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Research Article

Effect of Operating Table Height on Laryngeal View, Intubation Success and Time, and Operator Ergonomics in Children Aged 2–6 Years: A Four-Group Randomized Clinical Trial

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ABSTRACT

Background: Airway management in young children is challenging because of distinct anatomical and physiological characteristics. Operating table height may influence laryngeal view, intubation success, and operator ergonomics. This randomized clinical trial evaluated the effects of four operating table heights on laryngeal visualization, intubation success and time, and ergonomic parameters in children.

Methods: In this four-group randomized clinical trial, 180 children aged 2–6 years with ASA physical status I–II were allocated using block randomization to four table-height groups: umbilical (U), rib (R), xiphoid (X), and nipple (N) levels. Outcomes included Cormack–Lehane laryngeal view grade, intubation success and time (confirmed by capnography), operator ergonomic angles measured with a digital goniometer, and operator comfort assessed on a four-point scale. Data were analyzed using SPSS version 26, and statistical significance was set at $p < 0.05$.

Results: First-attempt intubation success was 100% across all groups. The mean intubation time was 25.4 ± 5.2 seconds, with no significant intergroup differences ($p = 0.72$). More than 97% of patients in all groups had a grade 1 laryngeal view. During mask ventilation, significant differences in neck and lumbar flexion were observed between groups (both $p < 0.001$). During intubation, knee flexion differed significantly among groups ($p = 0.001$). Overall, the umbilical level was associated with more favorable ergonomic angles compared with the other heights.

Conclusion: In children aged 2–6 years, operating table height did not significantly affect intubation success or time, but it did influence certain ergonomic parameters for the operator. Umbilical height was associated with more favorable ergonomic positioning and may be a practical option for pediatric direct laryngoscopy. Further multicenter studies are recommended to confirm these findings.

Introduction

Airway management in pediatric patients remains one of the most critical and technically demanding aspects of anesthetic practice. Children, particularly those in the preschool age group, present distinct anatomical and physiological characteristics that differentiate them from adults. These include a proportionally larger head, a relatively larger tongue, a more cephalad and anterior larynx, a soft and omega-shaped epiglottis, and a narrower airway at the level of the cricoid cartilage. These features increase the technical difficulty of direct laryngoscopy and tracheal

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intubation. In addition, the higher metabolic rate and lower functional residual capacity in children result in rapid oxygen desaturation during apnea, making airway management highly time-sensitive and clinically critical [1-2]. Proper patient positioning and optimal working conditions for the operator are fundamental determinants of successful laryngoscopy. Traditionally, the sniffing position has been recommended to facilitate alignment of the oral, pharyngeal, and laryngeal axes and thereby improve the laryngeal view during direct laryngoscopy [3-4]. However, the universality of the three-axis alignment theory has been questioned. More recent analyses suggest that the laryngoscopic view is influenced by multiple factors, including patient anatomy, head and neck positioning, operator technique, and ergonomic alignment rather than simple geometric axis alignment [5]. Among the modifiable factors affecting intubation conditions, the height of the operating table has received increasing attention. Table height directly influences the anesthesiologist's line of sight, arm elevation, and spinal posture, all of which may affect both the quality of laryngeal visualization and the ergonomic load on the operator. In a clinical trial involving adult patients, Lee et al. demonstrated that higher operating table positions improved laryngeal visualization during direct laryngoscopy [5]. Subsequent studies also confirmed that operator positioning and table height can influence intubation conditions and performance [7-8]. More recent investigations have specifically evaluated the relationship between table height and airway management difficulty. Ikeda et al., using pediatric simulation models, reported that inappropriate table height increased the difficulty of mask ventilation and worsened the laryngoscopic view [8]. Similarly, Kang et al. demonstrated that table height influenced intubation time when videolaryngoscopy was performed in the ramped position [9]. Despite the evident relevance of table height, most of the available evidence has been generated in adults or in simulation-based settings. This limitation is important because the pediatric airway cannot be treated as a scaled-down version of the adult airway; age-related differences in craniofacial proportion, laryngeal position, airway caliber, and oxygen reserve may alter the effect of both patient positioning and operator posture. Accordingly, even modest changes in the child's position or in the anesthesiologist's stance may meaningfully influence glottic exposure during pediatric direct laryngoscopy [1-2].

Meanwhile, videolaryngoscopy has become an important adjunct in pediatric airway management. By indirectly displaying the glottic inlet, videolaryngoscopes can improve laryngeal visualization and may increase first-attempt success in selected pediatric populations [11-13]. Nevertheless, direct laryngoscopy remains a common first-line technique in routine pediatric anesthesia, especially for children without predicted airway difficulty and in settings where advanced airway devices are not consistently available. For this reason, careful attention to basic procedural factors, including patient positioning and operating table height, remains clinically relevant [1-2].

