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# Diabetes Mellitus Is Not a Risk Factor for Difficult Intubation Among Critically Ill Adults: A Secondary Analysis of Multicenter Trials

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**OBJECTIVES:** Diabetes mellitus has been associated with greater difficulty of tracheal intubation in the operating room. This relationship has not been examined for tracheal intubation of critically ill adults. We examined whether diabetes mellitus was independently associated with the time from induction of anesthesia to intubation of the trachea among critically ill adults.

**DESIGN:** A secondary analysis of data from five randomized trials completed by the Pragmatic Critical Care Research Group (PCCRG).

**SETTING:** Emergency departments (EDs) or ICUs at 11 centers across the United States that enrolled in randomized trials of a pre-intubation checklist, fluid bolus administration, bag-mask ventilation between induction and laryngoscopy, and intubation using a bougie vs. stylet.

**PATIENTS:** Critically ill adults undergoing tracheal intubation with a laryngoscope in an ED or an ICU.

**INTERVENTIONS:** None.

**MEASUREMENTS AND MAIN RESULTS:** A total of 2654 patients were included in this analysis, of whom 638 (24.0%) had diabetes mellitus. The mean time from induction of anesthesia to intubation of the trachea was 169 seconds (sd, 137s). Complications occurred during intubation in 1007 patients (37.9%). Diabetes mellitus was not associated with the time from induction of anesthesia to intubation of the trachea ( $-4.4$  s compared with nondiabetes; 95% CI,  $-17.2$  to  $8.3$  s;  $p = 0.50$ ). Use of a video vs. direct laryngoscope did not modify the association between diabetes mellitus and the time from induction to intubation ( $p$  for interaction =  $0.064$ ). Diabetes mellitus was not associated with the probability of successful intubation on the first attempt (85.6% vs. 84.3%;  $p = 0.46$ ) or complications during intubation (39.8% vs. 37.4%;  $p = 0.52$ ).

**CONCLUSIONS:** Among 2654 critically ill patients undergoing tracheal intubation in an ED or an ICU, diabetes mellitus was not independently associated with the time from induction to intubation, the probability of successful intubation on the first attempt, or the rate of complications during intubation.

**KEYWORDS:** critical care; diabetes mellitus; difficult intubation; emergency procedure; intubation; laryngoscopy

**D**iabetes mellitus (DM) affects approximately 14.3% of adults in the United States (1). DM is associated with other medical comorbidities, including obesity and cardiovascular disease. Patients with DM are at increased risk of adverse outcomes in the setting of critical illness (2, 3).

Tracheal intubation of critically ill adults in the emergency department (ED) or ICU is a high-risk procedure complicated by frequent adverse outcomes (4). Patients with DM may be at higher risk of difficult tracheal intubation because of either comorbidities that affect airway anatomy, such as

## KEY POINTS

**Question:** Does difficult intubation occur more frequently in patients with diabetes mellitus?

**Findings:** Patients with a diagnosis of diabetes mellitus did not have an increased rate of difficult intubation assessed by time taken to successfully intubate the trachea or by the success of intubation on the first attempt. In addition, patients with diabetes mellitus did not have a higher rate of airway complications.

**Meanings:** In this study, a diagnosis of diabetes mellitus did not increase the risk of difficult intubation or intubation-related complications.

obstructive sleep apnea (OSA) (5, 6), or comorbidities that affect physiology during intubation, such as obesity or autonomic neuropathy. Patients with DM and chronic hyperglycemia may develop decreased mobility of the soft tissue and joints due to glycation of collagen in connective tissue, which is referred to as “stiff joint syndrome.”

Prior research has suggested that the inflexibility in connective tissue and joints that occurs in DM cause tracheal intubation to be more difficult, particularly with a direct laryngoscope (DL) (7–14). Prior studies have reported DM to be associated with rates of difficult tracheal intubation that are up to ten times higher than in patients without DM (8, 12–17). These studies primarily examined patients with long-standing, insulin-dependent diabetes in an era with fewer treatment options at a time most tracheal intubations occurred using a DL rather than a video laryngoscope (VL). Furthermore, these studies were limited to elective tracheal intubation in the operating room. No previous study has evaluated the association between DM and the difficulty of tracheal intubation in critically ill adults in the ED or ICU.

