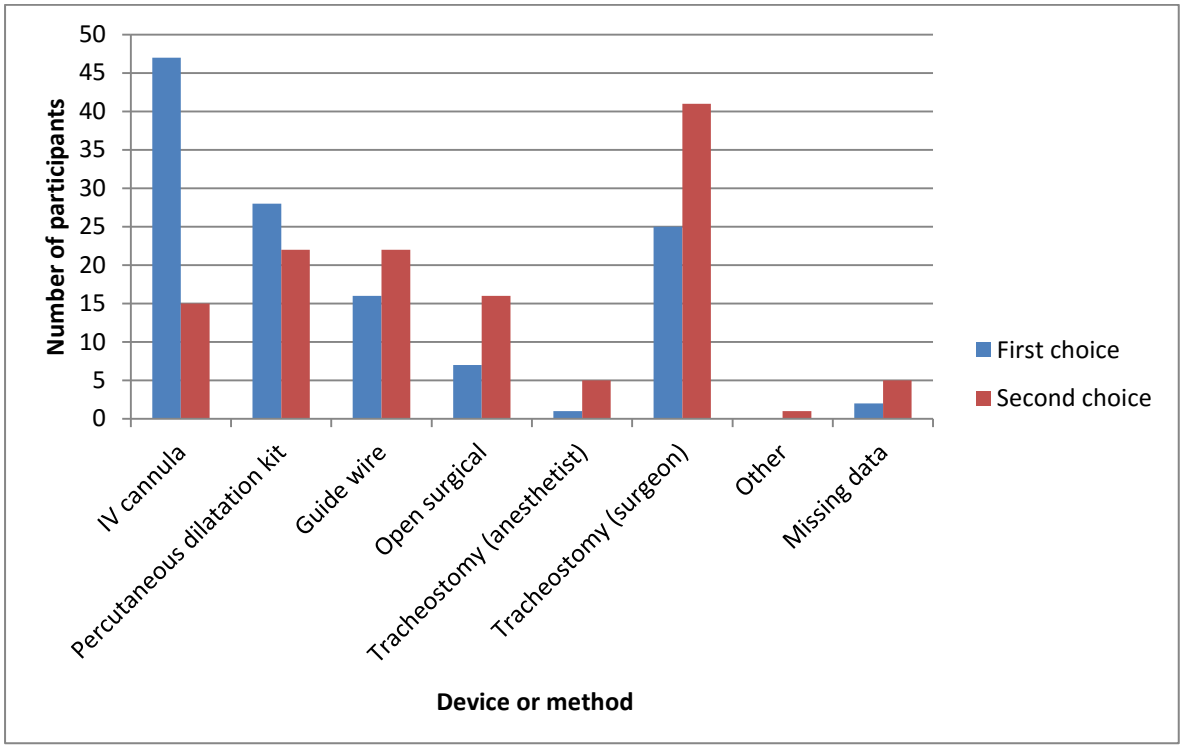

Figure 4.3 Preferences when managing a CICV scenario

4.3.4 Objective: to describe the experience and comfort level of anaesthetists when managing a difficult airway or CICV scenario

Experience and comfort level of anaesthetists when managing a difficult airway scenario

The videolaryngoscope is the most widely used alternative airway device, with 111 (88.1%) of participants having used it in asleep patients. The fibre-optic scope has also been used by the majority of participants in either an awake and/or an asleep patient. The retrograde wire set, the optical stylet and the rigid bronchoscope are all devices with which the majority of participants had no experience. These results are shown in Table 4.3. With this question, the participants could choose more than one option thus percentages may add up to more than 100%.

Table 4.3 Experience of anaesthetists with different airway devices used for difficult airway scenarios

Device	Never used n (%)	Used n (%)			
		Total n (%)	Mannequin n (%)	Awake n (%)	Asleep n (%)
Flexible fibreoptic scope	13 (10.3)	113 (89.7)	26 (20.6)	82 (65.1)	98 (77.7)
Intubating laryngeal mask	25 (19.8)	101 (80.2)	42 (33.3)	2 (1.6)	68 (54)
Videolaryngoscope	6 (4.8)	120 (95.2)	25 (19.8)	10 (7.9)	111 (88.1)
Retrograde wire set	79 (62.7)	47 (37.3)	41 (32.5)	0 (0)	6 (4.8)
Optical stylet	75 (59.5)	51 (40.4)	42 (33.3)	0 (0)	15 (11.9)
Rigid bronchoscope	93 (73.8)	33 (26.2)	10 (7.9)	1 (0.8)	26 (20.6)

Figure 4.4 shows the percentage of participants that are comfortable with each of the different devices. The overall percentages of participants that are comfortable using the devices are shown, as well as the percentages of consultants and registrars/MO's. The number of participants that have experience with each of the different devices (as shown in Table 4.3) corresponds well with the percentage of participants that are comfortable with the different devices.

