Video laryngoscopy as the standard of care for pediatric intubation—the time is now

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Tracheal intubation is a lifesaving procedure and one of the foundational practices in the fields of neonatology and pediatric critical care medicine. In the February 2023 issue of *Lancet Child & Adolescent Health*, Riva and colleagues (1) published the pivotal study entitled “Direct versus video laryngoscopy with standard blades for neonatal and infant tracheal intubation with supplemental oxygen: a multicentre, non-inferiority, randomised controlled trial”. Based on the preponderance of their findings, they concluded that “video laryngoscopy with oxygen should be considered as the technique of choice when neonates and infants are intubated” (1). In this invited Editorial Commentary for *Translational Pediatrics*, we discuss the salient results of the study by Riva and colleagues (1), and contextualize their findings relative to existing data on the use of video laryngoscopy in neonates and across the pediatric population.

Children require tracheal intubation for various elective, urgent, and emergent reasons across diverse medical care environments such as the operating room, intensive care unit, emergency department, general inpatient areas, and out-of-hospital settings. Even in the hands of seasoned providers under controlled conditions, intubating neonates and small infants can be challenging, given their heightened susceptibility to adverse events during the procedure. This vulnerability stems largely from their elevated oxygen consumption relative to older children and adults, coupled with a high chest wall compliance that results in a functional residual capacity near or below the closing capacity. Consequently, infants may rapidly develop hypoxemia when they enter the relaxed state typical of anesthetic induction. Furthermore, their immature nervous system increases the risk of bradycardia from laryngeal manipulation during the procedure. Adverse event rates ranging from 18% (2) to 68% (3) have been reported during intubations in the neonatal intensive care unit (NICU), with oxygen desaturation occurring in 39–51% (2-4). The high incidence of adverse events has led to the development of various strategies to enhance safety during neonatal intubation. These include the use of individualized airway bundles (5), premedication (6), stylets (7,8), high-flow nasal cannula oxygen supplementation during intubation attempts (3), simulation training (9), and video laryngoscopy (10). The latter has been the subject of intense debate, considering the fact that direct laryngoscopy has been the primary approach for neonatal intubation for decades.

Tracheal intubation of anesthetized infants in the operating room using video laryngoscopy has been shown to result in a significantly higher first-attempt success rate compared to direct laryngoscopy [93% *vs.* 88%; adjusted absolute risk difference 5.5%; 95% confidence interval (CI): 0.7% to 10.3%; P=0.024], and a significantly lower rate of severe complications (2% *vs.* 5.5%; adjusted absolute risk difference −3.7%; 95% CI: −6.5% to −0.9%; P=0.0087) (11).

A Cochrane systematic review and meta-analysis published in 2023 comprising eight studies that evaluated 759 intubation attempts in neonates concluded that video laryngoscopy was associated with a higher first-attempt success rate, the need for fewer intubation attempts, and less airway trauma compared to direct laryngoscopy (10). Another important variable known to influence first-attempt success in small infants is the provision of high-flow oxygen therapy (also called apneic oxygenation when neuromuscular blockade is administered) during the intubation procedure. Apneic oxygenation has been shown to increase safe apnea time in healthy children by more than 80 s compared controls (192 *vs.* 109.2 s; 95% CI: 28.8, respectively) (12). The use of high-flow oxygen therapy was also found to improve the likelihood of successful intubation on the first attempt without physiologic instability compared to standard care (50% *vs.* 31.5%; adjusted risk difference 17.6%; 95% CI: 6.0% to 29.2%; P=0.024) among premature neonates (3).

