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Hyperangulated versus Macintosh blades for intubation with videolaryngoscopy in ICU: the randomised multicentre INVIBLADE-ICU trial study protocol

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ABSTRACT

Introduction Compared with the operating room, tracheal intubations in the intensive care unit (ICU) are associated with worsened glottic view, decreased first-time success rate and increase in the technical difficulty of intubation and incidence of complications. Videolaryngoscopes (VLs) have been proposed to improve airway management, and while recent studies have confirmed that VLs improve intubation conditions in this patient population, there remains a lack of clarity regarding the selection between a standard Macintosh blade or a hyperangulated one, to determine which yields the best outcomes. The purpose of this study was to compare successful intubation on the first attempt with the Macintosh VL versus the hyperangulated VL during tracheal intubation in ICU patients. We hypothesise that tracheal intubation using the hyperangulated VL will improve the frequency of successful intubation on the first attempt.

Methods and analysis The INtubation VIdeolaryngoscopy BLADE-ICU trial is a prospective, multicentre, open-label, interventional, randomised, controlled superiority study conducted in 29 ICUs in Spain. Patients will be randomly assigned in a 1:1 ratio to undergo intubation using a Macintosh VL (control group) or a hyperangulated VL (experimental group) for the first intubation attempt. The primary outcome is successful intubation on the first attempt. The secondary outcomes include the time to intubation, attempts for successful intubation, laryngoscopic vision assessed with the modified Cormack-Lehane scale, the need for adjuvant airway devices for intubation, difficulty assessed by the anaesthesiologist and complications during tracheal intubation. Enrolment began on 1 May 2024 and is expected to be completed in 2025.

Ethics and dissemination The study protocol was approved on 29 February 2024, by the Ethics Committee of Galicia (CEImG, code No. 2024-031).
The results will be submitted for publication in a peer-reviewed journal.

Trial registration number NCT06322719.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The plan is to include at least 1036 patients in this multicentre, prospective, open-label, interventional, randomised study.
⇒ The trial aims to compare two different videolaryngoscopes (Macintosh vs hyperangulated) for tracheal intubation in intensive care unit.
⇒ Conduct in 29 different hospitals among anaesthesiologists with diverse prior experience with tracheal intubation will increase the external validity of results.
⇒ The nature of the study does not allow blinding.

INTRODUCTION

Background and rationale

Compared with the operating room, tracheal intubations in the intensive care unit (ICU) are associated with worsened glottic view, decreased first-time success rate and increase in the technical difficulty of intubation and incidence of complications.[1–3] Videolaryngoscopes have been proposed to improve airway management, and the use of these devices is recommended as first-line or after

