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ORIGINAL ARTICLE

Videolaryngoscopy vs. direct laryngoscopy in orotracheal intubation in obese critical patients: Systematic review and meta-analysis

Samuel David Gil-Bazán[a], Gustavo Adolfo Vásquez-Tirado[a,b,*], Edward Chávez-Cruzado[a], Edinson Dante Meregildo-Rodríguez[c], Claudia Vanessa Quispe-Castañeda[a], Wilson Marcial Guzmán-Aguilar[b], Leslie Jacqueline Liñán-Díaz[a,b]

[a] *Facultad de Medicina Humana, Universidad Privada Antenor Orrego, Trujillo, Peru*
[b] *Unidad de Cuidados Intensivos, Hospital Regional Docente de Trujillo, Trujillo, Peru*
[c] *Escuela de Posgrado, Universidad Señor de Sipán, Lambayeque, Peru*

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KEYWORDS
Video laryngoscopy;
Direct laryngoscopy;
Orotracheal intubation;
Obesity

Abstract
Objective: To determine whether the use of videolaryngoscopy (VL) is more effective than direct laryngoscopy (DL) for orotracheal intubation in obese patients.
Design: This is a systematic review and meta-analysis.
Setting: A comprehensive search was conducted in five databases for studies published up to December 26, 2023, using a PICO strategy. Fifteen studies were identified for quantitative analysis and included in our meta-analysis.
Participants: The participants of the included primary studies (obese patients).
Interventions: Orotracheal intubation with videolaryngoscopy or direct laryngoscopy.
Main variables of interest: Videolaryngoscopy, direct laryngoscopy, intubation time, first-pass success rate, minor complications.
Results: No significant differences were found in intubation time between VL and DL in obese patients (MD: −4.84; 95% CI: −13.49 to 3.80; I^2: 90%). In the subgroup analysis, the Airtaq technique showed a significant difference in intubation time compared to the Macintosh technique (MD: −25.29; 95% CI: −49.17 to −1.38; I^2: 95%). However, no significant differences were observed in the first-pass success rate (OR: 1.58; 95% CI: 0.77–3.23; I^2: 33%) or in complications such as pain (OR: 1.15; 95% CI: 0.75–1.75; I^2: 0%) and voice changes (OR: 0.76; 95% CI: 0.46–1.26; I^2: 0%) between the two methods.

* Corresponding author.
E-mail address: gavt13@gmail.com (G.A. Vásquez-Tirado).

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Conclusion: There are no significant differences in intubation time, first-pass success rate, or complications between VL and DL in obese critical patients.

PALABRAS CLAVE
Video laringoscopía;
Laringoscopia directa;
Intubación orotraqueal;
Obesidad

Video laringoscopía vs. laringoscopía directa en la intubación orotraqueal en pacientes obesos: revisión sistemática y metaanálisis

Resumen
Objetivo: Determinar si el uso de video laringoscopia es más eficaz que la laringoscopia directa en la intubación orotraqueal en pacientes obesos.
Diseño: Se trata de una revisión sistemática y meta-análisis.
Ámbito: Se realizó una búsqueda exhaustiva en cinco bases de datos para estudios publicados hasta el 26 de diciembre de 2023, utilizando una estrategia PICO. Se identificaron quince estudios para análisis cuantitativo e incluidos en nuestro meta-análisis.
Participantes: Los participantes de los estudios primarios incluidos (pacientes obesos).
Intervenciones: Intubación orotraqueal con video laringoscopía o laringoscopia directa.
Variables de interés principales: Video laringoscopía, laringoscopia directa, tiempo de intubación, tasa de éxito en el primer intento de intubación, complicaciones menores.
Resultados: No se encontraron diferencias significativas en el tiempo de intubación entre VL y DL en pacientes obesos (MD: −4.84; IC 95%: −13.49 a 3.80; I^2: 90%). En el análisis por subgrupos, la técnica Airtaq mostró una diferencia significativa en el tiempo de intubación en comparación con la técnica Macintosh (MD: −25.29; IC 95%: −49.17 a −1.38; I^2: 95%). Sin embargo, no se observaron diferencias significativas en el éxito del primer intento de intubación (OR: 1.58; IC 95%: 0.77 a 3.23; I^2: 33%) ni en complicaciones como dolor (OR: 1.15; IC 95%: 0.75 a 1.75; I^2: 0%) y cambios en la voz (OR: 0.76; IC 95%: 0.46 a 1.26; I^2: 0%) entre los dos métodos.
Conclusión: No existen diferencias significativas en el tiempo de intubación, la tasa de éxito en el primer intento, ni en las complicaciones entre VL y DL en pacientes obesos críticos.

Introduction

Obesity is an escalating global health issue, currently affecting 13% of adults worldwide, according to the World Health Organization (WHO). It is characterized by an excessive accumulation of body fat, assessed using the Body Mass Index (BMI). A BMI of $\geq$30 kg/m^2 categorizes obesity into grades I to III, depending on its severity.[1,2]

Airway management in obese patients presents significant clinical challenges due to anatomical and physiological factors, including increased neck circumference, submental fat deposition, and restrictive lung mechanics.[3,4] These features complicate airway access and elevate the risks of complications such as desaturation, hypertension or hypotension, airway trauma, hypoxemia, bronchoaspiration, arrhythmias, cardiac arrest, and mortality. Therefore, optimal airway management strategies are crucial in obese patients, as they are often considered to have inherently difficult airways.[5,6]

Two primary techniques are used for intubation: direct laryngoscopy (DL) and video laryngoscopy (VL). DL, the traditionally preferred method, requires aligning anatomical structures visually with tools like the Macintosh curved blade.[7,8] While effective in skilled hands, DL can be physically demanding, particularly in challenging cases. In contrast, VL employs a video camera to enhance glottis visualization, reducing the force needed to manipulate soft tissues and providing a broader field of view.[7–10]

VL offers significant advantages over DL, particularly in patients with difficult airways. It provides a direct and enhanced view of the vocal cords, facilitating successful orotracheal intubation while reducing the number of failed attempts.[11,12] Additionally, VL has been associated with lower rates of post-intubation pain and laryngeal trauma, making it especially beneficial for patients with predictably difficult airways, such as those with obesity.[11–15]

