ORIGINAL RESEARCH

Comparison of Video Laryngoscope (VL) and Intubating Laryngeal Mask Airway (I-LMA) for Endotracheal Intubation in a Manikin with Restricted Neck Motion

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Abstract: **Introduction:** Intubating patients undergoing manual in-line stabilization (MILS) can make airway management more challenging. This study aimed to compare the outcomes of intubation with video-laryngoscope (VL) and Intubating Laryngeal Mask Airway (I-LMA) in manikin with restricted neck motion using MILS. **Methods:** In this comparative study, emergency medicine residents and paramedics were randomly allocated to two crossover sets. Then the intubation outcomes (success rate, time to successful intubation, and cervical spine movement) were compared between intubation with VL and I-LMA in a manikin model with restricted cervical spine mobility, achieved through MILS. **Results:** 64 participants with a mean age of 28.86 ± 4.03 (range: 24-47) years and a mean duration of intubation experience of 3.63 ± 1.35 years were studied (43.75% male, 81.3% emergency medicine resident). The intubation success rate was 62 out of 64 (96.88%) in the VL method and 52 out of 64 (81.25%) in the I-LMA method (p = 0.008). The mean time to successful intubation was 33.03±16.94 seconds in the VL method and 55.03±17.34 seconds in the I-LMA method (p < 0.001). The mean cervical range of motion (CROM) in flexion-extension was 4.38±1.82 degrees in the VL method and 4.13±3.20 degrees in the I-LMA method (p = 0.158). The mean CROM in rotation was 4.27±2.62 degrees in the VL method and 4.65±2.47 degrees in the I-LMA method (p= 0.258) and the mean CROM in lateral bending was 5.35±4.45 degrees in the VL method and 7.71±6.14 degrees in the I-LMA method (p = 0.010). **Conclusions:** In a manikin model with restricted cervical spine mobility, the utilization of VL significantly improved intubation success rates, reduced time to successful intubation, and limited CROM.

Keywords: Video laryngoscope; intubating LMA; Manual in-line stabilization; Success intubation

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1. Introduction

Traumatic Spinal Injury (TSI) has an estimated global incidence of approximately 10.5 cases per 100,000 individuals (1). This injury often occurs in conjunction with severe mechanisms of injury, particularly among individuals experiencing concomitant head and facial injuries, chest injuries, or abnormalities in nervous system function, which can subsequently lead to disability or fatality (2). Patients with a potential cervical spine injury may require immediate airway management to protect their airway and prevent hypoxia. This can be due to a spinal cord injury or related to head or other injuries (3). Notably, only 7.73% of TSI patients who underwent Computed Tomography (CT) scans were diagnosed with cervical spine fractures (4). The secondary spinal cord injury occurs in 2–10% of spinal cord injuries, even in the absence of a clear causative factor such as tracheal intubation or patient movement/positioning. It's important to use airway management techniques that minimize associated cervical spine movement. However, there is limited evidence supporting any one technique, especially in a prehospital environment (5).

The foundational objective of cervical spine immobilization in suspected TSI patients is to mitigate the risk of secondary cervical spine injury (6), thereby minimizing the potential for exacerbating instability within the cervical column (7). Cervical spine immobilization necessitates the utilization of a rigid cervical collar, coupled with the choice of either Tradi-

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tional Spinal Immobilization (utilizing a long spinal board) (8) or Spinal Motion Restriction (utilizing a scoop stretcher) for safe patient transport (9, 10, 11). In airway management for TSI patients, the patient must assume a supine position with the cervical spine maintained in a neutral alignment, incorporating the application of manual in-line stabilization (MILS) to effectively limit cervical spine movement during airway management procedures (12). Many studies recommend the removal of the rigid cervical collar and adopting MILS techniques during airway management and the intubation process (13, 14).

