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TABLE OF CONTENTS

HEADER	1
ABSTRACT	1
PLAIN LANGUAGE SUMMARY	2
SUMMARY OF FINDINGS FOR THE MAIN COMPARISON	3
BACKGROUND	5
OBJECTIVES	6
METHODS	6
RESULTS	9
Figure 1.	10
Figure 2.	12
Figure 3.	13
Figure 4.	13
DISCUSSION	14
AUTHORS' CONCLUSIONS	15
ACKNOWLEDGEMENTS	15
REFERENCES	15
CHARACTERISTICS OF STUDIES	17
DATA AND ANALYSES	24
Analysis 1.1. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 1 Time required for successful intubation (seconds).	24
Analysis 1.2. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 2 Number of intubation attempts.	25
Analysis 1.3. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 3 Success rate at first attempt.	26
Analysis 1.4. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 4 Non-airway related adverse effects: saturations during intubation.	27
Analysis 1.5. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 5 Airway-related adverse effects: airway trauma.	27
APPENDICES	28
WHAT'S NEW	29
CONTRIBUTIONS OF AUTHORS	30
DECLARATIONS OF INTEREST	30
SOURCES OF SUPPORT	30
DIFFERENCES BETWEEN PROTOCOL AND REVIEW	30
INDEX TERMS	31

[Intervention Review]

Videolaryngoscopy versus direct laryngoscopy for tracheal intubation in neonates

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ABSTRACT

Background

Establishment of a secure airway is a critical part of neonatal resuscitation in the delivery room and the neonatal unit. Videolaryngoscopy has the potential to facilitate successful endotracheal intubation and decrease adverse consequences of delay in airway stabilization. Videolaryngoscopy may enhance visualization of the glottis and intubation success in neonates.

Objectives

To determine the efficacy and safety of videolaryngoscopy compared to direct laryngoscopy in decreasing the time and attempts required for endotracheal intubation and increasing the success rate at first intubation in neonates.

Search methods

We used the search strategy of Cochrane Neonatal. In May 2017, we searched for randomized controlled trials (RCT) evaluating videolaryngoscopy for neonatal endotracheal intubation in Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, Embase, CINAHL, abstracts of the Pediatric Academic Societies, websites for registered trials at www.clinicaltrials.gov and www.controlled-trials.com, and reference lists of relevant studies.

Selection criteria

RCTs or quasi-RCTs in neonates evaluating videolaryngoscopy for endotracheal intubation compared with direct laryngoscopy.

Data collection and analysis

Review authors performed data collection and analysis as recommended by Cochrane Neonatal. Two review authors independently assessed studies identified by the search strategy for inclusion.

We used the GRADE approach to assess the quality of evidence.

Main results

The search yielded 7057 references of which we identified three RCTs for inclusion, four ongoing trials and one study awaiting classification. All three included RCTs compared videolaryngoscopy with direct laryngoscopy during intubation attempts by trainees.

Time to intubation was similar between videolaryngoscopy and direct laryngoscopy (mean difference (MD) -0.62, 95% confidence interval (CI) -6.50 to 5.26; 2 studies; 311 intubations) (very low quality evidence). Videolaryngoscopy did not decrease the number

of intubation attempts (MD -0.05, 95% CI -0.18 to 0.07; 2 studies; 427 intubations) (very low quality evidence). Moderate quality evidence suggested that videolaryngoscopy increased the success of intubation at first attempt (typical risk ratio (RR) 1.44, 95% CI 1.20 to 1.73; typical risk difference (RD) 0.19, 95% CI 0.10 to 0.28; number needed to treat for an additional beneficial outcome (NNTB) 5, 95% CI 4 to 10; 3 studies; 467 intubation attempts).

Desaturation episodes during intubation attempts were similar between videolaryngoscopy and direct laryngoscopy (MD -0.76, 95% CI -5.74 to 4.23; 2 studies; 359 intubations) (low quality evidence). There was no difference in the incidence of airway trauma due to intubation attempts (RR 0.10, 95% CI 0.01 to 1.80; RD -0.04, 95% CI -0.09 to -0.00; 1 study; 213 intubations) (low quality evidence).

There were no data available on other adverse effects of videolaryngoscopy.

Authors' conclusions

Moderate to very low quality evidence suggests that videolaryngoscopy increases the success of intubation in the first attempt but does not decrease the time to intubation or the number of attempts for intubation. However, these studies were conducted with trainees performing the intubations and these results highlight the potential usefulness of the videolaryngoscopy as a teaching tool. Well-designed, adequately powered RCTs are necessary to confirm efficacy and address safety and cost-effectiveness of videolaryngoscopy for endotracheal intubation in neonates by trainees and those proficient in direct laryngoscopy.

PLAIN LANGUAGE SUMMARY

The use of video devices in assisting the placement of breathing tube in babies

Review question

Does placement of a breathing tube (intubation) using a video-assisted device (videolaryngoscope) increase the success and safety of the procedure in newborn babies compared to the standard approach of looking at the opening of the airway (vocal cords) without video assistance (direct laryngoscopy)?

Background

One in 100 newborn babies may need intubation to sustain life when they have difficulty breathing. The placement of a breathing tube using direct laryngoscopy may be challenging in newborns. When teaching this life-saving skill to trainees, supervisors rely mainly on the feedback from the trainee (junior colleague) rather than by visual confirmation. It is difficult for the supervisor to provide real-time feedback to the trainee in this situation. Videolaryngoscopy may make this procedure easier and safer than the direct laryngoscopy approach. We wanted to discover whether using the videolaryngoscope increased the success and safety of the intubation procedure in newborns compared to the direct laryngoscopy technique.

Study characteristics

We sought evidence for the usefulness of these video-assisted devices for the placement of breathing tubes in babies. We searched scientific databases for clinical trials of babies who needed intubation in the delivery room, operating room or intensive care unit. The studies could measure time to intubation, number of attempts at intubation, success rate of first intubation or side effects. The evidence is current to May 2017. We included three studies, which provided data on up to 467 intubation attempts in newborns by trainees.

Key results and quality of the evidence

Data from three included studies suggest that videolaryngoscopy increases the success of intubation at first attempt but does not decrease the time to intubation, the number of attempts or side effects due to placement of the breathing tube. These studies were done with trainees and highlights the use of videolaryngoscopy as a teaching tool. We make a case for further research in evaluating the use of video-assisted devices in the placement of breathing tubes in newborns.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON *[Explanation]*

Videolaryngoscopy compared with conventional direct laryngoscopy for tracheal intubation in neonates							
Patient or population: neonates who needed tracheal intubation Settings: delivery room, operating room or neonatal intensive care unit Intervention: videolaryngoscopy by trainees Comparison: conventional direct laryngoscopy							
Outcomes	Illustrative comparative risks* (95% CI)			Relative effect (95% CI)	No of intubations (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk		Corresponding risk				
	Conventional laryngoscopy	direct	Videolaryngoscopy				
Time required for successful intubation	The mean duration ranged across control groups from 55.04 to 57.54 seconds		The mean duration in the intervention group ranged from 54.78 to 67.85 seconds	MD -0.62 (95% CI -6.50 to 5.26)	311 intubations, 2 studies	⊕○○○ Very low ¹	-
Number of intubation attempts	The mean number of attempts ranged across control groups from 1.33 to 1.93		The mean number of attempts in the intervention groups ranged from 1.38 to 1.53	MD -0.05 (95% CI -0.18 to 0.07)	427 intubations, 2 studies	⊕○○○ Very low ²	-
Success rate at first attempt	Population at risk			RR 1.44 (95% CI 1.20 to 1.73)	467 intubations, 3 studies	⊕⊕⊕○ Moderate ³	-
	424 per 1000		611 per 1000				
Non-airway related adverse effects: saturations during intubation	The mean saturation ranged across control groups from 48%to 64%		The mean saturation ranged across the intervention groups from 45%to 65%	MD -0.76 (95% CI -5.74 to 4.23)	359 intubations, 2 studies	⊕⊕○○ Low ⁴	-

Airway-related adverse effects: airway trauma	Population		RR 0.10 (95% CI 0.01 to 1.80)	213 intubations, 1 study ⊕⊕○○ Low ⁵	-
	45 per 1000	0 per 1000			

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: confidence interval; MD: mean difference; RR: risk ratio

GRADE Working Group grades of evidence

High quality: further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: we are very uncertain about the estimate.

¹Risk of bias was high/unclear, data from only two studies leading to imprecision and inconsistency (moderate heterogeneity).

²Risk of bias was high/unclear, data from only two studies leading to imprecision and inconsistency (high heterogeneity).