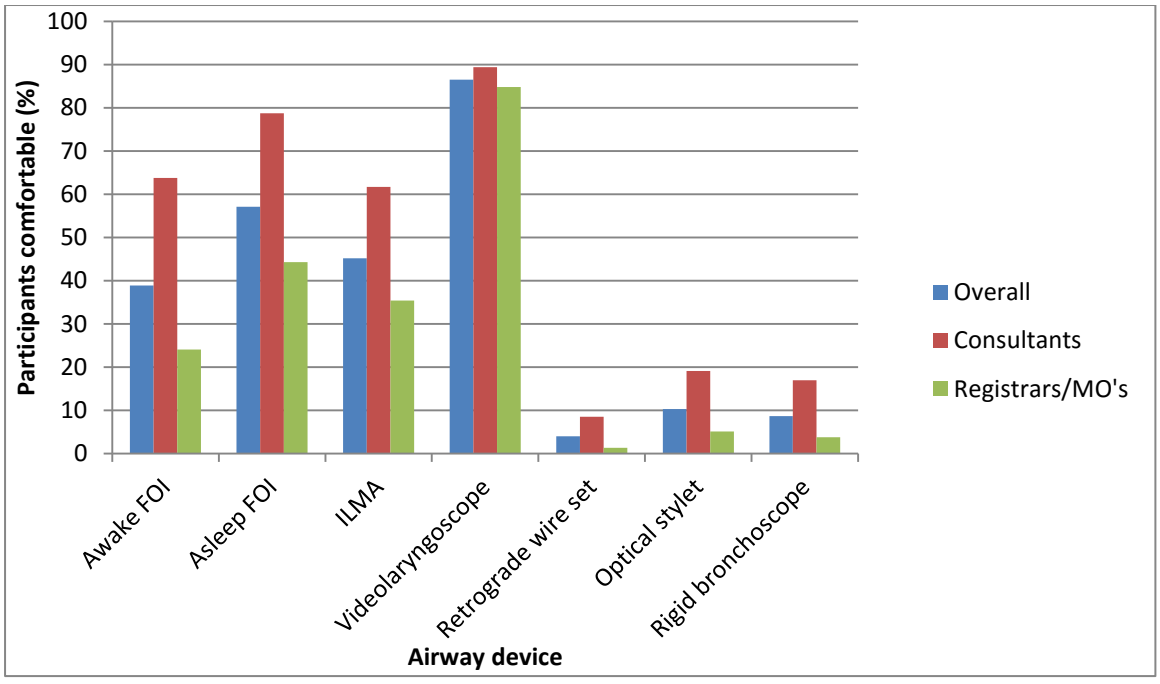

Figure 4.4 Participants comfortable with different airway devices used for difficult airway scenarios

Figure 4.5 shows the percentage of participants that are uncomfortable with each of the different devices. The group that selected "equivocal" were not included, thus the comfortable and uncomfortable groups will not add up to 100%.

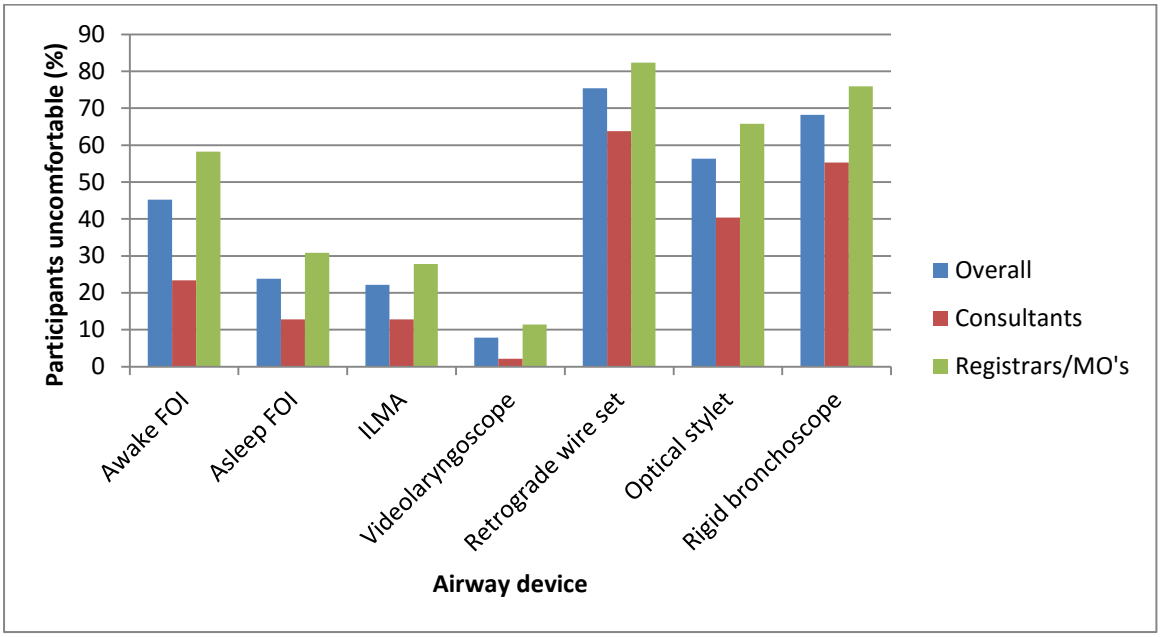

Figure 4.5 Participants uncomfortable with different airway devices used for difficult airway scenarios

A sub-analysis was done to compare the level of comfort with use of different airway devices between the consultants and registrars/MO's, using a Fisher's exact test. This is shown in Table 4.4. There was a statistically significant difference (p-value <0.05) in the level of comfort between the consultant and registrar/MO's groups with all the devices except for the videolaryngoscope.

Table 4.4 Comparison of the level of comfort of consultants vs registrars/MO's with the use of different airway devices

Airway device	Consultants Comfortable/ Uncomfortable	Registrars/MO's Comfortable/ Uncomfortable	p-value
Awake fibreoptic intubation	30/11	19/46	p=0.0001
Asleep fibreoptic intubation	37/6	35/24	p=0.0041
Intubating laryngeal mask	29/6	28/22	p=0.0108
Videolaryngoscope	42/1	67/9	p=0.0921
Retrograde wire set	4/30	1/65	p=0.0444
Optical stylet	9/19	4/52	p=0.0077
Rigid bronchoscope	8/26	3/60	p=0.0146

Experience and comfort level of anaesthetists when managing a CICV scenario

Sixty-three (50%) of the participants have experienced a CICV scenario in clinical practice, but only six (4.8%) have had more than two CICV experiences, as depicted in Table 4.5.

