

VIDEO LARYNGOSCOPY FOR ENDOTRACHEAL INTUBATION OF ADULT PATIENTS WITH SUSPECTED/ CONFIRMED COVID-19. A SYSTEMATIC REVIEW AND META-ANALYSIS OF RANDOMIZED CONTROLLED TRIALS

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ABSTRACT

INTRODUCTION: During a pandemic, medical personnel while in contact with patients with suspected/confirmed COVID-19 should wear full personal protective equipment (PPE) for aerosol-generating procedures to reduce the risk of infection. Most studies of intubation in level C PPE conditions have been relatively small. Our aim is to quantify the available data on success rates in order to provide an evidence-based benchmark to gauge performance in the published literature.

MATERIAL AND METHODS: A structured literature search was performed with PubMed, Scopus, Embase, Web of Science, and Cochrane databases. The electronic database search was supplemented by searching Google Scholar and by back-searching the reference lists of identified studies for suitable articles. Data were evaluated and extracted by two independent reviewers on the basis of qualitative and quantitative variables of interest. Q statistic and I^2 statistics were used to assess the heterogeneity between the studies.

RESULTS: Fifteen randomized controlled trials were included. The use of PPE during intubation as compared with intubation without PPE reduced intubation efficacy (90.0% vs. 97.9%; RR = 0.94; 95% CI: 0.90–0.99; $p < 0.001$) and increased the procedure time (MD = 7.73; 95% CI: 4.98–10.47; $p < 0.001$). Direct laryngoscopy compared with video laryngoscopes offered similar intubation success rate (93.6% vs. 92.3%; RR = 0.99; 95% CI: 0.97–1.02; $p = 0.66$) and shorter intubation time (MD = 63; 95% CI: –0.77–12.03; $p = 0.08$). However, subgroup analysis showed that intubation with Macintosh blade video laryngoscopes was more effective than that with direct laryngoscopes (98.1% vs. 96.4%; RR = 1.00; 95% CI: 0.97–1.03; $p = 0.90$).

CONCLUSIONS: Our meta-analysis suggests that PPE reduces the effectiveness of endotracheal intubation. The use of direct laryngoscopy for intubating patients with suspected/confirmed COVID-19 by an intubator wearing level C PPE is associated with overall intubation time reduction and an increase in intubation success rate compared with video laryngoscopes. However, the findings suggest that Macintosh blade video

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laryngoscopes during endotracheal intubation with PPE may be an alternative to direct laryngoscopes. Video laryngoscopy can be helpful for less experienced personnel.

KEY WORDS: endotracheal intubation, laryngoscope, infected patient, COVID-19, personal protective equipment, meta-analysis

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INTRODUCTION

Endotracheal intubation is the gold standard for airway management in many clinical situations [1, 2]. Direct laryngoscopy with a Macintosh laryngoscope is still commonly performed in endotracheal intubation. Unsuccessful or prolonged endotracheal intubation can be associated with many serious complications, such as desaturation, sympathetic stimulation leading to hypertension and tachycardia and even hypoxemic cardiac arrest causing permanent neurological sequel or even death [3]. In light of this, intubation with video laryngoscopes has become more commonly performed. It has been reported that video laryngoscopes can provide improved laryngeal visualization as well as increased intubation success rate, especially in difficult airway patients [4, 5].

In the current SARS-CoV-2 pandemic, each patient under emergency medical conditions should be considered potentially infected. Therefore, medical personnel should wear specialist personal protective equipment (PPE), including full PPE for aerosol-generating procedures, respiratory protection preferably with an FFP3 filter, goggles, face shield, and gloves [6]. The need for this protection of medical personnel at high risk of contact with suspected/confirmed COVID-19 patients results from the fact that the new coronavirus SARS-CoV-2 spreads via droplets, contact, and natural aerosols from human to human [7]. Moreover, the coronavirus is highly infectious, as verified by recent epidemiological data. As of April 10, 2020, the reported number of confirmed infection cases equaled 1,777,612. COVID-19 mortality is 6.1% and turns out lower than that in SARS or MERS, but the disease dynamics is very high. Patients with COVID-19, in severe cases, can progress rapidly and develop acute respiratory distress syndrome, septic shock, metabolic acidosis, and coagulopathy [8, 9]. In any case of patient deterioration and acute respiratory distress syndrome development, intubation should be performed and mechanical ventilation implemented [10]. Endotracheal intubation and advanced resuscitation should also be applied in the case of sudden cardiac arrest in such a patient [11]. It is therefore clear that the use of full PPE may reduce

the risk of virus transmission [9]. However, research shows that the effectiveness of medical procedures performed with a PPE suit may be reduced [12]. This also refers to endotracheal intubation. It is thus reasonable to evaluate the available studies concerning various methods of endotracheal intubation in order to search for the most effective method of airway management in patients with suspected/confirmed COVID-19.

Recently, several studies have evaluated the effect of video laryngoscopy compared with direct laryngoscopy performed in infectious patients by operators wearing level C PPE. With the aid of the increased power of meta-analytic methods, the goal of the present study was to review the relevant and available published randomized controlled trials (RCTs) to test the hypothesis that compared with direct laryngoscopy, the use of video laryngoscopy in infectious patients would increase the intubation success rate.

MATERIAL AND METHODS

The manuscript followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [13]. Before commencing the study, we agreed on the analysis methods and the inclusion and exclusion criteria to be applied. The protocol of this meta-analysis study has not been registered.