Beyond patient-related outcomes, the ergonomics of airway management have gained increasing recognition. Anesthesiologists are frequently exposed to repetitive and awkward postures during airway interventions, which predispose them to musculoskeletal disorders. Occupational studies have shown that excessive cervical or lumbar flexion, sustained arm elevation, and inappropriate table height are significant contributors to work-related musculoskeletal injuries among anesthesia providers [14-15]. Therefore, optimizing table height may improve not only patient-centered outcomes but also the long-term health and performance of the operator.

Although several studies have evaluated head and neck positioning, ramped positioning, and videolaryngoscopy in both adults and children [8,10–13], randomized clinical trials examining the effect of operating table height on laryngeal view and operator ergonomics in live pediatric patients remain scarce. Most pediatric evidence is limited to simulation studies or indirect comparisons [9]. Given the anatomical differences in children, the clinical importance of rapid and successful airway management, and the growing emphasis on operator ergonomics, determining the optimal operating table height in pediatric patients is both clinically and ergonomically relevant. Therefore, this randomized clinical trial was designed to evaluate the effects of four operating table heights—umbilical, rib, xiphoid, and nipple levels—on laryngeal view, intubation success and time, and operator ergonomic parameters in children aged 2–6 years. We hypothesized that the umbilical level would provide the best balance between airway visualization and operator ergonomics.

Methods

Study Design and Setting

This prospective, four-arm randomized controlled trial was conducted at Imam Hossein and Alzahra teaching hospitals affiliated with Isfahan University of Medical Sciences, Isfahan, Iran, between September 2024 and September 2025. The study protocol was approved by the Institutional Ethics Committee (IR.MUI.REC.1403.123) and registered in the Iranian Registry of Clinical Trials (IRCT20230918012345N1). Written informed consent was obtained from the parents or legal guardians of all participants.

Participants

Inclusion Criteria

Children aged 2–6 years who met the following criteria were enrolled:

- American Society of Anesthesiologists (ASA) physical status I or II
- Scheduled for elective surgery under general anesthesia requiring endotracheal intubation
- Normal weight and height percentiles for age
- Written informed parental consent

Exclusion Criteria

Participants were excluded if any of the following occurred:

- Known or suspected difficult airway
- Craniofacial anomalies or airway malformations
- Severe systemic disease (ASA ≥III)
- Change in surgical plan
- Intraoperative complications during induction (e.g., laryngospasm, oxygen saturation <90%)
- Withdrawal of parental consent

Randomization and Allocation

Participants were randomly assigned in a 1:1:1:1 ratio to one of four operating table height groups:

- U: umbilical level
- R: rib level
- X: xiphoid level
- N: nipple level

Block randomization with a block size of four was performed using a computer-generated randomization sequence. Group assignments were placed in sequentially numbered, opaque, sealed envelopes, which were opened immediately before induction of anesthesia.

Blinding

Due to the nature of the intervention, blinding of the anesthesiologist performing laryngoscopy was not feasible. However, outcome measurements, including intubation time and ergonomic angles, were recorded by an independent observer who was not involved in patient allocation.

Anesthesia Protocol

All patients received standard monitoring, including electrocardiography, non-invasive blood pressure, and pulse oximetry.

Premedication consisted of intravenous midazolam 0.03 mg/kg. Anesthesia was induced with:

- Propofol 2 mg/kg IV
- Fentanyl 2 μg/kg IV
- Atracurium 0.1 mg/kg IV

After adequate neuromuscular relaxation, direct laryngoscopy was performed using an age-appropriate Macintosh blade, and endotracheal intubation was attempted according to group allocation.

Intervention (Operating Table Height)

The height of the operating table was adjusted so that its surface corresponded to one of four anatomical landmarks of the anesthesiologist:

- Umbilical level (U)
- Lower rib level (R)
- Xiphoid process level (X)
- Nipple line level (N)

All intubations were performed by anesthesiologists with comparable clinical experience to minimize operator-related bias.

Outcome Measures

Primary Outcomes

1. Laryngeal view grade according to the Cormack–Lehane classification
2. First-attempt intubation success
3. Intubation time, defined as the interval from insertion of the laryngoscope blade into the mouth to confirmation of tracheal intubation by capnography

Secondary Outcomes

1. Operator ergonomic angles, including:
   - Neck flexion
   - Lumbar flexion
   - Knee flexion
   - Wrist deviation

   These were measured using a digital goniometer with 0.1° precision.
2. Operator comfort, assessed using a four-point Likert-type scale.