Table 4.5 Experience of CICV scenario

Experience of CICV scenario	Number (%)
Never	63 (50)
1-2 times	57 (45.2)
>2 times	6 (4.8)

Most participants have experience with performing a cricothyroidotomy on a mannequin, with an intra-venous (IV) cannula, a percutaneous dilation kit and/or the guidewire. The open surgical method and the performance of a tracheostomy were techniques with which the majority of participants had no experience with. Very few of the participants had experience with any of the devices or techniques on a patient. These results are shown in Table 4.6.

Table 4.6 Experience of anaesthetists with different airway devices used for CICV scenarios

Device	Never used n (%)	Used n (%)		
		Total n (%)	Mannequin n (%)	Patient n (%)
IV cannula	30 (23.8)	96 (76.2)	85 (67.5)	14 (11.1)
Percutaneous dilation kit	43 (34.1)	83 (65.9)	78 (61.9)	5 (4)
Guide wire	39 (31)	87 (69.0)	85 (67.5)	3 (2.4)
Open surgical method	79 (62.7)	47 (37.3)	42 (33.3)	6 (4.8)
Tracheostomy	101 (80.2)	25 (19.8)	14 (11.1)	11 (8.7)

Figure 4.6 shows the percentage of participants comfortable with using the different devices or techniques used in a CICV scenario. The IV cannula was the device with which most participants felt comfortable, even though the overall percentage of participants comfortable was only 34.9%. In the consultant group, 55.3% were comfortable with using the IV cannula, while only 22.8% of the registrars/MO's were comfortable.

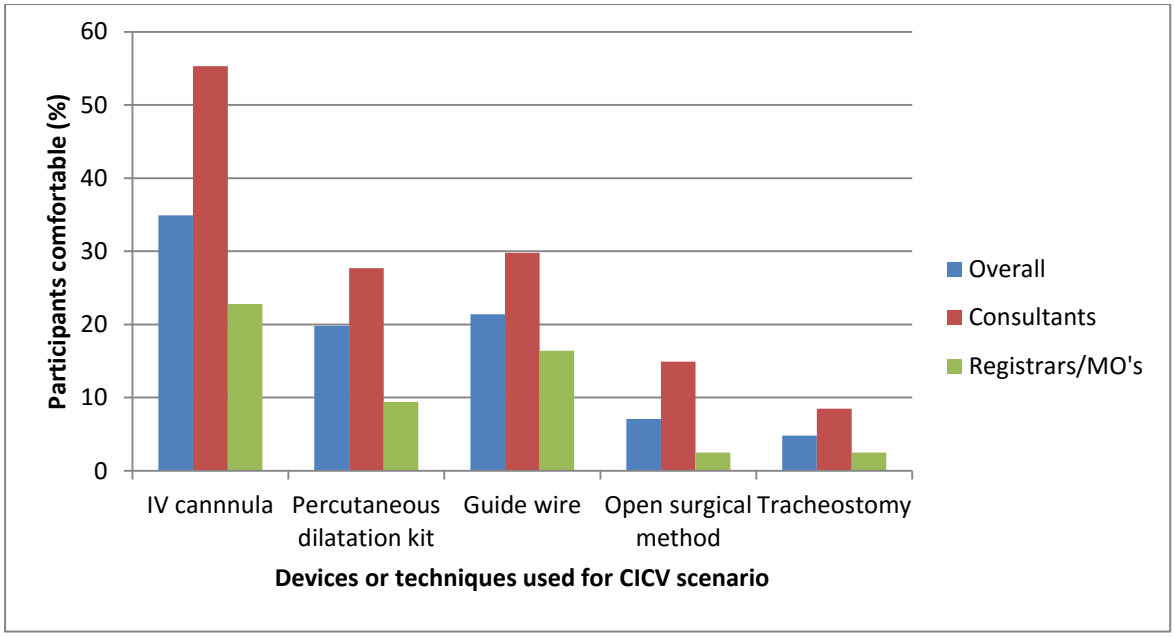

Figure 4.6 Participants comfortable with equipment used for cricothyroidotomy/ surgical airway in CICV scenario

Figure 4.7 shows the percentage of participants that are uncomfortable with each of the different devices or methods used for a CICV scenario. Again, the group that selected "equivocal" were not included, thus the comfortable and uncomfortable groups will not add up to 100%. The open surgical method and the tracheostomy are the two methods with which most participants felt uncomfortable with.