To address this knowledge gap, we examined the independent association between DM and: 1) the time from induction to intubation, 2) successful intubation on the first attempt, and 3) complications of intubation among critically ill adults undergoing tracheal intubation with a DL or a VL in the ED or ICU.

## METHODS

### Study Design and Oversight

We performed a post hoc secondary analysis of data from five previously published multicenter, randomized trials of tracheal intubation of critically ill adults in the ED or ICU conducted by the Pragmatic Critical Care Research Group (PCCRG) (**Supplemental Table 1**, <http://links.lww.com/CCM/H603>) (18–22). The trials examined a pre-intubation checklist, fluid bolus administration, bag-mask ventilation between induction and laryngoscopy, and intubation using a bougie vs. stylet, respectively. Each of the original trials was approved by the institutional review board at Vanderbilt University Medical Center and this secondary analysis of de-identified data from the completed trials was determined to represent nonhuman subjects research (No. 160158).

### Study Sites and Patient Population

This secondary analysis included all patients in the datasets of the five completed trials, except those who were missing data on the primary outcome (time to intubation). The patients were adults (age  $\geq 18$  yr) who were undergoing tracheal intubation in one of the seven participating EDs or 15 participating ICUs for whom time was sufficient to enroll and randomize, administration of an induction agent was planned, and the operator was a regular intubator in that location. Patients were excluded if the treating clinician felt that one of the interventions being compared was required or contraindicated.

### Exposure of Interest

The exposure of interest was a diagnosis of DM at the time of enrollment. In each of the five trials, trial personnel at each site assessed whether the patient had a diagnosis of DM at the time of enrollment using all data available in the electronic health record including clinical notes, medication records, and laboratory values. The trials did not collect information on the type of DM (e.g., type I vs. type II), the time since diagnosis of DM, measures of glycemic control (e.g., hemoglobin A1c), or the presence of complications of DM (e.g., retinopathy, neuropathy, or nephropathy).

## Outcomes

The primary outcome of this study was the time (in s) from the induction of anesthesia until successful intubation of the trachea with an endotracheal tube. Secondary outcomes included the rate of successful intubation on the first attempt (as defined in the original trial), the total number of intubation attempts, and the rates of the following complications: operator-reported aspiration, low heart rate (< 40 beats/min), low systolic blood pressure (< 80 mm Hg), hypoxemia (oxygen saturation [SpO<sub>2</sub>] < 90%), severe hypoxemia (SpO<sub>2</sub> < 80%), airway trauma, and esophageal intubation—all between induction of anesthesia and 2 minutes after intubation of the trachea; cardiac arrest within 1 hour of intubation; and in-hospital mortality.

## Primary Analysis

The association between the exposure of DM and the primary outcome of time between induction of anesthesia and intubation of the trachea was examined using a linear mixed-effects model with a random intercept for study site and fixed effects for the following prespecified baseline covariates: age; body mass index (in kg/m<sup>2</sup>); Acute Physiology and Chronic Health Evaluation (APACHE) II score; diagnosis of OSA; presence of shock at the time of intubation or the use of vasopressors in the hour before intubation; and the operator's self-reported previous number of intubations (categorized as 0–29, 30–99, 100–499, and > 499 prior intubations performed). The baseline covariates were selected a priori from those available in the database based on theoretical relationships to the study outcomes, before examining the data or fitting the model. In addition, because the type of laryngoscope used (video vs. direct) may moderate the association between DM and the primary outcome, we included an interaction term between DM and laryngoscope type in the model. Comparisons used Satterthwaite's adjustment for degrees of freedom.

