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VIDEO-ASSISTED VERSUS MACINTOSH DIRECT LARYNGOSCOPY FOR INTUBATION OF OBESE PATIENTS: A META-ANALYSIS OF RANDOMIZED CONTROLLED TRIALS

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ABSTRACT

INTRODUCTION: We performed a systematic review and meta-analysis of randomized controlled trials (RCTs) to compare the usefulness of video-assisted (VL) approaches with the Macintosh direct laryngoscope for endotracheal intubation of obese patients.

MATERIAL AND METHODS: Studies were obtained via a systematic search of SCOPUS, Medline, Web of Science, CINAHL, and the Cochrane Central databases. The polled relative risks (RRs) odds ratios (ODs) or standard mean differences (SMD) with 95% confidence intervals (CIs) were calculated with a random–effects model. Subgroup analyses were performed to evaluate the influence of VL types on the association.

RESULTS: First intubation attempt success rate in VL and DL group varied and amounted to 94.7% vs 89.5% respectively (OR = 2.04; 95% CI: 1.21–3.42; p = 0.007) and overall intubation success rate was 99.0% vs 97.5% respectively (OR = 2.20; 95% CI: 0.45–10.67; p = 0.33). Intubation time which was 48.0 ± 37.7 for VL and 48.4 ± 37.5 seconds for DL (SMD = 0.14; 95% CI: –0.33–0.61; p = 0.56). Cormack-Lehane 1 or 2 grade during intubation using VL was observed in 95.9% of cases and was statistically significantly higher than in the case of direct laryngoscopy (79.6%; OR = 6.68; 95% CI: 3.32–13.42; p < 0.001).

CONCLUSIONS: Our meta-analysis suggests that video-assisted intubation may be superior to conventional intubation in an obese patient population due to a higher first–attempt success rate, better glottis visibility, and a lower rate of intubation-related injuries.

KEY WORDS: video-laryngoscope, direct-laryngoscope, endotracheal intubation, obese, intubation attempt, intubation time, meta-analysis

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INTRODUCTION

Obese and morbidly obese patients belong to the group of patients in whom difficult intubation is expected [1]. The number of overweight, obese, and morbidly obese people worldwide is growing despite many campaigns and efforts to reduce this healthcare problem. As the incidence of obesity steadily increased over the past few years [2]. Anesthesiologists will be increasingly faced with potentially difficult intubations, as the number of obese patients who require endotracheal intubation is increasing, particularly in surgical patients but also due to respiratory failure in COVID-19 [3, 4]. An increasing number of patients undergo bariatric surgery, where one of the important problems is airway management, ventilation, and endotracheal intubation during surgery and the postoperative period.

Video laryngoscopes were introduced into clinical practice around the year 2000, and Video-assisted intubation is more prevalent in clinical practice than ever. Video-assisted intubation is particularly popular when patients with potentially or expected difficult airways have to be intubated [5, 6].

Several Video-assisted laryngoscopes and intubation aids with variable designs have been introduced into clinical settings. Video laryngoscope blades may be channeled or not, have angled or standard Macintosh shape [7], additionally, tubes with embedded cameras at the tip [8], or intubating laryngeal masks with the embedded camera [9] for video-guided intubation have been invented to improve success and facilitate tracheal intubation.

In this study, we performed a systematic review and meta-analysis of randomized controlled trials (RCTs) to compare the effectiveness of Video-assisted intubation aids compared to Macintosh direct laryngoscope for endotracheal intubation of obese patients. The aim of this trial is to examine intubation success rate, time to intubation, glottis visualization, and adverse events to determine whether the Video-assisted intubation aids are superior to the Macintosh direct laryngoscope. We also conducted a subgroup analysis to investigate the effect of obesity level (considering BMI > 35) and Video-assisted intubation aids (Macintosh blade video laryngoscopes; channeled video laryngoscopes; video tube and scopes; a supraglottic device with video channel) on endotracheal intubation.

MATERIAL AND METHODS

This systematic review and meta-analysis complied with the widely recognized Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [10]. Before commencing the study, all reviewers agreed on the analysis methods and the inclusion and exclusion criteria to be used. Ethical approval and consent were waived because this study was a systematic review and meta-analysis of published literature.

Search strategy

Two reviewers (T.E. and L.S.) independently performed a comprehensive literature search using SCOPUS, Medline, Web of Science, CINAHL, and the Cochrane Central Register for Controlled Trials electronic databases. The search was performed using the following terms: "Macintosh" OR "direct laryngoscope" OR "direct laryngoscopy" AND "videolaryngoscope" OR "video-laryngoscope" OR "video laryngoscopes" AND "bariatric" OR "obese" OR "obesity". The most recent search was performed in November 2021. Additionally, a manual search of references listed in reports and reviews was also performed. There were no restrictions regarding the language of the article or publication status.

Inclusion and exclusion criteria

Studies included in this meta-analysis met the following PICOS criteria: (1) PARTICIPANTS; adult obese patients, (2) INTERVENTION; endotracheal intubation with Video-assisted intubation aids, (3) COMPARISON; endotracheal intubation with Macintosh direct laryngoscope, (4) OUTCOMES; detailed information for intubation effectiveness (i.e. intubation success rate, time to intubation, glottis visualization, adverse events) (5) STUDY DESIGN; randomized controlled trials. Whereas the exclusion criteria are as follows: (A) Studies including pediatric patients; (B) Simulation trials; (C) Non–randomized trials; (D) Editorials; (E) Conference abstracts; (F) Letters to editors; (G) Guidelines.

Data extraction

Two reviewers (T.E. and L.S.) independently extracted data from eligible studies by using a specifically designed data extraction form. Another author cross–checked these data before analysis (B.K.). The following data from each study were extracted: first author's name; year of publication; a country where the study was performed; study design; participant characteristics (i.e., a number of patients in

research groups; age; sex, male, BMI), intubation effectiveness (*i.e.*, intubation success rate, time to intubation, glottic visualization, adverse events). Moreover, missing, or unpublished data were sought by trying to contact authors or sponsors via e–mail, and repeated messages were sent in case of no response.

Primary and secondary outcomes

The primary outcomes were: first intubation attempt success rate and overall intubation success rate. Secondary outcomes included time to intubation, glottic visualization (Cormack-Lehane grades 1 or 2 or modified Cormack–Lehane classification 1 or 2a, which are considered indications of an easy glottic view), and occurrence of adverse events related to endotracheal intubation.

