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Intubation techniques for the critical care unit: An awareness and equipment updates

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Abstract
Tracheal intubation in critically ill patients is linked to significant consequences, primarily include cardiovascular break down and severe hypoxemia. This narrative review provides an updated overview of strategies that try to reduce these problems. MACOCHA is a straightforward scoring system used to identify patients in the critical care unit (ICU) at a high risk of experiencing difficulties during intubation. The combination of inspiratory assistance and strong end-expiratory pressure should continue to be the established approach for preoxygenation in patients with low levels of oxygen in their blood. Apneic oxygenation, utilizing high-flow nasal oxygen, can be employed as an adjunctive measure to mitigate the risk of worsening hypoxemia throughout tracheal intubation. Face mask ventilation with rapid sequence induction can be employed as a measure to avoid hypoxemia in specific patients who do not have a significant likelihood of aspiration. Prior to, during, and following the intubation procedure, it is crucial to engage in hemodynamic optimization and management. All of the components can be consolidated into a single package. Every intensive care unit (ICU) should implement an airway management algorithm that is customized to the requirements, circumstances, and proficiency of each practitioner. Experienced operators should utilize video laryngoscopes.

Keywords: Airway, intubation, complications, laryngoscope, ICU

Introduction
Tracheal intubation is a commonly performed operation in the critical care unit (ICU) [1-3]. Tracheal intubation in severely ill patients can lead to life-threatening complications in around 50% of instances [4, 5]. The most frequent problems that arise during the intubation of severely ill patients are cardiovascular dysfunction and hypoxemia [4, 6]. They are linked to a higher rate of death within 28 days [6] and can lead to ventricular arrest [7, 8], lack of oxygen in the brain, and ultimately death [9, 10]. This narrative review provides a concise overview of the current knowledge regarding the strategies for optimizing airway management in ICU patients using endotracheal tubes. These strategies include preoxygenation, apneic oxygenation, selection of appropriate devices, implementation of an airway management algorithm, optimization of hemodynamics, careful selection of drugs, and proper timing of intubation. The writers provide a narrative evaluation [11] that is grounded in the existing literature, as well as their own experience and subjectivity.

Preoxygenation and apneic oxygenation
To extend apnea without desaturation, preoxygenation increases the functional remaining capacity and oxygen stores, reducing hypoxemia. Overweight patients benefit more from preoxygenation in the 25° head-up posture than supine [12]. Instead of lying flat on their back, non-overweight patients can be intubated and preoxygenated in a 20° to 30° semi-sitting or reverse Trendelenburg posture [13]. For self-breathing patients, preoxygenation alternatives include a face masks, high-flow nasal oxygen (HFNO), positive end-expiratory pressure (PEEP), pressure support with PEEP (NIV), and OPTINIV, which combines NIV and HFNO. Despite only using NIV in 11% of INTUBE patients, severe hypoxemic acute respiratory failure patients preoxygenated using NIV rather to a mask on their faces during intubation of the trachea are less likely to develop hypoxemia. Pressure support and PEEP reduce the collapse of alveolar and atelectasis. Get rid of the face mask and insert the endotracheal tube after preoxygenation.