## Secondary Analyses

For the analysis of secondary outcomes, we fit logistic regression models with the secondary outcome as the dependent variables and independent variables of DM, laryngoscope type, and the interaction between diabetes mellitus and laryngoscope type. Additional

analyses: 1) examined the association between primary outcome and secondary outcomes, 2) evaluate for a potential interaction between the previous intubating experience of the operator and the laryngoscope type, and 3) compared patients intubated using a VL vs. a DL with regard to: diagnosis of DM; diagnosis of OSA; body mass index; APACHE II score; and the presence of shock at the time of intubation or the use of vasopressors in the hour before intubation.

Analyses were performed using R (23) and packages lme4 (24), lmerTest (25), emmeans (26), and tableone (27) (Version 4.2.0; R Foundation for Statistical Computing, Vienna, Austria). The approach to handling missing data or multiple data points reflecting one variable is described in the **Supplemental Appendix** (<http://links.lww.com/CCM/H603>). The *p* values of less than 0.05 were deemed statistically significant; no correction of *p* values for multiple comparisons was performed.

## RESULTS

### Patients

Of 2702 patients in the trial datasets, 48 (1.7%) were excluded from the current analysis for missing data on the primary outcome and 2654 (98.2%) were included in the current analysis. A total of 638 patients (24.0%) had a diagnosis of diabetes at the time of enrollment. The characteristics of the patients at baseline are shown in **Table 1**.

### Primary Outcome

The mean time from induction of anesthesia to intubation of the trachea was 169 seconds (sd, 137 s). In the multivariable model of time from induction of anesthesia to intubation of the trachea adjusting for prespecified baseline covariates (**Fig. 1** and **Table 2**), there was no significant association with DM (–4.4 s compared with nondiabetes; 95% CI, –17.2 to 8.3 s; *p* = 0.50), nor with laryngoscope type (0.1 s longer for VL compared with DL; 95% CI, –13.2 to 13.3 s; *p* = 0.99). There was also no significant interaction between diabetes and laryngoscope type (*p* = 0.064).

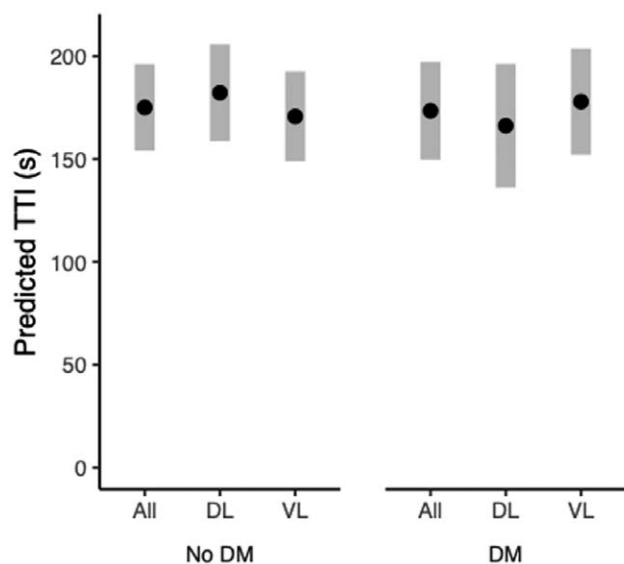
Among the baseline covariates adjusted for in the multivariable model, the age of the patient, presence of OSA, and the previous number of intubations the operator had performed were associated with the time

