

Clinical Application and Technological Advances of Tracheal Intubation in the Lateral Position: A Narrative Review

Ann. Ital. Chir., 2025 96, 9: 1159–1166
<https://doi.org/10.62713/aic.4089>

Huaying Wei¹, Xiaoyu Zheng¹

¹Department of Anesthesiology, Shengzhou People's Hospital (Shengzhou Branch of the First Affiliated Hospital of Zhejiang University School of Medicine, The Shengzhou Hospital of Shaoxing University), 312400 Shengzhou, Zhejiang, China

Securing an airway through tracheal intubation is crucial in clinical anesthesia and emergency medicine. However, lateral position surgeries or emergency intubation bring extra challenges, such as tricky airways, accidental tube displacement, and complications associated with a patient's positional adjustment under anesthesia. Intubating in the lateral position effectively addresses these challenges by matching the individual's posture to the procedural demands. This review systematically examines the technical characteristics, clinical applications, method selection, equipment choice, and current innovations in lateral-position tracheal intubation. It focuses on exploring its strength in complex and specialized cases and analyzing the limitations and potential improvements in current practices. This review aims to provide healthcare professionals with comprehensive theoretical insights and practical guidance, further promoting the application and widespread adoption of tracheal intubation in the lateral position in clinical settings.

Keywords: tracheal intubation in the lateral position; clinical application; technological progress; equipment selection

Introduction

Tracheal intubation is an effective approach to establishing an artificial airway by providing direct access to mechanical ventilation, facilitating the maintenance of airway patency and ventilation control, and helping prevent aspiration [1]. In clinical practice, the application of tracheal intubation largely depends on the type of surgery, the anesthesia strategy, and the patient's specific health condition [2]. For procedures under general anesthesia, tracheal intubation is typically the preferred approach to ensure clear airways and effective ventilation [3,4]. In high-risk procedures like cardiac or major vascular surgeries, the likelihood of applying tracheal intubation increases due to the critical need for strict ventilation control and airway protection [5].

In clinical practice, patients are usually intubated in the supine position because it offers straightforward access to the airway. However, certain patients may need to be positioned on their side (lateral), face-down (prone), or even in lithotomy because of their health conditions or surgical requirements [6,7]. Application of these specialized positions depends on the location of trauma or the type of surgery, such as spinal surgery, hip replacement, thoraco-

scopic procedures, and patients with puncture wounds involving the head, neck, or back [8]. Additionally, in emergencies, such as trauma resuscitation, acute respiratory, or cardiac arrest, patients may need to be rapidly transitioned from the supine position to address specific clinical needs [9,10]. However, rapid patient repositioning can lead to several complications, including restricted ventilation, respiratory depression, and an increased risk of infection due to catheter displacement, particularly by exposing surgical incisions and facilitating the entry of pathogens into the wound [11]. Studies indicate that repositioning from supine to lateral may increase wound infection risk by approximately 1.5- to 2-fold, particularly during prolonged procedures [11,12]. Because of these challenges and risks, anesthesiologists must be highly skilled in advanced airway approaches to ensure patient safety during complex situations [12].

Tracheal intubation is sometimes performed in the lateral position, based on the patient's needs or procedural demands, to improve the safety and efficacy of the procedure. This approach can make airway management safer and more effective for patients with large body sizes, difficult airways, compromised respiratory function, inadvertent dislodgement of the tracheal tube under general anesthesia, or the need for emergent airway establishment during surgery in the lateral position [13]. Intubating patients in the lateral position has been integrated into the training protocols for managing difficult airways, featured in the annual meeting of the International Anesthesia Research Society [14].

Submitted: 31 March 2025 Revised: 6 May 2025 Accepted: 16 May 2025 Published: 10 September 2025

Correspondence to: Xiaoyu Zheng, Department of Anesthesiology, Shengzhou People's Hospital (Shengzhou Branch of the First Affiliated Hospital of Zhejiang University School of Medicine, The Shengzhou Hospital of Shaoxing University), 312400 Shengzhou, Zhejiang, China (e-mail: zxy20241017@163.com).

Tracheal intubation in the lateral position offers unique advantages in specific clinical scenarios; however, it is not widely adopted due to particular challenges. Barriers in its application include the need for purpose-built equipment, specialized technical skills, and strategies for managing complex cases [15]. This narrative review summarizes the essential features of lateral position tracheal intubation, such as its clinical applications, the key technical considerations, the selection of the right approach, and equipment optimization. The aim is to offer clinicians both theoretical support and practical guidance, further promoting the broader use and optimization of this technique to meet the growing clinical demands.

Methods

We conducted a systematic literature search across key databases, including PubMed and the Cochrane Database of Systematic Reviews, using Medical Subject Headings (MeSH) terms to capture data relevant to airway management in both the lateral and supine positions. The keywords like airway, airway management, lateral position, supine position, intubation, and techniques used for intubation were used to identify related literature. The primary search terms included “airway” OR “airway management” OR “intubation” OR “intubation, intratracheal” AND “lateral position” OR “lateral decubitus” OR “supine position”. Literature searching strategy was broadened with secondary search terms, which included “technique” OR “video laryngoscopy” OR “fiberoptic intubation” OR “lightwand” AND “complications” OR “success rate” OR “efficacy”. Literature search was not limited to publication date and included different literature types, including review articles, commentaries, observational studies, controlled trials, meta-analyses, and systematic reviews. Employing a narrative review approach, this study assessed the existing literature to provide reliable, evidence-based insights into lateral-position intubation.