In obese patients, the time to achieve successful intubation is critical due to the increased risk of hypoxia resulting from reduced lung capacity. The American Society of Anesthesiology recommends limiting each attempt to no more than 60 seconds, as prolonged attempts raise the risk of complications such as hypoxemia and airway trauma. Achieving intubation on the first attempt is particularly crucial, as it significantly lowers the likelihood of complications. Factors such as the operator's expertise and the use of advanced techniques like VL improve success rates and reduce risks associated with multiple attempts.[16–18]

Obese patients are at a higher risk of complications during intubation, with rates ranging from 10% to 30%. These complications include hypoxemia, aspiration, and airway trauma, and they are more likely to occur with multiple intubation attempts, underscoring the importance of efficient airway management.[19,20]

Given the current lack of comprehensive secondary studies directly comparing DL and VL in obese patients,[11,21] combined with the growing body of primary research on this topic, this study proposes a systematic review and meta-analysis. The objective is to evaluate the effectiveness of these techniques, focusing on factors such as intubation time, first-attempt success rates, and associated complications.

Methods

Our systematic review adhered to the methodological standards outlined in the Cochrane Handbook for Systematic Reviews and the PRISMA guidelines. An advanced search was conducted in selected databases (PubMed, Scopus, Embase, Web of Science, and Ovid/Medline) using both controlled vocabulary (e.g., MeSH) and free terms based on the PICO framework: Patients (obese patients), Intervention (video laryngoscopy), Comparator (direct laryngoscopy), and Outcome (intubation time, first-attempt success, and post-intubation complications).

Articles identified through the advanced search were imported into Rayyan software for independent review by two authors. After duplicate removal, titles and abstracts were screened blindly by two reviewers based on inclusion and exclusion criteria. Discrepancies were resolved through discussion with a third author until consensus was reached. Selected articles were then assessed in full text to confirm their eligibility. To enhance study identification, reference lists and citations of included articles were manually searched. The selection process is detailed in Fig. 1.

Selection criteria

The review included randomized clinical trials from databases comparing the efficacy of VL and DL for orotracheal intubation in obese adult patients of both sexes, with no restrictions on date or language. Articles published until January 2024 were considered. Excluded studies were primary case-control, cohort, case reports, case series, descriptive cross-sectional, analytical studies, abstracts, letters to the editor, systematic reviews, narrative reviews, scoping reviews, pediatric studies, and unpublished or incomplete studies.

Outcomes

The primary outcome was intubation time, measured in seconds from the insertion of the endotracheal tube into the oral cavity to confirmation of tube placement in the trachea via the capnograph's end-tidal carbon dioxide curve. Secondary outcomes included first-attempt intubation success and complications such as tissue injury and voice changes.

Data extraction

Two independent investigators extracted relevant data from each included study using a standardized, blinded spreadsheet. Data collected included study details (author, country, publication year, design, total patients), participant characteristics (video vs. DL, sex, age, BMI), and outcomes (time to successful intubation, first-attempt success, and complications). For dichotomous variables, odds ratios (OR) with 95% confidence intervals (CI) were calculated. For continuous variables, means and standard deviations (SD) were recorded, converting medians and interquartile ranges (IQR) when necessary. Missing data were reported as applicable.

Statistical analysis

The data included in our study were processed using RStudio v4.2, and forest plots were created for each outcome variable. Subgroup analyses were conducted when necessary. Heterogeneity was assessed using the I^2 statistic, with values below 40% indicating low heterogeneity, values between 30% and 60% representing moderate heterogeneity, and values above 60% indicating high heterogeneity. Additionally, funnel plots were generated for the selected studies to visually inspect for potential publication bias.

Quality assessment

The risk of bias will be assessed using the Cochrane RoB 2.0 tool[22] for randomized clinical trials (RCTs), which evaluates five key domains.

Results

Search results and study characteristics

A total of 15 randomized clinical trials[23–37] were included, comprising 1,382 participants from studies conducted in France, Turkey, the United States, Spain, Brazil, Egypt, India, Denmark, Israel, and Sweden, published between 2008 and 2020. The extracted data were organized into two tables: one qualitative and one quantitative. The qualitative table detailed key characteristics of each study, including the author, country, study design, total participants (with a breakdown by sex), and the number of participants assigned to each intubation technique (Table 1). The quantitative table included information on intubation time, first-attempt success rates, and complications following intubation (Table 2).

Risk of bias in studies

The risk of bias was assessed in 15 randomized clinical trials using the RoB2 tool. Most studies showed a low risk of