**TABLE 1.**  
**Baselined Patient and Operator Characteristics, Including Initial Laryngoscopic Approach**

Clinical Characteristic	Whole Sample	No DM			DM		
		No DM	DM	DL	VL	DL	VL
<i>n</i>	2654	2016	638	772	1244	236	402
Age, median (IQR)	59 (47–69)	57 (44–67)	63 (55–72)	58 (45–67)	57 (43–68)	63 (54–72)	63 (55–72)
Body mass index, median (IQR)	27 (23–32)	27 (23–31)	30 (25–35)	26 (22–30)	27 (23–31)	29 (25–34)	30 (26–36)
Acute Physiology and Chronic Health Evaluation II, median (IQR)	19 (14–24)	18 (13–24)	21 (16–26)	20 (15–26)	17 (12–22)	23 (17–29)	19 (15–24)
Obstructive sleep apnea, <i>n</i> (%)	215 (8.1)	115 (5.7)	100 (15.7)	43 (5.6)	72 (5.8)	38 (16.1)	62 (15.4)
Shock, <i>n</i> (%)	531 (20.0)	372 (18.5)	159 (24.9)	183 (23.7)	189 (15.2)	73 (30.9)	86 (21.4)
Any vasopressors, <i>n</i> (%)	428 (16.1)	312 (15.5)	116 (18.2)	128 (16.6)	184 (14.8)	55 (23.3)	61 (15.2)
Operator experience, <i>n</i> (%)							
(0–29)	529 (19.9)	385 (19.1)	144 (22.6)	149 (19.3)	236 (19.0)	51 (21.6)	93 (23.1)
(30–99)	1441 (54.3)	1099 (54.5)	342 (53.6)	419 (54.3)	680 (54.7)	136 (57.6)	206 (51.2)
(100–499)	525 (19.8)	414 (20.5)	111 (17.4)	147 (19.0)	267 (21.5)	35 (14.8)	76 (18.9)
≥ 500	159 (6.0)	118 (5.9)	41 (6.4)	57 (7.4)	61 (4.9)	14 (5.9)	27 (6.7)

DL = direct laryngoscope, DM = diabetes mellitus, IQR = interquartile range, VL = video laryngoscope.

Descriptive statistics for clinical characteristics are shown with continuous variables presented as median with IQR (25th–75th percentiles), and binary and categorical variables presented as counts with percentage (*n* [%]).



**Figure 1.** Time from induction of anesthesia to intubation of the trachea by diabetes mellitus (DM) status. The predicted mean time to successful tracheal intubation (TTI) for each category is adjusted for other variables listed in Table 2. Shaded bars indicate 95% CIs for the mean. There was no significant association between TTI and DM status ( $p = 0.50$ ). There was no interaction between DM status and the type of laryngoscope (video laryngoscope [VL] vs. direct laryngoscope [DL]) on the primary outcome ( $p$  for interaction = 0.064).

from induction of anesthesia to intubation of the trachea (Table 2).

A simplified model with independent variables of DM, laryngoscope type (VL vs. DL), and the interaction between DM and laryngoscope types without adjustment for other baseline covariates also found no association between DM and the primary outcome ( $p = 0.88$ ), no association between laryngoscope type and the primary outcome ( $p = 0.95$ ), and no interaction between DM and laryngoscope type ( $p = 0.078$ ). There was also no significant difference in DL versus VL usage by operator experience category (**Supplemental Fig. 1**, <http://links.lww.com/CCM/H603>; Chi-squared test of independence,  $\chi^2(3) = 5.64$ ,  $p = 0.13$ ).

### Secondary Outcomes

DM was not significantly associated with the number of tracheal intubation attempts or any of the complications of intubation evaluated, including aspiration, heart rate less than 40 beats/min, systolic blood pressure less than 80 mm Hg, hypoxia less than 90%, severe hypoxia less than 80%, reported airway trauma, esophageal intubation, cardiac arrest, or in-hospital

mortality (Table 3). The rate of complications during intubation within specific subgroups are displayed in **Supplemental Table 2** (<http://links.lww.com/CCM/H603>).

### Additional Analyses

In an analysis evaluating the performance the surrogate outcome of time from induction of anesthesia to intubation of the trachea, the time from induction of anesthesia to intubation of the trachea demonstrate a positive, monotonic relationship with the number of intubation attempts (adjusted  $R^2 = 0.38$ ;  $F(6, 2647) = 276.3$ ;  $p < 0.001$ ; **Supplemental Fig. 2**, <http://links.lww.com/CCM/H603>). The median time from induction of anesthesia to intubation of the trachea when intubation was successful on the first attempt was 120 seconds (interquartile range [IQR], 90–165 s), compared with 275 seconds (IQR, 191–405 s) when more than one attempt was needed ( $p < 0.001$ ). A longer time from induction of anesthesia to intubation of the trachea was associated with higher rates of aspiration during intubation ( $p < 0.001$ ), hypoxemia ( $p < 0.001$ ), severe hypoxia ( $p < 0.001$ ), esophageal intubation ( $p < 0.001$ ), and airway trauma ( $p = 0.008$ ).