1. Inclusion and exclusion criteria

Studies were included if they met the following criteria: (1) RCT; (2) clinical, cadaver, or simulation trial; (3) intubation of an adult patient or a simulator; (4) comparison of intubation with different laryngoscopes with/without level C PPE; (5) reporting any of the following outcomes: intubation success rate, time to intubation, glottis visualization. Articles available only in abstract form and meeting reports were excluded. Studies in English were included.

2. Search strategy

A comprehensive literature search was performed with PubMed, Scopus, Embase, Web of Science, and

Cochrane databases, from the inception of each database up to March 30, 2020. The following terms were used: “Macintosh laryngoscope” or “Miller laryngoscopes” or “laryngoscope” or “video laryngoscopy” or “endotracheal intubation” or “tracheal intubation” or “airway management” and “PPE” or “personal protective equipment” or “HazMat” or “Level C protective” or “CBRN” or “Chemical” or “toxic” or “infectious patient”. The electronic database search was supplemented by searching Google Scholar and by back-searching the reference lists of identified studies for suitable articles.

3. Data extraction

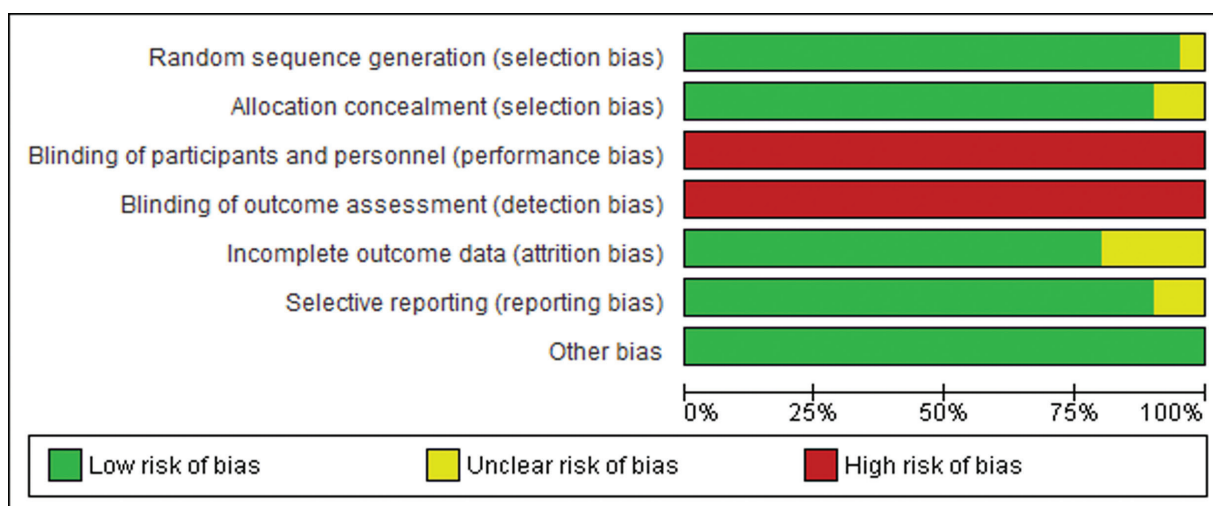
Two authors (K.L. and J.S.) independently assessed each article to determine whether or not it met the criteria for inclusion. Disagreements between the authors regarding values or analysis assignments were resolved through discussion with a third researcher (L.S.), and the decision was taken by the majority of the researchers. The agreement with respect to study inclusion was assessed by using the Cohen kappa statistics [14]. We were careful to avoid the inclusion of data from duplicate publications. In any case of suspected data discrepancies, we contacted the relevant author directly. Each author also performed independent data abstraction using standardized data collection forms. Data extracted from eligible studies included the following characteristics: study and year, country, type of participants, a number of participants, type of devices applied for intubation, intubation with/without PPE, intubation time, and success of intubation. If outcomes were reported for more than one follow-up period, we used data for the longest follow-up in each trial.

4. Quality assessment

The quality of eligible trials was assessed by using the “risk of bias” tool in accordance with the Review Manager software, version 5.3 (RevMan; Cochrane Collaboration, Oxford, UK). Two authors (L.S. and K.J.F.) estimated the risk of bias in the following methodological domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, others bias [15]. Each was graded “yes”, “no”, or “unclear”, which reflected a high risk of bias, low risk of bias, and uncertain bias, respectively (Suppl. digital content 1). The review authors’ judgments about each risk of bias item are provided in Suppl. digital content 2.

	Random 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)	Other bias
Aberle 2015	+	+	-	-	+	+	+
Burns 2010	?	?	-	-	?	+	+
Castle 2009	+	+	-	-	+	+	+
Castle 2011	+	+	-	-	+	+	+
Castle 2011 (II)	+	+	-	-	+	+	+
Claret 2016	+	+	-	-	+	+	+
Garner 2004	+	+	-	-	?	?	+
Greenland 2007	+	+	-	-	+	+	+
Grillet 2015	+	?	-	-	+	+	+
Koo 2018	+	+	-	-	+	+	+
Plazikowski 2018	+	+	-	-	+	+	+
Schröder 2016	+	+	-	-	+	+	+
Schumacher 2017	+	+	-	-	?	+	+
Shin 2013	+	+	-	-	+	+	+
Szarpak 2016	+	+	-	-	+	+	+
Taylor 2018	+	+	-	-	+	+	+
Udayasiri 2007	+	+	-	-	?	?	+
Wang 2016	+	+	-	-	+	+	+
Weaver 2015	+	+	-	-	+	+	+
Yousef 2017	+	+	-	-	+	+	+

SUPPLEMENT 1. The risk of bias (Suppl. digital content 1)



SUPPLEMENT 2. The review author's judgments about each risk of bias (Suppl. digital content 2)