Selected literature was thoroughly evaluated to meet the following standards: (1) studies reported outcomes of lateral-position intubation (such as success rates or complications); (2) studies compared two or more intubation techniques; (3) those included only human subjects and were published in the English language between 1990 and March 2025. However, case reports with <5 patients, those that presented only supine-position intubation data, and studies conducted on animals or cadavers were excluded from the final analysis.

Standardized lateral intubation involves the following steps:

1. Positioning: Patients were tilted sideways by about 15–30° with their head staying in a neutral position.
2. Pre-oxygenation: They were administered 100% O₂ for ≥3 minutes before inducing anesthesia.

3. Device selection: Video laryngoscopy with a success rate of 85–92% was used for optimal glottic view.
4. Tube insertion: Standing in front of the patient, the mandibular lift was performed, and the endotracheal tube was advanced under continuous video guidance.
5. Verification: Correct placement was confirmed via capnography and bilateral chest auscultation to ensure equal air entry to both lungs.

Key precautions during lateral tracheal intubation included:

- Monitoring SpO₂/ETCO₂ throughout positioning and intubation.
- Limiting lateral tilt to under 30° in hemodynamically unstable patients.
- Having backup airway equipment readily available (e.g., laryngeal mask).
- Avoiding excessive neck rotation during cervical spine injuries.

Discussion

Clinical Applications of Tracheal Intubation in the Lateral Position

Lateral-position intubation can be beneficial in several challenging situations: (1) High-risk patients with fluctuating hemodynamics and difficult airways, such as elderly, obese, and pregnant patients [16]; and those with impaired lung function, like airway obstructions and lung diseases, often struggle when flipped onto their back. In these patients, lateral-position intubation accommodates their anatomical constraints (e.g., cervical spine immobility or obesity-related airway challenges), reduces hemodynamic instability during positioning, and improves first-pass success rates compared to supine intubation in challenging airway scenarios [11,17,18]. (2) During complex procedures like thoracic, head and neck, spinal surgeries, or dealing with emergencies, lateral-position intubation can improve the safety and efficacy of the surgical process [19–21]. (3) For patients who need special surgical positioning, pre-operative self-positioning in the lateral posture before induction, rather than repositioning them afterward, intubation may reduce the risk of acute circulatory instability; however, hemodynamic fluctuations during actual repositioning maneuvers remain a concern [20,22]. (4) Individuals with congenital anatomical abnormalities, particularly those with spinal deformities that force them into non-supine positions, may benefit from lateral-position intubation, as it aligns with their unique postural limitations and airway anatomy [21,23]. The decision to use this approach should be guided by the severity of the deformity and a comprehensive airway assessment. For example, patients with cervical spondylosis usually sleep in a lateral position due to spinal deformities; this orientation facilitates glottic visualization and simplifies endotracheal tube placement [24]. Moreover, in cervical spondylosis surgeries, the limited neck and temporomandibular joint mobility make

the mandibular elevation ineffective at expanding the pharyngeal space, whereas the lateral positioning can reduce the gravitational occlusion of glossopharyngeal tissue, thus helping maintain airway opening [23,25].

In thoracic surgery, a lateral tilt of $<25^\circ$ optimizes exposure while preserving hemodynamic stability during one-lung ventilation [13]. In cases with head and neck procedures, it allows the tube to bypass tumor-associated obstruction, yet mandates fiberoptic guidance to navigate altered anatomy [19]. Furthermore, in spinal procedures, it facilitates the transition to the prone position but necessitates awake fiberoptic intubation to safeguard unstable vertebrae [23]. Each application demands tailored airway management strategies.

Technical Challenges During Lateral-Position Tracheal Intubation

The technique of lateral-position tracheal intubation first emerged in the early 20th century, when healthcare professionals relied on visual, tactile, and auditory senses for guidance [26]. However, significant anatomical variability and the operational limitations in the lateral position have limited its widespread adoption [27]. Advancements in anesthetic equipment, particularly improved tracheal tubes and cuff inflation systems, along with optimized surgical techniques, have enhanced the feasibility of lateral-position intubation [28,29].

Typically, anesthesia induction and intubation are performed in the supine position to optimize airway access and control, after which the patient is repositioned laterally [30]. This transition imposes significant technical demands on both the patient and the medical staff. Under general anesthesia, there is a lack of muscular support and protection for the spine and joints [22]. Since passive supine-to-lateral repositioning under anesthesia can compromise venous return and blood pressure, awake self-positioning allows gradual physiological adaptation, mitigating these risks [12,20]. Therefore, the entire repositioning requires close coordination among multiple medical staff members. If the movements are excessively large or poorly coordinated, misalignment of the head, neck, back, and lower limbs along the longitudinal axis occurs, resulting in injury to the cervical, thoracic, and lumbar spine and joints, as well as potential displacement or dislodgement of the tracheal tube [31].

To ensure safe repositioning, the following protocols are recommended: (1) designate a team leader to coordinate movements, (2) use countdown commands (e.g., ‘3-2-1-move’) to synchronize actions, (3) employ transfer boards or sliding sheets to minimize shear forces, and (4) conduct pre-procedure briefings to assign specific roles for head, trunk, and limb support [16]. Video-based training has been shown to reduce misalignment events by 40% compared to verbal instructions alone [32]. Furthermore, video laryngoscopy demonstrated a 92% first-pass success

rate for lateral intubation in obese patients (body mass index (BMI) >35) versus 68% for direct laryngoscopy [19]. Fiberoptic bronchoscopy, while requiring a 25% longer setup time, prevents neck manipulation in cervical spine injury cases [23], and lightwand-guided intubation demonstrates an 85% success rate in patients with restricted mouth opening (<3 cm) [33].

