A Systematic Review of Evidence on the Effectiveness of Video Laryngoscopes in Acute Care Facilities

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Thesis Declaration

I certify that this thesis entitled:

A Systematic Review of Evidence on the Effectiveness of Video Laryngoscopes in Acute Care Facilities

Submitted for the degree of Master of Clinical Science (Evidence Based Healthcare), is the result of my own research. This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Scott Mitchell

Date:
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Executive Summary

Aim
The objective of this systematic review was to synthesise the evidence on the effectiveness of the video laryngoscope in the acute care setting compared to the traditional method of direct laryngoscopy.

Methods
The search strategy implemented aimed to find both published and unpublished studies in English language only from 2001 to 2010 that compared the effectiveness of the video laryngoscope to direct laryngoscopy in the acute care setting. The search was conducted using databases such as Medline, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Database of Abstracts of Reviews of Effects, Cochrane Central Register of Controlled Trials (CENTRAL), Health Technology Assessment Data Base, BioMed Central, Bioscience & Health Technology Database, Embase, JBI Library of Systematic Reviews and Scopus. A manual search of references and unpublished studies held by manufacturers was also conducted. The following key words and terms were used: Laryngoscopes, Laryngoscopy, Videolaryngoscope, Video laryngoscope, Video assisted laryngoscope, Effectiveness, Experience, Theatre, operating theatre, Critical Care, Intensive Care, ICU and Emergency Department.

Findings
Thirty-nine studies were identified as suitable for critical appraisal. Utilising the MASTARI critical appraisal tool 22 studies were selected for review. The review identified that the available evidence of the effectiveness of the video laryngoscope in the acute care setting in comparison to direct laryngoscopy was weak related to poor study design and a lack of statistical power. The strength of this evidence does not allow for a statement supporting the use of video laryngoscopy over direct laryngoscopy. This finding is consistent with the ANZCA background paper on equipment for the management of difficult airways. Regardless of this, using the primary outcomes of time to intubate and number of intubation attempts, there is evidence to suggest that the use of a video laryngoscope may be effective in four of the identified subgroups. The four subgroups are patients with predicted or known difficult airways, those with restricted neck movement, and those who are obese and in situations where a novice is performing intubation.
**Conclusion**

The available evidence is inconclusive in identifying if the video laryngoscope is effective in the acute care setting when compared to direct laryngoscopy in the acute care setting.

**Implications for Research**

The review further emphasises the need for a multi-centre randomised controlled trial to validate the effectiveness of the video laryngoscope compared to direct laryngoscopy in the acute care setting. It is recommended that both adult and paediatric patients be included as participants. In order to further validate the clinical use of the video laryngoscope participants with Cormack Lehane Grades I – IV and ASA scores I – IV should be included.

**Implications for Practice**

Four recommendations are made by the review that impact on practice however the weakness of the available evidence limits the meaningfulness of the recommendations. The recommendations are:

A video laryngoscope should be immediately available to use for patients with predicted or known difficult airways, those with restricted neck movement and those who are obese when time to intubate is not considered to be a critical factor.

A video laryngoscope should be available for use by novice intubators at all times.

A video laryngoscope should be available on resuscitation trolleys.

A video laryngoscope should be located permanently in the Post Anaesthetic Care Unit (PACU). Alternatively a post intubation process that ensures used video laryngoscope equipment remains with the patient until discharged from PACU.
Chapter One: Introduction

Introduction
The uses of nonstandard laryngoscopes such as the video laryngoscope have been reported to improve glottic view during the process of intubation.1-3 By improving the view of the glottis by the use of a video laryngoscope a reduction in failed intubations and time to intubate should be achieved.4 Complications associated with the intubation may also be reduced.5 Despite the potential advantages of the video laryngoscope the Australian New Zealand College of Anaesthetists (ANZCA) recommends the use of direct laryngoscopy as a first line treatment for the purpose of intubation.6 ANZCA identifies this recommendation as the evidence supporting the clinical use of the video laryngoscope was weak.6

The objective of this systematic review was to identify evidence to fill the gap identified by ANZCA and provide appropriate recommendations to shape clinical practice. To achieve this objective the systematic review identified and critically appraised the available quantitative evidence on the effectiveness of the video laryngoscope compared to direct laryngoscopy in the acute care setting.

Thesis Structure
The structure of the thesis comprises five chapters as follows:

Chapter One provides a brief introduction of the need to evaluate the use of video laryngoscopes and state the objective of the critical review.

Chapter Two discusses the background of the thesis. The development of laryngoscopy is described, associated risks and the introduction of technology to reduce those risks.

Chapter Three outlines the methodology used for the systematic review. The research protocol addressed the objective of the review, review question, inclusion and exclusion criteria for selected studies, search strategy and collection. Critical appraisal, analysis and synthesis techniques are discussed and keywords defined.

Chapter Four reports on the data extracted using a standardised data extraction tool. Data collected from a variety of settings and patient classifications is presented together and within their sub groups.

Chapter Five describes the synthesised results and identifies implications for practice and research.
Chapter Two: Background

Introduction

Management of the human airway by intubation, passing a tube through the vocal cords into the trachea to provide an artificial airway, has become integral in the delivery of elective and emergency healthcare.\(^7\) Development of effective techniques and instruments required for intubation has taken place over four thousand years of documented history.\(^7\) Appropriate application of the techniques and instruments of airway management facilitates respiration and protects vital structures and organs such as the lung.\(^7\) To follow is a brief overview of the historical techniques and instruments required for intubation, along with evidence identifying their effectiveness. The overview will lead into a succinct discussion on the introduction of digital technology to airway management, and the need to identify the effectiveness of its application for this purpose.

Early Techniques for Endotracheal Intubation

The earliest forms of airway management revolved around the use of tracheostomies. Tracheostomy is a procedure that creates an artificial airway in the cervical trachea, thus allowing respiration to occur from an external opening other than the nose or mouth.\(^8\) It has been used throughout the centuries to treat upper airway obstruction.\(^8\) Friedrich Trendelenburg was the first to apply airway management in the surgical theatre setting in 1871 when through the use of a tracheostomy he administered the first endotracheal anaesthesia.\(^8\)

Despite an awareness of the benefits of the tracheostomy, descriptions of endotracheal intubation did not emerge until the mid-1800s.\(^7\) Endotracheal intubation involves inserting a tube orally then passing that tube through the vocal cords into the trachea.\(^7\) Initially this method was used for the resuscitation of drowning victims and neonates along with the treatment of laryngeal diphtheria.\(^7\) Early methods used to facilitate endotracheal intubation performed by Joseph O'Dwyer, Charles Kite and others, were achieved without obtaining a view of the larynx, are referred to as a blind techniques.\(^8\) This technique required the practitioner to place their fingers into the patients’ mouth in order to palpate the larynx, and then guide the endotracheal tube through the larynx and into the trachea.\(^9\)

Although differing in nature from that used by O'Dwyer, blind techniques continue to be used in contemporary medicine. Modern techniques may employ the use of a combination of equipment that may include a laryngoscope, bougie and a light wand. A light wand is a stylet with a light source at the tip whose glow may be seen externally, providing a guide to the
It is crucial that correct positioning of the endotracheal tube takes place. Correct placement may be determined by the use of a colometric carbon dioxide (C02) detection device or capnography, a measure of exhaled CO2 and auscultation of the chest, as blind techniques are difficult and often result in the endotracheal tube entering the oesophagus.

**The Emergence of Direct Laryngoscopy**

The original blind techniques for endotracheal intubation remained common until the mid-1890's. It was at this time that the first documented instrument to view the larynx, initially developed by a singing teacher in 1855 using mirrors, was adapted by Kirstein. He developed an instrument called the Autoscope. For the first time those performing endotracheal intubation were able to obtain a direct view of the larynx for the purpose of intubation. Equipment such as the Autoscope is generally referred to as a laryngoscope. The laryngoscope is battery powered, consists of a handle and a curved or straight rigid blade with a light source at the distal tip. When assembled the equipment resembles a small sickle.

Since the development of the laryngoscope, ‘direct laryngoscopy’ has become the preferred method for airway management. Unlike blind laryngoscopy, direct laryngoscopy requires alignment of the oral, pharyngeal and laryngeal axes, using a ridged laryngoscopy blade to facilitate a direct view of the vocal cords and other structures. To obtain a satisfactory view of the vocal cords, the patient will typically lay in a supine position, with the intubator standing behind the head introducing a laryngoscope blade into the right side of the mouth. The blade is then moved left to trap and sweep the tongue out of the line of sight of the vocal cords. Depending on the blade, the tip may lie anterior or posterior to the epiglottis. The laryngoscope is then lifted with an upwards and forward motion. The aim is to provide the best laryngeal view.

As the aim of direct laryngoscopy is to provide the best laryngeal view, many designs of ridged laryngeal blades have been developed to facilitate this procedure. Magill and Miller refined tools for the purpose of direct laryngoscopy in the early twentieth century. Miller developed a straight blade that was in common use prior to the 1940s, however, poor technique in the use of this device led to an opportunity for Macintosh to develop a curved laryngoscope blade. The ease of mastering this new technique, combined with Macintosh’s teaching skills and the equipment’s price, led to this device becoming the preferred tool for direct laryngoscopy. Improvements in battery and light source/transfer technology have been applied to ridged laryngoscopy blades to enhance reliability, useability, and ultimately the laryngeal view obtained from such devices.
The impetus to improve the laryngeal view obtained by direct laryngoscopy arose out of necessity, as the ability to intubate the trachea is dependent upon the time taken to obtain a clear view of the larynx and secure the airway. A common tool for reporting the laryngeal view is the Cormack-Lehane Classification (Figure 1), with which a grading of I or II suggests intubation may be achieved with minimal difficulty, while a grading of III or IV may require intervention by a senior practitioner. Mallampati developed a predictive tool in 1985 where a higher score may be an indication of a difficult airway management scenario (Figure 2). These tools are used to predict and prepare for patients where tracheal intubation via direct laryngoscopy may be difficult, if not impossible to achieve. Factors affecting direct laryngoscopy include the tongue, the epiglottis, mouth opening, the thyromental distance, the ability to position the patient correctly, clinical presentation and trauma. Up to nine percent of the population fall into the difficult airway category and require interventions to assist in the management of their airway. Techniques such as backward, upward, right pressure (BURP) may improve the view obtained by direct laryngoscopy. The use of bougies and stylets when combined with a laryngoscope blade facilitate intubation in patients with limited or no laryngeal view. Despite advances in technique and instruments, for some individuals, the process may be prolonged and require multiple attempts. For the most difficult airway the insertion of the endotracheal tube is a blind process.

**Potential Harms Associated with Direct Laryngoscopy**

Despite the high percentage of the population who may have a difficult airway, direct and blind laryngoscopy has a low failure rate of 0.035% in the surgical theatre, rising to 2.5% in other hospital settings. Failure to intubate in less than 2.5% of patients suggests that, while widely regarded as a relatively safe procedure, direct laryngoscopy as a method for endotracheal intubation is not without risk. The Anaesthesia Mortality Committee convened by ANZCA identified that there were 14 deaths directly attributable to ineffective airway management between 2003 – 2005. This was an increase of four deaths from the period between 2000 – 2002. After performing a literature review, Atkinhead identified that 7.5% of intra operative cardiac arrests are related to poor airway management. Using data compiled by the Australian Incident Monitoring System (AIMS), Holland identified that 35 of the first 2000 incident reports (1988 – 1993) related to airway management in the perioperative environment. In these incidents laryngoscopy resulted in the endotracheal tube being placed in the oesophagus, preventing the delivery of oxygen to the lung via the trachea. Subsequently, Holland compared the first 2000 AIMS reports (1988 – 1993) to 1000 Aims reports made between 2002 and 2006, and identified an increase in reports related to difficult airway management. Of these reports there was an increase of 16% related to failure
Mortality data generated in America is compiled from closed claim litigation. Claims related to respiratory complications make up 34% (approximately 500 cases) of litigation claims. Of these 500 incidents, 46% may be attributed to complications associated with airway management including aspiration, oesophageal intubation and difficult airways. Caplan identifies that 72% of the complication were considered preventable. 85% of litigations associated with airway management are related to death or brain damage. With failed intubation resulting in such catastrophic patient outcomes, and given that these failures may be preventable, is it suitable to accept a failure rate related to direct laryngoscopy? If not, what other options are there to the traditional method of direct laryngoscopy?