Although the preponderance of evidence supports using video laryngoscopy to increase first-attempt intubation success in infants, this practice had not been systematically studied against direct laryngoscopy when high-flow oxygen therapy is also applied during the intubation procedure. To address this gap, Riva and colleagues (1) conducted a non-inferiority, international, multicenter, randomized controlled trial in infants up to 52 weeks postmenstrual age (i.e., gestational age plus chronological age) intubated in the operating room or in the pediatric or NICU in seven tertiary pediatric hospitals. The trial was designed to test the hypothesis that, under administration of supplemental high-flow oxygen, direct laryngoscopy is non-inferior to video laryngoscopy (10% non-inferiority margin, 90% power, and one-sided significance level of 0.025). Subjects were randomly allocated in a 1:1 ratio to video laryngoscopy (using the C-MAC device) or direct laryngoscopy, both outfitted with size-appropriate blades (Miller 0 if weight <1 kg and Miller 1 if >1 kg). Patients were excluded if they underwent emergency surgery or experienced cardiopulmonary collapse, were anticipated to face a challenging intubation, utilized an alternative airway management strategy (such as fiberoptic bronchoscopy), or if contraindicated due to congenital heart disease mandating a FiO_2 of less than 1.0. Pre-oxygenation was conducted using bag-valve mask ventilation with 100% oxygen. All subjects received apneic oxygenation during the intubation procedure at 1 L/kg/min via nasal cannula or via the anesthesia circuit connected to a tracheal tube placed through the nostril. Crossover to another intubation method was allowed if the first attempt was unsuccessful, or additional attempts could be performed using the original method (not exceeding four attempts). The primary outcome was first-attempt intubation success rate, with success defined as the visualization of an end-tidal CO_2 ($EtCO_2$) waveform on capnography. Secondary outcomes included the occurrence of moderate (<90%) and severe (<80%) oxygen desaturation by pulse oximetry, number of attempts, intubation time, quality of laryngeal view, crossover rates, and various procedural complications.

Riva and colleagues (1) randomized a total of 250 infants (125 to each group), with 244 infants ultimately included in the modified intention-to-treat analysis; 123 in the direct laryngoscopy group and 121 in the video laryngoscopy group. The two groups were well balanced for pre-intubation characteristics and craniofacial comorbidities. On average, subjects were born at 38 weeks gestation and had a postmenstrual age between 44 and 46 weeks at intubation. All intubations occurred in the operating room or diagnostic suite, with the vast majority conducted to facilitate surgery (98%) and under elective or semi-elective conditions (96% to 98%). Oral intubation was the most common route (77% to 81%) and uncuffed tubes were less frequently used (25% to 31%). There was excellent adherence to the pre-oxygenation protocol (99%) and apneic oxygenation (100%) during attempts. Video laryngoscopy resulted in a significantly higher first-attempt success rate compared to direct laryngoscopy [89.3% (95% CI: 83.7% to 94.8%) *vs.* 78.9% (95% CI: 71.6% to 86.1%), with an unadjusted absolute risk difference of 10.4% (95% CI: 1.3% to 19.5%), P=0.025] and an adjusted absolute risk difference of 9.5% (95% CI: 0.8% to 18.1%, P=0.033). Therefore, direct video laryngoscopy did not reach the non-inferiority margin of 10%. In other words, in young infants receiving high-flow supplemental oxygen, direct laryngoscopy did not show non-inferiority and thus cannot be regarded as equally effective to video laryngoscopy. There were no observable differences in time to intubation, need for additional resources, adverse events, or non-intubation related adverse events. The video laryngoscopy group achieved superior laryngeal view and were less likely (11% *vs.* 2%, P=0.01) to fail due to an insufficient view. The video laryngoscopy group also less frequently (2% *vs.* 11%, P=0.007) required external laryngeal manipulation to achieve an adequate view. After adjusting for covariates, analysis revealed video laryngoscopy to be superior for first attempt success rate when used by operators with ≥5 years of experience. Importantly, while not all outcomes in the subgroup analysis were statistically significant, all point estimates favored video laryngoscopy except for when used by operators with <5 years of experience.

In light of the evident advantage of video laryngoscopy demonstrated by Rivas and colleagues (1), and others (10,11,13) under controlled non-emergent conditions, some practitioners may question the potential extension of these benefits beyond the operating room. Observational studies conducted outside the NICU setting, such as those including both neonates and older children in the pediatric intensive care unit (PICU) have reported benefits associated with the use of video laryngoscopy (14). These benefits also extend to when intubation is performed by advanced practice providers (15), respiratory therapists (16), and pediatric emergency medicine physicians (17). In parallel with these observed benefits, the use of video laryngoscopy in the PICU has increased over time, and has been independently associated with a lower occurrence of tracheal intubation adverse events (18). Despite the fact that the vast majority of subjects (99%) instrumented using video laryngoscopy in the study by Riva and colleagues (1) were successfully intubated in the first or second attempts (and none required more than 3 attempts), it must be noted that the use of video laryngoscopy does not necessarily guarantee intubation success. As with every invasive procedure with an inherent risk, the practitioner managing the intubation must have a well-delineated plan to be used should they encounter equipment failure or inability to complete the endotracheal intubation. The availability of a properly sized supraglottic device (e.g., laryngeal mask airway) or advanced airway equipment (e.g., lighted stylets, fiber-optic scopes) may be lifesaving should the operator encounter a "cannot ventilate, cannot oxygenate" scenario. This is especially important considering that attempting to establish an emergent front-of-neck airway on a small infant outside the operating room is extremely challenging (if not impossible) and associated with significant morbidity. The use of point-of-care ultrasound to delineate airway anatomy might also be of help in selected cases.

