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ORIGINAL ARTICLE

Impact of intervention time on hospital survival in patients requiring emergent airway management: a preliminary study

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Abstract

Background The time in the day of intervention for physiological deterioration reportedly impacts patient outcomes. This study aimed at determining the impact of the time of ETI on hospital survival in critically ill patients.

Methods Between January 2014 and December 2016, 151 patients who underwent emergency tracheal intubation (ETI) by the airway response team (ART) in the general wards of a tertiary referral center were retrospectively reviewed. Patients were divided into two groups based on the time of ETI (daytime group, 8:00 a.m.–4:00 p.m., $n = 57$, mean age 63.5 ± 14.1 years; nighttime group, 4:00 p.m.–8:00 a.m., $n = 94$, mean age 60.4 ± 14.9 years). Data regarding demographic information, comorbidities, trigger events for intubation, survival-to-discharge rates, acute physiology and chronic health evaluation II (APACHE II), ventilator-free days, and airway techniques were collected.

Results There was no significant difference in sex, age, body mass index, APACHE II, or comorbidities between the two groups, except that a higher proportion of patients presented with arrhythmias (21.1 vs. 8.5%, $p = 0.028$) and received fiberoptic intubation (24.6 vs. 11.7%, $p = 0.039$) in the daytime group than in the nighttime group. The time of the ART arrival after call was also shorter in daytime than that in nighttime (6.1 ± 1.4 vs. 10.5 ± 3.2 min, respectively, $p < 0.001$). There were no differences in the survival-to-discharge rate (45.6 vs. 43.6%, $p = 0.811$), ventilator-free days, or trigger events between the two groups.

Conclusions Emergent tracheal intubation in the nighttime may not have negative impact on the survival-to-discharge rate compared with that performed in the daytime.

Keywords Tracheal intubation · Hospital survival · Airway response team

Introduction

The time in the day of intervention for physiological deterioration has been reported to impact patient outcomes. Hospital survival is reportedly worse for patients admitted to hospitals or intensive care units (ICUs) at weekends and at night [1–3]. Studies have also reported that hospital survival is worse in patients suffering from acute myocardial infarction [4–6] or from in-hospital cardiac arrest (IHCA) [7, 8] during the night compared to those suffering from these diseases during the day. Extended work shifts and increasing number of work hours have been reported to increase the rates of serious medical errors by residents and nurses [9, 10]. These differences in hospital survival rates at night or weekend may be attributed to medical resources available, diurnal variations in physiological and disease status, lower nurse/patent ratios, or care difference [7, 11, 12].

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There is evidence that early detection and response to physiological deterioration may improve outcomes for hospitalized patients [13, 14]. The incidence of difficult tracheal intubation was reported to be higher in non-operating room (OR) settings compared with that in OR settings [15]. A previous study reported a reduction in the frequency of in-hospital code blue through the implementation of an emergency airway response team [16]. To reduce the adverse events related to airway management and improve patient outcomes, an airway response team (ART) that comprises anesthesiologists was implemented in our hospital. However, studies assessing trigger events for ETI and subsequent hospital survival according to the time of day are rare. Our study aimed to determine whether the time of day when ETI was performed had any impact on the hospital survival rate in critically ill patients. We hypothesized that the survival rate for patients receiving tracheal intubation in nighttime is not inferior to that in the daytime. Clarification of this issue may enable the use of methods to reduce patient mortality when ETI is indicated at night.

Methods

Patient population

With the approval of our institutional review board (EMRP-106-028), all call events for ART outside the OR at E-Da Hospital, a 1200-bed tertiary referral center, from January 1, 2014 to December 31, 2016, were retrospectively reviewed. All call events were identified using hospital committee records. The total number of admissions in 3 years was 130,545. All patients aged 18 years and older for whom ART was activated in the general wards were eligible. Patients intubated for IHCA were also included. Exclusion criteria included: (1) tracheal intubation not performed (observation only), (2) pregnancy, (3) incomplete data, (4) requirement for ETI because of accidental self-extubation, (5) documented “not for resuscitation” order, (6) tracheostomy in situ, (7) tracheal intubation performed in procedural areas, including intensive care units (ICUs), or emergency department. Based on the policy of our hospital, patients with physiological deterioration for whom mechanical ventilation was required would be sent to ICUs for further care after tracheal intubation. All patient data were anonymized and de-identified prior to analysis.

