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ORIGINAL RESEARCH

MONTH Score in Predicting Difficult Intubations in Emergency Department; a Prognostic Accuracy Study

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Abstract: **Introduction:** MONTH Difficult Laryngoscopy Score was developed for effectively identifying difficult intubations in the emergency department (ED). This study aimed to evaluate the accuracy of MONTH Score in predicting difficult intubations in ED. **Methods:** We prospectively collected data on all patients undergoing intubation in the ED of Ramathibodi Hospital, Bangkok, Thailand. The screening performance characteristics of the MONTH score in identifying the difficult intubation in ED were analyzed. All data were analyzed using STATA software version 18.0. **Results:** 324 intubated patients with the median age of 73 (63-82) years were studied (63.58% male). The proportion of difficult intubations was 19.44%. The sensitivity and specificity of MONTH in predicting difficult intubations were 74.6% (95% CI: 61.6%-85.0%) and 92.8% (95% CI: 89.0%-95.6%), respectively. These measures in subgroup of patients with Intubation Difficulty Scale (IDS) score ≥ 6 were 44.1% (95%CI: 31.2-57.6) and 98.5% (95% CI: 96.2%- 99.6%), respectively. The area under the receiver operation characteristic (ROC) curve of MONTH in predicting difficult intubations was 0.895 (95% CI: 0.856- 0.926). **Conclusion:** It seems that the MONTH Difficult Laryngoscopy Score could be considered as a tool with high specificity and positive predictive values in identifying cases with difficult intubations in ED.

Keywords: Laryngoscopy; Intubation; Emergency service, hospital; Validation study; Clinical decision rules

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1. Introduction

Emergency endotracheal intubation (ETI) is a critical lifesaving procedure frequently undertaken for critically ill or injured patients in the emergency department (ED). It stands as the gold standard for emergency airway management, ensuring oxygenation, ventilation, and protection from aspiration in acutely compromised patients. Given that patients in the ED often present with unpredictable and less manageable clinical conditions, intubations in this setting tend to be more challenging than those in other clinical environments (1, 2).

According to the definition proposed by the Statewide Anaesthesia and Perioperative Care Clinical Network (SWAPNET), difficult intubation is characterized by the need for multiple attempts or the use of additional equipment. In the ED setting, the incidence of difficult intubations ranges from 10% to 27% (3-6), whereas in the operating room, only 1% to 9% of elective intubations are considered challenging (7, 8).

The literature suggests that multiple intubation attempts elevate the risk of adverse events, including cardiac arrest, arrhythmia, regurgitation, and airway trauma (9-11). Failure to intubate can lead to oxygen desaturation, subsequently increasing mortality rates. Thus, early identification of potential intubation challenges is crucial for timely preparation and appropriate management. Studies have shown that predicting airway difficulty early on is a key factor in achieving successful intubation on the first attempt.

Numerous large-scale, multicenter studies have shed light on emergency intubation in the ED (4, 6, 11, 12). Various difficult airway prediction tools have emerged from this research and undergone evaluation. However, each tool exhibits certain limitations in terms of sensitivity and specificity (6, 12-15). Recently, a model named the 'MONTH (M: limited mouth opening, O: presence of obstructed airway, N: poor neck mobility, T: large tongue, and H: short hypomental distance) Difficult Laryngoscopy Score has been introduced to predict difficult laryngoscopy in patients undergoing emergency intubation in the ED (2, 16, 17).

Despite its suboptimal sensitivity (57.8%) and notable specificity (92.7%), the MONTH Difficult Laryngoscopy Score offers a user-friendly probability assessment that can be applied without patient cooperation. By categorizing patients into low, intermediate, and high-risk subgroups, this tool assists clinicians in refining their decision-making. This pertains to appropriate preparation, alternative management strategies, selecting the most effective intubation method in the ED, and guiding emergency airway decisions (16).

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To the best of our knowledge, no studies have validated the MONTH Difficult Laryngoscopy Score in the ED context. To bridge this gap in the literature, we carried out a prospective study to evaluate the validity of MONTH Difficult Laryngoscopy Score among ED patients undergoing emergency intubation.

2. Methods

2.1. Study design and setting

This study was a prospective cross-sectional study focused on ED patients undergoing emergency airway management at Ramathibodi Hospital, a university-affiliated, supertertiary care institution in Bangkok, Thailand. Data were sourced from the Ramathibodi Hospital database and its emergency medical record system. The screening performance characteristics of MONTH score in predicting difficult intubations in ED patients undergoing emergency intubation were calculated and reported.