**Non Traditional Laryngoscopy**

Direct laryngoscopy is not well tolerated by the conscious patient and requires, at best, a patient to be sedated to prevent vomiting, as well as to suppress the suitable gag and cough reflexes. The adaptation of fibre optic technology to airway management at the end of the 1960s resulted in the development of flexible endoscopes, which negate the need to manipulate the oral, pharyngeal and laryngeal axes in order to provide view of the vocal cords. As a result, these flexible endoscopes allow patients to be intubated while conscious. Flexible endoscopes are small in diameter, have a light source at the tip and transfer an image of the glottis to the anaesthetist via fibre optics. Although a view of the vocal cords is obtained, it is not a line of sight view, and is thus referred to as ‘indirect laryngoscopy’. The importance of this development may be judged by its inclusion in algorithms developed for the management of patients with difficult airways.

The use of fibre optic intubating equipment requires a well-planned and coordinated process. The equipment is expensive, easily damaged, cumbersome to use, and requires specialised skills to use and to clean after use. These factors often limit the use of this technology to elective and semi elective situations. Further development of this technology specifically for the purpose of intubation has led to the production of equipment such as the bonfils, wu and clariscope: ridged or semi ridged rods that carry a light source and fibreoptic/video capabilities, to provide an indirect view of the vocal cords. This equipment is not as cumbersome and the cleaning requirements not as specialised as a flexible endoscope.

The advent of digital technology and its application to airway management and anaesthetics has coined a phrase the “video revolution”. Simply described, this revolution is the video laryngoscope that combines a digital video camera placed toward the distal tip of a ridged laryngeal blade. The image is then displayed on a screen attached to the laryngoscope handle or on a separate screen. As with other non-traditional intubating tools, the need to
manipulate the oral, pharyngeal and laryngeal axes in order to provide a view of the vocal cords is not required.  

Applied first in the late 1990s and produced commercially from 2001, the proponents of digital methods of laryngoscopy identify many advantages to all previous methods. For example, the view obtained by the use of a video laryngoscope for indirect laryngoscopy is claimed to provide a consistently clear, equivalent or improved view of the larynx compared with direct laryngoscopy techniques. As a result of the improved view, a reduction in failed intubations and time to intubate should be achieved, and complications associated with the intubation could be reduced. It has also been suggested that as the devices are similar current to direct laryngeal components, the skills involved should be easily transferable to the new technology. The use of the video laryngoscope in the training of anaesthetists is also suggested, as it enables the teacher and the novice to view the process of laryngoscopy simultaneously. These commentaries in the main refer to the application of the video laryngoscope to an adult population. Discussion related to the application of the video laryngoscope to the paediatric population began to appear in 2005 and although increasing in frequency remain sparse when compared to the discussion held related to the use of the video laryngoscope in the adult population.

Conclusion
Since the introduction of the first commercially available product in 2001 there has been much commentary related to the use of the video laryngoscopy. ANZCA identifies in a background paper on guidelines on equipment to manage a difficult airway that although available evidence supporting the use of non-standard equipment such as video laryngoscopes is lacking. ANZCA’s position may be held by other professional bodies such as the American Society of Anaesthetists (ASA), the British Airways Society and various Resuscitation Councils who provide no recommendations for the use of the video laryngoscope. Literature related to the video laryngoscope focuses often on the adult with little evidence or discussion related to the effectiveness of this technology when applied to a paediatric context. The purpose of this systematic review of the effectiveness of video laryngoscopy in the acute care setting was to provide evidence to fill the gap in evidence for adult and paediatric patients related to the effectiveness of the video laryngoscope compared to direct laryngoscopy in the acute care setting.
**Definition of terms**

Blind techniques - endotracheal intubation achieved without visualising the glottis.  

Cormack Lehane Classification – Airway grading scale

![Figure 1 Airway grading based on Cormack and Lehane grading scale.](image)

Intubation - the passing of a tube through the vocal cords into the trachea to provide an artificial airway.

Direct laryngoscopy - direct view of the vocal cords obtained using a laryngoscope.

Indirect laryngoscopy – indirect view of the vocal cords not requiring the need to manipulate the oral, pharyngeal and laryngeal axes.

Mallampati Score – predictive difficult intubation tool.

![Figure 2 Mallampatti Score tool.](image)

Thyromental Distance - the distance from the mentum to the thyroid notch while the patient’s neck is fully extended. It is reported as a measure in cm. A distance greater than 6.5 cm is considered normal, 6 - 6.5 cm as less difficult while a measure less than 6 cm is considered difficult. The reason being the laryngeal axis is less likely to fall in line with the pharyngeal axis when the atlanto-occipital joint is extended by less than 6 cm.
Chapter Three: Methodology and methods

Introduction

Since the conclusion of the twentieth century health professionals have been faced with a vast amount of information available in multiple formats.36,37 Rys reported an estimated eighteen million articles were available on the Medline database with up to one million papers added each year.36 In 1992 the inability to integrate this wealth of information into the development of appropriate and effective clinical practice was identified.38 Reasons for the paralysis of integration have included the publication of multiple studies and the frequent heterogeneity of the results.36,37 Equally important was the concern that clinical confidence may have been placed on unreliable information as a bias to the publication of studies with positive outcome has also previously been documented.37,38 To facilitate the implementation of appropriate evidence as opposed to information the science of evidence synthesis has provided a frame work for rigorous identification, selection, appraisal and summary of available evidence in the form of the systematic review.38

Systematic review methodology

The frame work for the contemporary systematic reviews has roots in the social sciences of the 1960’s when clear efforts to reduce the introduction of bias in the review of literature began.39 Glass introduced the quantitative synthesis of the results of primary studies introducing the term meta-analysis, a mathematical method of pooling the results of several or more studies.36,39 Several groups such as The Cochrane Collaboration, The Campbell Collaboration, The Centre for Evidence Based Medicine and The Joanna Briggs Institute have taken this early work and developed rigorous processes for multistage processes intended to identify all reliable evidence regarding a specific clinical problem known as the systematic review. The evidence should be reviewed in the context of feasibility, appropriateness, meaningfulness and effectiveness of the environment the evidence was collected and where it is to be applied.40 Systematic reviews should include a defined clinical question, pre-specified inclusion and exclusion criteria, a complex a search strategy, critical evaluation of the reliability of the available evidence, data synthesis and evidence based conclusions.36,41 The steps of this process related to the effectiveness of the video laryngoscope in the acute care setting follow.
Review Objective
The objective of this systematic review was to synthesise the evidence on the effectiveness of the video laryngoscope in the acute care setting compared to the traditional method of direct laryngoscopy. A search was carried out to identify if a systematic review on the topic had been previously completed. No such review was identified.

Review Question
What is the best available evidence of effectiveness of new video laryngoscope in the acute care setting in comparison to direct laryngoscopy?

Effectiveness may refer to successful/failed intubation dependant on the reporting method used. It may also be measured by time required for the procedure. A secondary measure will be that of laryngeal grade obtained using avide laryngoscope.

Inclusion Criteria

Types of participants
Patients intubated using a video laryngoscopy in the acute care setting.

Such patient groups will include:

- Neonatal, paediatric and adult
- Patients with difficult airway
- Emergency and elective surgery
- Airway rescue cases of failed intubation by other methods
- Such patient groups will exclude
- Conscious intubations
- Nasal intubations

Participants presented with a variety of glottic pathologies determined by Cormack Lehane classification and Mallampati Classification; with a range of American Society of Anaesthesiologists classifications (ASA); however; studies were not excluded on the bases of diagnosis.

Types of Interventions
The review considered studies that evaluated the use of a video laryngoscope as the sole tool to facilitate endotracheal intubation
Such equipment groups will include:

- Coopdech C-Scope
- Glidescope AVL
- LMA Advance
- McGrath Video Laryngoscope
- Storz C-Mac
- Pentax AWS

It is acknowledged that there are no English studies for the Coopdech C-Scope and that the LMA Advance has been recently released with no studies identified during the literary search process.

Such equipment groups were excluded as the video image that is obtained from these devices is not obtained by a video camera at the distal end of a ridged laryngoscope blade.\(^{42}\)

Bonfils
Wu Scope
True view
Claris scope

**Comparison**
All methods of direct laryngoscopy that utilise a rigid laryngoscope blade of any description.

**Types of Outcomes**
This review will considered studies that included the following primary outcome measures:

- Number of attempts to achieve successful intubation
- Time to intubation
- Failure to intubate

**Secondary Outcomes**

- Glottic view
- Trauma
- Sore Throat
- Haemodynamic changes
Types of Studies
The review considered any randomised controlled trials; in the absence of RCTs other research designs, such as non-randomised controlled trials and before and after studies, were considered for inclusion to enable the identification of current best available evidence regarding the effectiveness of video laryngoscopes. Studies and case series that do not provide a comparison of a video laryngoscope and direct laryngoscopy were excluded from this systematic review.

Search Strategy
The search strategy aimed to find both published and unpublished studies in English language only from 2001 to 2010. The commencing year of the systematic review, 2001, was chosen as it was in this year that the video laryngoscope was first commercial available. A three-step search strategy was utilised in each component of this review and took place during February 2011. An initial limited search of MEDLINE and CINAHL was undertaken followed by analysis of the text words contained in the title and abstract, and of the index terms used to describe article. An example of the initial search identifying key words, Mesh terms, and use of Boolean operators may be found in Appendix 1. A second search using all identified keywords and index terms was then undertaken across all included databases. Thirdly, the reference list of all identified reports and articles was searched for additional studies.

The databases searched included:
Medline
The Cochrane Library
Cochrane Database of Systematic Reviews
Database of Abstracts of Reviews of Effects
Cochrane Central Register of Controlled Trials (CENTRAL)
Health Technology Assessment Data Base
BioMed Central
Bioscience & Health Technology Database
Cumulative Index to Nursing and Allied Health Literature
Embase
JBI Library of Systematic Reviews
Scopus

The search for unpublished or Grey Literature included:

Australian Digital Thesis Program

Dissertation Abstracts International

Mednar

Conference Proceedings

Australian Government, Anaesthetic and Nursing Professional bodies or association web sites were also searched. Such sites shall include

Australian New Zealand Collage of Anaesthetist (ANZCA)

Australian Society of Anaesthetists (ASA)

The Royal College of Anaesthetists (RCoA)

Australian College of Operating Room Nurses (ACORN)

South Australian Peri operative Nurses Association (SAPNA)

Critical Care Forum (http://ccforum.com)

Australian College of Critical Care Nurses (http://www.acccn.com.au/)

Keywords used were:

Laryngoscopes

Laryngoscopy

Videolaryngoscope

Video laryngoscope

Video assisted laryngoscope

Effectiveness

Experience

Theatre, operating theatre

Critical Care

Intensive Care, ICU

Emergency Department
Assessment of Methodological Quality
The full text of studies identified by title and abstract considered as being relevant to the population, intervention and outcome identified by the systematic review protocol were retrieved. Following retrieval the full text were independently assessed by two reviewers. Reviewers assessed the studies for methodological validity prior to inclusion in the review using standardised critical appraisal instruments from the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) (Appendix V). Several discussions were held over the inclusion of all studies related to the study designs prior to exclusion and inclusion.

Data Collection
Quantitative data from papers included in the review was extracted using the standardised data extraction tool from JBI-MAStARI (Appendix V). The independent reviewers agreed that statistical meta-analysis was not possible resulting in the findings being presented in a narrative format. The data extracted included specific details about the interventions, populations, study methods and outcomes of significance to the review question and specific objectives.

Conclusion
Systematic review facilitates rigorous identification, selection, appraisal and summary of available evidence. By articulating the implemented process the validity of the review may be tested and the feasibility, appropriateness, meaningfulness and effectiveness of the review outcomes may be contextualised. The application of this process as related to this systematic review of the effectiveness of the video laryngoscope in the acute care setting provides the opportunity for the integration of the synthetised evidence into practice.
Chapter Four: Results

Introduction
The search strategy for this systematic review was completed in February 2011 with 1093 titles and abstracts identified. A comprehensive description of the process of the critical appraisal of the 1093 titles and abstracts is supplied. The first step in this description discusses how the evidence was identified and the critical appraisal tool used. Following this the risk of bias within the included studies revealed by the use of the critical appraisal tool are acknowledged. The final step is a narrative review of the results contained within the included studies.