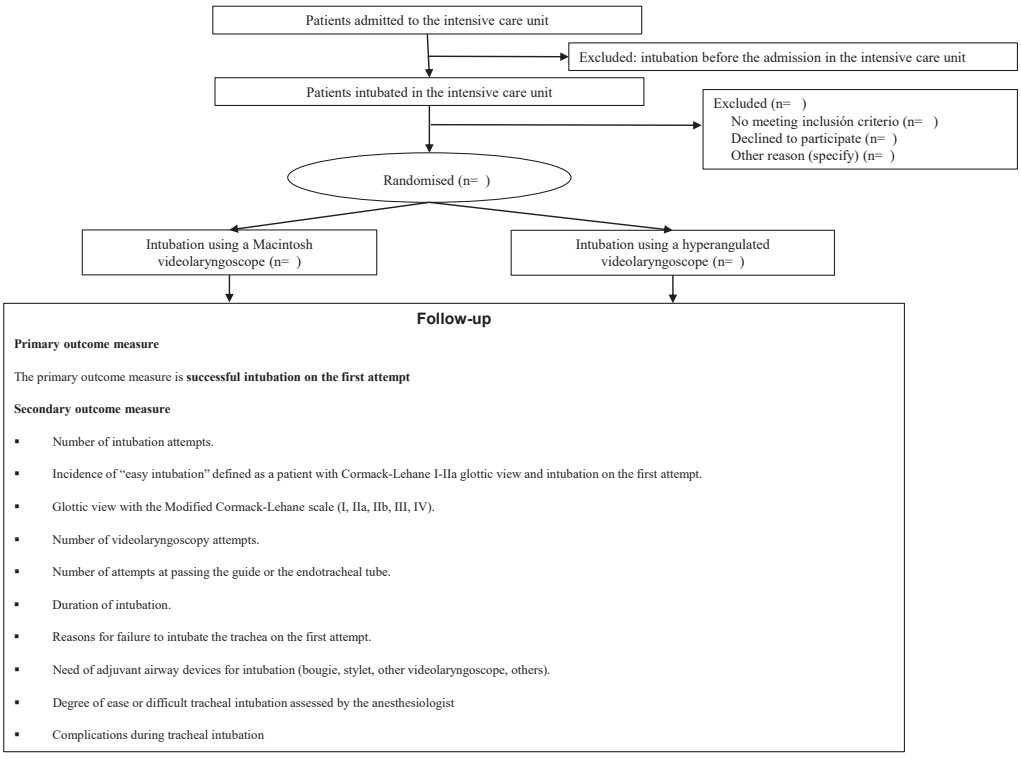

Figure 1 Flow of patients.

a first-attempt failure using direct laryngoscopy in ICU airway management algorithms.[4]

Although until relatively a few years ago there were doubts about whether videolaryngoscopes had advantages over direct laryngoscopy for endotracheal intubation in critically ill patients, two recent studies (DEVICE trial,[5] INTUBE subanalysis[6 7]), a Cochrane review[8] and a meta-analysis[9] have confirmed that these devices improve

Table 1 Participant timeline

Time point	Decision to perform TI	During TI	0–15 min after TI
Eligibility assessment	X		
Informed consent	X		
Enrolment	X		
Demographic data	X		
Patient characteristics	X		
Physical examination	X		
Interventions:			
Videolaryngoscope hyperangulated		X	
Videolaryngoscope McGrath		X	
Another device		X	
Screening for contraindications	X	X	
Assessments:			
First-pass success rate		X	
Glottic view		X	
Need of adjuvant airway device		X	
Occurrence of complications		X	X
Difficulty of TI assessed by the anaesthesiologist			X

TI, tracheal intubation.

intubation conditions in this patient population. The DEVICE trial[5] was a multicentre, randomised study conducted in the USA that compared videolaryngoscopy with direct laryngoscopy for tracheal intubation in 1417 critically ill patients. The use of a videolaryngoscope resulted in a higher incidence of successful intubation on the first attempt compared with direct laryngoscopy (85% vs 71%). The subanalysis of the INTUBE study[6] was a prospective, cohort study conducted internationally with 2916 critically ill patients intubated in 29 different countries. A videolaryngoscope was used for endotracheal intubation in 500 patients (17%) while direct laryngoscopy was used in 2416 (83%). The use of videolaryngoscopy was associated with a higher incidence of successful intubation on the first attempt (84% vs 79%). In the Cochrane review,[8] the use of videolaryngoscopy was associated with improved glottic visualisation and fewer failed intubation attempts and complications such as hypoxaemia when compared with direct laryngoscopy. Araújo *et al*[9] performed a meta-analysis, including 14 randomised controlled trials and 3981 patients comparing videolaryngoscopy versus direct laryngoscopy in critically ill patients, and they demonstrated that videolaryngoscopy is a more effective and safer strategy compared with direct laryngoscopy for increasing successful intubations on the first attempt, improving glottic visualisation and reducing oesophageal intubations in critically ill patients. After these results, they recommend the routine use of videolaryngoscopy in critically ill patients.

While we are beginning to accumulate evidence supporting the use of videolaryngoscopes as the preferred devices for intubating critically ill patients in the ICU, there is still a lack of clarity regarding the choice between a standard Macintosh blade or a hyperangulated one,[10] to determine which leads to the best outcomes. In the DEVICE trial,[5] a standard Macintosh blade was used in 85% of patients intubated with a videolaryngoscope while a hyperangulated blade was used in 15%. In the INTUBE subanalysis study,[6] a hyperangulated blade was used in 25% of patients intubated with a videolaryngoscope, and the standard Macintosh blade was used in 75%. These studies do not describe the reasons for choosing one blade over the other.

