Razi Med J. 2026;2(1):67-77
https://doi.org/10.69667/rmj.26110
Razi Medical Journal
https://razi.edu.ly/rmj/index.php/hm

Original article

Impact of Head Position on Laryngeal Exposure During Direct Laryngoscopy: A Randomized Controlled Trial

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Abstract
Patient head positioning is considered critical for successful tracheal intubation during direct laryngoscopy, yet comparative data on specific positioning techniques remain limited. This study was conducted to prospectively compare laryngeal exposure during direct laryngoscopy across three distinct head positioning techniques in anesthetized patients. Seventy-five ASA I-II patients scheduled for elective surgery were randomly assigned to three groups (n=25 each). Group 1: standard position (head level with body, maximum atlanto-axial extension); Group 2: sniffing position (head elevated 7-8 cm, maximum atlanto-axial extension); Group 3: flexion position (head elevated 7-8 cm, mild atlanto-axial flexion). All patients received standardized anesthesia (propofol 2-2.5 mg/kg, fentanyl 1-2 mcg/kg, rocuronium 0.6 mg/kg). A single experienced anesthesiologist performed all intubations using a Macintosh laryngoscope. Laryngeal views were classified according to Cormack-Lehane grades. Data were analyzed using one-way ANOVA with Student's t-test for pairwise comparisons and chi-square test for categorical variables (p<0.05 considered significant). Group 2 (sniffing position) achieved superior laryngeal visualization: Grade 1 in 64% of patients, Grade 2 in 32%, Grade 3 in 4%, with 96% combined Grade 1-2 success rate. Group 1 (standard position) achieved Grade 1 in 36%, Grade 2 in 44%, Grade 3 in 20%, with 80% combined success. Group 3 (flexion position) achieved Grade 1 in 12%, Grade 2 in 28%, Grade 3 in 40%, Grade 4 in 20%, with only 40% combined success and 20% complete visualization failure. The sniffing position achieves optimal laryngeal visualization and should be the standard default positioning for tracheal intubation. The standard position provides an acceptable alternative for patients with cervical spine pathology. The flexion position should be avoided due to poor visualization outcomes.
Keywords: *Airway Management, Direct Laryngoscopy, Sniffing Position, Cormack-Lehane Grade.*

Received*: 01/12/25*
Accepted*: 27/01/26*
Published*: 04/02/26*

Introduction

Laryngoscopy and tracheal intubation stand as cornerstone procedural skills within both anesthesia and emergency medicine [1,2]. The ability to secure the airway is critical, as failure in airway management continues to be a leading cause of perioperative morbidity and mortality. Among the contributing factors, difficult intubation remains a major determinant of adverse outcomes [3,4]. While seasoned clinicians consistently achieve success rates approaching 99%, less experienced operators may encounter failure rates as high as 30% [5]. The success of laryngoscopy is not determined by a single variable but rather by a constellation of interdependent factors.

Operator expertise, cervical spine mobility, thyromental distance, and the degree of mouth opening all play pivotal roles in determining the ease or difficulty of tracheal intubation [6]. To standardize the assessment of laryngeal exposure, the Cormack and Lehane classification has become the most widely adopted framework [7]. This system delineates four distinct grades of visualization: Class I, in which the vocal cords are fully visible; Class II, where only the anterior two-thirds of the cords can be seen; Class III, characterized by visualization of the epiglottis alone; and Class IV, where even the epiglottis is not visible (Figure 1).

Preoperative airway assessment enables prediction of intubation difficulty in >80% of cases, facilitating appropriate preparation [8]. Multiple validated assessment tools exist, including the Mallampati test, thyromental distance, sterno-mental distance, and atlanto-occipital joint extension [9-11].