5. Data analysis

For statistical analyses, we used the Review Manager (RevMan) software, version 5.3. Because there may be differences in the treatment effect between trials, especially those using different devices, we assumed a random-effects model. We employed the inverse-variance method for the continuous outcomes and the Mantel-Haenszel models for all dichotomous outcomes. We calculated mean differences (MD) for continuous measurements (time to intubation) and risk ratios (RR) for dichotomous outcomes (intubation success rate). All statistical variables were determined with 95% confidence interval (CI) to estimate the range of plausible treatment effects. When the continuous outcome was reported in a study as median, range, and interquartile range, we estimated means and standard deviations using the formula described by Hozo et al. [16]. We quantified heterogeneity in each analysis by the tau-squared and I-squared statistics. Studies were subgrouped by the type of intubation devices. Heterogeneity was detected with the chi-squared test with $n-1$ degree of freedom, which was expressed as I^2 . Values of $I^2 > 50\%$ and $> 75\%$ were considered to indicate moderate and significant heterogeneity among studies, respectively [16]. All p-values were tailed and considered statistically significant if $p < 0.05$.

RESULTS

1. Trial identification and characteristics

Initially, 297 articles were identified for review based on our search of the electronic databases. Of these, 133 were excluded because they were not relevant.

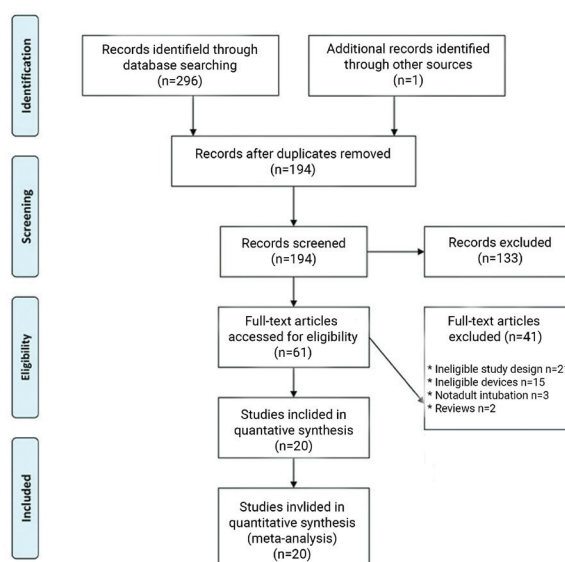


FIGURE 1. 20 studies with the inclusion criteria for data

The remaining 61 articles were carefully examined for meeting the inclusion criteria. Of those, 41 studies were excluded because they were not RCTs comparing direct laryngoscopy with video laryngoscopy ($n = 21$), provided comparisons between unrelated airway management devices ($n = 15$), did not refer to adult intubation ($n = 3$), were review articles ($n = 2$). Ultimately, 20 studies that met the inclusion criteria and contained the necessary data for the planned comparison were identified (Fig. 1). The details of the selected trials are summarized in Table 1. Among the 20 mentioned studies, two were cadaver studies [17, 18] and the others were simulation trials [12, 19–35].

Table 1. Characteristics of included studies.									
Study	n	Study design	Intubated object	Studied devices	Intubation conditions	Operators	Definition of intubation time	Definition of intubation success rate	
Aberle 2015	23	RCT	Manikin	GLS and ML	With PPE	Emergency Medicine residents	From blade pass the lips until the first breath was administered	Successful endotracheal tube placement was confirmed using lung expansion monitoring	
Burns 2010	47	RCT	Manikin	ML	With/without PPE	EMS personnel	From picking up the laryngoscope until the first breath was administered	symmetrical chest rise with manual ventilation	
Castle 2009	64	RCT	Manikin	ML	With/without PPE	6 resuscitation officers (RO), 14 paramedics, 15 anaesthetists and 25 emergency physicians	from when the laryngoscope was picked-up until tube placement was confirmed by simulated use of an esophageal detection device and colorimetric end-tidal CO ₂	Not specified	
Castle 2011	48	RCT	Manikin	ML	With/without PPE	final year paramedic students	from when the laryngoscope was picked-up and stopped when the ETT was placed within the manikin and simulated confirmation of ETT placement	confirmed visually by a researcher	
Castle 2011	66	RCT	Manikin	ATQ and ML	With/without PPE	final year paramedic students	From picking up the laryngoscope until the first breath was administered	utilising an oesophageal tube check (Positube) and colorimetric ETCO	
Claret 2016	30	RCT	Manikin	ATQ and ML	With PPE	Emergency physicians	From picking up the laryngoscope until the first breath was administered	symmetrical chest rise with manual ventilation	
Garner 2004	8	RCT	Manikin	ML	With/without PPE	Mixed prehospital medical personnel: three paramedics; three emergency physicians; and two anaesthetists	From picking up the laryngoscope until the first breath was administered	Successful lung expansion	
Grillet 2015	13	RCT Letter	Manikin	ML	With/without PPE	Senior ICU physicians	Not specified	Not specified	
Greenland 2007	18	RCT	Manikin	ML	With/without PPE	4 consultant anaesthetists and 14 anaesthetic trainees	confirmed by observation from the bottom of the manikin of the inflated tracheal tube cuff in the trachea in addition to successful inflation of the lung	successful inflation of the lungs	
Koo 2018	29	RCT	Cadaver	ML	With/without PPE	24 emergency medicine residents and 5 emergency medicine physician assistants	From the time the participant picked up the laryngoscope to the time the participant believed the endotracheal balloon went past the vocal cords	confirmed visually by a researcher	
Plazikowski 2018	30	RCT	Manikin	ATQ and ML and FSC	With/without PPE	anesthesiologists working in EMS	from stopping bag-mask ventilation until the first visible effective ventilation of the mannequin	Not specified	

Table 1. Characteristics of included studies.

