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Review Article

RESPIRATION AND THE AIRWAY

Effectiveness of intubation devices in patients with cervical spine immobilisation: a systematic review and network meta-analysis

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Abstract

Background: Cervical spine immobilisation increases the difficulty of tracheal intubation. Many intubation devices have been evaluated in this setting, but their relative performance remains uncertain.
Methods: MEDLINE, EMBASE, and the Cochrane Library were searched to identify randomised trials comparing two or more intubation devices in adults with cervical spine immobilisation. After critical appraisal, a random-effects network meta-analysis was used to pool and compare device performance. The primary outcome was the probability of first-attempt intubation success (first-pass success). For relative performance, the Macintosh direct laryngoscopy blade was chosen as the reference device.
Results: We included 80 trials (8039 subjects) comparing 26 devices. Compared with the Macintosh, McGrath™ (odds ratio [OR]=11.5; 95% credible interval [CrI] 3.19–46.20), C-MAC D Blade™ (OR=7.44; 95% CrI, 1.06–52.50), Airtraq™ (OR=5.43; 95% CrI, 2.15–14.2), King Vision™ (OR=4.54; 95% CrI, 1.28–16.30), and C-MAC™ (OR=4.20; 95% CrI=1.28–15.10) had a greater probability of first-pass success. This was also true for the GlideScope™ when a tube guide was used (OR=3.54; 95% CrI, 1.05–12.50). Only the Airway Scope™ had a better probability of first-pass success compared with the Macintosh when manual-in-line stabilisation (MILS) was used as the immobilisation technique (OR=7.98; 95% CrI, 1.06–73.00).
Conclusions: For intubation performed with cervical immobilisation, seven devices had a better probability of first-pass success compared with the Macintosh. However, more studies using MILS (rather than a cervical collar or other alternative) are needed, which more accurately represent clinical practice.
Clinical trial registration: PROSPERO 2019 CRD42019158067 (https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=158067).

Keywords: airway; cervical immobilisation; cervical spine; difficult airway; intubation; spinal injury; trauma

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Editor's key points

- The authors examined the literature to evaluate the effectiveness of intubation devices in facilitating orotracheal intubation during cervical immobilisation.
- This network meta-analysis included 75 eligible trials (8039 subjects) evaluating 21 intubation devices. A total of seven devices had a better probability of first-pass success compared with the Macintosh (the reference device).
- Blind intubation through the LMA Fastrach™ was associated with a lower probability of first-pass success, a longer time to intubation, and an increased risk of local complications.

Cervical spine immobilisation may prevent secondary cervical spine injury by protecting against the excessive or abnormal movement that can occur in an unstable vertebral column.[1] Restricting the motion of the cervical spine can increase intubation difficulty by disallowing the direct line of sight required to see airway structures with the standard Macintosh laryngoscope.[2] In recent years, there has been a proliferation of alternative intubation devices which do not require alignment of the laryngeal, pharyngeal, and oral axes in order to visualise the glottic opening, and therefore have a theoretical advantage over traditional laryngoscopes in certain scenarios.[3]

Many randomised comparative trials (RCTs) have compared various intubation devices in the setting of cervical immobilisation. In addition, a systematic review performed in October 2014 comparing intubation devices to the Macintosh in subjects with cervical immobilisation concluded that although the benefit of alternative devices overall appeared convincing, only the Airtraq™ was associated with a statistically significant reduction in the risk of intubation failure at first attempt.[4] This review, however, excluded RCTs comparing two or more alternative devices without a Macintosh 'control' group, and therefore limited its analysis of the available literature. Moreover, more recent RCTs have not included the Macintosh as a comparator, as interest has shifted towards evaluating the relative performance of alternative devices.[5–17]

Network meta-analysis (NMA) is an extension of traditional meta-analysis developed to permit the comparison of multiple treatment alternatives simultaneously.[18] NMA enables the synthesis of data from RCTs comparing any two or more eligible interventions, combining direct and indirect comparisons.[18] The aim of this study was to produce a coherent ranking of the effectiveness of intubation devices in adult patients with cervical immobilisation, based on all the available evidence, using NMA.

Methods

Protocol and registration

This study is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension statement for reporting systematic reviews incorporating network meta-analysis (PRISMA-NMA).[19] The review protocol was registered with PROSPERO (CRD42019158067).

