Limitations of Difficult Airway Prediction in Patients Intubated in the Emergency Department

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Study objective: Physiognomic assessment of difficult laryngoscopy before rapid sequence intubation has been advocated for all emergency department (ED) intubations. The study objectives were to evaluate whether Mallampati scores, thyromental distance, and neck mobility could have been assessed in non–cardiac arrest ED-intubated patients and determine whether such tests would have been feasible in our rapid sequence intubation–associated laryngoscopy failures.

Methods: We retrospectively reviewed 37 months of ED intubations using prospectively collected data from electronic medical records, critical care flow sheets, and a trauma registry. All non–cardiac arrest ED-intubated patients were included for analysis. Mallampati scoring was deemed unobtainable if patients could not follow simple commands. Neck mobility and thyromental measurement were deemed unobtainable with cervical spine precautions.

Results: Eight hundred fifty intubations met the inclusion criteria, and 838 patients underwent rapid sequence intubation. Laryngoscopy failed in 3 patients who underwent rapid sequence intubation. Eight patients had awake nasal intubation, and 4 oral intubations were done without rapid sequence intubation. Four hundred fifty-two (53%) patients could not follow simple commands, and cervical spine immobilization was present in 370 (44%) patients. Only 32% of patients could follow simple commands and were not cervical spine immobilized. Among the 3 rapid sequence intubation laryngoscopy failures, no patients were following commands.

Conclusion: Mallampati scoring, neck mobility testing, and measurement of thyromental distance could have been done in only one third of our non–cardiac arrest ED intubations and in none of the rapid sequence intubation failures. The inability to widely obtain these assessment tools, coupled with the low incidence of failed rapid sequence intubation, indicates limitations to using these screening tests in the ED setting.

[*Ann Emerg Med.* 2004;44:307-313.]

0196-0644/$30.00

doi:10.1016/j.annemergmed.2004.05.006

Editor's Capsule Summary

What is already known on this topic

A variety of pre-intubation clinical screening tests have been advocated to predict difficult laryngoscopy, but their usefulness in the emergency setting is not known.

What question this study addressed

This study retrospectively evaluated whether 3 commonly recommended screening tests for determining difficult laryngoscopy could be assessed in emergency department (ED) patients who were intubated over a 37-month period at a Level I trauma center.

What this study adds to our knowledge

In 838 patients who were intubated using rapid sequence intubation, only 32% could follow simple commands and were not cervical spine immobilized. Mallampati scoring, neck mobility testing, and measurement of thyromental distance could have been done in only one third of non–cardiac arrest intubations, and in none of the 3 failures.

How this might change clinical practice

Common screening tests for difficult laryngoscopy cannot be applied in a large number of ED intubations, and failed intubation with rapid sequence intubation is very rare.

INTRODUCTION

Background

Failed laryngoscopy after rapid sequence intubation can have catastrophic consequences when coupled with the inability to ventilate the patient. In 1993, the American Society of Anesthesiologists created the American Society of Anesthesiologists Difficulty Airway Algorithm.[1,2] The first step of this algorithm involves assessment of the likelihood of difficult intubation using a laryngoscope. Three physiognomic features reported to be associated with difficult laryngoscopy include the size of the tongue relative to the pharynx (the Mallampati score), limited neck mobility, and short thyromental distance.[1-8] These and other physiognomic screening tests of difficult laryngoscopy are now a routine aspect of preprocedural evaluation in elective anesthesia settings.

Mallampati scoring requires a cooperative patient sitting upright at 90 degrees, with the tongue fully protruded and the mouth opened as wide as possible.[3,4] Patient cooperation and maximal mouth opening effort are necessary to ensure validity and reproducibility.[9] As described by Mallampati,[3] the test is done without phonation, and several studies have demonstrated that phonation and patient cooperation significantly affect Mallampati scores.[4,9-13] Thyromental distance is measured with the patient upright, with full atlanto-occipital extension and the jaw protruded.[4,13,14] Neck mobility testing for predicting a difficult airway, especially the evaluation of maximal atlanto-occipital extension, is contraindicated in patients with known or potential cervical spine pathology.

The prediction of the difficult airway has been credited within the anesthesia literature for a reduction in airway-related morbidity and mortality.[2] Potential laryngoscopy difficulty in elective settings commonly leads to an alternative intubation strategy (such as awake fiberoptic intubation) that does not involve the ablation of spontaneous ventilation.[1,2,15] Within the past 5 years, the prediction of the difficult airway has become a widely promoted concept within emergency medicine.[16-18] Mallampati scoring and other screening tests of "the difficult airway" are now prominently featured in emergency medicine reference texts.[16-18] The ability to obtain such physiognomic measures before intubation to predict difficult airways in emergency department (ED) intubations has never been evaluated.