Study	n	Study design	Intubated object	Studied devices	Intubation conditions	Operators	Definition of intubation time	Definition of intubation success rate
Schroder 2016	42	RCT	Manikin	ATQ and GLS and APA and ML	With PPE	anesthesiologists	From the entrance of each laryngoscope through the mouth until the moment of chest extension by the first ventilation	Not specified
Schumacher 2017	30	RCT	Manikin	ML	With PPE	anesthesiologists	From picking up the laryngoscope until the first breath was administered	Not specified
Shin 2013	31	RCT	Manikin	AWS and ML	With PPE	medical doctors who had passed the national board examination, which includes performing ETI on a manikin using the ML	from grasping each device to the end of the procedure when the participants were deemed to have correctly positioned the tracheal tube	visible chest rise after bagging with the Bag-Valve-Mask device
Szarpak 2016	43	RCT Letter	Manikin	AWS and ML	With PPE	paramedics	Not specified	Not specified
Taylor 2018	15	RCT	Cadaver	MCG and ML	With/without PPE	emergency medicine residents and EMS personnel	Not specified	determined when two ventilations were given to the cadaveric model
Udayasiri 2007		RCT	Manikin			Seven emergency doctors and 11 ED nurses	Not specified	Not specified
Wang 2016	40	RCT	Manikin	ML	With/without PPE	emergency physicians with 1–4 years of residency experience participated	from the moment the physician first grasped the laryngoscope successful ventilation was achieved	satisfactory placement of the device on the basis of adequate symmetric expansion of the mannequin's lung
Weaver 2015	37	RCT	Manikin	GLS and ML	With/without PPE	Emergency medicine residents	From picking up the laryngoscope until the two successful ventilations was administered	Not specified
Yousif 2017	20	RCT	Manikin	GLS and KV and ML	With PPE	18 paramedics and 2 Emergency Medical Technicians-Cardiac	time from insertion of the device in the mouth to a clearly visible chest rise of the manikin when ventilated	confirmed visually by a researcher

ML — Macintosh laryngoscope; GVL — GlideScope; FSC — Ambu® fiberoptic aScopeTM; APA — AP Advance video laryngoscope; ETI — endotracheal intubation; AWS — The Pentax-Airwayscope; EMS — emergency medical service; MCG — McGarh video laryngoscope; KV — King Vision video laryngoscope

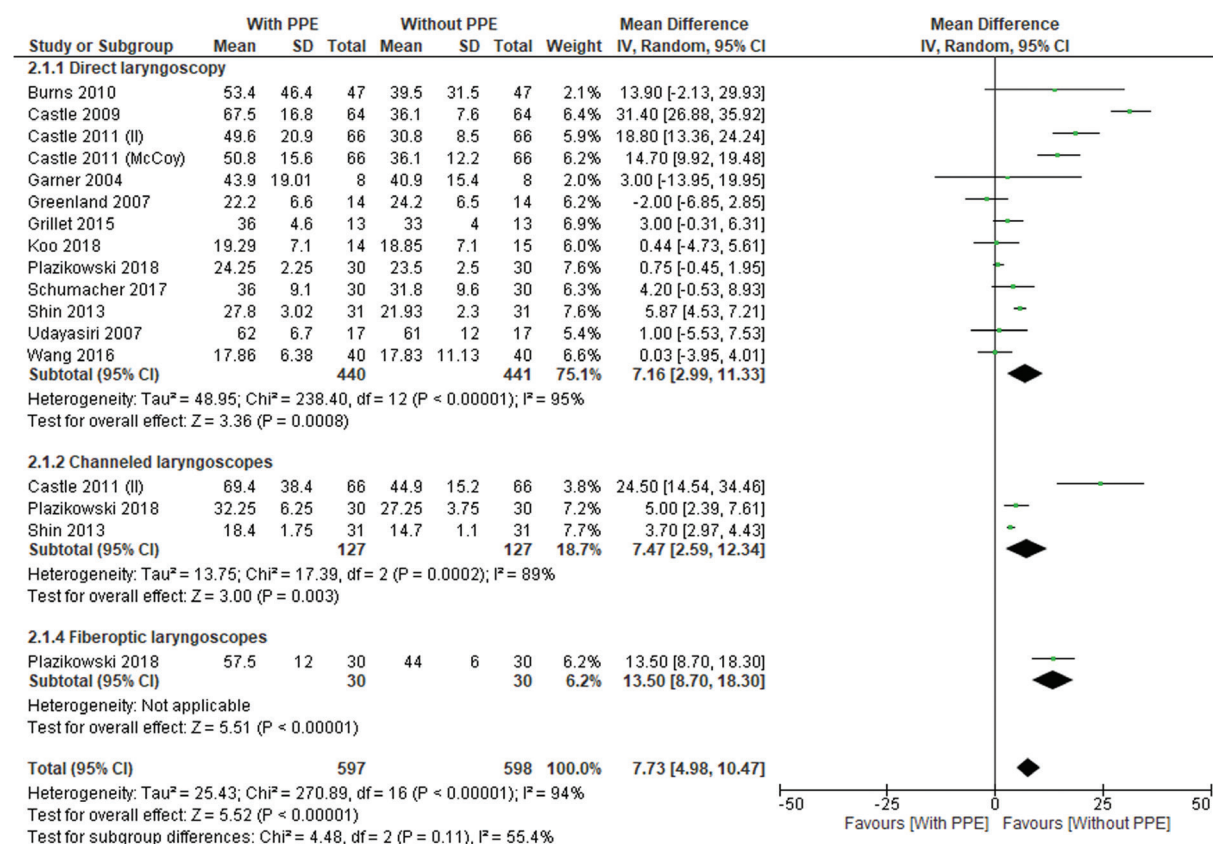


FIGURE 2. Time to intubation without PPE compared with PPE conditions

2. Personal protective equipment impact on endotracheal intubation

Thirteen studies with 1109 intubations reported impact of level C PPE on the duration of endotracheal intubation [12, 17, 20–22, 24–27, 29, 30, 32, 33]. Overall, time to intubation was shorter without PPE compared with PPE conditions (MD = 7.33; 95% CI: 4.98–10.47; $p < 0.001$) (Fig. 2).