This study was approved by the Faculty of Medicine, Committee on Human Rights Related to Research Involving Human Subjects, Ramathibodi hospital, Mahidol university (COA. MURA2023/286). The researchers adhered to the principles of Helsinki ethical recommendations and confidentiality of patients information.

2.2. Participants

Data were gathered prospectively from 25 April to 16 September 2023. The study included patients above 15 years who underwent emergency intubation in the ED. For this analysis, we excluded individuals who were intubated without the initial use of a direct laryngoscope (DL) or video laryngoscope (VL) and those who experienced cardiac arrest.

2.3. Definitions

Definition of difficult laryngoscopy Difficult laryngoscopy was defined based on the structures observed during the laryngoscopic procedure. Employing the four-grade classification outlined by Cormack and Lehane (18), intubation was categorized as easy (grades I or II) or difficult (grades III or IV). The laryngoscopic view was evaluated and classified based on the observation after the completion of each intubation. Difficult laryngoscopy is frequently regarded as a surrogate marker for challenging intubation (19, 20).

2.3.1 Intubation method

An "intubation method" was defined as one set of medication or devices, such as rapid-sequence intubation with direct laryngoscopy (2).

2.3.2 Intubation attempt

An "intubation attempt" was defined as one effort to place an airway. Each attempt could be performed using one or more methods, and each method could have one or more attempts. After each intubation was finished, the clinician entered all data in the medical record form (16).

2.3.3 Difficult intubation

Although there are several definitions for difficult intubation (3), in this work, we adopted the definition from the American Society of Anesthesiologists (ASA)(21) and the National Emergency Airway Registry studies (22). Difficult intubation was defined as follows: 1) an intubation course in which proper insertion of endotracheal tube with a laryngoscope requires 2 or more attempts by emergency attending physicians or anesthesiologists, and 2) an intubation course with subsequent surgical airway management (17). It should be mentioned that, by using this definition, the evaluation of the degree of difficulty in an intubation is very subjective and not straightforward. Therefore, in addition to the ASA's definition, we complementarily used the intubation difficulty scale (IDS) created by Adnet et al. This scale relies on objective criteria. It assesses the difficulty of intubation after it was performed (3).

2.3.4 Operator level

Less training has been shown to be associated with a higher rate of adverse events because less experienced physicians may take longer to intubate a patient and may apply extra force to oral structures. In a previous study, 20% lower success rate was reported for first-year residents (23). Thus, we classified the operator's level of training into three groups: low experience (general practitioners), moderate experience (first-year emergency medicine residents), and high experience (second-to third-year emergency medicine residents, emergency attending staff and anesthesiologists) (10).

2.4. Data gathering

After each intubation, the operator filled out a standard data collection form that included the patient characteristics (age, sex, body mass index, Glasgow coma scale score), primary indication for intubation, components of the MONTH Difficult Laryngoscopy Score (16), initial intubation method, operator level of training and specialty, number of attempts and success or failure at each attempt and intubation-related complications (16, 17).

The MONTH Difficult Laryngoscopy score consists of 5 significant factors. Each of the significant predictors is assigned a score based on its beta coefficient value, including limited mouth opening (1 point), large tongue (2 points), poor neck mobility (3 points), an obstructed airway (4 points), and a short hyomental distance (5 points). A risk score between 0 and 4 represents low to moderate risk, and risk score between 5 and 15 represents high risk of difficult laryngoscopy (16).

We also calculated the IDS score by summing up each score as follows: the number of intubation attempts, number of operators, number of alternative techniques, glottic exposure as defined by Cormack-Lehane grade, lifting force applied during laryngoscope, necessity of applied external pressure for optimized glottic exposure, and position of vo-

cal codes. An IDS score between 1 and 5 represents slight difficulty, and IDS score >5 represents moderate to major difficulty (3, 17, 24).

2.5. Statistical analysis

Sample size calculation was based on the study of Savatmongkorngul S et al. We selected the most significant sample size in each variable of MONTH Difficult Laryngoscopy Score. The assumptions were as follows: alpha = 0.05 (two-sided test), power of sample size = 0.8, and the ratio of sample size = 1:1. The total sample size was 158.