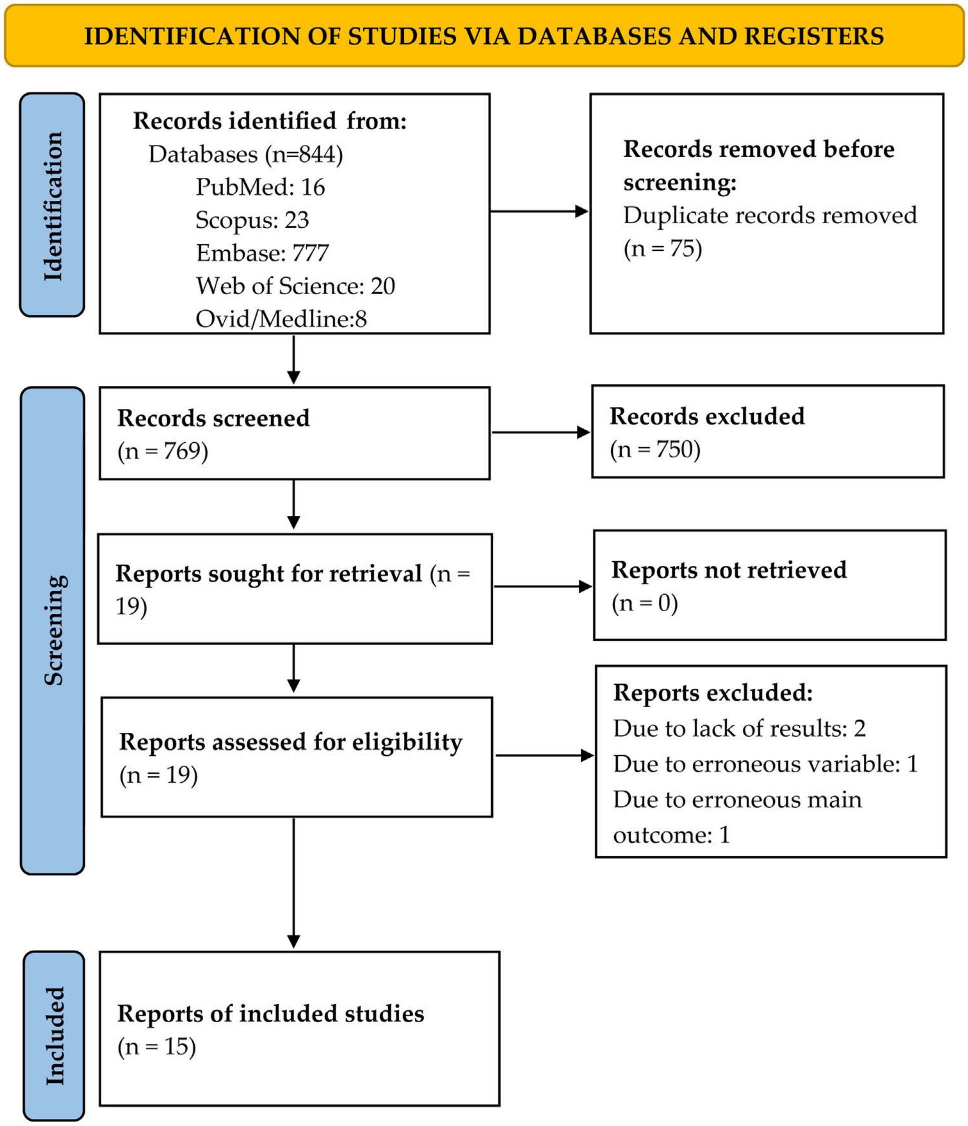

Figure 1 PRISMA 2020 flow: diagram of the selection process of the primary studies included.

bias across all domains, except for the "measurement of outcomes" domain, where four studies[26,28,32,36] were rated as unclear. The remaining domains (randomization, deviations, missing data, and selection of outcomes) showed a low risk of bias in all studies. The other eleven studies had a low risk of bias overall and in each domain. (Table 3)

Intubation time

All studies included in the meta-analysis contributed data for this outcome. A pooled analysis was performed, followed by subgroup analyses based on the VL technique used.

In the overall analysis, no significant difference was observed in intubation time for obese patients between the VL group and the DL group (MD: −4.84; 95% CI: −13.49 to 3.80; I^2: 97%) (Fig. 2A).

In the subgroup analysis by VL type (Fig. 2B):

- **MacGrath vs. Macintosh:** No significant difference in intubation time was found (MD: 6.83; 95% CI: −7.57 to 21.23; I^2: 88%).
- **GlideScope vs. Macintosh:** No significant difference in intubation time was observed (MD: −0.75; 95% CI: −32.34 to 30.85; I^2: 79%).
- **Airtraq vs. Macintosh:** A significant difference in intubation time was identified, favoring the Airtraq technique (MD: −25.29; 95% CI: −49.17 to −1.38; I^2: 95%).

First-attempt successful intubation

Nine studies[24,25,27,28,31,33–35,37] from the meta-analysis reporting this outcome were included. The analysis revealed no significant difference in first-attempt intubation success rates between obese patients who underwent VL and those who underwent DL (OR: 1.58; 95% CI: 0.77–3.23; I^2: 33%) (Fig. 3).

Table 1 General characteristics of included studies.

Author	Year	Country	Study design	Population	Intubation type	N° of patients	Sex (F/M)	BMI	Age
Dhonneur[43]	2008	France	RCT	212	DL: Macintosh	106	70/36	40 ± 7	38 ± 28
					VL: Airtaq	106	66/40	43 ± 6	41 ± 29
Ndoko[31]	2008	France	RCT	106	DL: Macintosh	53	33/20	43 ± 7	42 ± 24
					VL: Airtaq	53	16/37	44 ± 6	44 ± 34
Bathory[32]	2010	Sweden	RCT	38	DL: Macintosh	20	18/2	43.7 ± 4.8	42.7 ± 8.0
					VL: VIU	18	14/4	44.5 ± 5.2	37.7 ± 9.9
Andersen[33]	2011	Denmark	RCT	100	DL: Macintosh	50	41/9	41 ± 5	41 ± 8
					VL: GlideScope	50	35/15	42 ± 6	42 ± 10
Abdallah[34]	2011	USA	RCT	99	DL: Macintosh	49	39/10	42.5 ± 5.9	49 ± 14
					VL: Pentax AWS	50	39/11	41.2 ± 4.4	50 ± 12
Ranieri[35]	2012	Brazil	RCT	132	DL: Macintosh	64	48/16	42.7 ± 4.4	34.9 ± 9.4
					VL: Airtaq	68	53/15	43.5 ± 6.3	35.4 ± 8.8
Yousef[36]	2012	Egypt	RCT	60	DL: Macintosh	30	13/17	43.6 ± 9.5	51 ± 35
					VL: GlideScope	30	15/15	43.2 ± 7.4	44 ± 33
Barak[37]	2014	Israel	RCT	72	DL: Macintosh	32	23/9	43 ± 6.8	42.5 ± 3.2
					VL: VivaSight	40	26/14	44.8 ± 7.5	43.1 ± 4.9
Arici[23]	2014	Turkey	RCT	82	DL: Macintosh	40	16/24	27.98 ± 3.22	29.25 ± 4.41
					VL: McGrath	40	12/28	29.45 ± 5.60	27.55 ± 3.82
Yumul[24]	2016	USA	RCT	61	LD: Macintosh	31	23/8	42 ± 5	46 ± 12
					VL: GlideScope	30	23/7	43 ± 5	45 ± 12
					VL: MacGrath	30	20/10	41 ± 6	45 ± 12
					VL: Video-Mac	30	23/7	43 ± 8	44 ± 12
Castillo[25]	2017	Spain	RCT	46	DL: Macintosh	23	17/6	46.87 ± 4.38	41.57 ± 9.02
					VL: Airtaq	23	18/5	45.97 ± 3.61	43.4 ± 12.77
Ander[26]	2017	Sweden	RCT	80	DL: Macintosh	40	26/14	39.9 ± 4.0	42 ± 13
					VL: C-MAC	40	30/10	42.2 ± 5.6	42 ± 12
Nandakumat[27]	2018	India	RCT	30	DL: Macintosh	15	12/3	44.67 ± 6.64	40.6 ± 11.6
					VL: McCoy	15	12/3	43.11 ± 9.04	48.93 ± 9.33
					VL: GlideScope	15	12/3	46.91 ± 6.92	42.0 ± 13.25
Ruetzler[28]	2020	USA	RCT	129	DL: Macintosh	63	46/17	47 ± 6	47 ± 13
					VL: McGrath	66	49/17	46.7 ± 7	51 ± 14
Çakir[29]	2020	Turkey	RCT	62	DL: Macintosh	31	3/28	46.5 ± 4.2	39.0 ± 9.8
					VL: McGrath	31	7/24	46.1 ± 6.6	42.0 ± 10.5