Description of studies

Results of the search
At the completion of the search strategy a total of 1093 titles and abstracts were identified. Of those titles and abstracts retrieved by the search 113 duplicate studies were identified utilising the duplicate function in EndNote and by a review of the abstracts. After removing the duplicates 980 titles and abstracts were set aside for further scrutiny. An additional 10 titles and abstracts were identified by a hand search that included contacting the manufacturers of video laryngoscopes. A total of 990 titles and abstracts from both processes were further reviewed for inclusion criteria. Of the 990 titles and abstracts 39 studies were identified as suitable for critical appraisal. Utilising the MASTARI critical appraisal tool (Appendix V) 22 studies were selected for review. The same critical appraisal tool identified that 16 studies were of low quality related to their design or did not present data relevant to this studies outcomes of interest. The 16 studies were excluded. One study that was identified as being of interest was unable to be retrieved and therefore was not included in the study. Appendix IV provides a list of the excluded studies and the reasons for their exclusion. Figure 3 provides a flow chart of the steps that took place in the selection process followed.
Of those studies included 20 were RCT or pseudo randomised trials with 2 comparable cohort studies also included. The quality of the included studies was appraised using the JBI-MAStARI tool (Appendix V). This tool facilitated the identification of the risk of bias being included to the studies. A brief discussion on the risk of bias found within the included studies is provided. Although the RCT is the highest level of evidence the included studies were considered of poor quality related to their design and statistical power.

**Risk of Bias in Included Studies**

**RCT**
The included RCT’s were assessed on whether generation of the allocation sequence, allocation concealment, blinding, and follow up were met, not met, or unclear. Appendix III identifies the results of the assessment that was performed.

**Generation of Allocation Sequence**
The allocation of participants to treatment groups were reported to be random in the 20 RCT included. Randomisation was achieved by a variety of methods. Such methods included computer generated tables,43 online software44 and in one instance a coin toss.45 True random allocation of participants occurred in 12 of the 20 studies.43, 44, 46- 55 In seven of the included studies the methods used to generate allocation were unclear.45, 56 – 61 In the remaining study random allocation did not occur.62
**Allocation concealment**
Allocation concealment in most instances was achieved by placing the participant’s treatment allocation into envelopes that were opened prior to intubation. One study identified that allocation was not concealed.\(^6\) The full process of allocation concealment was unclear in the remaining 19 RCT studies.

**Blinding**
Blinding was not met in all the studies because it is not possible to blind both patients and operators to the type of intubating equipment used. Authors such as Theo identify the inability to blind the operator to the intubating equipment, as a limiting factor to their study design.\(^5\) Aio was another author who identified this limitation but also described the impractical nature of a double blind design for the purpose of their study.\(^6\)

**Follow Up**
Follow up was appropriately met in all studies based upon the individual studies outcome of interest. Failure to intubate, Laryngeal Grade and time to intubate were assessed and recorded at the time of intubation. Three studies collected data related to haemodynamic changes associated with intubation and were assessed and recorded at the intubation process.\(^5\)\(^-\)\(^3\) Three studies reviewed trauma associated with the intubation process and was assessed after extubation in Recovery and on the ward the following day.\(^5\)\(^,\)\(^5\)\(^,\)\(^6\)

**Cohort Studies**
Sample size in all included cohort studies were not representative of general population. Failure to address the compounding factors diluted the effect of the interventions they investigated.\(^6\)\(^,\)\(^5\)

**Description of the Studies**
The included studies did not have a consistent and uniform approach to the collection and presentation of the data captured. Due to the lack of homogeneity the results of the studies are presented in a narrative manner. The narrative discussion will provide an over view of the data collected. Where applicable the data will also be presented for identified sub groups found within the included studies.

The design of the included studies reflected a variety of clinical scenarios that may be found in two clinical settings within an acute care facility and numerous video laryngoscopes. Included studies provided data for the following clinical scenarios patients with predicted difficult airways, paediatric patients and simulated neck restriction. Operating theatres, twenty, was the most common clinical setting for studies while two were conducted within
Emergency Departments.\textsuperscript{64, 65} Seven designs of video laryngoscopes were used across the clinical scenarios and setting. The seven designs used were the Airway Scope,\textsuperscript{45,46,48,51,52,55,59} C-Mac,\textsuperscript{58} GlideScope,\textsuperscript{44,47,51-55,62,63,65} Kaplan and Berci video laryngoscope,\textsuperscript{43,49} MaGrath Series 5,\textsuperscript{56,61} X-Lite,\textsuperscript{58} and the Storz DCI.\textsuperscript{60}

Outcomes

Time to Intubate

Eighteen of the included studies compared the time to intubate between the treatment and control group. Sixteen of the included studies were RCT’s with the remaining two being Cohort Studies. Several factors may have introduced bias to the presented data. These factors will be discussed then the data presented.

Time to intubate was measured in seconds although data was noted to be heterogeneous in nature related to the design of data collection. Aio identified time to intubate as commencing from the time the airway device was handed to the operator while Platts-Mills commenced timing from when the blade entered the mouth.\textsuperscript{56, 65} The inconsistent approach to timing intubation was also displayed at the completion of the process. Shayeghi ceased timing the intubation process without confirmation of correct placement by capnography while Kim identified successful intubation by use of capnography.\textsuperscript{47, 53}

Another factor that may have introduced bias was operator experience with the use of a video laryngoscope. MacNair identified that all operators were equally proficient with both the treatment group, video laryngoscope, and the comparison group, traditional laryngoscopy.\textsuperscript{49} Studies conducted by Shayeghi and Lee identified that operators were not proficient with the use of videolaryngoscopy.\textsuperscript{53,57} Proficiency with the use of video laryngoscopy is further discussed by Platt-Mill who identified selection bias related to experience with techniques and equipment as a source of bias with in their study design.\textsuperscript{65}

Other study designs may also have introduced bias in the collection of time to intubate data. Bilehjani study design excluded patients with predicted difficult airway while Nouruzi-Sedeh excluded patients with mouth opening of less than 4 cm.\textsuperscript{44, 62} Enomoto required participants to undergo two consecutive laryngoscopy techniques.\textsuperscript{45} Such designs may have reduced or improved the effectiveness of the treatment or control groups at the time of comparison.

A comparison of time to intubate between the treatment group, video laryngoscopy and comparison group, traditional laryngoscopy occurred eighteen times. Eleven of the studies identified that time to intubate was quicker using traditional laryngoscopy.\textsuperscript{47,49,51-54,56,59,60,65} Six identified the use of a video laryngoscope reduced the time to intubate.\textsuperscript{43,45,46,62,63} One
study compared the effectiveness of multiple video laryngoscope designs with traditional laryngoscopy. This study identified that the design of the video laryngoscope impacts on time to intubate. Significant advantage related to time to intubate were not reported. Of the eighteen studies two, Kim and Sun compared time to intubate and Cormack Lehane Grade. Kim identified that for a Cormack Lehane grade I – II traditional laryngoscopy resulted in the quickest time to intubate while the videolaryngoscope was quicker for grades III – IV. In all instances Sun found time to intubate quickest with traditional laryngoscopy.

**Number of Attempts / Failure to Intubate**

After a review of the available data from the included studies a decision was made to report number of attempts to intubate and failure to intubate data as number of attempts with in this systematic review. This decision was made as the included studies did not articulate what was considered to be an intubation attempt and what was considered a failed intubation. For studies that reviewed multiple devices for the treatment group, video laryngoscopy or the control group traditional laryngoscopy, all attempts will be present as a single figure.

As with time to intubate similar factors that may have introduced bias into the presented data existed in the collection process. As already discussed no definitions of an attempt or failed intubation were provided. Operator experience, participant exclusion criteria and consecutive laryngoscopy may have reduced or improved the effectiveness of the treatment or control groups at the time of comparison.

Thirteen studies presented data that identified the number of intubation attempts for treatment group, video laryngoscopy and the control group traditional laryngoscopy. Overall less intubation attempts were required for the treatment group video laryngoscopy, than the control group traditional laryngoscopy. Although the combined total indicates significant differences one study resulted in 77 of the 149 intubation attempts. As a result intubation attempts data should be considered in the sub group categories.

**Secondary Outcomes**

As with the primary outcomes of interest the included studies did do provide homogeneity in the collection of presentation of data

**Trauma**

Five studies provided data that for the purpose of this systematic review has been presented as trauma. Authors identified the following as descriptions of trauma; laceration, the presence of blood on the laryngoscope blade or in the airway, sore or horse throat and
damage to teeth. Overall there were more indications of trauma for the control group traditional laryngoscopy, 31, 51, 55, 56 than treatment group video laryngoscopy, 26, 44, 61

**Haemodynamic Changes**

Three include studies reported data related to haemodynamic response to intubation with the treatment group video laryngoscope and the control group traditional laryngoscopy. The three studies identified that there were no significant differences in the results. Shayeghi identified that the duration taken to intubate the participants was significantly longer for the treatment group, video laryngoscope however there was no effect on haemodynamic responses.

**Glotic View**

Fifteen of the included studies provided data on the comparison of glottic view obtained using the treatment group video laryngoscopy and the control group traditional laryngoscopy. Five studies did not report glottic view. The Cormack Lehane Grade was used to report this data. Three studies conducted in an operating theatre, one with a paediatric focus and the others an adult focus included participants with predicted or previous difficult airways, while a study conducted in emergency departments had no airway related inclusion / exclusion criteria. Thirteen studies by design resulted in the inclusion of patients unlikely to have a Cormack Lehane Grade of three or greater. This was achieved by excluding patients with predicted or previous difficult airways and small mouth openings. Table 2 identifies the disparity between those participants with minimal difficulty airways and those with a potentially difficult airway.

Such designs may have reduced or improved the effectiveness of the treatment or control groups at the time of comparison. The comparison data presented as a result may have been biased. This bias may have presented as little or no improvement in glotic view between treatment group video laryngoscopy and the control group traditional laryngoscope for participants with Cormack Lehane Grades of I- II. While the exclusion of patients with limited mouth opening may have introduced bias by not exposing both the treatment group video laryngoscopy and the control group traditional laryngoscopy to the associated difficulties of this scenario.
<table>
<thead>
<tr>
<th>Cormack Lehane Grade I – II</th>
<th>Cormack Lehane Grade III – IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>1120</td>
</tr>
<tr>
<td></td>
<td>215</td>
</tr>
</tbody>
</table>

Table 1 Distribution of Cormack Lehane Grading via Direct laryngoscopy

Other study designs may also have introduced bias in the collection. Those designs that may have introduced bias were operator experience and the requirement for participants to undergo two consecutive laryngoscopy techniques. Such designs may have reduced or improved the effectiveness of the treatment or control groups at the time of comparison.

The data was presented in a variety of formats including table and narrative. Data in thirteen of the fifteen studies identified that indirect laryngoscopy using a video laryngoscope provided the same or better glottic view when compared to direct laryngoscopy using traditional laryngoscopy techniques. Two studies provided data that in some scenarios indirect laryngoscopy using a video laryngoscope may result in a poorer glottic view than that obtained by direct laryngoscopy using traditional laryngoscopy techniques.\(^48,64\) The data presented only identified the total number of Cormack Lehane Grades recorded and did identify if those grade found to be higher were the same reported for the treatment group video laryngoscopy and the control group traditional laryngoscopy.

Figure 2 Distribution of Subgroups Analysed
Sub groups

Neck Restriction
Five of the included studies design required patients to have simulated immobilisation of the cervical spine.\textsuperscript{45, 48, 51, 56, 59} The five studies were RCT’s. All measured glotic view with the Cormack Lehane assessment tool and time to intubate. Four studies identified the number of intubation attempts\textsuperscript{45, 48, 51, 56} and two data related to trauma.\textsuperscript{51, 56}

Time to Intubate
Five studies reported data related to time to intubate. Time to intubate was identified as being quicker for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy in two studies.\textsuperscript{45, 48} Three of the included studies identified time to intubate as being slower for the treatment, group video laryngoscopy than the comparison group direct laryngoscopy.\textsuperscript{51, 56, 59}

In one study the design resulted in two different methods for the timing of the procedure.\textsuperscript{45} The design allowed for the timing of direct laryngoscopy to commence when the blade was inserted into the mouth. Timing commenced for indirect laryngoscopy when the laryngeal tube was touched suggesting that the blade of the video laryngoscope was already in place.