Eligibility criteria

RCTs were eligible for inclusion if they compared two or more commercial intubation devices for the placement of single-lumen tracheal tubes via the oral route in anaesthetised adult patients with cervical spine immobilisation. The following were considered adequate techniques for cervical spine immobilisation: manual-in-line stabilisation (MILS), a cervical collar, a head immobiliser, or head taping with fixation of two or more points. Case reports, reviews, and studies featuring awake intubation, paediatric patients, cadaveric models, or manikin models were excluded. Techniques that involved combining alternative devices for intubation were excluded (e.g. the use of an LMA Fastrach™ as a conduit for the flexible fibrescope); however, the use of standard Macintosh direct laryngoscopy as an adjunct for an alternative device was considered acceptable. Study arms or subgroups involving nasal intubation, or the placement of double-lumen tubes were also excluded.

Where different versions of the same device existed, they were integrated into the same node, unless there were studies that compared different versions (e.g. C-MAC™ *vs* C-MAC™ D Blade). Different device versions were recognised as a potential source of heterogeneity; however, this was controlled for by the use of random-effects models.

Information sources

Relevant publications were identified by an electronic search of the MEDLINE, EMBASE, and the Cochrane Library databases. There was no restriction with regard to language. The last search was performed on December 20, 2019. Reference lists of included articles were also reviewed to identify additional publications.

Search

The searching strategy was designed as follows: (intubation OR intubate OR laryngoscope OR laryngoscopy) AND (cervical OR spine) AND (immobilisation OR immobilization OR stabilisation OR stabilization OR collar). The full search strategy for MEDLINE is provided in the Supplementary material, Appendix 1.

Study selection and data collection

Two investigators (BS and FM) independently performed title and abstract screening. The full text of all potentially relevant citations was evaluated for eligibility. Studies were included in the review if they met the eligibility criteria and had data for at least one outcome of interest. Non-English papers deemed potentially relevant were considered for inclusion if the full text could be translated using a free web-based resource.[20] Devices that had data for an outcome from at least two studies were included in the NMA. Any conflicting judgements were resolved by discussion.

The same two investigators also independently extracted data items using a standardised data extraction form that was piloted on a sample of five studies. Authors of the primary studies with missing data were contacted via email or ResearchGate (www.researchgate.net).

Screening and data extraction were facilitated by Covidence, a web-based systematic review production tool (www.covidence.org).

