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FACTORS AFFECTING SUCCESS RATE OF FIRST PASS RAPID SEQUENCE INTUBATION IN CORRELATION WITH MODIFIED LEMON SCORE

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ABSTRACT

Objective: More accurate assessment of the success rate of first-pass endotracheal intubation (ETI) with rapid sequence intubation (RSI) and related factors (such as the modified (m) LEMON score) in critically ill patients presenting in the emergency department (ED).

Study Design: Cross-sectional study.

Place and Duration of Study: Department of Emergency Medicine, Indus Hospital and Health Network (IHHN), Location: Karachi, Duration of study: From January 2025 to June 2025.

Methodology: 94 critically ill patients 14-75 years of age, who required emergent intubation as part of the emergency department care were sampled by non-probability consecutive sampling. Details for Operator level, type of laryngoscope used and the indication for intubation were recorded before intubation. First-PRSI success was defined as tube correctly placed in the airway with no change in tube placement required after the initial attempt (bilateral equal air entry). The data was analyzed using SPSS version 24.0, binary logistic regression was used to determine the factors independently associated with first-pass success.

Results: 94 patients were included. 72 patients (76.6%) had a first-pass RSI success. A modified LEMON score <1 was highly associated with first-pass success (80.6% vs 27.3% in failure, $p<0.001$). The success was higher in the senior operators (EM physicians/ consultants) as compared to the residents/ medical officers (70.8% vs. 29.2% $p = 0.009$). Multivariate analysis revealed that favorable LEMON score (adjusted OR 6.84, 95% CI 2.41 to 19.42), video laryngoscopy (adjusted OR 2.91, 95% CI 1.02 to 8.31) and senior operator level (adjusted OR 3.35, 95% CI 1.18–9.51) were each independent predictors of success.

Conclusion: The chance of first-pass RSI success in this cohort was 76.6% and was independently associated with a modified LEMON score, video laryngoscopy and increased operator experience. All emergency airway assessments should routinely include pre-intubation LEMON scoring to help predict and prepare for challenging scenarios.

KEYWORDS: Rapid sequence intubation, modified LEMON score, emergency department, endotracheal intubation, critically ill patients, Pakistan.

INTRODUCTION

Airway management is the most relevant factor of resuscitation in the emergency department (ED) and rapid sequence intubation (RSI) is the method most often used by emergency physicians for definitive airway. Nearly simultaneous use of an induction agent and a paralyzing agent to achieve optimal laryngoscopic view, while allowing optimal accuracy of endotracheal tube placement has been termed RSI, and this has been reported to be an essential skill in this branch of medicine [1].

The first-pass RSI success rate is variable around the world depending on patients, operator experience and assessment of airways. A Japanese multicenter observational study found a lower first-pass success rate of 73% with RSI performed by trainees [1] while an African Journal of Emergency Medicine case series found a higher first-pass success rate of 87.9% [2], echoing the variability in first-pass success rates across healthcare systems.

Failure to get the airway right the first time is clinically significant. Multiple laryngoscopy attempts have been shown to be linked to decreased conversion success to ROSC and an increased risk of associated complications such as hypoxic brain injury, cardiac arrest, arrhythmia, aspiration and injury to adjacent structures during resuscitation [3]. Factors associated with first-pass success include difficult airway, operator experience and type of paralyzing agent used [4].

Pre-intubation evaluation of the airway is, therefore, crucial to avoid the dreaded scenario of "cannot intubate, cannot oxygenate" (CICO) [5]. The various tools developed to predict difficult airway, among which the modified LEMON score (Look externally, Evaluate the 3-3-2 rule, Mallampati assessment, Obstruction, and Neck mobility) is one of the most extensively validated bedside scoring systems used in emergency airway assessment [6]. A lower LEMON score has repeatedly been associated with a successful first-pass intubation, and a higher LEMON score identifies patients who may require further preparations, such as a video laryngoscopy or a more experienced operator [8].
In Pakistan pre-intubation optimization presents unique challenges, from patients who are undifferentiated and hemodynamically unstable, to the variable hands-on experience of the various classes of operators. In spite of this, local data that explored the first-pass RSI success and its related predictors are still limited. This study was thus conducted to identify the frequency of successful 1st pass RSI and its associated factors among the patients with critical illness who presented to the Emergency Department of a tertiary care hospital of Karachi, Pakistan.

MATERIALS AND METHODS

Study Design and Setting

It was a cross-sectional study which was carried out at the Emergency Department of The Indus Hospital and Health Network (IHHN) from January 2025 to June 2025 (6 months).