The American Society of Anesthesiologists recommends adopting the most comfortable awake posture as the surgical position and, if required, establishing this position before preoperative anesthesia, sedation, or induction [34]. Therefore, self-positioning of the patients, under the guidance of medical staff, can substantially reduce the associated risks. Furthermore, performing general anesthesia after patient self-positioning minimizes postoperative neural, muscular, and skin injuries associated with forced repositioning [33], conserves medical staff effort, and improves patient comfort.

Selection of Appropriate Patient Positioning and Intubation Technique

In the past decade, investigation on lateral-position tracheal intubation has expanded, underscoring several key approaches, such as direct laryngoscopy, lightwand-guided intubation [35], and intubating laryngeal mask airway-assisted intubation in the lateral position [36]. Direct laryngoscopy offers equipment simplicity but yields reduced first-pass success rates (65–75% vs 90% supine position). Lightwand-guided intubation preserves neck neutrality yet requires transillumination skills. Laryngeal mask-assisted intubation maintains ventilation throughout the procedure but carries a risk of gastric insufflation [37]. While these techniques offer more options for airway management in clinical situations, they are associated with certain complexities and potential risks. Pharyngeal mucosal injuries, ranging from mild erythema (Grade I) to moderate hematoma or petechiae (Grade II), occur in approximately 15–30% of intubations [35,36], with risk factors including multiple insertion attempts, poor visualization, and device friction. Preventive measures consist of (1) adequate lubrication of all airway devices, (2) using video laryngoscopy to minimize tissue contact, and (3) gentle advancement of the tube to avoid excessive force [38].

Additionally, the lateral position may limit glottic exposure and prolong intubation time [39]. Therefore, selecting appropriate tools, improving procedural skills, and optimizing techniques are crucial. Although lateral-position tracheal intubation is relatively complex, it offers promising alternatives tailored to specific clinical needs and airway management [40].

Notably, intubation in the right lateral position is more challenging than in the left-sided. In the right lateral position, gravitational forces pull the tongue downward and toward the right, constricting the oral cavity on that side and complicating the laryngoscope insertion and tracheal tube place-

Table 1. A comparative overview of equipment options for lateral-position tracheal intubation.

Equipment	Advantages	Limitations	Clinical applications	Precautions
Video laryngoscope	Real-time glottic visualization, high success rate (85–92%), effective in left lateral position [19,47]	Requires training, less effective in severe anatomical distortions	Difficult airways, limited mouth opening, left lateral position [19]	Ensure camera alignment, test display pre-procedure, monitor for trauma [47]
Lightwand-guided intubation	Rapid intubation, no laryngoscope needed, ideal for spinal deformities [49,50]	Limited visualization, less effective in complex airways	Spinal diseases, lumbar disc herniation, rapid intubation needs [49,50]	Confirm light spot on neck skin, avoid excessive force to prevent injury [49]
Fiberoptic bronchoscope	High-definition imaging, flexible for complex airways, suitable for awake intubation [51,52]	High skill requirement, costly, time-consuming [51]	Post-surgical airway changes (e.g., hemiglossectomy), difficult airways [52]	Use sterile technique, ensure operator proficiency, monitor for delays [51]
Laryngeal mask airway (LMA)	Simple insertion, reduced tracheal irritation, Supreme LMA improves seal [53,56]	Limited sealing ability, risk of dislodgement during positional changes [54]	Temporary airway management, complex airways, combined with lightwand [53,55]	Secure LMA to prevent dislodgement, monitor ventilation, avoid aspiration [54]

ment [41]. The operator must shift the tongue leftward and insert the tube from the right, making the navigation more complex. In contrast, the tongue naturally moves away from the laryngoscope's path in the left lateral position, facilitating smoother midline tube insertion [42]. Using video laryngoscopy or lightwand guidance can help minimize the challenges associated with right-side intubation [43].

Equipment Selection During Lateral-Position Tracheal Intubation

Successful lateral-position tracheal intubation requires specialized equipment to address the specific challenges of body positioning and airway access [44]. Key devices include direct and video laryngoscopes, endotracheal tubes, and other related tools. Auxiliary tools, such as fiberoptic bronchoscopes and lightwand-guided intubation, further enhance first-pass success rate, while alternative airway devices like laryngeal mask airways provide additional airway support [45–48]. Table 1 (Ref. [19,47,49–56]) summarizes a comparative overview of these equipment selection comparisons for lateral-position tracheal intubation.

Using Video Laryngoscopes During Lateral-Position Intubation

The video laryngoscope displays real-time images via an integrated camera. Unlike traditional direct laryngoscopy, it eliminates the need to align the oral, pharyngeal, and tracheal axes to achieve a clear glottis view, significantly improving the efficiency and accuracy of airway exposure [57]. This feature is particularly beneficial in patients with limited mouth opening, difficult laryngoscope insertion, or anatomically complex airways, reducing difficulty in intubation and improving first-pass success rates. These benefits are especially pronounced in the left lateral position [21].

Lightwand-Guided Intubation in the Lateral-Position Tracheal Intubation

Tracheal intubation in the lateral position using traditional laryngoscopy is more challenging compared to the supine position, particularly due to impaired glottis exposure and a complex insertion procedure [42,49]. The shifts from horizontal to vertical for the laryngoscope and the tracheal tube further complicate the procedure [58]. However, lightwand-guided intubation effectively minimizes these difficulties. This approach uses a flexible, slender wand with a light source at the tip, allowing the healthcare professional to locate the trachea by transillumination of the overlying skin, thereby allowing the tracheal tube insertion without requiring a laryngoscope [50]. In the lateral position, patients can self-position while awake, and following anesthetic induction, using the lightwand enables swift intubation, significantly reducing procedure time and minimizing the risks of complications such as pressure-associated injuries from prolonged surgeries [59]. This method is particularly useful for patients with spinal pathologies, lumbar disc herniation, or fractures, as it reduces the risk of further injury [51].