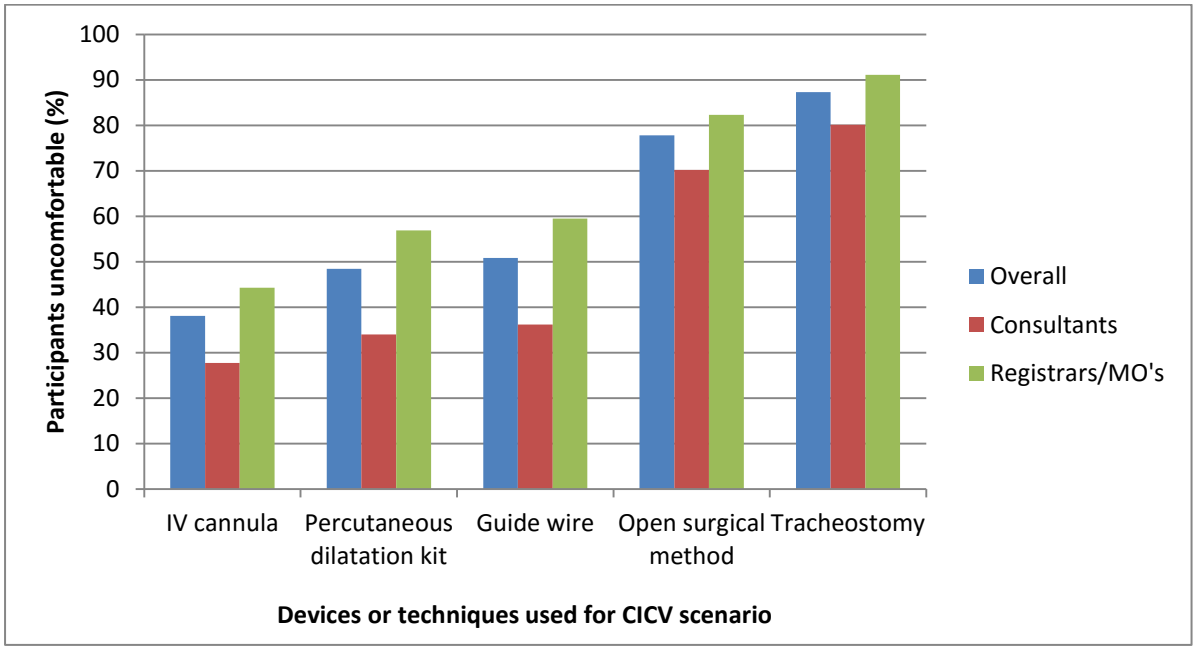

Figure 4.7 Participants uncomfortable with equipment used for cricothyroidotomy/ surgical airway in CICV scenario

A sub-analysis was done to compare the level of comfort with use of different devices and methods between the consultants and registrars/MO's, using a Fisher's exact test. This is shown in Table 4.7. There was a statistically significant difference (p-value <0.05) in the level of comfort between the consultant and registrar/MO's groups with all the devices except for the tracheostomy.

Table 4.7 Comparison of the level of comfort of consultants vs registrars/MO's with the use of different airway devices

Airway device	Consultants Comfortable/Uncomfortable	Registrars/MO's Comfortable/Uncomfortable	p-value
IV cannula	26/13	18/35	p=0.0029
Percutaneous dilation kit	13/16	12/45	p=0.0265
Guide wire	14/17	13/47	p=0.0290
Open surgical method	7/33	2/65	p=0.0130
Tracheostomy	4/38	2/72	p=0.1873

4.4 Discussion

The aim of the study was to describe the preferences, experience and level of comfort of anaesthetists in the Wits Department of Anaesthesiology in managing difficult intubation and CICV scenarios.

Several algorithms and guidelines for management of the difficult airway have been formulated by national societies as well as by local institutions (2, 5, 7, 11). The majority of participants, 103 (81.7%) in my study stated that they use described guidelines when managing a difficult airway scenario. The most common choice was the ASA guidelines, which was chosen by 50 (39.7%) participants. This was an open ended question, but the ASA guidelines were given as an example, which might have led to participants stating it as their choice. The other popular choices were the DAS guidelines, chosen by 21 (16.7%) and the Vortex approach, chosen by 13 (10.3%). The most recent SASA airway guidelines that were published in 2014 include the ASA difficult airway algorithm, the DAS guidelines as well and the Vortex approach, and the authors do not recommend one guideline above the other (65). A critique of the ASA as well as the DAS algorithms however, is that they are

complicated and allow for too many management choices at each stage, making it difficult to recall and apply in an emergency situation (2, 7). The Vortex approach serves as a straightforward “cognitive aid” to encourage a structured approach rather than progression through a linear algorithm when dealing with a difficult airway (2). This approach has been discussed and encouraged at airway workshops in our department.

Fourteen (11.2%) participants did not know the location of the difficult airway trolley at the hospitals where they were rotating. What was also of concern is that of the participants who did know the location, 43 (38.7%) were of the opinion that the trolley is not easily accessible in case of an airway emergency. This was shown to be problem in other centres as well. An example is a simulation study by Green (4) in a large teaching hospital in Glasgow, UK that showed that 62.9% of anaesthetists could not locate either of the two difficult airway trolleys in the theatre complex.

CMJAH had the highest percentage of participants, 17 (56.7%) who felt that the airway trolley is not accessible in an airway emergency. The airway trolley and videolaryngoscopes in the main theatre complex at this hospital are kept in the anaesthetic department behind an access controlled gate. At the HJH and RMMCH the numbers were better with only two (9.2%) of participants at these hospitals stating that the trolley is not accessible in an emergency. At these hospitals, the difficult airway trolleys are kept in the recovery rooms. The videolaryngoscopes at these hospitals (HJH and RMMCH) are however locked away and not easily accessible after hours without a consultant being present, while at the other hospitals they are accessible 24 hours a day.

In the difficult airway scenario, the videolaryngoscope was the most popular device and was chosen by 92 (73%) participants as their first choice. A possible explanation for this is that videolaryngoscopes are available at all of the Wits affiliated hospitals and their use is encouraged for the management of anticipated difficult airways. Almost all participants, 120 (95.2%) have used the videolaryngoscope and this was reflected in the large percentage (86.5%) of participants that are comfortable using this device. This was the only difficult airway device where there were no statistically significant difference in the comfort level between consultants and registrars ($p = 0.0921$). The latest DAS guidelines recommend that all anaesthetists should be competent in using the videolaryngoscope and that it should be

immediately available (10). Aziz et al (64) however stated that anaesthetic providers "should maintain their competency with alternate methods of intubation, especially for patients with neck pathology."