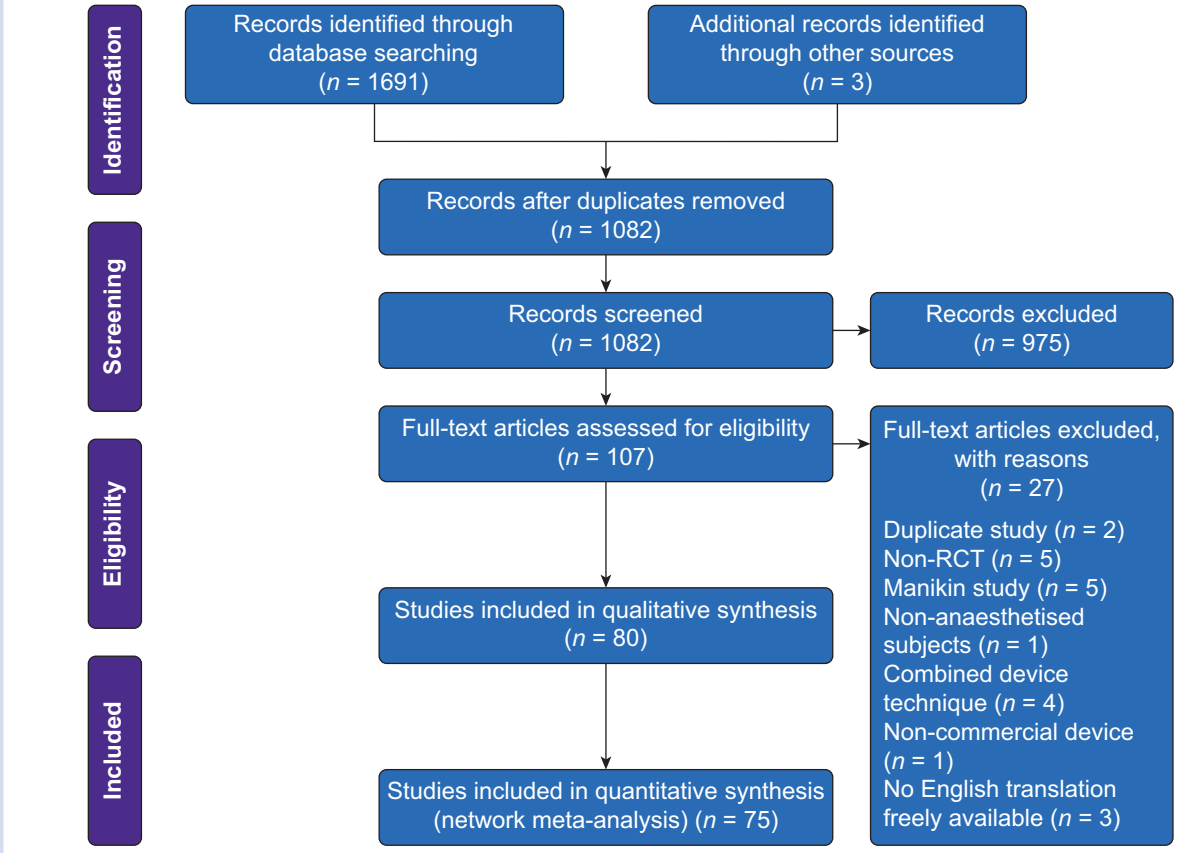

Fig 1. PRISMA study selection flow diagram. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT, randomised comparative trials.

Data items

The primary outcome was first-attempt success at intubation (first-pass success). Secondary outcomes included: Cormack–Lehane grade 1 laryngeal view (CL-1), duration of the first successful attempt at intubation (time to intubation), and the risk of dental or lip trauma, minor bleeding, or mucosal injury (local complications). For time to intubation, where data were only available as median and (inter-quartile) range, these were converted to mean and standard deviation using published equations.[21] The following data items were also extracted: eligibility criteria, immobilisation technique, indication for immobilisation, sample size, subject baseline characteristics, devices investigated, and the use of any tube or device adjuncts.

Geometry of the network

A conventional network graph was generated to investigate the configuration of the network. A network graph consists of nodes, with each node representing a different treatment or intervention – in this case, an intubation device – with 'edges' (lines) connecting the nodes if direct comparisons between pairs of interventions existed.

Risk of bias within individual studies

A modified Cochrane Collaboration tool was referred to in assessing the risk of bias for the included RCTs.[3] The risk of bias was assessed as 'low', 'unclear', or 'high' in the following domains: 'random sequence generation'; 'allocation concealment'; 'blinding'; 'incomplete data'; 'selective reporting of outcomes'; 'experience of intubator'; 'baseline characteristics'; and 'funding sources'. Two reviewers (BS and FM) independently assessed the risk of bias for each randomised trial. This process was also facilitated using *Covidence*.

Risk of bias across studies

Publication bias was assessed using visual inspection of comparison-adjusted funnel plots.[22] Plots were generated for the primary and secondary outcomes.

Sensitivity analysis

A sensitivity analysis for study quality was performed by stratifying studies into higher and lower quality, after assigning a composite quality score based on the risk of bias assessment. Lower scores indicated a lower risk of bias, and