Risk of bias and quality of evidence assessment

The risk of bias (RoB) of the included studies was independently assessed by three reviewers (T.E., L.S., and B.K.) according to the revised tool for Risk of Bias in randomized trials (RoB-2 tool) [11]. RoB-2 tool examines 5 domains of bias: (1) bias arising from the randomization process; (2) bias due to deviations from intended intervention; (3) bias due to missing outcome data; (4) bias in the measurement of the outcome; (5) bias in the selection of the reported results. The overall RoB-2 judgment at domain and study level was attributed according to the criteria specified in the ROBVIS tool [12].

We applied the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach [13] with GRADEpro software (version 3.6 for Windows; available from http://ims.cochrane.org/revman/gradepro) to assess the quality of evidence of the main outcomes. Furthermore, the quality of evidence was based on the presence or absence of the following variables: limitations in study design, inconsistency, indirectness, imprecision of the results, and publication bias. The quality of evidence for the primary outcomes was graded as very low, low, moderate, or high.

Role of the Funding Source

This study was not supported by any funding source. The corresponding author had full access to all the data and decided to submit it for publication.

Statistical analysis

Statistical analysis was performed in Review Manager (ver. 5.4, Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark). For dichotomous data, we used odds ratios (ORs) or risk ratios (RRs) as the effect measure with 95% confidence intervals (CIs), and for continuous data, we used mean differences (MDs) with 95%CI. When the continuous outcome was reported in a study as median, range, and inter-quartile range, we estimated means and standard deviations using the formula described by Hozo et al. [14]. For the meta-analysis, we used the random-effects model (assuming a distribution of effects across studies) to weigh estimates of studies in proportion to their significance [15]. Heterogeneity was assessed using the I2 statistic, in which the results range from 0% to 100%. Heterogeneity was interpreted as not observed when $I^2 = 0\%$, low when $I^2 = 25\%$, medium when $I^2 = 50\%$ and high when $I2 = 75\%$ [16]. The significance level for all statistical tests was $p < 0.05$ (two-tailed).

RESULTS

Literature search and study characteristics

We searched 871 potentially relevant studies in the databases (SCOPUS, Medline, Web of Science, CINAHL, and Cochrane Central). After excluding 156 duplicates, 715 studies were screened using title and abstracts; of those, 686 studies were excluded. After full-text assessment for eligibility, 13 were excluded because they were review articles or not a RCT studies. Finally, 16 studies were included in this systematic review and meta-analysis [17–32], as shown in Figure 1.

The study characteristics are summarized in Table 1 and Table S1. Studies were published between 2007 and 2020. All of the included studies were randomized controlled trials. Overall, eighteen studies including 1,587 patients (898 in VL group and 689 in DL group) from USA [17, 28, 32], Turkey [22, 28], France [24, 27], Switzerland [21, 25], Brazil [29], Denmark [19], Egypt [31], India [26], Israel [20], Spain [23] and Sweden [18] were included. Detailed patient characteristics are presented in the Supplementary Digital File* (Fig. S1 to Fig. S9 and Tab. S2).

Intubation success rate

First intubation attempt success rate in VL and DL group varied and amounted to 94.7% vs 89.5%, respectively (OR = 2.04; 95% CI: 1.21 to 3.42; $p = 0.007$). Sub-group analysis showed that first intubation attempt success rate in the morbidly obese

*all supplementary files are available at: https://journals.viamedica.pl/disaster_and_emergency_medicine/article/view/DEMJ.a2022.0004#supplementaryFiles