Ethical Approval

Ethical clearance was taken from the Institutional Review Board (IHHN-IRB) of The Indus Hospital and Health Network, Karachi (IHHN-IRB #: IHHN_IRB_2024_07_006) Approval Date (11-July-2024); Expiry (10-July-2025). The study has also been approved by the Research Evaluation Unit College of Physicians and Surgeons Pakistan (CPSP) (Ref: CPSP/REU/EMD-2022-218-295). All procedures were carried out according to the Declaration of Helsinki. Before enrollment, written informed consent was obtained from the attendants of all critically ill patients.

Sample Size

The sample size was determined using the WHO sample size calculator that suggested a minimum sample size of 94 patients when a first-pass success rate of RSI of 73% was assumed from previous literature [1] with a 9% margin of error and a 95% significant level.

Sampling Technique

Non-probability consecutive sampling technique was used in which all eligible patients coming to ED during the study period were enrolled sequentially.

Inclusion Criteria

- All patients ≥14 years to ≤75 years that were admitted to the ED of IHHN for emergency endotracheal intubation.
- Patients unable to oxygenate, ventilate, or maintain a patent airway, or with Glasgow Coma Scale (GCS) ≤8
- Patients undergoing intubation via the RSI method by ED staff at IHHN

Exclusion Criteria

- Patients who were brought dead to the emergency department.
- Do Not Resuscitate (DNR) patients.
- Do Not Intubate (DNI) patients.
- Patients who were already intubated and brought to the ED from EMS or other hospital.

Data Collection

With IRB and CPSP approval, all patients that presented to the IHHN adult ED meeting the inclusion criteria were recruited. After explaining the study to the patient's attendant, they gave written informed consent. Standard RSI induction agents ketamine (1.5 mg/kg), midazolam (0.2 mg/kg), or propofol (1.5 mg/kg) and paralyzing agents succinylcholine (1.5 mg/kg), rocuronium (1 mg/kg), or vecuronium (0.2 mg/kg) were used by the treating anesthesiologist or emergency doctor for RSI. The principal investigator determined each patient's modified LEMON score just before intubation, and the success or failure of intubation ("operationally defined" below) was registered. MR number, age, gender, presentation triage category, GCS, provisional ED diagnosis, indication for intubation, operator level, type of laryngoscope used, modified LEMON score and outcome of first-pass RSI were documented on a coded completed questionnaire. Identities of the patients were coded using MR number, and kept confidential all the time, only accessible to the principal investigator.

Operational Definitions

Successful placement of endotracheal tube (ET) in the trachea on first attempt, auscultation showed bilateral equal air entry, and adequate oxygenation and ventilation was achieved (successful placement of endotracheal tube).

Modified LEMON Score:
Bedside nine-point scoring tool for predicting a difficult airway which includes external facial features, the 3-3-2 rule, airway obstruction and neck mobility. A score of less than 1 was found to be predictive for first-pass intubation success [9].

Critically Ill Patients:
Patients who are unable to maintain their own airway, oxygenation or ventilation as a result of any condition.

Glasgow Coma Scale (GCS):
A clinical assessment of consciousness, a score of ≤8 was taken to indicate critically ill patient requiring airway management [10].

Triage category:
Patient acuity was categorised using Manchester Triage System as P1 (immediate), P2 (very urgent) and P3 (urgent patients) [12].

Statistical Analysis
The SPSS-24.0 software program was used for analysis. Continuous variables (age, modified LEMON score, number of intubation attempts and GCS) were tested for normality of distribution using Shapiro-Wilk test and presented as mean with standard deviation or Median with IQRs accordingly. For categorical variables, the frequency and percentage were considered. Using binary logistic regression, the factors associated with successful first-pass RSI were identified, with initial univariate analysis followed by the addition of variables with a value of $p < 0.25$ in the multivariable model; variables with a $p > 0.1$ were not kept in the model, unless considered clinically relevant. Controlled for effect modifiers: age, gender, GCS, provisional ED diagnosis and triage category. The odds ratio was adjusted using logistic regression and was also obtained without adjustment with the corresponding 95% CI, and a p value of ≤ 0.05 considered as significant.