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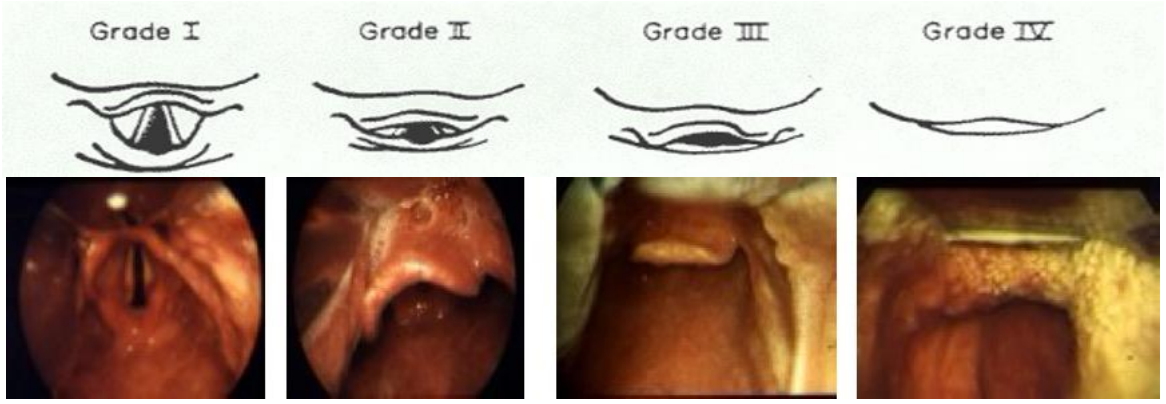

Figure 1. Laryngoscopic view according to Cormack and Lehane

Historical Development of Optimal Positioning

Patient head positioning is theoretically critical for achieving optimal laryngeal visualization through geometric alignment of the oral, pharyngeal, and laryngeal anatomic axes.[12] Chevalier Jackson first described optimal head positioning in 1913, proposing that patients be placed with the head extended, initially suggesting the use of a pillow and later recommending forceful downward pressure on the forehead to achieve anterior skull movement on the atlas.[13] Jackson emphasized the importance of combined anterior flexion of the lower cervical spine with extension of the atlanto-occipital joint. Bannister and Macbeth subsequently studied this positioning experimentally through radiographic analysis, demonstrating that three-axis alignment could be achieved through combined cervical flexion and atlanto-axial extension.[14] They proposed placing an additional pillow beneath the occiput to flex the cervical spine while extending the atlanto-occipital joint. Horton et al. later determined optimal angles for this positioning, identifying 35° of neck flexion and 15° of face extension as the ideal configuration [15].

The "sniffing position," characterized by cervical spine flexion combined with atlanto-axial extension, has been recommended as optimal and is currently universally recommended throughout the anesthesia community.[16] However, contemporary research has challenged the theoretical basis for this recommendation. Adnet and colleagues questioned whether the sniffing position actually achieves three-axis alignment, suggesting the three-axis alignment theory represents an anatomic oversimplification rather than a demonstrable physiologic reality [17,18]. Despite these theoretical critiques, sniffing position remains standard clinical practice. Comparative data directly evaluating the relative efficacy of different head positioning techniques in controlled settings remain limited in contemporary literature. This prospective randomized trial was designed to directly compare laryngeal exposure during direct laryngoscopy across three distinct head positioning techniques in a standardized patient population with controlled anesthetic conditions.

Mallampati Test

The Mallampati test, as modified by Samsoon and Young, provides a simple yet valuable screening tool for anticipating potential difficulties in tracheal intubation [19]. By assessing the relative size of the tongue in relation to the pharyngeal cavity, the test offers a practical means of predicting airway challenges before laryngoscopy. Patients are classified according to the pharyngeal structures visible when the mouth is opened to its maximum extent (Figure 2). In Grade 1, the soft palate, fauces, uvula, and both anterior and posterior tonsillar pillars are clearly visible. Grade 2 is characterized by visualization of the soft palate, fauces, and uvula, but without the tonsillar pillars. In Grade 3, only the soft palate and the base of the uvula can be seen. Finally, Grade 4 represents the most restricted view, in which the soft palate itself is not visible.

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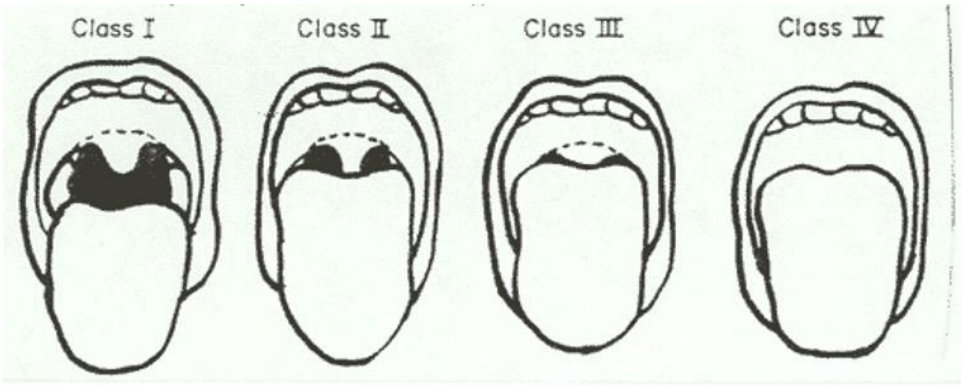