Importance

Rapid sequence intubation is the most common means of intubation in EDs.[19-24] It has many advantages over awake laryngoscopy, nasal, or surgical approaches in terms of first-pass success, overall success, speed, and complications.[19,22,23,25] Reported laryngoscopy failure rates range from 0.4% to 1.1% of all ED airways.[19-23,25] Having screening tests that could be applied to ED patients to predict laryngoscopy failure would be desirable, thereby averting "cannot intubate–cannot ventilate" situations and potentially improving patient safety. However, screening tests that cannot be consistently and properly applied or have poor positive predictive value might lead to alternate intubation techniques that have their own set of risks, and emergency physicians may not be as facile with alternative techniques compared with rapid sequence intubation. Finally, if physiognomic tests of laryngoscopy difficulty have limited potential for improving patient safety, this limitation needs to be recognized, and educational efforts should be directed elsewhere.

The objective of this study is to evaluate whether 3 commonly reported screening tests of laryngoscopy difficulty could have been assessed in ED patients we intubated during a 37-month period. We also want to specifically determine whether such tests would have been feasible in our rapid sequence intubation–associated laryngoscopy failures.

METHODS

Study Design

We performed a retrospective medical record review of all ED-intubated patients during the study period using electronic medical records, critical care flow sheets, and data from a trauma registry.

Setting

The study was conducted at an academic, urban, Level I trauma center with an ED census of approximately 50,000 and approximately 1,800 major trauma patients per year. There is a 4-year emergency medicine training residency program associated with the ED, and there are 25 attending physicians. All airways are supervised by an emergency medicine attending physician. During the study period, primary responsibility for trauma airways was officially split between emergency medicine residents and anesthesia residents, although the vast majority of trauma cases (and almost all nontrauma cases) were done by emergency medicine residents. Approximately two thirds of our intubations involve trauma patients and one third involve medical cases.

During the study period, it was not our departmental practice to do preintubation physiognomic airway assessment with Mallampati scoring, thyromental distance measurement, or neck mobility testing.

Selection of Participants

The study involved all ED intubations (trauma and medical) during a 37-month period from August 21, 1999, to September 23, 2002. This interval was used for 2 reasons. First, the trauma and ED airway data were available because of concurrent studies. Second, in the absence of any emergency medicine literature about the ability to obtain the physiognomic measures, we believed that a 37-month period would provide an appropriately large sample size of intubated patients to address the question.

Cardiac arrest cases were excluded for this study because rapid sequence intubation is not a consideration in these cases and there is also no potential opportunity to collect physiognomic data before laryngoscopy.

Methods of Measurement, Data Collection and Processing, and Outcome Measures

All patients in the ED have electronic medical records. Resuscitations are documented by an assigned recording nurse on a critical care flow sheet, in addition to detailed procedure notes in the medical records. All patients in the trauma bay have critical care flow sheets also completed by a dedicated recording nurse. All patients intubated in the trauma bay have an additional emergency airway data sheet completed by the person performing the intubation. The emergency airway data sheets include the following information: indications for intubation, medications used for the intubation, vital signs before and after intubation, route and method of intubation, number of attempts, tracheal tube size, laryngoscope blade size, training year and specialty of the physician intubating the patient, percentage of glottic opening visualized, sequence of tube placement confirmation, disposition of the patient, and an area for specific comments about the procedure. In the ED and the trauma bay, Glasgow Coma Scale (GCS) scores are documented upon triage presentation.

Screening for intubation was done on our electronic medical records and trauma registry using procedure coding for intubation, cardiac arrest, cricothyrotomy, and tracheotomy. All records involving disposition to the morgue or medical examiner were also individually reviewed. The trauma registry data was collected and recorded using Collector Trauma Registry software (Digital Innovation, Inc., Forest Hill, MD). The electronic medical record in our department (Emergency Medicine Tracking and Charting [EMTRAC]) was custom designed for our department and has been in continuous use for all patients since 1996.