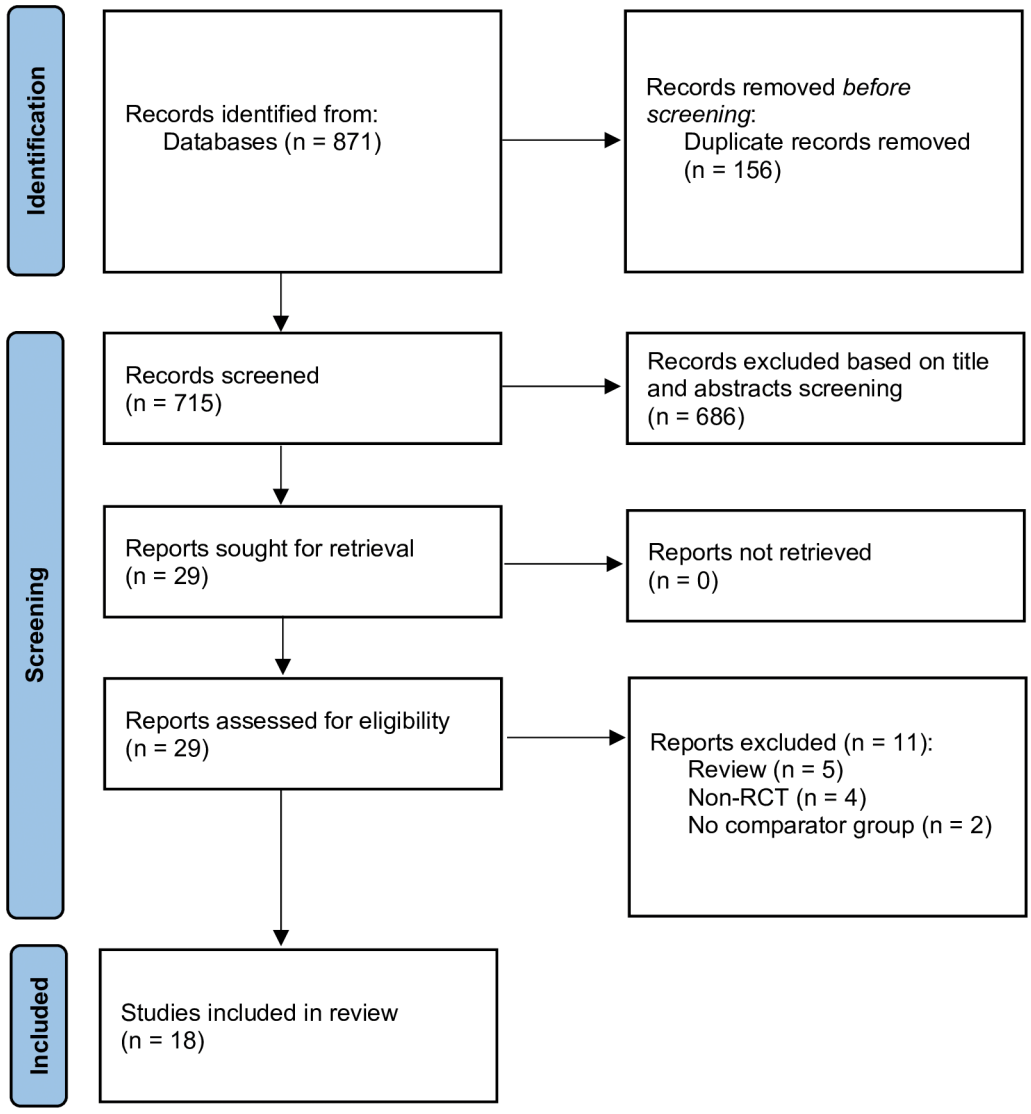

FIGURE 1. Database search and selection of studies according to PRISMA guidelines

patients group was 95.6% and was statistically significantly higher than with direct-laryngoscope group — 90.5% (OR = 1.93; 95% CI: 1.05 to 3.54; p = 0.03; Fig. 2).

Additionally performed subgroup analysis based on video–laryngoscopes types showed that intubation with VL was associated with higher first intubation attempt success rate compared to DL in all analyzed groups: Macintosh blade laryngoscopes (92.2% vs 85.3%; OR = 2.30; 95% CI: 1.33–4.01; p = 0.003), channeled laryngoscopes (97.0% vs 92.9%; OR = 2.44; 95% CI: 0.51–11.67; p = 0.26), video-tube and scopes group (97.5% vs 96.9%; OR = 1.26; 95% CI: 0.08–20.93; p = 0.87) as well as supraglottic devices with video channel (95.6% vs 92.6%; OR = 1.84; 95% CI: 0.60 to 5.59; p = 0.29; Fig. S10).

Overall success rate in VL group was 99.0% and in DL group – 97.5% (OR = 2.20; 95% CI: 0.45–10.67; p = 0.33). A detailed summary of the overall effectiveness of intubation by subgroups is presented in Table 2.

Time to intubation

Sixteen studies [17–32] were reported intubation time which was 48.0 ± 37.7 for VL and 48.4 ± 37.5 seconds for DL (SMD = 0.14; 95% CI: –0.33 to 0.61; p = 0.56). Intubation with VL and DL in morbidly obese patients did not show significant differences and was 52.2 ± 39.3 vs 52.7 ± 37.8 seconds, respectively (SMD = 0.11; 95% CI: –0.44 to 0.67; p = 0.69; Fig. 3).

Video-laryngoscopy intubation was associated with a longer procedure time com–pared

Table 1. Characteristic of included studies

Study	Country	Study desing	Laryngoscope	No. of patients	Age, years	Sex, male	BMI
Abdallah et al. 2011 [17]	USA	RCT	Pentax AWS	50	50 ± 12	11 (22.0%)	41.2 ± 4.4
			Macintosh	49	49 ± 14	10 (20.4%)	42.5 ± 5.9
Ander et al. 2017 [18]	Sweden	RCT	C-MAC	40	42 ± 12	10 (25.0%)	42.2 ± 5.6
			Macintosh	40	42 ± 13	14 (35.0%)	39.9 ± 4.0
Andersen et al. 2011 [19]	Denmark	RCT	GlideScope	50	42 ± 10	15 (30.0%)	42 ± 6
			Macintosh	50	41 ± 8	9 (18.0%)	41 ± 5
Arici et al. 2014 [20]	Turkey	RCT	McGrath	40	27.55 ± 3.82	NS	29.45 ± 5.60
			Macintosh	40	29.25 ± 4.41	NS	27.98 ± 3.22
Aziz et al. 2012 [21]	USA	RCT	C–MAC	149	54 ± 14	74 (49.7%)	34 ± 10
			Macintosh	147	55 ± 15	83 (56.5%)	34 ± 10
Barak et al. 2014 [22]	Israel	RCT	VivaSight	40	43.1 ± 4.9	14 (35.0%)	44.8 ± 7.5
			Macintosh	32	42.5 ± 3.2	9 (28.1%)	43 ± 6.8
Bathory et al. 2010 [23]	Switzerland	RCT	VIU	18	37.7 ± 9.9	4 (22.2%)	44.4 ± 1.9
			Macintosh	20	42.7 ± 8.0	2 (10.0%)	43.5 ± 1.7
Cakir et al. 2020 [24]	Turkey	RCT	McGrath	31	42.0 ± 10.5	7 (22.6%)	46.1 ± 6.6
			Macintosh	31	39.0 ± 9.8	3 (9.7%)	46.5 ± 4.2
Castillo- Monzón et al. 2017 [25]	Spain	RCT	Airtraq	23	43.43 ± 12.77	5 (21.7%)	45.97 ± 3.61
			Macintosh	23	41.57 ± 9.02	6 (26.1%)	46.87 ± 4.38
Dhonneur et al. 2008	France	RCT	Airtraq	106	42.5 ± 11.0	36 (34.0%)	43 ± 6
			LMA CTrach	106	43.3 ± 7.8	41 (38.7%)	41 ± 5
			Macintosh	106	39.8 ± 10.7	40 (37.7%)	40 ± 7
Marrel et al. 2007	Switzerland	RCT	X-Lite	40	45 ± 13	15 (37.5%)	42.8 ± 6.9
			Macintosh	40	45 ± 12	17 (42.5%)	43.5 ± 5.4
Nandakumar et al. 2018	India	RCT	GlideScope	15	42.06 ± 13.25	3 (20.0%)	46.91 ± 6.92
			Macintosh	15	40.6 ± 11.6	3 (20.0%)	44.67 ± 6.64
Ndoko et al. 2008	France	RCT	Airtraq	53	44.3 ± 13	10 (18.9%)	44 ± 6
			Macintosh	53	42 ± 9.2	13 (24.5%)	43 ± 5
Postaci et al. 2015	Turkey	RCT	McGrath	42	49.8 ± 10.3	0 (0.0%)	46.5 ± 7.2
			Macintosh	42	44 ± 10.4	0 (0.0%)	44.6 ± 7.5
Ranieri et al. 2012	Brazil	RCT	Airtraq	68	35.4 ± 8.8	15 (22.1%)	43.5 ± 6.3
			Macintosh	64	34.9 ± 9.4	16 (25.0%)	42.7 ± 4.4
Ruetzler et al. 2020	USA	RCT	McGrath	66	51 ± 14	17 (25.8%)	46.5 ± 2.3
			Macintosh	63	47 ± 13	17 (27.0%)	47 ± 2.3
Yousef et al. 2012	Egypt	RCT	GlideScope	30	44.3 ± 12.4	15 (50.0%)	43.2 ± 7.4
			LMA CTrach	30	45.3 ± 10.7	16 (53.3%)	44.2 ± 9.4
			Macintosh	30	50.8 ± 13.0	17 (56.7%)	43.6 ± 9.5
Yumul et al. 2016	USA	RCT	McGrath	30	45 ± 12	10 (33.3%)	41 ± 6
			GlideScope	30	45 ± 12	7 (23.3%)	43 ± 5
			Video-Mac	30	44 ± 12	7 (23.3%)	43 ± 8
			Macintosh	31	46 ± 12	8 (25.8%)	42 ± 5