Intubation Attempts
Four studies reported data related to intubation attempts.\textsuperscript{45, 48, 51, 56} Two studies identified that more attempts were required for treatment, group video laryngoscopy than the comparison group, direct laryngoscopy.\textsuperscript{48, 51} One study identified that less attempts to intubate were required for treatment, group video laryngoscopy than the comparison group, direct laryngoscopy.\textsuperscript{56} One study identified that the same number of attempts were required.\textsuperscript{45}

Trauma
Two studies provided data related to trauma associated with laryngoscopy. Both studies reported a similar number of patients in the treatment, group video laryngoscopy and the comparison group, direct laryngoscopy identified symptoms of trauma as a result of laryngoscopy.\textsuperscript{51, 56}

Glotic View
Five studies reported data related to glotic view. All five studies identified that glotic view was improved by the use of a video laryngoscope.
**Paediatric**
Four of the included studies design required the selection of paediatric participants. All studies were RCT’s.46, 49, 53, 60 The four studies measured time to intubate. Two studies measured glotic view with the Cormack Lehane assessment tool.46, 60 One study measured the number of intubation attempts53 and another haemodynamic response to intubation.49

**Time to Intubate**
The four studies reported data related to time to intubate. Time to intubate was identified as being longer for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy in all studies.

One study provided data for time to intubate related to the Cormack Lehane Grade.46 This study identified that for grades I - II time to intubate was identified as being longer for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy. For participants with grade III- IV time to intubate was identified as being quicker for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy.

**Intubation Attempts**
One study reported data related to failed intubation.53 The study identified that more attempts were required for treatment, group video laryngoscopy than the comparison group, direct laryngoscopy. In this study there were no failed intubations for direct laryngoscopy.

**Glotic View**
Two studies identified that glotic view was improved by the use of a video laryngoscope.46, 60

**Haemodynamic Response**
The one study identified that there were insignificant differences in haemodynamic responses.53

**Difficult Airway**
Three of the included studies design required the selection of participants with potential or known difficult airways.43, 52, 62 Two studies were RCT’s43, 52 and one was a cohort study.52 The three studies measured glotic view with the Cormack Lehane assessment tool and time to intubate. Two studies measured the number of intubation attempts.43, 52 Haemodynamic responses to intubation was reported by one study.52
Time to Intubate
All studies reported data related to time to intubate. Time to intubate was identified as being shorter for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy in two studies. The third study identified that time to intubate was identified as being longer for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy.

Intubation Attempts
Two studies reported data related to intubation attempts. Malik identified that for the treatment, group video laryngoscopy more intubation attempts were required than the comparison group, direct laryngoscopy. Nouruzi-Sedeh found that less intubation attempts were required for the treatment, group video laryngoscopy.

Haemodynamic Response
The study identified that there were insignificant differences in haemodynamic responses.

Glotic View
All studies reported data related to glotic view. All studies identified that glotic view was improved by the use of a video laryngoscope.

Novice Intubators
Three of the included studies design required novice intubators to perform laryngoscopy. All studies were RCT’s. Each study measured time to intubate. Two studies measured intubation attempts. One study measured glotic view with the Cormack Lehane assessment tool and to trauma related to the process of intubation.

Time to Intubate
Each study reported data related to time to intubate. Hirabayashi’s two studies identified time to intubate as being quicker for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy. Walker in contrast identified time to intubate as being slower for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy.

Intubation Attempts
Two studies reported data related to intubation attempts. Both studies identified that less attempts were required for treatment, group video laryngoscopy than the comparison group, direct laryngoscopy.
**Trauma**
One study provided data related to trauma associated with laryngoscopy. The study reported a fewer patients in the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy identified symptoms of trauma as a result of laryngoscopy.

**Glotic View**
One study reported data related to glotic view identifying that glotic view was improved by the use of a video laryngoscope.

**Obese Patients**
One of the included studies required the inclusion of obese patients. The study was a RCT. measuring time to intubate, the number of intubation attempts and glotic view.

**Time to Intubate**
Time to intubate was identified as being quicker for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy in the study.

**Intubation Attempts**
The study identified that less attempts were required for treatment, group video laryngoscopy than the comparison group, direct laryngoscopy.

**Glotic View**
The study reported that glotic view was improved by the use of a video laryngoscope.

**Emergency Department**
Two of the included studies were conducted in Emergency Departments. Both studies were cohort studies that measured time to intubate and the number of intubation attempts.

**Time to Intubate**
One study reported data related to time to intubate. Time to intubate was identified as being slower for the treatment, group video laryngoscopy than the comparison group, direct laryngoscopy in both studies.

**Intubation Attempts**
The studies identified that less attempts were required for treatment, group video laryngoscopy than the comparison group, direct laryngoscopy.
Conclusion
The critical appraisal identified 22 articles from which data was extracted. The review acknowledged that the available evidence of the effectiveness of the video laryngoscope in the acute care setting in comparison to direct laryngoscopy was weak related to poor study design and a lack of statistical power. The weakness of the evidence and the lack of heterogeneity for the outcome measures of time to intubate, intubation attempts, glottic view, trauma and haemodynamic response prevented meta-analysis and in some instances distorted the narrative description of the evidence. To facilitate further discussion the results were presented in the form of subgroups.
Chapter Five: Discussion

Introduction
There are many assertions video laryngoscopes improve glottic view and subsequent assumptions that time to intubate, intubation attempts, haemodynamic response and trauma are reduced.\textsuperscript{57} Utilising these measurable outcomes, time to intubate, intubation attempts, haemodynamic response and trauma this systematic review examined the available evidence of the effectiveness of video laryngoscopes in the acute care setting.

Time to Intubate
Time to intubate was a primary outcome measure of the effectiveness of the video laryngoscope in the acute care setting. By reducing the time to intubate there may be a concurrent reduction in non-hypoxic apnoea and risk the risk of hypoxic injury occurring.\textsuperscript{58} The available evidence identified that video laryngoscopes were not effective in reducing time to intubate when compared to direct laryngoscopy. Eighteen of the included studies provided data related to intubation times. Of these studies twelve identified that time to intubate was extended by the use of a video laryngoscope. Discussions related to the reasons why direct laryngoscopy was found to be quicker were limited. One study offers the number of manoeuvres and the equipment required to facilitate intubation as the likely reason for the increased time to intubate for the video laryngoscope.\textsuperscript{52} Coincidently another study that found the use of a video laryngoscope reduces time to intubate identified the number of optimizing manoeuvres required for direct laryngoscopy increased the time to intubate.\textsuperscript{51}

The twelve studies that found time to intubate was extended by the use of a video laryngoscope may have introduced bias to the data collection by inclusion criteria restricting the inclusion of patients with potential or predicted difficult airways. For this reason a review of the sub group analysis is worthwhile.

Subgroup analysis identifies that a video laryngoscope may reduce time to intubate in two categories that have been shown to be difficult to intubate using direct laryngoscopy, the obese patient and those with simulated neck restriction.\textsuperscript{43, 51, 61, 66} Also the evidence supports the use of video laryngoscopy to reduce intubation times for potential or known difficult airways. A study that found time to intubate paediatric patients with a Cormack Lehane grade of III or greater was reduced.\textsuperscript{47} The number of optimizing manoeuvres required for direct laryngoscopy to facilitate intubation was identified as the reason for the increased intubation
time. Data collected by Malik contradicts the effectiveness of a video laryngoscope to reduce intubation time. In this instance the data is presented but is not discussed.

A third sub group that identified that a video laryngoscope reduced time to intubate was when the equipment operator was a novice. Habaryashi identified the ability for a senior operator to share the view obtained by a video laryngoscope as the reason why video laryngoscopy achieved reduced time to intubate.

**Intubation Attempts**

The number of intubation attempts was a primary outcome measure of the effectiveness of the video laryngoscope in the acute care setting. The available evidence identified that video laryngoscopes may be effective in reducing the number of intubation attempts when compared to direct laryngoscopy. This statement must be carefully considered related to the influence of one study. Hirabayashi’s study accounted for over 50% of recorded intubation attempts for direct laryngoscopy. When broken into subgroups a video laryngoscope may be considered to be effective in patients with predicted or actual difficult airway, patients with restricted neck mobility and the obese patient. The evidence also indicated that the video laryngoscope was effective in reducing the number of intubation attempts when utilised by inexperienced intubators. The ability for an experienced intubator to share the same view as the novice and provide appropriate direction was identified as the reason for the reduced number of attempts to achieve intubation. The evidence identifies that for patients with Cormack Lehane grade I –II that the video laryngoscope is no more effective than direct laryngoscopy in relation to time to intubate.

**Glotic View**

Glotic view was a secondary outcome measure of the effectiveness of the video laryngoscope in the acute care. The available evidence identified that the use of a video laryngoscope improved the available glotic view. Seventeen studies measured glottic view and all found that the use of a video laryngoscope improve visualisation of glotic structures. Improved visualisation was not limited by sub group analyses. In one study improved visualisation occurred in 62% of paediatric patients with a Cormack Lehane grade greater than I. For adult patients with known difficult airways improved visualisation occurred at a rate of 95%. Marrel obtained a similar result of 93% when the Cormack Lehane score was recorded for obese participants. A study conducted within an Emergency department found that an improved view was obtained in 78% of participants with a Cormack Lehane grade III or greater.
Despite the overwhelming data identifying the effectiveness of video laryngoscopes improving glottic view evidence was also provided suggesting glotic view may be compromised by the use of a video laryngoscope. In one study 3% of participants with a Cormack Lehane Grade I or II obtained by direct laryngoscopy deteriorated with the use of a video laryngoscope. Explanations for the deterioration in laryngeal view include the presence of oral secretions including blood, anatomical abnormalities such as a large tongue, limited mouth opening, immobile or short necks, operator experience and equipment design such as uniform blade size and fogging.

The data suggests that although a clear glottic view is considered a vital component in the intubation process the included studies questioned the value of glottic view as an association with the ease of intubation when a video laryngoscope was used.

The availability of a video laryngoscope does not negate the need for an appropriate pre intubation assessment.

**Trauma**

The available data for the secondary measure of the effectiveness of video laryngoscopes in the acute care setting identified that the video laryngoscope was not effective in reducing trauma related to the intubation process. The increased rate of trauma in the treatment group was attributed to using blind techniques to insert the video laryngoscope into the oral cavity.

**Haemodynamic Response**

Evidence related to the secondary outcome of haemodynamic response to assess the effectiveness of the video laryngoscope in the acute care setting was limited. The limited evidence however implies that the video laryngoscope is no more effective than the control, direct laryngoscopy.

**Limitations of the Review**

There were several factors that limited the capability to extract reliable and robust evidence to shape clinical practice. These factors occurred because of internal limitations in the design of the systematic review and externally related to the weakness of the available evidence.
Outcomes
An internal limitation of the systematic review related to the primary and secondary measures of to assess the effectiveness of the video laryngoscope in the acute care setting. This review did not provide a definition for two of the primary outcome measures, intubation attempts and failed intubations. This limitation was reflected in the included studies. The absence or variations of definitions for these measures of effectiveness resulted in heterogeneous data.

Although a clear glottic view is considered as a vital component in the intubation process the included studies questioned the value of glottic view as an association with the ease of intubation when a video laryngoscope was used was not found.

Equipment Variety
Another internal limitation with the design of this study was the variety of video laryngoscope designs included within the study. Seven video laryngoscopes with varying designs were included in the studies. Such variations included laryngoscope blades with or without endotracheal guide channels. Similar variations also occurred in the design of the blade size used. Differences were also noted in the size and location of the video screen that in turn impacted on the size and weight of the laryngoscope handle used. This study did not investigate the impact of equipment design and the subsequent influence on the effectiveness individual video laryngoscopes.

Study Design
Further limitations were imposed upon the systematic review related to the weakness of the available evidence. The systematic review sought evidence throughout the acute care setting. Evidence was limited to two clinical environments within the acute care setting, Operating Theatres and the Emergency Department. As with the limited environment from which evidence was extracted the population were small reducing statistical power. Compounding the weakness of statistical power extracted evidence was found to be heterogeneous reducing the ability to perform meta-analysis.