Characteristics of airway response team

In our hospital, when patients require ETI based on physiological deterioration or airway protection (defined as a trigger event), residents or attending staffs in charge perform tracheal intubation. The consensus criteria for tracheal intubation included respiratory arrest, massive upper gastrointestinal bleeding, decreased level of consciousness (Glasgow Coma score < 9), airway obstruction due to head and neck tumor, severe dyspnea with use of accessory muscle and paradoxical abdominal motion, respiratory rate greater than 35 breaths per minute, life-threatening hypoxemia ($PaO_2 < 40$ mm Hg or $PaO_2/FiO_2 < 200$ mmHg), severe acidosis (pH < 7.25) and/or hypercapnia ($PaCO_2 > 60$ mmHg). If the airway is found to be more complex than expected (e.g., limited cervical spine range of motion, history of head and neck tumor, or limited oral opening) or if it cannot be successfully established after two intubation attempts with the Macintosh laryngoscopes based on the policy of our hospital, then the ART is activated. Before the arrival of the ART, the residents in charge provide noninvasive bag-valve-mask oxygen ventilation for patients if required.

The ART provides airway services 24 h per day and 7 days per week and is summoned to the location of the patient in need of ETI via a “stat” alert. The ART comprises an anesthesia resident with a minimum of 2 years of anesthesia training, an anesthesia nurse, and an attending anesthesiologist. During the day (first shift, 8:00 am–4:00 pm), the ART does not provide a routine anesthesia service and is always immediately available for providing airway service outside the OR. During the night (second shift, 4:00 pm–12:00 am and third shift, 12:00 am–8:00 am), the anesthesia service in the OR and airway service outside the OR is provided by the same anesthesia team. In most situations, the anesthesia resident acts as a first responder for ETI. The attending anesthesiologist may elect to participate in ETI if difficulty is anticipated or experienced by the resident. The ART uses its clinical judgment to determine the approach to ETI; e.g., intubation route and pre-medication. Advanced airway equipment, including fiberoptic bronchoscopes (Olympus LF-GP; Olympus Optical Co, Ltd, Japan), McCoy laryngoscope (Truphatek International Ltd, Netanya, Israel), ProSeal™ laryngeal mask airway (Laryngeal Mask Company, San Diego, CA, USA), Flexi-Slip stylet (Willy Rüsch AG, Kernen, Germany), Trachway intubating stylet (Trachway; Biotronic Instrument Enterprise, Tai Chung, Taiwan, China), Eschmann intubation stylet (tracheal tube introducer; SIMS Portex, Hythe, UK), and a Portex Cricothyrotomy Kit (PCK; Smith Medical International Ltd, Hythe, Kent, UK), are available at the bedside in a tackle box carried by the anesthesia nurse.

Data collection and statistical analysis

Data regarding demographic information, patient characteristics, comorbidities, trigger events for intubation, intervention time (daytime 8:00 am–4:00 pm; nighttime 4:00 pm–8:00 am), experience of anesthesiologists, acute Physiology and Chronic Health Evaluation II (APACHE II) score, survival-to-discharge rate, ventilator-free days, and airway techniques (use of fiberoptic scope for intubation), and time of the ART arrival after call were collected. The APACHE II score [17] was calculated after tracheal intubation and ICU admission. Ventilator-free days were defined as the number of days patients were alive and breathing without assistance during the first 28 day after tracheal intubation [18]. If the patient dies before 28 days or if the patient requires mechanical ventilation for 28 days or more, ventilator-free days were calculated as zero. The patients were divided into two groups based on the time of day when ETI was performed. The daytime group comprised patients in whom ETI was performed during the first shift (8:00 am–4:00 pm), and the nighttime group comprised those in whom ETI was performed during the second or third shift (4:00 pm–8:00 am). This cutoff time was chosen as immediate airway service could be provided by ART and the nurse/patient ratios were higher during the first shift compared to those during the other two shifts. The primary outcome was survival-to-discharge rate according to the time of day.

Quantitative variables were expressed as mean values (SD), and qualitative variables were expressed as percentages (%). Parametric values between the two groups were compared using the two-tailed Student's *t* test, and categorical variables were compared using the Chi-square or Fisher's exact test. Data were analyzed using SPSS (version 20, SPSS Inc, Chicago, IL, USA) and a p value of < 0.05 was considered statistically significant.