Pain as an intubation complication

Six studies[24,26,28,34,36,37] from the meta-analysis were included as they evaluated this outcome. In the overall analysis, no significant difference was observed in the incidence of pain as an intubation complication between obese patients who underwent VL and those who underwent DL (OR: 1.15; 95% CI: 0.75–1.75; I^2: 0%) (Fig. 4A).

In the subgroup analysis based on the VL technique used (Fig. 4B):

- **GlideScope vs. Macintosh:** A significant difference was found, with a higher incidence of pain in the GlideScope group compared to the Macintosh group (OR: 1.59; 95% CI: 1.44–1.75; I^2: 0%).
- **MacGrath vs. Macintosh:** No significant difference was observed in the incidence of pain (OR: 0.34; 95% CI: 0.00–12.00; I^2: 75%).

Voice changes as an intubation complication

Five studies[24,28,33,36,37] evaluated voice changes as an intubation complication. The overall analysis showed no significant difference between obese patients who underwent VL and those who underwent DL (OR: 0.76; 95% CI: 0.46–1.26; I^2: 0%) (Fig. 5A).

In the subgroup analysis by VL technique (Fig. 5B):

- **GlideScope vs. Macintosh:** No significant difference was found in voice changes as a complication (OR: 0.52; 95% CI: 0.13–2.09; I^2: 0%).
- **MacGrath vs. Macintosh:** Similarly, no significant difference was observed (OR: 0.90; 95% CI: 0.30–2.68; I^2: 0%).

Publication bias

When evaluating the intubation time of VL vs. DL, we found no publication bias, as assessed through the funnel plot and

Table 2 Quantitative statistical characteristics of included studies.

Author	Intubation type	Intubation time (seconds) (media ± SD)	Complications		Successful intubation on the first attempt (n)
			Sore throat (n)	Voice changes (n)	
			–	–	–
	VL: Airtaq	29 ± 12	–	–	–
Ndoko[31]	DL: Macintosh	56 ± 23	–	–	49
	VL: Airtaq	24 ± 16	–	–	53
Bathory[32]	DL: Macintosh	48.6402 ± 19.9462	–	–	–
	VL: VIU	44.8557 ± 16.0892	–	–	–
Andersen[33]	DL: Macintosh	89.3318 ± 96	–	16	46
	VL: GlideScope	74.1886 ± 96.1764	–	12	49
Abdallah[34]	DL: Macintosh	25.646 ± 5.3463	16	–	45
	VL: Pentax AWS	39.7695 ± 14.5028	16	–	43
Ranieri[35]	DL: Macintosh	36.9 ± 22.8	–	–	54
	VL: Airtaq	13.7 ± 3.1	–	–	68
Yousef[36]	DL: Macintosh	110.695 ± 54.4894	5	4	–
	VL: GlideScope	89.9215 ± 36.5858	7	1	–
Barak[37]	DL: Macintosh	24 ± 8	3	0	31
	VL: VivaSight	29 ± 10	2	0	39
Arici[23]	DL: Macintosh	32.2 ± 6.58	–	–	–
	VL: McGrath	47.25 ± 14.92	–	–	–
Yumul[24]	DL: Macintosh	70 ± 43	5	4	23
	VL: GlideScope	69 ± 34	7	1	28
	VL: MacGrath	62 ± 31	11	3	21
	VL: Video-Mac	49 ± 25	6	5	28
Castillo[25]	DL: Macintosh	22.11 ± 13.62	–	–	21
	VL: Airtaq	17.27 ± 16.1	–	–	21
Ander[26]	DL: Macintosh	26.7 ± 14.7	6	–	–
	VL: C-MAC	25 ± 8.3	9	–	–
Nandakumat[27]	DL: Macintosh	31.81 ± 8.57	–	–	13
	VL: McCoy	53.6 ± 19.27	–	–	12
	VL: GlideScope	35.27 ± 8.29	–	–	11
Ruetzler[28]	DL: Macintosh	27 ± 7.587	26	19	56
	VL: McGrath	28.7059 ± 7.579	29	19	61
Çakir[29]	DL: Macintosh	45.9 ± 19.1	–	–	–
	VL: McGrath	57.1 ± 15.8	–	–	–

Egger's test calculation: −0.64; 95% CI −6.1 to −4.8; p > 0.1 (Fig. 6)

Discussion

Orotracheal intubation is a critical procedure in anesthesia and critical care, particularly in obese patients who face unique challenges due to their anatomy and increased risk of complications.[20,21,38] VL has emerged as an alternative to DL, offering improved airway visualization that may facilitate intubation in this high-risk population. However, the effectiveness of these techniques regarding intubation time, first-attempt success rates, and associated complications remains a topic of debate.[14,21,38]

Our SR-Ms, which included a total of 15 RCTs involving 1,382 obese patients undergoing orotracheal intubation, demonstrated that in the analysis of intubation time, no significant differences were observed between VL and DL (MD −4.84; 95% CI −13.49 to 3.8; I^2: 97%). Similarly, regarding first-attempt intubation success, no significant differences were found between VL and DL (OR 1.58; 95% CI 0.77–3.23; I^2: 33%).