³Risk of bias was high/unclear.

⁴Risk of bias was high/unclear and data from only two studies leading to imprecision.

⁵Risk of bias was high/unclear and data from only one study leading to imprecision.

BACKGROUND

Description of the condition

Endotracheal intubation is a life-saving procedure performed in neonates in many clinical situations. Preterm birth, birth asphyxia, respiratory failure and respiratory problems including congenital anatomic abnormalities of the airway may require rapid and immediate endotracheal intubation to secure the airway, optimize oxygenation and achieve adequate ventilation. Successful intubation requires adequate visualization of the airway and related structures. Improved visibility may avoid prolonged or repeated intubation attempts. Several aspects of the anatomy of the neonatal airway, including the small size of the mouth and airway; the disproportionately large tongue, epiglottis and arytenoids; extensive secretions; and the keyhole appearance of the glottis, further complicate the process of intubation. The limited visibility often makes it difficult to train junior colleagues in the technique of neonatal endotracheal intubation. Supervisors of intubation training rely mainly on the feedback from the trainee rather than by visual confirmation. In addition, low pulmonary reserve and high oxygen consumption in small infants limit the time for instruction and correction during direct laryngoscopy. Thus, the instructors often cannot recognize the trainee's problem and have to perform the tracheal intubation themselves. This delays learning and achievement of proficiency in tracheal intubation for the trainee (Weiss 2001). Videolaryngoscopy can assist both the trainer and the trainee in identifying anatomical structures in the airway and enhance the success of intubation (Vanderhal 2009).

Description of the intervention

Direct laryngoscopy using the appropriate sized Miller straight or the Macintosh laryngoscope blade relies on the achievement of direct line of sight between the intubator and the glottis of the neonate and is the standard procedure for neonatal endotracheal intubation. Videolaryngoscopy is a form of indirect laryngoscopy in which the clinician does not directly view the larynx but the laryngeal visualization is performed with a fiberoptic or digital laryngoscope inserted transnasally or transorally (Pott 2008). These devices possess high-resolution microcameras and video monitors, which improve the view of the laryngeal inlet independent of the line of sight. Videolaryngoscopic techniques have been widely used in adult endotracheal intubation, and a variety of video-based devices has been developed. Technological advances have allowed a miniaturized device to be used in neonates. In this review, we intended to compare direct laryngoscopy with videolaryngoscopy for endotracheal intubation in neonates.

Videolaryngoscopes can be classified as follows: integrated channel laryngoscopes (CTracheal, Pentax, Airtaq), laryngoscopes with video stylets (Bonfils) and rigid blade laryngoscopes (C-MAC,

GlideScope, Truview EVO2) (Healy 2012). There have been many adult and pediatric trials with these devices. The GlideScope allows for superior laryngeal visualization in both routine and difficult airways in adults without the need for direct line of sight (Xue 2006), which facilitates faster learning when compared with the Macintosh laryngoscope (Lim 2005). One randomized controlled trial of 203 pediatric participants that compared GlideScope with direct laryngoscopy found that GlideScope provided a laryngoscopic view equal to or better than that of direct laryngoscopy but required a longer time for intubation (Kim 2008). The McGrath videolaryngoscope had a success rate of 98% in 147 adults (Shippey 2007), and provided improved laryngeal views in participants with known difficult airways (Shippey 2008). Similarly, the Pentax airway scope enables even the less-experienced operators to obtain an optimal view (Asai 2008), and faster and more successful intubation on first attempt for novices when compared with the Macintosh device (Hirabayashi 2007; Hirabayashi 2008).

In one meta-analysis of adult studies on videolaryngoscopy, there was no difference between the videolaryngoscope (GlideScope) and direct laryngoscope regarding successful first-attempt intubation or time to intubation (Griesdale 2012). In the same review, in two studies examining non-experts, successful first-attempt intubation (risk ratio (RR) 1.8, 95% confidence interval (CI) 1.4 to 2.4) and time to intubation (mean difference (MD) -43 seconds, 95% CI -72 to -14) were improved using the GlideScope. These benefits were not seen with intubation experts. The videolaryngoscope provided improved glottic visualization, particularly in people with potential or simulated difficult airways. One study evaluated the C-MAC videolaryngoscope in adults and found that a diverse group of anesthesia providers achieved a higher intubation success rate on first attempt with the C-MAC in people with predictors of difficult intubation (Aziz 2012). Pediatric studies reported time to intubation, number of intubation attempts, adverse effects of the laryngoscopic procedure and the view of the airway (Fiadjoe 2012; Singh 2009; Vlaten 2009). Time required for successful intubation was significantly longer in the videolaryngoscopy group compared with the direct laryngoscopy group. There was no difference in the number of intubation attempts between the two groups. There was airway trauma (minor gum bleeds) only in the direct laryngoscopy group in one study (Singh 2009), which was not observed in two other studies (Fiadjoe 2012; Vlaten 2009). The studies reported better visualization of the airway with the videolaryngoscope (Fiadjoe 2012; Singh 2009; Vlaten 2009).

Videolaryngoscopes are portable and can be used in both the delivery room and the neonatal intensive care unit (NICU) for neonates requiring endotracheal intubation. Videolaryngoscopes may be especially useful for neonates in whom a difficult airway is anticipated, for example in Pierre-Robin sequence, oral or neck masses, cleft palate, pharyngeal perforation and subglottic stenosis. One preliminary report by Vanderhal et al., in 47 infants weighing between 530 g and 6795 g using the Kaplan-Berci videolaryngo-

scope, showed promise for the use of this technique to improve airway management, evaluation and teaching (Vanderhal 2009). Significant differences exist between videolaryngoscopy and direct laryngoscopy in terms of the airway view obtained and the technique needed to insert the endotracheal tube (ETT) into the trachea. These differences may necessitate appropriate training curricula for videolaryngoscopy compared with direct laryngoscopic intubation.

How the intervention might work

Intubation is a common life-saving procedure in the NICU. It may be performed emergently in the delivery room or NICU, or non-urgently as in neonates going for surgery or for surfactant administration. The intubation may be attempted by trainees with varying degrees of skill and experience, and the neonates may have airway or facial abnormalities that may make the procedure more challenging than usual. Direct laryngoscopic tracheal intubation in neonates is an important but sometimes difficult skill to master that requires regular practice to maintain. The limited literature reviewing research in intubation success for trainees in pediatrics suggests that this vital skill needs to be reinforced (Falck 2003; Roberts 2006). The number of episodes that pediatric residents have for neonatal intubation has been decreasing due to several reasons including decreased time for residents in the NICU with varying patient acuity, duty hours restrictions and competition with other learners (nurse practitioners, respiratory therapists) who need to intubate to maintain their own skills. Successful direct laryngoscopy requires alignment of the oral, pharyngeal and laryngeal axes so that the vocal cords can be visualized (Thong 2009). The consequences of poorly performed intubation attempts, such as airway injury, prolonged hypoxia and other hemodynamic disturbances, are potentially serious (Maharaj 2006). Neonatal Resuscitation Program guidelines recommend that an intubation attempt should not be longer than 30 seconds (Kattwinkel 2011). In addition, the intubator may need to modify the technique in real time during the attempt under the guidance of the supervisor to achieve the optimal view of the glottis for intubation. Adverse events during endotracheal intubation may be reduced by a technique that is not dependent upon achieving the 'line of sight' required by direct laryngoscopy.

A videolaryngoscope collects electronically processed images from a camera attached at its tip. Images of the airway are visualized on a monitor, which results in improved glottic visualization compared with direct laryngoscopy. Videolaryngoscopy-assisted intubation removes the need for direct line of sight, and this is especially helpful for trainees learning intubation skills in a clinical setting. There is less cervical manipulation and spontaneous ventilation can be preserved during attempts. Videolaryngoscopy may also prove more effective in training scenarios, and may allow trainees to rapidly acquire and maintain their competency of this vital procedural skill.

Why it is important to do this review

Establishment of a secure airway is a critical part of neonatal resuscitation. Videolaryngoscopy is a technique that has the potential to facilitate successful intubation and decrease adverse consequences of failure or delay of airway stabilization. The costs of videolaryngoscopes (ranging upwards from a few thousand US dollars), personnel training and orientation, equipment storage and maintenance have to be balanced with the benefits achieved. The effects of videolaryngoscopy on improving neonatal outcomes have not been reviewed thus far.

OBJECTIVES

To determine the efficacy and safety of videolaryngoscopy compared to direct laryngoscopy in decreasing the time and attempts required for endotracheal intubation and increasing the success rate at first intubation in neonates.