Subgroup analysis showed that the use of PPE extended all intubation techniques, including those applying direct laryngoscopes (MD = 7.16; 95% CI: 2.99–11.33; $p < 0.001$), channeled laryngoscopes (MD = 7.47; 95% CI: 2.59–12.34; $p = 0.003$), as well as fiberoptic laryngoscopes (MD = 13.50; 95% CI: 8.70–18.30; $p < 0.001$).

The impact of PPE on endotracheal intubation success rate was recorded in eight studies [12, 17, 18, 21, 22, 25, 27, 30], and intubation without PPE was found to be superior to intubation with PPE in this regard (97.9% vs. 90.0%; RR = 0.94; 95% CI: 0.90–0.99; $p < 0.001$) (Fig. 3).

In subgroup analysis, intubation without PPE was superior to intubation with PPE for all laryngoscope types: direct laryngoscopes (98.3% vs. 89.3%; RR = 0.93; 95% CI: 0.88–1.00; $p = 0.04$), chan-

neled laryngoscopes (96.1% vs. 92.9%; RR = 0.98; 95% CI: 0.94–1.03; $p = 0.49$), Macintosh blade laryngoscopes (100% vs. 73.3; RR = 0.74; 95% CI: 0.54–1.02; $p = 0.07$), and fiberoptic laryngoscopes (100% vs. 93.3%; RR = 0.93; 95% CI: 0.83–1.05; $p = 0.24$).

3. Direct laryngoscopy versus video laryngoscopy in personal protective equipment conditions

Ten studies compared Macintosh laryngoscope with other laryngoscopes in PPE conditions [18, 19, 21, 23, 27, 28, 30, 31, 34, 35]. Overall, intubation with direct laryngoscopes was shorter than that with video laryngoscopes (MD = 5.63; 95% CI: -0.77–12.03), although the difference was not statistically significant ($p = 0.08$) (Fig. 4). The subanalysis revealed that intubation with direct laryngoscopes was slightly faster than with Macintosh blade video laryngoscopes (MD = -0.14; 95% CI: -5.61–5.33). For comparison of direct laryngoscopes with channeled laryngoscopes, faster intubation procedure was observed with direct laryngoscopy (MD = 6.41; 95% CI: -2.41–15.24). However, the above differences were not statistically significant ($p = 0.96$ and