This finding supports existing literature indicating high success rates regardless of the technique used. Operator skill and experience remain pivotal determinants of intubation outcomes in this population, emphasizing the need for robust training and clinical practice.[14,15,39]

Carron et al.[40] presents the results of their meta-analysis of 8 RCTs comparing VL and DL for orotracheal intubation in obese patients, published as a letter to the editor. The study shows that VL improves glottic visualization, particularly in patients with Cormack-Lehane grade 1. However, first-attempt intubation success was observed only with the use of the C-MAC (OR 1.13; 95% CI 1.01–1.25; I^2: 18%), losing significance with McGrath and GlideScope devices. Additionally, no statistically significant differences were found in intubation time between VL and DL.

Table 3 Risk of bias of the included studies using Risk of bias tool version 2 (RoB2) of Cochrane.

Study ID	D1	D2	D3	D4	D5	Overall
Ander[26] 2017	+	+	+	!	+	!
Ruetzler[28] 2020	+	+	+	!	+	!
Yumul[24] 2016	+	+	+	+	+	+
Andersen[33] 2011	+	+	+	+	+	+
Çakir[29] 2020	+	+	+	+	+	+
Barak[37] 2014	+	+	+	+	+	+
Bathory[32] 2010	+	+	+	!	+	!
Castillo[25] 2017	+	+	+	+	+	+
Abdallah[34] 2011	+	+	+	+	+	+
Nandakumat[27] 2018	+	+	+	+	+	+
Dhonneur[43] 2009	+	+	+	+	+	+
Renieri[35] 2012	+	+	+	+	+	+
Yousef[36] 2012	+	+	+	!	+	!
Ndoko[31] 2018	+	+	+	+	+	+
Arici[23] 2014	+	+	+	+	+	+

+ Low risk, ! some concerns; D1, Randomization process; D2, Deviations from the intended interventions; D3, missing outcome data; D4, measurement of the outcome; D5, selection of the reported result.

Similarly, Hojishima et al.[41] conducted a meta-analysis incorporating eight RCTs up to 2018, finding that VL was superior to DL in first-attempt intubation success rates (RR 1.11; 95% CI 1.04–1.18; I^2: 63%) and demonstrated a statistically significant reduction in intubation time (MD −16.1; 95% CI −31.1 to −1.1; I^2: 97%), albeit with low to very low evidence quality. Compared to our study, we incorporated more recent RCTs, assessed selection bias by including over ten RCTs, and conducted a more thorough evaluation of heterogeneity.

A recent SR-Ms by Chaudery et al.[38] evaluated the efficacy of VL versus direct DL in obese patients, reporting that VL was associated with a higher probability of first-attempt intubation (RR 0.42; 95% CI 0.22–0.78; I^2: 34%), no statistically significant difference was observed in intubation time between groups (SMD 0.13; 95% CI −0.26 to 0.52; I^2: 93%). While Chaudery et al.[38] included approximately 18 RCTs, it is essential to note that the pooled RR may have been calculated with errors, as the events in the experimental and control groups appear to have been inconsistently reported in the primary studies referenced (e.g., Andersen et al.,[33] Castillo et al.,[25] Korkusuz et al.,[42] Ndoko et al.,[31] Ranieri et al.[35]). Additionally, some studies, such as Ander et al.,[26] used a different definition of first-attempt intubation that included success within the first 60 seconds, while others, such as Korkusuz et al.,[42] involved study arms using stylets. Consequently, our findings are not directly comparable to those of the aforementioned SR-Ms.

In contrast, when examining the results of SR-MAs conducted on the general population, evidence suggests that VL outperforms DL in outcomes such as failed intubation, first-attempt success, and complications. Hansel et al.,[21] in a Cochrane SR-MA of 222 RCTs involving approximately 26,149 patients, found a lower risk of failed intubation with VL (all models) compared to DL (RR 0.44; 95% CI 0.35–0.56; I^2: 22%). Moreover, VL demonstrated a higher likelihood of first-attempt success compared to DL (RR 1.05; 95% CI 1.03–1.07; I^2: 81%). This review primarily included RCTs conducted in the operating room; however, it did not report pooled RR for obese patients in its subgroup analysis.

On the other hand, Arulkumaran et al.[14] conducted an SR-MA comparing VL and DL in emergency settings (outside the operating room), suggesting that although the advantage of VL lies in direct visualization, this does not necessarily translate into higher first-attempt intubation success. They further noted situations where DL might outperform VL, particularly when performed by experienced personnel. After analyzing 32 studies (both observational and RCTs) involving 15,604 patients, their results diverged from Hansel's findings, showing no statistically significant difference between the two techniques in achieving first-attempt success in emergency patients (OR 1.28; 95% CI 0.99–1.65). However,