Intubating the trachea might take seconds or minutes, contingent upon how difficult it is [5]. HFNO provides apneic oxygenation after tracheal intubation. Apneic oxygenation occurs when the alveoli's oxygen removal and carbon dioxide excretion rates diverge, creating a negative pressure differential of up to 20 cmH2O. Oxygen may reach the lungs via the negative pressure gradient if airway permeability, or the alveolar openness, and oxygen alveolar pressure are present. A 1959 study [14] reported eight people crippled and intubated for minor procedures obtaining pure oxygen through an endotracheal tube. While at 100% oxygen saturation, carbon dioxide tension and acidosis in the lungs increased significantly. Many field studies are confusing because preoxygenation and apneic oxygenation occur simultaneously. In a randomised controlled study of non-severely hypoxemic patients, median lowest SpO2 during intubation was not significantly different [15]. However, desaturation was milder. Preoxygenation research gives conflicting results [16]. This may be due to variances in the individuals tested, hypoxemia severity, and apneic oxygenation rates (15-60 L/min). HFNO's preoxygenation and apneic oxygenation effectiveness is also disputed. This is primarily due to a lack of differentiation between preoxygenation and apneic oxygenation, which are done before and after apnea, respectively. New professional practise guideline recommends HFNO for intubation for patients who previously received it, despite the debate. Only NIV allows external PEEP and pressure assistance to open and maintain alveoli. A recent 313-patient randomized controlled trial examined NIV and HFNO for preoxygenation of patients in critical condition with acute hypoxemic breathing problems [17]. Without a difference in significance, 33 of 142 NIV preoxygenation patients (23%) and 47 of 171 HFNO patients (27%) experienced severe hypoxemia at 80% pulse oximetry. In the selected group of patients with PaO2/FiO2 less than 200 mmHg (28 patients, 24% of the total, vs 44 patients, 35% of the entire sample; modified probability ratio 0.56 [0.32-0.99], p=0.0459), serious hypoxemia was less common following NIV preoxygenation than HFNO. The results of this randomized controlled trial corroborated a 2017 meta-analysis by Chaudhuri *et al*. [18]. Combining HFNO and NIV may be better than using NIV alone. Combined preliminary oxygenation with pressure assistance and PEEP (NIV) with HFNO for preoxygenation and apneic oxygenation increased oxygen saturation during intubation in severe hypoxemic patients compared to NIV alone. The ventilator should allow all team members to transition from benign to invasive ventilation. Keep an oxygen-connected bag-valve masks on hand for manual ventilation. Finally, the OPTINIV approach, which increases oxygen saturation during intubation for individuals with severe hypoxemia using NIV, HFNO, and facial mask oxygenation can help provide ample oxygen reserves during preoxygenation. Although challenging apneic oxygenation can increase the safe apnea time after endotracheal intubation in critically sick patients [15], facial mask ventilation is an especially effective method of oxygenating and ventilating patients while apnea. Due to poor stomach emptying or lack of fasting, critically ill patients undergo a quick induction to reduce gastric insufflation and pulmonary aspiration. The PREVENT research randomly assigned patients to mask ventilation or no ventilation between induction and intubation [19]. Mask ventilation did not increase pulmonary aspiration or severe hypoxemia. This study did not examine pulmonary aspiration, but it challenges long-held beliefs and supports the idea that modest mask breathing can improve hypoxemia during rapid sequence induction.

Devices for endotracheal tube positioning and airway management algorithms

Challenged intubation has been linked to death [4, 5]. Several studies have linked first-attempt intubation failure to per procedural complications and mortality. Effective first-attempt intubation is an airway management study endpoint. In INTUBE, initial-attempt ICU rates of success maintained about 80% [6]. In an observational analysis, potential risk factors for difficult intubation in critically ill patients were identified. After its development and external verification, the MACOCHA rating was used to predict difficult intubation instances. The patient's characteristics, pathophysiology, and operator training determined intubation difficulty (Table 1). The negative predictive ability and sensitivities were optimized by using a threshold value of 3, excluding difficult intubations. Reduced challenging intubations and higher first success rates depend on intubation device use. Prior to the 2019 COVID-19 pandemic, conventional laryngoscopy was the recommended intubation procedure in intensive care units, following airway management recommendations [3]. In critically ill patients, tracheal intubation using a conventional Macintosh laryngoscope usually used an endotracheal tube alone [3]. An intubating stylet can help implant the endotracheal tube, reducing intubation problems [20]. A preshaped endotracheal tube and stylet may improve first-attempt intubation [20]. A few traumatic injuries have been reported using stylets, which are normally safe. These injuries include enlarged throats, bleeding mucosa, and trachea or oesophagus perforations. The STYLETO experiment examined how an intubating stylet affected critically sick patients' initial endotracheal intubation success [21]. Our operational hypothesis was that using a stylet with an endotracheal tube would increase first-attempt intubation success. This randomized controlled experiment included 32 ICUs across 30 academic and 2 other than academic French hospitals.