METHODS

Criteria for considering studies for this review

Types of studies

Randomized, quasi-randomized or cluster-randomized controlled trials.

Types of participants

Neonates (0 to 28 days of age) who required intubation in the delivery room, operating room or NICU.

Types of interventions

Videolaryngoscopy with any device used for neonatal endotracheal intubation compared with direct laryngoscopy. Videolaryngoscopes that are available for neonatal use including GlideScope, C-MAC and Truview videolaryngoscope.

Types of outcome measures

Primary outcomes

- Time required for successful intubation defined as total time in seconds from the first insertion of the laryngoscope blade into the mouth until final confirmation of ETT placement by any or a combination of the following: clinical exam (auscultation, visible vapor in the ETT, adequate chest rise and

increase in saturation of peripheral oxygen (SpO₂)), by end-tidal carbon dioxide (ET-CO₂) estimation or by chest radiograph (Choong 2010; Feltman 2011).

- Number of intubation attempts: insertion and removal of the laryngoscope blade was defined as an attempt irrespective of the success of the intubation (Feltman 2011).
- Success rate at first attempt.

Secondary outcomes

- Non-airway related adverse effects:
 - first mean blood pressure in mmHg (as measured by a cuff or an arterial line) taken after tracheal intubation;
 - lowest recorded O₂ saturation (%) from the start of tracheal intubation to normalization of saturation (O₂ saturation greater than 95%);
 - time to attain normal saturation in seconds, from the start of tracheal intubation;
 - time to attain normal heart rate in seconds, from the start of tracheal intubation;
 - duration of bradycardia (heart rate less than 100 beats per minute) during and after tracheal intubation;
 - duration of hypoxia (O₂ saturation less than 80%) during and after tracheal intubation.
- Airway-related adverse effects: airway trauma to oral, pharyngeal and laryngeal structures, including lacerations and perforations, assessed by visual or laryngoscopic exam.

Search methods for identification of studies

We used the search strategy of the Cochrane Neonatal (neonatal.cochrane.org/). We applied no language restrictions.

Electronic searches

We updated the search in May 2017 in the following databases for relevant trials.

- The Cochrane Central Register of Controlled Trials (CENTRAL) (2017, Issue 1).
- MEDLINE (2013 to May 2017) and PREMEDLINE, Embase (2013 to May 2017) and CINAHL (2013 to May 2017).
- Biological abstracts in the database BIOSIS and conference abstracts from 'Proceedings First' (from 2013 to 2017).

The search strategy is detailed in Appendix 1.

Searching other resources

We also searched:

- abstracts of conferences: proceedings of Pediatric Academic Societies (American Pediatric Society, Society for Pediatric Research and European Society for Paediatric Research),

Pediatric Research (1990 to May 2013) and Abstracts2view (2000 to 2017);

- www.clinicaltrials.gov and www.controlled-trials.com for ongoing trials (May 2017);
- reference lists of identified clinical trials and in the review authors' personal files (May 2017).

We contacted authors in the field for possible unpublished studies and found none.

Data collection and analysis

We used the standardized method of the Cochrane Neonatal for conducting a systematic review (neonatal.cochrane.org/).

Selection of studies

Two review authors (KL and MP) independently assessed the titles and the abstracts of studies identified by the search strategy for inclusion eligibility in this review. If this could not be done reliably by title and abstract, we obtained the full-text version for assessment. We resolved any differences by discussion. We obtained the full-text version of all available studies for quality assessment and data extraction.

Data extraction and management

We designed forms for trial inclusion or exclusion, data extraction and for requesting additional published information from authors of the original reports. The review authors performed data extraction independently using specifically designed paper forms that were piloted and improved for data extraction from identified eligible trials. We compared the extracted data for differences, which we resolved by discussion.

Assessment of risk of bias in included studies

We found three studies meeting our inclusion criteria.

Two review authors (KL and MP) independently assessed the risk of bias (low, high or unclear) of all included trials using the Cochrane 'Risk of bias' tool for the following domains (Higgins 2011):

- sequence generation (selection bias);
- allocation concealment (selection bias);
- blinding of participants and personnel (performance bias);
- blinding of outcome assessment (detection bias);
- incomplete outcome data (attrition bias);
- selective reporting (reporting bias);
- any other bias.

Any disagreements were resolved by discussion or by a third review author. See Appendix 2 for a more detailed description of risk of bias for each domain. We judged two trials at low risk of allocation (selection), attrition and reporting bias (Moussa 2016;

O'Shea 2015), and the remaining trial at an unclear risk for the same (Volz 2016). None of the studies could be blinded as the participant knew which device he or she was using or if the supervisor had access to the videolaryngoscope screen during their attempt. The risk of performance bias on the trainee and the supervisor was high but unavoidable in such studies. None of the included studies explicitly reported blinding of outcome assessors. But the intubation success was assessed using objective criteria and the risk of detection bias was low.

Measures of treatment effect

We reported RR and risk difference (RD) for dichotomous outcomes and MD for continuous outcomes with 95% CIs. We calculated the number needed to treat for an additional beneficial outcome (NNTB) if there was a statistically significant reduction in RD with respective 95% CIs.

Unit of analysis issues

The unit of analysis was changed from participants to intubation attempts in this updated review as it was impossible to separate the number of intubations for each participant. We did not expect higher risk of bias because of this change.

Dealing with missing data

We contacted the authors of published studies for clarifications and additional information. In the case of missing data, we described the number of participants with missing data in the [Results](#) section and the [Characteristics of included studies](#) table.

Assessment of heterogeneity

We estimated the treatment effects of individual trials and examined heterogeneity between trials by inspecting the forest plots and quantifying the impact of heterogeneity using the I^2 statistic. We graded the degree of heterogeneity as low (25% to 50%), moderate (51% to 75%) or high (greater than 75%). We found statistical heterogeneity in the outcome of time to intubation and number of intubation attempts but were unable to explore the possible causes due to the inclusion of only two studies. We used a fixed-effect model for meta-analysis.

Assessment of reporting biases

We could not obtain study protocols of all included studies to compare outcomes reported in the protocols to those reported in the studies. We planned to investigate reporting and publication bias by examining the degree of asymmetry of a funnel plot if there were more than 10 included studies. Where we suspected reporting bias, we contacted study authors asking them to provide missing outcome data.

Data synthesis

We performed statistical analyses according to the recommendations of Cochrane Neonatal. We used Review Manager 5 software to perform statistical analysis and used a fixed-effect model for meta-analysis (RevMan 2014).

Quality of evidence

We used the GRADE approach, as outlined in the GRADE Handbook (Schünemann 2013), to assess the quality of evidence for the following (clinically relevant) outcomes:

- time to intubation;
- number of intubation attempts;
- success of intubation at first attempt;
- saturations during intubation in saturation percentage;
- airway trauma.

Two review authors independently assessed the quality of the evidence for each of the outcomes. We considered evidence from randomized controlled trials as high quality but downgraded the evidence one level for serious (or two levels for very serious) limitations based upon the following: design (risk of bias), consistency across studies, directness of the evidence, precision of estimates and presence of publication bias. We used [GRADEpro GDT](#) to create a 'Summary of findings' table to report the quality of the evidence.

The GRADE approach results in an assessment of the quality of a body of evidence in one of four grades:

- high: we are very confident that the true effect lies close to that of the estimate of the effect;
- moderate: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different;
- low: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect;
- very low: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

Subgroup analysis and investigation of heterogeneity

We will base subgroups on the following in future updates of the review when data are available. Currently we do not have data for meaningful subgroup analyses.

Birth weight groups

- 1500 g or less.
- Greater than 1500 g.

Personnel groups

- Personnel with less than one year of tracheal intubation experience.
- Personnel with one to three years of tracheal intubation experience.
- Personnel with greater than three years of tracheal intubation experience.

Presence of airway malformations

- Airway malformations.
- No airway malformations.

Type of neonatal videolaryngoscopy equipment

- Integrated channel laryngoscope (CTrach, Pentax AWS, Airtaq).
- Video stylets (Bonfils).
- Rigid blade laryngoscopes (C-MAC, GlideScope, McGrath, Truview).
- Direct laryngoscope.

Setting

- Emergent.
- Non-emergent.

Sensitivity analysis

We had planned to explore methodologic heterogeneity of eligible trials using sensitivity analyses but could not perform due to inclusion of only three studies.