Sample Size Calculation

The sample size was calculated based on a medium effect size (Cohen's d = 0.5), a statistical power of 80%, and a confidence level of 95%. A minimum of 45 patients per group was required.

Statistical Analysis

Data were analyzed using SPSS software version 26 (IBM Corp., Armonk, NY, USA).

- Normality of distribution was assessed using the Shapiro–Wilk test.
- Continuous variables were compared among groups using the Kruskal–Wallis test.
- Pairwise comparisons were performed using the Mann–Whitney U test with Bonferroni correction.
- Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate.
- Within-group comparisons were performed using the Wilcoxon signed-rank test.

A P value <0.05 was considered statistically significant.

Results

A total of 180 children meeting the inclusion criteria were enrolled in the study and successfully completed the trial protocol.

Of these participants, 84 cases were evaluated during the mask ventilation phase, while the remaining 96 cases were assessed during the tracheal intubation phase. All enrolled patients were included in the final analysis, and no cases were excluded after randomization.

Intubation Success, Time, and Laryngeal View

First-attempt tracheal intubation was achieved in every child in all four operating table-height groups, yielding an overall first-attempt success rate of 100%. No failed intubations occurred, and no patient required an alternative airway or rescue technique.

Across the full cohort, the mean intubation time was 25.4 ± 5.2 seconds. Intubation time was comparable among the four table-height groups, with no statistically significant intergroup difference (p = 0.72).

Assessment of the laryngeal view using the Cormack–Lehane classification revealed that more than 97% of cases in all groups achieved a grade 1 view. The remaining cases were classified as grade 2, and no grade 3 or 4 views were observed. There were no statistically significant differences in laryngeal view distribution among the four groups.

Mask Ventilation Phase

During mask ventilation, the umbilical-level group represented the largest proportion of assessments, accounting for 54.8% of mask ventilation cases.

The remaining cases were distributed among the rib (R), xiphoid (X), and nipple (N) levels. The distribution of operating table-height groups during mask ventilation is shown in (Figure 1).

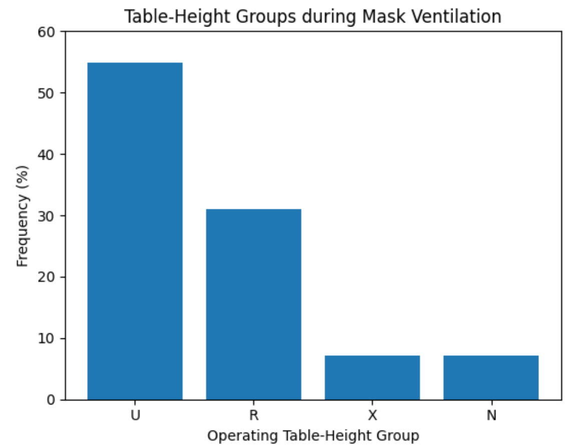

Figure 1- Distribution of operating table-height groups during mask ventilation (U = umbilical, R = rib, X = xiphoid, N = nipple), expressed as percentages.

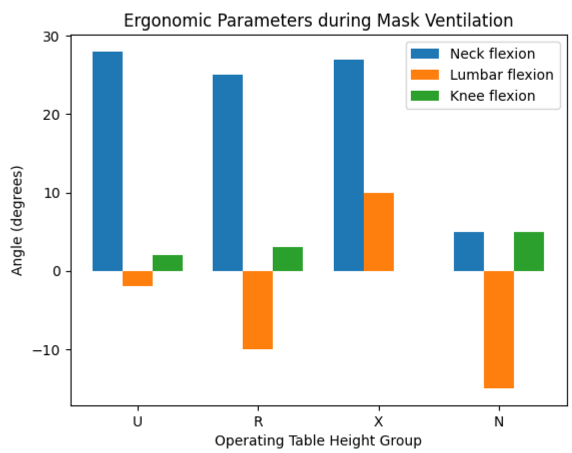

Figure 2- Ergonomic parameters during mask ventilation across the four operating table height groups (U = umbilical, R = rib, X = xiphoid, N = nipple). Values are presented as mean ± SD of joint angles in degrees.