Participants
As previously identified the included participants limited the systematic reviews ability to make meaningful recommendations related to patients with predicted and actual difficult airways. Of the twenty included studies only three include such participants. The disparity between those with a predicted difficult airway, 215 participants and those where intubation may be achieved with minimal difficulty, 1120 participants was identified by eighteen studies providing data on the glottic view obtained by direct laryngoscopy. As a result the ability
obtain significant data that identified the effectiveness of the video laryngoscope to improve glottic view, reduce intubation attempts and time to intubate was restricted by the available sample size.

Sample size also constrained the systematic review when related to paediatric participants. Four studies provide data for participants identified by the authors as paediatric. The combined sample size for the four studies was 33 participants. As a result the ability obtain significant data that identified the effectiveness of the video laryngoscope to improve glottic view, reduce intubation attempts and time to intubate was restricted by the available sample size.

**Australian Context**
The ability of this systematic review to assess the impact of the video laryngoscope in the Australia context was limited by the lack of research conducted in Australia.

**Implications for Practice**
Due to inconsistent study design and data collection techniques only weak evidence of the effectiveness of video laryngoscopy in the acute care setting is available. The strength of this evidence does not allow for a statement supporting the use of video laryngoscopy over direct laryngoscopy. This finding is consistent with the ANZCA back ground paper on equipment for the management of difficult airways. Regardless of this using the primary outcomes of time to intubate and number of intubation attempts there is evidence that suggest that the use of a video laryngoscope may be effective in four of the identified subgroups. The four subgroups are patients with predicted or known or difficult airways, those with restricted neck movement, those who are obese and in situations where intubation is being performed by a novice.

**The Difficult Airway**
When related to the clinical presentation of a patients with predicted or known or difficult airways, those with restricted neck movement, those who are obese the evidence suggest that the use of a video laryngoscope may reduce the number of attempts required to intubate a patient successfully. The reduced attempts may be at the expense of the time taken to achieve successful intubation. Professional bodies such as the Australian and New Zealand College of Anaesthetists (ANZCA) identify that non-standard laryngoscopes such as video laryngoscopes are available for use although still class the use of direct laryngoscopy with a Macintosh blade as the first line approach to managing a difficult airway. Based upon the
evidence it is recommended that a video laryngoscope be immediately available to use for patients with predicted or known difficult airways, those with restricted neck movement and those who are obese when time to intubate is not considered to be a critical factor.

**The Novice**
When related to the situation where intubation is being performed by a novice the evidence identified time to intubate, intubation attempts and trauma were reduced when a video laryngoscope was utilised. As such the strength of the evidence would suggest that a video laryngoscope should available for use by novice intubators at all times.

**Resuscitation**
Although none of the included studies assessed the effectiveness of the video laryngoscope during resuscitation it is recommended that a video laryngoscope be available on resuscitation trolleys. This would be a change to current Australia resuscitation guidelines as there is no mention of such equipment. This recommendation is made for the following reasons. Nine percent of the population is considered to have what may be considered a predicted difficult airway. When comparing video laryngoscopy and direct laryngoscopy studies that included predicted and known difficult intubation evidenced reduced time to intubate and number of intubation attempts for these patients. Studies also identify that even in what is considered a normal airway novice or inexperienced intubators time to intubate and number of intubation attempts are reduced by the use of a video laryngoscope. The American Heart Association in its recommendations for Advanced Life Support identifies the complications associated when intubation is performed by inexperienced intubators as being unacceptably high.69 When combined there becomes strong reason for the recommendation that a video laryngoscope be available on resuscitation trolleys.

**Post Anaesthetic Care**
The availability of video laryngoscope in the immediate postoperative phase should also be considered. The Australian Council on Health Standards collects data on the number of respiratory events that require the insertion of an artificial airway to support respiration. A comparable Canadian study identified a rate of 1.3% suggesting it is a rare event. Although rare such an event may include those patients with predicted or known or difficult airways, those with restricted neck movement and those who are obese or require a novice or inexperienced operator to perform the intubation. A coroners report into an airway related death in a PACU identified that although specialised airway equipment was available for use it was not immediately available within the unit and as such contributed to the death of the patient.70 Consideration should be given to locating a video laryngoscope permanently in the
PACU. Alternatively a post intubation processes that ensures if used video laryngoscope equipment remain with the patient until discharged from PACU.

**Implications for Research**

**Sample Size**
This systematic review identified that there was a lack of statistical power related to the sample size and that in general evidence was collected from within the Operating Theatres. To overcome this limitation a multi-centre RCT is recommend that encompasses clinical environments where intubation may occur.

**Study Design**
Inconsistency in study design and collection of data related to the effectiveness of video laryngoscopes in the acute care settings should also be addressed by researchers. The inconsistencies occurred in three areas of study design, the definition of an intubation attempt, the definition of a failed intubation and at what point timing intubation should commenced and cease. To facilitate consistent data collection the following definitions may be used.

**Intubation attempt** - the insertion of the laryngoscope blade into the oral cavity. 71

**Failed intubation** – failure of an intubation attempt where oxygenation cannot be maintained or three unsuccessful intubation attempts by an experienced operator72

A consistent definition related to the timing of intubation was not identified. Despite this the following may be used to facilitate consistent collection processes.

**Timing Commences when a laryngoscope blade enters the oral cavity**

**Timing cease when correct endotracheal placement is confirmed by CO2 monitoring with capnography or colometric CO2 detection devices.**

**Equipment Design**
Currently there is a broad spectrum of video laryngoscope design. These designs include variation on viewing screen, blade and handle design. It is recommended that a multi-centre RCT occur comparing the effective of video laryngoscope design in the acute care setting.
Australian Context

No studies were identified any studies that conducted primary human research comparing the effectiveness of video laryngoscope with direct laryngoscopy. It is recommended that a multi-centre RCT take place to provide evidence of effectiveness in the Australian context.

Conclusion

The purpose of this systematic review was to assess the effectiveness of the video laryngoscope in the acute care setting compared to direct laryngoscopy using the best available evidence. The weakness of the evidence limited the ability of the review to make a conclusive statement on the effectiveness of the video laryngoscope a position held by ANZCA. In line with ANZCA it is recommended that a video laryngoscope be available for use for patients with predicted or known difficult airways, those with restricted neck movement and the obese. The available evidence suggests that a video laryngoscope should be used at all time by novice intubators. Currently the British Airway Society, the ASA and ANZCA do not endorse the use of video laryngoscopes as a first line treatment in any airway management situation. These positions and the weak evidence related to the effectiveness of the video laryngoscope result in the following recommendation; a video laryngoscope be readily available for use for by novice intubators. Another clinical situation for which the ready availability of a video laryngoscope is recommended is during resuscitation. This recommendation based upon the high error rate by novice intubators in such situations identified by the American Heart Association. The weakness of the evidence reflects the inconsistences in study design and limited population supply rendering constraining the statistical power of the available evidence. As such a multi-site RCT that includes all acute care environments is recommended to facilitate the collection homogeneous data used to develop evidence with statistical power.

In conclusion the available evidence is inconclusive in identifying if the video laryngoscope is effective in the acute care setting when compared to direct laryngoscopy.
References


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68. Vicker E. Record of Investigation into Death of Richard Christopher Jankowski Ref No: 24/03, August 2003


70. No Authors Listed, Rapid Sequence Intubation. A guide for Assistance. Working out with the theatre setting. NHS Education for Scotland, 2005
Appendices

Appendix I: Search Strategy

<table>
<thead>
<tr>
<th>Laryngoscopy</th>
<th>Video</th>
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</thead>
<tbody>
<tr>
<td>Laryngoscopes[mh]</td>
<td>Videorecording[mh]</td>
</tr>
<tr>
<td>Laryngoscopy[mh]</td>
<td>Video*[tiab]</td>
</tr>
<tr>
<td>Laryngoscop*[tiab]</td>
<td></td>
</tr>
</tbody>
</table>

1. Laryngoscopes[mh] OR Laryngoscopy[mh] OR Laryngoscop*[tiab]
2. Videorecording[mh] OR Video*[tiab]
3. Videolaryngoscope[tiab] OR Video laryngoscope[tiab] OR Video assisted laryngoscope*[tiab]
4. 1 AND 2 OR 3
5. 1 AND 2 OR 3 limit English language and Human
6. (1 AND 2) OR 3 and then added (publisher[sb] OR inprocess[sb])
## Appendix II: Description of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Design</th>
<th>Setting</th>
<th>Population</th>
<th>Interventions</th>
<th>Comparison</th>
<th>Outcome</th>
<th>Author’s Conclusion</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aoi, Y., Inagawa, G., Nakamura, K., Sato, H., Kariya, T., Goto, T., Airway scope versus Macintosh laryngoscope in patients with simulated limitation of neck movements, Journal of Trauma - Injury, Infection and Critical Care, 2010</td>
<td>Pseudo Randomised Trial</td>
<td>Operating Theatres Yokohama City University Hospital</td>
<td>n = 36 patients scheduled for elective surgery ASA I - II Aged 20 – 80</td>
<td>Indirect Laryngoscopy (IL) Equipment – Airway Scope video laryngoscope</td>
<td>Direct Laryngoscopy (DL) Equipment – traditional ridged laryngoscope</td>
<td>Time to Intubate (s) IL – 62.9 (26.) DL – 56.6 (26) Cormack and Lehane Grade IL Grade 1-17 Grade 2-0 Grade 3-0 Grade 4-0 Grade 5-0 DL Grade 1-1 Grade 2-7 Grade 3-3 Grade 4 – 6 Unsuccessful Intubation</td>
<td>In neck-immobilised patients using a semi- rigid cervical collar, AWS improves laryngeal exposure and facilitates tracheal intubation. AWS may be a suitable intubation device for trauma patients.</td>
<td>The exclusion of participants with a predicted difficult airway may have limited the study's ability to explore the full benefits and limitations of all treatment groups. The measurement of time to intubate was taken from the time when the airway device was handed to the operator to capnography confirming correct placement. Multiple attempts this definition was not adhered to. The use of a single operator may have introduced bias related to technique in the treatment groups.</td>
</tr>
</tbody>
</table>

RCT Operating Theatres, Madani Heart Hospital, Tabriz, Iran

n = 80 patients scheduled for elective CABG. Exclusion criteria included a medical history of renal, hepatic disease, bleeding diathesis, diabetes, and malampati score III - IV (ASA IV)

Indirect Laryngoscopy (IL)
- Equipment – GlideScope video laryngoscope

Direct Laryngoscopy (DL)
- Equipment – traditional ridged laryngoscope

Cormack and Lehane Grade
- IL Grade 1-36
- Grade 2 -4
- Grade 3 -0
- Grade 4 -0
- DL Grade 1-30
- Grade 2 -7
- Grade 3 -1
- Grade 4 – 0
- Trauma
- IL – 1

IL - 4
DL – 4
Trauma
IL – 13
DI – 12

Glidescope technique did not have any benefit and increased laryngoscopy time, need to use stylet and required more attempts.

The exclusion of participants with a predicted difficult airway may have limited the study’s ability to explore the full benefits and limitations of all treatment groups.

The measurement of time to intubate was taken to the time of cuff inflation without capnography confirming correct placement.

A variety of stylets were used with the video laryngoscope treatment group; the authors do not identify if the process recommended by the manufacturer was implemented.

| Compara ble Cohort | Emergency Departments of Two Level 1 Trauma and Tertiary Referral Centres, America | n = 198 patients aged 15 years or older undergoing emergency tracheal intubation. | IL - 7 | Indirect Laryngoscopy (IL) Equipment – C-Mac video laryngoscope | Direct Laryngoscopy (DL) Equipment – traditional ridged laryngoscope | Time to Intubate (s) IL – 48.8 DL – 14.5 Cormack and Lehane Grade IL Grade 1-147 | Video laryngoscopy affords more grade I and II views than direct laryngoscopy and improves glottic exposure in most patients with poor direct glottic visualisation. In a small proportion of cases, glottic exposure is worse. Operators for treatment groups had various levels of experience with the use of traditional laryngoscopy methods but the same limited experience with video laryngoscopy. The variation in experience with in the treatment groups may have introduced bias. That bias may be reflected in

The operators were experience anaesthetists. The authors do not describe the operators experience with the video laryngoscope equipment.
### Study Design

A psuedo randomised trial was conducted in operating theatres in Japan. The study included 203 patients undergoing elective induction of general anaesthesia. Patients were randomised to either indirect laryngoscopy (IL) or direct laryngoscopy (DL) using the Pentax AWS. The primary outcome of interest was the time to intubate, defined as the time from the first viewing of the glottis to successful intubation.