Figure 2. View obtained during the Mallampati test

Clinically, Grades 1-2 typically predict easy intubation, while Grades 3-4 suggest significant difficulty. Combined assessment using modified Mallampati with thyromental distance improves predictive accuracy [20]. Thyromental distance (TMD) represents the measurement from the thyroid notch to the mandibular tip with the head extended (Figure 3). Normal distance exceeds 6.5 cm and depends on anatomical factors, including laryngeal position [20]. TMD >6.5 cm generally permits conventional intubation; TMD <6 cm suggests potential difficulty. Frerk demonstrated that patients with both Grade 3-4 Mallampati classification AND TMD <7 cm face substantially elevated intubation difficulty risk [20].

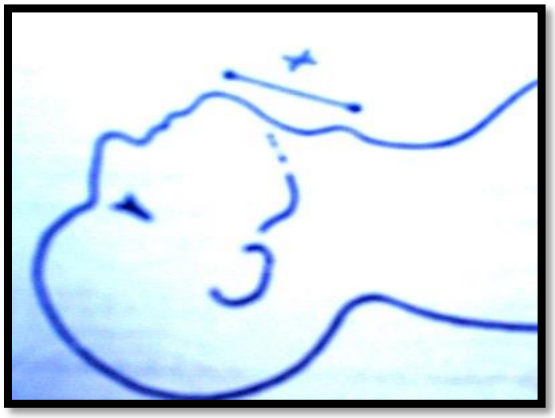

Figure 3. Thyro-mental distance

The sternomental distance, measured from the upper border of the sternum to the mandibular tip with the head fully extended, is a key parameter influenced by neck extension capacity. A measurement of 12.5 cm or less is strongly predictive of difficult intubation [21]. Complementing this, assessment of atlanto-axial joint mobility is performed by asking patients to flex the neck and then attempt to raise the face, thereby testing extension capability. Optimal laryngoscopy requires a coordinated posture of cervical flexion combined with atlanto-axial extension, and reduced movement at this joint is closely associated with intubation difficulty (Figure 4) [22,23]. Further evaluation of cervical spine mobility can be achieved through the grading of atlanto-occipital joint extension (AOJE). An extension greater than 35° is considered Grade 1, between 22° and 35° is Grade 2, between 13° and 22° is Grade 3, and less than 13° is classified as Grade 4. This structured system provides a standardized framework for quantifying head extension capacity and anticipating potential challenges in airway management.

Direct Laryngoscopy Mechanics

If a Macintosh-type laryngoscopic blade is used, the blade tip is positioned above the epiglottis, and the laryngoscope handle is lifted until the glottic opening is visualized. Approximately 15 degrees of head extension at the atlanto-occipital joint is required to expose the vocal cords in anesthetized elective surgery patients.[24] The cervical spine between the occiput and C3 extends approximately 45 degrees during laryngoscopy [24,25]. Laryngoscopy may be difficult if spine movement is limited by arthritis, disc disease, or structural abnormalities [25]. Conversely, extensive spine manipulation poses a risk in patients with cervical spine injury, potentially causing new neurological deficits

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[24,26]. Force requirements during laryngoscopy vary considerably among patients (range: 56 newtons), and also vary based on operator technique and equipment used [27]. Miller laryngoscopes generate approximately 30% less force compared to Macintosh laryngoscopes [28].

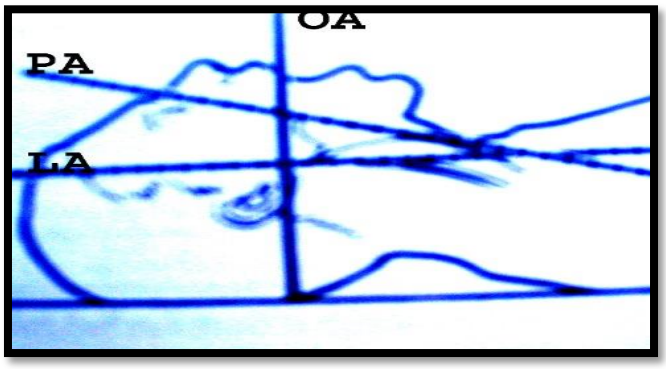

Figure 4. Diagram demonstrating head position for tracheal intubation.
(OA – oral axis, PA – pharyngeal axis, LA – laryngeal axis).