At the time of the original study by Wong et al (16) in 2005, videolaryngoscopes were not widely available yet and only 1.3% of participants chose the Glidescope™ as their first choice device. The lighted stylet was the most popular first choice in their study and was chosen by 44.5% participants. Even though there are still optical stylets available, it is not a widely preferred or used device and only 13 (10.3%) participants in my study felt comfortable using it.

The second choice devices for a difficult airway scenario were similar to the study by Wong et al (16). When comparing the figures from the two studies, the ILMA™ was chosen by 38.1% in my study vs 32.1% participants in the study by Wong et al (16) and the fibreoptic scope was chosen by 41.3% vs 40.5% as second choice devices. Even though 80.2% of participants had experience with the ILMA™, only 61.7% of consultants and 35.4% of registrars felt comfortable using this device. Separate studies by Kapila et al (41) and later by Baskett et al (42) showed that there is a learning curve associated with the use of the ILMA™. It is however recommended as essential equipment for airway rescue. In a review by Caponas (43) about the ability of the ILMA™ to facilitate blind intubation, the success rate of intubation was 95.7% in a total of 1110 patients.

The technique of fibreoptic intubation has become the "gold-standard" for awake intubation in cases where a difficult airway is expected, but requires practice and skill to be used effectively (31). Even though fibreoptic intubations have been done by 89.7% of participants in my study, only 38.9% feel comfortable performing it on an awake patient and 57.1% in an asleep patient. The registrars and medical officers were significantly less comfortable with awake ($p=0.0001$) and asleep ($p=0.0041$) fibreoptic intubations than the consultants.

Similar to the findings of Wong et al (16), the retrograde wire and the rigid bronchoscope are devices with which most participants had no experience and this is reflected by the low numbers in both the consultant and registrar groups that prefer these devices and are comfortable with using them.

Fifty percent of participants in my study had been involved in a CICV scenario, with 46.2% having had one or two CICV experiences and 4.8% participants having had more than two. These numbers are slightly lower but similar to the numbers in the study by Wong et al (16).

The cricothyroidotomy by IV cannula was the preferred first choice device to establish an infraglottic airway in a CICV scenario by the majority of participants, 47 (37.3%). A total of 96 (76.2%) participants have experience with this technique (although mostly only on a mannequin). Wong et al (16) had similar findings and they believe that this technique is preferred because it is readily available and the least complicated. The use of an IV cannula is however discouraged in the literature as it is not kink-resistant, it does not protect the patient from aspiration, does not provide effective ventilation, requires a special attachment for jet ventilation and is associated with a high incidence of barotrauma (1).

Several different large bore (>4 mm internal diameter) cannula cricothyroidotomy sets have been developed and are available commercially and the wide choice makes it difficult to know which device is most appropriate to use in an emergency (71). Two non-surgical techniques include the “cannula-over-trocar” and the guide wire (or Seldinger) technique, which is a technique that most anaesthetists are familiar with. More than 60% of participants had experience with both of these techniques on mannequins but only 19.8% and 21.4% of participants felt comfortable with these two techniques, respectively.

The open surgical method and the tracheostomy were the least popular choices for airway management in a CICV scenario. After the findings of NAP4 (27), the latest DAS guidelines recommend the use of the open surgical technique to secure the airway in a CICV scenario (10). Only 37.3% of participants had experience in performing an open surgical airway (mostly on a mannequin) and only 7.1% felt comfortable with this technique. There was again a statistically significant ($p=0.013$) difference between the level of comfort of consultants (of which 14.2% are comfortable) and registrars/MO’s (of which only 2.5% are comfortable) with this technique.

The benefit of formal airway training is evident and therefore an increasing number of registrar training programs have implemented formal airway rotations as part of their curriculum (80-82). Even though airway workshops are held in the Wits Department of Anaesthesiology on a bi-annual basis, there is no formal airway teaching program and

registrars are not formally assessed on their techniques when using different airway devices. Simulation training has shown to be an effective method to ensure skill retention and better compliance with difficult airway algorithms. Different studies agree that cricothyroidotomy skills can be maintained for up to one year if it was taught in a “high fidelity simulated” environment (83, 84). At this stage, no “high fidelity” simulation training has been done in our department to teach cricothyroidotomy skills and only occasional demonstrations and practice on mannequins are done at airway workshops. This study has shown that there is much room for improvement in the field of airway training in the department.

4.5 Summary

In this chapter the results and discussion were presented. The next chapter contains a summary of the study, the limitations, recommendations and a conclusion.

CHAPTER 5: Study summary, limitations, recommendations and conclusion

5.1 Introduction

In this chapter a summary of this study, limitations, recommendations for changes in practice, future research and a conclusion will be presented.

5.2 Study summary

5.2.1 Aim

The aim of the study was to describe the preferences, experience and level of comfort of anaesthetists in the Wits Department of Anaesthesiology in managing difficult intubation and CICV scenarios.

5.2.2 Objectives

The objectives of this study were to:

- describe the knowledge of anaesthetists regarding the location of the "difficult airway trolley" in the various hospitals affiliated to Wits;
- describe the preferences of anaesthetists with different airway devices and techniques when faced with a difficult intubation or CICV scenario; and
- describe the experience and comfort level of anaesthetists when managing a difficult airway or CICV scenario.