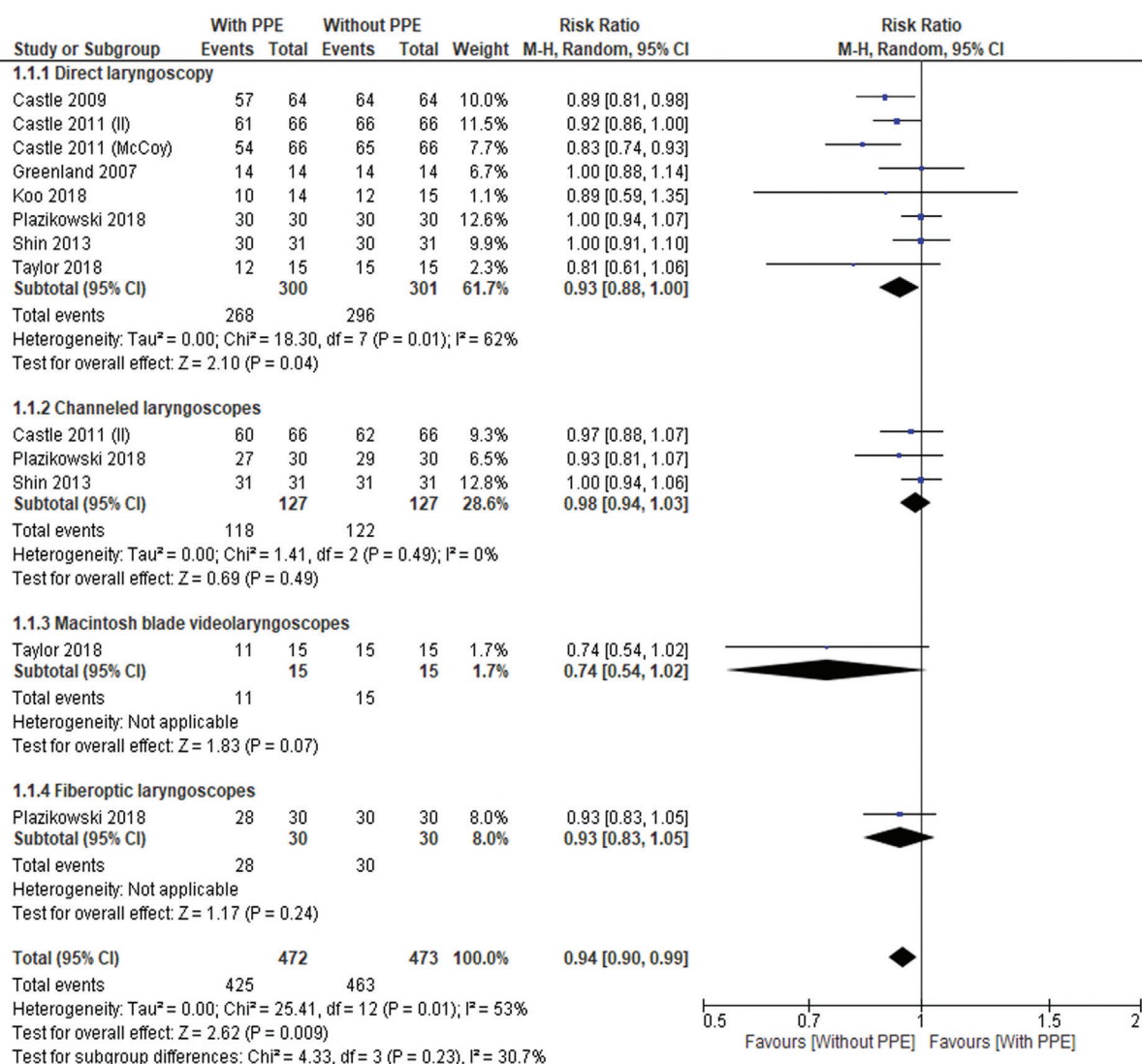


FIGURE 3. The impact of PPE on endotracheal intubation

$p = 0.15$, respectively). In the case of fiberoptic laryngoscopes intubation, the duration of the procedure was statistically significantly longer than that of direct laryngoscopy (MD = 32.90; 95% CI: 28.53–37.27; $p < 0.001$).

The intubation success rate for direct laryngoscopes versus other laryngoscopes in PPE conditions was reported in ten RCTs [18, 19, 21, 23, 27, 28, 30, 31, 34, 35]. The effectiveness of intubation was comparable between direct laryngoscopes and video laryngoscopes (93.6% vs. 92.3%; RR = 0.99; 95% CI: 0.96–1.02; $p = 0.66$) (Fig. 5). Subgroup analysis showed that intubation with Macintosh blade video laryngoscopes was more effective than that with direct laryngoscopes (98.1% vs. 96.4%; RR = 1.00; 95% CI: 0.97–1.03), although the difference was not statistically significant ($p = 0.90$). On the other

hand, direct laryngoscope intubation was associated with higher efficiency as compared with channeled laryngoscopes (88.5% vs. 91.2%; RR = 0.99; 95% CI: 0.93–1.05; $p = 0.74$) and fiberoptic laryngoscopes (100% vs. 93.3%; RR = 0.93; 95% CI: 0.83–1.05; $p = 0.24$).

Additional subanalysis with the division of operators into “Anesthesiology staff”, “Emergency medicine staff”, or “Mixed staff” revealed that in the first two groups, video laryngoscopy was associated with a longer procedure duration than direct laryngoscopy, while in the “Mixed staff” group, the opposite trend was observed (Tab. 2). Moreover, the analysis showed higher efficacy of direct laryngoscopy compared with video laryngoscopy (100% vs. 96.8%; RR = 0.97; 95% CI: 0.89–1.06; $p = 0.50$) (Tab. 3). For the “Emergency medicine staff”, the efficacy