RCT — randomized controlled trial; VIU — video intubation unit

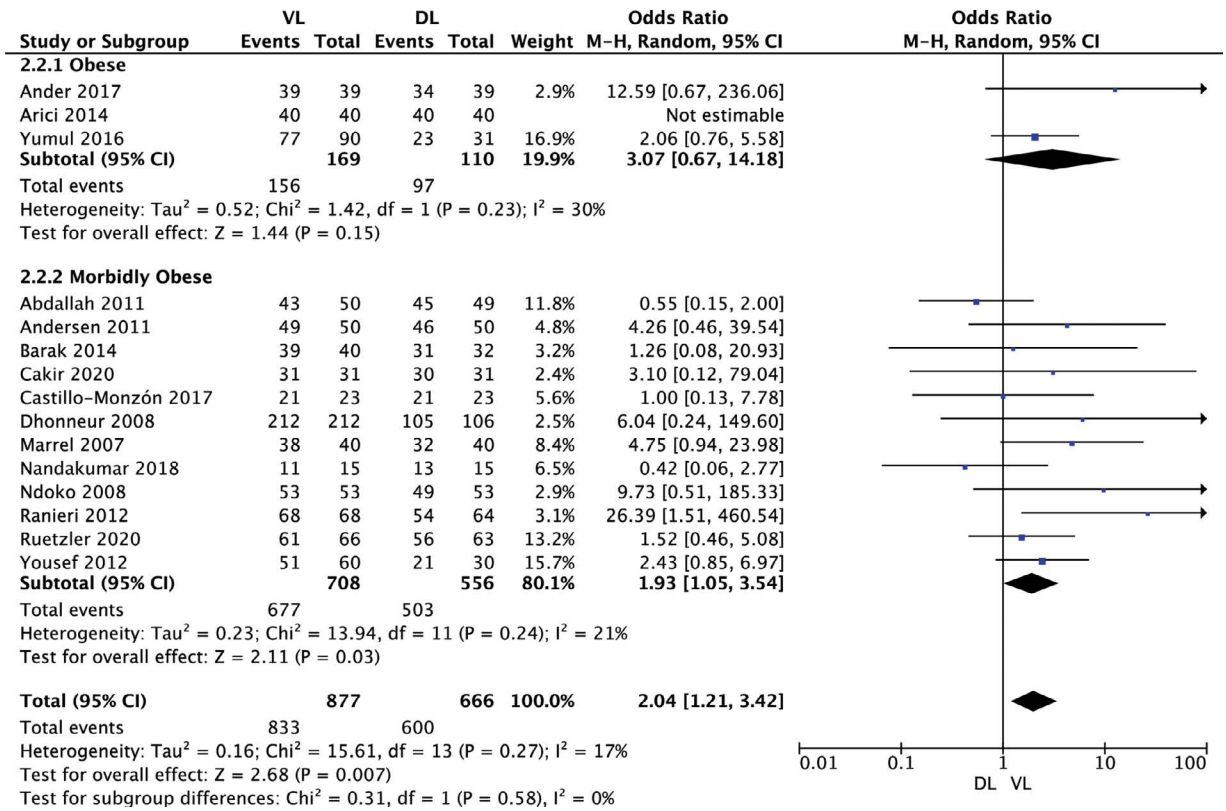

FIGURE 2. Forest plot of first intubation attempt success rate in Video-assisted intubation aids and direct-laryngoscope groups. The center of each square represents the weighted odds ratios for individual trials, and the corresponding horizontal line stands for a 95% confidence interval. The diamonds represent pooled results; CI — confidence interval; DL — direct-laryngoscope; MD — mean difference; VL — video-laryngoscope or video-assisted intubation aids

Table 2. Polled analysis of overall intubation success rate in video-laryngoscope and direct-laryngoscope groups

Overall success rate	No of studies	Events/participants		Events		Heterogeneity between trials		p-value for differences across groups
		VL	DL	OR	95% CI	P-value	I^2 statistic	
Total	14	937/956 (98.0%)	706/743 (95.0%)	2.27	0.78 to 6.55	0.13	39%	0.13
Obese	3	268/279 (96.1%)	195/218 (89.4%)	2.33	1.09 to 4.97	NA	NA	0.03
Morbidly obese	11	669/677 (98.8%)	511/525 (97.3%)	2.20	0.45 to 10.67	0.08	50%	0.33
Macintosh blade laryngoscopes	7	329/331 (99.4%)	256/269 (95.2%)	4.43	1.19 to 16.50	0.57	0%	0.03
Channeled laryngoscopes	5	295/300 (98.3%)	294/295 (99.7%)	0.47	0.01 to 16.46	0.10	63%	0.68
Video-tube & Scopes	1	39/40 (97.5%)	32/32 (100.0%)	0.41	0.02 to 10.28	NA	NA	0.58
Supraglottic devices with video channeled	2	136/136 (100.0%)	129/136 (94.9%)	7.57	0.87 to 65.82	0.44	0%	0.07

CI — confidence interval; DL — direct-laryngoscope; NA — not applicable; OR — odds ratio; VL — video-laryngoscope