5.2.3 Methodology

A prospective, contextual, descriptive research design was followed and a convenience sampling method was used. The study population consisted of the anaesthetists working in the Wits Department of Anaesthesiology. An extensive review of the literature was done and a questionnaire developed by Wong et al (16) in 2005 was identified as appropriate for this study. The questionnaire was adapted for local use and validated by four airway management experts in the Department of Anaesthesiology, thereby ensuring content and face validity of the questionnaire. Questionnaires (Appendix D) were distributed during

academic meetings, as well as at combined departmental meetings from June to December 2015. Data was captured onto spread sheets using Microsoft Excel® 2010 and analysed using GraphPad InStat®. Descriptive and inferential statistics were used to analyse the data.

5.2.4 Results

Of the 126 participants, it was found that a total of 111 (88.1%) participants knew the location of the difficult airway trolley, but 43 (38.8%) stated that the trolley is not easily accessible in case of an unanticipated difficult airway.

The majority, 92 (73%) participants preferred the videolaryngoscope as a first choice device when facing a difficult airway scenario. The predominant second choice devices were the flexible fibre-optic scope, chosen by 52 (41.3%) and the intubating laryngeal mask, chosen by 48 (38.1%). The videolaryngoscope was the most widely used alternative airway device, with 111 (88.1%) participants having used it in asleep patients. The retrograde wire set, the optical stylet and the rigid bronchoscope were all devices with which the majority of participants had no experience. The number of participants who had experience with the different devices corresponded well with the percentage of participants who were comfortable with the different devices.

The most popular choice, chosen by 47 (37.3%) participants for managing an airway in a CICV scenario, was to use an IV cannula to perform a cricothyroidotomy. The IV cannula was also the device with which most participants felt comfortable even though the overall number comfortable was only 44 (34.9%). As a second choice, 41 (32.5%) chose a tracheostomy by the surgeon. The open surgical method and tracheostomy by the anaesthetist were the least popular choices overall and most participants felt uncomfortable with these methods. Sixty-three (50%) of the participants have experienced a CICV scenario, but only 6 (4.8%) have had more than two CICV experiences.

5.3 Limitations

The following limitations were identified in this study.

- This study was contextual in nature and therefore the results of this study may not be extrapolated to other academic anaesthetic departments or private practice.

- Convenience sampling was used. This sampling method, although often used, can lead to bias as some elements might be over- or underrepresented (86).
- There is no standardisation of airway equipment between the different study hospitals. The participants' device preference and comfort level could therefore have been influenced by the devices they had available.

5.4 Recommendations

5.4.1 Clinical practice

The following recommendations are proposed for clinical practice.

- Difficult airway trolleys and equipment should be standardised at the various Wits affiliated hospitals.
- The airway trolley should be easily accessible at all hospitals and the location thereof should be regularly communicated to new and existing staff.
- A compulsory airway teaching program should be implemented in our department, based on published data regarding airway rotations in other anaesthetic departments, as part of registrar training.
- "High fidelity" simulation training should be implemented in our department, especially for the acquisition of cricothyroidotomy skills.
- Formal assessment of registrars' airway management skills with the use of different devices and techniques should be implemented in our department.

5.4.3 Further research

The following recommendations are proposed for further research.

- Similar studies could be performed in other anaesthetic departments in South Africa to determine where deficiencies in skills and experience lies, and whether further training is required.
- A follow-up study could be done after the implementation of an airway teaching program, to determine whether formal airway training improves the comfort level of anaesthetists in our department.

5.5 Conclusion

In conclusion, this study found that there is much room for improvement in airway training in our department. The location of the difficult airway trolley is not known by all anaesthetists in the department and many are of the opinion that it is not readily available in an emergency situation. Most anaesthetists have used and prefer the videolaryngoscope for the management of a difficult airway and are comfortable using it. There is however a significant difference in the comfort level of consultants and registrars with the use of all of the other devices used in a difficult airway scenario. In a CICV scenario, most anaesthetists prefer the IV cannula as a first choice to perform a cricothyroidotomy. Even though the open surgical method is the recommended method in the literature with the lowest complication and failure rate, the majority of anaesthetists have no experience with this method, even on a mannequin, and most feel uncomfortable performing this method.

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Appendix A: Ethics approval

R14/49 Dr Lize Buitenweg

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M150105

NAME: (Principal Investigator)	Dr Lize Buitenweg
DEPARTMENT:	Anaesthesiology Charlotte Maxeke Johannesburg Academic Hospital
PROJECT TITLE:	The Prerefences, Experience and Level of Comfort of Anoasthetists in Managing Difficult Intubation and Cannot Intubate, Cannot Ventile" Scenarios.
DATE CONSIDERED:	30/10/2015
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Helen Perrie et al
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	20/05/2015

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 yearly progress report.**

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix B: Postgraduate committee approval

UNIVERSITY OF THE
WITWATERSRAND
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

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

03 February 2015
Person No: 1018992
PAC

Dr L Buitenweg
77 Kessel Street
Fairland
Johannesburg
2170
South Africa

Dear Dr Buitenweg

Master of Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *The preferences, experience and level of comfort of anaesthetists in managing difficult intubation and "cannot intubate, cannot ventilate" scenarios* 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 C: Participant's information sheet

Dear Colleague,

Hello, my name is Lize, and I am a registrar in the Wits Department of Anaesthesiology. I am conducting a study as part of my MMed, entitled, "The preferences, experience and level of comfort of anaesthetists in managing difficult intubation and 'cannot intubate, cannot ventilate' scenarios" and would like to invite you to participate. This study has been approved by the Post-graduate Committee and the Human Research Ethics Committee (Medical) (M150105) of the University of the Witwatersrand.