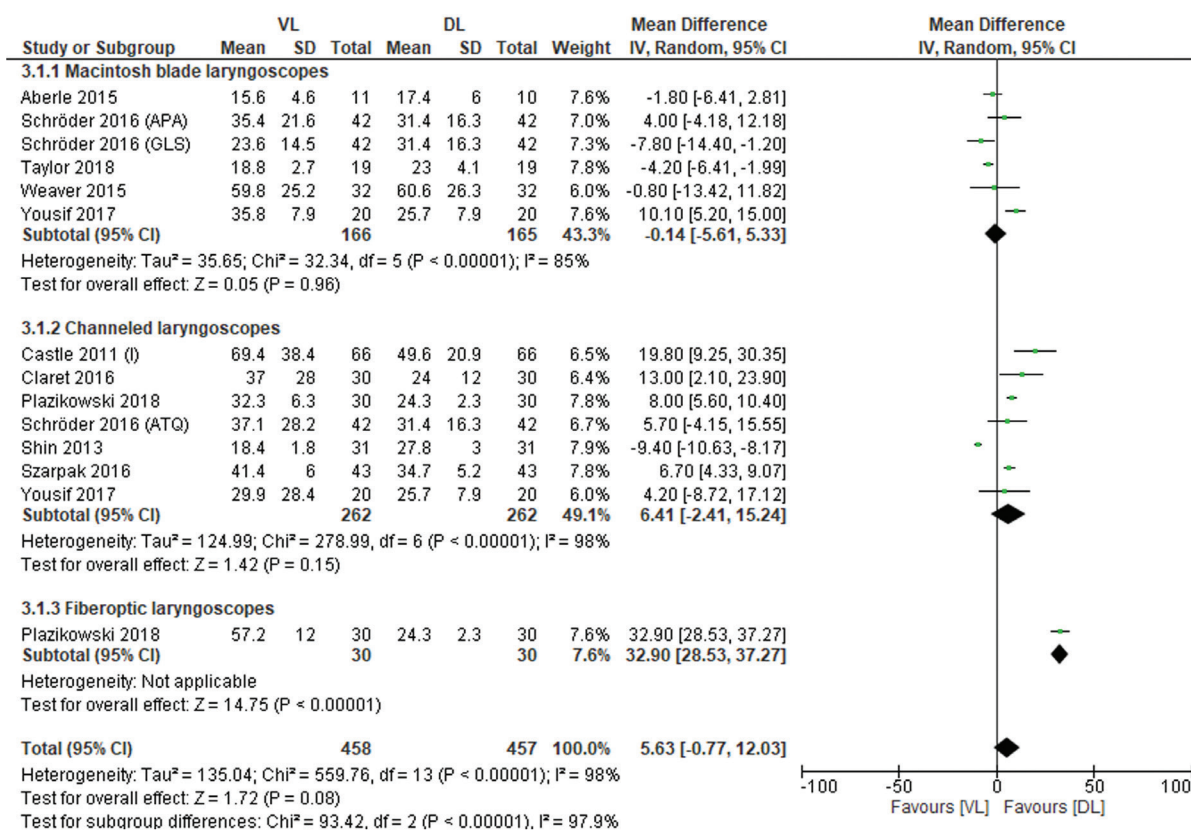


FIGURE 4. Intubation with direct laryngoscopes versus video laryngoscopes

with video laryngoscopy equalled 87.7% and was higher than that for direct laryngoscopy (87.3%) (RR = 1.02; 95% CI: 0.93–1.12). Among the “Mixed staff”, the efficacy of direct laryngoscopy and video laryngoscopy intubation was 94.7% vs. 93.8% respectively.

4. Risk of bias

The risk of bias in the included studies is outlined in Supplementary digital content 1 and 2. All the 20 studies clearly described random sequence generation [12, 17–35]. The risk of bias in the RCTs was assessed as either low or moderate across all domains, apart from the blinding of participants and personnel where blinding was clearly not possible.

Limitations

Our meta-analysis has some limitations. First, all the included studies were small and are at a high risk of bias as neither the operator nor the outcome assessor was blinded for obvious technical reasons. The second limitation is the influence of methodological heterogeneity from variations in the design of

the original studies, such as involvement of diverse “patients” or different skill levels of operators; this heterogeneity should be perceived as an inherent limitation of meta-analysis. Third, not all studies reported intubation time and intubation success rate at the same time. Fourth, most of the studies included in the meta-analysis were simulation studies; however, owing to the risk of infection of medical personnel and the need to secure the airway as soon as possible, it would be impossible to conduct such studies in clinical conditions.

DISCUSSION

Endotracheal intubation is considered to be one of the basic procedures in the scope of emergency medicine and medical rescue, as well as during cardiopulmonary resuscitation. The comparison of endotracheal intubation with direct laryngoscopy and other intubation methods, including video laryngoscopy, has been widely studied and meta-analyzed. However, both the more common epidemics, including SARS and MERS, and the risk of infection with other dangerous pathogens, especially during