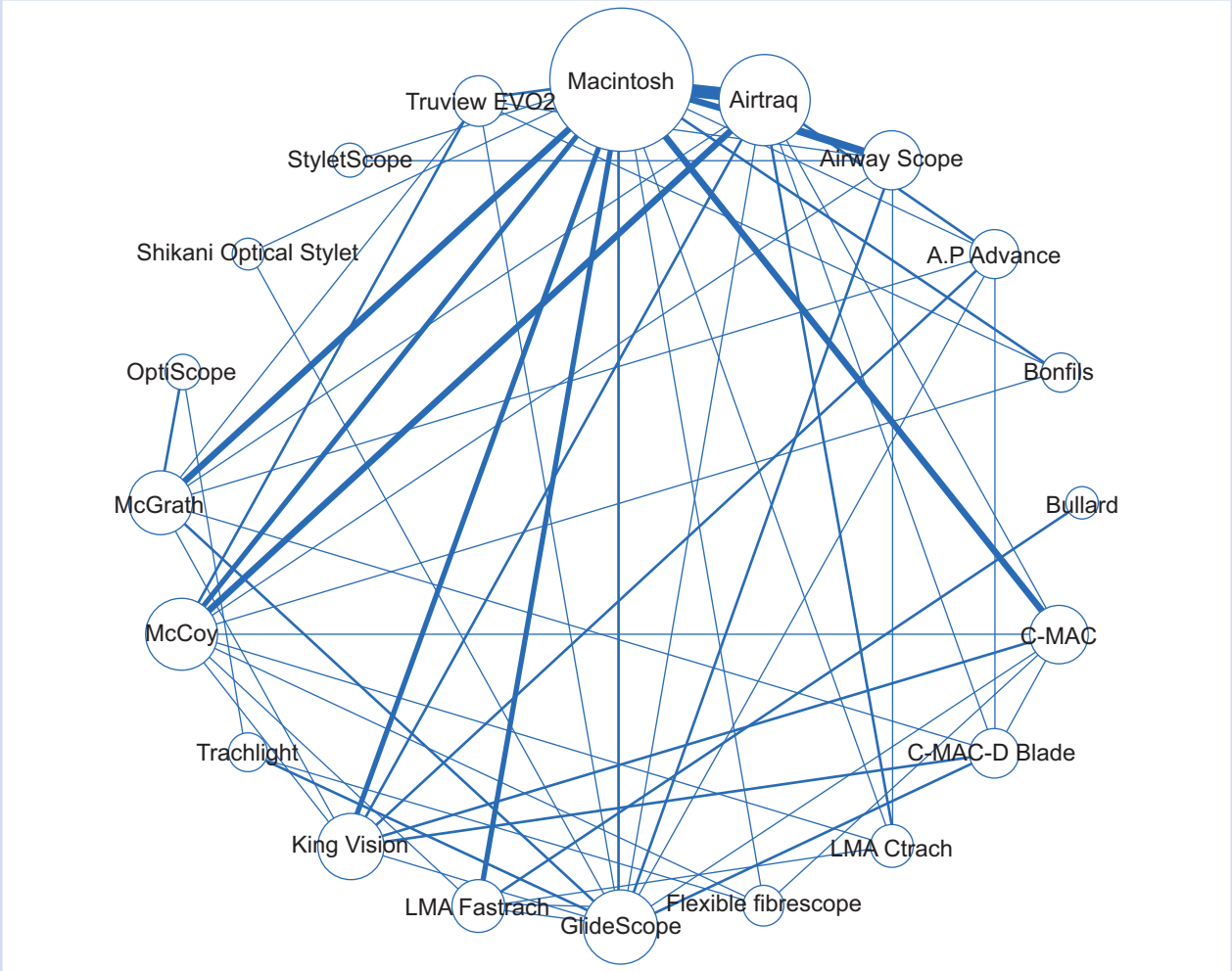

Fig 2. Network graph for first-attempt intubation success. The size of each node represents the number of patients included in studies featuring that device. The thickness of the lines connecting the nodes is proportional to the number of head-to-head randomised comparative trials (RCTs) in each comparison.

higher scores indicated a higher risk of bias; studies below the median score were considered to be higher quality, and those with the median score or higher were considered to be lower quality (see Supplementary material, Appendix 2 for full details). Analysis was then restricted to the higher quality subset of studies.

Subgroup analysis

Two prespecified subgroup analysis were performed. The first, the 'guided' subgroup, only included studies or study arms or subgroups with a method for guiding the tracheal tube: devices with an integral channel, standalone stylets or scopes, and non-channelled laryngoscopes when a tube adjunct was used or was available (stylet or bougie or tube exchanger). The second subgroup included only those studies using MILS as the immobilisation technique.

Statistical analysis

Odds ratios (OR) with 95% credible intervals (CrI) were calculated for dichotomous outcomes, and mean differences (MD) with 95% CrI were calculated for continuous outcomes. If the 95% CrI included a value of 1 for the OR, or 0 for MD, the difference was not considered statistically significant. The surface under the cumulative ranking curve (SUCRA) metric was used to rank the effectiveness of each device and identify the best device in respect of each outcome. SUCRA values range from 0% to 100%: the higher the percentage, the higher the probability that an intervention ranks first or is in one of the top ranks.[23]

A Bayesian NMA was performed using R version 3.6.3 (R Foundation for Statistical Computing, Vienna, Austria) with the *gemtc* version 0.8–4 package.[24] A random-effects model was used when pooling effect size. Inconsistency between indirect and direct comparisons was tested for by comparing