RESULTS

Description of studies

Results of the search

Our search strategy performed in May 2017 yielded 7057 references after removal of duplicates, which two review authors (MP and KL) independently reviewed ([Figure 1](#)). Most excluded randomized trials were performed on mannequins in a simulated environment and not on neonates. Clinical trials randomizing people to videolaryngoscopy or conventional direct laryngoscopy were mostly in adults and older children. We found nine potential studies, and excluded five studies either because the studies were conducted in simulation or in non-neonatal population ([Fiadjoe 2012](#); [Komasawa 2017](#); [Parmekar 2017](#); [Sørensen 2012](#); [Vlatten 2009](#)), and one study where we are awaiting a response from the author regarding the age of the participants ([Singh 2009](#)). We also identified two ongoing trials ([NCT01371032](#); [NCT01793727](#)).

Figure 1. Study flow diagram: review update.

Included studies

Our search strategy identified three randomized controlled trials that were eligible for inclusion. These three studies randomized intubations performed by trainees on neonates using the video or the direct laryngoscope (Moussa 2016; O'Shea 2015; Volz 2016). Refer to the [Characteristics of included studies](#) table for details.

Included studies

Moussa 2016 randomly assigned pediatric residents in the first to third year to endotracheal intubation with a conventional laryngoscope (Rusch, Teleflex Medical, Markham, Canada) with Miller blade size 00, 0 or 1, or the videolaryngoscope C-MAC VL (Karl Storz, Tuttlingen, Germany) with blade size 0 or 1. The primary outcome was success rate of endotracheal intubation. The secondary outcomes were time to successful intubation, number of bradycardia episodes, lowest oxygen saturation during procedure, occurrence of mucosal trauma, reason for intubation failure, and recognition of problems related to intubation by supervisor and resident.

O'Shea 2015 was a randomized controlled trial conducted at a single center in Australia during 2013 and 2014. O'Shea and colleagues enrolled doctors with less than six months' tertiary neonatal experience to perform endotracheal intubation with or without the modified traditional Miller videolaryngoscope (LaryFlex, Acutronics, Hirzel, Switzerland) screen visible to the instructor. The primary outcome was first-attempt intubation success rate confirmed by colorimetric detection of expired carbon dioxide.

Volz 2016 conducted a randomized controlled trial to compare intubation success by first and second year pediatric residents in neonates with or without guidance from the supervisor using videolaryngoscopy. This study was conducted at a single center in the US. The primary outcome was successful intubation within two attempts.

Excluded studies

We excluded five studies (Fiadjoe 2012; Komasaawa 2017; Parmekar 2017; Sørensen 2012; Vlatten 2009; see [Characteristics of excluded studies](#) table).

Vlatten 2009 randomized 56 children aged four years or less to direct laryngoscopy or videolaryngoscopy using C-MAC DCI videolaryngoscope. Outcomes reported were time to best view, time to intubate and percentage of glottis opening seen. The median age was 25 months (range 7 to 58 months) in the direct laryngoscopy group and 32 months (range 6 to 57 months) in the videolaryn-

goscopy group. No neonates were included in the study and hence we excluded the study.

Fiadjoe 2012 randomized 60 infants, aged less than one year who underwent elective surgery to GlideScope Cobalt videolaryngoscope or conventional direct laryngoscopy (Miller 1 blade) in Philadelphia, US. The mean age was 5.9 months (standard deviation (SD) 3.4) in the GlideScope group and 5.1 months (SD 3.3) in the direct laryngoscopy group. Boy to girl ratios were similar in the two groups. Outcomes were intubation time, time to best view, percentage of glottic opening score and intubation success. The youngest participant was aged one month and 12 days old and hence we excluded this study.

Sørensen 2012 randomized 10 children aged two years or younger scheduled for elective cleft lip/palate surgery to intubation with the C-MAC videolaryngoscope or the Airtraq Optical laryngoscope. The primary endpoint was success rate, defined as intubation in first attempt. Secondary endpoints were time from start of laryngoscopy to CL-score, tube positioning in front of the glottis and intubation. The youngest participant was three months old and there was no control group with the direct laryngoscope, hence this study was excluded.

Komasaawa 2017 and Parmekar 2017 studies were conducted using manikins and did not include human neonates and thus were excluded.

Studies awaiting classification

We found one study that randomized 60 neonates and infants who underwent surgery in New Delhi, India to Truview infant EVO2 or direct laryngoscopy with the Miller blade (Singh 2009; see [Characteristics of studies awaiting classification](#) table). The mean age (SD) of the participants was 0.69 months (1.20) in the Truview group and 0.74 months (1.21) in the direct laryngoscopy group. Boy to girl ratios in both groups were similar. All infants weighed between 1 kg and 10 kg. Exclusion criteria included the presence of raised intracranial pressure, high risk for pulmonary aspiration of gastric contents such as gastric outlet obstruction and bowel stasis, coagulopathy and presence of any pathology of head and neck. Outcomes reported were number of attempts required for intubation, time to intubation, percentage of glottic opening score, hemoglobin oxygen saturation and soft tissue injury related to intubation. We requested and are awaiting data for neonates from the investigators.

Ongoing studies

We identified four ongoing trials (ACTRN12614001134617; NCT01371032; NCT01793727; NCT03396432; see [Characteristics of ongoing studies](#) table).

Risk of bias in included studies

Allocation

[Moussa 2016](#) achieved randomization using a table of random numbers stratified by year of residency training and allocation concealment using opaque sealed envelopes with the allocation group. [O'Shea 2015](#) used a computer-generated variable-sized block randomization sequence and sequentially numbered opaque envelopes with randomization cards for allocation concealment. [Volz 2016](#) used a modified blocked randomization scheme and allocation concealment was unclear. Thus, we judged [Moussa 2016](#) and [O'Shea 2015](#) at low risk of allocation (selection) bias and [Volz 2016](#) at unclear risk of allocation bias.

Blinding

Performance bias: none of the three studies could be blinded as the participant knew which device he or she was using or if the supervisor had access to the videolaryngoscope screen during their attempt. The risk of performance bias on the trainee and the supervisor was high but unavoidable in such studies.

Detection bias: none of the included studies explicitly reported blinding of outcome assessors. But the intubation success was assessed using objective criteria and the risk of detection bias was low.

Incomplete outcome data

In the study by [Moussa 2016](#), 34 of the 37 enrolled residents completed the study. Investigators reported all outcomes that were specified in the protocol (low risk of attrition bias). [O'Shea 2015](#), after randomization, excluded only seven neonates, three in the intervention group and four in the control group (low risk of

attrition bias). Analysis was on an intention-to-treat basis. Details were not available for [Volz 2016](#) (unclear risk of attrition bias).

Selective reporting

There was no selective reporting in two published studies ([Moussa 2016](#); [O'Shea 2015](#)) (low risk of reporting bias). In the included study that was published as abstract, reporting bias was unclear ([Volz 2016](#)).

Other potential sources of bias

In one study, nearly two thirds of the intubations were nasotracheal ([Moussa 2016](#)). In the included study that was published as abstract, risk was unclear as the full details of the study were unavailable ([Volz 2016](#)).

Effects of interventions

See: [Summary of findings for the main comparison](#) Videolaryngoscopy compared with conventional direct laryngoscopy for tracheal intubation in neonates

Videolaryngoscopy versus conventional laryngoscopy

Time required for successful intubation (outcome 1.1)

Time to intubation was similar between videolaryngoscopy and direct laryngoscopy (MD -0.62 seconds, 95% CI -6.50 to 5.26; 2 studies; 311 intubations; [Analysis 1.1](#)) ([Moussa 2016](#); [O'Shea 2015](#)) ([Figure 2](#)). There was moderate heterogeneity ($I^2 = 69\%$). The quality of evidence was downgraded to very low quality due to high or unclear risk of bias, imprecision and inconsistency.

Figure 2. Forest plot of comparison: 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), outcome: 1.1 Time required for successful intubation (seconds).

Number of intubation attempts (outcome 1.2)

Videolaryngoscopy did not decrease the number of intubation attempts (MD -0.05, 95% CI -0.18 to 0.07; 2 studies; 427 intubations; [Analysis 1.2](#)) ([Moussa 2016](#); [O'Shea 2015](#)) ([Figure 3](#)). There was high heterogeneity ($I^2 = 89\%$). The quality of evidence was downgraded to very low quality due to high or unclear risk of bias, imprecision and inconsistency.

Figure 3. Forest plot of comparison: I Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), outcome: 1.2 Number of intubation attempts.

Success rate at first attempt (outcome 1.3)

Videolaryngoscopy increased the success of intubation at first attempt (typical RR 1.44, 95% CI 1.20 to 1.73; typical RD 0.19, 95% CI 0.10 to 0.28; NNTB 5, 95% CI 4 to 10; 3 studies; 467 intubations; [Analysis 1.3](#)) ([Moussa 2016](#); [O'Shea 2015](#); [Volz 2016](#)) ([Figure 4](#)). There was low heterogeneity ($I^2 = 10\%$). Evidence was downgraded to moderate as the risk of bias was unclear.