Primary Data Analysis

We retrospectively collected data elements suggestive of the ability or inability to collect the physiognomic markers. The primary author (RML) reviewed all trauma registry and medical records. Physiognomic factors were assumed to be collectable unless specific documentation (described below) was present. Each intubation was reviewed to determine whether the patient could follow simple commands, which was defined as a GCS motor score of 6 or specific documentation of "following commands" as documented in the trauma registry or the electronic medical record. The presence or absence of cervical spine immobilization was also determined for each patient from the same sources. When these data were not immediately available from the trauma registry or the electronic medical record, the individual critical care flow sheets or narrative descriptions within the electronic medical record were reviewed. Information about the medications used for intubation (used to define rapid sequence intubation) was gathered from the emergency airway sheets, critical care flow sheets, or procedural notes in the medical record.

Mallampati scoring was deemed unobtainable if the patient could not follow simple commands (ie, GCS

motor score <6). Neck mobility and thyromental distance measurement were deemed unobtainable in the setting of cervical spine immobilization. Unless it was clearly documented that the physiognomic variables could not be obtained, it was assumed that the data could have been collected.

For an intubation to be considered a rapid sequence intubation, it must have included documented use of a neuromuscular blocking agent (succinylcholine or vecuronium are the only agents used in our department). Use of an induction agent only (ie, etomidate, midazolam, ketamine) was not considered synonymous with rapid sequence intubation, and these cases were individually examined.

The results are reported as counts and percentages with 95% binomial confidence intervals (CIs). Data were entered into an Excel spreadsheet (Microsoft Corporation, Redmond, WA) and analyzed using Stata software (version 7.0, Stata Corporation, College Station, TX). The study was approved by the institutional review board.

RESULTS

A total of 944 intubations occurred during the study period. The 88 patients presenting in cardiac arrest and 6 additional patients who experienced cardiac arrest in the ED were not considered for this study because laryngoscopy was undertaken immediately, and rapid sequence intubation was not a consideration. Among the 850 intubated patients not in cardiac arrest, 838 underwent rapid sequence intubation (Table). Fifty-three percent (451/850; 95% CI 50% to 57%) could not follow simple commands. Cervical spine immobilization was present in 44% of patients (370/850; 95% CI 40% to 47%). Only 32% (271/850; 95% CI 29% to 35%) of patients could follow simple commands and also were not cervical spine immobilized. According to our feasibility definitions of Mallampati scoring, measure of thyromental distance, and neck mobility testing, these 3 screening tests could have been applied in less than one third of the ED patients we intubated.

Among the 838 intubations using rapid sequence intubation, there were 3 failures (rapid sequence intubation failure incidence 0.36%; 95% CI 0% to 1%). Each of the rapid sequence intubation laryngoscopy failures (2 medical, 1 trauma) could be ventilated by face mask or laryngeal mask airway. None of the 3 patients were following commands; 1 was also cervical spine immobilized. The trauma patient who was cervical spine immobilized had multiple blunt injuries and an intracranial bleed, with a total GCS score of 6. One of the cases of medical failed rapid sequence intubation was a woman with renal failure, altered mental status, and a massive hemorrhagic stroke. Her airway was secured using an intubating laryngeal mask airway. The other rapid sequence intubation failure involved a patient with status epilepticus who received a cricothyrotomy after repeated laryngoscopy attempts and failed retrograde intubation attempts.

Twelve of the 850 patients in the study criteria did not undergo rapid sequence intubation, including 8 who were nasally intubated and 4 who were orally intubated without the use of a neuromuscular blocker. Neuromuscular agents were avoided for the following reasons: myasthenia gravis (1 patient), multiple sclerosis (1 patient), and hyperkalemia plus morbid obesity (2 patients). All 4 of these patients had successful laryngoscopies with induction agents only (etomidate 2, midazolam 1, and ketamine 1).

Table.
Overall intubation success, patient conditions permitting physiognomic airway assessments, and rapid sequence intubation failures.

	Total Intubations	Non–Cardiac Arrest	Not Following Simple Commands*	C-Spine Immobilized	Not Following Simple Commands and C-Spine Immobilized	Following Simple Commands and No C-Spine Precautions
Failed RSI (all RSI=838)*	—	3	3	1	1	0
Total (%, 95% CI)	944	850[†]	452 (53, 50–57)	370 (43, 40–47)	210 (25, 22–28)	271 (32, 29–35)

C-spine, Cervical spine; **RSI,** rapid sequence intubation.
*A GCS motor score of <6 or specific medical record documentation ("not following commands") was used to define this.
[†]Twelve non–cardiac arrest patients were intubated without RSI (nasal, 8; laryngoscopy but with induction agents only, 4); 838 patients underwent RSI, of whom 597 were trauma patients and 241 were medical patients.