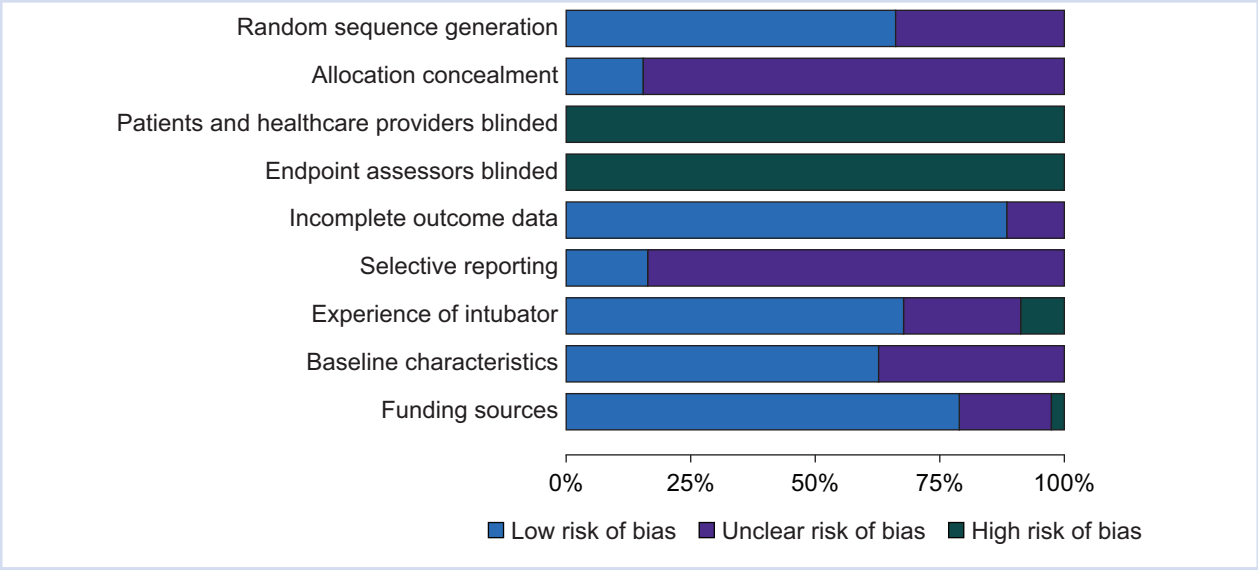

Fig 3. 'Risk of bias graph' illustrating the proportion of studies with each of the judgments ('low risk', 'high risk', 'unclear risk' of bias) for each entry in the tool.

the deviance information criteria (DIC) between the inconsistency and the consistency model.[25]

Results

Study selection and characteristics

From a total of 1694 records, 80 eligible studies were identified for inclusion in the qualitative synthesis (PRISMA flow selection diagram, Fig. 1).[4–17,26–93] Seventy-one studies involved patients without cervical pathology undergoing an elective procedure (simulated scenarios), eight involved patients undergoing elective cervical spine surgery, and one study involved the emergent intubation of blunt trauma patients. For cervical immobilisation, MILS was used in 48 studies, a cervical collar was used in 30 studies, and two studies used an alternative method. A total of 26 intubation devices were evaluated. A summary table of study characteristics and manufacturer details for all trademark devices are provided in the Supplementary material, Appendix 3.

Of the 80 studies included in the qualitative synthesis, five studies were excluded from the NMA because they were the only study evaluating that device (Fig. 1).[9,59,62,66,85] The quantitative synthesis therefore included a final total of 75 studies featuring 8039 subjects evaluating the performance of 21 intubation devices: Macintosh; Airtraq™; Airway Scope™; A.P. Advance™; Bonfils™; Bullard™; C-MAC™; C-MAC™ D Blade; flexible fibrescope; GlideScope™; King Vision™; LMA CTrach™; LMA Fastrach™; Trachlight™; McCoy; McGrath™; OptiScope™; SensaScope™; Shikani Optical Stylet™; StyletScope™; TruView EVO2™.

The network graph for first-pass success showed that the Macintosh featured the most randomised patients and the most direct comparisons with other devices (Fig. 2). Each device was compared directly with at least two other devices in the network. There was no direct comparison with the Macintosh for four devices: Bullard™, C-MAC D Blade™, OptiScope™, and Trachlight™.

Risk of bias within studies

Most studies were judged to be 'low' risk of bias in the 'random sequence generation', 'incomplete outcome data', 'experience of intubator', 'baseline characteristics', and 'funding sources' domains. The method used to conceal the allocation sequence was not mentioned in most studies – or was not described in enough detail – to determine whether device allocations could have been foreseen by investigators before or during enrolment; these studies were judged to be at an 'unclear' risk of bias. Most studies did not reference a study protocol and so were judged to be at an unclear risk of bias for 'selective reporting'. As it was not possible to blind neither operators nor outcome assessors to the device being used, all studies were judged be at high risk of bias in these domains. The proportion of studies with each of the judgements for each entry in the tool is illustrated in Fig 3. A risk of bias table with the judgements in each domain for all studies is provided in the Supplementary material, Appendix 2.

Risk of bias across studies

The funnel plot for first-pass success was unbalanced for the Airway Scope™, suggesting possible publication bias for this device. The funnel plot for CL-1 was unbalanced for the Airway Scope™ and King Vision™, also suggesting possible publication bias for these devices. All funnel plots are provided in the Supplementary material, Appendix 4.