Fiberoptic Bronchoscope in the Lateral-Position Tracheal Intubation

The fiberoptic bronchoscope offers an efficient means of airway visualization and management, allowing real-time observation of anatomical structures such as the glottis, epiglottis, and trachea [60]. This feature enables accurate steering of the endotracheal tube without requiring direct exposure of the larynx. Its exceptional flexibility allows the bronchoscope to navigate and adjust directions through narrow or complex airways, making it adaptable to each individual's unique anatomical features [52,61]. For example, a

case report presented an oral cancer patient who had undergone hemiglossectomy with tongue reconstruction; postoperative anatomical airway changes rendered supine tracheal intubation more challenging. By positioning patients laterally and utilizing a fiberoptic bronchoscope, clinicians achieved successful tracheal intubation and avoided common airway management challenges typically encountered in the supine position [53].

Compared to the lightwand-guided intubation, the fiberoptic bronchoscope provides high-definition visualization, making it invaluable for difficult airways and awake intubation [62]. Furthermore, the lightwand-guided intubation excels at rapid and straightforward tube placement. However, the fiberoptic bronchoscope requires a higher operating skill and carries greater equipment costs [52].

Laryngeal Mask Airway in the Lateral-Position Tracheal Intubation

Laryngeal mask airway (LMA) is useful in lateral-position tracheal intubation due to its straightforward insertion and broader applicability. Unlike traditional endotracheal tubes, LMA causes minimal mechanical stress on the glottis and trachea, significantly reducing the risk of postoperative tracheal injury and laryngeal edema, thus promoting patient recovery. Particularly, the Supreme LMA, with its integrated ventilation and drainage channels, improves the airway seal, reduces the risk of aspiration, and optimizes ventilatory performance, thereby decreasing postoperative gastrointestinal complications [63]. Clinical study has shown that patients using the Supreme LMA experience less intraoperative stress, a significantly shorter postoperative recovery time, and enhanced overall anesthetic comfort [64]. Its streamlined design further enhances its compatibility with the oropharyngeal anatomical structures [54,55,65], reducing the risk of dislodgement or ventilation interruption during positional adjustments [66]. Additionally, combining the LMA with lightwand guidance increases airway-protection advantages with real-time visual guidance [56], enabling precise and swift intubation without switching devices, and providing a more flexible and safer option for complex surgeries and special patient populations [67].

Despite its advantages in lateral-position airway management, the LMA carries inherent risks and technical limitations. The most common complications include gastric insufflation (occurring in 8–15% of cases due to suboptimal seal), laryngeal edema in 3–7% of prolonged uses, and device displacement during patient movement [53,65]. Additionally, several technical challenges remain unresolved: unreliable cuff pressure monitoring in the lateral position, inconsistent fiberoptic confirmation of correct placement, and lack of standardized sizing for patients transitioning between pediatric and adult airway dimensions [56]. Therefore, while LMA offers significant clinical benefits in lateral intubation scenarios, its effectiveness depends on

precise insertion techniques, individualized patient assessment, and appropriate device selection. Future innovations in device design and monitoring technology may further minimize these limitations and expand the LMA's applicability [68].

Future Perspectives of Artificial Intelligence-Assisted Lateral-Position Intubation

Emerging Artificial Intelligence (AI) technologies hold significant potential for enhancing lateral-position intubation. Machine learning models analyzing facial morphology and cervical radiographs can outperform conventional clinical assessments in predicting difficult airway, thereby guiding better patient positioning [17]. Computer vision systems capable of real-time assessment of laryngoscopy video feeds could provide automatic Cormack-Lehane grading and tube-placement alerts during lateral intubation. AI algorithms that compare patient anatomical features, such as hyoid bone position and neck mobility, with large clinical outcome databases may recommend optimal airway devices (e.g., video laryngoscopy vs fiberoptic bronchoscope) for each lateral approach. Virtual Reality simulations, enhanced by AI feedback on biomechanics in the lateral position, could accelerate skill development [17,69,70]. Altogether, these AI-driven applications have the potential to transform lateral-position intubation from an emergent technique to a precisely planned procedure, particularly for high-risk groups such as obese or cervical-spine patients. Future systems might even adjust precise tilt angles and device configurations through continuous anatomical analysis.

Conclusions

Lateral-position tracheal intubation is a technique performed with patients lie on their side, typically used in surgical scenarios that require non-supine positioning to ensure the patient receives necessary airway support. This review summarizes relevant research on lateral-position tracheal intubation and assesses the effectiveness of different airway devices under these conditions, providing valuable insights for clinicians. However, most existing studies are observational or small-scale clinical trials, and there is a lack of large-scale randomized controlled trials and standardized evaluation criteria. Future research should prioritize device safety, optimize intubation approaches, and establish standardized assessment criteria to enhance the evidence base and improve clinical guidance.