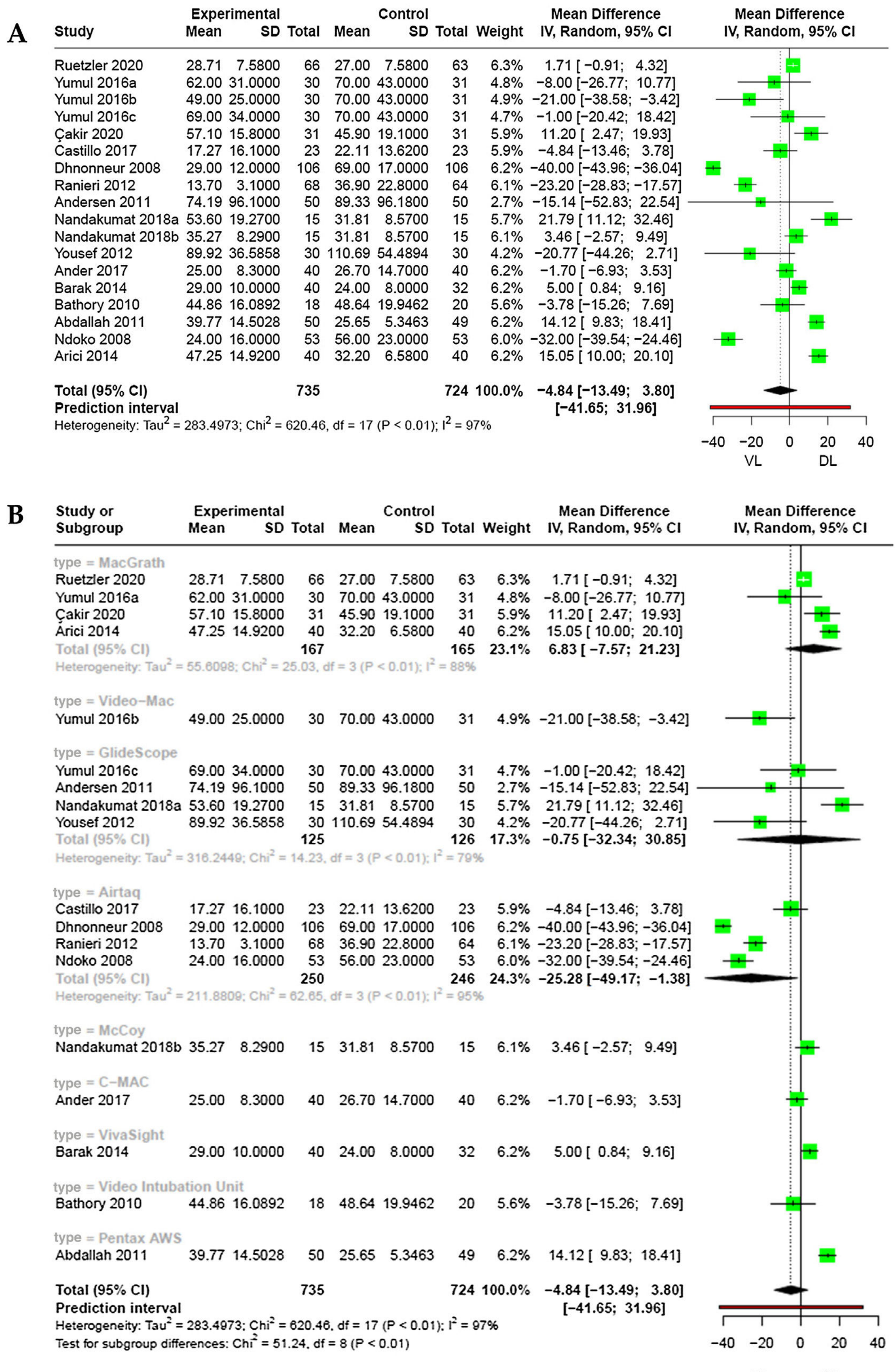

Figure 2 (A) Forest plot of overall analysis for intubation time in obese patients comparing VL and DL. (B) Subgroup analysis of intubation time by VL technique in Obese Patients.

Study	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Odds Ratio MH, Random, 95% CI
Ruetzler 2020	61	66	56	63	13.8%	1.52 [0.46; 5.08]
Yumul 2016a	21	30	23	31	14.8%	0.81 [0.26; 2.49]
Yumul 2016b	28	30	23	31	9.4%	4.87 [0.94; 25.22]
Yumul 2016c	28	30	23	31	9.4%	4.87 [0.94; 25.22]
Barak 2014	39	40	31	32	4.1%	1.26 [0.08; 20.93]
Andersen 2011	49	50	46	50	6.0%	4.26 [0.46; 39.54]
Castillo 2017	21	23	21	23	6.8%	1.00 [0.13; 7.78]
Abdallah 2011	43	50	45	49	12.7%	0.55 [0.15; 2.00]
Nandakumat 2018	11	15	13	15	7.8%	0.42 [0.06; 2.77]
Nandakumat 2018b	12	15	13	15	7.4%	0.62 [0.09; 4.34]
Ranieri 2012	68	68	54	64	4.0%	26.39 [1.51; 460.54]
Ndoko 2008	53	53	49	53	3.8%	9.73 [0.51; 185.33]
Total (95% CI)		**470**		**457**	**100.0%**	**1.58 [0.77; 3.23]**
Prediction interval						**[0.37; 6.76]**

Heterogeneity: $Tau^2 = 0.3283$; $Chi^2 = 16.37$, df = 11 (P = 0.13); $I^2 = 33\%$

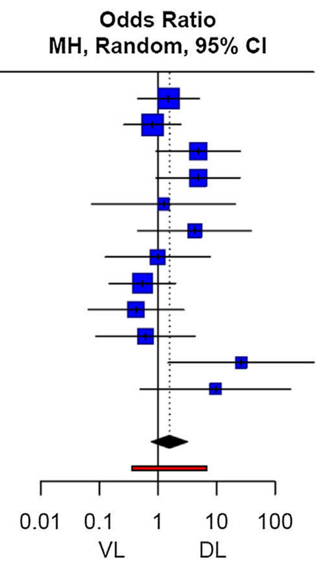

Figure 3 Forest plot of first-attempt intubation success in obese patients comparing VL and DL.

subgroup analysis revealed that in ICU patients, VL had a higher probability of success compared to DL (OR 2.02; 95% CI 1.43–2.85). Additionally, VL showed a significant advantage in trainees (OR 1.95; 95% CI 1.45–2.64; I^2: 58%) but lost significance in highly experienced operators (OR 0.52; 95% CI 0.24–1.13; I^2: 90%).

Subgroup analysis by VL technique revealed variable results, highlighting the heterogeneity in the effectiveness of different devices. No significant differences in intubation time were observed between the McGrath and Macintosh techniques or the GlideScope and Macintosh techniques, suggesting that device choice may be less critical than other clinical factors, such as operator experience and patient anatomy. However, Carron et al.,[40] in their subgroup analysis, found that the C-MAC had a higher likelihood of first-attempt intubation success compared to DL (OR 1.13; 95% CI 1.01–1.25; I^2: 18%). Nonetheless, Carron et al. included in this subgroup two RCTs by Aziz et al.[7] and Yumul et al.,[24] without considering that the former included a general population rather than solely obese patients, as specified by our research question and eligibility criteria.

Strengths

Our study possesses several notable strengths. First, we conducted a comprehensive search strategy across multiple high-impact databases, ensuring a thorough and inclusive identification of relevant randomized clinical trials. By exclusively focusing on RCTs, our analysis benefits from a robust methodological foundation, offering high-level evidence to evaluate the comparative effectiveness of VL and DL in obese patients. Second, we adhered to rigorous systematic review and meta-analysis protocols, following the Cochrane Handbook and PRISMA guidelines. Our methods included a meticulous risk of bias assessment using the RoB 2.0 tool, a detailed subgroup analysis, and statistical evaluation of heterogeneity, with I^2 values clearly reported to enhance transparency and reliability. This methodological rigor minimizes bias and ensures the validity of our findings. Third, our study is a current systematic review and meta-analysis to assess the outcomes of intubation techniques specifically in obese patients, incorporating a wide range of secondary outcomes such as complications (e.g., sore throat, voice changes) in addition to primary outcomes such as intubation time and first-attempt success rates. By including subgroup analyses for different VL devices, we provide granular information on device-specific performance, addressing clinical variability and offering practical guidance for airway management in this high-risk population. Finally, the inclusion of studies with low risk of bias across most domains, a detailed assessment of data extraction and processing, and the generation of robust forest plots to visualize effect sizes strengthen the overall reliability and applicability of our results. These efforts collectively make our study a valuable contribution to the field, supporting evidence-based decision-making in anesthetic management for obese patients.