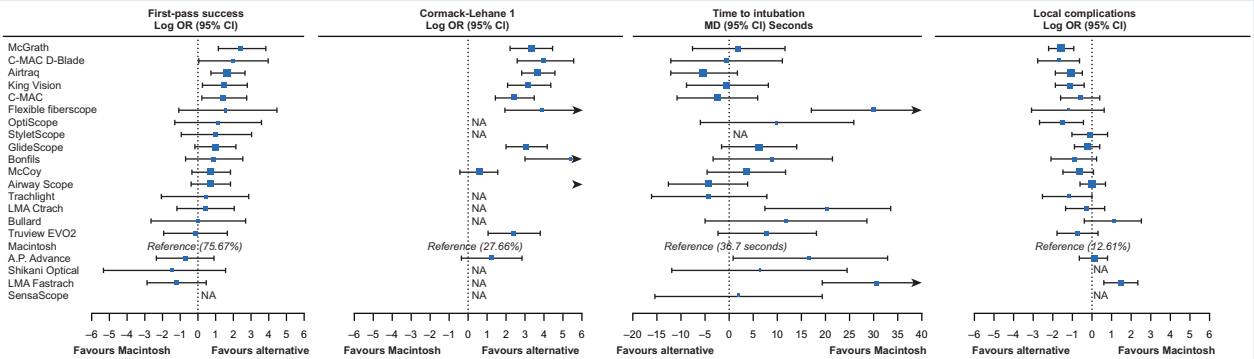

Fig 4. Forest plots of network meta-analyses of first-pass success Cormack-Lehane 1, time to intubation, and local complications for Macintosh *vs* other intubation devices. CrI, credible interval; OR, odds ratio; MD, mean difference; NA, not applicable or available.

Synthesis of results

First-pass success

Sixty-nine studies, involving 6964 subjects, reported first-pass success for 20 intubation devices. The pooled probability of first-pass intubation success with the Macintosh (reference device) was 75.67% (95% confidence interval [CI], 73.41–77.93). Five devices performed significantly better than the Macintosh, and none performed significantly worse (Fig. 4). The expected SUCRA values and ranking of each intubation device with regard to first-attempt intubation success is shown in Fig. 5. A league table of the results of all comparison pairs for first-attempt intubation success is presented in the Supplementary material, Appendix 5.

SUCRA

	First-pass success	Cormack-Lehane 1	Time to intubation	Local complications
McGrath	92%	57%	61%	88%
C-MAC-D Blade	81%	74%	70%	88%
Airtraq	78%	68%	88%	72%
King Vision	72%	53%	70%	71%
C-MAC	70%	33%	78%	50%
Flexible fibrescope	69%	69%	4%	71%
OptiScope	60%	NA	36%	84%
StyletScope	57%	NA	NA	32%
GlideScope	57%	49%	44%	35%
Bonfils	55%	87%	37%	62%
McCoy	49%	9%	54%	54%
Airway Scope	49%	99%	85%	24%
Trachlight	43%	NA	82%	71%
LMA Ctrach	41%	NA	15%	38%
Bullard	35%	NA	33%	7%
Truview EVO2	29%	34%	39%	55%
Macintosh	26%	2%	69%	25%
A.P Advance	16%	16%	22%	21%
Shikani Optical Stylet	13%	NA	47%	NA
LMA Fastrach	9%	NA	4%	2%
SensaScope	NA	NA	61%	NA

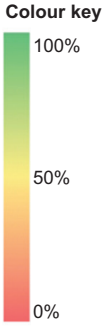

Fig 5. Heat map of surface under the cumulative ranking curve (SUCRA) values for all devices for each outcome. SUCRA values range from 0% to 100%: the higher the percentage, the higher the probability that an intervention ranks first or is in one of the top ranks; the lower the percentage, the higher the probability that an intervention ranks last or is in one of the bottom ranks.[23] Hence for first-pass success, the McGrath has a 92% probability of being ranked first or being in the top rank, whereas the LMA Fastrach has only a 9% probability. Results are colour coded such that comparators with larger SUCRA values are in green and those with a lower SUCRA values are shown in red. Devices are listed in order of their SUCRA value (highest to lowest) for first-pass success.

Cormack–Lehane 1

Forty-one studies, involving 4510 subjects, reported the Cormack–Lehane grade for 13 intubation devices. The pooled probability of a CL-1 laryngeal view for the Macintosh (reference device) was 27.66% (95% CI, 25.32–30.01). Every device apart from the A.P. Advance™ and McCoy had a significantly higher probability of providing a CL-1 view (Fig. 4). The majority of alternative devices were also significantly better than the McCoy or the A.P. Advance™; a league table of the results of all comparison pairs for CL-1 is presented in the Supplementary material, Appendix 5. The expected ranking and SUCRA values of each intubation device with regard to CL-1 is shown in Fig. 5.

Time to intubation

Seventy-three studies, involving 4510 subjects, reported the time to intubation – duration of the first successful attempt – for 20 intubation devices. The pooled mean time to intubation with the Macintosh (reference device) was 36.7 s (range, 11.0–73.2 s). Tracheal intubation using the A.P. Advance™, LMA CTrach™, flexible fibrescope, and LMA Fastrach™ took significantly longer than when using a Macintosh, and no device was significantly faster than the Macintosh (Fig. 4). The expected ranking and SUCRA values of each intubation device with regard to time to intubation is shown in Fig. 5. A league table of the results of all comparison pairs for time to intubation is presented in the Supplementary material, Appendix 5.