The purpose of this prospective multicentre randomised study is to compare successful intubation on the first attempt with the Macintosh videolaryngoscope versus the hyperangulated videolaryngoscope during tracheal intubation in ICU patients. We hypothesise that tracheal intubation using the hyperangulated videolaryngoscope will improve the frequency of successful intubation on the first attempt in critically ill patients requiring intubation in the ICU.

Study aims and objectives

Primary objective

The main objective of this study is to determine whether hyperangulated videolaryngoscopy improves the frequency of successful first-pass tracheal intubation compared with Macintosh videolaryngoscopy in critically ill patients requiring intubation in the ICU.

Secondary objectives

The secondary objective is to compare the time to intubation, attempts for successful intubation, laryngoscopic vision with the modified Cormack-Lehane scale, the need for adjuvant airway devices for intubation, difficulty assessed by the anaesthesiologist and complications during tracheal intubation, between the hyperangulated and the Macintosh videolaryngoscopes.

Study design

The INtubation VIdeolaryngoscopy BLADE-ICU (INVIBLADE-ICU) study is a prospective, multicentre, open-label, interventional, randomised, controlled superiority study.

Consolidated Standards of Reporting Trials diagram

Figure 1 shows the Consolidated Standards of Reporting Trials[11] diagram of the INVIBLADE-ICU trial.

METHODS: PARTICIPANTS, INTERVENTIONS AND OUTCOMES

Study settings

The INVIBLADE-ICU study will take place in 29 ICUs, in Spain.

Eligibility criteria

Inclusion criteria

- Adult (age ≥18 years).
- Patients were admitted to the ICU and required mechanical ventilation through an endotracheal tube.
- Planned procedure is tracheal intubation using a videolaryngoscope.

Exclusion criteria

- Patients who are intubated in a place other than the ICU (surgical area, emergency and hospitalisation floor) are not included.
- Refusal of the patient or next of kin to participate in the study.
- Pregnancy or lactation.
- Need for tracheal intubation with a device other than the videolaryngoscope (fiberoptic bronchoscope, direct laryngoscopy, tracheostomy, etc.).
- Emergent tracheal intubation that does not allow for the randomisation of the procedure (eg, because of cardiac arrest).

Assignment and intervention

Allocation

Patients eligible for inclusion will be randomly assigned in a 1:1 ratio to undergo intubation using a Macintosh videolaryngoscope or using a hyperangulated videolaryngoscope for the first attempt in permuted blocks of 2, 4 or 6, stratified and balanced by centre. The assignment to each type of videolaryngoscope will be generated using a computerised randomisation sequence, placed in

Table 2 Baseline, demographic and clinical characteristics of trial patients

Characteristic	Hyperangulated videolaryngoscopy (n=….)	Macintosh videolaryngoscope (n=….)
Age, mean (SD), years		
Male sex—No. (%)		
Weight, mean (SD), kg		
BMI, mean (SD)		
SOFA score†		
Diagnosis at admission to the intensive care unit, No. (%)		
Postoperative surg		
Acute respiratory failure		
Acute circulatory failure		
Acute neurological failure		
Trauma		
Other		
Indication for intubation, No. (%)		
Respiratory failure		
Circulatory failure		
Neurological failure		
Other		
Anticipated difficulty of intubation,‡ No. (%)		
Easy		
Moderate		
Difficult		
Not reported		
Criteria for difficult intubation, No. (%)		
History of difficult intubation, No. (%)		
Mallampati classification,§ No. (%)		
1		
2		
3		
4		
Limited mouth opening <30 mm, No. (%)		
Reduced cervical mobility, No. (%)		
Obstructive sleep apnoea syndrome, No. (%)		
Small mandible, No. (%)		
Large tongue, No. (%)		
History of radiation therapy to the head or neck, No. (%)		
Facial trauma, No. (%)		
Blood or vomit in airway, No. (%)		
BMI>30, No. (%)		
MACOCHA score,¶ mean (SD)		
MACOCHA score 0–3, low risk of difficult intubation, No. (%)		
MACOCHA score 4–7, moderate risk of difficult intubation, No. (%)		
MACOCHA score 8–12, high risk of difficult intubation, No. (%)		
Respiratory support prior to intubation, No. (%)		