### Methods

#### Indirect Laryngoscopy (IL)

- **Time to Intubate (s):** IL – 30 (14)

#### Direct Laryngoscopy (DL)

- **Time to Intubate (s):** DL – 28 (12)

### Results

In patients with stabilised neck, the Pentax AWS provided a better view than standard laryngoscopy. The second score provided a better view than the first score. All patients fitting the inclusion criteria may not have been included in the study.

### Discussion

Participants had two consecutive Cormack-Lehane scores, the primary outcome of interest. The second score may have been impacted by repositioning or trauma. The high number of grade III and IV scores may be a reflection of the unselected design of the study. Another explanation may be a reflection of the unselected design of the study. The same equipment was used for both traditional and video laryngoscopy as the equipment was considered to be compatible with traditional non-video design.

### Conclusion

The study demonstrated that the Pentax AWS provided a better view than standard laryngoscopy, particularly in patients with stabilised neck. The study was limited by the unselected design of the study, which may have impacted the results.
videolaryngoscope, is more effective than the Macintosh laryngoscope for tracheal intubation in patients with restricted neck movements: A randomized comparative study, British Journal of Anaesthesia, 2008

<table>
<thead>
<tr>
<th>Participant</th>
<th>Surgery, ASA I - II</th>
<th>Equipment</th>
<th>Equipment</th>
<th>Equipment-</th>
<th>Time to</th>
<th>The Airway Scope may reduce time to secure the airway and the incidence of failed tracheal intubation.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Participants were excluded if they had pathology of the neck, upper respiratory tract or alimentary tracts or at risk of aspiration.</td>
<td>Pentax AWS video laryngoscope</td>
<td>traditional ridged laryngoscope</td>
<td>DI – 40 (27)</td>
<td>Unsuccessful Intubation IL – 0 DL – 11 Cormack and Lehane Grade IL Grade 1-203 Grade 2 -0 Grade 3 -0 Grade 4 -0 DL Grade 1-124 Grade 2- 57 Grade 3 -21 Grade 4 -1</td>
<td></td>
</tr>
</tbody>
</table>

Hirabayashi, Y., Seo, N. Tracheal intubation by non-anaesthetist physicians using the Airway Scope RCT Operating Theatres, Japan 26 Novice intubators 200 scheduled for elective surgery. Indirect Laryngoscopy (IL) Equipment – Pentax AWS Direct Laryngoscopy (DL) Equipment- traditional ridged Time to Intubate (s) IL – 44 (19) DL – 71 (44) The exclusion of participants with a predicted difficult airway may have limited the study's ability to explore the full benefits and limitations of all treatment groups. May have been impacted by the first related to repositioning or trauma. Different time to intubate definitions were used for each treatment group. The exclusion of participants with pathology that may be a predictive of a difficult airway may have limited the study's ability to explore the full benefits and limitations of all treatment groups.
<table>
<thead>
<tr>
<th>Exclusion criteria</th>
<th>video laryngoscope</th>
<th>laryngoscope</th>
<th>Unsuccessful Intubation IL - 12 DL – 77</th>
<th>intubation in novice laryngoscopists.</th>
<th>treatment groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td>previous difficult intubation, cervical spine fracture / instability.</td>
<td></td>
<td></td>
<td></td>
<td>Correct ETT placement was confirmed with capnography.</td>
<td></td>
</tr>
<tr>
<td>Hirabayashi, Y., Otsuka, Y., Seo, N., GlideScope videolaryngoscope reduces the incidence of erroneous esophageal intubation by novice laryngoscopists, Journal of Anaesthesia, 2010</td>
<td></td>
<td></td>
<td></td>
<td>The study design enabled the novice operators to ask for advice. As the video laryngoscope provided the senior operators a view of what was occurring this may have introduced bias that may have affected time and success of intubation.</td>
<td></td>
</tr>
<tr>
<td>Pseudo Randomised Trial Operating Theatres, Japan n = 200 patients scheduled for elective surgery anaesthetised by 29 non-anaesthesia residents. Exclusion criteria included previous difficult</td>
<td>Indirect Laryngoscopy (IL) Equipment – GlideScope video laryngoscope</td>
<td>Direct Laryngoscopy (DL) Equipment-traditional ridged laryngoscope</td>
<td>Time to Intubate (s) IL – 64 (33) DL – 72 (47) Unsuccessful Intubation IL - 6 DL – 23</td>
<td>Tracheal intubation using the GlideScope video laryngoscope, compared to the Macintosh laryngoscope may be advantageous for medical personnel who only occasionally perform tracheal intubation. The GlideScope video laryngoscope</td>
<td>The exclusion of participants with a predicted difficult airway may have limited the study’s ability to explore the full benefits and limitations of all treatment groups. The study design enabled the novice operators to ask for advice. As the video laryngoscope provided the senior operators a view of what was occurring this may have introduced bias that may have affected time and success of intubation.</td>
</tr>
<tr>
<td>Jungbauer, A., Schumann, M., Brunkhorst, V., Borgers, A., Groeben, H., Expected difficult tracheal intubation: a prospective comparison of direct laryngoscopy and video laryngoscopy in 200 patients, Br J Anaesth, 2009</td>
<td>RCT</td>
<td>Operating Theatres, Germany</td>
<td>n = 200 patients aged over 18, having a Mallampati score III or IV, a history of difficult intubation and a mouth opening greater than 2cm. Exclusion criteria included an ASA IV or greater and rapid sequence induction.</td>
<td>Indirect Laryngoscopy (IL) Kaplan and Berci video laryngoscope</td>
<td>Direct Laryngoscopy (DL) Equipment - traditional ridged laryngoscope</td>
</tr>
<tr>
<td>Grade 1-23</td>
<td>Grade 2-41</td>
<td>Grade 3-26</td>
<td>Grade 4-10</td>
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</tr>
<tr>
<td>Kim, J. T., Na, H. S., Bae, J. Y., Kim, D. W., Kim, H. S., Kim, C. S., Kim, S. D., GlideScope video laryngoscope: a randomized clinical trial in 203 paediatric patients, Br J Anaesth, 2008</td>
<td>n = 203 patients scheduled for theatre age 3 months to 17 years of age. Exclusion criteria included those at risk of aspiration or those with raised intercranial pressure.</td>
<td>Indirect Laryngoscopy (IL) Equipment – GlideScope video laryngoscope</td>
<td>Direct Laryngoscopy (DL) Equipment – traditional ridged laryngoscope</td>
<td>Time to Intubate (s) Overall IL – 36 (17.9) DI – 23.8 (13.9) Time to Intubate (s) C&amp;L I&amp;II IL – 34 (16.5) DI – 22.6 (8.9) Time to Intubate (s) C&amp;L III&amp;IV IL – 52.8 (24.1) DI – 80 (70.7) Comack and In children, the GlideScope provided a laryngoscope view equal to or better than that of direct laryngoscopy but required longer tie for intubation. Participants had two consecutive Cormack Lehane scores, the primary outcome of interest. The second score may have been impacted by the first related to repositioning or trauma. Successful intubation was confirmed by capnography and the time to intubate measure was taken to this point and was continuously measured for multiple attempts. The experience of the operators was not discussed.</td>
<td></td>
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</tbody>
</table>

Pseudo Randomised Trial
Operating Theatres Koesi Hospital, Tokyo, Japan

n = 100 patients scheduled for elective surgery
ASA I - III
Aged 18 – 86
Patients were excluded if risk factors for

Indirect Laryngoscopy (IL)
Equipment – Airway Scope video laryngoscope

Unsuccessful Intubation
IL - 21
DL – 14
Time to Intubate (s)
IL – 30 (7)
DL – 40 (14)

Both indirect and direct laryngoscopy offer high success rates when difficult airways are simulated by application of a ridged cervical collar. However, the Airway Scope was 10 s faster than the

The exclusion of participants with a predicted difficult airway may have limited the study's ability to explore the full benefits and limitations of all treatment groups.

The DL involved the use of a McCoy blade that has an articulated tip allowing the epiglottis to be lifted. This feature was used at the time
gastric aspiration or difficult intubation were present and if there was a history of cervical spine pathology.

McCoy laryngoscope and less likely to result in oesophageal intubation than the McCoy laryngoscope. The Airway Scope thus appears preferable, especially when accidental oesophageal intubation is best avoided.

Successful intubation was confirmed by capnography; it is not identified if the time to intubate measure was taken to this point and if it was continuously measured for multiple attempts.

The IL equipment was provided on loan by the manufacturer.

The operators had limited experience for treatment group A indirect laryngoscopy. Participants had two consecutive Cormack Lehane scores, the primary outcome of interest. The second score may have been impacted by the first related to repositioning or trauma.
<table>
<thead>
<tr>
<th>Analg, 2009</th>
<th>the age of 18, those requiring other than a laryngoscope blade size 3, ASA IV or higher and surgery of the face or throat.</th>
<th>Grade 1 - 47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marrel, J., Blanc, C., Frascarolo, P., Magnusson, L. Videolaryngoscopy improves intubation condition in morbidly obese patients, European Journal of Anaesthesiology, 2007 24 12 1045-1049</td>
<td></td>
<td>Grade 2 - 18</td>
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<tr>
<td>Prospecti ve, randomised, single blind study</td>
<td>Operating Theatres of the University Hospital Lausanne, Switzerland</td>
<td>Grade 3 - 11</td>
</tr>
<tr>
<td>80 Morbidly obese patients (BMI greater than 35 kg m2) ASA II or III</td>
<td>Indirect Laryngoscopy (IL) X-Lite Video laryngoscope</td>
<td>Grade 4 - 2</td>
</tr>
<tr>
<td>23 - 76 years of age Elective bariatric surgery</td>
<td>Direct Laryngoscopy (DL) Equipment-traditional ridged laryngoscope</td>
<td></td>
</tr>
</tbody>
</table>
| Unsuccessful Intubation IL - 2 DL - 8 Cormack and Lehane Grade IL Grade 1 - 70 Grade 2 10 Grade 3 - 0 Grade 4 - 0 DL Grade 1 - 50 | The use of a video laryngoscope for the morbidly obese significantly improves the laryngoscopic grade using the Cormack Lehane scoring system. The use of a video laryngoscope for the morbidly obese may shorten the duration of intubation | Participates excluded prior to randomisation included patients with an ASA greater than 3, who had previous ENT surgery, radiotherapy or unstable cervical spine requiring stabilisation prior to intubation. A single laryngoscope was used for the study. The device was modified to facilitate direct laryngoscopy and intubation. The authors identify that the results obtained for time to intubate and number of intubation attempts may have
| MacNair, D., Baraclough, D., Wilson, G., Bloch, M., Engelhardt, T. | Pseudo Randomised Trial | Operating Theatres, Royal Aberdeen Children's Hospital, Aberdeen | n = 60 participants aged 2 - 16 with an ASA I-II requiring scheduled for surgery. | Exclusions included a predicted difficult airway, emergency surgery, neck instability and patients with respiratory, | Indirect Laryngoscopy (IL) Equipment – Berci-Kaplan video laryngoscope | Direct Laryngoscopy (DL) Equipment – traditional ridged laryngoscope | Unsuccessful Intubation IL - 5 DL -0 Time to Intubate (s) IL – 22(17.8-35) DI – 16 (14-20) | Video laryngoscopy provides better views than direct laryngoscopy at the expense of time to intubate. | The exclusion of participants with a predicted difficult airway may have limited the study's ability to explore the full benefits and limitations of all treatment groups. The operators were experienced in the use of all treatments. Participants had two consecutive Cormack Lehane scores, the primary outcome of interest. The second score may have been impacted by the first related to repositioning or trauma. |

Pediatric airway management: Comparing the Berci-Kaplan Video Laryngoscope with direct laryngoscopy, Paediatric Anaesthesia, 2009

Sp02 was also measured and found to have a smaller variation in the video assisted intubation group.

be influenced by the experience of the intubator and should not be generalised.