A stylet increased first-attempt intubation success compared to an endotracheal tube alone [21]. Te 11's point estimate for frstattempt intubation recommended endotracheal tubes and stylets in each subgroup [21]. The stylet offers airway management advantages due to its accessibility and affordability. Endotracheal intubation with a stylet increases the risk of mucosa haemorrhages laryngeal, endotracheal, mediastinal, and esophageal injuries. Although [21], both groups had equal traumatic injuries in our study. Boughies and stylests were compared in critical care patients undergoing endotracheal intubation [22]. A study of 1,106 patients found that an endotracheal tube with a stylet had a much higher success rate for primary intubation than a bougie. The study used direct and videolaryngoscopes, but the primary outcome was the same. Videolaryngoscopes are indicated for intensive care to improve airway management. Videolaryngoscopes are classified by blade type. Video equipment and Macintosh blades initially converge in videolaryngoscopes. Other choices include watching the glottis on TV or directly. Anatomically designed hyperangulated blades and a preshaped stylet simplify tracheal intubation in the second option. This method eliminates the need to pretend or extend the neck, but glottis observation is still required. The third category is channelled videolaryngoscopes, which use anatomically engineered blades with tube guides to avoid preshaped stylets. Videolaryngoscopes help see the glottis, but putting them into the trachea is difficult. Because the tube must penetrate the larynx at a sharp angle, "a 100% percentage of glottis opening (POGO) view during videolaryngoscopy-anatomically equivalent to a Cormack-Lehane grade 1 in direct laryngoscopy-does not guarantee a successful intubation". Videolaryngoscopes may reduce difficult intubation. A before-and-after study that outlined a quality improvement technique using a Macintosh videolaryngoscope in a respiratory management algorithm found that problematic intubation and laryngoscopy were significantly reduced [23]. The multivariate analysis showed that "standard laryngoscopy" was associated with intubation and/or difficulties. As measured by the MACOCHA score, the category of individuals who presented with difficult intubation had a significantly greater frequency of "standard laryngoscopy" (47% vs. 0% in the "Macintosh videolaryngoscope") [5]. Videolaryngoscopes may prevent difficulty intubation in the ICU, according to a 2014 systematic review and meta-analysis. Diffractional intubation, first-attempt success, Cormack 3/4 scores, and esophageal intubation were better with videolaryngoscopy than direct laryngoscopy. It did not affect severe hypoxemia, cardiovascular failure, or airway injury. However, a 2016 randomised controlled trial [1] found that videolaryngoscopy was linked with more severe, potentially fatal side effects and did not improve initial intubations compared to direct laryngoscopy. According to various meta-analyses, videolaryngoscopes are better than direct laryngoscopy for tracheal intubation in patients with serious illnesses [24]. In contrast, the samples were highly variable. Comparing direct laryngoscopy versus videolaryngoscope efficacy in studies must account for these potential confounding factors. Researchers recently conducted a prospective observational study to evaluate direct laryngoscopy with a Macintosh blade and the C-MAC® videolaryngoscope (Karl-Storz). The study included operators who performed 50 videolaryngoscope intubations in clinical simulation. The videolaryngoscope group had a higher first-attempt intubation rate than the Macintosh blade group. A recent study demonstrated that a Macintosh-style videolaryngoscope [25] used as originally intended equipment for tracheal intubation in the surgical suite showed a considerably higher proportion of simple airways than a regular Macintosh laryngoscope. No analogous study of critically unwell people has been done, to our knowledge. Unchanneled videolaryngoscopes