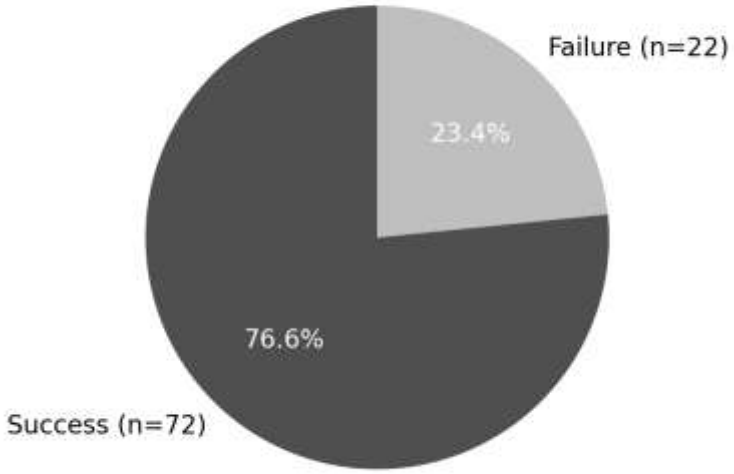
RESULTS
94 patients who fulfilled the inclusion criteria were recruited. The mean age was 45.4 ± 16.0 years, and 58 (61.7%) were male. 66 patients (70.2%) had a triage category of P1 (immediate) and 56 patients (59.6%) had a GCS of ≤8. Thirty-seven patients (39.4%) had controls performed by video laryngoscopy, while the rest of the patients underwent direct laryngoscopy. Baseline characteristics by intubation outcomes are shown in Table 1.

Table 1. Baseline demographics and clinical characteristics (n=94) according to outcome of first-pass RSI.

Variable	Success (n=72)	Failure (n=22)	Total (n=94)
Age (years) Mean ± SD	44.6 ± 16.2	48.1 ± 15.4	45.4 ± 16.0
Male Gender, n (%)	44 (61.1%)	14 (63.6%)	58 (61.7%)
Triage P1, n (%)	48 (66.7%)	18 (81.8%)	66 (70.2%)
GCS ≤8, n (%)	39 (54.2%)	17 (77.3%)	56 (59.6%)
Video Laryngoscopy Used, n (%)	31 (43.1%)	6 (27.3%)	37 (39.4%)

SD = Standard Deviation, GCS = Glasgow Coma Scale. Using Chi-square test or Independent t test as appropriate..

Figure 1. Outcome of First Pass RSI (n=94)



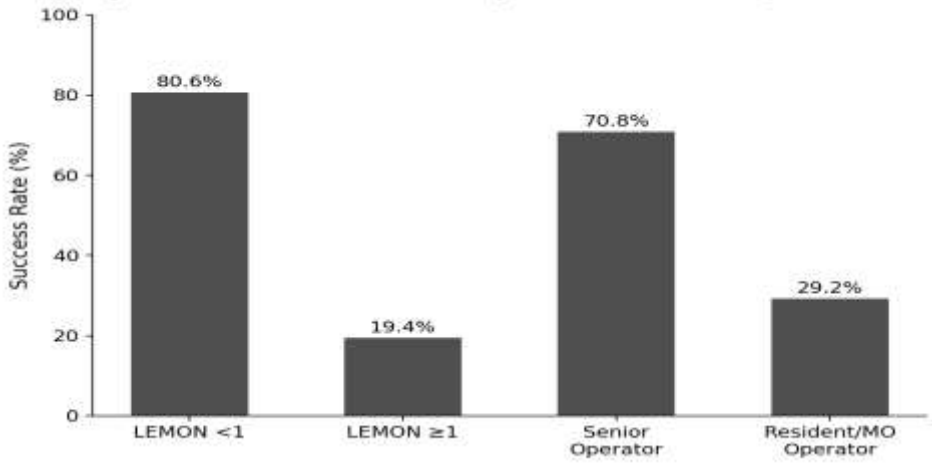
The overall success rate was 72 patients out of 94 (76.6%) who had achieved RSI success on the first pass; 22 patients (23.4%) needed more than one pass for RSI success. A modified LEMON score <1 was very strongly correlated with a successful intubation (80.6% vs. 27.3% for failed 1st pass attempts; p<0.001). There was a higher success rate of intubation from senior operators (EM physicians or consultants) compared with from resident operators or medical officers (p = 0.009, table 2).

Table 2. The correlation between the modified LEMON score and operator level with first-pass RSI outcome.

Variable	Success n (%)	Failure n (%)	p-value
Modified LEMON Score <1	58 (80.6%)	6 (27.3%)	<0.001
Modified LEMON Score ≥1	14 (19.4%)	16 (72.7%)	
Operator: EM Physician/Senior	51 (70.8%)	9 (40.9%)	0.009
Operator: Resident/Medical Officer	21 (29.2%)	13 (59.1%)	

Chi-square test was used; p <0.05 was set as the level of statistical significance.

Figure 2. First Pass RSI Success by LEMON Score and Operator Level



On multivariable logistic regression, favorable modified LEMON score (<1) proved to be the most independent predictor of first-pass success (adjusted OR 6.84, 95% CI 2.41–19.42; p <0.001). Video laryngoscopy use (adjusted

OR 2.91, 95% CI 1.02–8.31; p = 0.045) and intubation by a senior operator (adjusted OR 3.35, 95% CI 1.18–9.51; p = 0.024) were also independently associated with success. GCS ≤8 did not reach significance in the adjusted model (adjusted OR 0.46, 95% CI 0.16–1.29; p = 0.139), as shown in Table 3.