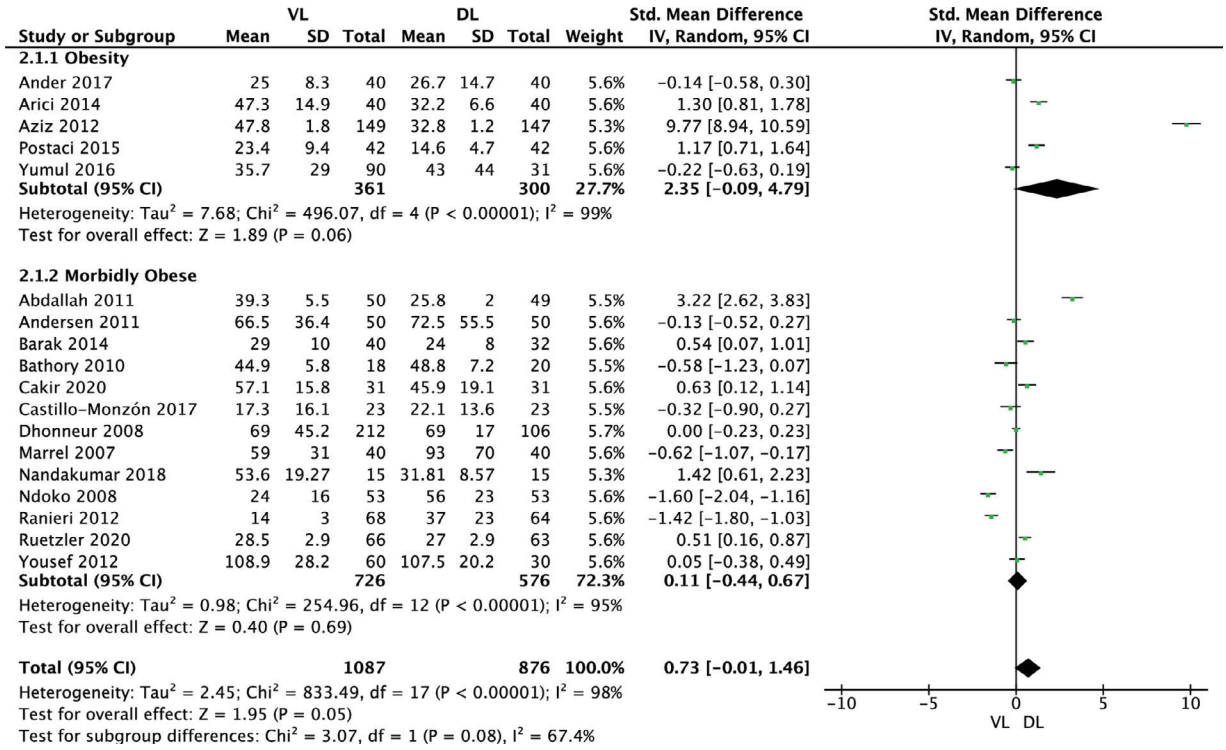

FIGURE 3. Forest plot of time to intubation parameter in Video-assisted intubation aid and video-laryngoscope vs direct-laryngoscope groups. The center of each square represents the weighted standard mean differences for individual trials, and the corresponding horizontal line stands for a 95% confidence interval. The diamonds represent pooled results; CI — confidence interval; DL — direct-laryngoscope; MD — mean difference; VL — video-laryngoscope and video-assisted intubation aids

to direct–laryngoscope. This applies to all analyzed subgroups of video–laryngoscopes: Macintosh blade video–laryngoscopes (44.6 ± 29.8 vs 50.2 ± 46.8, respectively; SMD = 0.15; 95% CI: –0.31 to 0.61; p = 0.52), channeled laryngoscopes (25.5 ± 13.9 vs 48.9 ± 25.6 s; SMD = –0.58; 95% CI: –2.29 to 1.14; p = 0.51), video-tubes & scopes (33.9 ± 11.6 vs 33.5 ± 14.4 s; SMD = 0.00; 95% CI: –1.09 to 1.10; p = 1.00) or supra-glottic devices with video channel (113.4 ± 27.7 vs 77.5 ± 23.9s; SMD = 1.38; 95% CI: 0.57 to 2.19; p < 0.001; Fig. S11).

Glottis visualization

A good degree of visualization of the glottis (Cormack-Lehane 1 or 2 grade) during intubation using video laryngoscopy was observed in 95.9% of cases and was statistically significantly higher than in the case of direct laryngoscopy (79.6%; OR = 6.68; 95% CI: 3.32–13.42; p < 0.001; Fig. S12).

Subgroup analysis showed better glottic visualization of VL compared to DL in the following subgroups: Macintosh-blades laryngoscopes (92.9% vs 72.5%, respectively; OR = 6.36; 95% CI: 3.53––11.49; p < 0.001), channeled laryngoscopes (100% vs 84.8%; OR = 28.49; 95% CI: 5.49–147.73; p < 0.001) as well as in supraglottic devices with video channel group (100% vs 76.7 %; OR = 19.47; 95% CI: 1.06 to 358.38; p = 0.05). An inverse relationship was observed in the video tube and scopes group (92.5% vs 96.9%; OR = 0.40; 95% CI: 0.04 to 4.02; p = 0.43).

Adverse events

A detailed summary of the adverse events observed in the studies is presented in Table 3. The use of video-laryngoscopy compared to direct-laryngoscopy was associated with statistically significantly lower occurrence of desaturation (1.2% vs 34.9%, respectively; RR = 0.04; 95% CI: 0.01–0.15; p < 0.001). A similar relationship was also observed in the aspect of morbidly obese patients (1.3% vs 41.0% respectively; RR = 0.04; 95% CI: 0.01 to 1.09; p < 0.001).

Risk of bias and quality of evidence assessment

The Cochrane risk of bias of the included studies is shown in Figures S13 and S14. In clinical trials, the overall risk of bias was judged as low in fourteen studies [17–26, 29–32] and reviewers indicate some concerns on the other two [27, 28].