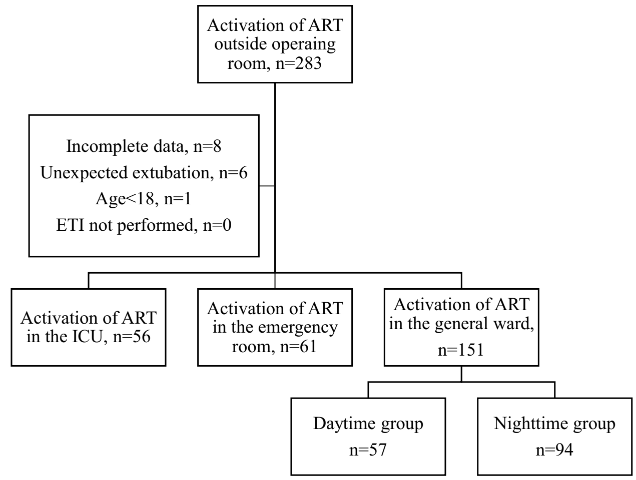

Fig. 1 Flowchart of recruitment process in the retrospective study. *ART* airway response team, *ETI* emergent tracheal intubation, *ICU* intensive care unit; daytime 8:00 am–4:00 pm; nighttime 4:00 am–8:00 am

Results

From January 1, 2014 to December 31, 2016, a total of 283 call events were retrospectively reviewed. After exclusion of 132 cases, 151 call events were included (Fig. 1). Overall, the final study population comprised 151 patients in whom ETI was performed in general wards. The baseline characteristics, comorbidities, and APACHE II of patients in the two groups are summarized in Table 1. Among the 151 patients, ETI was performed in 57 patients (37.7%) during the day (8:00 am–4:00 pm) and in 94 patients (62.3%) during the night (4:00 pm–8:00 am). There was no significant difference in sex, age, or body mass index between the two groups (Table 1). Patients in the daytime group were more likely to present arrhythmias than those in the nighttime group (21.1 vs. 8.5%, $p = 0.028$). There were no statistically significant differences in any other comorbidity or severity of illness score (APACHE II) between the two groups (Table 1).

Trigger events for ETI, advanced airway technique used (fiberoptic intubation), the time of the ART arrival after call, number of ventilator-free days, and survival-to-discharge rates are shown in Table 2. In the order of ranking, the most common trigger events were respiratory distress (53.6%), cardiac arrest (19.2%), altered mental status (11.3%), airway obstruction (9.3%), and airway protection (6.6%). There were no differences in trigger events between the patients in the two groups (Table 2). The distribution of trigger events throughout the day is shown in Fig. 2. The number of trigger events were equally distributed between the first (8:00 am–4:00 pm; $n = 57$; 37.7%) and second (4:00 pm–12:00 am; $n = 57$; 37.7%) shifts with 24.6% ($n = 37$) occurring during the third shift (12:00 am–8:00 am). Fiberoptic intubation was more commonly used during the day than during the night (24.6 vs. 11.7%, respectively, $p = 0.039$; Table 2). The time of the ART arrival after call was also shorter in daytime than that in nighttime (6.1 ± 1.4 vs. 10.5 ± 3.2 min, respectively, $p < 0.001$; Table 2). The overall survival-to-discharge rate was 44.4% among these 151 patients, and this rate was comparable between the two groups (45.6 vs. 43.6%, $p = 0.811$; Table 2). There was no significant difference in survival-to-discharge rate among first (45.6%, $n = 26$), second (50%, $n = 29$), and third (33.3%, $n = 12$) shifts ($p = 0.278$). The survival-to-discharge rates according to trigger events are shown in Fig. 3. Patients suffering from cardiac arrest in general wards had a low survival-to-discharge rate (10.3%; Fig. 3). There was also no significant difference between the two groups in the number of ventilator-free days (Table 2). Besides, comparison of the experience levels of anesthesiologists and residents responsible for emergent airway management outside OR showed no significant differences between the daytime and nighttime groups (Table 3).