Limitations

Our study has several limitations that should be acknowledged. First, a significant limitation is the potential risk of bias in the measurement of outcomes, as orotracheal intubation is a highly operator-dependent procedure. Variability in operator experience, training, and technique across the included studies may have influenced the results, introducing inconsistencies that are challenging to control. Second, the variability in VL techniques used in the randomized clinical trials included in this systematic review represents another important limitation. By comparing a single DL technique (typically the Macintosh blade) against a variety of VL devices and methodologies, we introduce heterogeneity that may complicate the interpretation and comparability of findings. This variability highlights the need for more standardized comparisons to isolate the specific advantages and limitations of each technique. Third, although the included RCTs focused on obese patients, the exact

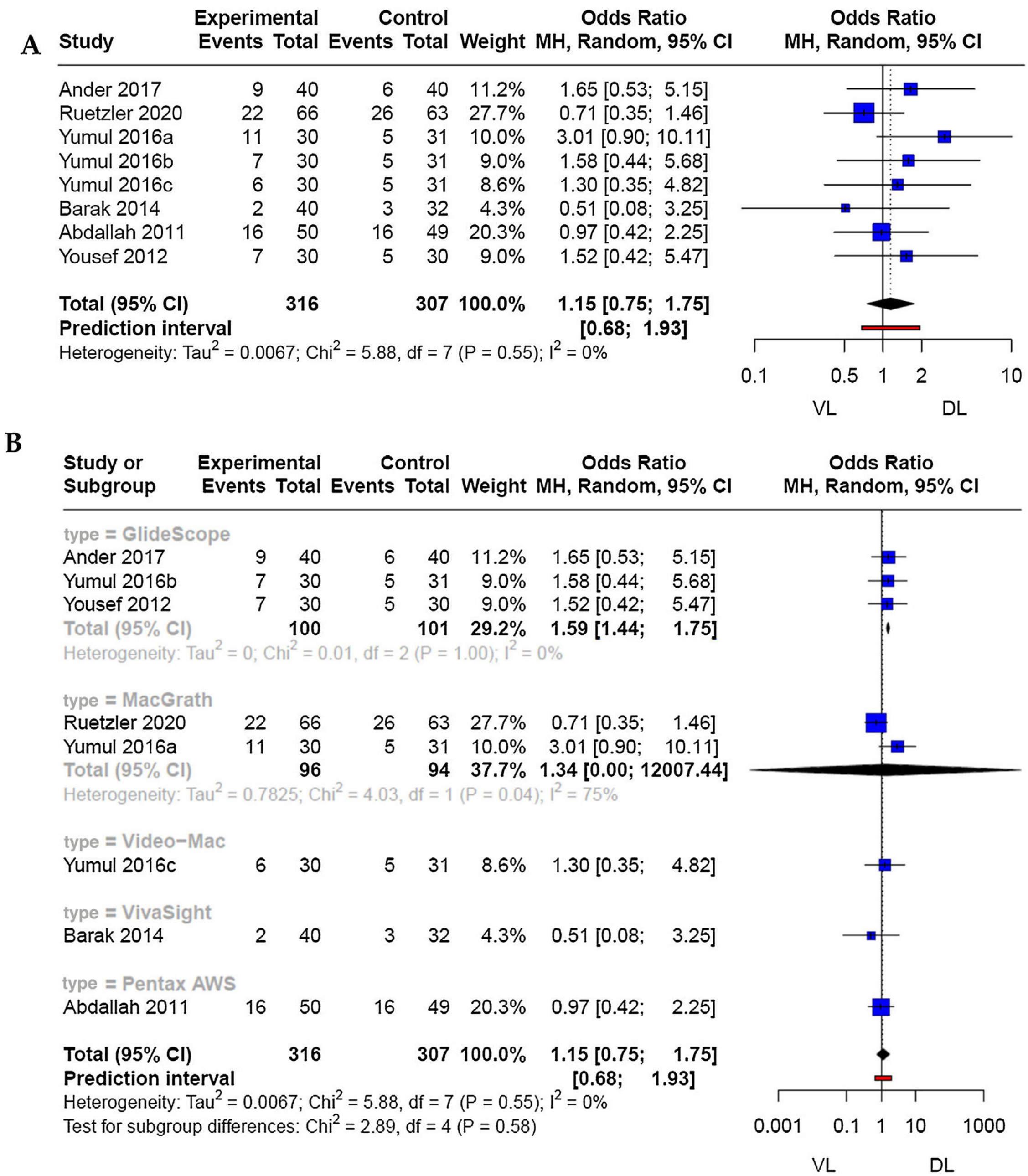

Figure 4 (A) Forest plot of pain as an intubation complication in obese patients comparing VL and DL. (B) Forest plot of pain as an intubation complication in obese patients: subgroup analysis by VL technique.

number of critically obese individuals within the primary studies is not clearly specified. Furthermore, the specific reasons for orotracheal intubation remain undefined, as the meta-analysis includes patients intubated for both medical and surgical indications. These considerations may inherently increase clinical heterogeneity, despite the use of RCT designs. Finally, while we included a comprehensive range of RCTs, the inherent differences in study design, sample sizes, and outcome measures further contribute to the heterogeneity observed in our analysis. Although statistical methods were employed to address this, the findings must be interpreted with caution, particularly when generalizing to broader clinical contexts.

Conclusions

Our results show that, despite the advantages of using VL in orotracheal intubation, there is no significant difference compared to DL regarding intubation time or first-attempt intubation success. However, these findings should be interpreted with caution due to the substantial heterogeneity among the primary studies included, despite being RCTs. Several variables, such as the intubation setting (operating room or emergency department), operator experience, and degree of obesity, are not consistently addressed across studies. Future RCTs should aim to standardize these gaps to facilitate more robust meta-analyses in the future.