### DISCUSSION

In this secondary analysis of data from 2654 critically ill adults undergoing tracheal intubation in the ED or ICU in five previous randomized trials, a diagnosis of DM was not independently associated with the time from induction of anesthesia to intubation of the trachea. This relationship was unchanged between intubated using a VL and those intubated using a DL. DM was not associated with a higher number of intubation attempts or an increased risk of complications during intubation.

Several previous studies reported an association between DM and an increased risk of difficult tracheal intubation (7–14). Several potential explanations exist for the difference in findings between previous studies and our current study. First, prior studies largely occurred before the widespread availability of VL, which may mitigate the effects of DM-induced soft tissue and joint inflexibility by allowing visualization of the glottis and tracheal intubation without as much displacement of soft tissue as is required during DL.

**TABLE 2.**  
**The Relationship Between Time to Successful Tracheal Intubation and Clinical Characteristics**

Clinical Characteristic	Predicted Difference in Time to Successful Tracheal Intubation (s)	95% CI	<i>p</i>
Chronic DM	-4.4	-17.2 to 8.3	0.50
First attempt with video laryngoscope	0.1	-13.2 to 13.3	0.99
Laryngoscope × DM	23.2	-1.3 to 47.8	0.064
Age (per 10 yr)	-4.6	-8.0 to -1.3	<b>0.0072</b>
Body mass index (per point)	0.6	-0.1 to 1.3	0.074
Acute Physiology and Chronic Health Evaluation II (per point)	0.3	-0.4 to 1.1	0.38
Obstructive sleep apnea	34	13.8 to 54.4	<b>0.0010</b>
Any shock (operator reported)	-0.7	-17.1 to 15.7	0.93
Vasopressors in the hour before intubation	-11.0	-28.2 to 6.4	0.21
Operator experience			<b>0.020</b>
(0–29)	Reference		
(30–99)	-4.4	-18.2 to 9.2	
(100–499)	-22.4	-39.2 to -5.7	
≥ 500	-23.2	-49.8 to 2.1	

DM = diabetes mellitus.

The change in time from induction of anesthesia to successful intubation of the trachea for patients with DM, vs. those without DM, represents a difference of this time averaged across laryngoscope type (direct laryngoscope [DL]/video laryngoscope [VL]). The time change for VL represents a difference from DL averaged across DM status (contrast coding). The interaction between laryngoscope and DM indicates the difference between VL and DL in patients with DM compared with the difference between VL and DL in patients without DM. *p* values are the results of *F* tests with degrees of freedom adjusted by Satterthwaite's method, with values of *p* < 0.05 in boldface font.

However, our study did not observe an association between DM and intubation outcomes even among patients intubated using a DL. Second, as obesity, OSA and DM have become more common in the general population, operators may have received more education about and become more familiar with intubating these patient groups, decreasing the effect of the underlying conditions on the difficulty of intubation.

The difference between the findings of our study and prior studies was not due to the use of the time between induction of anesthesia and intubation of the trachea as the primary outcome. Our findings were consistent across all outcomes evaluated. The time between induction of anesthesia and intubation of the trachea was associated with the rate of successful intubation on the first attempt, the number of intubation attempts, and complications during intubation. The time from induction of anesthesia to intubation of the trachea was also shorter when the intubation was performed by more experienced operators.