Table 1 Characteristics and comorbidities in patients treated at daytime versus nighttime

Variables	Daytime group ($n = 57$)	Nighttime group ($n = 94$)	p value
Gender (male)	40 (70.2)	66 (70.2)	0.996
Age (years)	63.5 ± 14.1	60.4 ± 14.9	0.214
Height (cm)	162.3 ± 10.7	163.1 ± 7.9	0.644
Weight (kg)	62.7 ± 18.8	66.9 ± 19.4	0.192
BMI (kg/m^2)	23.6 ± 5.9	25.1 ± 7.1	0.187
Underlying disease			
CAD	4 (7)	10 (10.6)	0.457
Heart failure	4 (7)	13 (13.8)	0.199
AMI	4 (7)	4 (4.3)	0.477
Sepsis	14 (24.6)	20 (21.3)	0.639
Arrhythmias	12 (21.1)	8 (8.5)	0.028
Hypertension	24 (42.1)	34 (36.2)	0.467
Diabetes mellitus	20 (35.1)	31(33)	0.791
Lung disease	30 (52.6)	52 (55.3)	0.748
Renal disease	24 (42.1)	37 (39.4)	0.739
Liver disease	5 (8.8)	18 (19.1)	0.085
Neurologic disease	9 (15.8)	19 (20.2)	0.498
Electrolyte imbalance	13 (22.8)	19 (20.2)	0.705
ENT cancer	16 (28.1)	15 (16)	0.074
Other cancer	13 (22.8)	22 (23.4)	0.933
Trauma	5 (8.8)	4 (4.3)	0.299
Airway obstruction	2 (3.5)	1 (1.1)	0.557
GI bleeding	5 (8.8)	10 (10.6)	0.710
Post-operative patients (< 24 h)	8 (14)	8 (8.5)	0.285
APACHE II score[a]	26.5 ± 10	24.6 ± 9.6	0.28

Data are presented as mean (SD) or number (proportion)

BMI body mass index, *CAD* coronary artery disease, *AMI* acute myocardiac infarction, *ENT cancer* ear, nose and throat cancer, *GI* gastrointestinal, *APACHE II* Acute Physiology and Chronic Health Evaluation II

[a]Data available in 127 patients (daytime group: $n = 49$; nighttime group: $n = 78$)

Table 2 Trigger events for emergent airway management, advanced airway techniques, and survival to discharge in patients treated at daytime versus nighttime

Variables	Overall ($n = 151$)	Daytime group ($n = 57$)	Nighttime group ($n = 94$)	p value
Trigger events				
Altered mental status	17 (11.3)	6 (10.5)	11 (11.7)	0.825
Respiratory distress	81 (53.6)	31 (54.4)	50 (53.2)	0.887
Airway protection	10 (6.6)	3 (5.3)	7 (7.4)	0.743
Airway obstruction	14 (9.3)	6 (10.5)	8 (8.5)	0.679
Cardiac arrest	29 (19.2)	11 (19.3)	18 (19.1)	0.982
Fiberoptic intubation	25 (16.6)	14 (24.6)	11 (11.7)	0.039
Time of arrival (min)	8.9 ± 3.4	6.1 ± 1.4	10.5 ± 3.2	<0.001
Survival to discharge	67 (44.4%)	26 (45.6%)	41 (43.6%)	0.811
Ventilator-free days[a]	8.3 ± 10.7	8.5 ± 10.8	8.1 ± 10.7	0.819

Data are presented as mean (SD) or number (proportion)

[a]Ventilator-free days were defined as the number of days patients were alive and breathing without assistance during the first 28 day after tracheal intubation

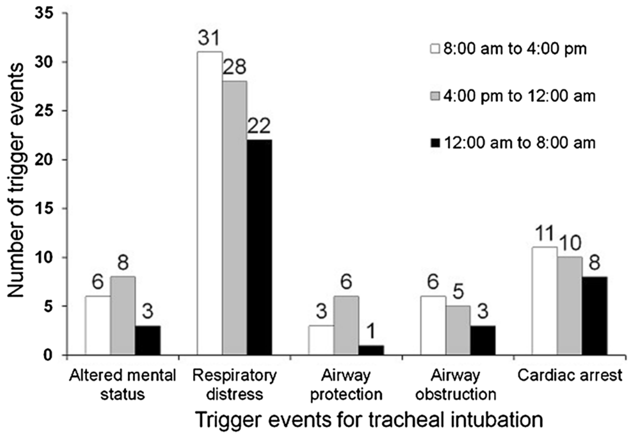

Fig. 2 Number and distribution of trigger events for tracheal intubation by airway response team (ART) during the three shifts of a day