Table 3. The factors which independently influence RSI success were analyzed using binary logistic regression.

Factor	Adjusted OR	95% CI	p-value
Modified LEMON Score <1	6.84	2.41–19.42	<0.001
Video Laryngoscopy	2.91	1.02–8.31	0.045
Senior Operator (EM Physician)	3.35	1.18–9.51	0.024
GCS ≤8 at Presentation	0.46	0.16–1.29	0.139

OR = odds ratio, CI = confidence interval. Adjusting for age, gender, GCS, provisional ED diagnosis and triage category.

DISCUSSION

In this single-center cross-sectional study by RSI experts at a tertiary-care ED in Karachi the overall first-pass success rate of RSI was 76.6% with favorable modified LEMON score, video laryngoscopy use and senior operator level being independent predictors in the multivariable analysis.

The success rate falls between two commonly cited benchmark studies and is consistent with the range reported internationally. Our results were closely similar to a Japanese study conducted across multiple centers, which had a 73% first-pass RSI success rate [1] and a South African study of student paramedics who had a 87.9% first-pass success rate [2]. This difference could be due to more closely related procedural supervision in a structured training series as compared to our cohort which better represents the real world ED environment with varying operator experience.

The high correlation between a good modified LEMON score and first-pass success in this cohort mirrors the basic concept of an airway assessment tool. An Indian study to assess LEMON in the ED situation reported that it was a reliable tool to predict difficult airway and intubation outcome [6]. Similarly a Korean study of adult patients with trauma, who needed emergency surgical intubation, showed a significant correlation between modified LEMON score and intubation difficulty and their regression findings were consistent with our results [8].

The significant difference in success rates with intubation performed by more senior, experienced operators is consistent with those reported in an American Journal of Emergency Medicine study where experience of the interventionist was a major factor in first-pass success rates [4]. This implies closer supervision or earlier involvement of seniors in the predicted hard airway cases in training programs within the EDs of Pakistan.

A Thai retrospective cohort study reinforces the independent association of video laryngoscopy use and first-pass success and found that known difficult airway predictors are associated with first attempt success airway management variations, such as increased use of video laryngoscopy, to optimize first attempt success [7]. The use of video laryngoscopy techniques provide better visualization of the glottis, especially in those who have anatomic challenging airway factors identified by the LEMON criteria, further supporting its use in higher risk patients.

Interestingly, although being a recognised indication of critical illness severity [10], GCS ≤8 was not statistically significant as an independent predictor after adjustment. This means that even with these adjustments of airway difficulties and operator experience, a depressed consciousness alone was not an independent predictor of successful procedure, although it remained an important marker of acuity, with 70.2% of patients in this cohort triaged as P1 (immediate) [12].

This study has certain limitations. It was performed at just one tertiary centre, and thus may be not applicable to peripheral emergency departments with different staffing patterns. The cross sectional design limits evaluation of longer term results like post intubation complications or mortality. The sample size was moderate which was sufficient for the main research question but reduced the precision of some results in the subgroups as indicated by the large confidence intervals of some odds ratios.

CONCLUSION

The first-pass intubations that were successful for critically ill patients in this emergency department had success rate of 76.6%. Favorable Modified-LEMON score, video Laryngoscopy use and intubation performed by senior operator stood independently associated with intubation first-pass success. It is recommended that routine use of the modified LEMON score should help identify patients who may benefit from video laryngoscopy; and that access to experienced operators and use of video laryngoscopy should be considered in patients with anticipated difficult airways to improve first-pass success in emergency department settings.

LIST OF ABBREVIATIONS
CI: Confidence Interval
CICO: Cannot Intubate, Cannot Oxygenate
ED: Emergency Department
EM: Emergency Medicine
GCS: Glasgow Coma Scale
IHHN: Indus Hospital and Health Network
IQR: Interquartile Range IRB: Institutional Review Board
LEMON: Look, Evaluate (3-3-2), Mallampati, Obstruction, Neck mobility
OR: Odds Ratio
RSI: Rapid Sequence Intubation
SD: Standard Deviation
SPSS: Statistical Package for Social Sciences WHO: World Health Organization

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CONFLICT OF INTEREST
None

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ETHICAL APPROVAL
Ethical approval was obtained from the Institutional Review Board of The Indus Hospital and Health Network, Karachi (IHHN-IRB #: IHHN_IRB_2024_07_006; Approval Date: 11-July-2024; Expiry: 10-July-2025), and from the Research Evaluation Unit, College of Physicians and Surgeons Pakistan (Ref: CPSP/REU/EMD-2022-218-295). All procedures were in agreement with the Declaration of Helsinki. Informed consent in writing was obtained from the attendants of all the participants.

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