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BRIEF REPORT

A Preprocedural Checklist Improves the Safety of Emergency Department Intubation of Trauma Patients

Kurt A. Smith, MD, Kevin High, RN, MPH, Sean P. Collins, MD, MSc, and Wesley H. Self, MD, MPH

Abstract

Objectives: Endotracheal intubation of trauma patients is a vital and high-risk procedure in the emergency department (ED). The hypothesis was that implementation of a standardized, preprocedural checklist would improve the safety of this procedure.

Methods: A preprocedural intubation checklist was developed and then implemented in a prospective pre-/postinterventional study in an academic trauma center ED. The proportions of trauma patients older than 16 years who experienced intubation-related complications during the 6 months before checklist implementation and 6 months after implementation were compared. Intubation-related complications included oxygen desaturation, emesis, esophageal intubation, hypotension, and cardiac arrest. Additional outcomes included time from paralysis to intubation and adherence to safety process measures.

Results: During the study, 141 trauma patients were intubated, including 76 in the prechecklist period and 65 in the postchecklist period. A lower proportion of patients experienced intubation-related complications in the postchecklist period (1.5%) than the prechecklist period (9.2%), representing a 7.7% (95% confidence interval = 0.5% to 14.8%) absolute risk reduction. Paralysis-to-intubation time was also lower in the postchecklist period (median = 82 seconds, interquartile range [IQR] = 68 to 101 seconds) compared to the prechecklist period (median = 94 seconds, IQR = 78 to 115 seconds; $p = 0.02$). Adherence to safety process measures also improved, with all safety measures performed in 69.2% in the postchecklist period compared to 17.1% before the checklist ($p < 0.01$).

Conclusions: Implementation of a preintubation checklist for ED intubation of trauma patients was associated with a reduction in intubation-related complications, decreased paralysis-to-intubation time, and improved adherence to recognized safety measures.

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Endotracheal intubation is routinely performed in the emergency department (ED) in severely injured trauma patients. The risk of an intubation-related complication for trauma patients intubated in EDs in the United States is approximately 10%.[1] Standardized preprocedural checklists have recently been used to improve the safety of several clinical procedures, including central venous catheter insertion and noncardiac surgeries.[2,3] Practice guidelines outline important preparation steps to maximize the safety of ED intubation; however, a standardized preintubation checklist is not widely used.[4–7] Therefore, we developed a standardized preprocedural checklist to assist clinicians in ensuring adequate preparation for intubation and then studied its effectiveness for reducing intubation-related complications in ED trauma patients.

METHODS

Study Design

This was a before-and-after evaluation of a quality improvement intervention in the adult ED of an academic

From the Department of Emergency Medicine, Vanderbilt University School of Medicine, Nashville, TN.
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trauma center in the United States. The local institutional review board approved the study as a quality improvement initiative with waiver of informed consent.

Study Setting and Population

The study was conducted in the ED of Vanderbilt University Medical Center. Emergency medicine residents and attending physicians performed all intubations. Rapid sequence intubation (RSI) was the preferred method of intubation throughout the study period.

All adult trauma patients (≥16 years old) who met American College of Surgeons criteria for tier I trauma activation[8] and underwent attempted endotracheal intubation while in the ED between November 2012 and October 2013 were included. Treating physicians decided which patients to intubate independent of the study protocol.

Study Protocol

A task force of emergency physicians, trauma surgeons, nurses, and paramedics at our institution reviewed available literature and practice guidelines to develop a preprocedural checklist of 15 essential safety elements (Data Supplement S1, available as supporting information in the online version of this paper). The checklist consisted of two parts: 1) a "prearrival checklist" designed for the primary intubator to perform while preparing the resuscitation room before arrival of the patient and 2) a "preinduction checklist" to be completed after the decision to intubate had been made, but prior to administering RSI medications. Each element of the preinduction checklist was verbalized by the scribe nurse and acknowledged as complete by the primary intubator.