<p>| RCT | Operating Theatres Galway University Hospital, Galway, Ireland | n = 120 patients scheduled for elective surgery ASA I - III Aged over 16. Patients were excluded if risk factors for gastric aspiration or difficult intubation were present and if there was a history of relevant drug allergies. | Indirect Laryngoscopy (IL) Equipment – AirwayScope video laryngoscope | Direct Laryngoscopy (DL) Equipment - traditional ridged laryngoscope | Unsuccessful Intubation IL - 2 DL - 1 Time to Intubate (s) AirwayScope-16.7 (7.6) GlideScope-18.9 (6.0) DL– 11 (11.6) Trauma AirwayScope-2 GlideScope-2 Total IL - 7 DL - 2 | The Airway Scope has several advantages over the Macintosh laryngoscope or C-Trach in patients undergoing cervical spine immobilisation. | The authors identified that all anaesthetist who participated in the study were experienced operators for each treatment group. Pentax Ltd provided the AWS device and disposable Blades. The exclusion of participants with a predicted difficult airway may have limited the study’s ability to explore the full benefits and limitations of all treatment groups. |</p>
<table>
<thead>
<tr>
<th>Measurements</th>
<th>IL AirwayScope prior to induction</th>
<th>Mean Arterial BP (mmHg) 90</th>
<th>Heart Rate 70</th>
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</thead>
<tbody>
<tr>
<td>Measurements</td>
<td>after induction</td>
<td>Mean Arterial BP (mmHg) - 70</td>
<td>Heart Rate - 70</td>
</tr>
<tr>
<td>Measurements</td>
<td>1 minute after intubation</td>
<td>Mean Arterial BP (mmHg) 80</td>
<td>Heart Rate - 72</td>
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<tr>
<td>Measurements</td>
<td>five minutes</td>
<td></td>
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</table>
### Measurements

<table>
<thead>
<tr>
<th>Time</th>
<th>Mean Arterial BP (mmHg)</th>
<th>Heart Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>prior to induction</td>
<td>92</td>
<td>78</td>
</tr>
<tr>
<td>after induction</td>
<td>70</td>
<td>74</td>
</tr>
<tr>
<td>1 minute after induction</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Metric</td>
<td>Value</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
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<td></td>
</tr>
<tr>
<td>Heart Rate - Measurements five minutes after induction</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Mean Arterial BP (mmHg)</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Heart Rate - Cormack and Lehane Grade IL</td>
<td>80</td>
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</tr>
<tr>
<td>Grade 1</td>
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<td>Grade 2</td>
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<td>DL</td>
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<tr>
<td>Grade 1</td>
<td>29</td>
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<td>Grade 3</td>
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<td>Grade 4</td>
<td>0</td>
<td></td>
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<td>Trueview</td>
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</tbody>
</table>

| RCT | Operating Theatres | N = 75 patients scheduled for elective surgery | Indirect Laryngoscopy (IL) Equipment – AirwayScope and GlideScope video laryngoscope | Direct Laryngoscopy (DL) Equipment – traditional ridged laryngoscope | Unsuccessful Intubation IL AirwayScope - 7 IL GlideScope – 3 Total Il -10 DL - 8 Time to Intubate (s) AirwayScope - 15(8,31) GlideScope - 17(12,31) DL – 13.8 (8,23) | The Glidescope and Airway Scopes reduce the difficulty of tracheal intubation to a similar extent compared with the Macintosh laryngoscope, in patients at increased risk for difficult tracheal intubation. | The authors identified that all anaesthetist who participated in the study were experienced operators for each treatment group. |
| Heamodyami
<p>| c Measurements |
| IL AirwayScope |
| Measurements prior to induction |
| Mean Arterial BP (mmHg) | 102 |
| Heart Rate | 75 |
| Measurements after induction |
| Mean Arterial BP (mmHg) | 82 |
| Heart Rate | 73 |
| Measurements 1 minute after induction |
| Mean Arterial BP (mmHg) | 86 |</p>
<table>
<thead>
<tr>
<th>Measurements</th>
<th>Mean Arterial BP (mmHg)</th>
<th>Heart Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>five minutes after induction</td>
<td>87</td>
<td>74</td>
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<tr>
<td>Mean Arterial BP (mmHg)</td>
<td>98</td>
<td>78</td>
</tr>
<tr>
<td>prior to induction</td>
<td>81</td>
<td>71</td>
</tr>
<tr>
<td>Measurements after induction</td>
<td>81</td>
<td>71</td>
</tr>
<tr>
<td>Measurements</td>
<td>1 minute after induction</td>
<td>Mean Arterial BP (mmHg)</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Measurements</td>
<td>five minutes after induction</td>
<td>Mean Arterial BP (mmHg)</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>DL</td>
<td></td>
<td>IL</td>
</tr>
<tr>
<td>IL AirwayScope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurements</td>
<td>prior to induction</td>
<td>Mean Arterial BP (mmHg)</td>
</tr>
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<td>Heart Rate</td>
<td>78</td>
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<tr>
<td>Measurements after induction</td>
<td>Mean Arterial BP (mmHg)</td>
<td>81</td>
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</tr>
<tr>
<td>Heart Rate</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Measurements 1 minute after induction</td>
<td>Mean Arterial BP (mmHg)</td>
<td>85</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>Measurements five minutes after induction</td>
<td>Mean Arterial BP (mmHg)</td>
<td>79</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Cormack and Lehane Grade</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Maruyama, K., Yamada, T., Kawakami, R., Kamata, T., Yokochi, M., Hara, K., Upper cervical spine movement during Pseudo Randomised Trial

Operating Theatres Iida Municipal Hospital, Japan

N = 45 patients were scheduled for elective surgery, were ASA I – II, aged 18 -82.

Indirect Laryngoscopy (IL) Equipment – AirwayScope video

Direct Laryngoscopy (DL) Equipment- traditional ridged laryngoscope

Time to Intubate (s)
IL – 29 (15.4)
DL (Macintosh) – 16 (10.7)

The AWS allowed intubation with less movement with less movement of the upper c-spine but a longer intubation time inpatients with By excluding patients with anticipated difficult airways the study may have limited the ability to identify the advantages and disadvantages of the treatment groups.
<table>
<thead>
<tr>
<th>Study Description</th>
<th>Design Type</th>
<th>Setting</th>
<th>Sample Size</th>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
<th>Intubation Equipment</th>
<th>Time to Intubate (s)</th>
<th>Intubation Success Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nouruzi-Sedeh, P., Schumann, M., Groeben, H.</strong></td>
<td>Pseudo Randomised Trial</td>
<td>Operating Theatres, Essen, Germany</td>
<td>n = 200</td>
<td>Patients scheduled for elective surgery, ASA I – II, aged over 18 with Mallampati score I – II, 20 novice intubators</td>
<td></td>
<td>Indirect Laryngoscopy (IL) Equipment – GlideScope video laryngoscope</td>
<td>IL: 63 (30)</td>
<td>IL: Grade 1-66 Grade 2-26 Grade 3-5 Grade 4-3</td>
</tr>
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<td></td>
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<td></td>
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<td>Direct Laryngoscopy (DL) Equipment - traditional ridged laryngoscope</td>
<td>DL: 89 (35)</td>
<td>DL: Comack and Lehane Grade IL</td>
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<td>In subjects with no or only minimal experience in tracheal intubation, the success rate of intubation can be significantly increased with a video assisted technique (GlideScope) and does not require more time than direct laryngoscopy.</td>
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<td>The 20 operators were novice intubators in relation to both treatment groups.</td>
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<td></td>
<td>Excluding patients with predicted difficult intubation may have limited the studies ability to adequately compare the treatment groups results.</td>
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<td>Excluding patients with a mouth opening less than 4 cm may have reduced the study's ability to expose a limitation in the design of the indirect laryngoscopy technique.</td>
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<td>Platts-Mills, T. F., Campagne, D., Chinnock, B., Snowden, B., Glickman, L. T., Hendey, G. W.</td>
<td>Comparable Cohort</td>
<td>Emergency Department, Level 1 Trauma Centre, America</td>
<td>280 Emergency Department patients aged over 16 requiring intubation.</td>
<td>Indirect Laryngoscopy (IL) Equipment – GlideScope video laryngoscope</td>
<td>Direct Laryngoscopy (DL) Equipment- traditional ridged laryngoscope</td>
<td>Time to Intubate (s) IL -42 (35-50) DL – 30 (30-30) Failure Rate % IL – 9 DL – 17</td>
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A comparison of GlideScope video laryngoscopy versus direct laryngoscopy intubation in the emergency department Academic Emergency Medicine 2009

Comparable Cohort

Rates of successful intubation on first attempt were not significantly different between video and direct laryngoscopy. However, intubation using video laryngoscopy required significantly more time to complete. The authors identified clinical experience and familiarity with equipment / techniques may have had implications for the allocation of participants to a treatment group and the success of techniques used. No description of pre intubation treatment was provided. The inclusion/exclusion of certain medication in this time frame may have had a direct effect on the performance of equipment in both treatment groups.

The authors identified clinical experience and familiarity with equipment / techniques may have had implications for the allocation of participants to a treatment group and the success of techniques used. No description of pre intubation treatment was provided. The inclusion/exclusion of certain medication in this time frame may have had a direct effect on the performance of equipment in both treatment groups.
participants that may have been enrolled in the study potentially were not.

The study design identified time to intubate from when the blade entered the mouth until the first successful forced ventilation.

Shayeghi, S., Ghasemi, M., Sadeghi, A., Razavi, S. S.
Hemodynamic responses to orotracheal intubation with a video laryngoscope in infants: A comparison study
Journal of Research in Medical Sciences 2007

| Study Design                  | Operating Theatre, Mofid Childrens Hospital, Tehran, Iran | n = 64 infants scheduled for elective surgery. Exclusion criteria included probable or confirmed raised intracranial pressure, those with known airway pathology, cervical spine injury, rapid | Indirect Laryngoscopy (IL) | Direct Laryngoscopy (DL) | Time to Intubate (s) IL - 20.87 (7.95) DL - 15.41 (4.10) | Similar haemodynamic responses in both groups suggest that laryngoscopy and intubation with a video laryngoscope, although with longer duration and therefore resulting in more stimulation, has no significant effect on haemodynamic status and oxygen saturation in infants. The study was a single operator design that may have introduced bias. The intubator had limited paediatric laryngoscopy experience and no experience with the use of the GlideScope. The first ten intubations using the GlideScope were excluded from the statistical data as they were used to achieve a level of competency with the equipment. The definition of a successful intubation did not allow for recognition of correct placement of the endotracheal | Pseudo Randomised Trial | GlideScope video laryngoscope | traditional ridged laryngoscope | Measurements prior to induction Systolic BP 95.8 |
sequence induction, patients in an emergency situations, unstable haemodynamically and shock.

<table>
<thead>
<tr>
<th>Time</th>
<th>Systolic BP</th>
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<th>Heart Rate</th>
<th>SpO2</th>
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<tr>
<td>Measurements after induction</td>
<td>93.37</td>
<td>54.5</td>
<td>160.67</td>
<td>97.17</td>
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<tr>
<td>Measurements 1 minute after induction</td>
<td>99.77</td>
<td>58.10</td>
<td>165.70</td>
<td>97.70</td>
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tube by capnography or securement of the artificial airway.
The strict inclusion criteria may have introduced bias by not allowing the equipment to be exposed to those patients most likely to experience haemodynamic changes.
<table>
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<th>SpO2 97.17</th>
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<td>five minutes</td>
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<tr>
<td>after induction</td>
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<tr>
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<td>Diastolic BP</td>
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<tr>
<td>Heart Rate</td>
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<td>SpO2 97.77 DL</td>
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<td>prior to induction</td>
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<td>Diastolic BP</td>
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<td>SpO2 97.16 Measurements</td>
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<td>Measurements</td>
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<td>1 minute after induction</td>
<td>95.25</td>
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<tr>
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<td>Heart Rate</td>
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<tr>
<td>Diastolic BP</td>
<td>53.66</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>159.63</td>
</tr>
<tr>
<td>SpO2 97.50</td>
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<td>Measurements five minutes after induction</td>
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<td>Diastolic BP</td>
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Sun, D. A., Warriner, C. B., Parsons, D. G., Klein, R., Umedaly, H. S., Moult, M.
The GlideScope Video Laryngoscope: randomized clinical trial in 200 patients
Br J Anaesth 2005

RCT Operating Theatres Vancouver General Hospital, Canada

N = 200 patients scheduled for elective surgery.