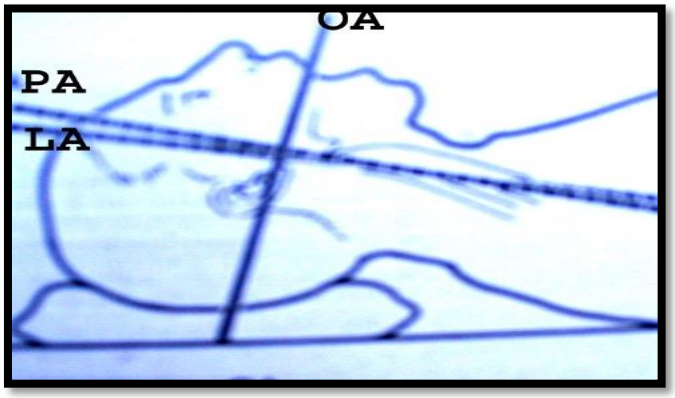

Figure 5. Level head and body position with no Atlanto-axial extension. Lead elevated with no Atlanto-axial extension

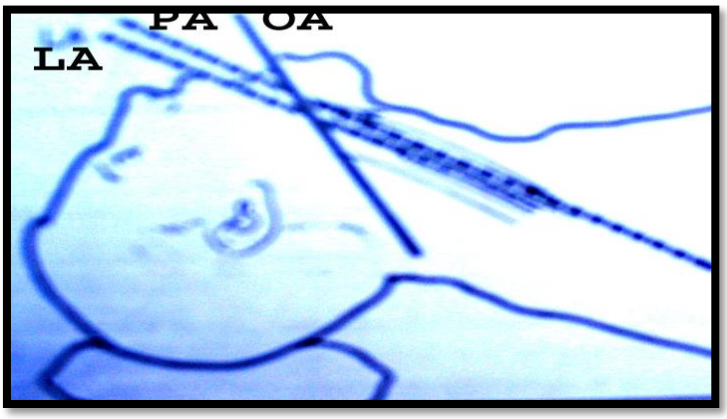

Figure 6. Head elevated with Atlanto-axial extension

Methods

Study Design and Setting

This prospective randomized controlled trial was conducted at Al-Helal University Hospital in Misurata, Libya, from May 2024 to April 2025. The study was approved by the hospital institutional review board, and written informed consent was obtained from all participants prior to enrollment.

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Study Population

Patients eligible for enrollment were those classified as ASA physical status I or II, aged 18 years or older, and scheduled for elective surgical procedures requiring general anesthesia with endotracheal intubation. All participants were required to demonstrate normal head and cervical spine mobility during preoperative assessment. Exclusion criteria were applied to ensure patient safety and methodological consistency. Individuals with severe obesity (BMI greater than 40 kg/m²), anatomic maxillofacial abnormalities, or a history of difficult tracheal intubation were excluded. Patients requiring rapid sequence induction, those with cervical spine injury or degenerative disease, and pregnant women—to eliminate the confounding influence of hormonal changes on airway edema—were also excluded. Finally, individuals with severe gastroesophageal reflux disease were not considered for inclusion.

Sample Size and Randomization

Sample size calculation was based on preliminary data indicating a 15% difference in Grade 1 laryngoscopic view between sniffing and standard positions. With α=0.05 and β=0.20 (80% power), 23 patients per group were required. To account for potential dropouts, 75 patients were enrolled (25 per group). Random allocation to three equal groups (n=25 each) was achieved using sealed envelope randomization. An independent research assistant prepared and maintained randomization records to minimize selection bias. Group assignment was revealed only after written consent was obtained.

Study Groups

Group 1 (Standard Position, n=25)

Head positioned level with body, atlanto-axial junction maximally extended (no flexion), no cervical spine flexion.

Group 2 (Sniffing Position, n=25)

Head elevated 7-8 cm above body level using a single pillow, atlanto-axial junction maximally extended, cervical spine flexed approximately 35 degrees.