Continued

Table 2 Continued

Characteristic	Hyperangulated videolaryngoscopy (n=….)	Macintosh videolaryngoscope (n=….)
Standard oxygen		
Non-invasive ventilation		
High-flow nasal cannula		
Continuous positive airway pressure		
Other		
Oxygenation during induction of intubation, No. (%)		
Non-reabreater mask		
Bag and mask ventilation		
Non-invasive positive pressure ventilation		
High-flow nasal cannula		
Not preoxygenation		
Other		
Urgency of ICU intubation procedure, No. (%)		
Emergent		
Urgent		
Semielective		

*Calculated as weight in kilograms divided by height in meters squared.
†SOFA score, score range: 0 (no organ failure) to 24 (most severe level of multiorgan failure).
‡Subjective, global clinical assessment made by the anaesthesiologist before randomisation.
§Predicts difficult intubation.
¶MACOCHA score includes seven clinical items discriminates difficult and no difficult intubation in the I.
BMI, body mass index; ICU, intensive care unit; SOFA, Sequential Organ Failure Assessment.

sequential numbers in opaque envelopes and distributed to the participating hospitals.

Blinding

Blinding to the type of videolaryngoscope is only possible for the patient. The anaesthesiologist will be informed of the type of videolaryngoscope (hyperangulated vs Macintosh) prior to induction of anaesthesia.

Interventions

Before beginning enrolment, operators at each hospital received previously theorical introduction and hands-on training in the use of hyperangulated and Macintosh videolaryngoscopy, and information about the protocol of the study.

The experimental group involves tracheal intubation using a hyperangulated videolaryngoscope on the first laryngoscopy attempt, including devices such as the GlideScope, Storz C-MAC D-Blade and McGrath X blade, or any other videolaryngoscope with the same blade geometry. The control group involves tracheal intubation using a standard Macintosh videolaryngoscope on the first laryngoscope attempt, including devices such as the Storz C-MAC, McGrath MAC, GlideScope MAC or any other videolaryngoscope with the Macintosh blade geometry. In both groups, the trial recommends that the operator performing the first intubation attempt looking the video screen) ('indirect laryngoscopy'). The trial protocol does not dictate the brand of videolaryngoscope that will be used, but the device used in each group will be recorded. All other aspects of the procedure will be at the discretion of anaesthesiologist, including sedative and neuromuscular drugs, preoxygenation, endotracheal tube size and the use of bougie or a stylet. The trial recommends using a stylet inside the tube or a bougie to facilitate intubation with the Macintosh videolaryngoscope. With the hyperangulated videolaryngoscope, the trial recommends a style inside the tube with an angulation of at least 30°–40° at the tip, a flexible-tipped bougie or another similar bougie, considering the hyperangulation of the blade. If the first attempt is unsuccessful, the anaesthesiologist may use any method of intubation on subsequent intubation attempts, including the use of a hyperangulated videolaryngoscope in the Macintosh videolaryngoscope group or use of a Macintosh videolaryngoscope in the hyperangulated videolaryngoscope group. The type of videolaryngoscope used during the first and final laryngoscopy attempts will be collected and reported.

Outcome measures

Primary outcome measure

The primary outcome measure is successful intubation on the first attempt defined as the placement of an

endotracheal tube in the trachea following a single insertion of a laryngoscope blade into the mouth and either a single insertion of an endotracheal tube into the mouth or a single insertion of a bougie into the mouth followed by a single insertion of an endotracheal tube into the mouth.[5]

Secondary outcomes measure

- Number of intubation attempts.
- Incidence of 'easy intubation' is defined as a patient with Cormack-Lehane I–IIa glottic view and intubation on the first attempt.
- Glottic view with the Modified Cormack-Lehane scale (I, IIa, IIb, III, IV).
- Number of videolaryngoscopy attempts.
- Number of attempts at passing the guide or the endotracheal tube.
- Duration of intubation is defined as the time from insertion of the videolaryngoscope blade into the mouth until the endotracheal tube passes through the vocal cords.
- Reasons for failure to intubate the trachea on the first attempt (inadequate view of the larynx, inability to intubate the trachea with an endotracheal tube, inability to cannulate the trachea with a bougie, attempt aborted due to a change in patient condition (eg, worsened hypoxaemia, hypotension, bradycardia, vomiting, bleeding), technical failure of the laryngoscope (eg, battery, light source, camera, screen) and others.
- Need of adjuvant airway devices for intubation (bougie, stylet, other videolaryngoscope and others).
- Degree of ease or difficult tracheal intubation assessed by the anaesthesiologist (without difficulty, mild, moderate and severe difficulty).
- Complications during tracheal intubation and within 15 min after successful intubation (eg, desaturation <90%, desaturation <80%, systolic blood pressure <80 mm Hg, systolic blood pressure <65 mm Hg, oesophageal intubation, pulmonary aspiration, dental injuries, airway injuries, cardiac arrest and others).
- Need to change the device for intubation (replaced by another videolaryngoscope, a different angled blade, requirement for a fiberoptic bronchoscope…).