Nasal intubation occurred in 8 patients for the following reasons: 1 trauma patient had a wired jaw and presented shot in the head (blind nasal intubation); another trauma patient had a known cervical spine fracture and was intubated with a fiberscope. Two patients had angioedema (one angiotensin-converting enzyme inhibitor related and the other after contrast administration in the computed tomography scanner) and both patients were intubated using fiberscopes. In 2 other medical cases, the rationale for selecting nasal intubation as opposed to rapid sequence intubation was not documented. Finally, 2 medical patients were blindly nasally intubated, with specific documentation of anatomic features about difficult laryngoscopy (massive obesity, short thick neck, and full dentition); neither was following commands (one hypercarbic respiratory failure and the other polysubstance sedative overdose). The patient with hypercarbic respiratory failure was extubated 2 days later in the medical ICU but became hypercarbic again, requiring reintubation. Laryngoscopy efforts failed despite numerous attempts by pulmonologists, anesthesiologists, and ear, nose, and throat physicians. The patient ultimately received a bedside tracheotomy.

LIMITATIONS

Our study is a retrospective medical record review using specific criteria to define the feasibility of performing Mallampati scoring, thyromental distance measurement, and neck mobility testing in patients intubated in the ED. We did not attempt to use these tests prospectively.

The results of our study are significantly influenced by the fact that 71% (597/838) of the patients we intubated with rapid sequence intubation were trauma patients, and 61% (362/597) of this group were cervical spine immobilized. The feasibility of thyromental distance measurement and neck mobility testing may be significantly higher at nontrauma centers.

We suspect that our feasibility criteria using GCS motor scores or specific medical record documentation about following commands overestimates the ability to properly perform Mallampati scoring. Among the 90 medical patients, for instance, who could "follow simple commands," there were 50 patients with marked respiratory distress, 19 patients with central nervous system pathology (intracranial bleeding, stroke, or seizure), and 21 patients who were lethargic (eg, shock, sepsis, overdose). "Following commands" in this group was based on hand grip or other simple tasks. Although all of these patients were considered feasible for Mallampati scoring in our study, we doubt that many of these patients could sit upright, maximally open their mouth, and extend their tongue without phonation as required for proper Mallampati scoring.[3,4,9-13]

With thyromental distance and neck mobility testing, we deemed these tests unfeasible only in cases of documented cervical spine precautions. We suspect this is also an overestimation of feasibility because some patients in extremis and about to get intubated would likely not be able to comply with thyromental distance measurement (full atlanto-occipital extension) or neck mobility testing because of noncooperation or increased tone from agitation, seizures, meningismus, or other factors.

Our study might be improved if done prospectively in ED patients about to be intubated. Conversely, a prospective study of physiognomic screening tests may alter practice patterns, modify the rapid sequence intubation rate, and make it more difficult to determine the value of screening on patient outcome (ie, Hawthorne effect). Interobserver reliability could be tested by having 2 practitioners do each assessment, although in elective settings the interobserver reliability of Mallampati scoring, thyromental distance measurement, and atlanto-occipital extension is poor to moderate.[26] It would also be ideal if screening tests for each patient were repeated under nonemergency conditions to verify consistency and reproducibility.

DISCUSSION

According to the inability to follow simple commands and the presence of cervical spine immobilization, we conclude that Mallampati scoring, thyromental distance measurement, and neck mobility testing could not have been properly applied to at least two thirds of our patients who were intubated using a rapid sequence intubation technique. Among the 3 patients for whom rapid sequence intubation failed, no patients could have undergone all 3 screening tests; no patients were following simple commands, and 1 patient was also in a cervical collar.

Among the 12 patients intubated without rapid sequence intubation, there were 8 nasal intubation patients, 5 of whom had documented evident anatomic abnormalities (wired jaw, 1; angioedema, 2; and massive obesity, 2). One of the patients with massive obesity could not be reintubated using an oral approach several days later in the medical ICU. Although it could be argued physiognomic screening was useful in this case, the appearance of this patient was striking, and specific physiognomic measurement was not needed to appreciate the difficulty

of laryngoscopy. In terms of feasibility, the neck was so large that no neck landmarks could be identified either by palpation or visual inspection, rendering thyromental distance measurement impossible. Mallampati scoring could not be done because the patient was not following commands and resisted mouth opening.