Group 3 (Flexion Position, n=25)

Head elevated 7-8 cm above body level, atlanto-axial junction mildly flexed (5-7 degrees), cervical spine flexed.

Anesthetic Protocol

All patients received standardized anesthesia to minimize confounding variables:[29]

Induction Agents

Propofol: 2-2.5 mg/kg intravenously. Propofol is a rapid-acting hypnotic alkylphenol derivative with an onset time of 30-40 seconds, peak effect at 1-2 minutes, and duration of action 5-10 minutes when given as a single bolus.[29] It provides rapid loss of consciousness without airway reflexes, facilitating laryngoscopy. The dose range (2-2.5 mg/kg) is standard for induction in non-premedicated ASA I-II patients.[30] Propofol's lipid formulation allows rapid redistribution to inactive tissues, enabling quick recovery. Propofol commonly causes dose-dependent hypotension (15-25% reduction in mean arterial pressure) and respiratory depression, which were monitored intraoperatively.

Opioid Analgesic

Fentanyl: 1-2 mcg/kg intravenously. Fentanyl is a potent synthetic opioid agonist with selective mu-receptor activity, providing analgesia and hemodynamic stability during laryngoscopy and intubation.[31] At doses of 1-2 mcg/kg, fentanyl attenuates the hypertensive and tachycardic responses to laryngoscopy, reducing catecholamine release. Onset occurs within 1-3 minutes with peak effect at 5-15 minutes. The opioid's rapid onset and offset, combined with its analgesic properties, make it ideal for intubation procedures. Fentanyl was administered prior to propofol to optimize hemodynamic stability.

Neuromuscular Blocking Agent

Rocuronium bromide: 0.6 mg/kg intravenously (Esmeron®; Merck Sharp & Dohme, Whitehouse Station, NJ). Rocuronium is a non-depolarizing steroidal aminosteroid neuromuscular blocker with a rapid onset of 60-90 seconds.[32] This agent competitively antagonizes acetylcholine at the neuromuscular junction, blocking nicotinic

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acetylcholine receptors on muscle membranes. The 0.6 mg/kg dose produces complete paralysis within 1-2 minutes, enabling optimal visualization without muscular interference during laryngoscopy [32]. Rocuronium's rapid onset (faster than succinylcholine alternatives) with intermediate duration (30-40 minutes) makes it ideal for elective intubation. Complete neuromuscular blockade was confirmed using peripheral nerve stimulation (train-of-four monitoring; cessation of all visible muscular activity and train-of-four count zero) before laryngoscopy, ensuring maximum laryngeal mobility and preventing inadvertent patient movement [32].

Direct laryngoscopy was initiated 3 minutes following rocuronium administration to ensure peak neuromuscular blockade was achieved. This timing follows the drug's known pharmacokinetic profile and allows complete receptor saturation at the neuromuscular junction. No additional doses of neuromuscular blocker were administered during the study procedure. The combination of propofol (induction), fentanyl (hemodynamic stability), and rocuronium (neuromuscular blockade) represents a standard balanced anesthesia technique. This regimen ensures stable conditions for laryngoscopy while isolating head position as the primary variable under investigation. All medications were administered intravenously through peripheral IV access established prior to induction.

Laryngoscopy Procedure

A single experienced anesthesiologist performed all intubations. A Macintosh-type laryngoscopic blade (number 4, curved configuration) was used for all patients to eliminate blade-type variability as a confounding factor. No external laryngeal pressure (cricoid pressure) was applied, as this technique can disrupt anatomic axis alignment. The same anesthesiologist performed all procedures to standardize operator technique.

Outcome Measurement

The primary outcome of the study was the quality of laryngeal visualization, assessed using the widely adopted Cormack–Lehane classification [7]. This grading system provides a standardized framework for describing the view obtained during laryngoscopy. A Grade 1 view corresponds to complete visualization of the vocal cords, whereas Grade 2 indicates partial visualization, typically limited to the anterior two-thirds. In Grade 3, only the epiglottis is visible, and Grade 4 represents the most restricted view, in which even the epiglottis cannot be seen. Combined success was defined as Grade 1-2 (acceptable for first-attempt intubation). Secondary outcomes included intubation success rate, number of intubation attempts, and procedure time (first visualization to tube confirmation).