Our study has a number of limitations. Information regarding the diagnosis of DM (type 1 vs. type 2), its severity, and its management were limited to the data collected in the original trials. We did not have data on the duration of DM, glycemic control, or treatments, which may affect the development of complications of DM that may affect the difficulty of intubation. Further studies are needed to determine whether patients with long-standing or poorly controlled DM are at increased risk of difficult intubation. Screening for DM was also not standardized between hospitals, and prior work has supported high frequency of previously undiagnosed DM in hospitalized patients (1). Further, since four of the five trials had no difference in outcomes between randomized trial groups, and since the prevalence of DM should not have been different between any interventions evaluated or be expected to affect the efficacy of any of the study interventions, we did not adjust for the intervention groups in each of the included studies. Similarly, hospital-level differences in airway training,

**TABLE 3.**  
**Unadjusted Rate of Intubation Complications, Only Between Patients With and Without Diabetes Mellitus**

Clinical Characteristic	Whole Sample	No DM	DM	p
Total number (n)	2654	2016	638	
Multiple intubation attempts (%)	409 (15.4)	317 (15.7)	92 (14.4)	0.46
Any airway complication	1007 (37.9)	753 (37.4)	254 (39.8)	0.29
Specific complications, including:				
Cardiac arrest within 1 hr	42 (1.6)	31 (1.5)	11 (1.7)	0.88
Hospital mortality	957 (36.1)	727 (36.1)	230 (36.1)	0.99
Aspiration	36 (1.4)	33 (1.6)	3 (0.5)	0.043
Heart rate < 40 beats/min	16 (0.6)	11 (0.5)	5 (0.8)	0.70
Low systolic blood pressure	309 (11.6)	234 (11.6)	75 (11.8)	0.98
Hypoxia	761 (28.7)	563 (27.9)	198 (31.0)	0.14
Severe hypoxia	367 (13.8)	273 (13.5)	94 (14.7)	0.49
Airway trauma	5 (0.2)	4 (0.2)	1 (0.2)	0.99
Esophageal intubation	34 (1.3)	26 (1.3)	8 (1.3)	0.99

DM = diabetes mellitus.

“Any airway complication” refers to a composite of the specific complications listed. *p* values describe the relationship between the listed complication and diabetes status. Occurrences are displayed as count (%). *p* values are unadjusted.

education strategies, intubation team approaches or experience, and safety mechanisms may differ between the included studies and other hospitals that were not fully controlled for in our post hoc analysis.

## CONCLUSIONS

In an analysis of 2654 critically ill patients undergoing tracheal intubation in and ED or ICU, a diagnosis of DM was not independently associated with the time from induction of anesthesia to intubation of the trachea. DM was not associated with the rate of successful intubation on the first attempt or complications during intubation.

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## REFERENCES

1. Wang L, Li X, Wang Z, et al: Trends in prevalence of diabetes and control of risk factors in diabetes among US adults, 1999-2018. *JAMA* 2021; 326:1-13
2. Long MT, Coursin DB: The perils of perioperative dysglycemia. *Int Anesthesiol Clin* 2020; 58:21-26
3. Kastora S, Patel M, Carter B, et al: Impact of diabetes on COVID-19 mortality and hospital outcomes from a global perspective: An umbrella systematic review and meta-analysis. *Endocrinol Diabetes Metab* 2022; 5:e00338
4. Russotto V, Myatra SN, Laffey JG, et al; INTUBE Study Investigators: Intubation practices and adverse peri-intubation events in critically ill patients from 29 countries. *JAMA* 2021; 325:1164-1172
5. Subramanian A, Adderley NJ, Tracy A, et al: Risk of incident obstructive sleep apnea among patients with type 2 diabetes. *Diabetes Care* 2019; 42:954-963
6. Alshehri Z, Subramanian A, Adderley NJ, et al: Risk of incident obstructive sleep apnoea in patients with type 1 diabetes: A population-based retrospective cohort study. *Diabetologia* 2022; 65:1353-1363
7. Hashim K, Thomas M: Sensitivity of palm print sign in prediction of difficult laryngoscopy in diabetes: A comparison with other airway indices. *Indian J Anaesth* 2014; 58:298-302
8. Erden V, Basaranoglu G, Delatioglu H, et al: Relationship of difficult laryngoscopy to long-term non-insulin-dependent diabetes and hand abnormality detected using the 'prayer sign'. *Br J Anaesth* 2003; 91:159-160
9. Baig MM, Khan FH: To compare the accuracy of prayer's sign and Mallampatti test in predicting difficult intubation in diabetic patients. *J Pak Med Assoc* 2014; 64:879-883
10. Francia P, Sorelli M, Piccini B, et al: Glycemic control maintained over time and joint stiffness in young type 1 patients: What is the mathematical relationship? *J Diabetes Sci Technol* 2019; 13:728-733
11. Gerrits EG, Landman GW, Nijenhuis-Rosien L, et al: Limited joint mobility syndrome in diabetes mellitus: A minireview. *World J Diabetes* 2015; 6:1108-1112
12. Nowcid L, Valentine E: Difficult airway in diabetes. *Transl Perioper & Pain Med* 2015; 2:19-21
13. Hogan K, Rusy D, Springman SR: Difficult laryngoscopy and diabetes mellitus. *Anesth Analg* 1988; 67:1162-1165
14. Warner ME, Contreras MG, Warner MA, et al: Diabetes mellitus and difficult laryngoscopy in renal and pancreatic transplant patients. *Anesth Analg* 1998; 86:516-519