Participant timeline

The participant timeline is described in table 1.

Recruitment

Trial investigators identify consecutive patients admitted in 29 ICUs in Spain, who need to be intubated and meet the inclusion criteria. Patient enrolment began on 1 May 2024 and is expected to be completed in 2025.

Data collection, management and analysis

Data collection and management

All outcome measurements are recorded during and after the intubation procedure by an independent and trained observer using a specific paper-based case report form (CRF). Trained observers may include clinical personnel in the enrolling UCI unit, such as anaesthesiologists or nurses. Also, pseudonymised data are collected and managed using Research Electronic Data Capture (REDCap), a REDCap tool hosted at Sanitary Research Institute Foundation of Santiago (IDIS).[12 13] REDCap is a secure, web-beased software platform designed to support data capture for research studies, providing (1) an intuitive interface for validated data capture; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages and (4) procedures for data integration and interoperability with external source.

The database will be protected by encryption software and a single user password will be provided to each centre. Every intubated patient is coded with a specific patient number. Any protocol deviations are recorded on the eCRF, and a clinical research assistant ensure that all protocol deviations and adverse events are recorded in the database.

Access to data

Data safety, data quality and statistical analysis will be managed by two investigators (AE-G and OV), who are responsible for notifying any issues that may arise during the whole study. Data will be collected and stored according to good clinical practice guidelines and will be available to all participants' study centres. Any issue occurring during the study will be reported to these two investigators. Data registered are described in tables 2–4.

Statistical methods

Description of the patient groups at baseline and time period for analysis

The baseline characteristics of all patients will be described. Categorical variables will be reported as absolute numbers (n) and percentages and quantitative variables as mean (±SD) or median (25th–75th percentile). Normality will be calculated with the Kolmogorov-Smirnov test with Lilliefors correction.

Primary analysis

The main analysis will be an unadjusted, intention-to-treat comparison of successful intubation on the first attempt comparing hyperangulated videolaryngoscopy with Macintosh videolaryngoscopy in critically ill patients requiring intubation in the ICU. A χ^2 test will be used to compare the primary outcome between the two groups. Also, incidence rates, RR, risk differences and 95% CIs will be calculated.

Secondary analysis

Secondary outcomes

For secondary outcomes, we will conduct unadjusted, intention-to-treat analyses comparing patients randomised to the hyperangulated videolaryngoscopy group to patients randomised to the Macintosh videolaryngoscopy group. Continuous variables will be compared

Table 3 Intubation characteristics

Outcome	Hyperangulated videolaryngoscopy (n=….)	Macintosh videolaryngoscope (n=….)
Device used on first intention intubation, No. (%)		
McGrath videolaryngoscope		
McGrath XBlade		
C-MAC D-Blade videolaryngoscope		
C-MAC standard blade		
Glidescope videolaryngoscope hyperangulated		
Glidescope videolaryngoscope standard blade		
Other		
Device used in successful intubation, No. (%)		
McGrath MAC		
McGrath XBlade		
C-MAC Mac		
C-MAC D-Blade videolaryngoscope		
Glidescope Mac		
Airtraq videolaryngoscope		
Fibrobronchoscopy		
Macintosh direct laryngoscope		
Other		
Size of Macintosh blade on first intention intubation, No. (%)		
Size 3		
Size 4		
Rank of the operator, No. (%)		
Resident of anaesthesia		
Attending anaesthesiologist (≤5 years)		
Attending anaesthesiologist (>5 years)		
Skill level of anaesthesiologist making first intubation attempt, No. (%)		
<20 intubations performed with videolaryngoscope		
20–50 intubations performed with videolaryngoscope		
>50 intubations performed with videolaryngoscope		
<20 intubations performed with hyperangulated videolaryngoscope		
20–50 intubations performed with hyperangulated videolaryngoscope		
>50 intubations performed with hyperangulated videolaryngoscope		
<20 intubations performed with Macintosh videolaryngoscope		
20–50 intubations performed with Macintosh videolaryngoscope		
>50 intubations performed with Macintosh videolaryngoscope		
Need to change of the first operator, No. (%)		
Need of adjuvant airway devices for intubation, No. (%)		
Bougie		
Bougie flextip		
Stylet		
McGrath XBlade		
C-MAC D-Blade videolaryngoscope		
Glidescope videolaryngoscope		