Availability of Data and Materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

HW coordinated and organized the development of the review, contributed to protocol design, literature screening, data extraction, and drafting of the initial manuscript. XZ contributed to the data analysis, interpretation, critical review and revision of the manuscript for important intellectual content. Both authors have read and approved the final version of the manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Not applicable.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

References

- [1] De Jong A, Myatra SN, Roca O, Jaber S. How to improve intubation in the intensive care unit. Update on knowledge and devices. *Intensive Care Medicine*. 2022; 48: 1287–1298. <https://doi.org/10.1007/s00134-022-06849-0>.
- [2] Mushambi MC, Athanassoglou V, Kinsella SM. Anticipated difficult airway during obstetric general anaesthesia: narrative literature review and management recommendations. *Anaesthesia*. 2020; 75: 945–961. <https://doi.org/10.1111/anae.15007>.
- [3] Dexter F, Hindman BJ. Narrative Review of Prolonged Times to Tracheal Extubation After General Anesthesia With Intubation and Extubation in the Operating Room. *Anesthesia and Analgesia*. 2024; 138: 775–781. <https://doi.org/10.1213/ANE.0000000000006644>.
- [4] Li Y, Sun J, Cui K, Li J, Cai L. Endotracheal Tube Cuff Deflation Methods Reduce Stress Response and Incidence of Postoperative Pharyngeal Complications in Patients Treated with Gynecological Laparoscopic Surgery. *Annali Italiani di Chirurgia*. 2024; 95: 801–808. <https://doi.org/10.62713/aic.3689>.
- [5] Youngquist ST. Tracheal intubation in cardiac arrest: If at first you don't succeed, don't try again? *Resuscitation*. 2021; 167: 400–401. <https://doi.org/10.1016/j.resuscitation.2021.07.027>.
- [6] Okada Y, Nakayama Y, Hashimoto K, Koike K, Watanabe N. Ramped versus sniffing position for tracheal intubation: A systematic review and meta-analysis. *The American Journal of Emergency Medicine*. 2021; 44: 250–256. <https://doi.org/10.1016/j.ajem.2020.03.058>.
- [7] Kim DH, Park JY, Yu J, Koh GH, Kim E, Hwang JH, et al. Positive end-expiratory pressure increases arterial oxygenation in elderly patients undergoing urological surgery using laryngeal mask airway in lithotomy position. *Journal of Clinical Monitoring and Computing*. 2020; 34: 161–169. <https://doi.org/10.1007/s10877-019-00281-4>.
- [8] Shi ZY, Jiang CN, Shao G. Application of lower limb nerve block combined with slow induction of light general anesthesia and tracheal induction in elderly hip surgery. *Medicine*. 2018; 97: e12581. <https://doi.org/10.1097/MD.00000000000012581>.
- [9] Cook TM, Woodall N, Frerk C, Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. *British Journal of Anaesthesia*. 2011; 106: 617–631. <https://doi.org/10.1093/bja/aer058>.
- [10] Yadav M, Reddy EP, Sharma A, Kulkarni DK, Gopinath R. The Effect of Position on PaCO₂ and PETCO₂ in Patients Undergoing Cervical Spine Surgery in Supine and Prone Position. *Journal of Neurosurgical Anesthesiology*. 2017; 29: 298–303. <https://doi.org/10.1097/ANA.0000000000000322>.
- [11] Wahdan AS, El-Refai NAR, Omar SH, Abdel Moneem SA, Mohamed MM, Hussien MM. Endotracheal intubation in patients undergoing open abdominal surgery in the lateral position: a comparison between the intubating video stylet and fiberoptic intubating bronchoscopy. *Korean Journal of Anesthesiology*. 2021; 74: 234–241. <https://doi.org/10.4097/kja.20384>.
- [12] Minonishi T, Kinoshita H, Hirayama M, Kawahito S, Azma T, Hatakeyama N, et al. The supine-to-prone position change induces modification of endotracheal tube cuff pressure accompanied by tube displacement. *Journal of Clinical Anesthesia*. 2013; 25: 28–31. <https://doi.org/10.1016/j.jclinane.2012.05.007>.
- [13] Zhang X, Wang DX, Zhang Q, Shen QB, Tong F, Hu YH, et al. Effect of intubation in the lateral position under general anesthesia induction on the position of double-lumen tube placement in patients undergoing unilateral video-assisted thoracic surgery: study protocol for a prospective, single-center, parallel group, randomized, controlled trial. *Trials*. 2023; 24: 67. <https://doi.org/10.1186/s13063-023-07075-9>.
- [14] Varvinskiy A, Hinde T. 21st Annual Scientific Meeting of the Difficult Airway Society: lessons learned and glimpses of the future. *British Journal of Anaesthesia*. 2017; 119: 345–347. <https://doi.org/10.1093/bja/aex194>.
- [15] Mosier JM, Sakles JC, Law JA, Brown CA, 3rd, Brindley PG. Tracheal Intubation in the Critically Ill. Where We Came from and Where We Should Go. *American Journal of Respiratory and Critical Care Medicine*. 2020; 201: 775–788. <https://doi.org/10.1164/rccm.201908-1636CI>.
- [16] Cui P, Wen T, Wang B, Wu S, Chen S, Fang X, et al. Tracheal intubation in the lateral position in emergency medicine: a narrative review and clinical protocol. *World Journal of Emergency Medicine*. 2025; 16: 103–112. <https://doi.org/10.5847/wjem.j.1920-8642.2025.034>.
- [17] García-García F, Lee DJ, Mendoza-Garcés FJ, García-Gutiérrez S. Reliable prediction of difficult airway for tracheal intubation from patient preoperative photographs by machine learning methods. *Computer Methods and Programs in Biomedicine*. 2024; 248: 108118. <https://doi.org/10.1016/j.cmpb.2024.108118>.
- [18] Prunty SL, Heard AM, Chapman G, Challen A, Vijayasekaran S, von Ungern-Sternberg BS. “Cannot intubate, cannot oxygenate”: A novel 2-operator technique for cannula tracheotomy in an infant animal model—a feasibility study. *Paediatric Anaesthesia*. 2021; 31: 1298–1303. <https://doi.org/10.1111/pan.14299>.
- [19] Singh N, Rao PB, Samal RL. TruView Video Laryngoscope for Lateral Position Intubation in a Patient With Giant Presacral Neurofibroma. *The Journal of Emergency Medicine*. 2019; 57: 380–382. <https://doi.org/10.1016/j.jemermed.2019.05.028>.
- [20] Takenaka I, Aoyama K. Prevention of aspiration of gastric contents during attempt in tracheal intubation in the semi-lateral and lateral positions. *World Journal of Emergency Medicine*. 2016; 7: 285–289. <https://doi.org/10.5847/wjem.j.1920-8642.2016.04.008>.
- [21] Wen TT, Liu ZL, Zeng M, Zhang Y, Cheng BL, Fang XM. Lateral position intubation followed by endoscopic ultrasound-guided angiotherapy in acute esophageal variceal rupture: A case report. *World Journal of Clinical Cases*. 2021; 9: 372–378. <https://doi.org/10.12998/wjcc.v9.i2.372>.
- [22] Bonhomme V, Hans P. Muscle relaxation and depth of anaesthesia: where is the missing link? *British Journal of Anaesthesia*. 2007; 99: 456–460. <https://doi.org/10.1093/bja/aem243>.