Detailed ergonomic parameters recorded during mask ventilation are presented in (Table 1). In the umbilical-level group, the mean ergonomic angles were as follows: wrist deviation 10.2 ± 3.4°, arm elevation 18.5 ± 10.2°, neck flexion 27.8 ± 10.5°, lumbar flexion −2.5 ± 9.8°, and knee flexion 2.1 ± 3.6°. Statistical analysis demonstrated significant intergroup differences in neck flexion and lumbar flexion during mask ventilation (both p < 0.001). In contrast, no statistically significant differences were observed among groups with respect to wrist deviation, arm elevation, or knee flexion. A graphical representation of the ergonomic parameters during mask ventilation is provided in (Figure 2), which visually illustrates the variation in joint angles across the four operating table height groups and highlights the differences observed in neck and lumbar flexion.

Intubation Phase

During the tracheal intubation phase, the umbilical-level position again accounted for the highest proportion of cases, representing 41.7% of all intubation assessments.

The remaining cases were distributed among the rib, xiphoid, and nipple level groups.

Ergonomic parameters recorded during intubation are summarized in (Table 2). In the umbilical-level group, the mean values were: wrist deviation 10.7 ± 5.8°, arm elevation 30.4 ± 12.2°, neck flexion 41.0 ± 13.2°, lumbar flexion 27.3 ± 12.0°, and knee flexion 17.1 ± 18.4°.

Among the evaluated ergonomic variables during intubation, a statistically significant difference between groups was observed only for knee flexion ($p = 0.001$). No statistically significant differences were detected for wrist deviation, arm elevation, neck flexion, or lumbar flexion across the four table height groups during the intubation phase.

The distribution of ergonomic angles during tracheal intubation across the four operating table-height groups is illustrated in Figure 3, demonstrating intergroup variation primarily in knee flexion.

Summary of Main Findings

Across the four operating table height groups, first-attempt tracheal intubation success was 100% in all patients. The mean intubation time was 25.4 ± 5.2 seconds, with no statistically significant differences among groups. A grade 1 laryngeal view was achieved in more than 97% of cases in all groups.

The umbilical-level table height was the most frequently used position during both mask ventilation (54.8%) and tracheal intubation (41.7%). Significant ergonomic differences were observed in neck and lumbar flexion during the mask ventilation phase, as well as in knee flexion during the intubation phase, while other ergonomic parameters remained comparable across groups.

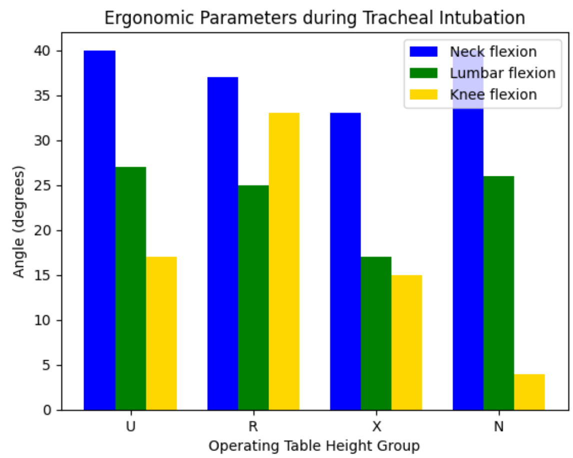

Figure 3- Ergonomic parameters during tracheal intubation across the four operating table-height groups (U = umbilical, R = rib, X = xiphoid, N = nipple). Values are presented as mean ± SD of joint angles in degrees.

Table 1- Ergonomic parameters during mask ventilation

Group	Wrist deviation	Arm elevation	Neck flexion	Lumbar flexion	Knee flexion
U (n=46)	10.2±3.4	18.5±10.2	27.8±10.5	-2.5±9.8	2.1±3.6
R (n=26)	11.5±4.1	22.3±12.4	24.6±11.2	-10.4±8.7	2.8±4.2
X (n=6)	10.7±2.9	17.3±9.8	26.7±9.5	10.0±5.0	0.0±0.0
N (n=6)	15.0±5.0	25.0±5.8	5.0±5.0	-15.0±5.0	5.0±5.0

Kruskal–Wallis test followed by Bonferroni-corrected Mann–Whitney.

Table 2- Ergonomic parameters during intubation

Group	Wrist deviation	Arm elevation	Neck flexion	Lumbar flexion	Knee flexion
U (n=40)	10.7±5.8	30.4±12.2	41.0±13.2	27.3±12.0	17.1±18.4
R (n=34)	12.8±6.1	38.7±13.5	37.6±10.8	25.6±10.2	33.5±23.2
X (n=14)	11.4±7.2	32.1±9.7	32.9±15.6	17.1±11.4	15.7±16.8
N (n=8)	11.9±8.3	31.3±7.4	40.6±9.2	26.3±8.7	3.8±4.1

Kruskal–Wallis test followed by Bonferroni-corrected Mann–Whitney.