Figure 4. Forest plot of comparison: I Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), outcome: 1.3 Success rate at first attempt.

Non-airway related adverse effects: saturations during intubation (outcome 1.4)

Videolaryngoscopy did not decrease desaturation episodes during intubation attempts (MD -0.76, 95% CI -5.74 to 4.23; 2 studies;

359 intubations; [Analysis 1.4](#)). Evidence was downgraded to low as the risk of bias was high/unclear and only two studies reported this outcome ([Moussa 2016](#); [O'Shea 2015](#)).

Non-airway related adverse effects: other than saturations during intubation

None of the studies reported on other secondary outcomes namely, first mean blood pressure (as measured by a cuff or an arterial line) taken after tracheal intubation, time to attain normal saturation from the start of tracheal intubation, time to attain normal heart rate from the start of tracheal intubation, duration of bradycardia (heart rate less than 100 beats per minute) during and after tracheal intubation, and duration of hypoxia (O_2 saturation less than 80%) during and after tracheal intubation.

Airway-related adverse effects: airway trauma (outcome 1.5)

There was no difference in the incidence of airway trauma due to intubation attempts (RR 0.10, 95% CI 0.01 to 1.80; RD -0.04, 95% CI -0.09 to -0.00; 1 study; 213 intubations; [Analysis 1.5](#)). Evidence was downgraded to low as the risk of bias was unclear and data were available from only one study.

DISCUSSION

Summary of main results

We included three randomized controlled trials that compared videolaryngoscopy with conventional direct laryngoscopy for endotracheal intubation in newborns during intubation attempts by trainees. There was no difference in time to intubation (MD -0.62, 95% CI -6.50 to 5.26; 2 studies; 311 intubations; very low quality evidence) or number of attempts (MD -0.05, 95% CI -0.18 to 0.07; 2 studies; 427 intubations; very low quality evidence) between direct and videolaryngoscopy. Videolaryngoscopy increased the success of intubation at first attempt (typical RR 1.44, 95% CI 1.20 to 1.73; typical RD 0.19, 95% CI 0.10 to 0.28; NNTB 5, 95% CI 4 to 10; 3 studies; 467 intubation attempts; moderate quality evidence). There was no difference in airway trauma between direct and videolaryngoscopy (RR 0.10, 95% CI 0.01 to 1.80; RD -0.04, 95% CI -0.09 to -0.00; 1 study; 213 intubations; low quality evidence) ([Moussa 2016](#); [O'Shea 2015](#); [Volz 2016](#)). We are awaiting neonatal data from investigators of one study that has the potential for inclusion but is currently awaiting classification ([Singh 2009](#)). We also identified four ongoing trials ([ACTRN12614001134617](#); [NCT01371032](#); [NCT01793727](#); [NCT03396432](#)).

Overall completeness and applicability of evidence

The three randomized controlled trials were performed in NICUs in Canada, Australia and the US. These studies involved trainees with limited intubation expertise.

The current increase in interest in videolaryngoscopy as a clinical teaching tool is in the wake of duty hour restrictions and decreasing intubation opportunities for trainees to gain competence in the procedure. The number of intubation opportunities is further decreased by the presence of additional advanced providers such as respiratory therapists and nurse practitioners and growing adaptation of non-invasive respiratory support in preterm neonates. Even though this review showed that based on the three included studies videolaryngoscopy increased success of intubation on the first attempt by trainees, it cannot be extended to intubation by expert providers. In addition, the cost may be prohibitive and availability limited for these devices in some low resource settings.

Quality of the evidence

We assessed the quality of evidence using GRADE methodology ([Guyatt 2008](#)); we downgraded the evidence to moderate to very low on the basis of unclear risk of bias, imprecision and inconsistency. We could not assess publication bias, as we identified only three studies. [Moussa 2016](#) and [O'Shea 2015](#) used established techniques to randomize intubation attempts and achieved a low risk of selection bias and allocation concealment. Limited information is available on [Volz 2016](#), which was published as an abstract only. Performance bias could have been an issue as the study could not be blinded and the trainees could have known if the supervisor had access to the videolaryngoscopy screen. The outcome (intubation success) was assessed using objective criteria thus decreasing the chances of detection bias. There was no attrition bias as the studies performed all outcome assessments and adequately accounted for incomplete data.

Potential biases in the review process

We used the standard methods of Cochrane Neonatal for conducting this systematic review. We strove to decrease biases in the review process. Two review authors performed the literature search using an inclusive search strategy and combined their results. Our search strategy identified three randomized controlled trials on prespecified neonatal outcomes. We pursued the investigators of published randomized controlled trials and searched conference proceedings for data and missing information with limited success. The unit of analysis was changed from participants to intubation attempts in this updated review but do not expect this change to increase risk of bias.

Agreements and disagreements with other studies or reviews

We found no other reviews that quantitatively synthesized data from trials of videolaryngoscopy for endotracheal intubation in neonates.

AUTHORS' CONCLUSIONS

Implications for practice

We found moderate to very low quality evidence from three randomized trials to suggest that videolaryngoscopy may increase success of intubation at first attempt, when the intubations are being performed by trainees. There was no difference in time to intubation or number of intubation attempts or decrease in the incidence of airway trauma (low to very low quality evidence). However, these studies were conducted with trainees performing the intubations and these results highlight the potential usefulness of the videolaryngoscopy as a teaching tool.

Implications for research

Well-designed randomized controlled trials are necessary to confirm the efficacy and safety of videolaryngoscopy in neonatal intubation by trainees and those proficient in direct laryngoscopy. Such trials should also evaluate cost-effectiveness and address training

of carers. Clinically relevant outcomes, such as decrease in oxygen saturation, prolonged bradycardia or hypoxia, should be reported. Videolaryngoscopy should be evaluated in settings where intubation is commonly performed including the delivery room and the neonatal intensive care unit. Comparison of videolaryngoscopy and direct laryngoscopy in neonates with a difficult airway also needs further evaluation.

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The methods section of this review was based on a standard template used by Cochrane Neonatal.

REFERENCES

References to studies included in this review

Moussa 2016 {published data only}

Moussa A, Luangxay Y, Tremblay S, Lavoie J, Aube G, Savoie E, et al. Videolaryngoscope for teaching neonatal endotracheal intubation: a randomized controlled trial. *Pediatrics* 2016;**137**(3):e20152156. DOI: 10.1542/peds.2015-2156; PUBMED: 26908701

O'Shea 2015 {published data only}

O'Shea JE, Thio M, Kamlin CO, McGrory L, Wong C, John J, et al. Videolaryngoscopy to teach neonatal intubation: a randomized trial. *Pediatrics* 2015;**136**(5): 912–9. DOI: 10.1542/peds.2015-1028; PUBMED: 26482669

Volz 2016 {published data only}

Volz S, Stevens TP, Dadiz R. A randomized controlled trial: does guidance using video laryngoscopy improve residents' success in neonatal intubations?. *Pediatrics Academic Societies Annual Meeting*; 2016 30 Apr-3 May 2016; Baltimore (MD). 2016.

References to studies excluded from this review

Fiadjoe 2012 {published and unpublished data}

Fiadjoe JE, Gurnaney H, Dalesio N, Sussman E, Zhao H, Zang X, et al. A prospective randomized equivalence trial of the GlideScope Cobalt video laryngoscope to traditional direct laryngoscopy in neonates and infants. *Anesthesiology* 2012;**116**(3):622–8. DOI: 10.1097/ALN.0b013e318246ea4d; PUBMED: 22270505

Komasawa 2017 {published data only}

Komasawa N, Hattori K, Mihara R, Minami T. Direct laryngoscopy training is important for videolaryngoscopy

skill acquisition. *British Journal of Anaesthesia* 2017;**118**(2):269–70. DOI: 10.1093/bja/aew458; PUBMED: 28100534

Parmekar 2017 {published data only}

Parmekar S, Arnold JL, Anselmo C, Pammi M, Hagan J, Fernandes CJ, et al. Mind the gap: can videolaryngoscopy bridge the competency gap in neonatal endotracheal intubation among pediatric trainees? A randomized controlled study. *Journal of Perinatology* 2017;**37**(8): 979–83. DOI: 10.1038/jp.2017.72; PUBMED: 28518132

Sørensen 2012 {published data only}

Sørensen M, Holm-Knudsen R. Endotracheal intubation with Airtraq® versus Storz® videolaryngoscope in children younger than two years - a randomized pilot-study. *BMC Anesthesiology* 2012;**12**:7. DOI: 10.1186/1471-2253-12-7; PUBMED: 22545575

Vlatten 2009 {published data only}

Vlatten A, Aucoin S, Litz S, Macmanus B, Soder C. A comparison of the STORZ video laryngoscope and standard direct laryngoscopy for intubation in the Pediatric airway - a randomized clinical trial. *Paediatric Anaesthesia* 2009;**19**(11):1102–7. DOI: 10.1111/j.1460-9592.2009.03127.x; PUBMED: 19708910

References to studies awaiting assessment

Singh 2009 {published data only}

Singh R, Singh P, Vajifdar H. A comparison of Truview infant EVO2 laryngoscope with the Miller blade in neonates and infants. *Paediatric Anaesthesia* 2009;**19**(4):338–42. DOI: 10.1111/j.1460-9592.2009.02929.x; PUBMED: 19335346

References to ongoing studies

ACTRN12614001134617 *{unpublished data only}*

Bellhouse S. A randomised controlled clinical trial comparing C-MAC (Trademark) videolaryngoscope intubation with direct laryngoscope intubation in neonates. The HEADS UP Study. www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=367096 Date first received: 24 October 2014.

