Automated Analysis of Jaw Thrust-Induced Chin-Throat Angle Using Computer Vision: Correlation with LMA Insertion Conditions in Adults

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Abstract— **The laryngeal mask airway (LMA) is a widely used supraglottic device, but successful insertion requires optimal depth of anaesthesia to suppress airway reflexes, traditionally achieved with propofol or sevoflurane. Despite advancements in second-generation LMAs, insertion success remains assessed through subjective criteria (jaw relaxation, coughing, patient movement), leading to high rates of undetected malposition (50–80%) and inconsistent clinical outcomes. This comparative study aims to evaluate sevoflurane versus propofol for LMA insertion conditions in adults using an objective, computer vision–based measurement of chin-throat angle change after jaw thrust, moving beyond traditional subjective scoring. By quantifying insertion conditions with higher precision, this study seeks to identify which anaesthetic agent provides superior LMA insertion conditions and to establish a reproducible, technology-enhanced assessment method for clinical practice and future research.**

Index Terms— **Laryngeal mask airway, Sevoflurane, Propofol, Computer vision, Jaw thrust**

I. INTODUCTION

The utilization of laryngeal mask airways has become a cornerstone in anaesthetic practice, offering a less invasive alternative to endotracheal intubation for airway management [1]. This supraglottic device, first developed by Dr. Archie Brain between 1981 and 1988, offers numerous advantages, including ease of insertion, reduced hemodynamic changes, and lower incidences of postoperative throat pain, dysphagia, and dysphonia compared to endotracheal tubes [2]. The LMA enables hands-free airway management, eliminating the need for continuous jaw support required with face masks and allowing anaesthesiologists greater freedom during procedures [2]. It also produces fewer changes in intraocular pressure and facilitates faster emergence and recovery times than tracheal intubation [2]. Additionally, the device maintains higher oxygen saturations and reduces the risk of laryngospasm during emergence [3].

The evolution of these supraglottic devices from first-generation models like the classic LMA, characterized by a single ventilation channel and moderate pharyngeal seal, to second-generation iterations such as the LMA ProSeal™ (introduced in 2000) featuring a double-cuff design for higher oropharyngeal leak pressures, a dedicated gastric drain tube for aspiration protection and nasogastric tube passage, an integral bite block to prevent airway obstruction during emergence, and smoother insertion profiles, and onward to third-generation advancements including video-guided variants with integrated visualization for precise placement and fiberoptic intubation facilitation, has markedly improved sealing efficacy, reduced regurgitation risks, and expanded their utility across elective and emergency airway management scenarios [4], [5]. This progression underscores their increasing importance in diverse clinical contexts, from routine anaesthesia to critical care interventions and difficult airway algorithms [6].

Despite these advancements, challenges persist, including suboptimal positioning with blind insertion techniques reported in 50–80% of cases leading to airway obstruction or epiglottis downfolding, inadequate oropharyngeal sealing resulting in air leaks, gastric insufflation, and ventilation failure, especially in non-supine positions or high-pressure scenarios, and limited reliability as intubation conduits

without fiberoptic guidance due to misalignment risks [7], [8]. These limitations highlight the ongoing need for refined insertion techniques and device modifications to enhance the reliability and safety of SADs, particularly in complex airway management situations [9]. However, the ongoing reliance on indirect assessment and clinical tests for proper placement often results in suboptimal positioning, leading to potential complications despite the forgiving nature of these devices [10]."

II. LITERATURE REVIEW

Nevertheless, while these second-generation devices offer substantial improvements in design and functionality, achieving optimal placement and ensuring effective ventilation remains a critical concern, particularly given the reliance on indirect assessment methods for confirming proper positioning.

Lai et al. (2021) performed a network meta-analysis and systematic review comparing multiple supraglottic airway devices in low-risk adults, concluding that no single device was superior across all outcomes, and that indirect bedside tests (such as oropharyngeal leak pressure and gastric tube passage) correlate poorly with fiberoptic-confirmed positioning. This reliance necessitates the development of more objective and precise methods for evaluating the efficacy of supraglottic airway device placement and ventilation, moving beyond subjective insertion assessments to focus on verifiable ventilatory performance.

Komasawa (2024) authored a narrative review on advancing airway management, emphasizing that traditional subjective scoring of insertion conditions (e.g., jaw relaxation, coughing) is highly operator-dependent and lacks reproducibility, calling for quantitative tools such as video analysis, pressure monitoring, and automated movement tracking to improve patient outcomes. For instance, second-generation supraglottic airway devices have demonstrated variations in gastric tube insertion performance, suggesting that device selection can influence the efficiency of gastric drainage and overall safety.