Statistical Analysis

Continuous variables were expressed as mean ±standard deviation. Categorical variables were compared using the chi-square (χ^2) test or Fisher's exact test as appropriate. Continuous variables were compared using one-way analysis of variance (ANOVA) with Student's t-test for pairwise comparisons.[1] Odds ratios with 95% confidence intervals were calculated to estimate the probability of achieving Grade 1 visualization in Group 2 versus Groups 1 and 3. Statistical significance was set at $p<0.05$ (two-tailed). All analyses were performed using SPSS statistical software (version 27.0).

Results

Demographic Characteristics

Seventy-five patients completed the study (38 males, 37 females; mean age 40±8 years; age range 19-67 years). Demographic characteristics were comparable across groups (Table 1). No statistically significant differences were identified in age ($F=0.31$, $p=0.73$), gender distribution ($\chi^2=0.18$, $p=0.91$), or ASA status ($\chi^2=0.15$, $p=0.93$) among the three groups. Mean BMI was similar across groups (Group 1: 25.2±2.8, Group 2: 25.5±3.1, Group 3: 25.1±2.9 kg/m²; $p=0.82$).

Table 1. Demographic Characteristics

Characteristic	Group 1 (n=25)	Group 2 (n=25)	Group 3 (n=25)	p-value
Age (years)	39±8	41±9	40±7	0.73
Gender (M/F)	13/12	12/13	13/12	0.91
BMI (kg/m²)	25.2±2.8	25.5±3.1	25.1±2.9	0.82
ASA I/II	15/10	16/9	15/10	0.93

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Primary Outcome: Laryngeal Visualization by Group

Group 1 - Standard Position

In Group 1, where patients were positioned with the head level to the body and maximum atlanto-axial extension was achieved, laryngoscopic visualization demonstrated a varied distribution across the Cormack–Lehane grades. A Grade 1 view, representing complete vocal cord visualization, was obtained in 9 patients (36%). Grade 2 views, with partial visualization of the anterior two-thirds of the cords, were observed in 11 patients (44%). Grade 3 views, limited to visualization of the epiglottis, occurred in 5 patients (20%), while no patients exhibited a Grade 4 view, in which the epiglottis is not visible. When Grades 1 and 2 were combined as indicators of successful laryngeal exposure, the overall success rate in this group was 80% (20 patients).

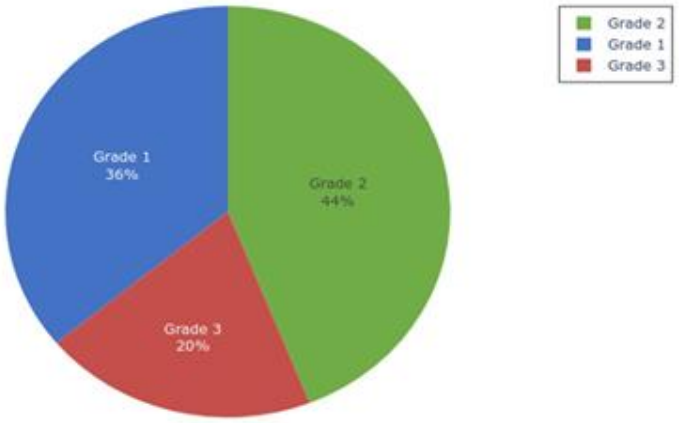

Figure 7. Laparoscopic view in group 1

In Group 2, where patients were positioned in the classic sniffing position with the head elevated 7–8 cm and maximum atlanto-axial extension achieved, laryngoscopic visualization yielded markedly improved outcomes. A Grade 1 view, representing complete visualization of the vocal cords, was obtained in 16 patients (64%), while Grade 2 views, with partial visualization of the anterior two-thirds of the cords, were observed in 8 patients (32%). Only a single patient (4%) demonstrated a Grade 3 view, limited to epiglottis visualization, and no patients exhibited a Grade 4 view, in which the epiglottis is absent from sight. When combining Grades 1 and 2 as indicators of successful laryngeal exposure, the overall success rate in this group reached 96% (24 patients), underscoring the effectiveness of the sniffing position in optimizing laryngoscopic visualization.