Prior to checklist implementation (November 2012 through April 2013), patients were intubated according to routine care without a standardized checklist (prechecklist period). Checklist education occurred during April 2013, with final implementation into clinical practice on May 1, 2013. Large printed copies of the checklist were posted in each resuscitation bay. Departmental policy recommended checklist use for all trauma intubations between May and October 2013 (postchecklist period).

All tier I trauma resuscitations during the study period were video recorded with a high-definition recording system. Data were collected by a single investigator (KAS) by reviewing these recordings with a standardized data collection instrument. These data included time points for the decision to intubate, administration of RSI medications, confirmation of tube placement, execution of each item on the checklist, and intubation-related complications (defined under "Measures"). Data unavailable from the video, including Cormack-Lehane view during laryngoscopy,[9] were obtained from the medical chart. Preoxygenation was considered adequate if it was performed using high-flow facemask and nasal cannula during the entire procedure for patients spontaneously breathing, or bag-valve-mask ventilation for those not spontaneously breathing.

Measures

The primary outcome was an intubation-related complication, which included any of the following events after induction (or after laryngoscopy for intubations without medications): oxygen desaturation < 90% by pulse oximetry, emesis, esophageal intubation, severe hypotension (systolic blood pressure < 70 mm Hg), or cardiac arrest. A secondary outcome was paralysis-to-intubation time, defined as the time between administration of a paralytic medication and confirmation of correct endotracheal tube placement by capnography. Patients who were intubated without RSI medications were excluded from this secondary analysis. Additionally, we tracked stated adherence with checklist use as well as video confirmation of each of the unique safety elements on the checklist (condensed from 21 individual points on the checklist to 15 key actions due to redundancy between the two checklists).

Data Analysis

Data were analyzed with comparisons between patients intubated during the 6-month prechecklist period and those during the 6-month postchecklist period. The absolute change in intubation-related complications was calculated as the difference between the proportions of patients with a complication during the prechecklist and postchecklist periods. Paralysis-to-intubation time and adherence to process measures were compared between groups using the Wilcoxon rank-sum test and chi-square test, respectively. Analyses were conducted with Stata 12.0.

RESULTS

A total of 141 patients were included in the study, including 76 in the prechecklist period and 65 in the postchecklist period. No patients were included multiple times. Baseline characteristics for patients and intubators were similar between the groups (Data Supplement S2, available as supporting information in the online version of this paper). Two patients, both in the prechecklist period, were intubated without any paralytic medications; one of these patients had an intubation-related complication, which included emesis and hypoxia. In the postchecklist period, the checklist was verbally stated for 54 (83.1%) patients and entirely executed for 45 (69.2%) patients, as confirmed by video review.

An intubation-related complication was experienced by one (1.5%) patient in the postchecklist period, compared to seven (9.2%) patients during the prechecklist period, representing a 7.7% (95% confidence interval = 0.5% to 14.8%) absolute risk reduction (Table 1). Median paralysis-to-intubation time during the postchecklist period was 82 seconds (interquartile range [IQR] = 68 to 101 seconds), compared to 94 seconds (IQR = 78 to 115 seconds) during the prechecklist period ($p = 0.02$). First-pass intubation success was similar in the postchecklist (86%) and prechecklist periods (79%; $p = 0.28$). Times from the decision to intubate to administration of the last RSI medication, and to confirmed tube placement, were also similar (Data Supplement S3, available as supporting information in the online version of this paper). Successful completion of all 15 unique intubation safety measures included on the checklist occurred for 45 (69.2%) patients in the postchecklist

Table 1
Patient Outcomes During the Prechecklist and Postchecklist Periods

Outcome	Prechecklist Period (n = 76)	Postchecklist Period (n = 65)
Intubation-related complications		
Oxygen desaturation	6 (7.9)	1 (1.5)
Emesis	2 (2.3)	0
Esophageal intubation	0	0
Severe hypotension	2 (2.6)	0
Cardiac arrest	0	0
Any intubation-related complication	7 (9.2)	1 (1.5)
Median paralysis-to-intubation time (paralytic medication to tube confirmation), seconds (IQR)*	94 (78–115)	82 (68–101)
First-pass intubation success	60 (79)	56 (86)
All 15 predefined safety measures completed	13 (17)	45 (69)

Data are presented as n (%) unless otherwise noted.
IQR = interquartile range; RSI = rapid sequence intubation.
*Two patients intubated in the prechecklist period without the use of RSI medications were not included in this analysis.

period, compared to 13 (17.1%) patients in the prechecklist period ($p < 0.01$; Data Supplement S4, available as supporting information in the online version of this paper).