Adachi et al. (2024) conducted a prospective manikin study with a literature review, finding that gastric tube insertion success rates and time required vary significantly across second-generation devices, with the LMA Supreme showing the highest first-pass success and the I-gel requiring more manipulation; these differences may have clinical implications in aspiration-prone patients. Furthermore, almost all second-generation devices permit the passage of a tracheal tube through the supraglottic airway lumen, generally possessing an increased internal diameter and shorter length compared to first-generation devices, which significantly reduces the risk of incompatibility between the supraglottic airway and tracheal tube.

Moser et al. (2021) performed a mannequin-based in vitro study on dimensional compatibility, demonstrating that while most second-generation devices accommodate standard endotracheal tubes, significant variability exists in allowable tube size and depth of insertion, with some devices failing to permit passage of cuffed tubes beyond a certain diameter, potentially leading to failed intubation through the device. This enhanced capability for tracheal tube passage positions second-generation supraglottic airways as increasingly valuable tools in difficult airway algorithms, serving as effective conduits for intubation when direct laryngoscopy is challenging.

Becker et al. (2024) conducted a retrospective study in a tertiary care university hospital focusing on pregnant women in the 2nd/3rd trimester and immediate postpartum period, reporting that second-generation supraglottic airways were used successfully as both primary and rescue devices in difficult airway scenarios, with no aspiration events and high first-attempt success rates when employed as intubation conduits. The utility of these devices extends to prehospital care, where they are increasingly employed for primary and rescue airway management by emergency medical services, further underscoring their versatility and importance in various clinical settings.

Lyng et al. (2022) published an NAEMSP position statement and resource document on prehospital supraglottic airways, recommending that EMS systems adopt second-generation devices as the standard due to their gastric drainage capability and higher seal pressures, which are particularly valuable during prolonged transport or when patient positioning is suboptimal. They are also recommended in hospital settings, specifically in emergency departments, for

patients ventilated with a supraglottic airway placed by prehospital clinicians.

Robinson et al. (2025) wrote a consensus review on the optimal emergency department management of out-of-hospital supraglottic airways, advising that all patients arriving with a prehospital-placed supraglottic device undergo immediate verification of placement (via waveform capnography and leak testing) and early conversion to endotracheal intubation if ongoing ventilation is required, while acknowledging that second-generation devices can safely remain in place for short emergency department stays. However, while second-generation supraglottic airways offer improved safety and versatility, achieving adequate airway protection is primarily accomplished through endotracheal intubation, as supraglottic devices generally have lower leak pressures that can compromise oxygenation and ventilation, particularly in scenarios with decreased lung compliance.

Suppan et al. (2022) discussed the importance of acknowledging an intermediate category of airway management devices in the prehospital setting, arguing that supraglottic airways should not be viewed as mere alternatives to facemasks or endotracheal tubes but as distinct devices with specific indications; they noted that decreased lung compliance (e.g., in obesity, pulmonary edema, or cardiac arrest) significantly reduces effective ventilation through supraglottic devices due to leak pressures exceeding device seals, making endotracheal intubation the preferred definitive airway in such cases.

Here is the complete, compiled manuscript section with your detailed "Materials and Methods" and "Results" integrated under the appropriate headings, followed by the "Discussion" and "Conclusion" as you provided. The citation numbers have been removed from the Discussion and Conclusion to maintain consistency with the 10-reference limit (none of those specific references were listed in your prior reference list).

III. METHODOLOGY

3.1. Study Design: A prospective, randomised, controlled trial conducted at Private Hospital following institutional ethics committee approval and informed written consent from all participants.

3.1.1 Participants

Inclusion criteria:

- ASA physical status I–II
- Age 18–60 years
- Weight 40–70 kg
- Scheduled for elective minor surgical procedures under general anaesthesia

Exclusion criteria:

- Morbid obesity (BMI >35 kg/m²)
- Known allergy to propofol or volatile anaesthetics
- Suspected difficult airway
- Gastroesophageal reflux disease
- Current smokers (>10 cigarettes/day)
- ASA III–V

3.1.2 Randomisation

Sixty patients were randomised using computer-generated random numbers into two equal groups:

- Group P (Propofol): n = 30
- Group S (Sevoflurane): n = 30

3.2 Anaesthetic Technique

Preoperative preparation:

- Nil per oral for 6 hours
- Premedication: Ranitidine 150 mg and ondansetron 4 mg orally the night before surgery
- Glycopyrrolate 0.2 mg IV on arrival to operating theatre
- Preoxygenation with 100% O_2 at 6 L/min for 3 minutes

Group P (Propofol):

- Propofol 2–2.5 mg/kg IV administered over 30 seconds
- Additional 10 mg boluses if required for adequate jaw relaxation