Beyond the practical limitations of applying screening tests to ED patients who are ultimately intubated, there are also significant statistical limitations to these tests for predicting failed intubation. Failed laryngoscopy by experienced practitioners, in the absence of evident anatomic abnormality, is a relatively rare event. Reported laryngoscopy failure rates range from 0.4% to 1.1% of all ED airways.[19-23,25] In our study, it occurred in only 3 of our 838 rapid sequence intubation intubations (rapid sequence intubation failure incidence 0.36%; 95% CI 0% to 1%). The more rare an occurrence is, the more sensitive and specific a prediction test must be to have positive and negative predictive values that would make the predictive test clinically useful.[27-31]

When prospectively studied, combining Mallampati score, thyromental distance, and neck mobility in elective anesthesia cases has questionable utility.[15,27-30,32] For example, in 5 prospective studies examining prediction of difficult laryngoscopy and intubation, involving a total of 2,480 patients, the defined "difficult" cases ranged from 3% to 26%, but all patients were successfully intubated using laryngoscopes.[4,27-29,32,33]

The statistical problems with predictive tests and their limited clinical utility have been acknowledged even within elective anesthesia, where the feasibility of physiognomic assessment is not an issue.[27-29,31-34] The 2003 Updated Report of the American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway states, "In patients with no gross upper airway pathology or anatomic anomaly, there is insufficient published evidence to evaluate the effect of a physical examination on predicting the presence of a difficult airway."[35]

The final problem with the effectiveness of screening tests in the ED is that alternative airway management options in the predicted difficult situation are different than in elective anesthesia. Awake fiberoptic intubation has become standard in the potentially difficult elective situation but has almost no role when the patient is uncooperative, needs intubation immediately, and secretions, blood, and emesis are present.[1,2,36,37] Blind nasal intubation and awake laryngoscopy have lower success rates than rapid sequence intubation, and awake approaches have their own risks, including active vomiting, airway trauma, bleeding, and edema.[22,23,25,38] These complications can precipitate clinical deterioration and worsen subsequent laryngoscopy and ventilation efforts.

If laryngoscopy difficulty is anticipated because of a combination of clearly evident physiognomic factors and other problems common to emergency airways (eg, distortion, vomitus, bleeding), it is counterintuitive to expect that attempting laryngoscopy with suboptimal conditions (ie, without muscle relaxation) is going to succeed.[19,25,39-41] A recent study looking at failed intubations in the ED concluded that the most common means of rescuing a failed awake approach was to use rapid sequence intubation.[19]

We believe that a general knowledge of what contributes to laryngoscopy difficulty, coupled with an awareness of patient safety issues in emergency airway management, is useful for deciding when rapid sequence intubation should be avoided.[42] Despite such an approach, unexpected impossible laryngoscopy can result from pathology at the base of the tongue and epiglottis, which external assessment will not predict.[43] According to our retrospective analysis of the practical limitations of physiognomic screening, we do not believe that the routine use of Mallampati scoring, thyromental distance measurement, and neck mobility testing will improve outcomes or patient safety in emergency airways. If patient safety cannot be improved through specific physiognomic assessment (as we suspect), educational efforts should be directed elsewhere, such as standardizing the availability of rescue ventilation devices and defining best practice approaches to laryngoscopy.[42]

The data set used in this article includes medical and trauma cases: the 656 trauma patients were partially presented in a previously published study (Levitan RM, Rosenblatt B, Meiner EM, et al. Alternating day emergency medicine and anesthesia resident responsibility for management of the trauma airway: a study of laryngoscopy performance and intubation success. *Ann Emerg Med*. 2004;43:48-53.), which examined laryngoscopy performance broken down by resident service (anesthesiology versus emergency medicine). That article reported on success rates of laryngoscopy and blunt or penetrating trauma designation but did not address issues of difficult airway prediction, GCS motor scores, cervical collars, or ability to follow commands. It also did not include any medical cases.

Author contributions: RML conceived the study, performed the chart review, and wrote the initial draft. EAO and WWE assisted in the study design, provided revisions, and statistical support. RML takes responsibility for the paper as a whole.

Received for publication February 20, 2004. Revisions received April 26, 2004, and May 18, 2004. Accepted for publication May 18, 2004. Available online August 25, 2004.

Presented as an abstract at the Society for Academic Emergency Medicine annual meeting, Boston, MA, May 2003.

The authors report this study did not receive any outside funding or support.

Reprints not available from the authors.

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