This study aims to describe the preferences, experience and comfort level of all anaesthetists in the department to manage an unanticipated difficult airway, and a "cannot intubate, cannot ventilate" (CICV) scenario. This is a rare situation in anaesthetic practice, but has devastating consequences if not managed appropriately. Anaesthetists working in this department are occasionally in a situation where senior help is not immediately available, should an airway emergency occur. It is not known whether anaesthetists in the Department of Anaesthesiology at Wits have the necessary experience and comfort to manage a CICV scenario. This will be determined by a self-administered questionnaire.

Participation in this study is voluntary and consent will be implied on completion of this questionnaire. All information will be collected anonymously as there will be no personal identifiers on the questionnaire. Numbering of the questionnaire is for practical purposes only, to prevent replication when capturing data. If you choose not to participate, it will not have any negative consequences for you. You can choose to withdraw from this study at any time.

The questionnaire should not take longer than 10 minutes to complete. Please place your questionnaire into the sealed box provided. Confidentiality will be ensured as the questionnaires will only be viewed by me and my supervisors.

No incentives will be provided for completion of the questionnaire. The results will help identify whether additional airway training is needed in this department and will assist our continued professional development.

All questions regarding this study can be directed to Lize Buitenweg (researcher) on 073 120 1962 or the Chair of the Human Research Ethics Committee (Medical) on 011 717 1234.

Thank you for taking the time to read this letter.

Sincerely,

Lize Buitenweg

Appendix D: Questionnaire

Section 1: Demographics

1. Gender

Male	
Female	

2. Professional designation

Consultant	
Registrar	
Medical officer	

3. Years of experience in anaesthetics

< 1 year	
1-5 years	
6-10 years	
11-20 years	
> 20 years	

4. Have you ever attended an airway workshop?

Yes		No	

5. If yes to question 4, how long ago did you attend?

In the last year	
1-2 years ago	
2-4 years ago	
> 4 years ago	

6. Do you use a described algorithm/guidelines when managing a difficult airway (eg. the ASA guidelines)?

Yes		No	

7. If yes to question 6, please state which guidelines?

_____
_____

Section 2: Management of difficult intubation and CICV scenarios

1. At which hospital are you currently working/rotating through?

CMJAH	
CHBAH	
Wits Donald Gordon Medical Centre	
HJH/RMMCH	

2. Are you aware of the location of the difficult airway trolley at this hospital?

Yes	
No	

3. If yes, is this difficult airway trolley easily accessible to you in case of an *unanticipated* difficult airway?

Yes	
No	

4. You have a 65 year old man for elective colonic resection. After induction, you fail intubation twice with direct laryngoscopy and using an introducer or "bougie", due to an "anterior larynx". You can still mask ventilate. His SpO_2 is 98%. You have decided to move to an alternative device to establish a definitive airway. What would be your first and second choice devices?

Device	**First choice (Choose 1)**	**Second choice (Choose 1)**
Flexible fibreoptic bronchoscope		
Intubating laryngeal mask		
Videolaryngoscope		
Retrograde wire set		
Optical stylet		
Rigid bronchoscope		
Other, please specify		

5. Have you personally used the following intubation devices/techniques? If so, state if on a mannequin or on a patient.

Device	**Never used**	**Mannequin**	**Patient**	
			Awake	**Asleep**
Flexible fibreoptic bronchoscope				
Intubating laryngeal mask				
Videolaryngoscope				
Retrograde wire set				
Optical stylet				
Rigid bronchoscope				

6. What is your comfort level using the following devices?

1= Completely uncomfortable 2 = Somewhat uncomfortable 3 = Equivocal 4 = Somewhat comfortable 5 = Very comfortable					
Awake fibreoptic intubation	**1**	**2**	**3**	**4**	**5**
Asleep fibreoptic intubation	**1**	**2**	**3**	**4**	**5**
Intubating laryngeal mask	**1**	**2**	**3**	**4**	**5**
Videolaryngoscope	**1**	**2**	**3**	**4**	**5**
Retrograde wire set	**1**	**2**	**3**	**4**	**5**
Optical stylet	**1**	**2**	**3**	**4**	**5**
Rigid bronchoscope	**1**	**2**	**3**	**4**	**5**

7. Have you ever been involved in a “can’t intubate, can’t ventilate” (CICV) scenario and if so, how many times?

Never	
1-2 times	
3 or more times	

8. You are in a CICV situation and the patient's SpO_2 is less than 50%, you have exhausted all non-surgical options (including an LMA). You need to perform a surgical airway, what will your first and second choices be? Assume all devices are available for use.

Device	**First choice (Choose 1)**	**Second choice (Choose 1)**
Cricothyroidotomy with IV cannula (Jelco)		
Cricothyroidotomy with percutaneous dilation kit (needle-over-trocar)		
Cricothyroidotomy with guide wire (Seldinger) kit		
Cricothyroidotomy by open surgical method		
Tracheostomy by anaesthetist		
Tracheostomy by surgeon		
Other, please specify		