Continued

Table 3 Continued

Outcome	Hyperangulated videolaryngoscopy (n=….)	Macintosh videolaryngoscope (n=….)
Airtraq videolaryngoscopy		
Fibrobronchoscopy		
Other		
Need of manoeuvre during intubation, No. (%)		
BURP manoeuvre		
Sellick manoeuvre		
Other (head elevation,…)		
Not necessary		
Hypnotic agent, No. (%)		
Propofol		
Etomidate		
Halogenated		
Other		
No sedative agent used		
Neuromuscular blockade, No. (%)		
Succinylcholine		
Rocuronium		
Cisatracurium		
Other		
No neuromuscular blockade used		
Status previous intubation,		
SpO2 when intubation is decided, mean (SD)		
PAS when intubation is decided, mean (SD)		
SpO2 (pre-intubation), mean (SD)		
Receiving vasopressors/inotropes (preintubation), n (%)		

PAS, systolic blood pressure
SpO2, blood oxygen saturation
BURP, applying backward, upward, rightward and posterior pressure on the larynx.

with the Wilcoxon's rank-sum test and categorical variables with a χ^2 test or the Fisher's exact test, according to the conditions of application. Between-group differences in continuous and categorical variables and the associated 95% CIs will be presented.

Per-protocol analysis

We will perform a per-protocol analysis comparing patients in the hyperangulated videolaryngoscopy group to patients randomised to the Macintosh videolaryngoscopy group (regardless of group assignment).

Effect modification (subgroup analyses)

We will investigate if predetermined baseline variables influence the effect of the study group on the primary outcome. To assess this, we will use a logistic regression model focused on the primary outcome of first-attempt success. The independent variables in the model will consist of the study group assignment, the potential effect modifier of interest and the interaction between these two factors. Significance will be assessed by the p value for the interaction term, with values under 0.10 indicating a possible interaction and values under 0.05 confirming an interaction. Subgroups from categorical variables will be shown as a forest plot. Continuous variables will be analysed using cubic splines with 3–5 knots. If needed for data presentation, continuous variables will be dichotomised for inclusion in a forest plot. Prespecified subgroups that may modify the effect of the study group on the primary outcome (table 5).

1. Body mass index ≥30 kg/m^2.
2. Sequential Organ Failure Assessment score ≥10.
3. Rank of the operator (attending anaesthesiology >5 years, attending anaesthesiology ≤5 years and resident).
4. MACOCHA score (0–3, 4–7 and 8–12)

Table 4 Primary and secondary outcomes by assigned treatment groups

Outcome	Hyperangulated videolaryngoscopy (n=….)	Macintosh videolaryngoscope (n=….)
Primary outcome		
Successful intubation on the first attempt, No. (%)		
Secondary outcomes		
Number of intubation attempts, No. (%)		
1		
2		
3		
Best modified Cormack-Lehane view, No. (%)		
Grade I		
Grade IIa		
Grade IIb		
Grade III		
Grade IV		
First device entered into mouth after the videolaryngoscope, No. (%)		
Bougie		
Flex-tip bougie		
Endotracheal tube+stylet		
Endotracheal tube without stylet		
Not attempted passage of bougie or endotracheal tube		
Other		
Reason for intubation failure on first attempt, No. (%)		
Inadequate view of vocal cords		
Inability to insert an endotracheal tube or bougie		
Inability to insert the blade into the mouth		
Technical failure (battery, other…)		
Secretions or blood		
Other		
Rapid sequence induction, No. (%)		
Time of intubation, seconds, mean (SD)		
Difficult intubation assessed by the anaesthesiologist No. (%)		
Not difficult		
Slight difficult		
Moderate difficult		
Severe difficult		
Complications, No. (%)		
Need to change the device for intubation,		
Desaturation <90%		
Desaturation <80%		
Hypotension PAS <90 mm Hg		
Hypotension PAS <65 mm Hg		
Oesophageal intubation		
Pulmonary aspiration		
Dental injuries		
Airway injuries		
Other		