NCT01371032 *{unpublished data only}*

NCT01371032. Study to compare video miller device to direct laryngoscopy [A randomized, prospective study to compare the video miller device to direct laryngoscopy using a standard pediatric Miller Blade for tracheal intubation of children < 3 years of age undergoing general anesthesia]. clinicaltrials.gov/show/NCT01371032 Date first received: 10 June 2011.

NCT01793727 *{unpublished data only}*

NCT01793727. Infant Glidescope® learning curve. clinicaltrials.gov/show/NCT01793727 Date first received: 15 February 2013.

NCT03396432 *{unpublished data only}*

Fiadjoe 2018. The Videolaryngoscopy in Small Infants (VISI). clinicaltrials.gov/ct2/show/NCT03396432 Date first registered: 11 January 2018.

Additional references

Asai 2008

Asai T, Enomoto Y, Shimizu K, Shingu K, Okuda Y. The Pentax-AWS video-laryngoscope: the first experience in one hundred patients. *Anesthesia and Analgesia* 2008;**106**(1):257–9. DOI: 10.1213/01.ane.0000287647.46165.bc; PUBMED: 18165587

Aziz 2012

Aziz MF, Dillman D, Fu R, Brambrink AM. Comparative effectiveness of the C-MAC video laryngoscope versus direct laryngoscopy in the setting of the predicted difficult airway. *Anesthesiology* 2012;**116**(3):629–36. DOI: 10.1097/ALN.0b013e318246ea34; PUBMED: 22261795

Choong 2010

Choong K, Alfaleh K, Doucette J, Gray S, Rich B, Verhey L, et al. Remifentanyl for endotracheal intubation in neonates: a randomised controlled trial. *Archives of Disease in Childhood. Fetal and Neonatal Edition* 2010;**95**(2):F80–4. DOI: 10.1136/adc.2009.167338; PUBMED: 20231228

Falck 2003

Falck AJ, Escobedo MB, Baillargeon JG, Villard LG, Gunkel JH. Proficiency of pediatric residents in performing neonatal endotracheal intubation. *Pediatrics* 2003;**112**(6 Pt 1):1242–7. [PUBMED: 14654592]

Feltman 2011

Feltman DM, Weiss MG, Nicoski P, Sinacore J. Rocuronium for nonemergent intubation of term and preterm infants. *Journal of Perinatology* 2011;**31**(1):38–43. DOI: 10.1038/jp.2010.74; PUBMED: 20539274

GRADEpro GDT [Computer program]

McMaster University (developed by Evidence Prime). GRADEpro GDT. Version accessed 16 November 2017. Hamilton (ON): McMaster University (developed by Evidence Prime), 2015.

Griesdale 2012

Griesdale DE, Liu D, McKinney J, Choi PT. Glidescope (R) video-laryngoscopy versus direct laryngoscopy for endotracheal intubation: a systematic review and meta-analysis. *Canadian Journal of Anaesthesia* 2012;**59**(1):41–52. DOI: 10.1007/s12630-011-9620-5; PUBMED: 22042705

Guyatt 2008

Guyatt GH. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;**336**(7650):924–6.

Healy 2012

Healy DW, Maties O, Hovord D, Kheterpal S. A systematic review of the role of videolaryngoscopy in successful orotracheal intubation. *BMC Anesthesiology* 2012;**12**:32. DOI: 10.1186/1471-2253-12-32; PUBMED: 23241277

Higgins 2011

Higgins JP, Green S, editor(s). *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 (updated March 2011). The Cochrane Collaboration, 2011. Available from handbook.cochrane.org.

Hirabayashi 2007

Hirabayashi Y, Seo N. Tracheal intubation by non-anesthetist physicians using the Airway Scope. *Emergency Medicine Journal* 2007;**24**(8):572–3. DOI: 10.1136/emj.2007.048546; PUBMED: 17652682

Hirabayashi 2008

Hirabayashi Y, Seo N. Airway Scope: early clinical experience in 405 patients. *Journal of Anesthesia* 2008;**22**(1):81–5. DOI: 10.1007/s00540-007-0580-4; PUBMED: 18306022

Kattwinkel 2011

Kattwinkel J. *Textbook of Neonatal Resuscitation*. 6th Edition. Elk Grove Village (IL): American Academy of Pediatrics and American Heart Association, 2011.

Kim 2008

Kim JT, Na HS, Bae JY, Kim DW, Kim HS, Kim CS, et al. GlideScope video laryngoscope: a randomized clinical trial in 203 paediatric patients. *British Journal of Anaesthesia* 2008;**101**(4):531–4.

Lim 2005

Lim TJ, Lim Y, Liu EH. Evaluation of ease of intubation with the GlideScope or Macintosh laryngoscope by anaesthetists in simulated easy and difficult laryngoscopy. *Anaesthesia* 2005;**60**(2):180–3. DOI: 10.1111/j.1365-2044.2004.04038.x; PUBMED: 15644017

Maharaj 2006

Maharaj CH, Costello JF, Higgins BD, Harte BH, Laffey JG. Learning and performance of tracheal intubation by novice personnel: a comparison of the Airtraq and

- Macintosh laryngoscope. *Anaesthesia* 2006;**61**(7):671–7. DOI: 10.1111/j.1365-2044.2006.04653.x; PUBMED: 16792613
- Pott 2008**
Pott LM, Murray WB. Review of video laryngoscopy and rigid fiberoptic laryngoscopy. *Current Opinion in Anaesthesiology* 2008;**21**(6):750–8. DOI: 10.1097/ACO.0b013e3283184227; PUBMED: 18997526
- RevMan 2014 [Computer program]**
Nordic Cochrane Centre, The Cochrane Collaboration. Review Manager (RevMan). Version 5.3. Copenhagen: Nordic Cochrane Centre, The Cochrane Collaboration, 2014.
- Roberts 2006**
Roberts KD, Leone TA, Edwards WH, Rich WD, Finer NN. Premedication for nonemergent neonatal intubations: a randomized, controlled trial comparing atropine and fentanyl to atropine, fentanyl, and mivacurium. *Pediatrics* 2006;**118**(4):1583–91. DOI: 10.1542/peds.2006-0590; PUBMED: 17015550
- Schünemann 2013**
Schünemann H, Brożek J, Guyatt G, Oxman A, editor (s). Handbook for grading the quality of evidence and the strength of recommendations using the GRADE approach (updated October 2013). GRADE Working Group, 2013. Available from gdt.guidelinedevelopment.org/app/handbook/handbook.html.
- Shippey 2007**
Shippey B, Ray D, McKeown D. Case series: the McGrath videolaryngoscope—an initial clinical evaluation. *Canadian Journal of Anaesthesia* 2007;**54**(4):307–13. [PUBMED: 17400984]
- Shippey 2008**
Shippey B, Ray D, McKeown D. Use of the McGrath videolaryngoscope in the management of difficult and failed tracheal intubation. *British Journal of Anaesthesia* 2008;**100**(1):116–9.
- Thong 2009**
Thong SY, Lim Y. Video and optic laryngoscopy assisted tracheal intubation - the new era. *Anaesthesia and Intensive Care* 2009;**37**(2):219–33. [PUBMED: 19400485]
- Vanderhal 2009**
Vanderhal AL, Berci G, Simmons CF Jr, Hagiike M. A videolaryngoscopy technique for the intubation of the newborn: preliminary report. *Pediatrics* 2009;**124**(2):e339–46. DOI: 10.1542/peds.2008-3653; PUBMED: 19620189
- Weiss 2001**
Weiss M, Schwarz U, Dillier CM, Gerber AC. Teaching and supervising tracheal intubation in paediatric patients using videolaryngoscopy. *Pediatric Anesthesia* 2001;**11**(3):343–8. [PUBMED: 11359595]
- Xue 2006**
Xue F, Zhang G, Liu J, Li X, Sun H, Wang X, et al. A clinical assessment of the GlideScope videolaryngoscope in nasotracheal intubation with general anesthesia. *Journal of Clinical Anesthesia* 2006;**18**(8):611–5. DOI: 10.1016/j.jclinane.2006.03.018; PUBMED: 17175432
- * Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Moussa 2016