require stylet preshaping of the endotracheal tube. Lascarrou *et al*. found less than 20% usage [1]. Instead of a standard endotracheal tube, a pre-shaped one with a stylet can improve videolaryngoscopy intubation [20]. Form and stiffness of the endotracheal tube are additionally important. Consider operator proficiency when judging the validity of reported randomized and observational research. Importantly, it has been [1] found that over 80% of operators lacked experience. A recent prospective observational study compared the C-MAC® videolaryngoscope (Karl-Storz) to a Macintosh blade [26]. The research operators performed 50 videolaryngoscope intubations in a clinical simulation. The videolaryngoscope group had a higher first-attempt intubation rate than the Macintosh blade group. A 90% familiarity rate was used to determine ideal videolaryngoscope performance. That degree of hyperangulated videolaryngoscope expertise requires at least 75 tries. The McGrath MAC videolaryngoscope (Medtronic) was used in a quality improvement project. They used the videolaryngoscope for severely ill intubations to concentrate skill improvement. Multivariate research identified unconsciousness, subordinate status, and videolaryngoscopy knowledge as independent risk variables for first-attempt failure. They discovered for the first time that the number of previous videolaryngoscopies did not affect the achievement rate of first-attempt intubation in critically unwell patients. This shows that videolaryngoscopy skill training directly affects this outcome. Operator competence enhanced first-attempt success rates. Videolaryngoscopy experience over 15 procedures was related with an 87% first-time success rate. Medical simulations or cadaveric practice must precede videolaryngoscope use in critically ill patients, emphasising the need of education and training. Table 2 lists 10 videolaryngoscope optimization tips for initial intubation. When the direct laryngoscope fails or an airway is difficult, the Difficult Airway Society (DAS) clinical practice guidelines for tracheal intubation in the critically ill recommend the use of a videolaryngoscope. The All India Difficult Airway Association (AIDAA) guidelines [27] recommend their accessibility and utilization in the intensive care unit, especially when a difficult airway is anticipated Videolaryngoscopes were preferred for intubating MACOCHA score 3 or higher patients in the airway management protocol [5]. It also served as a backup if a direct laryngoscopy was unable to intubate. These suggestions followed the 2017 professional recommendations on intubation and extubation in critical care units published by the SFAR and SRLF. A recent meta-analysis found that videolaryngoscopes reduced difficulty intubation and slightly increased the number of adults who were successfully intubated on the first try. In the ICU, videolaryngoscopy reduces airway operator contamination during intubation. This is especially true after the COVID-19 epidemic. International standards for COVID-19 airway management [28] advocate increasing the patient-airway operator distance via video laryngoscopy. Only experienced operators should perform tracheal intubation. Operators must be careful when retrieving bougies or stylets to avoid secretions on intubators [28]. The significance of videolaryngoscopy in the ICU for airway adjuncts such stylets will be studied. Research has shown that the first intubation success rate is a reliable main outcome that strongly correlates with intubation problems [29]. Upcoming randomized clinical trials must consider operator experience as a confounding variable. Critically ill patients may benefit from specific tracheal intubation algorithms in circumstances of foreseen or unexpected intubation issues. Figure 1 shows a redesigned airway management technique based on current clinical trials [21]. This strategy needs more research to determine if it can reduce ICU intubation risks. The airway management algorithm can be customized for each intensive care unit.