Continued

Table 4 Continued

Outcome	Hyperangulated videolaryngoscopy (n=….)	Macintosh videolaryngoscope (n=….)
PAS, systolic blood pressure *Reflects glottis visualisation. Score range: I (good) to IV (no glottis visualisation).		

Table 5 Subgroup analyses of the primary outcome: successful intubation on the first attempt

Subgroup	Conventional group N=50	CMAC VL group N=50	Absolute difference (95% CI)†	Adjusted common ORs (95% CI)†	P value
Body mass index					
<30					
≥30					
Mallampati score					
Scores I–II					
Scores III–IV					
SOFA score					
<10					
≥10					
Rank of the operator					
Attending anaesthesiology >5 years					
Attending anaesthesiology ≤5 years					
Resident					
MACOCHA score					
0–3					
4–7					
8–12					
Skill level of anaesthesiologist making first intubation attempt					
Expert (more than 50 intubations with videolaryngoscope)					
Non-expert (20–50 intubations with videolaryngoscope)					
Non-expert (less than intubations with videolaryngoscope)					
Saturation oxygen at the moment when intubation is decided					
<80%					
≥80%					
Indication for intubation					
Acute respiratory failure					
Other					
Difficult airway characteristics					
None					
≥1					

SOFA, Sequential Organ Failure Assessment.

5. Skill level of anaesthesiologist making first intubation attempt.
   a. Number of previous intubation performed with videolaryngoscope (>50, 20–50 and <20).
   b. Number of previous intubation performed with hyperangulated videolaryngoscope (>50, 20–50, <20).
   c. Number of previous intubation performed with Macintosh videolaryngoscope (>50, 20–50 and <20).
6. Saturation oxygen <80% at the moment when intubation is decided.
7. Indication for intubation (acute respiratory failure vs other).
8. Presence of difficult airway characteristics as fixed effects (≥1 vs none).
9. Multivariable modelling to account for confounding.

Subsequent secondary analysis involving adjustment for prespecified baseline variables will be undertaken by fitting a regression mixed model for the primary outcome (successful intubation on the first attempt) as the dependent variable. Study site and operator will be considered as random effects, and study group (hyperangulated videolaryngoscopy or Macintosh videolaryngoscopy). Continuous variables will not be dichotomised for analysis but could be dichotomised for data presentation. We will present as RR and 95% CI.

Sample size calculation

We aim to compare the efficacy of first-attempt intubation in a critically ill patient using a hyperangulated blade compared with the efficacy achieved with a Macintosh blade. The efficacy percentage for the Macintosh blade is estimated at 84.0% (p1=0.84), and for the hyperangulated blade, it is 90.0% (p2=0.90). The sample proportion in each group will be balanced at a 1:1 ratio (w=0.50). Considering a significance level of 5.00% (α=0.05), in order to achieve a power of 80.00% (β=0.80) to detect significant differences, it will be necessary to recruit 492 patients in the hyperangulated blade group and 492 in the Macintosh blade group. Assuming a drop-out rate of 5% (ab=5%), a total of 1036 patients need to be recruited for the study. This justification has been carried out using statistical software ene3.0 for sample size calculations.

Monitoring

Data monitoring

Before the start of the study, all anaesthesiologists in the 20-night hospitals attended formal training sessions on the study protocol and data collection in the CRF. All documents required for the study are available for each researcher. Medical researchers oversee patients screening and inclusion. Data are collected in a web-based eCRF by trial personal. The eCRF is provided and managed by the Research Methodology Unit (Fundación Instituto de Investigaciones Sanitarias (FIDIS)) of Santiago de Compostela (Spain). Each patient receives a unique trial identification number. Only the investigators and research team have access to any protected health information of study participants and any study data. The principal investigators (MT, AE-G, JF and OV) meet with the principal investigators of each hospital to discuss any problems with data collection and protocol compliance and to evaluate study progress.