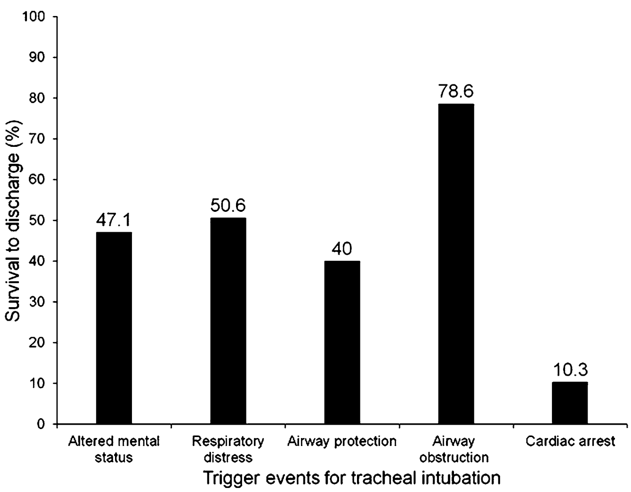

Fig. 3 Percentages of survival to discharge for patients receiving tracheal intubation by airway response team (ART) of different causes

Table 3 Comparison of experience levels of anesthesiologists and residents responsible for emergent airway management outside operating room between the daytime and nighttime groups

Variables	Daytime group ($n = 57$)	Nighttime group ($n = 94$)	p value
Attending anesthesiologists			0.754
Experience level 1–5 years	21 (36.8)	30 (31.9)	
Experience level 6–10 years	25 (43.9)	47 (50)	
Experience level > 10 years	11 (19.3)	17 (18.1)	
Residents			0.948
CA2	20 (35.1)	31 (33)	
CA3	21 (36.8)	37 (39.4)	
CA4	16 (28.1)	26 (27.7)	

Data are presented as number (proportion). CA2, CA3, CA4 are resident in second, third, or fourth year of anesthesia training

Discussion

In a retrospective cohort of 151 patients undergoing ETI in the general wards, we observed that fiberoptic intubation was more commonly performed and the time of arrival was shorter during the daytime than those during the nighttime. There were comparable survival-to-discharge rates between patients treated during the daytime and those treated during the nighttime (45.6 vs. 43.6%, $p = 0.811$). Trigger events for ETI were similar between the two groups; respiratory distress (53.6%) and cardiac arrest (19.2%) were the most common trigger events for ETI in the general wards.

In our hospital, there are variations in the nurse/patient ratios according to the time of day in general wards. Furthermore, airway complications have been reported to more commonly occur when ETI is performed in general wards [15]. Therefore, our study focused on patients requiring ETI in general wards. It is well known that tracheal intubation is more difficult outside the OR than within the OR [15]. Based on 3423 ETIs performed outside the OR, Martin et al. reported a 10% difficulty rate of intubation [15] as opposed to 5.8% during elective intubation performed in the OR [19]. Fiberoptic intubation remains the standard of care for difficult airway management, which may decrease the chances of failed tracheal intubation outside the OR. We observed that fiberoptic intubation was more commonly performed during the day than during the night, which suggests a difference in airway management based on the time of day when ETI was indicated. Although the reasons for this finding were unknown, Weinger et al. reported that fiberoptically guided procedures such as fiberoptic intubation would be rated higher in workload than those involving direct visualization [20]. Overworked and sleep-deprived staff physicians and nursing personnel are more likely to provide substandard care [21, 22]. Therefore, it appears rational that a procedure involving higher workload (e.g., fiberoptic intubation) is not the preferred option for anesthesiologists working during the night.

In our study, we observed that the number of trigger events were equally distributed between the first ($n = 57$, 37.7%) and second ($n = 57$, 37.7%) shifts with 24.6% ($n = 37$) occurring during the third shift, which indicates that the incidence of several medical emergencies was similar between the different times of day. This finding may corroborate with the study by Herlitz et al. that reported that cardiac arrests were more common during the night (4:30 pm–8:00 am; 58%) than during the day (8:00 am–4:30 pm; 42%) [8]. In our hospital, the nurse/patient ratios are usually low during the night, and the staff physicians may be sleep-deprived and overloaded with work during this time. Hence, it is logical that medical care and resource utilization may be suboptimal during the night. Interestingly, we did not observe a decrease in the survival-to-discharge rates in patients undergoing ETI during the nighttime.