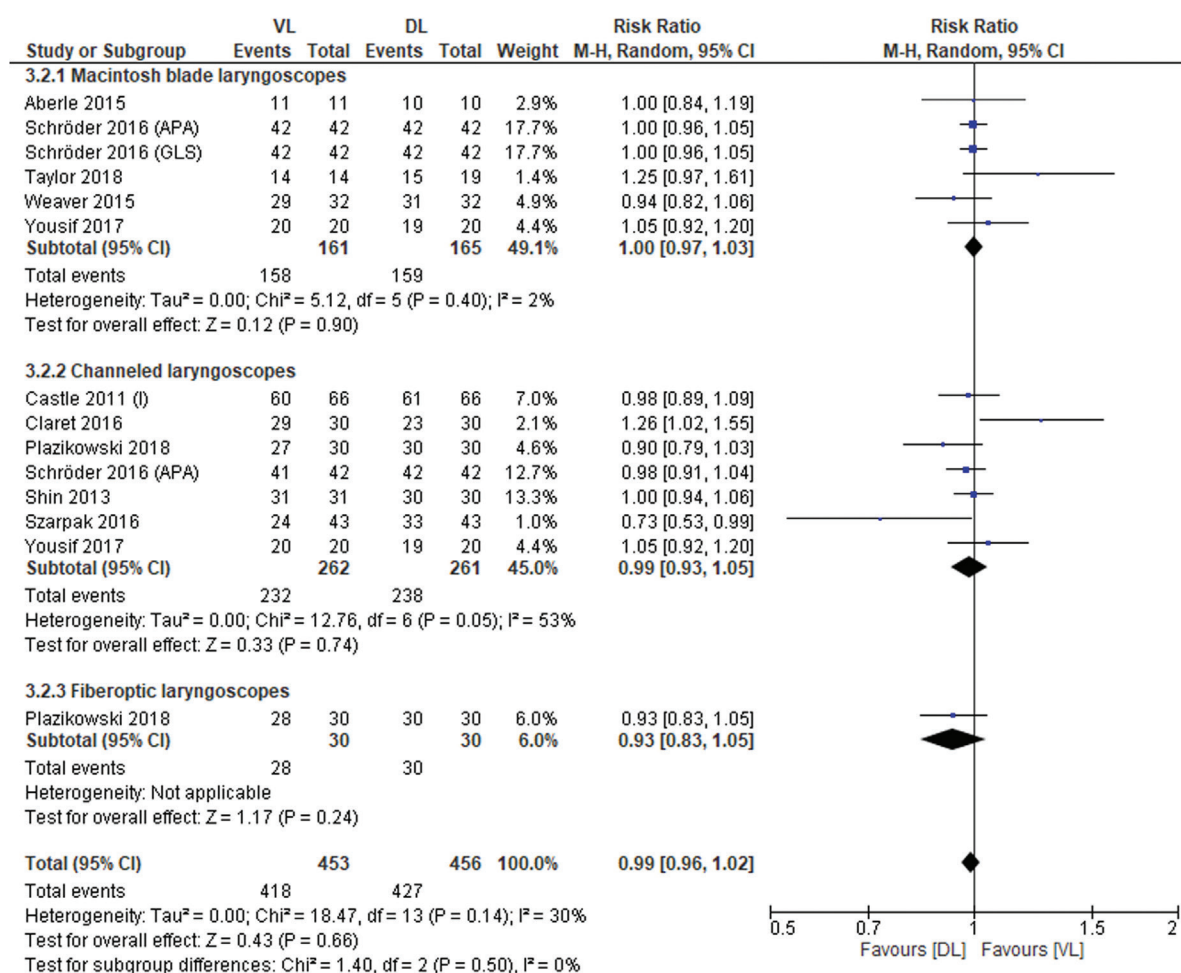


FIGURE 5. The effectiveness of intubation between direct laryngoscopes and video laryngoscopes

Table 2. Compared the video laryngoscopes with the Macintosh laryngoscope intubation time in subgroup analysis

	Number of trials	MD (95% CI)	P value	I ² statistic, %
Anesthesiology staff	2	10.27 (0.44, 20.11)	0.04	97%
Emergency staff	6	3.64 (-1.99, 9.26)	0.20	90%
Mixed staff	2	4.71 (-23.89, 33.31)	0.75	97%

MD — mean differences; N/A — not applicable

Table 3. Compared the video laryngoscopes with the Macintosh laryngoscope intubation success rate in subgroup analysis

	Number of trials	Effectiveness VL	Effectiveness DL	RR (95% CI)	P value	I ² statistic, %
Anesthesiology staff	2	96.8%	100%	0.97 (0.89, 1.06)	0.50	71%
Emergency staff	4	87.7%	87.3%	1.02 (0.93, 1.12)	0.65	57%
Mixed staff	2	93.8%	94.7%	1.00 (0.94, 1.05)	0.87	0%

N/A — not applicable; RR — risk ratios

the current COVID-19 pandemic, suggest studies on the performance of medical procedures, also with reference to respiratory protective devices.

The number of available studies on respiratory protection under such conditions is limited and there are no meta-analyses of pooled data.

According to our knowledge, this was the first meta-analysis comparing Macintosh laryngoscope with video laryngoscopes in level C PPE conditions. We performed a *priori* subgroup analyses in order to investigate [1] the effect of PPE on intubation time and overall intubation success rate while

using different types of laryngoscopes; [2] the effect of video laryngoscopy compared with direct laryngoscopy on intubation success rate and intubation time by type of video laryngoscopes under PPE conditions; [3] the influence of the type of operator on success rate and intubation time. Our study suggests that intubation with class C protective suits has a statistically significant effect on prolonging the duration of the procedure and reducing its effectiveness. Moreover, the use of video laryngoscopes did not improve the overall success rate of endotracheal intubation when operators were wearing full PPE; on the contrary, video laryngoscopy intubation was associated with longer endotracheal intubation time and slightly lower efficacy compared with direct laryngoscopy. The analysis in subgroups showed only a slight advantage of Macintosh blade video laryngoscopes over direct laryngoscopy regarding the efficacy of intubation. Video laryngoscopes display the glottis on an external monitor by using a camera attached to the device blade without alignment of the oral-pharyngeal-tracheal axes.

Direct laryngoscopy also requires optimal head and neck positioning, proper insertion of the laryngoscope into the mouth, and glottis visibility, which demands a high level of operator experience [36]. Since video laryngoscopes — especially in conditions of difficult airways or difficult access to the patient — may offer better glottis visualization compared with direct laryngoscopes [37], they can facilitate endotracheal intubation, especially for less experienced staff.

The above relationships seem to be confirmed by numerous studies [39, 40]. Additionally, as research indicates, the learning curve for video laryngoscopes is significantly shorter than for Macintosh or Miller laryngoscopes, which allows for effective endotracheal intubation by using video laryngoscopes after a short training [41, 42]. The subanalysis of the study material showed that in the subgroup of “Emergency medicine staff”, video laryngoscopy was associated with higher efficacy in comparison with direct laryngoscopy, but this difference was not statistically significant. Therefore, it may be inferred that for this professional group, including emergency physicians, paramedics, or emergency nurses, video laryngoscopy may be a good alternative to direct laryngoscopy for intubation under difficult conditions, which undoubtedly comprises intubation in full PPE.

A number of prospective and observational studies reveal that in emergency medicine conditions, the effectiveness of direct laryngoscopy intubation

is insufficient [36, 43]. As indicated in the study by Hoshijima et al. [44], another aspect that supports the use of video laryngoscopy, apart from the fact that it improves the visibility of the glottis, is that it significantly reduces the incidence of soft tissue bleeding compared with the Macintosh laryngoscope. Multiple attempts to intubate a patient may lead to desaturation and then intensify soft tissue bleeding and glottis edema, which in turn may result in a situation described by the Difficult Airway Society as “can’t intubate, can’t ventilate” [45]. Video laryngoscopes, owing to better visibility of the glottis compared with direct laryngoscopes, can reduce the risk of esophageal intubation in emergency and intensive care patients [46, 47].

CONCLUSIONS

Our meta-analysis suggests that PPE reduces the effectiveness of endotracheal intubation. The use of direct laryngoscopy for intubating patients with suspected/confirmed COVID-19 by an intubator wearing level C PPE is associated with overall intubation time reduction and an increase in intubation success rate compared with video laryngoscopes. However, the findings suggest that Macintosh blade video laryngoscopes during endotracheal intubation with PPE may be an alternative to direct laryngoscopes. Video laryngoscopy can be helpful for less experienced personnel.

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