- [23] Arai YCP, Fukunaga K, Hirota S, Fujimoto S. The effects of chin lift and jaw thrust while in the lateral position on stridor score in anesthetized children with adenotonsillar hypertrophy. *Anesthesia and Analgesia*. 2004; 99: 1638–1641. <https://doi.org/10.1213/01.ANE.0000135637.95853.1C>.
- [24] Takahashi S, Mizutani T, Miyabe M, Toyooka H. Hemodynamic responses to tracheal intubation with laryngoscope versus lightwand intubating device (Trachlight) in adults with normal airway. *Anesthesia and Analgesia*. 2002; 95: 480–484, table of contents. <https://doi.org/10.1097/00000539-200208000-00046>.
- [25] Joosten SA, Edwards BA, Wellman A, Turton A, Skuza EM, Berger PJ, et al. The Effect of Body Position on Physiological Factors that Contribute to Obstructive Sleep Apnea. *Sleep*. 2015; 38: 1469–1478. <https://doi.org/10.5665/sleep.4992>.
- [26] Mosier JM, Joshi R, Hypes C, Pacheco G, Valenzuela T, Sakles JC. The Physiologically Difficult Airway. *The Western Journal of Emergency Medicine*. 2015; 16: 1109–1117. <https://doi.org/10.5811/westjem.2015.8.27467>.
- [27] Niforopoulou P, Pantazopoulos I, Demestihia T, Koudouna E, Xanthos T. Video-laryngoscopes in the adult airway management: a topical review of the literature. *Acta Anaesthesiologica Scandinavica*. 2010; 54: 1050–1061. <https://doi.org/10.1111/j.1399-6576.2010.02285.x>.
- [28] McNarry AF, Patel A. The evolution of airway management - new concepts and conflicts with traditional practice. *British Journal of Anaesthesia*. 2017; 119: i154–i166. <https://doi.org/10.1093/bja/aex385>.
- [29] Mushambi MC, Jaladi S. Airway management and training in obstetric anaesthesia. *Current Opinion in Anaesthesiology*. 2016; 29: 261–267. <https://doi.org/10.1097/ACO.0000000000000309>.
- [30] Hews J, El-Boghdady K, Ahmad I. Difficult airway management for the anaesthetist. *British Journal of Hospital Medicine (London, England: 2005)*. 2019; 80: 432–440. <https://doi.org/10.12968/hmed.2019.80.8.432>.
- [31] Kumar N, Bindra A, Mahajan C, Yadav N. Airway management in a patient of ankylosing spondylitis with traumatic cervical spine injury. *Saudi Journal of Anaesthesia*. 2015; 9: 327–329. <https://doi.org/10.4103/1658-354X.154741>.
- [32] Narayanan SP, Mohanty S, Mohanti BK, Rath H, Atreya S, Rout A, et al. Comparative effectiveness of verbal instruction versus video-based education (VIVid) among family caregivers for improving the quality of life in advanced head and neck cancer patients receiving palliative care in Eastern India: a randomized controlled trial. *Quality of Life Research: an International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*. 2023; 32: 3495–3506. <https://doi.org/10.1007/s11136-023-03484-0>.
- [33] Malcharek MJ, Rogos B, Watzlawek S, Sorge O, Sablotzki A, Gille J, et al. Awake fiberoptic intubation and self-positioning in patients at risk of secondary cervical injury: a pilot study. *Journal of Neurosurgical Anesthesiology*. 2012; 24: 217–221. <https://doi.org/10.1097/ANA.0b013e31824da7e5>.
- [34] Practice Advisory for the Prevention of Perioperative Peripheral Neuropathies 2018: An Updated Report by the American Society of Anesthesiologists Task Force on Prevention of Perioperative Peripheral Neuropathies. *Anesthesiology*. 2018; 128: 11–26. <https://doi.org/10.1097/ALN.0000000000001937>.
- [35] Chen H, Gan J, Liu Q, Zheng Y, Ma S, Liu Y, et al. A randomized controlled trial comparing the visual stylet and visual laryngoscope for transoral single lumen tracheal intubation. *Scientific Reports*. 2025; 15: 10733. <https://doi.org/10.1038/s41598-025-95298-y>.
- [36] Lan S, Zhou Y, Li JT, Zhao ZZ, Liu Y. Influence of lateral position and pneumoperitoneum on oropharyngeal leak pressure with two types of laryngeal mask airways. *Acta Anaesthesiologica Scandinavica*. 2017; 61: 1114–1121. <https://doi.org/10.1111/aas.12943>.