The similar survival-to-discharge rates observed during day and night may be attributed to several possible explanations. First, although the nurse/patent ratios are usually low at night, there are lesser procedures, medical orders, and surgeries performed during this time. The workload of nursing staff may be comparable between the daytime and nighttime, which may decrease the care difference between the different times of day. Second, early intervention in deteriorating patients may decrease the risk of cardiac arrest and avoidable death [23]. Critically ill patients may be in a monitored area for the occurrence of physiological deterioration, which may, therefore, improve the survival rate in patients treated during the night. Third, even during the night, ETI was performed by the anesthesia team in our hospital, which may, therefore, increase the success rate of ETI and significantly decrease the number of respiratory arrests and subsequent cardiac arrest. Fourth, the admission of critically ill patients to ICU after tracheal intubation is a routine practice in our hospital. Nursing shortages during the night are uncommon in ICU, and one critical care staff physician is always available during this time. Therefore, essential services are maintained for critically ill patients. In a retrospective cohort study of 6034 patients, Morales et al. reported that the nighttime admission to ICU is not associated with a higher mortality rate than the daytime admission [3]. They posited that if there are enough medical resources, staff physicians, and other services needed to provide optimal patient care, the timing of admission to ICU is unlikely to be associated with mortality rate [3]. Our findings may be consistent with those of Morales et al. [3].

In our study, the most common indications for ETI in the general wards were respiratory distress (53.6%) and cardiac arrest (19.2%). This finding is consistent with a study by Martin et al., which reported that respiratory distress and cardiac arrest accounted for 51.7 and 44.6% of patients, respectively, requiring ETI outside the OR [15]. Acute respiratory failure has been identified as a risk factor for cardiovascular collapse related to intubation in the ICU [24]. Furthermore, the 28-day mortality rate was reported to be higher in patients who experienced cardiovascular collapse than those who did not experience cardiovascular collapse [24]. To improve the survival rates, specific bundles should be used to prevent cardiovascular collapse related to ETI. The survival-to-discharge rate was low (10.3%) in our patients suffering from IHCA. As cardiac arrest was a trigger event for ETI, we suggest that these patients were at a non-monitored area. Due to a lack of early intervention, the survival-to-discharge rate is expected to be low. In addition, tracheal intubation has been reported to be more difficult in patients suffering from IHCA [25], which may be a reason for the poor outcomes observed in these patients.

Rapid response teams (RRT), including medical emergency teams (MET) and ART, have been widely implemented to improve short- and long-term outcomes in hospitalized patients [13]. MET are established in many medical institutes for early detection of pre-critical condition in which the patients show signs of physiological instability and may require ETI. It has been reported that the implementation of MET may effectively reduce the incidence of cardiac arrest in hospitalized patients [14]. Nevertheless, only ART was available at our hospital. It is rational to propose that implementation of MET may reduce the incidence of ETI and subsequent in-hospital mortality.

Our study had several limitations. first, the medical/surgical residents, nursing staff, or physicians may have been at an increased risk for errors in care processes when sleep-deprived or when working at extended shifts. The level of in-hospital staffing by nurses may also be associated with patient outcome and mortality [26]. Second, although ART should be activated after two unsuccessful intubation attempts, activation of the ART and intubation may be delayed by less experienced attending physicians. However, these possible confounders including the intubating skill of the attending physicians and the number of unsuccessful intubation attempts could not be identified in the present retrospective cohort study. Third, our results may not be generalizable to other hospitals where an ART is absent. The presence of the ART may have decreased a significant number of respiratory arrests and subsequent hospital mortality. Fourth, the retrospective study included only patients in whom tracheal intubation was performed by the ART. Consequently, we were unable to compare the outcomes between patients who received ETI by the ART and those whom ART did not attend. Fifth, the time of hospital admission may have impacted the patient outcomes [1–3], which was not evaluated. Finally, we did not collect information regarding the number of intubation attempts and complications related to ETI according to the time of day.

In conclusion, the survival-to-discharge rate was comparable between patients receiving emergent tracheal intubation during the day and those receiving emergent tracheal intubation during the night. Our results suggested that emergent tracheal intubation in the nighttime may not have significant impact on the survival-to-discharge rate compared with that performed in the daytime. Because of the small number of subjects and the preliminary nature of this study, the results should be interpreted with caution and a large prospective study is required to further support our findings.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

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