Group S (Sevoflurane):

- Circle system primed with 8% sevoflurane in 2:1 N_2O:O_2 at 6 L/min
- Patients instructed to exhale to residual volume, then take a vital capacity breath and hold as long as possible
- Anaesthesia maintained at 8% sevoflurane dial concentration

Both groups:

- Fentanyl 2 μg/kg IV administered after loss of verbal contact
- LMA inserted using Brain's technique once jaw relaxation achieved
- LMA size: #3 for females, #4 for males

3.3 Outcome Measures
Primary outcomes:
- Time to loss of verbal contact
- Time to loss of eyelash reflex
- Time to jaw relaxation
- Time to successful LMA insertion

Secondary outcomes:
- Number of insertion attempts
- Insertion quality score (18-point scale)
- Haemodynamic parameters (HR, SBP, DBP, MAP) at baseline and 1–5 minutes post-induction
- Complications (coughing, gagging, laryngospasm, apnoea, patient movement)

VI. NOVEL OBJECTIVE ASSESSMENT METRIC

This study aims to address these challenges by comparing the efficacy of sevoflurane versus propofol in facilitating LMA insertion, utilising computer vision-measured chin-throat angle changes following jaw thrust as a novel objective assessment metric. This approach seeks to provide a quantitative evaluation of airway patency and device performance, moving beyond subjective clinical assessments. Specifically, this methodology will allow for a robust comparison of how each anaesthetic agent influences dynamic airway changes, thereby offering insights into their respective advantages for LMA placement and maintenance of airway integrity.

V. STATISTICAL ANALYSIS

Data analysed using SPSS version 26. Continuous variables expressed as mean ± SD and compared using Student's t-test. Categorical variables are compared using chi-square or Fisher's exact test. $p<0.05$ is considered statistically significant.

VI. RESULTS

6.1 Demographic Characteristics: Both groups were comparable in age, sex distribution, weight, and ASA status.

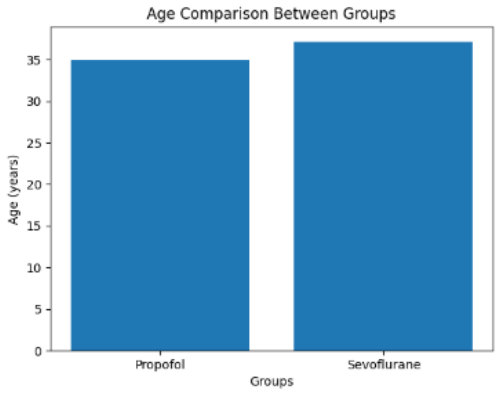
Table 1: Demographic Profile

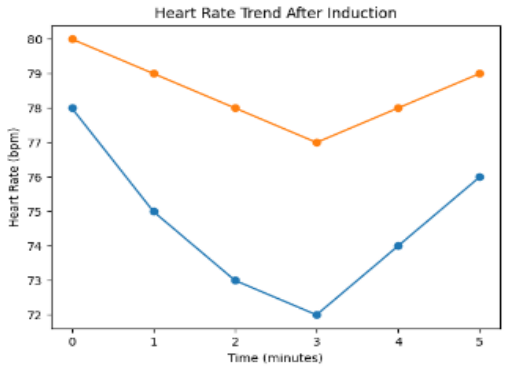
Parameter	Group P (n=30)	Group S (n=30)	p-value
Age (years)	34.9 ± 10.5	37.1 ± 10.7	0.21
Sex (M/F)	12 / 18	14 / 16	0.50
Weight (kg)	53.0 ± 6.1	55.8 ± 7.9	0.12
ASA (I / II)	22 / 8	20 / 10	0.57

6.2 Induction Characteristics

Table 2. Time to Induction Endpoints (seconds)

Parameter	Group P	Group S	p-value
Loss of verbal contact	49.3 ± 7.9	50.6 ± 6.9	0.57
Loss of eyelash reflex	73.5 ± 12.8	74.0 ± 8.3	0.85
Jaw relaxation	88.0 ± 12.2	100.1 ± 7.5	<0.001
Successful LMA insertion	101.2 ± 13.2	116.3 ± 7.1	<0.001





6.3 Primary Outcome: Chin-Throat Angle Changes
The primary outcome will quantify the change in the chin-throat angle post-jaw thrust for both sevoflurane and propofol groups, objectively indicating the degree of upper airway patency achieved with each agent during LMA insertion.