Numerous previous studies have demonstrated that the utilization of a Video Laryngoscope (VL) leads to enhanced tracheal Intubation (TI) outcomes, improved glottic visualization, and reduced time to achieve TI success (15, 16, 17, 18, 19), particularly among inexperienced operators (20, 21). In trauma patients necessitating MILS and encountering challenging airway management scenarios, VL has exhibited superior efficacy compared to direct laryngoscopes (14, 19, 22, 23). The Laryngeal Mask Airway (LMA), categorized as a supraglottic airway device, was initially introduced in 1981 by Dr. Archie Brain. Subsequently, the Intubating Laryngeal Mask Airway (I-LMA) was explicitly designed to facilitate tracheal intubation (24). Staikou et al. have shown that the I-LMA achieved a 100% success rate, demonstrating ease of use and no interference with crucial anatomical parameters such as thyromental distance, mouth opening, Mallampati classification, and Cormack-Lehane view (25). Notably, I-LMA has demonstrated a remarkably high success rate (25, 26, 27), user-friendliness in the prehospital setting (28), and a reduced incidence of cervical spine movement (29). Jakhar et al. explored the success rate and total intubation time of VL compared to I-LMA in elective cervical spine surgery patients under the application of MILS and intubation by anesthesiologists. The findings revealed that utilizing VL resulted in a significantly higher success rate and shorter intubation duration compared to I-LMA, attaining statistical significance. However, I-LMA exhibited a shorter period of patient apnea and a reduced incidence of cervical spine movement (29).

There is limited evidence on the benefit of using VL compared to I-LMA for airway management in these cases. This study aimed to compare the intubation outcomes between VL and I-LMA in a manikin model under cervical spine stabilization through MILS.

2. Methods

2.1. Study design and setting

This comparative study, enlisting the participation of emergency medical residents and paramedics affiliated with the Department of Emergency Medicine at Ramathibodi Hospital, Mahidol University, Bangkok, Thailand. The study period was between April and October 2023. This comparison was made between the utilization of VL and I-LMA in a manikin model with restricted cervical spine mobility regarding intubation success rate, time to successful intubation, and cervical range of motion (CROM).

This study was approved by Human Research Ethics Committee, Faculty of Medicine Ramathibodi Hospital, Mahidol University on November 30, 2022 (IRB COA. MURA2022/697).

2.2. Participants

In this research, eligible participants were recruited from the Department of Emergency Medicine through online and onsite poster announcements within the department. Eligible criteria for participants include providing written informed consent for the study, being first to third-year emergency medicine residents who have passed the resuscitation course (which includes difficult airway management procedure practice), being paramedic staff who have completed the advanced procedure curriculum during their training period, being age over 18, and having at least one year of experience in endotracheal intubation procedures. Exclusion criteria encompassed individuals who declined to participate or did not furnish consent.

2.3. Procedures

Participants were randomly allocated to two crossover sets using a computer-generated block randomization method, specifically employing sequential numbering within opaque sealed envelopes (SNOSE). The two crossover sets were defined as follows: one set executed intubation using a VL (HugeMed VL3R) before employing an I-LMA and the second set followed the reverse sequence, commencing with an I-LMA prior to intubation with VL guide. Eligible participants in this study did not observe a designated washout period; they transitioned seamlessly to perform the alternative method immediately upon completing the first method. All intubations were made under MILS and without applying a rigid cervical collar.

Both VL and I-LMA intubations underwent an assessment of the CROM involving flexion-extension, rotation, and lateral bending. This assessment was conducted using two sensors from the Noraxon IMU (Inertial Measurement Unit) system (30, 31, 32), a motion analysis system renowned for providing invaluable insights into human movement across diverse applications, as depicted in Figure 1C. These sensors were affixed to the forehead and sternum of a human-patient simulator to gauge cervical spine motion, as illustrated in Figure 1D. The collaboration of a biomechanics specialist with sports science expertise was enlisted to oversee and facilitate these measurements during the study.

The manikin remained stationary throughout the intubation procedures, and MILS was consistently applied to stabilize the cervical spine. One designated individual was responsible for providing MILS to ensure uniformity in positioning and technique for each intubation. Equipment employed for the comparative analysis included a portable VL featuring a standard angulation blade, specifically the HugeMed VL3R

(Figure 1A), and an I-LMA No.4 (Figure 1B). Additionally, an ET Tube No. 7 was utilized.

2.4. Data gathering

Demographic variables of the study participants were meticulously documented, encompassing general characteristics such as sex, age, and years of intubation experience. Data on intubation success rate, time to successful intubation, and absolute angles of cervical spine movement across its range of motion (ROM), including flexion-extension, rotation, and lateral bending, were systematically collected.