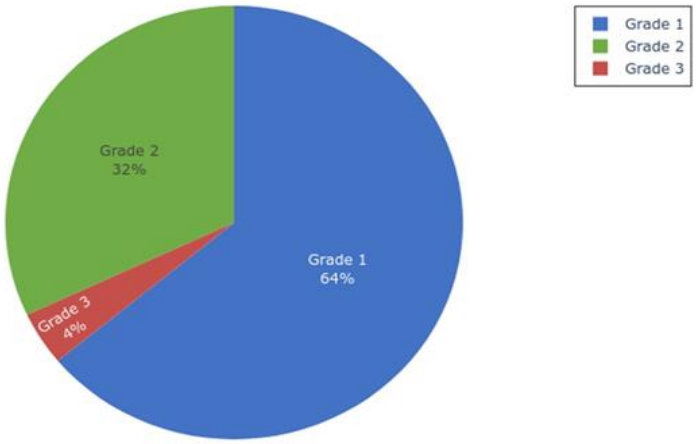

Figure 8. Laparoscopic view in group 2

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In Group 3, where patients were positioned with the head elevated 7–8 cm and placed in mild atlanto-axial flexion, laryngoscopic visualization was notably less favorable compared to the other groups. A Grade 1 view, representing complete visualization of the vocal cords, was achieved in only 3 patients (12%). Grade 2 views, with partial visualization of the anterior two-thirds of the cords, were observed in 7 patients (28%). The majority of patients demonstrated more restricted views, with Grade 3 visualization—limited to the epiglottis—occurring in 10 patients (40%), and Grade 4 views, in which the epiglottis was not visible, observed in 5 patients (20%). When combining Grades 1 and 2 as indicators of successful laryngeal exposure, the overall success rate in this group was markedly reduced, reaching only 40% (10 patients).

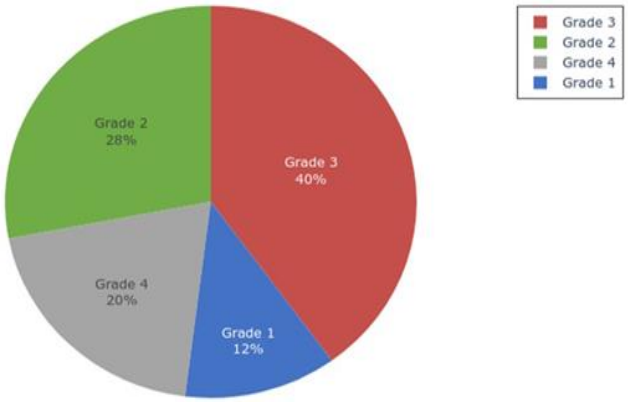

Figure 9. Laparoscopic view in group 3

Comparative Analysis of Groups

Group 2 (sniffing position) achieved significantly superior laryngeal visualization compared to both Group 1 and Group 3 (Table 2). The 96% combined success rate in Group 2 was significantly higher than Group 1 (80%, χ^2=4.12, p<0.05) and Group 3 (40%, χ^2=21.68, p<0.001). The 64% Grade 1 visualization rate in Group 2 was significantly superior to Group 1 (36%, χ^2=4.08, p<0.05) and Group 3 (12%, χ^2=15.42, p<0.001). Group 1 (standard position) demonstrated intermediate performance, with 80% combined success rate significantly superior to Group 3 (χ^2=13.44, p<0.01). Group 3 (flexion position) demonstrated markedly inferior outcomes, with only 40% combined success and 20% complete visualization failure (Grade 4). This was significantly worse than both Group 1 (p<0.01) and Group 2 (p<0.001).

Odds ratios for Grade 1 visualization:

- Group 2 vs. Group 1: OR=3.11 (95% CI: 1.35-7.16, p=0.008)
- Group 2 vs. Group 3: OR=11.56 (95% CI: 3.02-44.28, p<0.001)
- Group 1 vs. Group 3: OR=3.71 (95% CI: 1.10-12.48, p=0.034)

Table 2. Laryngoscopic Visualization Outcomes

Cormack-Lehane Grade	Group 1 (%)	Group 2 (%)	Group 3 (%)	χ^2	p-value
Grade 1	9 (36%)	16 (64%)*	3 (12%)†	15.42	<0.001
Grade 2	11 (44%)	8 (32%)	7 (28%)	2.15	0.34
Grade 3	5 (20%)	1 (4%)	10 (40%)†	8.92	<0.05
Grade 4	0 (0%)	0 (0%)	5 (20%)†	9.38	<0.05
Grade 1-2 Success	**20 (80%)**	**24 (96%)***	**10 (40%)†**	**21.68**	**<0.001**