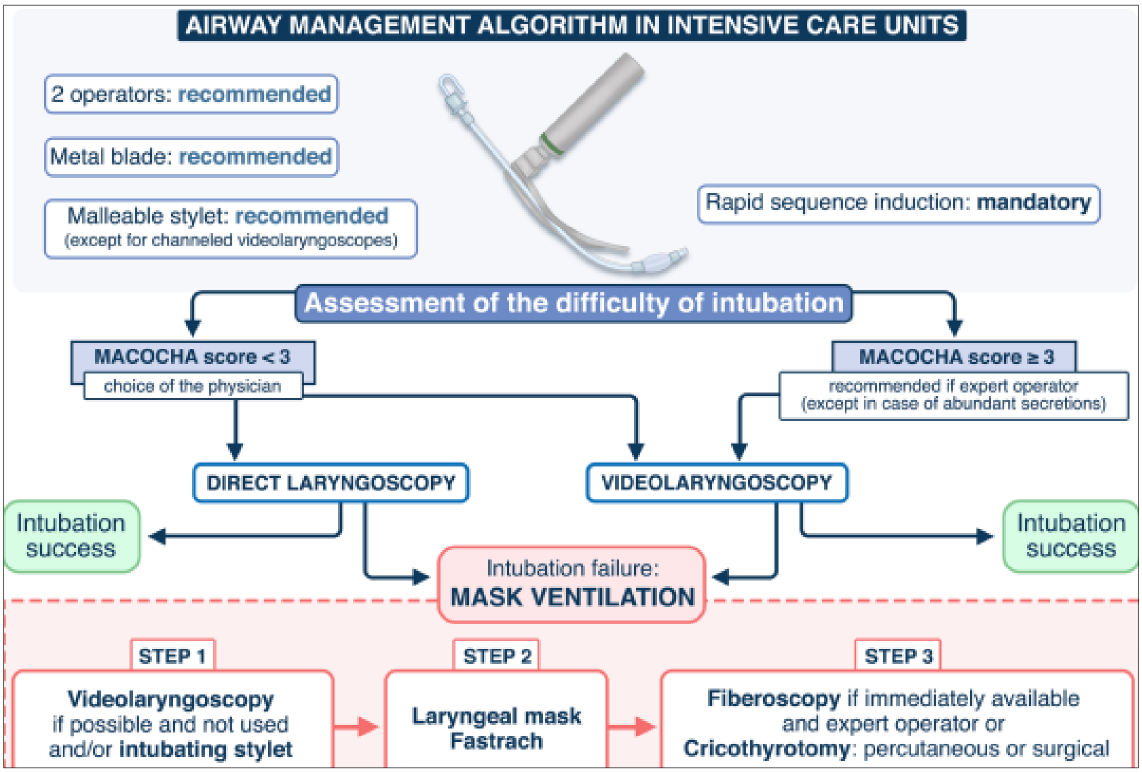

Fig 1: Airway management algorithm

Confirmation of tracheal tube position

Deadly hypoxemia, brain damage, and intubation that goes undetected can happen [30]. According to the 4th National Audit Study of the Royal College of Anaesthetists and Difficult Airway Society [31], a significant majority of the airway-related deaths in the intensive care unit (74% to be exact) were caused by the non-use of capnography. Therefore, it is not possible to rule out esophageal intubation based on a clinical examination alone. Even during cardiac resuscitation, it is important to confirm the tracheal tube location with sustained waveform capnography for at least 5-7 breaths after each intubation. Having regular waveforms helps with endotracheal tube placement, and routinely producing EtCO2 values over 10–20 mmHg allows one to track the effectiveness of cardiopulmonary resuscitation [32]. If carbon dioxide cannot be detected during persistent exhalation, the tracheal tube location must be confirmed immediately using laryngoscopic or bronchoscopic methods. Ventilation with and a face mask as well as a supraglottic airway should be performed during tube removal in cases where esophageal implantation cannot be ruled out.