- Intubation success rate was defined as the proportion of the endotracheal tube (ET) being correctly placed within the trachea of a manikin within 120 seconds, as confirmed by observing a visible chest rise when ventilated using a self-inflating bag. This must be accomplished within a maximum of two attempts.
- Time to successful intubation was precisely defined as the interval elapsed from the moment of passing either VL or I-LMA through the manikin's front teeth to the point at which chest rise was observed during ventilation. Any intubation procedure exceeding the 120-second timeframe was categorized as a failed intubation.

2.5. Outcome

The primary outcomes of this study were the intubation success rate and time to successful intubation made between the utilization of VL and I-LMA in a manikin model with restricted cervical spine mobility, achieved through the application of MILS. Additionally, the secondary outcome was the measurement of cervical spine movement in degrees during intubation.

2.6. Statistical analysis

The sample size for this study was determined through a statistical analysis based on data from a prior research study conducted by Jakhar et al. (29), which investigated endotracheal intubation using a VL compared to an I-LMA while also considering cervical spine motion restriction through MILS. For sample size estimation, the study employed statistical calculations involving a two-sample comparison of proportions and means using Stata version 16.1. The assumptions included an alpha level of 0.05 (for a two-sided test), a statistical power of 0.8, and a ratio of N2/N1 equal to 1. These parameters determined the minimum sample size required to detect a statistically significant difference. The estimated sample size was N=128, with N per method of intubation equaling 64. This estimation was derived from the intubation success rate observed in the prior study as a basis for the sample size determination.
In this study, statistical analysis employed chi-square and Fisher's exact tests to compare independent categorical data, while independent t-tests were utilized to compare independent continuous data. McNemar's test was applied to assess changes in dependent categorical data, and for dependent continuous data, paired t-tests and Wilcoxon signed-rank tests were employed. All statistical analyses were conducted using Stata software version 17.0 (StataCorp, College Station, TX, USA). The threshold for statistical significance was set at a p-value of less than 0.05.

3. Results

64 participants with a mean age of 28.86 ± 4.03 (range: 24-47) years and a mean duration of intubation experience of 3.63 ± 1.35 years were studied (43.75% male, 81.3% emergency medicine resident). Table 1 presents a baseline characteristic of participants.
Table 2 compares the intubation outcome between VL and I-LMA methods. The intubation success rate was 62 out of 64 (96.88%) in the VL method and 52 out of 64 (81.25%) in the I-LMA method (p = 0.008). The mean time to successful intubation was 33.03±16.94 seconds in the VL method and 55.03±17.34 seconds in the I-LMA method (p <0.001).
The mean CROM in flexion-extension was 4.38±1.82 degrees in the VL method and 4.13±3.20 degrees in the I-LMA method (p = 0.158). The mean CROM in rotation was 4.27±2.62 degrees in the VL method and 4.65±2.47 degrees in the I-LMA method (p= 0.258) and the mean CROM in lateral bending was 5.35±4.45 degrees in the VL method and 7.71±6.14 degrees in the I-LMA method (p = 0.010).
There was no statistically significant difference in the intubation success rate between emergency medicine residents and paramedics (p =1.000 for both VL and I-LMA). Additionally, the time to successful intubation did not show statistical significance when comparing emergency medicine residents and paramedics (VL, p = 0.279 and I-LMA, p = 0.620).

4. Discussion

Our study findings illustrate that when administered by emergency medicine residents or paramedics, the utilization of a VL for intubation resulted in a notably higher success rate compared to the I-LMA (96.88% vs. 81.25%; p = 0.008). Additionally, the time required to achieve successful intubation was significantly shorter with the use of VL. Conversely, no statistically significant differences were observed in the CROM in flexion-extension and in rotation between the two intubation methods.
Our study findings align with previous research, demonstrating consistent evidence supporting the superior intubation success rate and shortening time to successful intubation of VL compared to I-LMA. (29, 33, 34)
A predominant proportion of our participants were emergency medicine residents. The study included an almost equal number of first-, second-, and third-year emergency medicine residents. The subgroup analysis revealed a comparable intubation success rate among the emergency medicine residents and paramedic groups when utilizing VL and I-LMA. Consequently, these findings suggest that in a prehospital setting, VL remains the preferred first-line ap-

proach for intubation, akin to its application in the ED.