For emergency intubation, we reported the patient's characteristics, primary indication, method of intubation, and success rates of intubation as proportions and medians with interquartile ranges (IQRs). We calculated the sensitivity, specificity, and predictive values of the MONTH Difficult Laryngoscopy Score in different subgroups of patients who underwent intubation in ED. We performed all analyses using STATA software version 18.0 (StataCorp, College Station, TX, USA).

3. Results

3.1. Baseline characteristics of studied cases

The data of 359 patients who underwent ETI in the ED of Ramathibodi Hospital from February 2023 to August 2023 were collected.

Among these, 33 patients who developed cardiac arrest and 2 patients aged < 15 years were excluded. The remaining 324 intubations were included for further analysis (figure 1). The median age of the patients was 73 (63-82) years (63.58% male). Table 1 illustrates the characteristics of patients as well as physicians who intubated the patients in the ED. All cases were intubated with a VL at the first attempt because the only available method of intubation is the use of a VL according to the post-COVID-19 pandemic intubation protocol. 19.44% of patients experienced difficult intubation (≥ 2 attempts by emergency physicians or anesthesiologists or an intubation with subsequent surgical airway management).

Table 1: Baseline characteristics of patients and physicians who intubated the patients (n = 324)

Characteristics	Value
Age (year)	
Median (IQR)	73 (63-82)
Sex	
Male	206 (63.58)
Female	118 (36.42)
Body mass index (kg/m^2)	
median (IQR)	22.04 (19.53-24.22)
Cause of intubation	
Traumatic	13 (4.01)
Non-traumatic	311 (95.99)
Glasgow coma scale	
3-8	52 (16.05)
9-12	29 (8.95)
13-15	243 (75.00)
Main Indication of intubation	
Failure to oxygenation or ventilation	156 (48.15)
Failure to airway maintenance and protection	45 (13.89)
Anticipated clinical course	112 (34.57)
Crash airway	11 (3.40)
Method of intubation	
Rapid sequence intubation	185 (57.10)
Sedation only, without paralysis	95 (29.32)
Non-medicine-assisted	44 (13.58)
Intubation attempt	
1 attempt	261 (80.56)
≥2 attempts	63 (19.44)
Physician who intubated the cases	
Sex (male)	125 (38.58)
General practitioners	56 (17.28)
First-year emergency residents	71 (21.91)
Second-year emergency residents	166 (51.23)
Third-year emergency residents	17 (5.25)
Emergency attending staff	9 (2.78)
Anesthesiologists	5 (1.54)

3.2. Screening performance of MONTH score

The performance of MONTH Difficult Laryngoscopy Score in predicting difficult intubations in the ED is shown in table 2. The sensitivity and specificity of MONTH in predicting difficult intubations were 74.6% (95% CI: 61.6%-85.0%) and 92.8% (95% CI: 89.0%-95.6%), respectively. The negative predictive value of 69.8% (95% CI: 57.0%-80.8%) and the positive predictive value of 94.3% (95% CI: 90.7%-96.7%) were detected for MONTH in this regard. The area under the receiver operating characteristic (ROC) curve of MONTH in predicting difficult intubations was 0.82 (95% CI: 0.76 - 0.88).

3.3. Subgroup analysis on IDS score ≥ 6

Furthermore, we found that, out of 324 intubations, 30 patients (9.26%) had an IDS score of at least 6 in the ED. The same statistical analyses were performed for this subgroup of patients and the result is shown in table 2. We found that the performance of the MONTH Difficult Laryngoscopy Score did not change significantly. The sensitivity was 44.1% (95% CI: 31.2%-57.6%) and the specificity was 98.5% (95% CI: 96.2%- 99.6%).

3.4. Subgroup analysis on experience of the physicians

Statistical analyses on the subgroup of data (table 2) which excluded patients intubated by physicians with low-to-moderate experience (n = 196) revealed the sensitivity of 72.2% (95% CI: 54.8%-85.8%) and the specificity of 93.8% (95% CI: 88.8%-97.0%) for MONTH.