Participants were excluded if there was known airway pathology, raised intracranial pressure, cervical spine injury and the need for rapid sequence induction

Indirect Laryngoscopy (IL)
Equipment – GlideScope video laryngoscope

Direct Laryngoscopy (DL)
Equipment – traditional ridged laryngoscope

Time to Intubate (s)
IL - 46 (43-49)
DL - 30 (28-33)

Time to Intubate Cormack and Lehane Grade
IL
Grade 1 - 44 (41-48)
Grade 2 - 50 (41-48)
Grade 3 - 50 (36-63)
DL
Grade 1 - 26 (24-27)

In most patients the GlideScope provided a laryngoscopic view equal to or better than that of direct laryngoscopy, but it took an additional 16 seconds (average) for tracheal intubation. It has potential advantages over standard direct laryngoscopy for difficult intubations.

By excluding known airway pathology and cervical spine injury bias was introduced into the study.

Seventy patients are identified as being excluded from the statistical data presented as there was a change in the definition of time to intubate with the authors acknowledge this may have resulted in bias. The explanation may suggest the allocator was not blinded to the allocation process.

The design of the study required direct laryngoscopy to be performed prior to indirect laryngoscopy. This may have influenced the outcome of the indirect laryngoscopy by causing
<table>
<thead>
<tr>
<th>Cormack and Lehane Grade</th>
<th>Grade 1-</th>
<th>Grade 2-</th>
<th>Grade 3-</th>
<th>Grade 4-</th>
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<tr>
<td>and time to intubate(s)</td>
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<td>44</td>
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<td>IL</td>
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<tr>
<td>DL</td>
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The authors state that a further two hundred and fifty participants would be required to achieve statistical equivalence.
<table>
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<tr>
<th>Study</th>
<th>Design</th>
<th>Setting</th>
<th>Participants</th>
<th>Equipment</th>
<th>Time to Intubate (s)</th>
<th>Time to successful intubation</th>
<th>Notes</th>
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<td>Teoh, W. H., Saxena, S., Shah, M. K., Sia, A. T.</td>
<td>RCT</td>
<td>Operating Theatres, 830 bed Tertiary Referral Hospital, Singapore</td>
<td>N = 400 patients scheduled for elective surgery, ASA I - III, 21 -80 years of age, Exclusion criteria include patients who were pregnant, ASA IV or greater, weight 30 kg or less and a BMI greater</td>
<td>I Indirect Laryngoscopy (IL) Equipment – C-Mac and Glidescope video laryngoscope Direct Laryngoscopy (DL) Equipment - traditional ridged laryngoscope</td>
<td>The time to successful intubation was shorter with the C-Mac or Glidescope but was comparable with the Macintosh laryngoscope.</td>
<td>The inclusion of patients with a mouth opening less than 2.5 cm, respiratory tract pathology, sore throat, high risk of aspiration and relevant drug allergies allowed for the potential comparison of the benefits and limitations of all devices. All incubators were experienced and familiar with the equipment used. All participants were Asian females so results may not be easily extrapolated.</td>
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<td>than 40 kg/m²</td>
<td>AirwayScope IL</td>
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<tr>
<td>Grade 1 - 97</td>
<td>Grade 2 - 3</td>
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<td>Grade 4 - 0</td>
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<table>
<thead>
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<th>C-Mac IL</th>
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<td>Grade 4 – 0</td>
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<table>
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<th>GlideScope IL</th>
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<td>Grade 2 - 21</td>
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<tr>
<td>Grade 4 - 0</td>
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<table>
<thead>
<tr>
<th>DL</th>
<th>Grade 1 - 58</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 2 - 37</td>
<td>Grade 3 - 5</td>
</tr>
</tbody>
</table>
| Vlatten, A., Aucoin, S., Litz, S., MacManus, B., Soder, C. | RCT | Operating Theatres of IWK Health Centre, Halifax, NS Canada | N=56 participants aged four and under scheduled for elective | Indirect Laryngoscopy (IL) Equipment – STORZ DCI | Direct Laryngoscopy (DL) Equipment-traditional ridged | Time to Intubate (s) IL - 27 (11-50) DL - 21 (11 – 37) | Using the STORZ DCI video laryngoscope to intubate the trachea of a child with normal airway | The operator performing the intubation had limited experience with the indirect laryngoscopy technique as opposed to extensive experience with the

| Grade 4 – 0 Unsuccessful Intubations AirwayScope IL - 5 C-Mac IL - 7 GlideScope IL - 9 DL -2 Trauma AirwayScope IL - 2 C-Mac IL - 1 GlideScope IL – 7 DL – 1 |
Exclusions included a predicted difficult airway, rapid sequence induction and hemodynamic instability.

The strict exclusion criteria may have further biased the data toward traditional laryngoscopy as the true advantage of an indirect view of the larynx for Cormack Lehane grade II - III could not assessed.

The study allowed for external manipulation of the airway prior to the recording of the Cormack Lehane grade. Other studies have recorded this grade without external manipulation and this when combined with the exclusion criteria may be why this grade was similar in both treatment groups.
Walker, L., Brampton, W., Halai, M., Hoy, C., Lee, E., Scott, I., McLernon, D. J.

Randomized controlled trial of intubation with the McGrath® Series 5 videolaryngoscope by inexperienced anaesthetists

British Journal of Anaesthesia (2009)

| Operating Theatres of a 900 bed acute teaching hospital. Scotland | n=120 patients over the age of 18 scheduled for elective theatre and a first year anaesthetic trainee to perform the intubation. Patients were excluded if rapid sequence induction was required. | Indirect Laryngoscopy (IL) Equipment – McGrath Series 5 video laryngoscope | Direct Laryngoscopy (DL) Equipment – traditional ridged laryngoscope | Intubation Time (s) IL 47.0 (25-202) DL 29.5 (15-121) Cormack and Lehane Grade IL Grade 1 - 55 Grade 2 - 4 Grade 3 - 1 Grade 4 - 0 DL Grade 1 - 47 Grade 2 - 13 Grade 3 - 0 Grade 4 – 0 Trauma IL – 3 DL - 8 | There was no advantage to using the McGrath Laryngoscope for uncomplicated tracheal intubation and duration of intubation was longer, so it should not be used as a first line laryngoscope instrument by inexperienced anaesthetists. No Cormack Lehane grades 3 or 4 were reported for direct laryngoscopy and in the background the authors make reference to uncomplicated intubations. This may suggest that there was more exclusion criteria that would result in the exclusion of participants with potentially difficult intubations. |
## Appendix III: Randomised Control Trial / Pseudo-randomised Trial

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### Comparable Cohort / Case Control Studies

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| % | 0.0 | 100.0 | 0.0 | 50.0 | 100.0 | 0.0 | 0.0 | 100.0 | 100.0 |
Appendix IV: Excluded Studies

Baba, M., Fujimoto, J., Mizutani, K., Nakamura, K., Kamiya, Y., Ohtsuka, M., Goto, T., Tracheal intubation using Airway Scope® in two patients with difficult airway during cardiopulmonary resuscitation
Reason for Exclusion Poor design with no statistical data available

Bathory, I., Granges, J. C., Frascarolo, P., Magnusson, L., Evaluation of the Video Intubation Unit in morbid obese patients
Reason for Exclusion Video device does not fit the criteria of a video laryngoscope

Hackell, R. S., Held, L. D., Stricker, P. A., Fiadjoe, J. E., Management of the difficult infant airway with the Storz Video Laryngoscope: a case series
Reason for Exclusion Study method and overall outcome not clear The findings are not valid and reliable due to lack of control of biases

Karsli, C., Armstrong, J., John, J., A comparison between the GlideScope® Video Laryngoscope and direct laryngoscope in paediatric patients with difficult airways - A pilot study: Original article
Reason for Exclusion The study provided only a brief description but no assessable data on any of the outcomes of interest

Kitamura, M., Dohgomori, H., Okamoto, K., Difficult airway management in the emergency room using an airway scope
Reason for Exclusion The study provided no comparison or significant data.

Reason for Exclusion The comparison group of interest was not reported in a meaningful manner.

Maassen, R., Lee, R., Hermans, B., Marcus, M., Van Zundert, A., A comparison of three videolaryngoscopes: The macintosh laryngoscope blade reduces, but does not replace, routine stylet use for intubation in morbidly obese patients
Reason for Exclusion The study provides no comparison data for the comparison group
Mahjoubifar, M. and Boroojeny, S. B., Hemodynamic changes during orotracheal intubation with the glidescope and direct laryngoscope

Reason for Exclusion Allocation, collection and reporting process e.g. non-reporting of exclusions may have influenced outcomes

Maruyama, K., Yamada, T., Kawakami, R., Hara, K., Randomized cross-over comparison of cervical-spine motion with the AirWay Scope or Macintosh laryngoscope with in-line stabilization: a video-fluoroscopic study

Reason for Exclusion The randomisation process was not. The authors did not recruit the number of participants to achieve a meaningful result. The number of participants to each group was not clear

Noppens, R. R., Möbus, S., Heid, F., Schmidtmann, I., Werner, C., Piepho, T., Evaluation of the McGrath® Series 5 videolaryngoscope after failed direct laryngoscopy

Reason for Exclusion Poor quality


Reason for Exclusion Secondary outcomes were discussed but not presented

Sadamori, T., Kusunoki, S., Ishida, M., Otani, T., Tanigawa, K., Video laryngoscopy for emergency tracheal intubation during chest compression

Reason for Exclusion No statistical data was provided and level of evidence was poor


Reason for Exclusion Unable to retrieve

Turkstra, Erratum: Cervical spine motion: A fluoroscopic comparison during intubation with lighted stylet, glidescope, and Macintosh laryngoscope (Anesthesia and Analgesia (September 2005) 101 (910-915))

Reason for Exclusion The study does not provide data for outcomes of interest

Vanderhal, A. L., Berci, G., Simmons, C. F., Jr., Hagiike, M., A videolaryngoscopy technique for the intubation of the newborn: preliminary report
Reason for Exclusion: Outcome measure were unreliable and participant inclusion was inconsistent.

Wald, S. H., Keyes, M., Brown, A., Pediatric video laryngoscope rescue for a difficult neonatal intubation

Reason for Exclusion: Limited data collection and study design not described.

Weiss, M., Schwarz, U., Dillier, C. M., Gerber, A. C., Teaching and supervising tracheal intubation in paediatric patients using videolaryngoscopy

Reason for Exclusion: The data was not collected in a reliable manner and the design of the study not accurately reported.
Appendix V: JBI Critical Appraisal Checklist for Experimental Studies

Reviewer ___________________ Date __________
Author _____________________ Year __________ Record Number ______

Yes  No  Unclear

1. Was the assignment to treatment groups truly random?
   Were participants blinded to treatment allocation?

2. Was allocation to treatment groups concealed from the allocator?

3. Were the outcomes of people who withdrew described and included
   in the analysis?

4. Were those assessing outcomes blind to the treatment allocation?

5. Were the control and treatment groups comparable at entry?

6. Were groups treated identically other than for the named
   interventions?

7. Were outcomes measured in the same way for all groups?

8. Were outcomes measured in a reliable way?

9. Was appropriate statistical analysis used?

Overall appraisal: Include Exclude Seek further info.

Comments (Including reasons for exclusion)
### Appendix VI: JBI Critical Appraisal Checklist for Comparable Cohort/ Case Control

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Unclear</th>
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</thead>
<tbody>
<tr>
<td>1. Is sample representative of patients in the population as a whole?</td>
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<td>2. Are the patients at a similar point in the course of their condition/illness?</td>
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<td>3. Has bias been minimised in relation to selection of cases and of controls?</td>
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<td>4. Are confounding factors identified and strategies to deal with them stated?</td>
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<td>5. Are outcomes assessed using objective criteria?</td>
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<td>6. Was follow up carried out over a sufficient time period?</td>
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<tr>
<td>7. Were the outcomes of people who withdrew described and included in the analysis?</td>
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<tr>
<td>8. Were outcomes measured in a reliable way?</td>
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<tr>
<td>9. Was appropriate statistical analysis used?</td>
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</tbody>
</table>

**Overall appraisal:** Include Exclude Seek further info

**Comments (Including reason for exclusion)**