Methods	Non-blinded, randomized controlled trial with cross-over of only the experimental group	
Participants	Pediatric residents in the first to third year of residency.	
Interventions	Endotracheal intubation with conventional laryngoscope (Rusch, Teleflex Medical, Markham, Canada) with Miller blade size 00, 0 or 1 OR the videolaryngoscope C-MAC VL (Karl Storz, Tuttlingen, Germany) with blade size 0 or 1	
Outcomes	Primary outcome: success rate of endotracheal intubation. Secondary outcomes: time to successful intubation, number of bradycardia episodes and lowest oxygen saturation during procedure, occurrence of mucosal trauma, reason for intubation failure, and recognition of problems related to intubation by supervisor and resident	
Notes	Performed at the University of Montreal, Canada.	
<i>Risk of bias</i>		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Table of random numbers stratified by year of residency training
Allocation concealment (selection bias)	Low risk	Sealed envelopes with the allocation group.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Study could not be blinded.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Change in color of the carbon dioxide detector, vapor mist in the endotracheal tube, thoracic expansion, assessment of bilateral lung air entry, absence of air entry in the stomach by auscultation, and improvement of clinical parameters were used as objective criteria to assess intubation success
Incomplete outcome data (attrition bias) All outcomes	Low risk	34/37 enrolled residents completed the study.
Selective reporting (reporting bias)	Low risk	Investigators reported all outcomes that were specified in the protocol

Moussa 2016 (Continued)

Other bias	Unclear risk	More than two-thirds of intubations were nasotracheal.
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O'Shea 2015

Methods	Randomized controlled trial to compare intubation success by physicians with < 6 months' tertiary neonatal experience in neonates with or without the videolaryngoscope screen visible to the instructor
Participants	Infants without facial or airway anomalies in the delivery room or intensive care unit
Interventions	Endotracheal intubation with or without the modified traditional Miller videolaryngoscope (LaryFlex, Acutronics, Hirzel, Switzerland) videolaryngoscope screen visible to the instructor
Outcomes	First-attempt intubation success rate confirmed by colorimetric detection of expired carbon dioxide
Notes	Single-center, unblinded study conducted in 2013-2014 at the Royal Women's Hospital, Melbourne, Australia, a tertiary perinatal center

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Computer-generated variable-sized block randomization sequence used
Allocation concealment (selection bias)	Low risk	Sequentially numbered opaque envelopes with randomization cards
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Participant could potentially know if the supervisor had access to the videolaryngoscope screen during their attempt, which could potentially impact their performance
Blinding of outcome assessment (detection bias) All outcomes	High risk	Primary outcome was success at the intubation attempt.
Incomplete outcome data (attrition bias) All outcomes	Low risk	After randomization, only 7 neonates were excluded, 3 in the intervention group and 4 in the control group. Analysis on an intention-to-treat basis
Selective reporting (reporting bias)	Low risk	Investigators reported all outcomes that were specified in the protocol

O'Shea 2015 (Continued)

Other bias	Low risk	No other potential sources of bias identified.
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Volz 2016

Methods	Randomized controlled trial to compare intubation success by first and second year pediatric residents in neonates with or without guidance from the supervisor using videolaryngoscopy
Participants	First- and second-year pediatric residents
Interventions	Endotracheal intubation with conventional or the videolaryngoscope (details of the laryngoscopes and blades used not available)
Outcomes	Successful intubation within 2 attempts
Notes	Abstract only and hence risk of bias could not be assessed.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Abstract only and hence risk of bias could not be assessed.
Allocation concealment (selection bias)	Unclear risk	Abstract only and hence risk of bias could not be assessed.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Abstract only and hence risk of bias could not be assessed.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Abstract only and hence risk of bias could not be assessed.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Abstract only and hence risk of bias could not be assessed.
Selective reporting (reporting bias)	Unclear risk	Abstract only and hence risk of bias could not be assessed.
Other bias	Unclear risk	Abstract only and hence risk of bias could not be assessed.

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Fiadjoe 2012	No neonates included in the study.
Komasawa 2017	Study in simulation.
Parmekar 2017	Study conducted in neonatal manikins.
Sørensen 2012	No neonates included in the study.
Vlatten 2009	Participants aged < 4 years but no neonates.

Characteristics of studies awaiting assessment *[ordered by study ID]*

[Singh 2009](#)

Methods	Prospective randomized study to compare the Truview infant EVO2 laryngoscope with the Miller straight blade laryngoscope to determine whether the Truview EVO2 laryngoscope provided an improved laryngeal view at laryngoscopy and to assess the time taken for intubation with the 2 devices
Participants	60 neonates and infants undergoing surgery under general anesthesia weighing 1-10 kg Exclusion criteria: raised intracranial pressure, high risk for pulmonary aspiration of gastric contents such as gastric outlet obstruction and bowel stasis, coagulopathy and presence of any pathology of head and neck
Interventions	Endotracheal intubation using a Truview blade (Group I) versus a Miller blade number 0 (Group II)
Outcomes	Number of attempts required for intubation, time to intubation, percentage of glottic opening score, hemoglobin oxygen saturation and soft tissue injury related to intubation
Notes	Awaiting data related to neonates from the investigators.

Characteristics of ongoing studies *[ordered by study ID]*

[ACTRN12614001134617](#)

Trial name or title	A Randomised Controlled Clinical Trial Comparing C-MAC Videolaryngoscope Intubation with Direct Laryngoscope Intubation in Neonates. The HEADS UP Study
Methods	Randomized trial of babies born at ≥ 24 completed weeks' gestation, and require endotracheal intubation in the delivery room or delivery theater or in the neonatal intensive care unit and aged 0-6 months Exclusion criteria: infants with major oral or upper airway malformation excluded from the analysis and emergency intubations and babies < 24 weeks' gestation

Participants	Babies 0-6 months of age
Interventions	C-MAC videolaryngoscope Intubation versus direct laryngoscope intubation
Outcomes	First attempt success rate, time to intubation, proportion of intubations occurring within 30 second American Academy of Pediatric guidelines, stability of infant during the intubation as measured by the length of time of hypoxia, based on infants saturations and heart rate, rate of complications related to intubation such as trauma to lips, gums, pharynx, lacerations or perforation and acceptability of the videolaryngoscope by the operator
Starting date	2014
Contact information	Sarah.Bellhouse@sswahs.nsw.gov.au
Notes	The principal investigator will be contacted for information regarding trial status

NCT01371032

Trial name or title	Study to Compare Video Miller Device to Direct Laryngoscopy.
Methods	Randomized prospective study comparing the video Miller device with direct laryngoscopy for tracheal intubation in children aged < 3 years undergoing general anesthesia
Participants	Children aged < 3 years American Society of Anesthesiologists I-II undergoing general anesthesia
Interventions	Intubation using the Video-Miller laryngoscope versus direct laryngoscope
Outcomes	Primary outcome: intubation time Secondary outcome: glottic visualization and percentage of glottic opening score
Starting date	June 2011
Contact information	roya.yumul@cshs.org
Notes	Clinical Trials.gov ID: NCT01371032

NCT01793727

Trial name or title	Infant GlideScope Learning Curve
Methods	Prospective interventional efficacy study evaluating the learning curve associated with the use of videolaryngoscopy compared with conventional direct laryngoscopy in infants intubated by anesthesiology residents
Participants	Infants < 10 kg, aged ≤ 18 months undergoing general anesthesia and requiring tracheal intubation
Interventions	Tracheal intubation using the GlideScope videolaryngoscope versus direct laryngoscopy

NCT01793727 (Continued)

Outcomes	Primary outcome: time to optimum visualization of the vocal cords Secondary outcome: time to tracheal intubation
Starting date	July 2011
Contact information	cengiz.karsli@sickkids.ca
Notes	Clinical Trials.gov ID: NCT01793727