3.5. Subgroup analysis on physicians with high experience plus IDS score ≥ 6

In the subgroup of patients with IDS score ≥ 6 who were intubated by highly experienced physicians, the sensitivity and

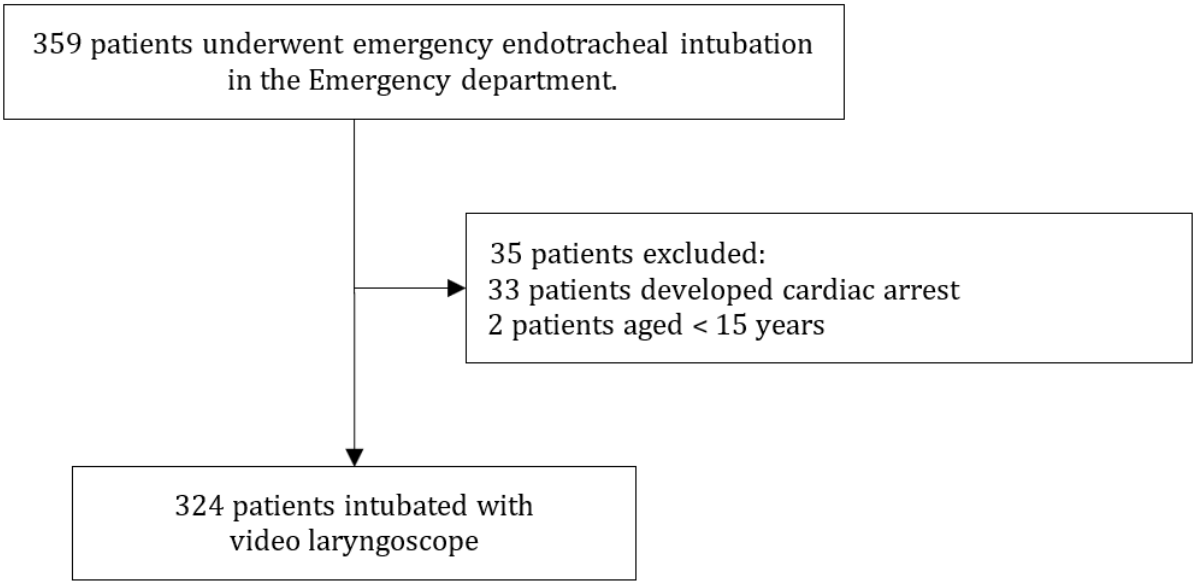

Figure 1: Flowchart of patient inclusion in this study.

Table 2: screening performance characteristics of MONTH score in predicting difficult intubations (≥2 attempts by emergency physicians or anesthesiologists) in different subgroups (n = 324)

Characteristics	Total	Subgroups		
		IDS ≥6	Experienced*	Both#
True positive	44	26	26	16
True negative	246	261	150	157
False positive	15	33	10	3
False negative	19	4	10	27
Sensitivity	74.6 (61.6-85.0)	44.1 (31.2-57.6)	72.2 (54.8-85.8)	44.4 (27.9-61.9)
Specificity	92.8 (89.0-95.6)	98.5 (96.2- 99.6)	93.8 (88.8-97.0)	98.1 (94.6-99.6)
NPV	69.8 (57.0-80.8)	86.7 (69.3-96.2)	72.2 (54.8-85.8)	84.2 (60.4-96.6)
PPV	94.3 (90.7-96.7)	88.8 (84.6-92.1)	93.8 (88.8-97.0)	88.7 (83.1-93.0)
PLR	10.4 (6.58-16.4)	29.2 (10.6-80.5)	11.6 (6.13-21.8)	23.7 (7.29-77.1)
NLR	0.27 (0.18-0.43)	0.57 (0.45-0.71)	0.30 (0.18-0.50)	0.57 (0.42-0.76)
Total accuracy	0.895 (0.856- 0.926)	0.886 (0.846-0.918	0.898 (0.846-0.936)	0.852 (0.795-0.898)

PPV: positive predictive value; NPV: negative predictive value; PLR: positive likelihood ratio; NLR: negative likelihood ratio. MONTH: (M: limited mouth opening, O: presence of obstructed airway, N: poor neck mobility, T: large tongue, and H: short hypo-mental distance). *: excluding intubations performed by physicians with low-to-moderate experience. #: Intubation Difficulty Scale (IDS) ≥6 and high experience.

specificity of MONTH were 44.4% (95% CI: 27.9%-61.9%) and 98.1% (95% CI: 94.6%-99.6%), respectively (table 2).