9. Have you personally used the following intubation devices/techniques? If so, state if on a mannequin or on a patient.

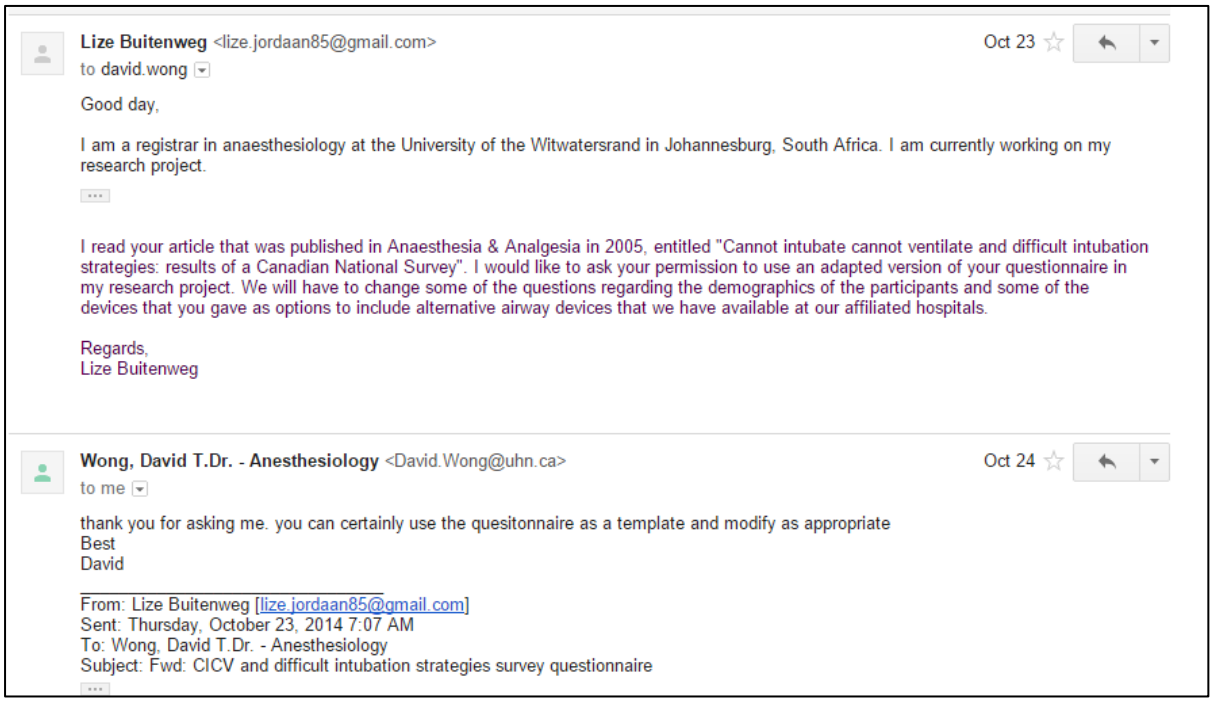
Device	**Never used**	**Mannequin**	**Patient**
Cricothyroidotomy with a IV cannula			
Cricothyroidotomy with percutaneous dilation kit (needle-over-trocar)			
Cricothyroidotomy with guide wire (Seldinger) kit			
Cricothyroidotomy by open surgical method			
Tracheostomy			

10. What is your level of comfort using the devices/techniques on patients? (circle one)

1= Completely uncomfortable 2 = Somewhat uncomfortable 3 = Equivocal 4 = Somewhat comfortable 5 = Very comfortable					
Cricothyroidotomy with a IV cannula	**1**	**2**	**3**	**4**	**5**
Cricothyroidotomy with percutaneous dilation kit (needle-over-trocar)	**1**	**2**	**3**	**4**	**5**
Cricothyroidotomy with guide wire (Seldinger) kit	**1**	**2**	**3**	**4**	**5**
Cricothyroidotomy by open surgical method	**1**	**2**	**3**	**4**	**5**
Tracheostomy	**1**	**2**	**3**	**4**	**5**

Thank you for taking the time to complete this questionnaire!

Appendix E: Permission to use questionnaire



Lize Buitenweg <lize.jordaan85@gmail.com> Oct 23

to david.wong

Good day,

I am a registrar in anaesthesiology at the University of the Witwatersrand in Johannesburg, South Africa. I am currently working on my research project.

I read your article that was published in Anaesthesia & Analgesia in 2005, entitled "Cannot intubate cannot ventilate and difficult intubation strategies: results of a Canadian National Survey". I would like to ask your permission to use an adapted version of your questionnaire in my research project. We will have to change some of the questions regarding the demographics of the participants and some of the devices that you gave as options to include alternative airway devices that we have available at our affiliated hospitals.

Regards,
Lize Buitenweg

Wong, David T.Dr. - Anesthesiology <David.Wong@uhn.ca> Oct 24

to me

thank you for asking me. you can certainly use the quesitonnaire as a template and modify as appropriate
Best
David

From: Lize Buitenweg [lize.jordaan85@gmail.com]
Sent: Thursday, October 23, 2014 7:07 AM
To: Wong, David T.Dr. - Anesthesiology
Subject: Fwd: CICV and difficult intubation strategies survey questionnaire

Appendix F: Likert scale data

Number of participants selecting different comfort levels with use of difficult airway devices

Device	1	2	3	4	5	Missing data
Awake FOI	22	35	19	34	15	1
Asleep FOI	11	19	23	42	30	1
ILMA	6	22	40	46	11	1
Videolaryngoscope	3	7	6	36	73	1
Retrograde wire	66	29	22	4	1	4
Optical stylet	49	22	36	12	1	6
Rigid bronchoscope	66	20	26	8	3	3

Number of participants selecting different comfort levels with use of devices/methods used in a CICV scenario

Device	1	2	3	4	5	Missing data
Cricothyroidotomy with a IV cannula	15	33	32	39	5	2
Cricothyroidotomy with percutaneous dilation kit (needle-over-trocar)	29	32	37	21	4	3
Cricothyroidotomy with guide wire (Seldinger) kit	31	33	31	24	3	4
Cricothyroidotomy by open surgical method	69	29	15	6	3	4
Tracheostomy	86	24	6	3	3	4

1 = Completely uncomfortable
2 = Somewhat uncomfortable
3 = Equivocal
4 = Somewhat comfortable
5 = Very comfortable