NCT03396432

Trial name or title	The Videolaryngoscopy in Small Infants (VISI)
Methods	Prospective randomized, multicenter, clinical trial in the US comparing videolaryngoscopy with direct laryngoscopy. Enrolling 460 participants. The study intervention will be a 1:1 randomization to perform tracheal intubation with the Storz C-MAC Miller 1 (VL) or the conventional Miller laryngoscope (DL)
Participants	0-12 months of age, undergoing intubation for anesthesia for elective surgery
Interventions	Tracheal intubation with the Storz C-MAC Miller 1 (VL) versus conventional Miller laryngoscope (DL)
Outcomes	Primary objective: to compare the tracheal intubation first attempt success rate using VL versus DL in children aged ≤ 12 months Secondary objectives: to compare the lowest oxygen saturation during tracheal intubation with VL versus DL
Starting date	15 February 2018
Contact information	FIADJOEJ@email.chop.edu
Notes	Completion date: 31 December 2020

DATA AND ANALYSES

Comparison 1. Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Time required for successful intubation (seconds)	2	311	Mean Difference (IV, Fixed, 95% CI)	-0.62 [-6.50, 5.26]
2 Number of intubation attempts	2	427	Mean Difference (IV, Fixed, 95% CI)	-0.05 [-0.18, 0.07]
3 Success rate at first attempt	3	467	Risk Ratio (M-H, Fixed, 95% CI)	1.44 [1.20, 1.73]
4 Non-airway related adverse effects: saturations during intubation	2	359	Mean Difference (IV, Fixed, 95% CI)	-0.76 [-5.74, 4.23]
5 Airway-related adverse effects: airway trauma	1	213	Risk Ratio (M-H, Fixed, 95% CI)	0.10 [0.01, 1.80]

Analysis 1.1. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 1 Time required for successful intubation (seconds).

Review: Videolaryngoscopy versus direct laryngoscopy for tracheal intubation in neonates

Comparison: 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL)

Outcome: 1 Time required for successful intubation (seconds)

Analysis 1.2. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 2 Number of intubation attempts.

Review: Videolaryngoscopy versus direct laryngoscopy for tracheal intubation in neonates

Comparison: 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL)

Outcome: 2 Number of intubation attempts

Analysis 1.3. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 3 Success rate at first attempt.

Review: Videolaryngoscopy versus direct laryngoscopy for tracheal intubation in neonates

Comparison: 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL)

Outcome: 3 Success rate at first attempt

Analysis 1.4. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 4 Non-airway related adverse effects: saturations during intubation.

Review: Videolaryngoscopy versus direct laryngoscopy for tracheal intubation in neonates

Comparison: 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL)

Outcome: 4 Non-airway related adverse effects: saturations during intubation

Analysis 1.5. Comparison 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL), Outcome 5 Airway-related adverse effects: airway trauma.

Review: Videolaryngoscopy versus direct laryngoscopy for tracheal intubation in neonates

Comparison: 1 Videolaryngoscopy (VDL) versus conventional direct laryngoscopy (CDL)

Outcome: 5 Airway-related adverse effects: airway trauma

APPENDICES

Appendix 1. MEDLINE search strategy

The following is the MEDLINE and PREMEDLINE search strategy. We adapted this to suit CENTRAL, Embase and CINAHL.

1. explode 'intubation' [all subheadings in MIME, MJME]
2. laryngoscopy
3. 'direct laryngoscopy'
4. videolaryngoscopy
5. Glidescope
6. 'McGrath airwayscope'
7. 'Pentax airwayscope'
8. 'Truview' optical laryngoscope
9. 'C-MAC video laryngoscope'
10. 'Airtraq video laryngoscope'
11. 'LMA CTrach' video laryngoscope
12. #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11
13. explode 'infant - newborn' [all subheadings in MIME, MJME]
14. Neonat*
15. Newborn*
16. #13 or #14 or #15
17. #12 and #16

We applied no language restrictions.

Appendix 2. 'Risk of bias' tool

1. Sequence generation (checking for possible selection bias). Was the allocation sequence adequately generated?

For each included study, we categorized the method used to generate the allocation sequence as:

- low risk (any truly random process, e.g. random number table; computer random number generator);
- high risk (any non-random process, e.g. odd or even date of birth; hospital or clinic record number); or
- unclear risk.

2. Allocation concealment (checking for possible selection bias). Was allocation adequately concealed?

For each included study, we categorized the method used to conceal the allocation sequence as:

- low risk (e.g. telephone or central randomization; consecutively numbered sealed opaque envelopes);
- high risk (open random allocation; unsealed or non-opaque envelopes, alternation; date of birth); or
- unclear risk.

3. Blinding of participants and personnel (checking for possible performance bias). Was knowledge of the allocated intervention adequately prevented during the study?

For each included study, we categorized the methods used to blind study participants and personnel from knowledge of which intervention a participant received. Blinding was assessed separately for different outcomes or class of outcomes. We categorized the methods as:

- low risk, high risk or unclear risk for participants; and
- low risk, high risk or unclear risk for personnel.

4. Blinding of outcome assessment (checking for possible detection bias). Was knowledge of the allocated intervention adequately prevented at the time of outcome assessment?

For each included study, we categorized the methods used to blind outcome assessment. Blinding was assessed separately for different outcomes or class of outcomes. We categorized the methods as:

- low risk for outcome assessors;
- high risk for outcome assessors; or
- unclear risk for outcome assessors.

5. Incomplete outcome data (checking for possible attrition bias through withdrawals, dropouts, protocol deviations). Were incomplete outcome data adequately addressed?

For each included study and for each outcome, we described the completeness of data including attrition and exclusions from the analysis. We noted whether attrition and exclusions were reported, the numbers included in the analysis at each stage (compared with the total number of randomized participants), reasons for attrition or exclusion where reported, and whether missing data were balanced across groups or were related to outcomes. Where sufficient information was reported or supplied by the trial authors, we reincluded missing data in the analyses. We categorized the methods as:

- low risk (< 20% missing data);
- high risk ($\geq$ 20% missing data); or
- unclear risk.

6. Selective reporting bias. Were reports of the study free of suggestion of selective outcome reporting?

For each included study, we described how we investigated the possibility of selective outcome reporting bias and what we found. For studies in which study protocols were published in advance, we compared prespecified outcomes versus outcomes eventually reported in the published results. If the study protocol was not published in advance, we contacted study authors to gain access to the study protocol. We assessed the methods as:

- low risk (where it was clear that all the study's prespecified outcomes and all expected outcomes of interest to the review were reported);
- high risk (where not all the study's prespecified outcomes were reported; one or more reported primary outcomes were not prespecified outcomes of interest and were reported incompletely and so could not be used; study failed to include results of a key outcome that would have been expected to have been reported); or
- unclear risk.

7. Other sources of bias. Was the study apparently free of other problems that could have put it at a high risk of bias?

For each included study, we described any important concerns we had about other possible sources of bias (e.g. whether there was a potential source of bias related to the specific study design or whether the trial was stopped early due to some data-dependent process). We assessed whether each study was free of other problems that could put it at risk of bias as:

- low risk;
- high risk; or
- unclear risk

If needed, we explored the impact of the level of bias through undertaking sensitivity analyses.

WHAT'S NEW

Last assessed as up-to-date: 30 November 2017.

Date	Event	Description
4 April 2018	Feedback has been incorporated	Editorial feedback incorporated on the review update

(Continued)

28 November 2017	New citation required and conclusions have changed	No studies were available for the previous publication of the review. The update now includes data from 3 studies
8 November 2017	New search has been performed	Updated search, added 3 included studies and analyzed data

CONTRIBUTIONS OF AUTHORS

KL reviewed the literature and wrote the review.

MP assisted in the review of literature, wrote the review and performed the analysis.

JA, TS and CF critiqued and helped to incorporate peer review comments in the review.

DECLARATIONS OF INTEREST

KL: no conflicts of interest.

JA: no conflicts of interest.

TS: no conflicts of interest.

CF: no conflicts of interest.

MP: no conflicts of interest.

SOURCES OF SUPPORT

Internal sources

- None, Other.

External sources

- No sources of support supplied

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We changed the unit of analysis from participants to intubation attempts and we do not expect an increase in risk of bias because of this change.

We added the methodology and plan for 'Summary of findings' tables and GRADE recommendations, which were not included in the original protocol, or the last published version of this review.

INDEX TERMS

Medical Subject Headings (MeSH)

*Resuscitation; Intubation, Intratracheal [*methods]; Laryngoscopy [*methods]

MeSH check words

Humans; Infant, Newborn