Although only meticulously conducted prospective randomized trials can conclusively address this matter, we posit that the favorable effects of video laryngoscopy are likely applicable to the more challenging critical care setting, where emergent airway instrumentation is frequent, and optimizing the first attempt success rate is paramount due to the patient's limited physiologic reserve. Successful tracheal intubation on the first attempt is crucial for avoiding delays in reestablishing gas exchange and obviates the need for additional attempts, which have been associated with cardiorespiratory instability and life-threatening complications (2,17,19). Another often overlooked advantage of video laryngoscopy, not captured in a randomized trial involving experienced proceduralists like the one conducted by Rivas and colleagues (1), is its role in procedural training and coaching. By creating a real-time shared visual model between the proceduralist and other team members, video laryngoscopy has been associated with improved outcomes when used as a coaching device during intubation attempts by inexperienced operators (13), and during simulation (20). In fact, first-attempt intubation success rates among inexperienced trainees learning endotracheal intubation is significantly improved when an instructor provides real-time coaching while sharing the operator's view on the video laryngoscope (21). Coaching has the potential to shorten the learning curve associated with laryngoscopy, addressing the challenge posed by the highly variable number of intubations required for competency (22). The learning curve for clinicians performing neonatal intubations with direct laryngoscopy has not been thoroughly outlined, but proficiency may require over 100 attempts (23). Anesthesiologists demonstrate higher first attempt success rates with direct laryngoscopy as their experience increases, whereas this trend is not observed with video laryngoscopy (21). This suggests a potentially shorter learning curve for video laryngoscopy compared to direct laryngoscopy (24).

The choice of video laryngoscopy system and training may also affect intubation outcomes. When selecting video laryngoscopy blades, clinicians have two blade choices: standard geometric (e.g., Miller, Macintosh) or hyper-angulated. Standard blades can be used to perform both video and direct laryngoscopy, whereas hyper-angulated blades mandate the use of video laryngoscopy and require a modified technique for obtaining an optimal laryngeal view and tube passage into the airway; they do not allow for direct laryngoscopy due to lack of a direct line of sight. Available data in adults have not noted an observable difference in intubation success between the two blades types (25). An observational study of video laryngoscopy in children comparing standard and non-standard (hyper-angulated) blades found that the use of standard blades was associated with greater success both at initial (51% *vs.* 26%, P=0.002) and eventual intubation attempts (81% *vs.* 58%, P=0.002) in children weighing <5 kg, respectively, but not in those ≥5 kg (26). A perennial concern regarding the use of video laryngoscopy is the possibility of secretions or blood obscuring the camera, and other types of equipment malfunction (e.g., loss of power, cable discontinuity). In such unexpected emergencies, the use of a standard blade could still enable intubation as the operator may rapidly pivot from video to direct laryngoscopy without the need to clean or exchange blades. Team members assisting intubation using hyper-angulated blades also need specific training as an extra pair of hands is often required when removing stylet, especially in neonates, so as to prevent accidental dislodgment of the endotracheal tube.

Given the totality of the available evidence and our own clinical experience, we believe video laryngoscopy with high-flow oxygen supplementation should be the standard of care for tracheal intubation of neonates, infants, and children, when readily available. Multiple barriers exist, however, to the universal adoption and implementation of this technology, especially in resource-limited settings where the need to acquire and maintain expensive equipment might be cost-prohibitive. Additional hurdles to the widespread use of video laryngoscopy in children include the unavailability of blades suitable for extremely premature neonates, staff reticence to learning a new technique and maintaining newly acquired skills, and the limited portability of some video systems that complicate their use for unexpected intubations outside the intensive care unit, to name a few. Strategies to overcome these obstacles have been well studied in the PICU environment by Davis and colleagues (27) and include device accessibility, fostering a quality improvement culture, and strong leadership. Provided these barriers can be overcome, the next logical should be the widespread implementation of video laryngoscopy with apneic oxygenation in the care of neonates and small infants, with additional real-world data to evaluate its impact on patient safety.

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