15. Stevanovic K, Sabljak V, Toskovic A, et al: Anaesthesia and the patient with diabetes. *Diabetes Metab Syndr* 2015; 9:177–179
16. Babayigit M, Dogan E, Babayigit MA, et al: Is airway management more risky in bariatric surgery? *J Perianesth Nurs* 2022; 37:247–252
17. Reissell E, Orko R, Maunuksela EL, et al: Predictability of difficult laryngoscopy in patients with long-term diabetes mellitus. *Anaesthesia* 1990; 45:1024–1027
18. Janz DR, Casey JD, Semler MW, et al; PrePARE Investigators: Effect of a fluid bolus on cardiovascular collapse among critically ill adults undergoing tracheal intubation (PrePARE): A randomised controlled trial. *Lancet Respir Med* 2019; 7:1039–1047
19. Janz DR, Semler MW, Joffe AM, et al; Check-UP Investigators\*: A multicenter randomized trial of a checklist for endotracheal intubation of critically ill adults. *Chest* 2018; 153:816–824
20. Casey JD, Janz DR, Russell DW, et al; PreVent Investigators and the Pragmatic Critical Care Research Group: Bag-mask ventilation during tracheal intubation of critically ill adults. *N Engl J Med* 2019; 380:811–821
21. Driver BE, Semler MW, Self WH, et al; BOUGIE Investigators and the Pragmatic Critical Care Research Group: Effect of use of a bougie vs endotracheal tube with stylet on successful intubation on the first attempt among critically ill patients undergoing tracheal intubation: A randomized clinical trial. *JAMA* 2021; 326:2488–2497
22. Russell DW, Casey JD, Gibbs KW, et al; PREPARE II Investigators and the Pragmatic Critical Care Research Group: Effect of fluid bolus administration on cardiovascular collapse among critically ill patients undergoing tracheal intubation: A randomized clinical trial. *JAMA* 2022; 328:270–279
23. R Core Team: R: A Language and Environment for Statistical Computing. Vienna, Austria, R Foundation for Statistical Computing, 2023. Available at: <https://www.R-project.org/>. Accessed February 21, 2024
24. Bates D, Mächler M, Bolker B, et al: Fitting linear mixed-effects models using lme4. *J Stat Softw* 2015; 67:1–48
25. Kuznetsova A, Brockhoff PB, Christensen RHB: lmerTest package: Tests in linear mixed effects models. *J Stat Softw* 2017; 82:1–26
26. Lenth RV, Bolker B, Buerkner P, et al: Estimated Marginal Means, Aka Least-Squares Means. Vienna, Austria, R Foundation for Statistical Computing, 2023. Available at: <https://www.R-project.org/>. Accessed February 21, 2024
27. Yoshida K, Bartel A, Chipman JJ, et al: Tableone: Create 'Table 1' to Describe Baseline Characteristics With or Without Propensity Score Weights. Vienna, Austria, R Foundation for Statistical Computing, 2023. Available at: <https://www.R-project.org/>. Accessed February 21, 2024