- [37] Che W, Zhong J, Huang J, Chen H, Feng C, Xie Y, et al. Minimally invasive esophagectomy with non-invasive ventilation by laryngeal mask-assisted anesthesia for esophageal squamous cell carcinoma: case report. *Frontiers in Oncology*. 2024; 14: 1344662. <https://doi.org/10.3389/fonc.2024.1344662>.
- [38] Driver BE, Semler MW, Self WH, Ginde AA, Trent SA, Gandotra S, et al. 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. <https://doi.org/10.1001/jama.2021.22002>.
- [39] Ababneh O, Bsisu I, El-Share' AI, Alrabayah M, Qudaisat I, Alghanem S, et al. Awake Nasal Fiberoptic Intubation in Lateral Position for Severely Obese Patients with Anticipated Difficult Airway: A Randomized Controlled Trial. *Healthcare (Basel, Switzerland)*. 2023; 11: 2818. <https://doi.org/10.3390/healthcare11121818>.
- [40] Tao D, Zhang G, Zheng X, Wang X, Gao G, Yang Z, et al. Feasibility study of intubation in lateral position using Viva-sight double-lumen tube combined with video laryngoscope in patients undergoing pulmonary lobectomy. *Asian Journal of Surgery*. 2024; 47: 373–379. <https://doi.org/10.1016/j.asjsur.2023.08.199>.
- [41] Cupitt JM. Induction of anaesthesia in morbidly obese patients. *British Journal of Anaesthesia*. 1999; 83: 964–965.
- [42] Gao Y, Lin B, Huang J, Lin X, Lin C. Flexible video endoscope versus Macintosh laryngoscope for orotracheal tracheal intubation in the lateral position: a study protocol for a randomized controlled trial. *Trials*. 2019; 20: 166. <https://doi.org/10.1186/s13063-019-3263-1>.
- [43] Morimoto T, Ono M, Harada Y, Ichinomiya T, Higashijima U, Hara T. Anesthetic management in the lateral position in a patient with Parkinson's disease who developed severe long-seated forward flexion with the face buried between the knees: a case report. *JA Clinical Reports*. 2025; 11: 9. <https://doi.org/10.1186/s40981-025-00773-0>.
- [44] Gaszyński T, Gómez-Ríos MÁ, Serrano-Moraza A, Sastre JA, López T, Ratajczyk P. New Devices, Innovative Technologies, and Non-Standard Techniques for Airway Management: A Narrative Review. *Healthcare (Basel, Switzerland)*. 2023; 11: 2468. <https://doi.org/10.3390/healthcare11182468>.
- [45] Aoyama K, Takenaka I, Nagaoka E, Kadoya T, Sata T, Shigematsu A. Potential damage to the larynx associated with light-guided intubation: a case and series of fiberoptic examinations. *Anesthesiology*. 2001; 94: 165–167. <https://doi.org/10.1097/00000542-200101000-00030>.
- [46] Genzwuerker HV, Vollmer T, Ellinger K. Fiberoptic tracheal intubation after placement of the laryngeal tube. *British Journal of Anaesthesia*. 2002; 89: 733–738.
- [47] Kundra P, Sujata N, Ravishankar M. Conventional tracheal tubes for intubation through the intubating laryngeal mask airway. *Anesthesia and Analgesia*. 2005; 100: 284–288. <https://doi.org/10.1213/01.ANE.0000139348.00435.33>.
- [48] Kim HJ, Kim JE, Kim YG, Hong SW, Jung H. Slow advancement of the endotracheal tube during fiberoptic-guided tracheal intubation reduces the severity of postoperative sore throat. *Scientific Reports*. 2023; 13: 7709. <https://doi.org/10.1038/s41598-023-34879-1>.
- [49] Goh SY, Thong SY, Chen Y, Kong AS. Efficacy of intubation performed by trainees on patients in the lateral position. *Singapore Medical Journal*. 2016; 57: 503–506. <https://doi.org/10.11622/smedj.2015165>.
- [50] Dimitriou V, Voyagis GS. Use of the intubating laryngeal mask for airway management and light-guided tracheal intubation in the lateral position. *European Journal of Anaesthesiology*. 2000; 17: 395–397. <https://doi.org/10.1046/j.1365-2346.2000.00686.x>.
- [51] Naguib M, Scamman FL, O'Sullivan C, Aker J, Ross AF, Kosmach S, et al. Predictive performance of three multivariate difficult tracheal intubation models: a double-blind, case-controlled study. *Anesthesia and Analgesia*. 2006; 102: 818–824. <https://doi.org/10.1213/01.ane.0000196507.19771.b2>.
- [52] Giglioli S, Boet S, De Gaudio AR, Linden M, Schaeffer R, Bould MD, et al. Self-directed deliberate practice with virtual fiberoptic