4. Discussion

The prediction of difficult laryngoscopy in the emergency setting is clinically complicated and nontrivial. It was found that difficult laryngoscopy is considered as a surrogate indicator of difficult intubation (19, 25). The failure in predicting difficult intubation may delay further management and/or preparation of alternative airway equipment, if needed. Repeated attempts of intubation may increase the risk of adverse events such as cardiac arrest, arrhythmia, regurgitation, and airway trauma (9-11). Previous studies showed that, while the proportion of difficult elective intubations in the operating room setting was only 1% to 9%, the proportion of difficult intubations in the ED setting ranged from 10% to 27% (3-6).

In our study, we conducted a single-center prospective observational study. The data of 324 emergency intubations in the ED of Ramathibodi Hospital were analyzed. We found the proportion of difficult laryngoscopy to be 19.44%, which is in the same range as that of the previous studies. The intubated patients in this study were only intubated using video laryngoscopy. This is due to the intubating protocol after the COVID-19 pandemic. According to a systematic review, VL has gained prominence as a reliable alternative, providing multiple benefits compared to traditional DL (26).

The validation of a prior score (obtained by modified LEMON criteria to predict difficult intubations in the ED) showed high sensitivity and negative predictive value (85.7% and

98.2%, respectively) but poor specificity and positive predictive value (47.6% and 8.9%, respectively) (17). The study of Jeong Jin Min et al. demonstrated that the area under the ROC curve of LEMON ≥ 2 points in prediction of difficult laryngoscopy was 64.8% (95%CI: 58.5, 70.8) and sensitivity and specificity were 54.3% (95% CI: 36.6, 71.2) and 73.6% (95% CI: 67.0, 79.4), respectively (27).

Our study found that the MONTH Difficult Laryngoscopy Score had high specificity and positive predictive value in predicting difficult intubation. While the MONTH Score showed high sensitivity for cases with ≥2 attempts, it revealed low sensitivity for cases with IDS ≥ 6. However, the majority of cases were non-traumatic (4.01%). Among adult trauma patients, a LEON score (which omits the Mallampati classification from the original LEMON score) of ≥ 3 demonstrated a strong predictive value for difficult intubation (13).

In addition, the performance of MONTH Difficult Laryngoscopy Scores was not significantly different between low, moderate, and high-experience physicians. This implies that this score can help low-experienced intubators, such as general practitioners and medical students, to assess difficult intubations.

To our best knowledge, this is the first study to have externally validated the performance of MONTH Difficult Laryngoscopy Score in predicting difficult intubation. It was suggested that this score is more user-friendly and can be used without patient cooperation for intubation in the ED. A MONTH Difficult Laryngoscopy Score of ≥5 points indicates a risk of difficult laryngoscopy, and clinicians should immediately consult a specialist for appropriate alternative management (16).

The MONTH Difficult Laryngoscopy Score was associated with a more difficult laryngoscopy and a decrease in intubation success as defined by ETI on the first attempt. Therefore, it may be useful for a better early recognition of difficult laryngoscopy leading to better outcomes for critically ill patients in the ED setting.

5. Limitations

There are several potential limitations to this study that should be pointed out. First of all, our data were collected from a single center, and this was a prospective observational study. We leave a multicenter prospective study or randomized controlled trial study for future work. Second, to our knowledge, there are not any standard and generally accepted definitions of difficult laryngoscopy (18) and difficult intubations (17, 21, 22) in the ED setting. We believe, however, that the definition we took in this work is the most optimal definition. Another potential limitation of the study was the number of patients intubated only with VL. This may affect the statistical analysis. However, it should be noted that there are no selection biases in choosing the method of intubation. The VL is a preferred method according to the post-COVID-19 pandemic intubation protocol. We advocate for the application of the MONTH Difficult Laryngoscopy Score in intubations conducted using a VL. Future research will focus on intubations performed with a DL to further elucidate its validation. Finally, this study only included adult patients whose anatomical appearances differ from children. Therefore, the results of this study cannot be immediately applied to children.

6. Conclusions

It seems that the MONTH Score has high specificity and positive predictive value for identifying cases with difficult intubation in the ED.

7. Declarations

7.1. Acknowledgments

None.

7.2. Conflict of interest

The authors declare that they have no competing interests.

7.3. Funding source

No funding was obtained for this study.

7.4. Authors' contribution

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 accept responsibility for the integrity of all aspects of the work.

7.5. Ethical considerations

This study was approved by the Faculty of Medicine, Committee on Human Rights Related to Research Involving Human Subjects, Ramathibodi hospital, Mahidol university (COA. MURA2023/286).

7.6. Availability of data and material

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

7.7. Using artificial inteligence chatbots

None.

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