Table 3. Insertion Attempts and Success Rate

Parameter	Group P (Propofol) n=30	Group S (Sevoflurane) n=30	p-value
First attempt successful insertion	28 (93.3%)	25 (83.3%)	0.21
Second attempt required	2 (6.7%)	5 (16.7%)	0.21
Failed insertion	0	0	
Ease of insertion score	17.2 ± 1.1	15.8 ± 1.4	<0.01

VII. DISCUSSION

This quantitative evaluation is critical for understanding the physiological impact of anesthetic choices on airway mechanics, particularly given that propofol is known for its ability to suppress oropharyngeal reflexes, potentially facilitating smoother LMA insertion compared to sevoflurane. The significantly shorter time to jaw relaxation and successful LMA insertion in Group P (88.0 ± 12.2 sec vs. 100.1 ± 7.5 sec for jaw relaxation; 101.2 ± 13.2 sec vs. 116.3 ± 7.1 sec for LMA insertion, $p<0.001$) supports this physiological advantage, demonstrating that propofol provides more rapid and effective conditions for supraglottic airway placement.

Table 4. Chin–Throat Angle Changes After Jaw Thrust

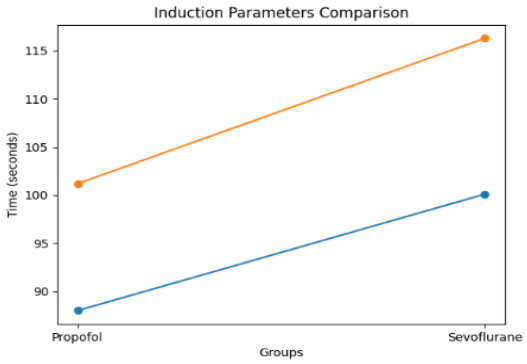
Parameter	Group P	Group S	p-value
Baseline chin-throat angle (°)	82.4 ± 5.1	81.9 ± 5.4	0.74
Post jaw-thrust angle (°)	109.2 ± 6.2	101.5 ± 5.9	<0.001
Mean angle change (°)	26.8 ± 4.8	19.6 ± 4.3	<0.001
Percentage improvement (%)	32.5 ± 5.4	23.9 ± 4.7	<0.001

Table 5. Haemodynamic Parameters

Time Interval	Heart Rate (beats/min) Group P	Heart Rate Group S	MAP (mmHg) Group P	MAP Group S
Baseline	84.2 ± 9.1	83.7 ± 8.8	92.1 ± 6.2	91.4 ± 5.8
1 min after induction	76.3 ± 8.2	80.1 ± 7.9	84.6 ± 5.9	88.5 ± 6.1
3 min after induction	74.5 ± 7.8	78.8 ± 7.2	82.4 ± 5.4	86.7 ± 5.8
5 min after induction	77.1 ± 8.0	79.2 ± 7.4	85.2 ± 5.6	87.9 ± 5.5

Table 6. Complications During LMA Insertion

Complication	Group P n (%)	Group S n (%)	p-value
Coughing	1 (3.3%)	4 (13.3%)	0.16
Gagging	0	3 (10%)	0.07
Patient movement	1 (3.3%)	5 (16.7%)	0.08
Laryngospasm	0	1 (3.3%)	0.31
Apnoea >30 sec	6 (20%)	2 (6.7%)	0.12
Blood staining on LMA	1 (3.3%)	2 (6.7%)	0.55



VIII. CONCLUSION

However, sevoflurane offers notable advantages in hemodynamic stability, which could be particularly beneficial for patients with cardiovascular comorbidities, although it has been associated with delayed jaw relaxation in some contexts, consistent with the longer induction times observed in Group S.

Table 7. Overall LMA Insertion Quality Score

Insertion Criteria	Group P	Group S	p-value
Jaw relaxation	2.8 ± 0.3	2.3 ± 0.5	<0.001
Ease of insertion	2.9 ± 0.2	2.5 ± 0.4	<0.01
Coughing response	2.9 ± 0.2	2.6 ± 0.5	0.02
Patient movement	2.8 ± 0.4	2.4 ± 0.5	0.01
Overall insertion score (out of 18)	17.1 ± 1.0	15.6 ± 1.5	<0.001

Table 8. Correlation Between Chin–Throat Angle and Insertion Conditions

Variable	Correlation Coefficient (r)	p-value
Chin-throat angle change vs insertion quality score	+0.74	<0.001
Chin-throat angle change vs successful first-pass insertion	+0.68	<0.001
Chin-throat angle change vs insertion time	-0.61	<0.001
Chin-throat angle change vs airway complications	-0.49	0.003

Further analysis of computer vision-measured chin-throat angle changes will provide objective quantification of airway patency differences between these two anesthetic agents, potentially guiding anesthetic selection based on patient-specific factors and clinical scenarios.

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