Local complications

Fifty-six studies, involving 6042 subjects, reported the risk of local complications – dental or lip trauma, minor bleeding, or mucosal injury – for 20 intubation devices. The average risk of local complications with the Macintosh (reference device) was 12.61% (95% CI, 10.60–14.62). Five devices had a significantly lower risk of complications compared with the reference device, and one device had a significantly higher risk (Fig. 4). The expected ranking and SUCRA values of each intubation device with regard to local complications is shown in Fig. 5. A league table of the results of all comparison pairs for the probability of local complications is presented in the Supplementary material, Appendix 5.

Exploration for inconsistency

The model fit for the consistency model was better than for the inconsistency model, for all outcomes, as measured by the deviance information criterion (DIC); first-pass success 236.42 *vs* 237.59, CL-1 179.14 *vs* 183.33, time to intubate 297.05 *vs* 297.26, and local complications 173.15 *vs* 186.49.

Sensitivity analysis

Sensitivity analysis for study quality did not significantly affect the NMA result for the outcomes first-pass success or CL-1. For time to intubation, performance of Airtraq™ and Airway Scope™ significantly improved, whereas performance of the GlideScope™ significantly worsened. For local complications, performance of StyletScope™ and OptiScope™ significantly worsened, whereas the LMA Fastrach™ significantly improved. Forest plots and SUCRA values for the sensitivity analyses are provided in the Supplementary material, Appendix 6.

Subgroup analyses

When using an adjunct to 'guide' the tracheal tube, first-pass intubation success was significantly better using the GlideScope™, and significantly worse using LMA Fastrach™ and Shikani Optical Stylet™. Device performance in terms of CL-1 and time to intubate were not affected by use of a guide. The Bullard™ was associated with significantly lower risk of local complications when used with a guide.

When MILS was used as the immobilisation technique, the most important difference compared with the overall results was that only the Airway Scope™ was associated with a significantly higher probability of first-pass success. The Airway Scope™ was also the top-ranked treatment according to the SUCRA values. The Airtraq™ remained the third-ranked treatment, whereas the McGrath™ fell from the top-rank to being ranked fourth; there was a moderately positive correlation ($r = 0.62$) between the overall ranking for first-pass success and the ranking within the MILS subgroup.[94] The performance of three other devices (McCoy, LMA Fastrach™, and OptiScope™) also significantly changed in respect of one or more of the secondary outcomes; forest plots and SUCRA values for the subgroup analyses are provided in the Supplementary material, Appendix 6.

Discussion

The most important finding from this study was that McGrath™, C-MAC™ D Blade, Airtraq™, King Vision™, and C-MAC™ significantly improved first-pass success for subjects with cervical immobilisation. These five devices were also significantly increased the probability of a CL-1 view. McGrath™, C-MAC™ D Blade, and Airtraq™ also significantly reduced the risk of local complications. These results were not sensitive to study quality.

The Cormack–Lehane grading system has traditionally been used as a surrogate marker for intubation difficultly, but despite doubts abouts its relevance in the era of video laryngoscopy, it continues to be widely reported in studies featuring various intubation devices.[95] In our study, only five of the 10 devices that significantly improved laryngeal view also significantly improved first-pass success. There was also only a low positive correlation ($r = 0.44$) overall between device ranking based on first-pass success and ranking based on CL-1.[94] These results highlight further the need for studies to contextualise the CL grade to the device being used. Moreover, maintaining a full view of the glottis with certain video laryngoscopes may in fact make intubation more difficult, compared with using a more restricted view.[96]

Although no intubation device significantly shortened the intubating time, the SUCRA values and the results of the sensitivity analysis suggest an advantage for devices with blades that allow preloading of the tracheal tube, namely Airtraq™ and Airway Scope™. Although intubation took significantly longer with LMA CTrach™ and LMA Fastrach™, it should be noted that these LMA devices can provide ventilation without intubation. Although intubation took significantly longer with the flexible fibrescope, again it must be noted that this device is usually used for 'awake intubation' where the patient's respiratory drive is preserved to maintain spontaneous ventilation.

The LMA Fastrach™ had a significantly lower probability of first-pass success, a significantly longer time to intubation, and was the only device with a significantly increased risk of

local complications; it was lowest ranked treatment according to the SUCRA values for each of these outcomes. These results caution against the use of the LMA Fastrach™ for blind intubation in patients with cervical immobilisation, although it may have a role as a rescue device or as an adjunct for a flexible fibrescope.