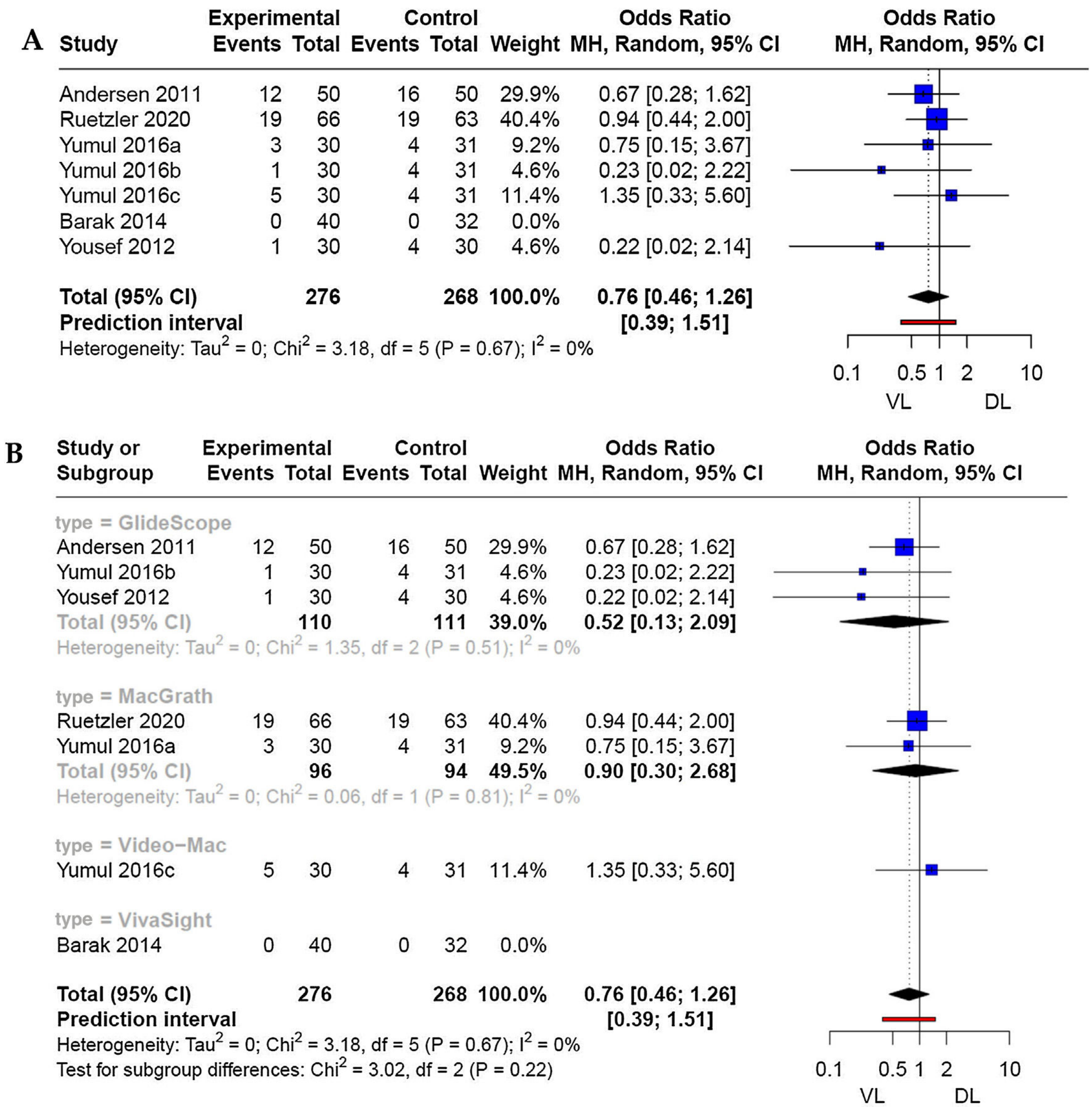

Figure 5 (A) Forest plot of voice changes as an intubation complication in obese patients: overall analysis comparing VL and DL. (B) Forest plot of voice changes as an intubation complication in obese patients: subgroup analysis by VL technique.

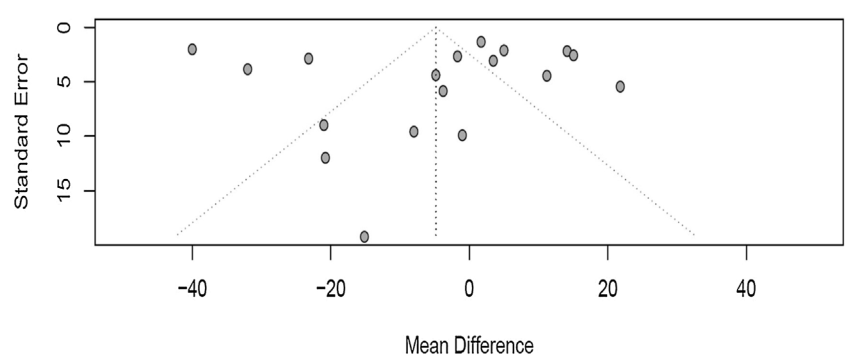

Figure 6 Funnel plot of the included studies in the meta-analysis of intubation time with VL vs. DL. No publication bias is evident, Egger's test: −0.64; 95% CI −6.1 to −4.8; p > 0.1.

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CRediT authorship contribution statement

SG-B: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

GV-T: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

EC-C: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

EM-R: Conceptualization, Formal analysis, Methodology, Project administration, Writing – original draft. MC-C: Validation, Visualization, Writing – review & editing.

CQ-C: Methodology, Writing – original draft.

WG-A: Writing – original draft, Funding.

LL-D: Writing – original draft, Funding.

Declaration of Generative AI and AI-assisted technologies in the writing process

The authors declare that no form of AI has been used in the preparation of this manuscript.

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Data Availability Statement

All data supporting the findings of this study are provided within the article and its supplementary material. For additional information or specific inquiries, please contact the corresponding author.

Declaration of competing interest

The authors declare that this research was carried out without any commercial or financial relationships that could be perceived as potential conflicts of interest.

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