Harms

The study may be temporarily stopped for an individual patient, at the discretion of the attending physician, in case of major serious adverse events (SAEs) suspected to be associated with the type of videolaryngoscope used. Reporting of SAEs will be per the standard operating procedures of the Ethics Committee of Galicia (CEI). SAEs will include the following when occurring as a result of airway manipulation (eg, cardiac arrest, death, vocal cord injury and oesophageal rupture). The principal investigator will inform the CEI about the SAEs. No specific reporting procedure for unexpected serious adverse events is planned because strategies used in the two groups studied are standard care in the 30 hospitals of the study.

Auditing

The Research Methodology Unit (FIDIS) of Santiago, reviews the screening forms and clinical data at regular intervals.

Limitations of the study

The main limitation is that the study is not blinded. The nature of the trial intervention did not allow blinding of the operators or observers.

Ethics and dissemination

Research ethics approval

This study is conducted in compliance with the current version of the Declaration of Helsinki and Good Clinical Practice guidelines. The research project was approved by the Ethics Committee of Galicia (CEImG), Galicia, Spain (code No. 2024/031). The INVIBLADE-ICU trial was registered into the ClinicalTrials.gov clinical trials registry with ClinicalTrials.gov Registry: No. NCT06322719.

Consent or assent

Written informed consent is mandatory and will be obtained from all patients or their next of kin as required by the Ethics Committee of Galicia (CEImG). We will be able to use three methods to obtain written informed consent:

1. If possible, and the patient understands the information provided and is capable of responding, we will request written informed consent directly from the patient.
2. If the patient is unable to consent due to an underlying disease, they will be included after written informed consent is provided by a next of kin, if present.
3. If urgent intubation is necessary and no next of kin is present, the patient will be included in the study, randomised and data will be collected. Subsequently, consent will be sought from the next of kin. If the patient recovers from the condition that necessitated

intubation, we will also seek their confirmation to participate in the trial.

A patient may leave the study at any time if the person informed about the study (patient or next of kin) is unwilling to continue in the study. Data from patients who request full withdrawal will not be considered in the analysis.

Patient and public involvement

The development of the research question and outcome measures was not informed by patients' priorities, experiences and preferences. Patients were not involved in the design, recruitment and conduct of the study. The results will be available for study participants on demand.

Confidentiality

All original records will be archived on file at the trial sites for 15 years. The cleaned electronic trial database file will be anonymised and kept for 15 years.

Declaration of interest

None of the authors has any financial or other competing interests in relation to the study. The study is an investigator-initiated trial. The promotion of the study is carried out by 29 hospitals of Spain previously mentioned and the Health Research Institute of Santiago (IDIS). There is no industry support or involvement in the trial.

Protocol changes

Any additional amendments to the protocol will be documented on ClinicalTrials.gov in accordance with Standard Protocol Items: Recommendations for Interventional Trials guidelines.

Dissemination plan

Trial results will be submitted to a peer-reviewed journal and will be presented at one scientific conference.

DISCUSSION

To the best of our knowledge, the INVIBLADE-ICU trial is the first randomised control study comparing successful intubation on the first attempt with the Macintosh videolaryngoscope versus the hyperangulated videolaryngoscope during tracheal intubation in critically ill patients. The standard Macintosh blades offer a lower angle of vision, but their advantage lies in their similarity to the blades commonly used in direct laryngoscopy, making them user-friendly for the person performing the tracheal intubation. Hyperangulated blades have a greater angle of vision, improving glottic visualisation, especially in patients with more complex airways.[14] However, the need to overcome this angulation could potentially hinder the passage of the endotracheal tube to the vocal cords. It is unknown whether either blade could have an advantage for intubating critically ill patients.

After the study, we hope to have sufficient data to recommend the optimal blade for intubation with a videolaryngoscope in critically ill patients.

Trial status

Enrolment began on 1 May 2024 and is expected to be completed in 2025.

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