**p<0.05 vs. Group 1; †p<0.001 vs. Group 2*

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Discussion

This prospective randomized controlled trial demonstrates that patient head positioning significantly influences laryngeal exposure during direct laryngoscopy. The sniffing position achieved superior laryngeal visualization with 64% Grade 1 success and 96% combined Grade 1-2 success, compared to 36% and 80% in the standard position and 12% and 40% in the flexion position, respectively. The sniffing position's superiority derives from geometric alignment of the three airway axes (oral, pharyngeal, laryngeal) achieved through combined atlanto-axial extension (15-20 degrees) and cervical spine flexion (35 degrees). This positioning creates a linear configuration permitting direct laryngeal visualization without excessive lifting force [15,31].

The standard position creates suboptimal but acceptable axis alignment, achieving 80% combined success. While less ideal than the sniffing position, this position remains clinically adequate in most patients. The modest 16% difference in combined success between standard and sniffing positions represents a trade-off acceptable for certain patient populations. The flexion position creates severe geometric misalignment by flexing the atlanto-axial junction, moving the laryngeal inlet away from the line of sight. This results in only 40% success and 20% complete visualization failure. Paradoxically, head elevation alone (without proper atlanto-axial extension) worsens visualization compared to the standard position, suggesting that positioning technique specificity is critical. These findings align with and provide quantitative support for extensive literature recommending the sniffing position as optimal for direct laryngoscopy [12,14,16]. Classic studies by Bannister and Macbeth demonstrated three-axis alignment with this positioning through radiographic analysis [14]. Our prospective randomized trial extends these investigations through direct comparison of three distinct positioning approaches in a controlled setting with standardized anesthesia and operator technique.

The superior performance of the sniffing position (96% combined success) compared to alternatives supports current clinical practice guidelines recommending this positioning as standard [16,32]. Our results provide contemporary evidence base for practices historically based on earlier anatomic studies. However, our findings do not definitively settle the theoretical debate regarding three-axis alignment raised by Adnet and colleagues [17,18]. While the sniffing position empirically produces superior visualization, the anatomic mechanism may involve factors beyond simple three-axis alignment. Future studies using magnetic resonance imaging or computed tomography during laryngoscopy could further elucidate the exact mechanisms underlying our clinical observations.

The sniffing position should constitute the default positioning for all elective surgical patients undergoing general anesthesia requiring tracheal intubation, achieving optimal visualization in approximately two-thirds of patients and successful intubation in >95%. The standard position provides a clinically valuable alternative in patients with cervical spine pathology (trauma, degenerative disease, instability) where extensive neck manipulation poses neurologic risk. The modest reduction in success rate (80% vs 96%) represents an acceptable trade-off for patient safety [33]. In high-risk cervical pathology patients, the 80% success rate with first-attempt intubation using standard positioning eliminates the need for extensive head manipulation while maintaining acceptable success. The flexion position should be explicitly avoided in routine practice. The 20% complete visualization failure (Grade 4) necessitates transition to alternative airway management strategies (fiberoptic bronchoscope, videolaryngoscope, surgical airway), increasing patient risk and complexity [33]. Clinicians should ensure patients are explicitly positioned in the sniffing position, not merely elevated, to achieve optimal results.

Methodological strengths include a prospective randomized design with sealed envelope allocation to minimize selection bias, a standardized single-operator technique to eliminate operator variability, standardized pharmacological regimen with complete neuromuscular paralysis confirmed by peripheral nerve stimulation isolating head position as the primary variable, an adequate sample size (25 patients per group based on power analysis), and clear outcome measurement using internationally standardized Cormack-Lehane classification [7]. Enrollment is limited to ASA I-II patients without anatomic abnormalities; results may not generalize to difficult airway populations. Only Macintosh laryngoscopes evaluated; results may not transfer to alternative designs or videolaryngoscopy.

Conclusion

This prospective randomized controlled trial provides robust evidence that the sniffing position achieves optimal laryngeal visualization during direct laryngoscopy, with 96% combined Grade 1-2 success compared to 80% with standard positioning and 40% with flexion positioning. The sniffing position should be the standard default positioning for tracheal intubation in elective surgery patients. The standard position provides an acceptable alternative for patients with cervical spine pathology. The flexion position should be avoided due to poor visualization outcomes. These

findings support current anesthesia practice guidelines and provide contemporary evidence for optimal airway management positioning.

Conflict of interest. Nil

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