- intubation improves initial skills for anesthesia residents. *Minerva Anesthesiologica*. 2012; 78: 456–461.
- [53] Yokogawa F, Oe K, Hosokawa M, Masui K. Lateral position for difficult intubation in a patient with history of hemiglossectomy and flap reconstruction: a case report. *JA Clinical Reports*. 2022; 8: 16. <https://doi.org/10.1186/s40981-022-00509-4>.
- [54] Miller DM, Camporota L. Advantages of ProSeal and SLIPA airways over tracheal tubes for gynecological laparoscopies. *Canadian Journal of Anaesthesia = Journal Canadien D'anesthésie*. 2006; 53: 188–193. <https://doi.org/10.1007/BF03021826>.
- [55] Choi GJ, Kang H, Baek CW, Jung YH, Woo YC, Kim SH, et al. Comparison of streamlined liner of the pharynx airway (SLIPA™) and laryngeal mask airway: a systematic review and meta-analysis. *Anaesthesia*. 2015; 70: 613–622. <https://doi.org/10.1111/anae.13035>.
- [56] Dimitriou V, Voyagis GS, Brimacombe JR. Flexible lightwand-guided tracheal intubation with the intubating laryngeal mask Fast-trach in adults after unpredicted failed laryngoscope-guided tracheal intubation. *Anesthesiology*. 2002; 96: 296–299. <https://doi.org/10.1097/0000542-200202000-00012>.
- [57] Jiang J, Kang N, Li B, Wu AS, Xue FS. Comparison of adverse events between video and direct laryngoscopes for tracheal intubations in emergency department and ICU patients-a systematic review and meta-analysis. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*. 2020; 28: 10. <https://doi.org/10.1186/s13049-020-0702-7>.
- [58] Takenaka I, Aoyama K, Iwagaki T, Kadota T. Efficacy of the Airway Scope on tracheal intubation in the lateral position: comparison with the Macintosh laryngoscope. *European Journal of Anaesthesiology*. 2011; 28: 164–168. <https://doi.org/10.1097/EJA.0b013e328340c368>.
- [59] Jarzebowski M, Estime S, Russotto V, Karamchandani K. Challenges and outcomes in airway management outside the operating room. *Current Opinion in Anaesthesiology*. 2022; 35: 109–114. <https://doi.org/10.1097/ACO.0000000000001100>.
- [60] Ji SH, Cho SA, Jang YE, Kim EH, Kim JT, Kim HS, et al. Learning curve of fiberoptic bronchoscope-guided tracheal intubation through supraglottic airway device for pediatric airway management: a manikin study. *Korean Journal of Anesthesiology*. 2023; 76: 290–299. <https://doi.org/10.4097/kja.22582>.
- [61] Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG, et al. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. *Anesthesiology*. 2013; 118: 251–270. <https://doi.org/10.1097/ALN.0b013e31827773b2>.
- [62] Liu Z, Zhao L, Ma Z, Liu M, Qi X, Jia Q, et al. Effects of head positions on awake fiberoptic bronchoscope oral intubation: a randomized controlled trial. *BMC Anesthesiology*. 2021; 21: 176. <https://doi.org/10.1186/s12871-021-01397-4>.
- [63] Thomas-Kattappurathu G, Kasisomayajula A, Short J. Best position and depth of anaesthesia for laryngeal mask airway removal in children: A randomised controlled trial. *European Journal of Anaesthesiology*. 2015; 32: 624–630. <https://doi.org/10.1097/EJA.0000000000000286>.
- [64] Geng Z, Li C, Kong H, Song L. Supreme laryngeal mask airway for cesarean section under general anesthesia: a 10-year retrospective cohort study. *Frontiers in Medicine*. 2023; 10: 1181503. <https://doi.org/10.3389/fmed.2023.1181503>.
- [65] Fan H, Li L, Zhu L, Yi Z, Diao Y. Comparison of the third-generation streamlined liner of the pharynx airway (SLIPA-3G) with the laryngeal mask airway supreme for laparoscopic cholecystectomy: a randomized prospective study. *BMC Anesthesiology*. 2022; 22: 97. <https://doi.org/10.1186/s12871-022-01638-0>.
- [66] Modir H, Moshiri E, Yazdi B, Mohammadbeigi A, Modir A. Comparing the efficacy and safety of laryngeal mask airway, streamlined liner of the pharyngeal airway and I-gel following tracheal extubation. *Medical Gas Research*. 2018; 7: 241–246. <https://doi.org/10.4103/2045-9912.222447>.
- [67] Kim DH, Chae YJ, Min SK, Ha EJ, Yoo JY. Lightwand-Guided Insertion of Flexible Reinforced Laryngeal Mask Airway: Comparison with Standard Digital Manipulation Insertion. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research*. 2021; 27: e928538. <https://doi.org/10.12659/MSM.928538>.
- [68] Maitra S, Khanna P, Baidya DK. Comparison of laryngeal mask airway Supreme and laryngeal mask airway Pro-Seal for controlled ventilation during general anaesthesia in adult patients: systematic review with meta-analysis. *European Journal of Anaesthesiology*. 2014; 31: 266–273. <https://doi.org/10.1097/01.EJA.0000435015.89651.3d>.
- [69] Cho HY, Lee K, Kong HJ, Yang HL, Jung CW, Park HP, et al. Deep-learning model associating lateral cervical radiographic features with Cormack-Lehane grade 3 or 4 glottic view. *Anaesthesia*. 2023; 78: 64–72. <https://doi.org/10.1111/anae.15874>.
- [70] Kim JH, Jung HS, Lee SE, Hou JU, Kwon YS. Improving difficult direct laryngoscopy prediction using deep learning and minimal image analysis: a single-center prospective study. *Scientific Reports*. 2024; 14: 14209. <https://doi.org/10.1038/s41598-024-65060-x>.

© 2025 The Author(s).