In a systematic review and network meta-analysis conducted by Singleton et al. (14), which investigated the effectiveness of various types of VL in patients with cervical spine immobilization, they identified seven specific VL models (McGrath^{TM}, C-MAC D Blade^{TM}, Airtraq^{TM}, King Vision^{TM}, C-MAC^{TM}, and GlideScope^{TM}) as having a higher probability of intubation success.

However, our study employed the HugeMed VL3R as a VL representative; interestingly, we have limited data to compare its effectiveness with other brands of VL. Only Pascarella et al. (35) published that the use of VL3 in patients undergoing elective general anesthesia showed no significant differences in successful TI rate, number of attempts, total intubation time, and time to glottis visualization between predicted difficult airway and non-predicted difficult airway. Our study is one of the pioneers in the portable VL to compare VL3R with I-LMA in prehospital healthcare personnel. Furthermore, our data on the intubation success rate of VL3R aligns with Pieters et al. (21) This study showed a high intubation success rate across various levels among healthcare providers in seven devices of VL compared with Macintosh laryngoscope in manikins.

Jakha et al. compared VL and I-LMA for intubation under MILS in cervical spine surgery patients and reported similar success rates to our study. Specifically, VL achieved a success rate of 96.97%, which parallels our study's result of 96.88%, while I-LMA exhibited success rates of 81.25% in both studies.(29)

Regarding the time required for successful intubation, Jakhar et al. (29) found that VL had a mean time of 33.13±11.82 seconds, comparable to our study's finding of 33.03±16.94 seconds for VL. However, for I-LMA, they reported a significantly shorter mean time of 22.03±7.14 seconds, whereas our study observed a longer mean time of 55.03 ±17.34 seconds for I-LMA. It is noteworthy that in our study, emergency medical personnel were less familiar with I-LMA, which could have contributed to the longer time required for successful intubation compared to the participants (anesthesiologists) in the Jakhar et al. study.

Additionally, Ydemann et al. have provided supporting evidence indicating that the time required for successful intubation with I-LMA tends to be longer. They reported the mean intubation time with I-LMA was 61 seconds. (36) Moreover, Marouf and Khalil reported an even longer mean intubation time for I-LMA, with a duration of 133.7±44.12 seconds. (33) These findings demonstrate that I-LMA often necessitates more time for successful intubation than VL.

Our study also evaluated the impact of different intubation methods on cervical spine movement angles across various planes, encompassing flexion-extension, rotation, and lateral bending. The results indicated that compared to the I-LMA, a VL did not yield any statistically significant differences in the angles of flexion-extension and rotation. However, it was observed that I-LMA induced a statistically significant increase in cervical movement in the lateral bending plane when contrasted with VL.

Nevertheless, it is essential to emphasize that our study did not encompass the examination of how these observed angles might impact neurological outcomes in the context of cervical spine injuries. Consequently, further investigation is warranted to assess the potential implications of cervical spine angles on patient outcomes.

5. Limitations

While this study offers valuable insights, it is essential to recognize its inherent limitations. The research was conducted in a simulated environment, which may not entirely mirror the complexities of real-world clinical scenarios. Moreover, the study sample was limited to emergency medical residents and paramedics, potentially restricting the generalizability of the findings to the broader spectrum of healthcare providers. Consequently, further investigations with larger, more diverse participant cohorts are warranted to corroborate and extend these findings.

Another limitation is the absence of data regarding the specific angles of cervical spine movement and their potential associations with neurological outcomes. As a result, there exists a need for supplementary research in this domain to gain a more comprehensive understanding of the impact of cervical spine angles on patient outcomes.

6. Conclusions

In the context of a manikin model with restricted cervical spine mobility, the utilization of VL offers several advantages over the use of I-LMA. These advantages include the potential for improved intubation success rates, reduced time to successful intubation, and limited CROM.

7. Declarations

7.1. Acknowledgments

None.

7.2. Authors' contributions

All contributors to this work have substantially participated in its development, encompassing the concept formation, study design, implementation, data collection, data analysis, and interpretation. Each author has been involved in the drafting and revision process, providing critical feedback on the manuscript. They have unanimously approved the final version for publication, concurred on the choice of journal for submission, and collectively accepted responsibility for the integrity of all aspects of the work.