DISCUSSION

Implementation of an ED preintubation checklist for trauma patients was associated with a decrease in intubation-related complications, reduction in the time between administration of paralytic medication and confirmed tracheal tube placement, and increased adherence to predefined safety measures. These data suggest that implementation of a standardized checklist for intubating trauma patients may improve patient safety during this high-risk procedure.

In the 6 months prior to checklist implementation, adherence with all 15 preintubation safety measures was low at 17%. Checklist implementation was associated with substantial improvement in adherence to these safety measures, with clinicians completing all 15 preintubation items in 69% of intubations in the postchecklist period. We believe that improved preparation for intubation, as measured by adherence to these safety measures, was the key mechanism for the decrease in complications in the postchecklist period. Specifically, we found that improvements in attention to preoxygenation, patient positioning, team roles, and medication choices and doses were associated with a reduction in oxygen desaturation, emesis, and hypotension. Interestingly, the one intubation-related complication in the postchecklist period occurred in one of 11 patients who did not have the checklist used. Review of this resuscitation video demonstrated no particular reason why the checklist was not used in this case. Team roles were not assigned, and a back-up plan in the event of a difficult airway was not discussed until the initial attempt failed. Laryngoscopy was difficult, hypoxia ensued, and there was a delay in initiating bag-valve-mask ventilation.

Checklists can have unintended negative effects; in particular, cumbersome checklists can cause unnecessary delays in patient care. Therefore, we measured the time delay between administration of the paralytic agent and endotracheal tube confirmation to assess if checklist implementation was associated with an increase in apnea time, when the patient is particularly vulnerable to complications. We found that checklist implementation was actually associated with a small reduction in induction-to-intubation time. Although a 12-second reduction may not directly improve patient outcomes, it suggests that checklist implementation was not associated with prolonged delays in apnea time and may result in a more organized approach following paralysis.

Similar to evaluations of other quality improvement initiatives that involved bundled implementation of several practice changes simultaneously,[2,3] we were unable to distinguish which specific elements of the checklist led to improvement in patient outcomes. However, several specific safety measures showed substantial improvement with checklist implementation, including verbalization of the intubation technique, preoxygenation with both facemask and nasal cannula, assignment of team member roles, and optimal patient positioning (Data Supplement S4). We hypothesize that improvements in these items were critical to lowering complications. Future work will focus on "unbundling" the checklist to explore if it can be simplified to a smaller number of critical items.

LIMITATIONS

While use of comprehensive video review facilitated accurate and detailed data collection, the study was limited by its single-center pre-/postintervention design. Future studies would be useful for external validation, as well as evaluating whether educational efforts alone could achieve similar results. Adherence to the checklist was not perfect in the postchecklist period; clinicians used the checklist in 83% of these intubations. Discussions with our clinicians suggested that the checklist was not used in some cases because of a perceived lack of time. Further study is needed to more fully understand barriers to implementation of a preintubation checklist.

CONCLUSIONS

We found use of a standardized preprocedural checklist is feasible when intubating severely injured trauma patients, and checklist implementation was associated with a reduction in immediate, intubation-related complications in a single academic ED.

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Supporting Information

The following supporting information is available in the online version of this paper:

Data Supplement S1. A standardized pre-procedural checklist for intubating trauma patients.

Data Supplement S2. Patient and intubator characteristics.

Data Supplement S3. Time elapse from the decision to intubate until administration of the last rapid sequence intubation medication, and confirmation of successful placement of an endotracheal tube.

Data Supplement S4. Adherence to intubation safety measures in the pre-checklist and post-checklist periods. These 15 items represent unique safety elements included on the checklist. The documents are in PDF format.