Hemodynamic optimization and choice of drugs

Critically sick patients are at increased risk for hemodynamic failure, a major consequence of endotracheal intubation. There is an elevated risk of intensive care unit and 28-day death linked with peri-intubation cardiac failure [33]. Complications linked to hemodynamic intubation are less likely to occur when fluid infusion and early administration of vasopressors are used simultaneously to avoid severe collapse. Having said that, the evidence is still quite weak. Three hundred thirty-seven seriously sick persons undergoing tracheal intubation were randomly assigned to receive an IV injection of crystalloid liquid alone or no fluid bolus at all in a realistic, multicenter, unblinded, randomised experiment. Cardiovascular collapse after tracheal intubation was still as common when an intravenous fluid dose was administered without systematic vasopressor delivery. Notably, the results can be partially explained by the very low amount of fuid that was administered, and it was not accompanied with regular vasoactive support. The occurrence of cardiac arrest was not significantly reduced by administering an intravenous fluid bolus alone, without also systemically administering norepinephrine, according to a recent randomized controlled trial [34] that included 1067 critically ill patients going through tracheal intubation. Efficacy of fluid loading and vasopressor administration prior to tracheal intubation in preventing catastrophic cardiovascular collapse is being investigated in the ongoing FLUVA trial (NCT05318066). When hemodynamic difficulties arise, the intubation medicines become even more crucial. All anaesthetics cause hemodynamic instability following induction after a certain point in time of peak sympathomimetic system activity. The primary indication for the use of vasopressors is prevention. In Fig. 2 we can see the benefits and drawbacks of the intubation medications. In a post-hoc evaluation [33] of the INTUBE research [6] has cautioned us regarding the possibility of hemodynamic problems using propofol. Crucially, there was an elevated mortality rate linked to these hemodynamic problems. Interestingly, just 75% of cases utilized rapid sequence induction, which involves combining a neurological blocker and a quick-onset hypnotic [33]. When comparing the success rates of rocuronium and succinylcholine for endotracheal intubation in out-of-hospital emergency settings, the former did not show noninferiority in terms of the percentage of patients whose first attempt was successful. Both medications have the potential to be used safely, as there were no significant differences between them in a clinical setting.

DRUGS FOR RAPID SEQUENCE INDUCTION

HYPNOTICS

	PROS	CONS
ETOMIDATE	• More hemodynamic stability • Rapid onset: 15 to 45 s	• Corticosurrenal insufficiency
KETAMINE	• More hemodynamic stability • Bronchodilatator • Analgesic effect • Rapid onset: 45 to 60 s	• Hallucinations
PROPOFOL	• Bronchodilatator • Rapid onset: 15 to 45 s • Anti-epileptic • Better suppression of upper airway reflexes	• Hemodynamic compromise

+ NEUROMUSCULAR BLOCKERS

	PROS	CONS
SUCCINYLCHOLINE	• Rapid onset: 45-60 s • Improved glottic visualization	• Risk of hyperkalemia • Anaphylactic risk • Increase in oxygen consumption
ROCURONIUM	• No risk of hyperkalemia • Antidote: suggamadex	• Less rapid onset: 45-90 s • Anaphylactic risk

Fig 2: Drugs used for Intubation

Intubation bundle to limit complications related to intubation procedure (update of the Montpellier-ICU intubation algorithm)