Table 3. Polled analysis of observed adverse events in analyzed trials

Overall success rate	No of studies	Events/participants		Events		Heterogeneity between trials		p-value for differences across groups
		VL	DL	OR	95% CI	p-value	I^2 statistic	
Sore throat (total)	7	186/487 (38.2%)	184/391 (47.1%)	0.90	0.75 to 1.09	0.32	15%	0.28
Macintosh blade laryngoscopes	5	161/367 (43.9%)	166/310 (53.5%)	0.90	0.67 to 1.20	0.12	45%	0.47
Channeled laryngoscopes	1	16/50 (32.0%)	15/49 (30.6%)	1.05	0.58 to 1.87	NA	NA	0.88
Video-tube & Scopes	1	2/40 (5.0%)	3/32 (9.4%)	0.53	0.09 to 3.00	NA	NA	0.48
Supraglottic devices with video channeled	1	7/30 (23.3%)	11/30 (36.7%)	0.64	0.29 to 1.42	NA	NA	0.27
Hoarseness (total)	5	40/306 (13.1%)	39/206 (18.9%)	0.85	0.58 to 1.25	0.84	0%	0.42
Macintosh blade laryngoscopes	4	40/236 (16.9%)	39/174 (22.4%)	0.85	0.58 to 1.25	0.84	0%	0.42
Video-tube & Scopes	1	0/40 (0.0%)	0/32 (0.0%)	NE	NE	NA	NA	NA
Supraglottic devices with video channeled	1	0/30 (0.0%)	0/30 (0.0%)	NE	NE	NA	NA	NA
Desaturation (total)	6	19/564 (3.4%)	45/430 (10.5%)	0.26	0.08 to 0.88	0.01	72%	0.03
Macintosh blade laryngoscopes	4	9/269 (3.3%)	13/271 (4.8%)	0.54	0.08 to 3.58	0.09	65%	0.53
Channeled laryngoscopes	2	7/159 (4.4%)	32/159 (20.1%)	0.23	0.10 to 0.51	0.44	0%	< 0.001
Supraglottic devices with video channeled	2	3/136 (2.2%)	29/136 (21.3%)	0.12	0.04 to 0.36	0.73	73%	< 0.001
Increased lifting force required (total)	4	19/178 (10.7%)	55/147 (37.4%)	0.34	0.11 to 1.09	0.009	74%	0.07
Macintosh blade laryngoscopes	3	15/95 (15.8%)	33/94 (35.1%)	0.51	0.14 to 1.83	0.07	63%	0.30
Channeled laryngoscopes	1	4/53 (7.5%)	22/53 (41.5%)	0.18	0.07 to 0.49	NA	NA	< 0.001
Supraglottic devices with video channeled	1	0/30 (0.0%)	10/30 (33.3%)	0.05	0.00 to 0.78	NA	NA	0.03
Dental injuries (total)	4	1/271 (0.4%)	0/261 (0.0%)	2.96	0.12 to 72.08	NA	NA	0.51
Macintosh blade laryngoscopes	3	1/231 (0.4%)	0/229 (0.0%)	2.96	0.12 to 72.08	NA	NA	0.51
Video-tube & Scopes	1	0/40 (0.0%)	0/32 (0.0%)	NE	NE	NA	NA	NA
Lip/gum/oral trauma and bleeding (total)	6	36/431 (8.4%)	34/331 (10.3%)	0.82	0.20 to 3.34	0.001	77%	0.78
Macintosh blade laryngoscopes	4	32/311 (10.3%)	31/250 (12.4%)	0.90	0.18 to 4.56	0.010	78%	0.90
Channeled laryngoscopes	1	2/50 (4.0%)	0/49 (0.0%)	4.90	0.24 to 99.57	NA	NA	0.30
Video-tube & Scopes	1	0/40 (0.0%)	3/32 (9.4%)	0.11	0.01 to 2.15	NA	NA	0.15

→

Table 3. cont. Polled analysis of observed adverse events in analyzed trials

Overall success rate	No of studies	Events/participants		Events		Heterogeneity between trials		P-value for differences across groups
		VL	DL	OR	95% CI	p-value	I^2 statistic	
Supraglottic devices with video channeled	1	2/30 (6.7%)	12/30 (40.0%)	0.17	0.04 to 0.68	NA	NA	0.01
Adverse events in morbidly obese group								
Sore throat	5	69/266 (25.9%)	76/224 (33.9%)	0.81	0.61 to 1.08	0.34	11%	0.15
Hoarseness	4	31/216 (14.4%)	35/175 (20.0%)	0.86	0.57 to 1.30	0.57	0%	0.48
Desaturation	4	5/375 (1.3%)	98/239 (41.0%)	0.04	0.01 to 0.15	0.19	41%	<0.001
Increased lifting force required	4	19/178 (10.7%)	55/147 (37.4%)	0.34	0.11 to 1.09	0.009	71%	0.07
Dental injuries	1	0/40 (0.0%)	0/32 (0.0%)	NE	NE	NA	NA	NA
Lip/gum/oral trauma and bleeding	3	6/150 (4.0%)	15/111 (13.5%)	0.35	0.05 to 2.62	0.09	58%	0.31

CI — confidence interval; DL — direct-laryngoscope; NA— not applicable; NE — not estimable; RR— risk ratio; VL — video-laryngoscope

The quality of evidence was graded as "low" for the effect of the video–laryngoscope compared with the Macintosh laryngoscope for first intubation attempt success rate, overall intubation success rate, intubation time, and glottic visualization and was presented in Figure S15.

DISCUSSION

The advantages of VL are widely recognized; due to better visualization of laryngeal structures resulting from the camera position, they facilitate endotracheal intubation with or without stylets and guides or elastic bougie. The superiority of selected types of VL is particularly visible in emergency medicine when the time to perform the procedure is limited, and the person performing endotracheal intubation has limited experience in direct intubation.

Difficulties in intubation of obese and morbidly obese patients, prolonged time to intubation, and associated complications are well known and result from numerous anatomic and physiological factors. The main factors impeding endotracheal intubation and ventilation in this group of patients include limited neck mobility, reduced oropharyngeal space, and time to intubation due to low oxygen reserve. Endotracheal intubation in morbidly obese patients is commonly performed for elective bariatric surgery when optimal preparation with a full set of airway management equipment and experienced personnel are available.

Our results demonstrate that first attempt intubation rate and glottis visibility are improved, and intubation-related adverse events are reduced, when Video-assisted compared to conventional intubation is performed in obese patients. Our results are largely in line with a previous meta-analysis [33], which described a higher success rate, a shorter intubation time, and better glottis visibility when channeled or unchanneled video-laryngoscopy compared to conventional laryngoscopy were used.