Discussion

This randomized clinical trial evaluated the effect of four operating table heights on laryngeal view, intubation success and time, and operator ergonomics in children aged 2–6 years. The principal finding was that operating table height did not significantly influence intubation success or time, whereas certain ergonomic parameters differed among the four positions. Among the tested heights, the umbilical level was associated with more favorable ergonomic alignment.

The absence of significant differences in intubation success and laryngeal view among groups may be explained by the characteristics of the study population. Most patients had uncomplicated airways, and more than 97% of cases demonstrated a Cormack–Lehane grade 1 view. In such conditions, minor procedural variables, such as table height, may have limited influence on clinical outcomes. Previous pediatric airway studies have similarly emphasized that anatomical predictors of difficult airways play a more dominant role in intubation difficulty than technical or positional factors in otherwise normal airways [1,2].

Our findings differ from some adult studies that reported improved laryngeal views at higher table positions. Lee et al. demonstrated that higher operating table heights improved glottic visualization during direct laryngoscopy in adults [6]. The discrepancy between adult and pediatric findings may be attributed to anatomical differences. Children have a relatively larger occiput, smaller mandible, and more anterior larynx, which may facilitate acceptable laryngeal exposure across a wider range of table heights, particularly in uncomplicated airways [1,2].

Clinical evidence on operating table height in pediatric airway management remains limited. In a manikin study, Ikeda et al. found that inappropriate table height increased the difficulty of mask ventilation and worsened glottic visualization [9]. Kang et al. likewise reported that table height affected intubation time during videolaryngoscopy in the ramped position [10]. These findings support a possible relationship between table height and airway performance, but their applicability to the present trial is limited by differences in setting, airway device, patient population, and the use of simulation in some studies.

Videolaryngoscopy has increasingly been incorporated into pediatric airway practice. Randomized trials and meta-analyses suggest that, compared with direct laryngoscopy, videolaryngoscopy can improve glottic visualization and first-attempt success in children, although the magnitude of benefit depends on the device, operator experience, and clinical context [11–16]. Direct laryngoscopy therefore remains important in everyday pediatric anesthesia, particularly for uncomplicated airways and in resource-limited environments. Within this context, optimization of simple modifiable factors such as table height remains relevant [17–21].

The ergonomic findings of the present study are also clinically relevant. Although intubation-related clinical outcomes were similar across groups, neck, lumbar, and knee flexion differed significantly. The umbilical-level position produced joint angles closer to neutral alignment than the other tested heights. This observation is consistent with ergonomic evidence indicating that cervical or lumbar flexion and sustained non-neutral postures increase the risk of musculoskeletal symptoms among anesthesia providers [22–25].

Ergonomics should not be treated as a secondary concern in airway management. Repeated airway maneuvers performed in poorly aligned postures may contribute to chronic neck and back pain, upper-limb symptoms, fatigue, and reduced professional longevity [22–25]. Studies evaluating work posture in anesthesiology have similarly shown that inappropriate table height and sustained non-neutral joint positions increase biomechanical load [22–25]. Adjusting the operating table to promote a more neutral posture is therefore a simple, no-cost intervention that may improve operating-room working conditions. From a clinical standpoint, the present findings suggest that table height has little measurable effect on intubation success or intubation time in children with normal airways, but it does affect operator positioning. Selecting an ergonomically favorable table height may improve comfort and reduce strain without compromising airway outcomes.

Limitations

Several limitations should be acknowledged. First, the study was conducted in two academic centers, which may limit generalizability. Second, high-risk pediatric populations, such as those with craniofacial anomalies or obesity, were not included. Third, the relatively small sample sizes in some groups may have reduced statistical power for certain comparisons. Finally, only direct laryngoscopy was evaluated, and the effect of table height during videolaryngoscopy was not assessed.

Clinical Implications

Although no differences were observed in primary clinical outcomes, the ergonomic advantages associated with the umbilical-level table height suggest that this position may provide a practical balance between airway visualization and operator comfort. Given the simplicity of adjusting table height, this modification may represent an easy and cost-neutral approach to improving working conditions during pediatric airway management.

Conclusion

In children aged 2–6 years with uncomplicated airways, operating table height did not significantly influence intubation success or time. However, it had measurable effects on operator ergonomic parameters. The umbilical-level table height was associated with more favorable ergonomic positioning and may represent a practical option during pediatric direct laryngoscopy. Further multicenter trials, including high-risk airway populations and videolaryngoscopic techniques, are warranted to confirm these findings.

Ethics approval

The trial was approved by the Ethics Committee of Isfahan University of Medical Sciences and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

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