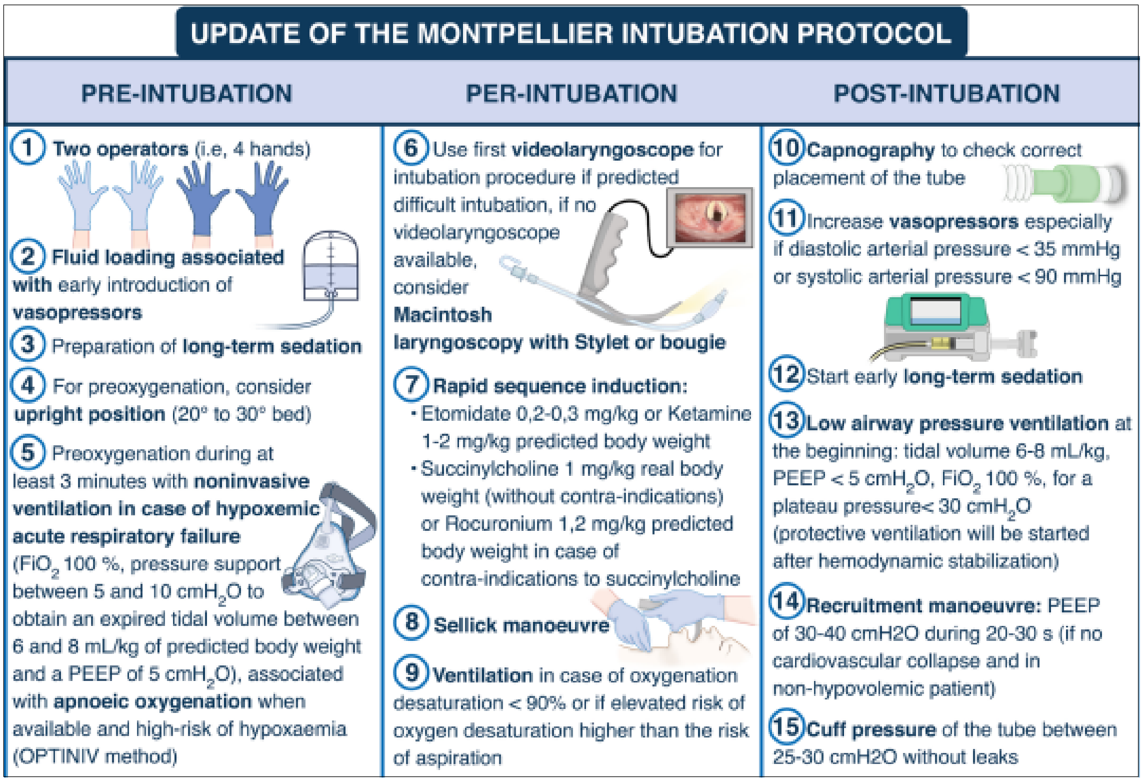

Fig 3: Update of the Montpellier intubation protocol

An intubation protocol was created by [35] to offer a useful resource for optimizing and planning the intubation procedure. Fig. 3 shows the revised Montpellier intubation protocol, which details what needs to be done or thought about at each stage of tracheal intubation: pre-, during-, and post-intubation. Using this bundle has been shown to make tracheal intubation safer. According to [35], there was a significant decrease in fatalities (21% vs. 34%, p=0.03) along with additional problems (9 vs. 21%, p=0.01) when the Montpellier intubation strategy was used during the intervention phase in comparison with the control phase. It has been presented the results of a third-party examination of the Montpellier intubation protocol [36]. This validation was conducted using a modified version of the methodology. A modified Montpellier approach was found by They to significantly increase the rate of first-attempt intubation success by 16.2% (95% CI 5.1-30.0%) and reduce the rate of all intubation-related problems by 12.6% (95% CI 1.2-23.6%). Just like in these two trials, the rate of serious complications was lower in the current STYLETO trial conducted in the large prospective international study [6]. The comparatively low rate for complications observed in both the endotracheal tube+stylet and endotracheal tube alone groups contrasted with the high pace observed in the INTUBE study [6] may be explained, in part, by the fact that the Montpellier intubation protocol was strongly recommended in the STYLETO study. As an example, capnography was utilized in a mere 25% of instances in the INTUBE study [6]. There needs to be further evaluation of the benefits of implementing an algorithmic system for tracheal intubation, but careful planning is mandated by the combination of critically ill patients' limited physiologic reserve and the potential for difficult mask ventilation and intubation [39]. The use of a verbal checklist before intubation to decrease lower blood pressure or saturation throughout the surgery was not shown to be superior in a randomised controlled trial [37]. Note that measures that improve physiologic variables, such as fluid load, vasopressors, and sufficient preoxygenation, were not included in this checklist. The usage of checkpoints for other intensive care unit procedures and the high level of airway management competence at the participating centres raise the possibility that the control group also had a high rate of checklist items. However, when the checklist incorporates actions to optimize physiology, it may be effective, especially with less experienced teams, prior to intubation [38].

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