There are, however, some interesting differences in our study findings compared to this previous meta-analysis [35]: our analysis does not point to a shorter intubation time when Video-assisted intubation is compared to direct laryngoscopy-guided intubation. This difference might be based on the fact, that we included all types of Video-assisted intubation devices, while Hoshijima and colleagues only considered channeled and non–channeled video-laryngoscopes. Individual experience is key for reducing intubation time when performing direct laryngoscopy [34] and most likely also for Video-assisted intubation. Most anesthesiologists are more familiar with direct laryngoscopy, but we couldn't analyze the level of experience in our review, as the level of experience with video-laryngoscopes or advanced airway technology has not been consistently reported. While previous

studies have demonstrated a lower force applied on the teeth [35], the tongue [36], and the glottis [37] in patients undergoing video-laryngoscopy compared to direct laryngoscopy, this is, to our knowledge, the first study to systematically evaluate the incidence of intubation related injury in Video-assisted compared to direct laryngoscopy.

The data obtained from the analysis of studies may suggest the superiority of particular methods of management; however, the clinical decision concerning the use of particular types of laryngoscopes must depend on the practice and protocols of a given institution as well as individual experience in the use of a given device and anatomical conditions of a specific patient.

This study has potential limitations. First, in most studies, the number of participants was limited, influencing the results. Secondly, most studies analyzed only patients undergoing elective bariatric surgery. Thirdly, anesthesiologists performing endotracheal intubation differed in their experience using various laryngoscopes; the groups in which various types of laryngoscopes were used varied in size.

CONCLUSIONS

Our meta-analysis suggests that Video-assisted intubation may be superior to direct laryngoscopy-guided intubation in obese patients due to a higher first-attempt success rate improved glottis visualization, and a lower rate of intubation-related injuries.

Author Contributions

For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, T.E., and L.S.; methodology, T.E., and L.S.; software, L.S.; validation, T.E., L.S., and B.K.; formal analysis, T.E., and L.S.; investigation, T.E., B.K., and L.S.; resources, T.E., B.K. and L.S..; data curation, T.E., and L.S.; writing—original draft preparation, T.E., L.S. and B.K.; writing—review and editing, all authors; visualization, L.S. and B.K.; supervision, T.E. and B.K.; project administration, L.S. and T.E. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors declare no conflict of interest.

REFERENCES

1. Wang T, Sun S, Huang S. The association of body mass index with difficult tracheal intubation management by direct laryngoscopy: a meta-analysis. BMC Anesthesiol. 2018; 18(1): 79, doi: 10.1186/s12871-018-0534-4, indexed in Pubmed: 29960594.
2. Hruby A, Hu FB. The Epidemiology of Obesity: A Big Picture. Pharmacoeconomics. 2015; 33(7): 673–689, doi: 10.1007/s40273-014-0243-x, indexed in Pubmed: 25471927.
3. Szarpak L, Drozd A, Smereka J. Airway management and ventilation principles in COVID-19 patients. J Clin Anesth. 2020; 65: 109877, doi: 10.1016/j.jclinane.2020.109877, indexed in Pubmed: 32446177.
4. Ludwin K, Bialka S, Czyzewski L, et al. Video laryngoscopy for endotracheal intubation of adult patients with suspected/ confirmed COVID-19. A systematic review and meta-analysis of randomized controlled trials. Disaster and Emergency Medicine Journal. 2020, doi: 10.5603/demj.a2020.0023.
5. Maslanka M, Smereka J, Pruc M, et al. Airtraq® versus Macintosh laryngoscope for airway management during general anesthesia: A systematic review and meta-analysis of randomized controlled trials. Disaster and Emergency Medicine Journal. 2021, doi: 10.5603/demj.a2021.0001.
6. Güngörer B, Findik M, Kayipmaz A. USB-endoscope laryngoscope is as effective as video laryngoscope in difficult intubation. Disaster and Emergency Medicine Journal. 2021; 6(2): 75–79, doi: 10.5603/demj.a2021.0012.
7. Niforopoulou P, Pantazopoulos I, Demestiha T, et al. Video-laryngoscopes in the adult airway management: a topical review of the literature. Acta Anaesthesiol Scand. 2010; 54(9): 1050–1061, doi: 10.1111/j.1399-6576.2010.02285.x, indexed in Pubmed: 20887406.
8. Huitink JM, Koopman EM, Bouwman RA, et al. Tracheal intubation with a camera embedded in the tube tip (Vivasight(™)). Anaesthesia. 2013; 68(1): 74–78, doi: 10.1111/anae.12065, indexed in Pubmed: 23121322.
9. Liu EHC, Goy RWL, Chen FG. The LMA CTrach, a new laryngeal mask airway for endotracheal intubation under vision: evaluation in 100 patients. Br J Anaesth. 2006; 96(3): 396–400, doi: 10.1093/bja/ael001, indexed in Pubmed: 16415313.
10. Page MJ, McKenzie JE, Bossuyt PM, et al. Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. J Clin Epidemiol. 2021; 134(3): 103–112, doi: 10.1016/j.jclinepi.2021.02.003, indexed in Pubmed: 33577987.
11. Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019; 366: l4898, doi: 10.1136/bmj.l4898, indexed in Pubmed: 31462531.
12. McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and shiny web app for visualizing risk-of-bias assessments. Res Synth Methods. 2021; 12(1): 55–61, doi: 10.1002/jrsm.1411, indexed in Pubmed: 32336025.
13. Atkins D, Briss PA, Eccles M, et al. GRADE Working Group. Systems for grading the quality of evidence and the strength of recommendations II: pilot study of a new system. BMC Health Serv Res. 2005; 5(1): 25, doi: 10.1186/1472-6963-5-25, indexed in Pubmed: 15788089.

14. Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. BMC Med Res Methodol. 2005; 5: 13, doi: 10.1186/1471-2288-5-13, indexed in Pubmed: 15840177.
15. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.2 (updated February 2021). Cochrane, 2021. www.training.cochrane.org/handbook (20.09.2021).
16. Higgins JPT, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. BMJ. 2003; 327(7414): 557–560, doi: 10.1136/bmj.327.7414.557, indexed in Pubmed: 12958120.
17. Abdallah R, Galway U, You J, et al. A randomized comparison between the Pentax AWS video laryngoscope and the Macintosh laryngoscope in morbidly obese patients. Anesth Analg. 2011; 113(5): 1082–1087, doi: 10.1213/ANE.0b013e31822cf47d, indexed in Pubmed: 21918156.
18. Ander F, Magnuson A, Berggren L, et al. Time-to-intubation in obese patients. A randomized study comparing direct laryngoscopy and videolaryngoscopy in experienced anesthetists. Minerva Anestesiol. 2017; 83(9): 906–913, doi: 10.23736/S0375-9393.17.11740-2, indexed in Pubmed: 28358178.
19. Andersen LH, Rovsing L, Olsen KS. GlideScope videolaryngoscope vs. Macintosh direct laryngoscope for intubation of morbidly obese patients: a randomized trial. Acta Anaesthesiol Scand. 2011; 55(9): 1090–1097, doi: 10.1111/j.1399-6576.2011.02498.x, indexed in Pubmed: 22092206.
20. Barak M, Assalia A, Mahajna A, et al. The use of VivaSight™ single lumen endotracheal tube in morbidly obese patients undergoing laparoscopic sleeve gastrectomy. BMC Anesthesiol. 2014; 14: 31, doi: 10.1186/1471-2253-14-31, indexed in Pubmed: 24817827.
21. Bathory I, Granges JC, Frascarolo P, et al. Evaluation of the Video Intubation Unit in morbid obese patients. Acta Anaesthesiol Scand. 2010; 54(1): 55–58, doi: 10.1111/j.1399-6576.2009.02119.x, indexed in Pubmed: 19764907.
22. Çakir M, Özyurt E. Comparison of direct laryngoscope and McGrath videolaryngoscope in terms of glottic view and hemodynamics in bariatric surgery. Turk J Med Sci. 2020; 50(1): 213–218, doi: 10.3906/sag-1905-77, indexed in Pubmed: 31931553.
23. Castillo-Monzón CG, Marroquín-Valz HA, Fernández-Villacañas-Marín M, et al. Comparison of the macintosh and airtraq laryngoscopes in morbidly obese patients: a randomized and prospective study. J Clin Anesth. 2017; 36: 136–141, doi: 10.1016/j.jclinane.2016.10.023, indexed in Pubmed: 28183552.
24. Dhonneur G, Abdi W, Ndoko SK, et al. Video-assisted versus conventional tracheal intubation in morbidly obese patients. Obes Surg. 2009; 19(8): 1096–1101, doi: 10.1007/s11695-008-9719-0, indexed in Pubmed: 18836785.
25. Marrel J, Blanc C, Frascarolo P, et al. Videolaryngoscopy improves intubation condition in morbidly obese patients. Eur J Anaesthesiol. 2007; 24(12): 1045–1049, doi: 10.1017/S0265021507000889, indexed in Pubmed: 17608975.
26. Nandakumar KP, Bhalla AP, Pandey RK, et al. Comparison of Macintosh, McCoy, and Glidescope video laryngoscope for intubation in morbidly obese patients: Randomized controlled trial. Saudi J Anaesth. 2018; 12(3): 433–439, doi: 10.4103/sja.SJA_754_17, indexed in Pubmed: 30100843.
27. Ndoko SK, Amathieu R, Tual L, et al. Tracheal intubation of morbidly obese patients: a randomized trial comparing performance of Macintosh and Airtraq laryngoscopes. Br J Anaesth. 2008; 100(2): 263–268, doi: 10.1093/bja/aem346, indexed in Pubmed: 18211999.
28. Wallace CD, Foulds LT, McLeod GA, et al. A comparison of the ease of tracheal intubation using a McGrath MAC(®)laryngoscope and a standard Macintosh laryngoscope. Anaesthesia. 2015; 70(11): 1281–1285, doi: 10.1111/anae.13209.
29. Ranieri D, Filho SM, Batista S, et al. Comparison of Macintosh and Airtraq™ laryngoscopes in obese patients placed in the ramped position. Anaesthesia. 2012; 67(9): 980–985, doi: 10.1111/j.1365-2044.2012.07200.x, indexed in Pubmed: 22670846.
30. Ruetzler K, Rivas E, Cohen B, et al. McGrath video laryngoscope versus Macintosh direct laryngoscopy for intubation of morbidly obese patients: a randomized trial. Anesth Analg. 2020; 131(2): 586–593, doi: 10.1213/ANE.0000000000004747, indexed in Pubmed: 32175948.
31. Yousef GT, Abdalgalil DA, Ibrahim TH. Orotracheal intubation of morbidly obese patients, comparison of GlideScope(®) video laryngoscope and the LMA CTrach™ with direct laryngoscopy. Anesth Essays Res. 2012; 6(2): 174–179, doi: 10.4103/0259-1162.108304, indexed in Pubmed: 25885612.
32. Yumul R, Elvir-Lazo OL, White PF, et al. Comparison of three video laryngoscopy devices to direct laryngoscopy for intubating obese patients: a randomized controlled trial. J Clin Anesth. 2016; 31: 71–77, doi: 10.1016/j.jclinane.2015.12.042, indexed in Pubmed: 27185681.
33. Hoshijima H, Denawa Y, Tominaga A, et al. Videolaryngoscope versus Macintosh laryngoscope for tracheal intubation in adults with obesity: A systematic review and meta-analysis. Journal of Clinical Anesthesia. 2018; 44: 69–75, doi: 10.1016/j.jclinane.2017.11.008.
34. Brettig S, Shurgott M, Quinn SJ, et al. Validation of a difficult endotracheal intubation simulator designed for use in anaesthesia training. Anaesth Intensive Care. 2017; 45(2): 228–234, doi: 10.1177/0310057X1704500213, indexed in Pubmed: 28267945.
35. Pieters B, Maassen R, Van Eig E, et al. Indirect videolaryngoscopy using Macintosh blades in patients with non-anticipated difficult airways results in significantly lower forces exerted on teeth relative to classic direct laryngoscopy: a randomized crossover trial. Minerva Anestesiol. 2015; 81(8): 846–854, indexed in Pubmed: 25311949.
36. Aleksandrowicz D, Gaszyński T. The pressure exerted on the tongue during intubation with simultaneous cervical spine immobilisation: a comparison between four videolaryngoscopes and the Macintosh laryngoscope—a manikin study. Journal of Clinical Monitoring and Computing. 2017; 32(5): 907–913, doi: 10.1007/s10877-017-0095-y.
37. Carassiti M, Biselli V, Cecchini S, et al. Force and pressure distribution using Macintosh and GlideScope laryngoscopes in normal airway: an in vivo study. Minerva Anestesiol. 2013; 79(5): 515–524, indexed in Pubmed: 23419341.