The 'guided' subgroup analysis was prespecified on the basis that non-channelled laryngoscopes may be disadvantaged by the lack of an adjunct that could be used to direct the tracheal tube. The Macintosh, for example is often used with a bougie in difficult airway scenarios, whereas hyperangulated video laryngoscopes are generally designed to be used with a stylet that mimics the shape of the blade; such adjuncts for these devices are recommended by the Difficult Airway Society (DAS) as best clinical practice.[97] In our 'guided' subgroup analysis, the GlideScope™ – which is designed to be used with the GlideRite™ stylet – significantly improved first-pass success. The performance of two devices (LMA Fastrach™ and Shikani Optical Stylet™) for first-pass success also worsened significantly relative to the Macintosh. These results highlight the need for studies to test devices with the recommended adjuncts used in standard practice.

The 'MILS' subgroup was prespecified on the basis that this is the preferred immobilisation technique in real scenarios.[98,99] Although the Airway Scope™ significantly improved first-pass success and was the top-ranked device according to the SUCRA values, concerns about publication bias undermine the validity of these results. This contrasts to the results of a previous review, where the Airtraq™ reduced the risk of intubation failure at first attempt, even after studies using a technique other than MILS were excluded from the analysis.[4] The difference between the overall results and those for the 'MILS' subgroup may reflect a difference in treatment effect: cervical collars reduce mouth opening, which may make intubation disproportionally more difficult with certain devices, including the Macintosh.[100–102] The differences may also reflect a lack of data from studies using MILS: most alternative devices still ranked above the Macintosh, but credibility intervals around the point estimates were wide.

Limitations

Studies involving airway devices are inherently limited by the fact that it is not possible to blind intubators or the outcome assessors to the device being used. This leaves the potential for both performance and observer bias. If such biases exist, they would likely lead to inaccurate effect estimates.[103] Such biases have been previously demonstrated to overestimate the beneficial effect of video laryngoscopes relative to the Macintosh – the reference treatment in our review.[104]

The intubation devices in this review were also not evaluated for their effect on cervical spine motion. Studies have suggested that McGrath™, Airtraq™, and King Vision™ may result in less motion compared with the Macintosh, but McGrath™ and C-MAC™ may result in more movement compared with other devices included in this review.[77,105–109] It remains unclear whether different intubation devices are associated with clinically significant differences in cervical spine motion.

As alluded to above, the populations included in the studies are generally not reflective of those found in clinical practice. The fact that the results for the 'MILS' subgroup were significantly different from the overall results limits the applicability of our findings. It is worth noting, however, that most studies using MILS (43/48) excluded patients with characteristics predictive of difficult intubation, including limited mouth opening. In the general trauma population, patients may have limited mouth opening for a variety of reasons: normal anatomical variation, pre-existing pathology, or maxillofacial injury causing mechanical trismus or oedema, and so on.

Of the 80 studies included, only one involved the emergent intubation of blunt trauma patients. In such scenarios, intubation can be complicated by the presence of blood and vomitus in the airway, which may contaminate the lens of a video or optical device and thereby obscure or even obliterate the view of the glottis.[110,111] For this reason, laryngoscopes which can provide both a 'direct' and 'indirect' view, such McGrath™ or C-MAC™, may be preferable in such scenarios.

Strengths

This systematic review of intubation devices in the setting of cervical immobilisation used NMA to include evidence on as many devices and from as many subjects as possible. NMA also allows the simultaneous comparison of multiple intubation devices and increases the precision by combining direct and indirect estimates. Other strengths of this study included the comprehensive search, independent citation screening and data extraction, use of the Cochrane risk of bias assessment tool, and adherence to the PRISMA-NMA guideline.

Conclusions

For tracheal intubation performed with cervical immobilisation, McGrath™, C-MAC™ D Blade, and Airtraq™ significantly improved first-pass success while significantly reducing the risk of local complications. King Vision™, C-MAC™, and GlideScope™ (when used with a tube guide) also significantly improved first-pass success. Only the Airway Scope™ had better probability of first-pass success when MILS was used as the immobilisation technique; however, concerns about publication bias undermine the validity of this result. More studies using MILS are warranted, and the elective setting of most of the studies cautions against relying on such devices in emergent scenarios where airway soiling may feature.

Authors' contributions

Study conception/design: BS, ZP
Data acquisition: BS, FM
Data analysis: BY
Data interpretation: BS, FM, ZP, DB
Article writing: BS, ZP, DB
Revision of the article: all authors
All authors approved the final version of the article for submission and have agreed to be accountable for all aspects of the work.

Declarations of interest

Donal J. Buggy is a member of the Editorial Board of the *British Journal of Anaesthesia*.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2020.12.041.

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