7.3. Funding Source

No funding was obtained for this study.

7.4. Ethical considerations

This study was approved by Human Research Ethics Committee, Faculty of Medicine Ramathibodi Hospital, Mahidol University on November 30, 2022 (IRB COA. MURA2022/697).

7.5. Availability of data and material

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

7.6. Conflict of interest

The authors declare that they have no competing interests.

7.7. Using artificial inteligence chatbots

None.

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Table 1: The baseline characteristics of participants between two groups

Variables	EMR (N=52)	Paramedic (N=12)	P value
Age (year)			
Mean ± SD	28.44 ± 2.41	32.34 ± 8.41	< 0.001
Sex			
Male	18 (34.61)	10 (83.34)	0.003
Female	34 (65.39)	2 (16.66)	
Intubation experience (year)			
Mean ± SD	3.52 (1.26)	4.08 (1.68)	0.194
Experiences for intubating			
Direct Laryngoscope	52 (100)	12 (100)	0.972
Video Laryngoscope	52 (100)	12 (100)	0.989
Intubating Laryngeal Mask Airway	10 (19.2)	5 (41.4)	0.028

Data are presented as mean± standard deviation (SD) or number (%).

Table 2: Comparing the intubation characteristic between Video Laryngoscope (VL) vs. Intubating Laryngeal Mask Airway (I-LMA)

Variables	VL (64 times)	I-LMA (64 times)	P-value
Intubation Success Rate			
Total	62 (96.88)	52 (81.25)	0.008
EMR (n = 52)	50 (96.15)	42 (80.77)	0.021
Paramedic (n = 12)	12 (100)	10 (83.33)	0.157
Time to Success Intubation			
Total	33.03 ± 16.94	55.03 ± 17.3	< 0.001
EMR (n = 52)	34.14 ± 18.34	55.55 ± 18.93	< 0.001
Paramedic (n = 12)	28.23 ± 7.19	52.76 ± 7.33	< 0.001
Cervical spine range of motion (degree)			
Flexion-extension	4.38 ± 1.82	4.13 ± 3.20	0.158
Rotation	4.27 ± 2.62	4.65 ± 2.47	0.258
Lateral Bending	5.35 ± 4.45	7.7 ± 6.14	0.010

Data are presented as mean± standard deviation (SD) or number (%). EMR: emergency medicine resident.

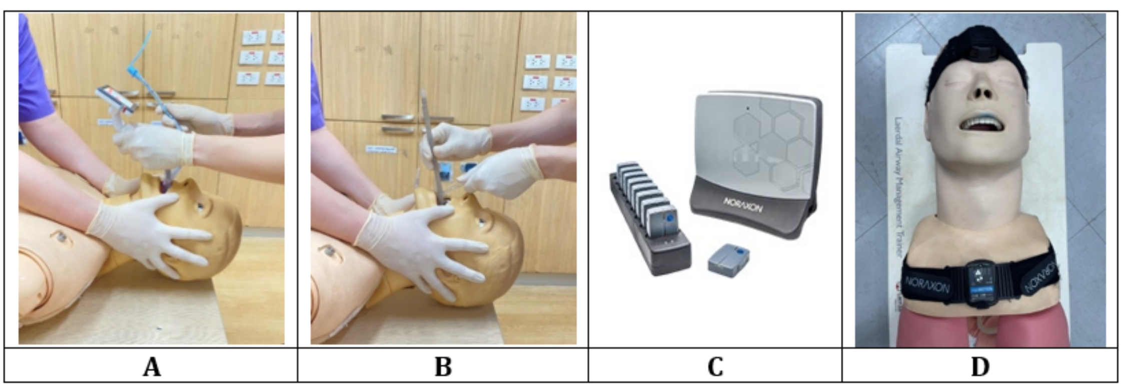

Figure 1: Video Laryngoscope (VL) assisting intubation technique (A); Intubating Laryngeal Mask Airway (I-LMA) assisting intubation technique (B); Naraxon Inertial Measurement Unit (IMU) system; (C); Sensors at forehead and sternum (D).